1.0 Introduction

Entergy Operations, Inc. (Entergy)[a] operates Arkansas Nuclear One (ANO), Units 1 (ANO-1) and 2 (ANO-2) in west-central Arkansas under operating licenses (OLs) DPR-51 and NPF-6, issued by the U.S. Nuclear Regulatory Commission (NRC). These OLs will expire in 2014 for Unit 1 and 2018 for Unit 2. By letter dated January 31, 2000, Entergy submitted an application to the NRC to renew the ANO-1 OL for an additional 20 years under Part 54 of Title 10 of the Code of Federal Regulations (10 CFR Part 54). A separate application will be submitted for ANO-2. Entergy is a *licensee* for the purposes of its current OLs and an *applicant* for the renewal of the OL.

The National Environmental Policy Act of 1969 (NEPA) requires an environmental impact statement (EIS) for major Federal actions significantly affecting the quality of the human environment. As provided in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996; 1999),[b] under NRC's environmental protection regulations in 10 CFR Part 51 implementing NEPA, renewal of a nuclear power plant operating license is identified as a major Federal action significantly affecting the quality of the human environment. Therefore, an EIS is required for a plant license renewal review. The EIS requirements for a plant-specific license renewal review are specified in 10 CFR Part 51. Pursuant to 10 CFR 54.23 and 51.53(c), Entergy submitted an Environmental Report (ER) (Entergy 2000a) in which Entergy analyzed the environmental impacts associated with the proposed action, considered alternatives to the proposed action, and evaluated any alternatives for reducing adverse environmental effects.

As part of NRC's evaluation of the application for license renewal, the NRC staff is required under 10 CFR Part 51 to prepare an EIS for the proposed action, issue the statement in draft form for public comment, and issue a final statement after considering public comments on the draft. This report is the final plant-specific supplement to the GEIS, that is, the Supplemental Environmental Impact Statement (SEIS), for the Entergy license renewal application for ANO-1**.** The staff will also prepare a separate safety evaluation report in accordance with 10 CFR Part 54.

The following sections in this introduction describe the background and the process used by the staff to assess the environmental impacts associated with license renewal, describe the proposed Federal action, discuss the purpose and need for the proposed action, and present

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(a) Entergy Operations, Inc. holds the license for the ANO Units 1 and 2. Entergy Operations, Inc. is an operating subsidiary of the Entergy Corporation. Entergy Arkansas, Inc., is the owner of ANO Units 1 and 2.

(b) 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.

the status of compliance with environmental quality standards and requirements that have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection. Chapter 2 describes the site, power plant, and interactions of the plant with the environment. Chapters 3 and 4 discuss the potential environmental impacts of plant refurbishment and plant operation during the renewal term, respectively. 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, and Chapter 7 discusses decommissioning. The alternatives to license renewal are considered in Chapter 8. Finally, Chapter 9 summarizes the findings of the prior chapters, draws conclusions related to 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 commitments of resources), and presents the recommendation of the staff with respect to the proposed action. Additional information is included in Appendices. Appendix A contains a discussion of comments obtained during the public scoping meetings and the public meetings held to discuss the draft SEIS. Appendix B lists preparers of this supplement, and Appendix C lists the chronology of correspondence between NRC and Entergy and others with regard to this supplement. The remaining appendices are identified in subsequent sections.

Generic Environmental Impact Statement

The 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. The GEIS 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) described the activity that affects the environment, (2) identified the population or resource that is affected, (3) assessed the nature and magnitude of the impact on the affected population or resource, (4) characterized the significance of the effect for both beneficial and adverse effects, (5) determined whether the results of the analysis applied to all plants, and (6) considered whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC established its standard of significance using the Council on Environmental Quality terminology for "significantly" (40 CFR 1508.27) for assessing environmental issues. Using the Council on Environmental Quality guidelines, the NRC established three significance levels 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 assigned a significance level to each environmental issue. In assigning these levels, it was assumed that ongoing mitigation measures would continue.

The GEIS included 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 were 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 not likely 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 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 two issues were not categorized. The latter two issues, environmental justice and chronic effects of electromagnetic fields, are to be addressed in a plant-specific analysis. Of the 92 issues, 10 are related to refurbishment, 74 are related to operations during the renewal term, and 8 apply to both refurbishment and operations during the renewal term. A summary of the findings for all 92 issues of the GEIS is codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1.

License Renewal Evaluation Process

An applicant seeking to renew its operating license is required to submit an ER as part of its application. This ER must provide an analysis of the issues listed as Category 2 in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 in accordance with 10 CFR 51.53(c)(3)(ii). The ER must include a discussion of actions to mitigate 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 need not 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 essential for determination of whether an alternative should be included in the range of alternatives considered or relevant to mitigation. Section 51.53(c)(2) also provides that certain other issues, including the need for power and other issues not related to the environmental effects of the proposed action, need not be considered in the ER. In addition, the ER need not 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). Pursuant to 10 CFR 51.53(c)(3)(iii) and (iv), the ER is not required to contain an analysis of any Category 1 issues unless there is significant new information on a specific issue. New and significant information is (1) information that identifies a significant environmental issue not covered in the GEIS and codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding different from that codified in 10 CFR Part 51.

In preparing to submit its application to renew the ANO-1 operating license, Entergy developed a process to ensure that new and significant information regarding the environmental impacts of license renewal for ANO-1 would be properly reviewed before submitting the ER and to ensure that new and significant information related to renewal of the ANO-1 license would be identified, reviewed, and addressed during the period of NRC review. Entergy reviewed the Category 1 issues appearing in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, to verify that the conclusions of the GEIS remained valid with respect to ANO-1. To conduct this review, Entergy

established an investigative team from ANO and corporate headquarters that was knowledgeable in plant systems, site environment, plant environment, and plant environmental issues. Entergy also contracted with an organization that was familiar with NEPA issues and the scientific disciplines involved in the preparation of a license renewal ER to assist Entergy with the review of new and significant information.

The NRC staff also has a process for identifying new and significant information. That process is described in detail in the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*, NUREG-1555, Supplement 1 (NRC 2000b). The search for new information includes a review of an applicant's ER and the process for discovering and evaluating the significance of new information; review of records of public meetings and correspondence; review of environmental quality standards and regulations coordination with Federal, State, and local environmental protection and resource agencies; and review of the technical literature. Any 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. Neither Entergy nor the staff has identified any new issue applicable to ANO-1 that has a significant environmental impact.

The discussion of the environmental issues considered in the GEIS that are applicable to ANO-1 is found in Chapters 3 through 7. 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 short paragraphs that state the GEIS conclusion codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, 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 discussing the Category 2 issues are listed immediately following the table.

The NRC prepares an independent analysis of the environmental impacts of license renewal as well as a comparison of these impacts to the environmental impacts of alternatives. The evaluation of Entergy's license renewal application began with publication of a notice of acceptance for docketing and opportunity for a hearing in the Federal Register (FR) (65 FR 11609, March 3, 2000). The staff published a notice of intent to prepare an EIS and conduct scoping (65 FR 13061, March 10, 2000). Two public scoping meetings were held on April 4, 2000, in Russellville, Arkansas. Comments received during the scoping meetings are

summarized in the *Environmental Impact Statement Scoping Process: Summary Report - Arkansas Nuclear One Unit 1, Russellville, Arkansas,* August 21, 2000 (NRC 2000a).

The staff visited ANO-1 on April 4-6, 2000, 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 of this document. Other documents related to ANO-1 were also reviewed and are referenced.

The staff followed the review guidance contained in the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*, NUREG-1555, Supplement 1 (NRC 2000b). The staff issued requests for additional information (RAIs) to Entergy by letters dated April 12 and June 5, 2000 (NRC 2000c; 2000d). Entergy provided its responses in letters dated June 26 and July 31, 2000 (Entergy 2000b; 2000c). The staff reviewed this information and incorporated it into its analysis. The results of the staff evaluation and recommendation are contained in this SEIS.

On the date of publication of the U.S. Environmental Protection Agency Notice of Filing of the draft SEIS (October 20, 2000), a 75-day comment period began during which members of the public could comment on the preliminary results of the NRC staff's review. During this comment period, two public meetings were held in Russellville, Arkansas, on November 14, 2000. During these meetings, the staff described the preliminary results of the NRC environmental review and was available to answer questions related to it to provide members of the public with information to assist them in formulating their comments. The comment period for the ANO-1 draft SEIS ended on January 4, 2001.

This report presents the staff's analysis that considers and weighs the environmental effects of the proposed renewal of the ANO-1 license, the environmental impacts of alternatives to license renewal, and alternatives available for avoiding adverse environmental effects. The staff considered the comments that were received during the comment period. The disposition of these comments are addressed in Appendix A of this SEIS. The staff modified the analysis set forth in the draft SEIS to address certain comments, where appropriate. A vertical bar in the margin indicates where the staff made changes to the draft SEIS. In addition, Chapter 9, "Summary and Conclusions," provides the NRC staff's final recommendation to the Commission on whether the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decision-makers would be unreasonable.

1.1 The Proposed Federal Action

The proposed Federal action is renewal of the operating license for ANO-1. ANO-1 is located in southwestern Pope County, Arkansas, approximately 91 km (57 mi) northwest of Little Rock,

Arkansas and 109 km (68 mi) east of Fort Smith, Arkansas. The plant has two units; however, only ANO-1 is described in the license renewal application. ANO-1 is a pressurized light-water reactor, with a design rating for net electrical power output of 836 megawatts electric (MW[e]). Plant cooling is provided by a once-through heat dissipation system into Lake Dardanelle. Lake Dardanelle is a reservoir made by the Dardanelle Lock and Dam on the Arkansas River. The Dardanelle project was completed primarily to aid in navigation; however, it was soon determined to be a good location for the ANO site. The current operating license for ANO-1 expires on May 20, 2014. By letter (Entergy 2000a), Entergy submitted an application to renew the operating license for an additional 20 years of operation (i.e., until May 20, 2034).

1.2 Purpose and Need for the Action

Although a licensee must have a renewed license to operate a plant beyond the term of the existing operating license, 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 Commission 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, as amended, 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 operating license is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the plant's license.

1.3 Compliance and Consultations

Entergy is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements. Entergy provided a list in its ER of the status of authorizations from Federal, State, and local authorities for current operations as well as environmental approvals and consultations associated with ANO-1 license renewal. Authorizations most relevant to the proposed license renewal action are summarized in Table 1-1.

The staff reviewed the list and has 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. Agency interactions did not identify any new and significant environmental issues. Correspondence related to these consultations are provided in Appendix E. The staff has also not identified any new and significant environmental issues.

1.4 References

10 CFR Part 50, “Domestic licensing of production and utilization facilities.”

10 CFR Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.”

10 CFR 51.23, “Temporary storage of spent fuels after cessation of reactor operation – generic determination of no significant environmental impact.”

10 CFR 51.53, “Postconstruction environmental reports.”

10 CFR 51.53(c), “Operating license renewal stage.”

10 CFR Part 51, Subpart A, Appendix B, Table B-1, “Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants.”

10 CFR Part 54, “Requirements for renewal of operating licenses for nuclear power plants.”

10 CFR 54.23, “Contents of application - environmental information.”

40 CFR 1508.27, “Terminology and Index - ‘Significantly’.”

10 USC 2668, Armed Forces, “Easements of rights-of-way.”

Table 1-1. Federal, State, and Local Authorizations

Agency	Authority	Requirement	License Permit Number	Permit Expiration or Consultation Date	Activity Covered
NRC	Atomic Energy Act, 10 CFR Part 50	Operating license	DPR-51	May 20, 2014	Operation of ANO Unit 1
FWS	Endangered Species Act, Section 7	Consultation		August 7, 1997 October 1, 1999	
CoE	Title 10 USC Section 2668	Dardanelle water use agreement	DACW03-71-0002	NA	--
CoE	Rivers and Harbors Act, Section 10		Nationwide Permit No. 00241-6	September 30, 2001	--
CoE	FWPCA, Section 404	Dredging permit	00241-5	NA	Dredging of intake canal as needed
DOT	Hazardous Materials Transportation Act	--	--	June 30, 2001	--
ADEQ	FWPCA	State discharge permit	AR0001392	October 31, 2002	Sewage wastewater and emergency cooling water pond, plant waste waters
ADEQ	Clean Air Act, Section 112	Air discharge permit	0090-AR-2	NA	Diesel generators, plant heating boiler
ADEQ	RCRA-Subtitle I	Petroleum storage tank registration	58000008 58000009	July 31, 2001 July 31, 2001	Fuel storage
ASHPO	National Historic Preservation Act, Section 106	Consultation	NA	Letter from ASHPO dated March 30, 1998	Operation during the renewal term
ASWCC	Arkansas Soil and Water Conservation Commission	Water use registration	4124	NA	--

ADEQ – Arkansas Department of Environmental Quality
ASHPO – Arkansas State Historic Preservation Office
ASWCC – Arkansas Soil and Water Conservation Commission
CoE – U.S. Army Corps of Engineers
DOT – U. S. Department of Transportation
FWPCA – Federal Water Pollution Control Act of 1977 (also known as the Clean Water Act)
FWS – U.S. Fish and Wildlife Service
RCRA – Resource Conservation and Recovery Act of 1976
NA – Not applicable.

65 FR 11609, “Notice of Acceptance for Docketing of the Application and Notice of Opportunity for a Hearing Regarding Renewal of License No. DPR-51 for an Additional Twenty-Year Period.” March 3, 2000.

65 FR 13061, “Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process.” March 10, 2000.

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

Clean Air Act of 1970, as amended, 42 USC 7401, et seq.

Endangered Species Act of 1973, as amended, 16 USC 1531, et seq.

Entergy Operations Inc. 2000a. Letter from C. Randy Hutchinson, Vice President, Operations ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

Entergy Operations Inc. 2000b. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance. Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, Environmental Report RAIs. Dated June 26, 2000.

Entergy Operations Inc. 2000c. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, License Renewal Application RAIs (TAC Nos. MA8054 and MA8055). Dated July 31, 2000.

Federal Water Pollution Control Act of 1977, as amended, 33 USC 1251, et seq. (also known as the Clean Water Act).

Hazardous Materials Transportation Act of 1975 as amended, 40 USC 1811, et. seq.

National Environmental Policy Act of 1969, as amended, 42 USC 4321, et seq.

National Historic Preservation Act of 1966, as amended, 16 USC 470, et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901

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

U.S. Nuclear Regulatory Commission (NRC). 2000a. *Environmental Impact Statement Scoping Process: Summary Report - Arkansas Nuclear One Unit 1, Russellville, Arkansas*. Washington, D.C. Dated August 21, 2000.

U.S. Nuclear Regulatory Commission (NRC). 2000b. *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). 2000c. Letter from U.S. NRC to C. Anderson, Entergy Operations Inc. Subject: Request for Additional Information for the Review of Arkansas Nuclear One Unit 1 Environmental Report Associated with License Renewal-SAMA. Dated April 12, 2000.

U.S. Nuclear Regulatory Commission (NRC). 2000d. Letter from U.S. NRC to C. Anderson, Entergy Operations Inc. Subject: Request for Additional Information for the Review of Arkansas Nuclear One Unit 1 Environmental Report Associated with License Renewal-SAMA. Dated June 5, 2000.

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

Arkansas Nuclear One, Unit 1 (ANO-1) is located near Interstate 40 on a peninsula formed by Lake Dardanelle in southwestern Pope County, Arkansas, approximately 109 km (68 mi) east of Fort Smith, Arkansas, and about 91 km (57 mi) northwest of Little Rock, Arkansas. The town of Russellville, Arkansas, is about 10 km (6 mi) east-southeast of the site. The site is in the west-central part of the State, approximately 112 km (70 mi) east of the Oklahoma border and the same distance south from the Missouri border, as shown in Figure 2-1. ANO is a two-unit plant, but only ANO-1 has currently submitted an application for license renewal. ANO-1 is equipped with a nuclear steam supply system manufactured by Babcock and Wilcox that uses a pressurized light-water reactor (LWR) and once-through cooling with water from Lake Dardanelle. The electricity generated is transferred to the switchyards located at the ANO site. ANO-1 has a design rating for net electrical power output of 850 megawatts electric (MW[e]), and rated at 836 MW(e) power. Descriptions of the plant and its environs follow in Section 2.1, and the plant's interaction with the environment is presented in Section 2.2.

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

ANO-1 is located on 471 ha (1164 acres) in a rural part of west-central Arkansas. Figure 2-1 shows the location of ANO-1 in Arkansas. The site is surrounded by an exclusion area of 1-km (0.7-mi) radius as shown in Figure 2-2. Entergy owns most of the property on the peninsula. The property that is not owned by Entergy is privately owned, with the U. S. Army Corps of Engineers also owning easements around Lake Dardanelle.

The region surrounding ANO-1 was identified in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996; 1999)[(1)] as having a low population density. Approximately 1313 persons comprise the non-outage work force at ANO. Normally, there are 1145 Entergy employees onsite. The remaining 168 persons are baseline contractor employees. The plant is located near the towns of London and Russellville, Arkansas. The ANO site is located on a peninsula formed by Lake Dardanelle, and three sides of the site are surrounded by lake water. Outside of the property line on the southern end of the peninsula, the majority of the land area is forest and residential development. Pasture and croplands are insignificant to nonexistent on the peninsula.

(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.

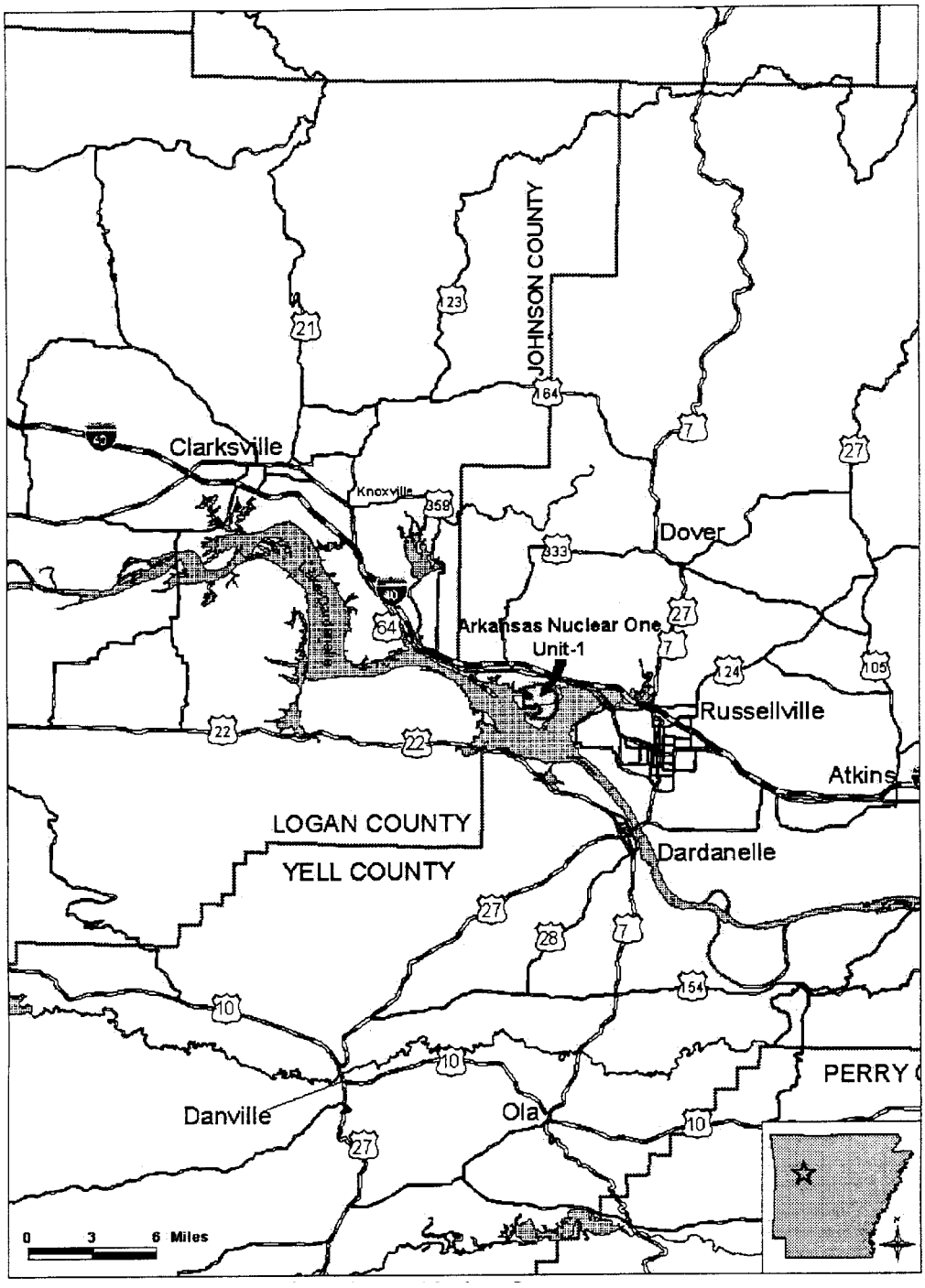

Figure 2-1. Location of Arkansas Nuclear One

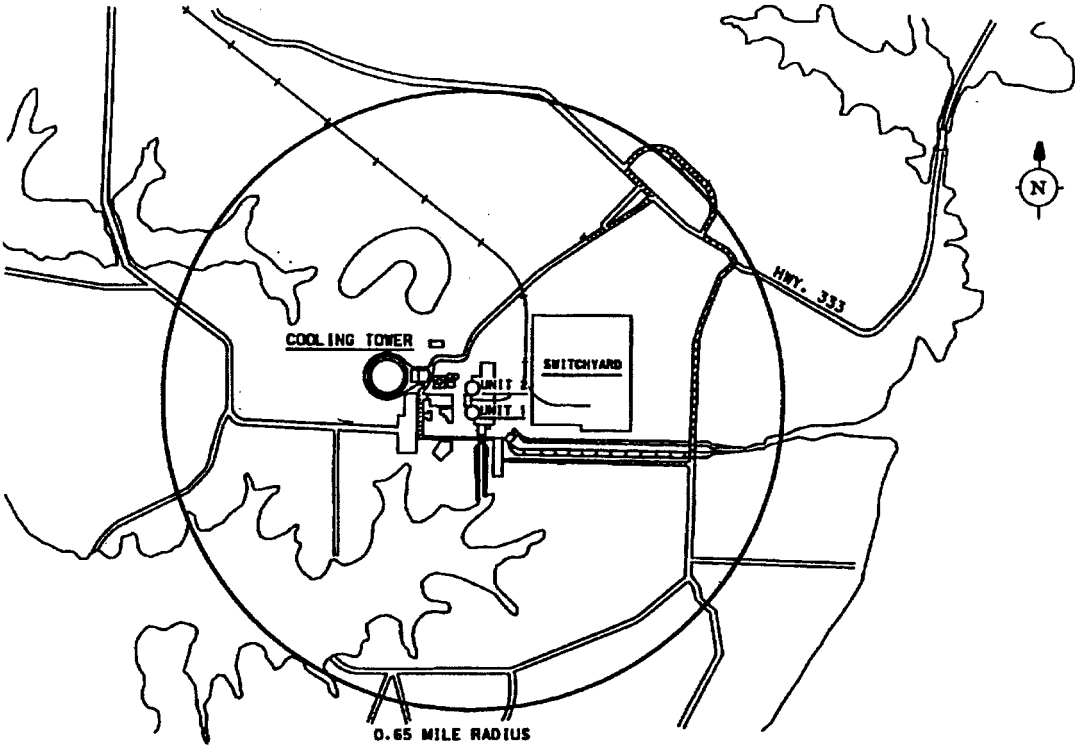

Figure 2-2. Arkansas Nuclear One - Exclusion Area

The property consists primarily of meadows, with surface elevations ranging from about 120 m (400 ft) to 150 m (500 ft) on the peninsula. The site has excellent natural drainage. Surface runoff from the site is collected in storm water drains, the intake canal, and the emergency cooling pond where it is discharged to Lake Dardanelle. The average annual rainfall at the site area is approximately 124 cm (49 in).

Lake Dardanelle is part of the Arkansas River and is 80 km (50 mi) long. The lake was created as part of the multi-purpose project for improvement of the Arkansas River by the construction of the Dardanelle Lock and Dam. The Dardanelle Lock and Dam facilitates navigation on the river and provides for generation of hydroelectric power, as well as recreation and fish and wildlife resources. The lake was one of 17 impoundments built along the Arkansas River to provide a 724-km (450-mi) navigable channel from the Mississippi River to Catoosa, Oklahoma. Lake Dardanelle is over 18 m (60 ft) deep at its lower end, averaging 3 m (10 ft). The lake has a surface area of approximately 14,975 ha (37,000 acres) and a storage capacity of 6×10^8 m^3 (486,000 acre-ft). ANO is located about 9.5 km (6 mi) upstream from the Dardanelle Dam. The Arkansas River Navigation Channel is about 2.2 km (1.4 mi) south of the reactor buildings.

- **External Appearance and Setting**

The cooling tower for ANO-2 is the most distinctive feature of the ANO site and can be seen from a considerable distance, especially from Interstate 40. ANO sits on a 3.2-km-wide and 3.2-km-long (2-mi-wide and 2-mi-long) peninsula on Lake Dardanelle. The peninsula elevation varies from 122 to 150 m (400 to 500 ft). The land around the site is mostly meadow, and outside the property line is mostly forest, with the remaining land-use being pasture and residential development. Recently, Entergy initiated an onsite reforestation project.

North of the site, the land gradually ascends to 305 m (1000 ft) to the Boston Mountains, which has a maximum height of 823 m (2700 ft). The Arkansas River follows along the base of the Boston Mountains. Across from the Arkansas River, south and west of the site, is a range of hills, with Mount Nebo, at an elevation of 573 m (1880 ft), directly south of the site. From the top of Mount Nebo, you can get a clear view of the ANO site. Forty km (25 mi) west of the site is Magazine Mountain; at an elevation of 927 m (3042 ft), it is the highest point in the State. East and south of the site is moderately level land, interspersed with rolling hills and covered with woods.

The geology around ANO is fairly simple. Under the site is a 4- to 7-m (13- to 24-ft) deep layer of heavy clay or silty clay, which rests on horizontally laid hard shale and sandstone of the McAlester formation. The nearest faults are 4 to 8 km (2.5 to 5 mi) from the site and have not been active for over 65-million years. After intermittent submergence by relatively shallow seas during most of the Paleozoic Periods, the late Mississippian time opened dramatic episodes of ocean-trough development and thick sedimentary and volcanic deposition, followed by late Pennsylvanian mountain-folding and faulting, which caused the bedrock features seen today. The bedrock under ANO is part of a large syncline, known as the Scranton syncline, which lies in an east and west direction (AEC 1973).

Entergy Operations has an independent spent fuel storage installation (ISFSI) on the ANO site. This ISFSI is authorized pursuant to the general license issued in 10 CFR 72.210. The ISFSI is outside the scope of this review.

- **Reactor Systems**

ANO is a two-unit site. Both units are pressurized water reactors. ANO-1, which is the unit that is currently applying for license renewal, has a Babcock and Wilcox nuclear steam supply system, and ANO-2 has a Combustion Engineering nuclear steam supply system. ANO-1 has a design rating for net electrical power output of 850 MW(e) and is operated at a maximum core thermal power output level of thermal rating of 2568 MW(t). ANO-1 obtained its license and began commercial operation in 1974.

The primary structures for ANO-1 are the reactor building and auxiliary building, and a common turbine building shared with ANO-2. The reactor and nuclear steam supply systems are housed in the reactor building. The mechanical and electrical systems required for the safe operation of ANO-1 are located in the auxiliary and reactor buildings. Figure 2-3 shows the general layout of the ANO buildings and structures.

Reactor containment structures are designed with engineered safety features to protect the public and plant personnel from an accidental release of radioactive fission products, particularly in the unlikely event of a loss-of-coolant accident. These safety features function to localize, control, mitigate, and terminate such events to limit exposure levels below applicable dose guidelines. The reactor is controlled using a combination of chemical controls and solid absorber material (control rods).

• Cooling and Auxiliary Water Systems

The ANO-1 condensers utilize once-through cooling. Lake Dardanelle serves as the cooling water source for ANO-1. ANO-1 uses approximately 48.1 m^3/s (1700 ft^3/s) of cooling water to condense steam during normal operation. The cooling water from the Illinois Bayou arm of Lake Dardanelle flows through a 1340-m (4400-ft) long canal to the intake structure. After flowing through the main condenser, the cooling water is then discharged to a 158-m (520-ft) long canal before entering Lake Dardanelle.

The main features of the intake structure include bar grates, traveling screens, and four circulating water pumps. The bar grates have 7.62-cm (3-in.) openings to prevent large debris from entering the intake structure. Inside the bar grates, cooling water passes through the intake traveling screens, which have a 0.95 cm (0.375 in.) effective opening designed to remove smaller debris. The maximum water velocity through the traveling screens is approximately 0.67 m/s (2.2 ft/s). After passing through the traveling screens, the water enters circulating pumps, which have a rated capacity of 12.3 m^3/s (195,550 gpm) each.

• Radioactive Waste Management Systems and Effluent Control Systems

ANO uses liquid, gaseous, and solid waste processing systems to collect and treat, as needed, the radioactive materials that are produced as a by-product of plant operations. Radioactive materials in liquid and gaseous effluents are reduced to levels as low as reasonably achievable (ALARA) and below the plant's specified discharge limits. Radionuclides removed from the liquid and gaseous effluents are retained in a solid waste form for eventual disposal with other solid radioactive wastes in a licensed disposal facility.

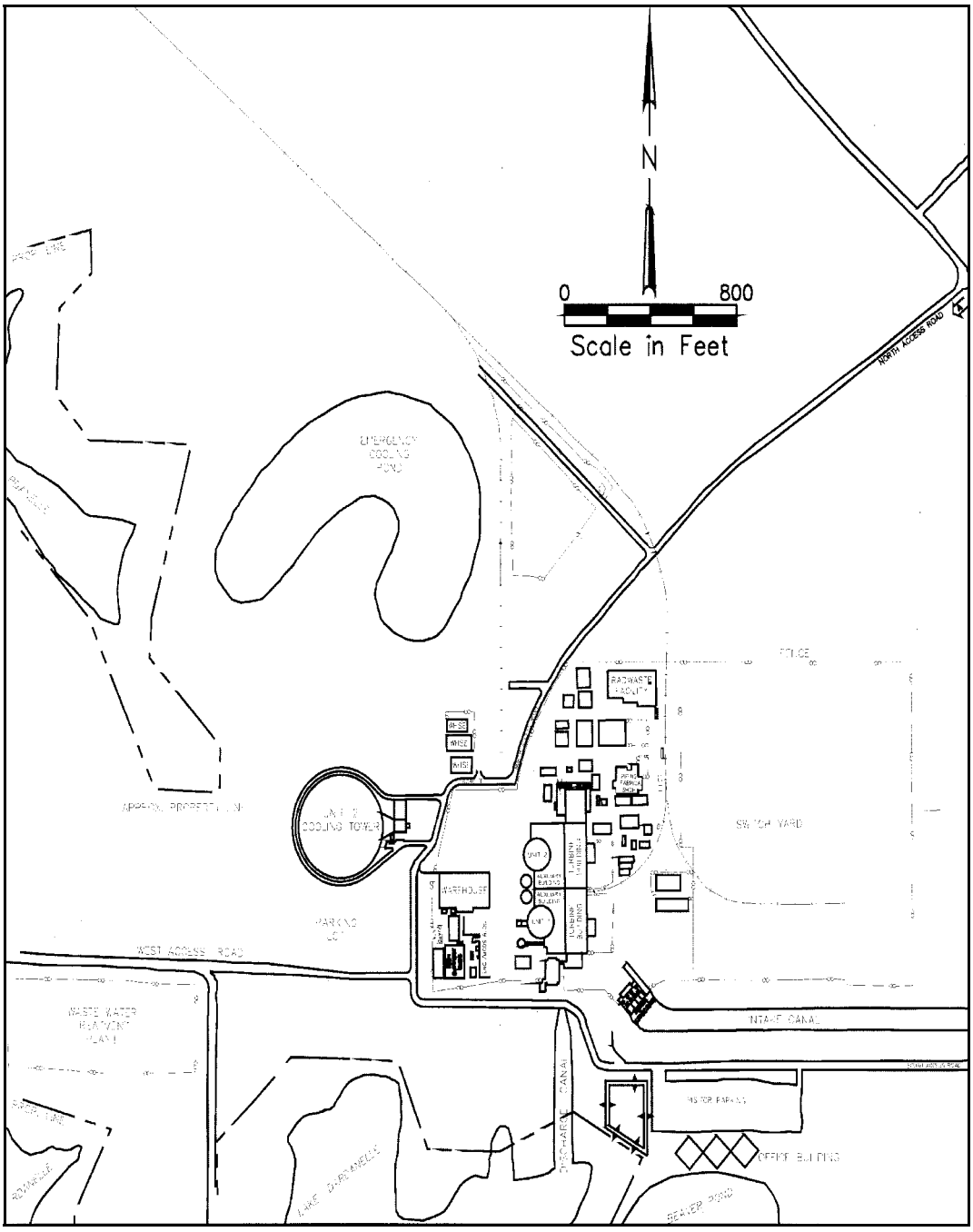

Figure 2-3. Arkansas Nuclear One Site - General Features

The ANO-1 waste processing systems meet the design objectives of 10 CFR Part 50, Appendix I, and control the processing, disposal, and release of radioactive liquid, gaseous, and solid wastes. Radioactive material in the reactor coolant is the source of most liquid, gaseous, and solid radioactive wastes in LWRs. Radioactive fission products build up within the fuel as a consequence of the fission process. The fission products are contained within the sealed fuel rods; however, small quantities of radioactive materials may be transferred from the fuel elements to the reactor coolant under normal operating conditions. Neutron activation of materials in the primary coolant system may also contribute to radionuclides in the coolant.

Solid wastes, other than fuel, result from treating gaseous and liquid effluents to remove radionuclides. Contaminated spent resins and filters, and concentrates generated during the treatment processes are dewatered, packaged, stored, and ultimately shipped offsite for further treatment or disposal. Other types of solid waste consist of contaminated materials removed from various reactor areas, including hardware components, equipment, tools, protective clothing, rags, paper, and other trash generated during plant modifications or maintenance activities. Some types of waste may be shredded or compacted to reduce their final disposal volume.

Reactor fuel assemblies that have exhausted a certain percentage of their fissile uranium content are referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced by fresh fuel during routine refueling outages, typically every 18 to 24 months. The spent fuel assemblies are then stored for a period of time in the spent fuel pool within the Auxiliary Building and may later be transferred to dry storage at the onsite ISFSI. ANO has the capability to provide for temporary onsite accumulation of mixed wastes, which contain both radioactive and chemically hazardous materials. Storage of radioactive materials is regulated by the NRC under the Atomic Energy Act of 1954, and storage and/or accumulation of hazardous wastes is regulated by the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act of 1976 (RCRA).

Systems used at ANO-1 to process liquid, gaseous, and solid radioactive wastes are described in the following sections.

- **Liquid Waste Processing Systems and Effluent Controls**

Radioactive liquid waste generated from the operation of ANO-1 may be released to the Dardanelle Reservoir in accordance with the limits specified in the ANO *Offsite Dose Calculation Manual* (ODCM) (Entergy 1999a). Liquid wastes enter the reservoir through the discharge canal.

ANO liquid waste is processed by two major systems: (1) the *clean liquid radioactive waste system*, which processes liquids from reactor coolant system bleed valves and drains, reactor coolant auxiliary system relief valves and drains, and radwaste system relief valves and drains, and (2) the *dirty liquid radioactive waste system*, which processes waste from various floor drains and sumps. The liquid radwaste system is used to reduce the radioactive material concentrations in liquid wastes before discharge to ensure that they are consistent with limits specified in the ODCM.

Controls for limiting the release of radiological liquid effluents are described in the ODCM. Controls are based on (1) concentrations of radioactive materials in liquid effluents and projected dose or (2) dose commitment to a hypothetical member of the public. Concentrations of radioactive material that may be released in liquid effluents to unrestricted areas are limited to the concentration specified in 10 CFR Part 20, Appendix B, Table 2, for radionuclides other than dissolved or entrained noble gases. The total concentration of dissolved or entrained noble gases in liquid releases is limited to 2×10^{-4} microcurie/mL. The ODCM dose limits during any calendar quarter are 0.015 millisievert (mSv) (1.5 mrem) to the whole body and 0.05 mSv (5 mrem) to the critical organ. During the calendar year, the ODCM dose limits are 0.03 mSv (3 mrem) to the whole body and 0.10 mSv (10 mrem) to the critical organ. Radioactive liquid wastes are subject to the sampling and analysis program described in the ODCM.

Liquids entering the clean radwaste system are degasified to remove hydrogen and fission product gases. The liquid wastes are then transferred to receiver tanks that provide temporary storage to allow for radioactive decay. This maintains releases to the environment ALARA, as well as ensuring that the concentrations in effluents are below the ODCM limits. Wastes from the receiver tanks are filtered to remove particulate materials and treated in two demineralizer systems to remove soluble radionuclides before transfer to a treated waste monitor tank. Sampling and release of liquid waste from the monitor tank is performed on a batch basis rather than a continuous basis to provide better control over effluent discharge. If the activity level in the monitor tank is within discharge limits, the liquid may be released in a controlled, monitored fashion to meet the administrative limits in the ODCM. If radionuclide levels in the liquids exceed the discharge limits, they are returned to the receiver tank for additional time to decay and for treatment.

Liquids entering the dirty liquid radwaste system are expected to contain lower levels of activity than those in the clean system and are collected in one of two sections of a drain tank. When one section is filled, the liquid is recirculated, sampled, and pumped through one or two filters, as needed. The filtrate is collected in a filtered waste monitoring tank, mixed, and sampled before discharge. If radionuclide concentrations in the filtered waste tank exceed discharge limits, the wastes would be transferred to the clean liquid radwaste system for additional treatment.

Liquid effluents are monitored continuously as wastes are discharged, and effluent release is automatically discontinued if monitors indicate that radionuclide concentrations in the wastes exceed permitted levels. Waste tanks are vented to a gas collection header and are purged with nitrogen to remove any accumulated gases.

- **Gaseous Waste Processing Systems and Effluent Controls**

Radioactive gases generated by fission and neutron activation of materials in the plant are managed by the Gaseous Waste Processing System (GWPS). Radioactive constituents in gaseous effluents include noble gases, iodine, tritium, and fine particulate materials. Radioactive gaseous effluents generated from operation of ANO-1 are released to the atmosphere through the main vent stacks or the turbine building ventilation exhaust. Smaller, intermittent releases may also occur through the emergency air lock, the plant compressed air system, the main steam line penetrations, the containment equipment hatch, and the auxiliary feedwater pumps.

The GWPS collects, stores, and disposes of gases from the liquid radwaste vacuum degasifiers, the volume control tanks, and other miscellaneous hydrogenated sources associated with the primary reactor cooling system. During normal operation, the GWPS is designed to store gases to allow for radioactive decay before release. The GWPS consists of a surge tank, two compressors, waste gas decay tanks, and several filter systems. Each of the filter systems contains a roughing filter, a high-efficiency particulate air (HEPA) filter, and a charcoal adsorber. The gas storage tanks are sampled before release via the gaseous waste discharge header. Both activity and flow rates in the discharge stream are continuously monitored to ensure that the effluents comply with discharge limits.

The GWPS also processes effluents from the auxiliary system equipment and tanks, the spent fuel storage area ventilation, and the radwaste area ventilation. These effluents contain air and are separated from the hydrogenated primary system effluents to minimize the potential for explosion. These effluents typically contain low levels of activity and are released directly to the station vent plenum through a filter system. These effluents are continuously monitored as they are released and are diverted to the GWPS surge tank for additional storage and decay if they exceed discharge limits.

ANO maintains gaseous releases within ODCM limits. The GWPS is used to reduce radioactive materials in gaseous effluents before discharge to meet the dose design objectives in 10 CFR Part 50, Appendix I. In addition, the limits in the ODCM are designed to provide reasonable assurance that radioactive material discharged in gaseous effluents would not result in the exposure of a member of the public in an unrestricted area in excess of the limits specified in 10 CFR Part 20, Appendix B.

The quantities of gaseous effluents released from ANO-1 are controlled by the administrative limits defined in the ODCM. The controls are specified for dose rate, dose due to noble gases, and dose due to radioiodine and radionuclides in particulate form. For noble gases, the dose rate limit at or beyond the site boundary is 5 mSv/yr (500 mrem/yr) to the whole body, and 30 mSv/yr (3000 mrem/yr) to the skin. For iodine and particulates with half-lives greater than 8 days, the limit is 15 mSv/yr (1500 mrem/yr) to any organ. The limit for air dose due to noble gases released in gaseous effluents to areas at or beyond the site boundary during any calendar quarter is 0.05 milligray (mGy) (5 mrad) for gamma radiation and 0.1 mGy (10 mrad) for beta radiation. For any calendar year, the limit is 0.1 mGy (10 mrad) for gamma radiation and 0.2 mGy (20 mrad) for beta radiation. The radioactive gaseous waste sampling and analysis program specifications that are provided in the ODCM address the gaseous release type, sampling frequency, minimum analysis frequency, type of activity analysis, and lower limit of detection.

- **Solid Waste Processing**

The ANO Solid Radioactive Waste Program (SRWP) provides the capabilities for solidification, stabilization, encapsulation, and packaging of wastes. The SRWP processes wastes from the liquid and gaseous effluent treatment systems, as well as other miscellaneous solid wastes generated during plant operation and maintenance. Solid waste is packaged in containers to meet the applicable requirements of 10 CFR Parts 61 and 71 for transportation and disposal. The SRWP provides the capability for preparing solid waste for shipment to an offsite treatment or disposal facility. The system is designed to maintain radiation exposure ALARA for personnel who handle solid wastes and to minimize the quantities of solid waste generated at the plant.

The SRWP manages high specific activity wastes (HSAWs) from the liquid and gaseous effluent treatment systems, which consists mainly of spent ion exchange resin and filter cartridges. Spent resin is transferred to a storage tank where it is held for radioactive decay. The resins are dewatered or solidified before offsite shipment for disposal. Radioactive filters are transported from each filter housing to the waste disposal area. The packaging of other dry active wastes (DAW) is performed in a low-level waste work area. Volume-reduction treatments, such as shredding or compaction, may be used where appropriate. All solid wastes are packaged in containers suitable for transfer to an offsite treatment or disposal facility.

ANO stores both HSAW and DAW in an onsite Low Level Radioactive Waste Storage Building in preparation for shipment to offsite treatment or disposal facilities. The storage facility is designed to accommodate more than 5 years of waste expected to be generated at ANO-1 based on normal operations. The functions of the facility include interim storage of HSAW, DAW, and other radioactively contaminated materials; receiving, sorting, compacting, packaging, and shipment of DAW; and office space for radwaste management activities. The

HSAW storage area is shielded to minimize doses to nearby workers, as well as remote-handling equipment for HSAW containers. Dose rates within the facility are continuously monitored. The facility ventilation system operates at negative pressure, and effluents are continuously monitored after passing through a HEPA filter system to remove particulate materials. A separate shielded facility is available for temporary storage of radioactively contaminated, but reusable, tools and equipment.

All ANO radioactive waste shipments are packaged in accordance with NRC and U.S. Department of Transportation requirements. The type and quantities of solid radioactive waste generated and shipped at ANO vary from year to year, depending on plant activities. During 1998 and 1999, there were 39 shipments of radioactive waste consisting of about 900 m^3 (32,000 ft^3) of HSAW and DAW. ANO currently transports radioactive waste to a licensed treatment facility in Oak Ridge, Tennessee. ANO may also transport material from an offsite processing facility to a disposal site or back to the plant site for reuse or storage.

- **Nonradioactive Waste Systems**

Nonradioactive waste is produced from plant maintenance and cleaning processes. Most of these wastes are from boiler blowdown (as impurities are purged from plant boilers), water treatment sludges and other wastes, metal cleaning wastes, floor and yard drains, and stormwater runoff. Chemical and biocide wastes are produced from processes used to control the pH in the coolant, to control scale, to control corrosion, to regenerate resins, and to clean and defoul the condenser. Waste liquids are typically combined with cooling water discharges. Sanitary waste water is treated at an onsite facility before discharge under a permit from the Arkansas Department of Environmental Quality (ADEQ).

Nonradioactive gaseous effluents result from operation of the oil-fired boilers used to heat the plant and from testing of the emergency diesel generators. Discharge of regulated pollutants is minimized by use of low-sulfur fuels and is within Arkansas air quality standards.

- **Plant Operation and Maintenance**

Routine maintenance performed on plant systems and components is necessary for safe and reliable operation of a nuclear power plant. Some of the maintenance activities conducted at ANO-1 include inspection, testing, and surveillance to maintain the current licensing basis of the plant and to ensure compliance with environmental and public safety requirements. Certain activities can be performed while the reactor is operating. Others require that the plant be shut down. Long-term outages are scheduled for refueling and for certain types of repairs or maintenance, such as replacement of a major component. Scheduled refueling outages commonly occur every 18 months with a duration for a single unit of 35 days. Approximately 700 additional workers are onsite during a typical refueling outage.

Entergy performed an aging management review and developed an Integrated Plant Assessment (IPA) for assessing and managing the effects of aging on systems, structures, and components in accordance with 10 CFR Part 54. In addition, the IPA provides a discussion of plant-specific programs and activities that will manage the aging effects identified. These activities include inspections and replacement of certain components. The replacement of these components is considered within the bounds of normal plant operations. Therefore, Entergy expects to conduct these activities during plant operation or normal refueling and other outages, but plans no outages specifically for the purpose of refurbishment. Entergy has no plans to add additional full-time persons (non-outage workers) at the plant during the period of the extended license.

- **Power Transmission System**

The ANO *Final Environmental Statement* (AEC 1973) lists the transmission lines shown in Table 2-1 as being "required to effectively distribute electricity from Arkansas Nuclear One." These lines account for 308 km (191 mi) of lines and about 1500 ha (3700 acres) of land in the rights-of-way. Figure 2-4 illustrates the location of these transmission lines. The first four lines in the table are attributable to ANO-1, the fifth line is attributable to ANO-2.

These transmission lines were constructed concurrently with the construction of ANO. The applicant indicates that these transmission lines would have to remain in service to provide power for the area transmission loads if ANO were removed from service.

Table 2-1. Transmission Lines from Arkansas Nuclear One

Destination	kV	Distance, km (mi)		Rights-of-way Widths, m (ft)		Date Line was Energized
Fort Smith-Mabelvale line to Fort Smith	500	38.8	(24.1)	97.5	(320)	1971
Fort Smith-Mabelvale line to Mabelvale	500	39.0	(24.2)	97.5	(320)	1971
Russellville	161	19.3	(12.0)	30.5	(100)	1971
Morrilton	161	62.6	(38.9)	30.5	(100)	1971
Mabelvale Substation via Mayflower Substation	500	148	(92)	54.9	(180)	1976

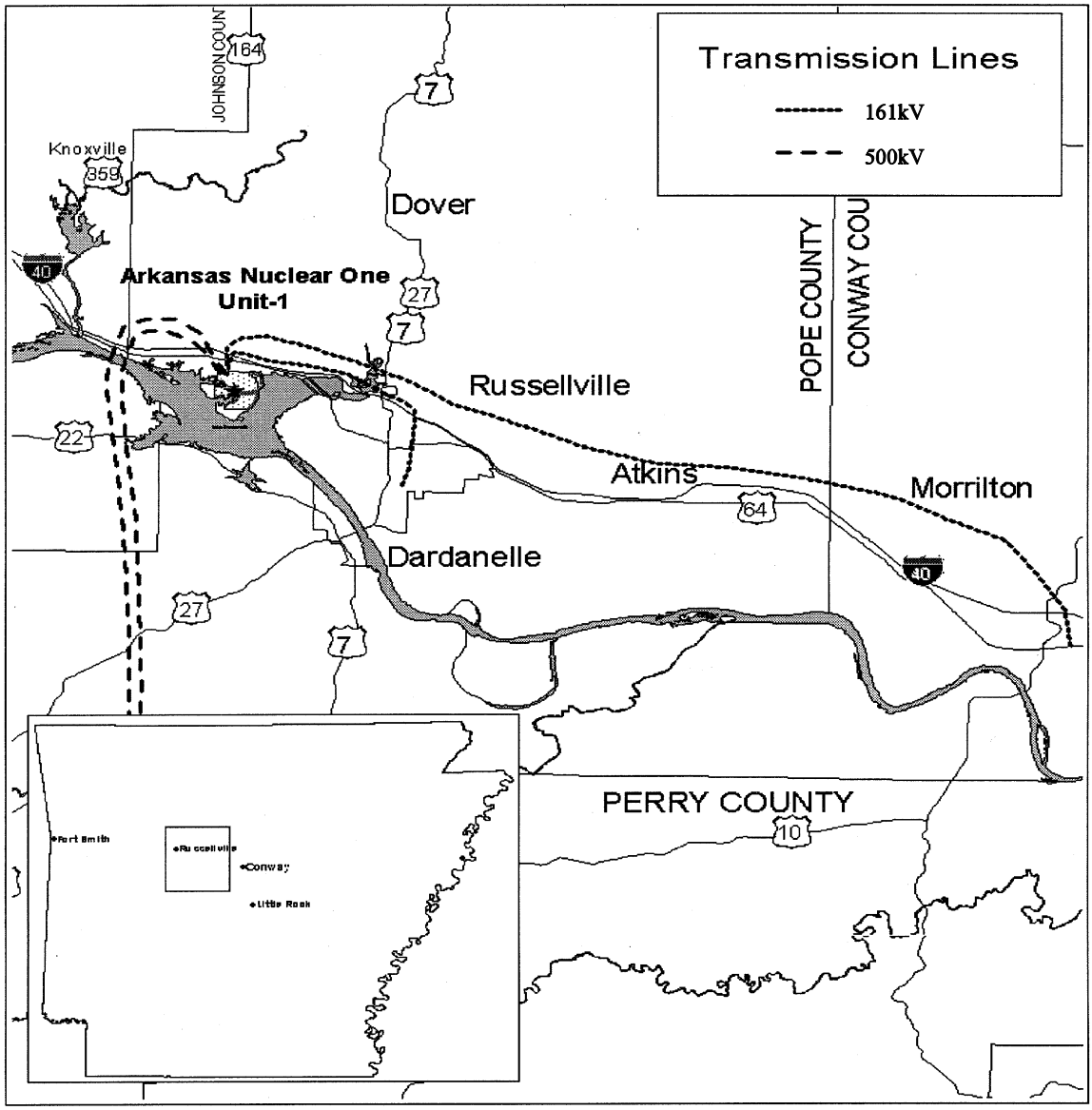

Figure 2-4. Transmission Lines Attributable to Arkansas Nuclear One, Unit 1 in the Final Environmental Statement (AEC 1973)

2.2 Plant Interaction with the Environment

Subsections 2.2.1 through 2.2.8 provide general descriptions of the environment as background information. They also provide detailed descriptions where needed to support the analysis of potential environmental impacts of refurbishment and operation during the renewal term as discussed in Chapters 3 and 4. Subsection 2.2.9 describes the historic and archaeological resources in the area and 2.2.10 describes possible impacts on other Federal project activities.

- **Land Use**

ANO-1 is located in southwestern Pope County, Arkansas. The plant site is approximately 10 km (6 mi) west-northwest of the town of Russellville, Arkansas. Russellville is also the county seat of Pope County.

The plant site occupies 471 ha (1164 acres). Site topography is primarily flat. The plant site is on a peninsula formed by Lake Dardanelle. Lake Dardanelle is formed by the Dardanelle Lock and Dam on the Arkansas River. The peninsula is approximately 3 km (2 mi) wide and 3 km (2 mi) long. Forests and residential development cover the majority of the peninsula because pasture and croplands are insignificant-to-nonexistent on the peninsula.

The ANO-1 site is not in an incorporated area of Pope County. No land use or zoning restrictions are applicable to land within unincorporated portions of Pope County.

- **Water Use**

Water from Lake Dardanelle (3.5×10^6 m^3/d [946-million gpd]) provides once-through condenser circulating water for ANO-1. Water from the Russellville water treatment plant is used as potable and makeup water. ANO-1 does not use any groundwater. Discharges from the plant's once-through system, liquid radioactive waste system, sanitary waste system, sumps, and drains are returned to Lake Dardanelle via the discharge canal.

Lake Dardanelle is impounded behind Dardanelle Lock and Dam. The lock and dam are operated by the U.S. Army Corps of Engineers as part of the Arkansas River Navigation Project, which provides for navigation, flood control, hydropower production, water supply, and recreation throughout the Arkansas River Basin. Currently, the U.S. Army Corps of Engineers has no anticipated plans to change the operation of Lake Dardanelle that might affect the water supply available to ANO-1.

- **Water Quality**

Besides serving the needs of ANO-1, Lake Dardanelle serves a variety of other uses. The lake's water quality has been designated as suitable for the propagation of fish/wildlife, primary and secondary contact recreation, and public and industrial water supplies.

Discharges from the plant's once-through condenser circulating water system, liquid radioactive waste system, sanitary waste system, sumps, and drains are returned to Lake Dardanelle via the discharge canal. Pursuant to the Federal Water Pollution Control Act of 1977, also known as the Clean Water Act, the water quality of plant effluent discharges is regulated through the National Pollutant Discharge Elimination System (NPDES). The ADEQ is the State agency delegated by EPA to issue the NPDES permit. The current permit (AR0001392) was issued on September 30, 1997, and is due to expire on October 31, 2002. Any new regulations promulgated by EPA or the ADEQ would be included in future permits.

Thermal plume numerical modeling studies were performed for Lake Dardanelle before the operating license for ANO-1 was issued. In these modeling studies, critical flow condition was presumed to be the once-in-10-year weekly minimum flow (7Q10). At the time of these numerical modeling studies, the 7Q10 was estimated to be 99.1 m^3/s (3500 ft^3/s). Current estimates of the 7Q10 flow are much lower: 20.5 m^3/s (725 ft^3/s). The modeling studies would have shown much greater impact on the thermal plume if the current 7Q10 estimate had been used. However, based on previous operational studies and current thermal monitoring within the discharge canal and lake required by the NPDES permit, it has been demonstrated that thermal impacts continue to be consistent with preoperational predicted modeling studies described in the ANO-1 FES. Therefore, no significant impacts to Lake Dardanelle's biota as a result of the thermal discharge have been identified.

- **Air Quality**

ANO is located in west-central Arkansas, approximately mid-way between Fort Smith and Little Rock. It is on Lake Dardanelle, which is part of the Arkansas River, at an elevation of about 120 m (400 ft) mean sea level. To the north of the site are the Boston Mountains, and the Ouachita Mountains are to the south.

Pope County is hot in the summer and moderately cool in the winter, and has fairly heavy rainfall that is well distributed throughout the year (USDA 1981). Climatological records for Russellville, Arkansas, which should be generally representative of the site, show normal daily maximum temperatures ranging from about 11°C (51°F) in January to about 34°C (93°F) in July; normal daily minimum temperatures range from about -3°C (27°F) in January to about 21°C (69°F) in July. Precipitation averages about 124 cm (49 in) per year, with an average of

about 7 cm (3 in.) of snow per year. Based on statistics for the 30-year period from 1954 through 1983 (Ramsdell and Andrews 1986), the probability of a tornado striking the site is estimated to be approximately 3×10^{-4} per year.

The primary wind resource in Arkansas is limited to about 4300 km^2 (1600 mi^2) of exposed ridges and mountains on the Ozark Plateau and in the Ouachita Mountains (Edwards, et al. 1981). In these areas, wind power densities are estimated to be in the 400 to 500 W/m^2 (37 to 46 W/ft^2) range at 50 m (160 ft) above ground during the winter and spring. During the summer and fall in these areas and for the remainder of the State, the wind power density is estimated to be less than 300 W/m^2 (28 W/ft^2).

Arkansas is in *attainment* of the National Ambient Air Quality Standards (40 CFR 81.304). The Pollutant Standards Index (PSI) is an air quality index developed by the EPA in cooperation with the Council on Environmental Quality. For 1997, the average PSI for Pope County was less than 50, which is associated with *Good* air quality.(1) With one exception, the daily PSIs were in the *Good* range; the remaining daily PSI was in the *Moderate* range. The *Moderate* PSI resulted from small particles (PM_{10}).

ANO has several diesel generators and boilers. Emissions from these generators and boilers are covered by an air permit issued by the ADEQ under the Clean Air Act. The permit limits the hours of operation of these emission sources. In practice, the sources are only operated a small fraction of the permitted hours.

The Caney Creek and Upper Buffalo Wilderness Areas are the closest wilderness areas to ANO. These areas are designated in 40 CFR 81.404 as mandatory Class I Federal areas in which visibility is an important value. The Caney Creek Wilderness Area is more than 160 km (100 mi) from the ANO site, but the Upper Buffalo Wilderness Area is within 80 km (50 mi) of the site. The staff considered the potential impacts on visibility in these wilderness areas in its review of alternatives to license renewal (see Section 8.2.1 of this report).

- **Aquatic Resources**

Lake Dardanelle at the ANO site is a man-made lake. The lake is upstream of the Dardanelle Lock and Dam on the Arkansas River. The water level of the lake is controlled at the Dardanelle Dam and other dams on the Arkansas River. The river was impounded and the lake formed in 1967. In addition to providing water for ANO, Lake Dardanelle serves a variety of other uses. The lake is designated as suitable for propagation of fish and wildlife, recreation, and public and industrial water supplies. The water quality of Lake Dardanelle is monitored by

(a) http://tree2.epa.gov/CEIS/CEIS.NSF/$$All/0505115AIR, February 11, 2000.

the ADEQ. Water-based recreation activities, such as boating and fishing, are a focal point of interest. Additionally, the environs of the lake are used for camping, picnicking, sightseeing, photography, and nature studies. The lake has a commercial fishing industry.

The various trophic communities of Lake Dardanelle have been surveyed and monitored over the years (Rickett 1994). Phytoplankton populations are diverse and fluctuate seasonally. Green algae (Chlorophyta) are the dominant algal group throughout the year. Diatoms (Chrysophyta) are secondary in abundance and the bluegreens (Cyanophyta) and dion-flagellates (Pyrrhopyta) are minor constituents. Zooplankton vary seasonally. Rotifers dominate during the early summer. Other zooplankton species occurring at Lake Dardanelle include *Kellicottia bostoniensis, Platyias patulus, Brachionus* spp., *Keratela cochlearis, Polyarthra* sp., and *Leptodora kindti*. The benthic community includes Chironomidae, Oligochaeta, and Spheriidae (Rickett and Watson 1994). Additional benthic organisms that have been introduced into Lake Dardanelle include the *Corbicula fluminea* and *Dreissena polymorpha*.

The fish community of the area varies with the current. Flathead catfish (*Pylodictis olivaris*), channel catfish (*Ictalurus punctatus*), and blue catfish (*I. furcatus*) occur where there is a current. Also available are largemouth bass (*Micropterus salmoides*), spotted bass (*M. punctulatus*), green sunfish (*Lepomis cyanellus*), bluegill sunfish (*L. macrochirus*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*), and warmouth (*L. gulosus*). These fish are in slack water areas and also in the Illinois Bayou.

The fish community near ANO also changes seasonally. Striped bass (*Morone saxatilis*), and white bass (*M. chrysops*) are generally more abundant in the spring. Rough or commercial fishes are generally abundant throughout the year. These fish include European carp (*Cyprinus carpio*), bigmouth buffalo (*Ictiobus cyprinellus*), black buffalo (*I. niger*), smallmouth buffalo (*I. bubalus*), carpsuckers (*Carpiodes spp.*), freshwater drum (*Aplodinotus grunniens*), and redhorses (*Moxostoma* spp). The most important forage fish species in the lake are gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*).

The importance of ANO to the aquatic resources of the region is illustrated by the consideration of ANO as beneficial to fish and wildlife of the region. The ANO site provides a number of diverse habitats such as fields, hardwood stands, conifer stands, and wetlands. There are numerous transitional areas or edge communities resulting in high-quality habitats for species diversity. The cooling water intake canal provides habitat for numerous species of fish. During warm months, the intake flow mixes warm, less oxygenated surface water with cool, more highly oxygenated Illinois Bayou channel water. This provides a highly productive habitat within the canal. Numerous species of fish and waterfowl utilize the warm water effluent during cold water conditions. The use of the intake and discharge canals by fish communities provides a

sports fishery for the local sports fishers. A small, inundated wetland south of the effluent bay provides habitat for mammals, fish, reptiles, amphibians, and waterfowl. The aquatic environment at ANO provides habitat for fish and wildlife, thus providing fishing, hunting, and other recreational opportunities for the public throughout the area.

• Terrestrial Resources

ANO and its associated transmission line rights-of-way lie within the oak-hickory biome of the eastern deciduous forest (Greller 1988). This biome ranges from dense forests of oaks (*Quercus* spp.) and hickory (*Carya* spp.) to more open savanna habitat. Eastern red cedar (*Juniperus virginiana*) and short-leaf pine (*Pinus echinata*) are common in the open habitats.

Land cover at the ANO site includes mixed pine and hardwood and disturbed, early successional habitat (Table 2-2). Approximately 2 ha (5 acres) of wetlands are present on the site. The transmission line rights-of-way cross Dardanelle Reservoir and a number of small streams and wetlands in addition to forests, savanna, and farmland.

Mammals at the ANO site and the transmission line rights-of-way include white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), red and grey fox (*Vulpes fulva* and *Urocyon cinereoargenteus*), eastern gray and fox squirrels (*Sciurus carolinensis* and *niger*), eastern chipmunk (*Tamias striatus*), and a variety of mice and voles. White-tailed deer are the most important game mammal.

The open water of Lake Dardanelle and emergent wetland habitat supports a number of migrant waterfowl species, including common mergansers (*Mergus merganser*) and double-crested cormorants (*Phalacrocorax auritus*). Osprey (*Pandion haliaetus*) use the lake areas near the ANO site. American white pelicans (*Pelecanus erythrorhynchos*) use the open water habitats of the Reservoir. Great blue herons (*Ardea herodias*) nest in trees near the ANO site.

Table 2-2. Land Cover at ANO

Land Cover Class	Area, ha (acres)	Percentage of Site
Mixed pine-hardwood forest	184 (461)	40
Early successional habitats	194 (485)	41
Developed areas	72 (180)	15
Open water	12 (30)	3
Wetlands	2 (5)	1

The applicant contacted the Arkansas Natural Heritage Commission (ANHC) regarding rare or special species and habitats within the ANO site and its associated transmission line rights-of-way. The ANHC identified three species and three habitat areas within the corridors that are of interest (Table 2-3). None of the species are likely to be affected by continued operation of ANO or the transmission line rights-of-way. The presence of the corridors in the three habitats of concern does not pose a threat to the values of these habitats.

Table 2-3. Rare Species and Elements of Special Concern Within ANO and Its Transmission Line Rights-of-Way (Entergy 2000a)

Species or Habitat	Common Name	Federal Status	State Status	Reason for ANHC Listing
Philadelphus hirsutus	Mock orange	None	None	Uncommon in State; disjunct from eastern range
Castanea pumila var. *ozarkensis*	Ozark chinquapin	None	None	Declining numbers due to chestnut blight
Aimophila aestivalis	Bachman's sparrow	None	None	Regular summer resident; rangewide declines
Illinois Bayou	--	None	Extraordinary Resource Waters	Limitations on new impacts
Cadron Creek	--	None	Extraordinary Resource Waters	Limitations on new impacts
Goose Pond Natural Area	--	None	Natural Area	Conservation easement to ANHC

• Radiological Impacts

ANO has conducted a radiological environmental monitoring program around ANO predating station operation in 1974. The radiological impacts to workers, the public, and the environment have been carefully monitored, documented, and compared to the appropriate standards. The program's purposes are to

- verify that radioactive materials and ambient radiation levels attributable to plant operation are within the limits contained in the ODCM and the Environmental Radiation Protection standards as stated in 40 CFR Part 190
- detect any measurable buildup of long-lived radionuclides in the environment
- monitor and evaluate ambient radiation levels
- determine whether any statistically significant increase occurs in the concentration of radionuclides in important pathways.

The radiological environmental monitoring program includes monitoring of the aquatic environment (surface water in Lake Dardanelle, aquatic organisms, and shoreline sediment), the atmospheric environment (air particulates and iodine), and the terrestrial environment including the vegetation, and direct radiation. Radionuclide concentrations in environmental media (air, water, sediment, fish, vegetation, milk, and other food products) as well as external radiation dose rates are summarized in the ANO *Annual Radiological Environmental Operating Report* (Entergy 1999b). Radioactive materials released to the environment via liquid or gaseous effluents, estimated doses to members of the public from those releases, and quantities of radionuclides disposed in solid waste are summarized in the *Annual Radioactive Effluent Release Report* for each calendar year. The limits for all radiological releases are specified in the ODCM, and these limits are designed to meet Federal standards and requirements.

• Doses to Individuals

Review of historical data on releases from ANO-1 and the resultant dose calculations revealed that the dose to the maximally exposed individual for each pathway in the vicinity of ANO was a fraction of each of the limits specified in EPA's environmental radiation standards 40 CFR Part 190 as required by 10 CFR 20.1301(d). For 1998 and 1999, dose calculations were performed using the plant effluent release data, onsite meteorological data, and appropriate pathways identified in the ODCM (Entergy 1999a). The summary results for doses to the maximally exposed individual in 1998 and 1999, which are representative of the doses from recent plant operations, are listed in Table 2-4 (Entergy 1999b; 2000c). Entergy does not

Table 2-4. Radiation Dose to Members of the Public from ANO-1 Operations During 1998 and 1999

Dose to	40 CFR Part 190 Limit	Dose, mSv (mrem)[(a)] 1998	Dose, mSv (mrem)[(a)] 1999
Thyroid	0.75 mSv/yr (75 mrem/yr)	0.00011 (0.011) 0.014% of limit child: gases	0.00011 (0.011) 0.014% of limit child: gases
Other organ	0.25 mSv/yr (25 mrem/yr)	0.0011 (0.11) 0.45% of limit adult: liquids, gastro-intestinal tract	0.0001 (0.01) 0.041% of limit child: gases, total body
Whole body	0.25 mSv/yr (25 mrem/yr)	0.00017 (0.017) 0.069% of limit adult: liquids	0.0001 (0.01) 0.041% of limit child: gases

[(a)]Maximum dose to the receptor (child or adult), the effluent pathway (liquid or gaseous airborne emissions), and where applicable, the organ receiving the maximum dose.

anticipate any significant changes to the radioactive effluent releases or exposures from ANO-1 operations during the renewal period and, therefore, the impacts to the environment are expected to be similar to those in recent years.

- **Socioeconomic Factors**

The staff reviewed the applicant's ER and information obtained from several Pope County staff members, local real estate agents/appraisers, and social service providers during the April 2000 site visit. The following information describes the economy, population, and communities near ANO.

- **Housing**

Between 1970 and 1990, total housing units in Pope County increased from 9882 to 14,885 (USCB 1998). As of August 1998, a total of 938 ANO employees lived in Pope County, 82 ANO employees lived in Johnson County, and 75 lived in Yell County (see Table 2-5). Information is not available for the individual ANO units, but only for the entire facility. Roughly half of plant employment and resource use is associated with ANO-1.

Table 2-5. Employee Residence Information, ANO Units 1 and 2, August 1999

County and City	Entergy Employees	County and City	Entergy Employees
CONWAY COUNTY	**11**	**PERRY COUNTY**	**1**
Hattieville	1	Bigelow	1
Morrilton	7	**POPE COUNTY**	**938**
Springfield	3	Atkins	33
CRAWFORD COUNTY	**1**	Dover	89
Alma	1	Hector	8
FAULKNER COUNTY	**19**	London	62
Conway	19	Pelsor	1
FRANKLIN COUNTY	**2**	Pottsville	30
Alix	1	Russellville	715
Ozark	1	**PULASKI COUNTY**	**6**
GARLAND COUNTY	**1**	Little Rock	3
Hot Springs	1	Maumelle	1
JOHNSON COUNTY	**82**	North Little Rock	1
Clarksville	31	Sherwood	1
Coal Hill	4	**YELL COUNTY**	**75**
Hagerville	1	Belleville	4
Hartman	4	Casa	3
Knoxville	15	Centerville	1
Lamar	27	Danville	4
LOGAN COUNTY	**8**	Dardanelle	55
New Blaine	1	Delaware	2
Scranton	5	Havana	1
Subiaco	2	Ola	3
LONOKE COUNTY	**1**	Plainview	1
Austin	1	Waveland	1
		Total	**1145**

Source: Entergy (2000a)

County growth has continued since 1990. Operations at the ANO site have influenced population growth in Pope County. In 1989, 2205 permanent plant staff were onsite at ANO; additional contract workers were onsite during outages. Of the permanent work force, 90 percent (1985) lived in Pope County (APL 1990; NRC 1996; 1999). Based on the residential settlement pattern of ANO's 1977 work force, the staff estimated that 43.8 percent (869) of those residing in Pope County in 1989 were prior residents who obtained jobs and that 56.2 percent (1116) were workers who migrated into the area for jobs. Also following the pattern set during plant operations, it is estimated that 60 percent of the in-migrants (670) were accompanied by their families. Assuming the 1990 Arkansas average family size of 3.06 persons, this represents a total in-migration of 2496 residents for the county. Based on the ratio of nonplant jobs created in Pope County in 1977, it is estimated that ANO's 1989 operations created an additional 860 indirect jobs in service industries supported by the spending of ANO workers (NRC 1996; 1999). As a result of these indirect jobs, an estimated 454 additional workers and their families (a total of 922 persons) moved into Pope County. In all, approximately 3418 new residents are estimated to have moved into Pope County as a result of ANO's 1989 operations. These new residents made up about 7.7 percent of Pope County's 1989 population of 44,534 (NRC 1996; 1999).

Since 1990, the Pope County population has continued to increase from 45,883 at the 1990 Census to 52,598 in 1999 (see Table 2-6). Johnson County increased in population from about 18,221 in 1990 to 21,358 in 1999, and Yell County increased from about 17,759 in 1990 to 18,853 in 1999 (Table 2-6). In 1997, Pope County employed 5534 in major manufacturing facilities, compared with 3281 in Johnson County and 3038 in Yell County (USCB 1997). Housing availability in the tri-county area is not limited by growth-control measures. The number of occupied housing units in Pope and Johnson Counties has more than doubled since 1970 (see Table 2-7).

Table 2-6. Population Growth in Pope, Johnson, and Yell Counties, Arkansas, 1970-1999

	Pope County		Johnson County		Yell County	
Date	Population	Annual Growth %	Population	Annual Growth %	Population	Annual Growth %
1970	28,607	--	13,630	--	14,208	--
1980	38,964	3.6	17,423	2.8	17,026	2.0
1990	45,883	1.8	18,221	0.5	17,759	0.4
1999	52,598	1.5	21,358	1.7	18,853	0.6

Source: USCB (1999).

Table 2-7. Housing Units and Housing Units Vacant (Available) by County, 1970-1999

	1970	1980	1990	1999[(a)]
Pope County				
Housing Units	9882	14,903	18,430	
Occupied Units	9014	13,615	16,828	20,153
Vacant Units	868	1288	1602	
Johnson County				
Housing Units	5278	7179	7984	
Occupied Units	4761	6395	7059	8543
Vacant Units	517	784	925	
Yell County				
Housing Units	5361	6877	7868	
Occupied Units	4725	6219	6907	7393
Vacant Units	636	658	961	

Sources: USCB (1991; 1998).
(a) Estimation based on average household size in 1990 and U.S. Census Bureau County Population Estimates for July 1, 1999 (USCB 1999).

- **Public Services**

Water Supply. Potable water used within a 16-km (10-mi) radius of ANO is from subsurface and surface sources and is used for domestic and industrial purposes. The area has seven public water systems and four wastewater systems that serve the incorporated towns and rural areas. Table 2-8 shows source and capacity information on selected water supply systems in communities near ANO, as well as the area served by each. Russellville, Dover, and London are all primarily served with surface water from the Illinois Bayou. Large areas of Pope County are not served by public water supplies. In 1997, the City of Russellville completed the construction of a new water supply source, the Huckleberry Creek Reservoir. The new reservoir significantly increases the water system storage capacity, and provides residential and industrial customers in the area with a reliable supply of high-quality water. Plans are being made to double the current water treatment processing capacity of 0.4 m^3/s (10 million gpd).

Table 2-8. Major Public Water Supply Systems Within 16-km (10-mi) Radius of ANO in 2000

Water System	Source	Min. Daily Capacity, m^3 (gallons)	Ave. Daily Capacity, m^3 (gallons)	Max. Daily Capacity, m^3 (gallons)	Area Served
City Corporation	Illinois Bayou	17,200 (4,536,000)	21,000 (5,566,000)	94,500 (25,000,000)	City of Russellville
Dardanelle Water Department	Wells	No data	4500 (1,200,000)	9300 (2,458,000)	City of Dardanelle
Dover Water Department	City Corporation (Illinois Bayou)	240 (62,400)	450 (118,100)	1600 (432,000)	City of Dover and surrounding rural areas
London Water Department	City Corporation (Illinois Bayou)	270 (72,000)	300 (79,000)	820 (216,000)	City of London and surrounding rural areas
Northeast Yell County Water Association, Inc.	Danville Water Department (Cedar Piney Reservoir)	No data	200 (52,000)	No data	Rural Yell, Conway, and Perry Counties
Tri-County Regional Water Distribution District	City Corporation (Illinois Bayou); also some from Atkins Water Department (Galla Lake)	No data	1650 (436,000)	20,000 (5,328,000)	Rural Pope County from above London east to Conway County line
West Crow Mountain Water Association	City Corporation (Illinois Bayou)	No data	770 (203,000)	5200 (1,382,000)	Rural area east of Russellville

Source: Arkansas Department of Health, Facsimile Correspondence, October 3, 2000

Availability of wastewater collection is currently considered to be adequate. In 1990, public wastewater collection was provided for 51 percent of the Pope County residents while 49 percent used septic tanks or other private means of disposal. Public wastewater collection was provided for only 35 percent of the residents of Johnson County and 39 percent of the residents of Yell County.

Education. In 1990, there were 20,459 students enrolled in schools in the Pope-Yell-Johnson County area (USCB 1998). Enrollment averaged 9234 for the public schools in Pope County during the 1999-2000 school year.[(1)] An additional 3 percent of Pope County school-age children attend private schools. The primary school district serving the area around ANO is the Russellville School District (5350 enrolled in October, 1999), providing schooling with seven elementary schools, two middle schools, and one high school. Other school districts around the ANO site include the Clarksville School District in Johnson County, with enrollment of approximately 1700 during the 1999-2000 school year, and the Dardanelle School District in Yell County with an average enrollment of 1743 in 1999-2000. The Clarksville School District is made up of two elementary schools, one middle school, and one high school, and the Dardanelle School District has two elementary schools, one middle school, and one high school. Pope County also has an Area Vocational Center and a state university, Arkansas Technical University, with an enrollment of 1840 in 1999.

The student/teacher ratio began falling steadily after 1968 (after reaching a high of 35 to1 in 1960s); by 1980, it had fallen to 20 to 1, and the Russellville School District teachers were being paid more than others in Arkansas (NRC 1996; 1999). The recipient of the largest tax payments within Pope County is the Russellville School District. The Russellville School District ranked 66th out of the 329 school districts in the State of Arkansas for expenses per student in 1989. The district was ranked 7th out of 329 in teachers' salaries in 1989.

Transportation. Pope County is served by Interstate 40 (I-40), which runs through the southern part of the county, plus U.S. Highway 64 and Scenic Highways 7, 22, and 27, and State Highways 28, 124, and 333. ANO is on a two-lane highway with service to the site being convenient from four main directions. Highway access is adequate, but population growth in the county may create crowded conditions in the future, particularly at selected intersections.

Yell County is not served by the Interstate Highway system, but has ready access to the I-40 corridor via Scenic Highways 7, 154, and 309. State Highways 10, 60, and 247 complete the major road net. No roads in Yell County were identified as having serious congestion problems. Johnson County is served by the I-40 corridor, as well as U.S. Highway 64 and State Highways 21, 103, and 123. No roads in Johnson County were identified as having serious congestion problems.

(a) County enrollment figures are gathered by captolImpact.com, located at http://hpi.www.com/arcty (August 15, 2000) and individual schools and school district enrollment information was confirmed and obtained through phone conversations with individuals from the schools and districts (August 2000).

The transportation infrastructure appears to adequately serve the residents living in communities near the plants. Two traffic issues, however, were identified by staff from the Arkansas Highway and Transportation Department and Pope County Sheriff's Office as potentially problematic. These issues include congestion at the intersection of State Highway 333 and U.S. Highway 64, which serves as a major ingress/egress point for ANO traffic. Residents have also indicated that an additional east-bound on-ramp is needed onto I-40 at the west end of Russellville. The Arkansas Highway and Transportation Department has initiated a preliminary investigation regarding the addition of an on-ramp.

- **Offsite Land Use**

The continued availability of ANO and the associated tax base is an important feature in Pope County's ability to continue to invest in infrastructure and to draw industry and new residents. In 1999, the Pope County Operational Budget was $3.73 million, and the school operating budget was $21.44 million, for a total of $25.16 million. Entergy paid $8.66 million in taxes on ANO in 1999, or roughly one-third of the county combined operational and school budget.[(1)] In Yell and Johnson County, continued presence of the plant will have less influence on development or land use, because the plant does not directly contribute to the tax base of those counties.

- **Visual Aesthetics and Noise**

From the air, the principal visual features of the ANO region are Lake Dardanelle and the countryside, which is generally wooded and residential. The position of the plant relative to Lake Dardanelle is such that ANO-1 is only visible from the water within the first few kilometers to the south, southwest, and southeast. The cooling tower of ANO-2, however, is visible from at least 16 km (10 mi) away, and its plume can be seen from a much greater distance. From the lake, the shoreline appears mostly wooded with housing developments and boat launches.

Because of woods and topography, noise from ANO is generally not an issue. The only sounds heard offsite are the plant loudspeakers and shooting range, which can be heard nearby on the lake.

(a) Taken from Pope County 1999 Taxes Payable Statement 2000 and 1999 Pope County Tax Statement, provided by Bobbye McAlister, Pope County Collector, April 2000.

- **Demography**

Entergy's emergency response plan estimated resident population as 33,754 within 16 km (10 mi) of ANO for 1980 (NRC 2000). The ANO-1 Environmental Report (ER) estimates for the year 2000 indicate that the population within the 16 km (10 mi) radius has increased by approximately 33 percent to 42,569 since 1980 (Entergy 2000a).

Tables 2-9 through 2-12 estimate resident population for 2000 and each decade through the proposed ANO-1 license renewal term (2010, 2020, 2030). The 2010 projections represent the estimated population near the first year of license renewal for ANO-1 (2014). Near the end of the license renewal term (2030), the population within 80 km (50 mi) of ANO is projected to be 322,991, as compared with 274,037 in 2000 (Entergy 2000a). Data for 2000 are based on the 1990 U.S. Bureau of the Census data (USCB 1990).

Table 2-9. Estimated Population Distribution in 2000 within 80 km (50 mi) of ANO

Sector	0-16 km (0-10 mi)	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Total
N	1503	1030	355	352	1850	5090
NNE	2221	3859	269	380	822	7551
NE	14,775	4630	1929	363	1320	23,017
ENE	11,507	2987	2023	1849	4848	23,214
E	4506	5772	9009	5091	21,611	45,989
ESE	1899	639	4794	3294	38,275	48,901
SE	841	894	1305	1825	3311	8176
SSE	1118	701	332	4640	12,334	19,125
S	473	2037	172	781	9257	12,720
SSW	606	1341	504	484	1898	4833
SW	391	3026	617	615	600	5249
WSW	315	1142	881	1198	1372	4908
W	58	237	5062	8033	6521	19,911
WNW	713	1781	4455	9993	4078	21,020
NW	322	2295	10,073	1838	1330	15,858
NNW	1321	3333	2377	748	696	8475
Total	42,569	35,704	44,157	41,484	110,123	274,037

Source: Entergy 2000a.

Table 2-10. Estimated Population Distribution in 2010 within 80 km (50 mi) of ANO

Sector	0-16 km (0-10 mi)	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Total
N	1622	1112	383	380	1997	5494
NNE	2398	4165	291	410	887	8151
NE	15,948	4998	2082	392	1425	24,845
ENE	12,421	3224	2184	1995	5234	25,058
E	4864	6231	9724	5495	23,328	49,642
ESE	2050	689	5175	3556	41,316	52,786
SE	907	965	1409	1970	3574	8825
SSE	1207	757	358	5009	13,314	20,645
S	510	2198	185	843	9993	13,729
SSW	654	1447	544	523	2049	5217
SW	422	3266	666	664	648	5666
WSW	340	1233	951	1293	1481	5298
W	62	256	5465	8671	7040	21,494
WNW	769	1922	4809	10,787	4402	22,689
NW	347	2477	10,873	1984	1435	17,116
NNW	1426	3598	2565	808	751	9148
Total	45,947	38,538	47,664	44,780	118,874	295,803

Source: Computed from Table 2-9.

Table 2-11. Estimated Population Distribution in 2020 within 80 km (50 mi) of ANO

Sector	0-16 km (0-10 mi)	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Total
N	1712	1174	404	401	2108	5799
NNE	2530	4395	307	433	936	8601
NE	16,830	5274	2197	413	1503	26,217
ENE	13,107	3403	2304	2106	5523	26,443
E	5133	6575	10,262	5799	24,618	52,387
ESE	2164	727	5461	3752	43,600	55,704
SE	958	1018	1487	2079	3771	9313
SSE	1274	799	378	5285	14,050	21,786
S	539	2320	196	890	10,545	14,490
SSW	690	1527	574	551	2162	5504
SW	445	3447	703	700	684	5979
WSW	359	1301	1003	1365	1563	5591
W	66	270	5767	9150	7429	22,682
WNW	812	2029	5075	11,384	4645	23,945
NW	366	2614	11,474	2094	1515	18,063
NNW	1505	3797	2707	853	792	9654
Total	48,490	40,670	50,299	47,255	125,444	312,158

Source: Computed from Table 2-10.

Table 2-12. Estimated Population Distribution in 2030 within 80 km (50 mi) of ANO

Sector	0-16 km (0-10 mi)	16-32 km (10-20 mi)	32-48 km (20-30 mi)	48-64 km (30-40 mi)	64-80 km (40-50 mi)	Total
N	1771	1215	418	415	2181	6000
NNE	2618	4548	317	448	969	8900
NE	17,414	5457	2273	428	1555	27,127
ENE	13,562	3521	2384	2179	5715	27,361
E	5311	6803	10,618	6000	25,472	54,204
ESE	2239	753	5651	3883	45,113	57,639
SE	991	1053	1539	2151	3902	9636
SSE	1318	827	391	5469	14,538	22,543
S	557	2400	202	921	10,911	14,991
SSW	714	1580	594	571	2237	5696
SW	461	3567	727	725	707	6187
WSW	371	1346	1038	1412	1617	5784
W	68	279	5967	9468	7686	23,468
WNW	840	2099	5251	11,779	4807	24,776
NW	379	2705	11,872	2167	1567	18,690
NNW	1557	3929	2801	882	820	9989
Total	50,171	42,082	52,043	48,898	129,797	322,991

Source: Computed from Table 2-11.

The 2000 resident population distribution (by distance and directions) is found in Tables 2.4-1 through 2.4-7 of the Entergy ER (Entergy 2000a). Populations for the sectors[(1)] were calculated using population values at the census block level, the smallest enumeration level used by the U.S. Bureau of the Census. The computer program SECPOP90 was used to process block level 1990 census data to prepare population estimates for the region surrounding ANO (Scientech 1999). Census blocks whose geographic centroid was located within a sector were considered to lie within that sector. For each sector that is located within 80 km (50 mi) of the plant, the population numbers for the blocks within each sector were summed to give a total for that sector. The projected population within the sectors for the years 2000, 2010, 2020, and 2030 was calculated by increasing the 1990 population for each sector by the percentage increases between the respective periods.

Current projections in the ANO-1 ER (Entergy 2000a) indicate that by the year 2015, the population within 80 km (50 mi) will be approximately 304,000, which is about 20 percent higher than projected in the original *Final Environmental Statement* (AEC 1973). The higher growth within the 16-km (10-mi) radius is primarily related to population growth in Pope and Johnson Counties. Between 1990 and 1999, Pope and Johnson Counties grew nearly twice as fast as the State of Arkansas (14.6 percent [Pope] and 17.2 percent [Johnson] per year versus

(a) A sector is identified by a combination of its compass direction and the distance of its outer edge from the plant. For instance, the sector that is between 11.25 and 33.75 degrees and 64 km (40 mi) and 80 km (50 mi) from a plant is identified as NNE50.

8.5 percent for the State of Arkansas). Factors stimulating growth in Pope County include growth of the food processing industry. Between 2000 and 2030, the population within 80 km (50 mi) of ANO is estimated to increase approximately 18 percent, from about 274,000 to about 323,000 (Entergy 2000a).

Table 2-13 lists the age distribution of Pope County in 1990 compared to the U.S. population. The distributions are similar, with a slightly higher percentage of school-age children in Pope County compared with the nation as whole.

Transient Population. The transient population in the vicinity of ANO can be identified as daily or seasonal. Daily transients are associated with places where a large number of people gather regularly, such as local businesses, industrial facilities, and schools. Seasonal transients result from the use of weekend recreational areas such as Lake Dardanelle or Mount Nebo, which is located about 13 km (8 mi) directly south of the plant. The seasonal automobile counts associated with selected recreation within 80 km (50 mi) of the station are listed in Table 2-14.

• Historic and Archaeological Resources

This section discusses the cultural background and the known and potential historic and archaeological resources at the ANO site and in the surrounding area.

Table 2-13. Estimated Age Distribution of Population in 1990

	Pope County, Arkansas		United States	
Age Group	**Number**	**Percentage**	**Number**	**Percentage**
Under 5	3350	7.3	19,512,000	7.6
5-19	10,601	23.1	53,523,000	21.0
20-44	17,809	38.8	101,416,000	39.8
45-64	8438	18.4	48,348,000	19.0
65 and Over	5685	12.4	32,283,000	12.7
	45,883	100.0	255,082,000	100.0

Source: USCB 1990.

Table 2-14. Seasonal Transient Automobile Count in Recreation Areas within 80 km (50 mi) of ANO, 1980

Recreation Area	Peak Autos	Average Autos	Night Autos
Mt. Nebo	2000	500	250
Lake Dardanelle	2500	100	25
Ouita	500	300	100
Russellville State Park	4000	1000	300
Cabin Creek		133	57
Dam Site East		1323	0
Delaware Use Area		129	64
Dike View		0	0
Flat Rock		142	71
Highway 64 Cove		10	0
Illinois Bayou		0	0
Piney Bay		313	157

Source: NRC 2000.

- **Cultural Background**

The area around the ANO site is rich in prehistoric and historic Native American and historic Euroamerican resources. This part of west-central Arkansas has an archaeological sequence that extends back about 12,000 years, although human use of the region was probably limited during the first few thousand years of human presence. Similar to much of the surrounding southeastern states, archaeological periods defined for this part of Arkansas fall into several sequential cultural periods of Native American occupation: the Paleo-Indian era (about 9500 B.C. to 8000 B.C.), the Archaic era (8000 B.C. to 500 B.C.), the Woodland era (500 B.C. to A.D. 900), the Mississippian era (A.D. 900 to A.D. 1541), and the Historic era, initiated by the initial intrusion of Spanish explorers into the area (A.D. 1541 to A.D. 1850) (Schambach and Newell 1990).

The prehistoric periods were marked by initial reliance on big game hunting subsistence, followed by increased use of smaller game animals and plant foods in the Archaic era. Trends toward more sedentary villages with greater reliance on cultivated crops began late in the Woodland era and increased in importance in the following Mississippian era. In Arkansas, the Mississippian cultures were largely focused in the eastern part of the state, along the Mississippi River valley. In the region of western Arkansas, including the Arkansas River valley, contemporaneous cultures included the Caddoan groups who, like the Mississippians, grew cultivated crops, but, unlike their neighbors to the east, continued to rely heavily on hunting, fishing, and gathering of wild plants.

Following initial contact by the Spanish, and later Euroamerican settlers, the Native American Historic-era in the vicinity of ANO was marked by nearly continual occupation and visits by several tribes as they coped with the Euroamerican expansion into their former homelands (Sabo 1992). Before a large land cession in 1808, the region north of the Arkansas River was primarily occupied by the Osage, while the area south of the river was occupied by the Quapaw until that land was ceded to the U.S. in 1818. Other tribes that either visited or occupied smaller areas during this time included the historic Caddos, Tunicas, Shawnee, and Delaware.

Beginning immediately after the 1808 Osage cession and their removal to the region of present-day Oklahoma, the Arkansas River valley was occupied by the Cherokees, who had begun to be pushed out of their traditional homelands in the Carolinas. Known as the “Arkansas Cherokees” (Markham 1972; Davis 1987), the Cherokees occupied the Arkansas River corridor from Little Rock on the east to Fort Smith on the west between 1809 and 1828. In 1817, a reservation was set aside for the Arkansas Cherokees on the north side of the river that included the ANO site. Soon after, additional Cherokees emigrated into the area from the Southern Appalachian area, bringing the population of Cherokees in the Arkansas River valley from 4000 to 5000. Increasing pressure from white settlers brought about another land cession by the Arkansas Cherokees, and in 1828 they once again moved westward to the Oklahoma Territory, marking the end of Native American occupation in the project area.

Though relatively brief, the Cherokee occupation of the area including the ANO site was fairly intense and left a lasting mark in the archaeological and historic records. The primary historic site associated with this period is the Dwight Mission, a Presbyterian mission to the Cherokees, established in 1820 on the west bank of Illinois Bayou, about 2.4 km (1.5 mi) east of the ANO property line (Turrentine 1962). When the Cherokees were forced out of the area a few years later, the mission relocated to Oklahoma as well. Lake Dardanelle inundated some of the original mission compound in the 1960s. The archaeological record from the Cherokee villages and home sites in the area outside the ANO property line is relatively unknown, but recent investigations indicate that the local archaeological remains hold great promise for significant research potential (Stewart-Abernathy 1998).

Following Cherokee removal, the area, including the ANO property, was immediately taken up by Euroamerican settlers, including the May and Rye families, who settled the land in the immediate vicinity of the ANO site in the 1830s (Anonymous 1975; Vance 1970). Although early Euroamerican use of the land within the ANO property was primarily agricultural, numerous important Historic-era resources exist a short distance north of the site (Pope County Historical Association 1979, 1981; Vance 1970). Completed in 1823, a military road passed through the river valley, just north of ANO, that connected Memphis, Little Rock, Fort Smith, and the Oklahoma Territory. In 1838-39, this road was used as part of the final Cherokee removal from the Southern Appalachians and northern Georgia, along the infamous "Trail of Tears." The area just northwest of the plant site that would eventually become the town of London had a population of 65 people in 1832, although the town itself was not incorporated until 1882 with a population of 119. Three cotton gins were in the vicinity of London at one time. One of these was built in 1847 on the Rye farm, located just west of the plant on ANO property; the gin was torn down in 1902.

There were two routes of the 1838 Trail of Tears that passed by the present-day ANO site (U.S. Department of the Interior 1992). The first was the water route that in part followed the Arkansas River into Indian Territory. In the summer of that year, three detachments of Cherokees followed the water route to Fort Smith, west of Russellville, then on into their new homelands. The second route, designated Bell's Route, involved a detachment of 600-700 Cherokees, led by John A. Bell, that followed the land route along the north side of the Arkansas River. For the ANO site, the water route passed along the southern boundary, using the now submerged Arkansas River waterway, and the land route passed just to the north, along the military road.

The Trail of Tears was designated a National Historic Trail by Congress in 1987, and granted additional protection under the National Trails System Act of 1990. The legislatively-designated historic trail includes only the water route in the vicinity of the ANO site; Bell's Route was not formally included, although it's designation as part of the national trail system is still under study.

Transportation and communication features soon followed. Just north of the ANO property, the Fort Smith and Little Rock Railroad was constructed in 1873; later, it was the Iron Mountain Railroad; currently, it is the Union-Pacific line. Telephone service to the area began about 1900, and U.S. Highway 64 was constructed in 1921. The Arkansas-Louisiana gas main was completed in 1928, and electrical power became available in the late 1930s.

- **Historic and Archaeological Resources at the ANO Plant Site**

Prehistoric. Construction of the ANO-1 nuclear plant within the 1164-acre site began in 1968. In 1969, the Arkansas Archaeological Society conducted a reconnaissance field survey of the lands within the site that were not within the construction zone and which were not heavily vegetated (Cole 1969). From the report, it is not possible to define the actual acreage examined, although it is important to note that the goal of the fieldwork was only to identify and record Native American archaeological properties.

Five prehistoric sites (3PP62-66)[(1)] were recorded by the survey. All represented light surface scatters of archaeological materials with few age diagnostic artifacts. No ceramics, indicative of later Caddoan occupation, were located, and the sites probably represent pre-ceramic or Archaic-era campsites. Because each of the archaeological sites was located away from the construction area, Cole (1969) recommended that no further analysis was necessary at the time, although he cautioned that if any of the sites were to be impacted by project activities, further evaluation would be necessary. To date, none of these sites has been fully evaluated for potential significance for nomination to the National Register of Historic Places. Until these evaluations are completed, the Arkansas Historic Preservation Program considers these sites to be potentially eligible for inclusion in the National Register of Historic Places[(2)] and, therefore, subject to consideration under the provisions of the National Historic Preservation Act of 1966 and its implementing regulations.

A site-file search of the archaeological records maintained at the Arkansas Archaeological Society Research Station of Arkansas Tech University in Russellville, Arkansas, revealed another 13 prehistoric archaeological sites that have been recorded within less than 1.6 kilometers (1 mile) of the ANO site boundary. These results, along with the reconnaissance-level survey methodology employed in the 1969 survey, indicate a potential for additional prehistoric Native American sites to exist on ANO property.

Cole (1972) conducted a site-file search for five transmission line rights-of-way emanating from ANO that were either already constructed, under construction, or proposed for construction. Scanty data of past archaeological surveys or known archaeological sites along any of the transmission line rights-of-way were available. There is no record that archaeological fieldwork was ever conducted along the ANO transmission line rights-of-way beyond the site-file search.

(a) This is the nomenclature used by the Arkansas Archaeological Society for site identification.
(b) Letter from Cathy Buford Slater, State Historic Preservation Officer, to Dr. Gary Tucker, FTN Associates, March 30, 1998.

Historic. As noted above, the 1969 archaeological survey of the ANO site only focused on potential Native American properties, even though Historic-era Euroamerican sites were present. Consequently, none of the Historic-era properties has been recorded or evaluated for National Register of Historic Places eligibility.

Review of Historic-era records and maps during the site visit revealed that more than 35 Historic-era properties existed within the ANO property boundaries, dating from approximately 1830 to 1967, when the property was acquired by the Arkansas Power and Light Company. Although occupation of the area was continuous during the 1800s, specific information was not found on either the number of or precise locations of Historic-era sites. It is known that the May farm was located south of the nuclear plant, and that the Rye farm, with its cotton gin, was located just west of the plant.

Examination of three sequential Historic-era maps from the 1900s indicates intensive occupation of the project area, along with some interesting trends in density of the occupation. The maps that were examined, along with the results, include the following:

- 1913 Soils Map, U.S. Department of Agriculture, Bureau of Soils – This map indicates the presence of between 13 and 16 farms that were located on the ANO property at the time of the soil survey.

- 1940 Arkansas Tributary and Tributaries Map, U.S. Army Corps of Engineers, Little Rock District, Arkansas Survey River Survey Board – Data reflected on this map show that by 1940, some 35 to 37 farms were located on the ANO property.

- 1963, U. S. Geological Survey, Russellville West Topographic Map – By the time this map was published (1963), the number of farms located on the soon-to-be ANO site had been reduced to 11 to 13 properties. According to an article in the Russellville, Arkansas, *Daily Courier Democrat* (August 22, 1967), one-half dozen landowners were affected by the Arkansas Power and Light land-acquisition activity.

No standing structures remain at any of these former historic sites except for a few storm shelter/storage cellars. They exist as unrecorded and unevaluated Historic-era archaeological sites that exhibit house and outbuilding foundations, artifact scatters, trash dumps, and buried features, along with the historic roads and trails that linked the farming community.

In addition to the farms, one Historic-era cemetery, the May Cemetery, is located on ANO property, about one-half mile south of the plant. The cemetery is protected by a chain link fence and is well maintained. According to Lemley (1981, pp. 188-190), 106 marked and named graves are in the cemetery, along with a number of unnamed graves, both marked and unmarked. The cemetery was established in 1885. Because the plant site property was initially

homesteaded about 55 years earlier, earlier interments were either buried elsewhere or are co-located with early farmsteads in unknown and unmarked graves. Two other historic cemeteries exist in proximity to the ANO site: the Swan (Finchum) Cemetery, located about 0.8 km (0.5 mi) west of the northwest corner of the ANO boundary, and the Crain Cemetery, situated immediately north of State Highway 333, between the plant entrance and London, and about 183 m (200 yd) from the ANO property line (Lemley 1981, pp. 122-123 and 368). The Crain Cemetery does not appear on ANO or U.S. Geological Survey base maps, but includes some 32 marked graves dating back to 1865.

- **Related Federal Project Activities**

The staff reviewed the possibility that activities of other Federal agencies might impact the renewal of the operating license for ANO-1. Any such activities could result in cumulative environmental impacts and the possible need for the Federal agency to become a cooperating agency for preparation of the SEIS.

The ANO-1 plant obtains its cooling water from Lake Dardanelle formed by the Dardanelle Lock and Dam. The Dardanelle Lock and Dam was authorized by Congress. It was constructed and is operated by the U.S. Army Corps of Engineers. The Dardanelle Lock and Dam produces hydroelectric power. Under the Federal Power Act of 1920, the Federal Energy Regulatory Commission does not license Federally-owned hydroelectric facilities such as the Dardanelle Lock and Dam.

No Federal agencies participated in the public meetings or submitted written comments during the review, concerning related Federal project activities. The staff determined that there were no Federal project activities directly related to renewal of the operating license for ANO-1 that could result in cumulative environmental impacts or that would make it desirable for another Federal agency to become a cooperating agency for preparation of the SEIS.

2.3 References

10 CFR Part 20, Appendix B, Table 2, “Annual limits on intake (ALIs) and derived air concentrations (DACs) of radionuclides for occupational exposure; effluent concentrations; concentrations for Release to Sewerage.”

10 CFR 20.1301(d), “Dose limits for individual members of the public.”

10 CFR Part 50, Appendix I, “Numerical guides 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.”

10 CFR Part 54, “Requirements for renewal of operating licenses for nuclear power plants.”

10 CFR Part 61, “Licensing requirements for land disposal of radioactive waste.”

10 CFR Part 71, “Packaging and transportation of radioactive material.”

10 CFR Part 72, “Licensing requirements for the independent storage of spent nuclear fuel and high-level radioactive waste.”

40 CFR 81.304, “Arkansas.”

40 CFR 81.404, “Identification of Mandatory Class 1 Federal Areas where visibility is an important value: Arkansas.”

40 CFR Part 190, “Environmental radiation protection standards for nuclear power operations.”

Anonymous. 1975. *May Family in Pope County, Arkansas*. Pope County Historical Association Quarterly, Volume 9, Number 3, pp. 69-81.

Arkansas Power and Light (APL). 1990. *Survey Response from Arkansas Power & Light Company*. Little Rock, Arkansas.

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

Clean Air Act of 1970, as amended, 42 USC 7401 et seq.

Cole, K. W. 1969. *Archaeological Survey of the Arkansas Power and Light Company Nuclear Power Plant Construction Area, Pope County, Arkansas, 1969*. Arkansas Archaeological Survey, University of Arkansas Museum, Fayetteville, Arkansas.

Cole, K. W. 1972. *Preliminary Investigation of the Power Transmission Lines Emanating from Units One and Two of Nuclear One, The Arkansas Power and Light Company Nuclear Power Generating Plant*. Arkansas Archaeological Survey, University of Arkansas Museum, Fayetteville, Arkansas.

Davis, H. A. 1987. “The Cherokee in Arkansas: An Invisible Archaeological Resource.” *In “Visions and Revisions: Ethnohistoric Perspectives on Southern Cultures*,” edited by G. Sabo III and W. M. Schneider, pp. 48-58. University of Georgia Press, Athens, Georgia.

Edwards, R. L., L. F. Graves, A. C. Sprankle, D. L. Elliott, W. R. Barchet, and R. L. George. 1981. *Wind Energy Resource Atlas: Volume 7–The South Central Region*. PNL-3195 WERA-7, Pacific Northwest Laboratory, Richland, Washington.

Entergy Operations, Inc. 1981. ANO Emergency Plan. Russellville, Arkansas.

Entergy Operations, Inc. 1999a. *Offsite Dose Calculation Manual*. Arkansas Nuclear One, Revision 13, PC-3. Entergy Operations, Inc., Russellville, Arkansas.

Entergy Operations, Inc. 1999b. Arkansas Nuclear One- Units 1 and 2. *Annual Radiological Environmental Operating Report for 1997.* Entergy Operations, Inc. Russellville, Arkansas.

Entergy Operations, Inc. 1999c. *Arkansas Nuclear One - Units 1 and 2 Annual Radioactive Effluent Release Report for 1998*. Entergy Operations, Inc., Russellville, Arkansas (February 25, 1999).

Entergy Operations, Inc. 2000a. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report).

Entergy Operations, Inc. 2000b. *Arkansas Nuclear One - Units 1 and 2 Annual Radioactive Effluent Release Report for 1999*. Entergy Operations, Inc., Russellville, Arkansas (February 28, 2000).

Federal Power Act of 1920, as amended, 16 USC 791 et seq.

Federal Water Pollution Control Act of 1977, as amended, 33 USC 1251 et seq. (also known as the Clean Water Act).

Greller, A.M. 1988. “Deciduous Forest.” Pp. 287-316, in *North American Terrestrial Vegetation*, M.G. Barbour and W.D. billings, eds., Cambridge University Press, New York.

Lemley, J. B., Editor and Compiler. 1981. *Cemeteries of Pope County, Arkansas, 2nd Edition*. Pope County Genealogy and Family Group, Russellville, Arkansas.

Markman, R. P. 1972. *The Arkansas Cherokees: 1817-1828*. Ph.D. Dissertation. The Graduate College, University of Oklahoma, Norman, Oklahoma.

Pope County Historical Association. 1979. *History of Pope County, Arkansas*. Hunter Publishing Company, Winston-Salem, North Carolina.

Pope County Historical Association. 1981. *History of Pope County, Arkansas: Volume II*. Josten's Publishing Company, Topeka, Kansas.

Ramsdell, J. V. and G. L. Andrews. 1986. *Tornado Climatography of the Contiguous United States*. NUREG/CR-4461, U.S. Nuclear Regulatory Commission, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901 et seq.

Rickett, J.D. 1994. *Dardanelle Reservoir-Illinois Bayou Embayment Survey Progress Report No. 34*. Submitted to Entergy Corporation, Arkansas Nuclear One, Russellville, Arkansas by J. D. Rickett, University of Arkansas, Little Rock, Arkansas.

Rickett, J. D., and R. L. Watson. 1994. "First record of *Leptodora kindti* in Dardanelle Reservoir and status of other recent additions to Dardanelle fauna." *Proc. Ark. Acad. Sci*. 48.

Sabo, G. III. 1992. *Paths of Our Children: Historic Indians of Arkansas*. Arkansas Archaeological Survey, Popular Series Number 3. Fayetteville, Arkansas.

Schambach, F., and L. Newell. 1990. *Crossroads of the Past: 12,000 Years of Indian Life in Arkansas*. Arkansas Archaeological Survey, Popular Series Number 2. Fayetteville, Arkansas.

Scientech. 1999. *Regional Population 2000-2030 Projections, ANO-1 Level 3 Model Preparation*. September 1999. Gaithersburg, MD.

Stewart-Abernathy, L. C. 1998. *Some Archaeological Perspectives on the Arkansas Cherokee*. The Arkansas Archaeologist, Volume 37, pp. 39-54.

Turrentine, G. R. 1962. *Dwight Mission*. Arkansas Valley Historical Papers, Number 25, Russellville, Arkansas.

U.S. Atomic Energy Commission (AEC). 1973. *Final Environmental Statement Related to the Arkansas Nuclear One Unit 1, February 1973*. Washington, D.C.

U.S. Bureau of the Census (USCB). 1990. 1990 Census of Population and Housing, STF-3A, <http://www.aiea.ualr.edu/csdc/cntydata> (accessed May 10, 2000).

U.S. Bureau of the Census (USCB). 1991. 1990 Census Population and Housing; Public Law 94-171 Data. Washington, D.C.

U.S. Bureau of the Census (USCB). 1997. County Business Patterns. <http://her2.census.gov> (accessed May 10, 2000), Washington, D.C.

U.S. Bureau of the Census (USCB). 1998. USA Counties 1998 CD-ROM <http://her2.census.gov> (accessed May 2, 2000). Washington, D.C.

U.S. Bureau of the Census (USCB). 1999. County Estimates for July 1, 1999 and Population Change for April. <http://www.census.gov/population/estimates/county/co-99/99C2-05.txt> (accessed May 2, 2000).

U.S. Department of Agriculture (USDA). 1981. *Soil Survey of Pope County Arkansas*. Little Rock, Arkansas.

U.S. Department of the Interior. 1992. *Trail of Tears National Historic Trail: Comprehensive Management and Use Plan* (with Map Supplement volume). National Park Service, Denver Service Center, Denver, Colorado.

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

U.S. Nuclear Regulatory Commission (NRC). 2000. *Summary of Site Audit to Support License Renewal Application of Arkansas Nuclear One Unit 1*. Dated May 1, 2000. Washington, D.C.

Vance, D. L. 1970. *Early History of Pope County: A History of Pope County in the Nineteenth Century and in the Early Part of the Twentieth Century*. Foreman-Payne Publishers, Mabelville, Arkansas.

3.0 Environmental Impacts of Refurbishment

Environmental issues associated with refurbishment activities were discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996; 1999).[(1)] The GEIS included 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 were 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 did not meet one or more of the criteria of Category 1, and, therefore, additional plant-specific review for 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. Category 1 and Category 2 issues related to refurbishment that are not applicable to Arkansas Nuclear One, Unit 1 (ANO-1) because they are related to plant design features or site characteristics not found at ANO are listed in Appendix F.

(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. Entergy Operations, Inc. (Entergy) indicated that it has performed an evaluation of structures and components pursuant to 10 CFR 54.21 to identify activities that are necessary to continue operation of ANO-1 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 *Arkansas Nuclear One – Unit One, License Renewal Application* (Entergy 2000).

Table 3-2. Category 2 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	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 (non-attainment 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	

However, Entergy stated that the replacement of these components and the additional inspection activities are within the bounds of normal plant component replacement and inspections; therefore, they are not expected to affect the environment outside the bounds of plant operations as evaluated in the *Final Environmental Statement* (AEC 1973). In addition, Entergy'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 operation of ANO-1 beyond the end of the existing operating licenses. Therefore, refurbishment is not considered in this Supplemental Environmental Impact Statement (SEIS).

3.1 References

10 CFR Part 51, Subpart A, Appendix B, Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants."

10 CFR 51.53, "Postconstruction environmental reports."

10 CFR 54.21, "Contents of application - technical information."

Entergy Operations, Inc. 2000. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

U.S. Atomic Energy Commission (AEC). 1973. *Final Environmental Statement Related to the Arkansas Nuclear One Unit 1*. February 1973. Washington, D.C.

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

4.0 Environmental Impacts of Operation

Environmental issues associated with operation during the renewal term were discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS),[(1)] NUREG-1437 (NRC 1996a; 1999). The GEIS included 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 were 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 did not meet one or more of the criteria of Category 1, and, therefore, additional plant-specific review for these issues is required.

This chapter addresses those issues related to operation during the renewal term that are listed in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 that are applicable to Arkansas Nuclear One, Unit 1 (ANO-1). Section 4.1 addresses the Category 1 issues applicable to the ANO-1 once-through cooling system, while Category 2 issues applicable to the ANO-1 cooling system are discussed at greater length in Sections 4.1.1 through 4.1.4. Section 4.2 addresses Category 1 issues related to transmission lines and land use, while Category 2 issues are discussed in Sections 4.2.1 and 4.2.2. Section 4.3 addresses the radiological impacts of normal operation. There are no Category 2 issues related to radiological impacts of normal operation. Section 4.4 addresses the Category 1 issues related to the socioeconomic impacts

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(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.

of normal operation during the renewal term. Category 2 socioeconomic issues are discussed in Sections 4.4.1 through 4.4.6. Section 4.5 addresses the Category 1 issues related to groundwater use and quality. Section 4.6 discusses the impacts of renewal-term operations on threatened and endangered species, a Category 2 issue. Section 4.7 addresses new information that was raised during the scoping period. The results of the evaluation of environmental issues related to operation during the renewal term are summarized in Section 4.8. Finally, Section 4.9 lists the references for Chapter 4.

4.1 Cooling System

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to ANO-1 cooling system operation during the renewal term are listed in Table 4-1. Entergy Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2000a) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating licenses. No significant new information has been identified by the staff during its review. 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 GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, 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: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information, including reports of studies of Lake Dardanelle. Therefore, the staff concludes that there are no impacts of altered current patterns during the renewal term beyond those discussed in the GEIS.

- Altered thermal stratification of lakes: Based on information in the GEIS, the Commission found: "Generally, lake stratification 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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information, including reports of studies of Lake Dardanelle and results of thermal surveillance program required by ANO's National Pollutant Discharge Elimination System (NPDES) permit. Therefore, the staff

concludes that there are no impacts of altered thermal stratification of Lake Dardanelle during the renewal term beyond those discussed in the GEIS.

Table 4-1. Category 1 Issues Applicable to the Operation of the ANO-1 Cooling System During the 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; 4.4.2.2
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 waste water	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
HUMAN HEALTH	
Microbial organisms (occupational health)	4.3.6
Noise	4.3.7

- Temperature effects on sediment transport capacity: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of temperature effects on sediment transport capacity during the renewal term beyond those discussed in the GEIS.

- Scouring caused by discharged cooling water: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of scouring during the renewal term beyond those discussed in the GEIS.

- Eutrophication: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information including plant monitoring data and technical reports. Therefore, the staff concludes that there are no impacts of eutrophication during the renewal term beyond those discussed in the GEIS.

- Discharge of chlorine or other biocides: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information including the NPDES permit for ANO. Therefore, the staff concludes that there are no impacts of discharge of chlorine or other biocides during the 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: "Effects are readily controlled through NPDES permit and periodic modifications, if needed, and are not expected to be a problem during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit,

the scoping process, or its evaluation of other available information including the NPDES permit for ANO. Therefore, the staff concludes that there are no impacts of discharges of sanitary wastes and minor chemical spills during the renewal term beyond those discussed in the GEIS.

- Discharge of other metals in waste water: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information including the NPDES permit for ANO. Therefore, the staff concludes that there are no impacts of discharges of other metals in waste water during the 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: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of available information. Therefore, the staff concludes that there are no water-use conflicts during the renewal term beyond those discussed in the GEIS.

- Accumulation of contaminants in sediments or biota: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of accumulation of contaminants in sediments or biota during the renewal term beyond those discussed in the GEIS.

- Entrainment of phytoplankton and zooplankton: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information.

Therefore, the staff concludes that there are no impacts of entrainment of phytoplankton and zooplankton during the renewal term beyond those discussed in the GEIS.

- Cold shock: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of cold shock during the renewal term beyond those discussed in the GEIS.

- Thermal plume barrier to migrating fish: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of thermal plumes during the renewal term beyond those discussed in the GEIS.

- Distribution of aquatic organisms: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts on the distribution of aquatic organisms during the renewal term beyond those discussed in the GEIS.

- Premature emergence of aquatic insects: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of premature emergence of aquatic insects during the renewal term beyond those discussed in the GEIS.

- Gas supersaturation (gas bubble disease): Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of gas supersaturation during the renewal term beyond those discussed in the GEIS.

- Low dissolved oxygen in the discharge: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of low dissolved oxygen during the 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: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of losses from predation, parasitism, and disease among organisms exposed to sub-lethal stresses during the renewal term beyond those discussed in the GEIS.

- Stimulation of nuisance organisms: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes

that there are no impacts of stimulation of nuisance organisms during the renewal term beyond those discussed in the GEIS.

- Microbiological organisms (occupational health): Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of microbiological organisms during the renewal term beyond those discussed in the GEIS.

- Noise: Based on information in the GEIS, the Commission found: "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 significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of noise during the renewal term beyond those discussed in the GEIS.

Category 2 issues related to cooling system operation during the renewal term that are applicable to ANO-1 are discussed in the sections that follow. These issues are listed in Table 4-2.

Table 4-2. Category 2 Issues Applicable to the Operation of the ANO-1 Cooling System During the Renewal Term

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
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	4.1.1
Impingement of fish and shellfish	4.2.2.1.3; 4.4.3	B	4.1.2
Heat shock	4.2.2.1.4; 4.4.3	B	4.1.3
HUMAN HEALTH			

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
Microbiological organisms (public health)	4.3.6	G	4.1.4

- **Entrainment of Fish and Shellfish in Early Life Stages**

Entrainment of fish and shellfish in early life stages into cooling water systems associated with nuclear power plants is considered a Category 2 issue, requiring a site-specific assessment before license renewal. The impact of entraining larval fish and shell fish is of concern with the once-through cooling system. Entergy has performed environmental monitoring, including the ecological assessment of the effects of the ANO-1 once-through cooling water system (Rickett 1982). This monitoring was required in the original ANO-1 Technical Specifications.

Entrainment occurs when planktonic larval fish and shellfish drifting in the Illinois Bayou are carried with cooling water through the intake screens, pumps, and steam condensers. High mortality to larval fish can result from mechanical and hydraulic forces experienced within the cooling system.

Entrainment of larval fish at ANO was monitored between 1977 and 1987 (APLC 1982; 1987). The studies of entrainment during 1981 resulted in 110 samples collected during the 12-month period. Samples were collected two or three times per week. There were 365 reactor power days for the year (APLC 1982). The purpose of the entrainment monitoring was to provide sufficient information for the accurate determination of entrainment impacts by ANO on fish populations of Lake Dardanelle. The objective of the monitoring program was to determine the species composition and abundance of larval fish entrained at ANO during April to June. Results of these studies correlated with standing crop fish community data collected from Lake Dardanelle. The results indicate that the entrainment of fish from Lake Dardanelle does not adversely affect population levels. For most of the years monitored, over 95 percent of the larval fish entrained at ANO were Clupeidae, gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*). About 5 percent of the entrained fish were carp (*Cyprinus carpio*), suckers (Catostomidae), white bass (*Morone chrysops*), and freshwater drum (*Aplodinotus grunniens)*. Additional entrainment studies were conducted during monitoring that was continued through 1988.

The results of monitoring at ANO demonstrate that entrainment losses do not adversely affect the Clupeidae populations, or any other populations of fish or aquatic organisms in Lake Dardanelle. Additionally, the Arkansas Game and Fish Commission (AGFC) concluded that

entrainment losses have not affected the maintenance of a quality recreational fishery in Lake Dardanelle (AGFC 1995).

No significant changes have been made to the operation of the ANO intake structure since construction (Entergy 2000a). Based on the results of entrainment studies and operating

history of the ANO intake, the staff has reviewed the available information relative to potential impacts from entrainment of fish and other aquatic organisms, and concludes that the potential impacts are SMALL and mitigation is not warranted.

- **Impingement of Fish and Shellfish**

Lake Dardanelle covers about 14,975 ha (37,000 acres). There were more than an estimated 14,820 fish per hectare (6,000 fish per acre) and 678 kg of fish per hectare (605 pounds of fish per acre) during the 1981 study (APLC 1982). The estimated total impingement for 1981 was calculated to be about 8.1-million fish with a weight of 44,000 kg (97,000 pounds). This represents about 3.6 percent of the calculated total fish population and 0.43 percent of the total weight of fish in Lake Dardanelle. The most frequently impinged fish were gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*). These fish represented 99.25 percent of the total number of fish impinged and 95.34 percent of the total weight for fish impinged.

The highest impingement occurs during late fall, winter, and early spring (October through March). Shad were the most common fish impinged. Shad become thermally stressed at temperatures less than 16°C (60°F). Threadfin shad in Arkansas will most likely not survive the winter in lakes in which the temperature drops below 5°C (41°F) for any length of time (Chance and Miller 1952; Strawn 1965). Temperature data collected at the ANO intake indicates that the water temperature is typically below 5°C (41°F) during January and February. During this time period, shad decline in numbers in the reservoir.

Texas Instruments, Inc. (1976) concluded that the loss and possible subsequent reduction in shad standing crop due to natural mortality and impingement will effect little change in the numbers and/or biomass of the sport or commercial fish in the lake. They also concluded that any shift in predator-prey relationships brought on by a reduction in standing crop of threadfin shad may be buffered by compensatory changes in gizzard shad population levels. Reservoir data collected over the 9 years after this Texas Instruments, Inc. (1976) study supported these conclusions (APLC 1985).

Shad species in Lake Dardanelle are thermally stressed during the winter months. A comparison of the number and weight of the forage fish in Lake Dardanelle indicates that gizzard and threadfin shad make up the greatest number of impinged fish. The high impingement rate for these fish can be attributed to their inability to withstand thermal stress during winter months. The results of impingement studies at ANO and field surveys in Lake Dardanelle indicate that fluctuation in shad populations occur naturally in the lake and the declines are related to low winter temperatures (NRC 1979). The study concluded that the shad impinged at the ANO intake during periods with cold water temperatures were dead or cold-stressed and would likely

have died in any case. The study also concluded that threadfin shad and gizzard shad populations are able to reestablish themselves in the lake. During 1995, the AGFC concluded that impingement losses have not affected the maintenance of a quality recreational fishery in Lake Dardanelle (AGFC 1995). Additionally, the operation and design of the intake structure has not changed since it was constructed.

The staff has reviewed the available information relative to potential impacts of the cooling water intakes on the impingement of fish and shellfish, and based on these data, concludes that the potential impacts are SMALL and mitigation is not warranted.

- **Heat Shock**

For plants with once-through cooling systems, the effects of heat shock are listed as a Category 2 issue and require plant-specific evaluation before license renewal. Lake Dardanelle is a part of the Arkansas River. The lake serves as the cooling water source for ANO-1. ANO-1 uses about 48 m^3/s (1700 ft^3/s) of cooling water to condense steam during normal operation. The cooling water from the Illinois Bayou arm of the lake flows through a 1340-m (4400-ft) long canal to the intake structure. After flowing through the main condenser, the cooling water is discharged to a 156-m (520-ft) long canal before entering Lake Dardanelle. The lake was constructed by the U.S. Army Corps of Engineers in 1966 as part of the McClellan-Kerr Arkansas River Navigation Project.

With four circulating water pumps in operation, ANO-1 has a design flow of approximately 48 m^3/s (1700 ft^3/s) and increases the temperature of ambient intake lake water a maximum of 8°C (15°F) as it passes through the plant (*Final Environmental Statement* [FES] [AEC 1973]). Heated cooling water is discharged into Lake Dardanelle by way of an 32-ha (80-acre) embayment. The discharge limits for ANO are currently established in NPDES Permit Number AR0001392, dated September 30, 1997. The effluent discharge limits are 43°C (110°F) daily maximum and 40.5°C (105°F) daily average. These limits apply to the point where the cooling water enters the discharge canal. Since 1973, when ANO was originally permitted to discharge cooling water to Lake Dardanelle, no violations of established thermal permit limits have occurred.

A specific condition of NPDES Permit Number AR0001392 requires the applicant to monitor water temperatures after the discharged cooling water passes through the discharge embayment and enters the main channel of Lake Dardanelle. During the period from June to September, water temperatures are monitored twice a month at three locations in the lake within the influence of the ANO cooling water discharge. This is to ensure that the thermal water quality standard for the lake is not exceeded.

The Arkansas Water Quality Standard for Lake Dardanelle is 35°C (95°F). Because water quality standards for temperature are being met in Lake Dardanelle, no Section 316(a) variance is required or needed. In support of previous conclusions by State and Federal regulatory agencies (APLC 1984; 1985), the AGFC concluded in 1995 that thermal discharges from ANO have not affected the maintenance of a quality recreational fishery in the lake (AGFC 1995).

Entergy complies with State standards and has an approved NPDES permit, and no Section 316(a) variance is required. Under such circumstances, pursuant to 10 CFR 51.53(c)(3)(ii)(B), no further assessment of heat shock is required. Thus, the staff concludes that potential heat shock impacts resulting from operation of the plant's cooling water discharge system to the aquatic environment on or in the vicinity of the site are SMALL, and mitigation is not warranted.

- **Microbial Organisms (Public Health)**

For plants discharging cooling water to cooling ponds, lakes, canals, or small rivers, the effects of microbiological organisms on public health are listed as a Category 2 issue and require plant-specific evaluation before license renewal. ANO-1 has a once-through cooling system that uses Lake Dardanelle as the cooling source.

During 1981, 11 nuclear plants took part in a study to determine the potential presence of thermophilic pathogens in the cooling water systems. ANO participated in this study and was one of the 10 plants that had thermophilic free-living amoebae in the study samples. However, the amoebae were not pathogenic. *Naegleria* sp., which is pathogenic, was not detected in the water or sediment samples from the ANO intake canal or discharge embayment. *Legionella* was detected in water samples collected in Lake Dardanelle at ANO, but the concentrations were similar to the concentrations in local surface-water control sources.

Studies on thermophilic pathogens at ANO have concluded that any risk of infection from aerosols containing *Legionella* sp. is not a public health risk, but rather, a potential industrial hygiene concern that is managed through appropriate industrial hygiene practices.

The Arkansas Department of Health (ADH) was contacted to determine whether it had any concerns regarding thermophilic pathogens in Lake Dardanelle and the Arkansas River. The ADH had no information indicating that a human-health exposure problem exists with thermophilic pathogens in Lake Dardanelle or the Arkansas River (Entergy 2000a).

Although there is a potential for deleterious thermophilic microorganisms to be associated with the cooling system, the actual hazard to public health has not been documented or substantiated. The results of analyses and evaluations, including the results of consultation with ADH,

indicate that the impacts of deleterious microbiological organisms during continued operation of the plant during the renewal term are expected to be SMALL, and mitigation is not warranted.

4.2 Transmission Lines

The FES (AEC 1973) discussed four transmission lines with a total length of 380 km (240 mi) that were built to connect ANO-1 to the existing transmission system. Two 500-kV lines run south about 38 km (24 mi) and then split with one line going west about 109 km (68 mi) and the other line going east about 107 km (67 mi). The other two transmission lines are 161-kV lines routed toward the vicinity of Russellville, about 24 km (15 mi) east, and Morrilton, about 72 km (45 mi) east southeast. The Entergy ER indicates that these lines, which were energized in 1971, are shorter than the lengths listed in the FES. The lengths of the 500-kV lines are listed as about 38 km (24 mi), and the 161-kV lines routed toward the vicinity of Russellville and Morrilton are listed as 19 km (12 mi) and 61 km (38 mi), respectively. The FES discussed an additional 500-kV line routed toward the vicinity of Little Rock for ANO-2. This line is not addressed in the ER (Entergy 2000a).

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to the ANO-1 transmission lines are listed in Table 4-3. Entergy stated in its ER (Entergy 2000a) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of those issues, the GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of these issues follows:

- Power line right-of-way management (cutting and herbicide application): Based on information in the GEIS, the Commission found: "The impacts of right-of-way maintenance on wildlife are expected to be of small significance at all sites." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the scoping process, its review of public comments, consultation with the U.S. Fish and Wildlife Service (FWS)(FWS 2000), or its evaluation of other available information. During the staff site visit, the staff observed several instances of erosion on moderate grades beneath the 500-kV power line. However, these were not sufficiently extensive to alter the conclusions in the GEIS. Therefore, the staff concludes that there are no impacts of power line right-of-way management during the renewal term beyond those discussed in the GEIS.

Table 4-3. Category 1 Issues Applicable to the ANO-1 Transmission Lines During the Renewal Term

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
TERRESTRIAL RESOURCES	
Power line right-of-way management (cutting and herbicide application)	4.5.6.1
Bird collisions with power lines	4.5.6.2
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3
Floodplains and wetland on power line right-of-way	4.5.7
AIR QUALITY	
Air quality effects of transmission lines	4.5.2
LAND USE	
Onsite land use	4.5.3
Power line right-of-way	4.5.3

- Bird collisions with power lines: Based on information in the GEIS, the Commission found: "Impacts [of bird collisions with power lines] are expected to be of small significance at all sites." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of bird collisions with power lines during the renewal term beyond those discussed in the GEIS.

- Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock): Based on information in the GEIS, the Commission found: "No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of electromagnetic fields on flora and fauna during the renewal term beyond those discussed in the GEIS.

- Floodplains and wetland on power line right-of-way: Based on information in the GEIS, the Commission found: "Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, consultation with the FWS, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts on floodplains and wetland on the power line right-of-way during the renewal term beyond those discussed in the GEIS.

- Air quality effects of transmission lines: Based on information in the GEIS, the Commission found: "Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no air quality impacts of transmission lines during the renewal term beyond those discussed in the GEIS.

- Onsite land use: Based on information in the GEIS, the Commission found: "Projected onsite land use changes required during ... the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no onsite land-use impacts during the renewal term beyond those discussed in the GEIS.

- Power line right-of-way (land use): Based on information in the GEIS, the Commission found: "Ongoing use of power line rights of way would continue with no change in restrictions. The effects of these restrictions are of small significance." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of restriction on use of power line rights-of-way during the renewal term beyond those discussed in the GEIS.

There is one Category 2 issue related to transmission lines, and another issue related to transmission lines is being treated as a Category 2 issue. These issues are listed in Table 4-4. They are discussed in Sections 4.2.1 and 4.2.2.

Table 4-4. Category 2 Issues Applicable to the ANO-1 Transmission Lines

During the Renewal Term

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
HUMAN HEALTH			
Electromagnetic fields, acute effects (electric shock)	4.5.4.1	H	4.2.1
Electromagnetic fields, chronic effects	4.5.4.2	NA	4.2.2

- **Electromagnetic Fields - Acute Effects**

In the GEIS, the Commission found that without a review of the conformance of each nuclear plant transmission line with National Electric Safety Code (NESC) criteria (NESC 1997), it is not possible to determine the significance of the electric shock potential. Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For the other plants, some may have chosen to upgrade line voltage, or land use in the vicinity of transmission lines may have been changed. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the potential shock hazard if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of NESC for preventing electric shock from induced currents.

As noted in the ER (Entergy 2000a), the 161-kV and 500-kV transmission lines were constructed to the standards of NESC, 6th edition, published in November 1961. According to the ER, there have been no upgrades in line voltage on these transmission lines since they were constructed. Entergy further states that the 500-kV transmission lines meet the 1997 NESC clearance requirements and that the voltage to ground for the 161-kV lines falls below the threshold for the NESC requirement related to potential shock hazard.

Entergy (2000) states that the vertical clearances of the 161-kV transmission lines were designed to be 7.8 m (26 ft) at 49°C (120°F). The loadings on these lines have increased since installation such that increased conductor sag at maximum operating temperatures could decrease clearance to less than 6.4 m (21 ft), the 1997 NESC clearance requirement, during certain limited transmission line outages. However, even though no known incidents of electric shock have been reported since the lines were put into service, Entergy upgraded the 161 kV-lines during 2000 to meet the threshold for the 1997 NESC clearance requirements.

The 1961 NESC did not address the shock hazard associated with a person contacting a large vehicle parked under a transmission line. The ER (Entergy 2000a) includes the results of an analysis of this potential for the 500-kV transmission lines for major road crossings. These results indicate that the maximum steady-state current for a large tractor-trailer rig would exceed the 1997 NESC limit of 5 mA at three of the crossings, with a highest current of 5.5 mA. However, Entergy states that mitigation is not warranted because (1) it is unlikely that a large truck would park in perfect position beneath the 500-kV transmission lines at one of the nine major road crossings, (2) the actual current would be significantly less than 5 mA because the truck would not be perfectly insulated and the person would not be perfectly grounded, and (3) the NESC does not require modification of existing facilities to comply with revisions to the code. Entergy also calculated the steady-state current for a school bus parked below a conductor with a 10.7-m (35-ft) clearance, which is the minimum off-road clearance for the 500-kV transmission lines. The current was less than 4 mA.

Entergy states that the transmission lines that connect ANO-1 to the ANO switchyard meet the vertical clearance and electric shock requirements of NESC (1997).

Based on the above, the staff concludes that the impact of the potential for electrical shock is SMALL, and mitigation is not warranted.

- **Electromagnetic Fields - Chronic Effects**

In the GEIS, the chronic effects of electromagnetic fields from power lines were given a finding of “not applicable” rather than a Category 1 or 2 designation until a scientific consensus is reached on the health implications of these fields.

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy. A recent report (NIEHS 1999) includes the following paragraph:

> The NIEHS concludes that ELF-EMF (extremely low frequency-electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the staff to change its position with respect to the chronic effects of electromagnetic fields. The staff considers the GEIS finding of "not applicable" still appropriate and will continue to follow developments on this issue.

4.3 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to ANO-1 with regard to radiological impacts are listed in Table 4-5. Entergy stated in its ER (Entergy 2000a) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of those issues, the GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of these issues follows:

- Radiation exposures to public (license renewal term): Based on information in the GEIS, the Commission found: "Radiation doses to the public will continue at current levels associated with normal operations." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of radiation exposures to the public during the renewal term beyond those discussed in the GEIS.

Table 4-5. Category 1 Issues Applicable to Radiological Impacts of Normal Operations During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
HUMAN HEALTH	
Radiation exposures to public (license renewal term)	4.6.2
Occupational radiation exposures (license renewal term)	4.6.3

- Occupational radiation exposures (license renewal term): Based on information in the GEIS, the Commission found: "Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of occupational radiation exposures during the renewal term beyond those discussed in the GEIS.

4.4 Socioeconomic Impacts of Plant Operations During the License Renewal Period

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to socioeconomic impacts during the renewal term are listed in Table 4-6. Entergy stated in its ER (Entergy 2000a) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of those issues, the GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-6. Category 1 Issues Applicable to Socioeconomics During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SOCIOECONOMICS	
Public services: public safety, social services, and tourism and recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6
Public services: education (license renewal term)	4.7.3.1
Aesthetic impacts (license renewal term)	4.7.6
Aesthetic impacts of transmission lines (license renewal term)	4.5.8

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of these issues follows:

- Public services–public safety, social services, and tourism and recreation: Based on information in the GEIS, the Commission found: "Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites." The staff has not identified any significant new information during its independent review of the Entergy ER, the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts on public safety, social services, or tourism and recreation during the renewal term beyond those discussed in the GEIS.

- Public services–education (license renewal term): Based on information in the GEIS, the Commission found: "Only impacts of small significance are expected." The staff has not identified any significant new information during its independent review of the Entergy ER, the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts on education during the renewal term beyond those discussed in the GEIS.

- Aesthetic impacts (license renewal term): Based on information in the GEIS, the Commission found: "No significant impacts are expected during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER, the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no aesthetic impacts during the renewal term beyond those discussed in the GEIS.

- Aesthetic impacts of transmission lines (license renewal term): Based on information in the GEIS, the Commission found: "No significant impacts are expected during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER, the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no aesthetic impacts of transmission lines during the renewal term beyond those discussed in the GEIS.

Table 4-7 lists the Category 2 socioeconomic and environmental justice issues, which require plant-specific analysis. These were not addressed in the GEIS.

Table 4-7. Category 2 Issues Applicable to Socioeconomics and Environmental Justice During the Renewal Term

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
SOCIOECONOMICS			
Housing impacts	4.7.1	I	4.4.1
Public services: public utilities	4.7.3.5	I	4.4.2
Offsite land use (license renewal term)	4.7.4	I	4.4.3
Public services, transportation	4.7.3.2	J	4.4.4
Historic and archaeological resources	4.7.7	K	4.4.5
ENVIRONMENTAL JUSTICE			
Environmental justice	Not addressed		4.4.6

- **Housing Impacts During Operations**

In determining housing impacts, the applicant chose to follow Appendix C of the GEIS (NRC 1996a), which presents a population characterization method that is based on two factors, "sparseness" and "proximity" (GEIS, Appendix C, Section C.1.4). Sparseness measures population density within 32 km (20 mi) of the site, and proximity measures population density and city size within 80.5 km (50 mi). Each factor has categories of density and size (GEIS, Appendix C, Table C.1), and a matrix is used to rank the population category as "low," "medium," or "high" (GEIS, Appendix C, Figure C.1). ANO was selected by the NRC to be evaluated as a potential socioeconomic case study site. The results of this evaluation, published in the GEIS, classify the current ANO population as "low" (GEIS, Appendix C, Table C.2).

As described in Section 2.2.8, the Pope, Johnson, and Yell County areas around ANO are not subject to growth-control measures that effectively limit housing. In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, the NRC concluded that impacts on housing availability may be of MODERATE or LARGE significance at plants located in a "low" population area where growth control measures are in effect. ANO is located in a low population area; however, growth control measures are not in effect and Entergy has not identified any increases in staffing related to license renewal-related programs.

SMALL impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion is required to meet new demand. Although the ANO case study in the GEIS, Appendix C, assumed an additional staff of 60 permanent workers might be needed during the license renewal period, Entergy indicates in the ANO-1 ER that they "have not identified any increases in staffing related to license renewal-related programs." On the basis of the information obtained during its interviews with real estate professionals in the Russellville area and the information described in Section 2.2.8, the staff concludes that the impacts on housing during the license renewal period are SMALL, and mitigation is not warranted.

- **Public Services: Public Utility Impacts During Operations**

Impacts on public utility services are considered SMALL if there is little or no change in the capability of the system to respond to the level of demand and, thus, there is no need to add capital facilities. Impacts are considered MODERATE if overtaxing of service capabilities occurs during periods of peak demand. Impacts are considered LARGE if existing levels of service (e.g., water or sewer services) are substantially degraded, and additional capacity is needed to meet ongoing demands for services. The GEIS indicates that, absent new significant information to the contrary, the only impacts on public utilities that could be significant are impacts on public water supplies. Any increases in public water supply systems would not be warranted as a result of the impact of additional ANO-1 workers because no need for additional workers has been identified.

Analysis of impacts to the public water supply system considered both plant demand and plant-related population growth. Section 2.2.2 describes the plant's permitted withdrawal rate and the plant's actual use of water. The applicant does not expect plant demand to have a direct effect on water resources.

The water supply systems servicing the towns surrounding ANO-1, as described in Section 2.2.8, are adequate and reliable. To meet future needs, the City of Russellville is planning on doubling the current water treatment processing capacity of 0.4 m^3/s (10 million gpd). Because no increase in population is expected as a result from the renewal of the ANO-1 operating license, the staff concludes that the impact on water supply is SMALL, and mitigation is not warranted.

- **Offsite Land Use During Operations**

Land use in the vicinity of a nuclear power plant may change as a result of plant-related population growth. Offsite land use during the license renewal term is a Category 2 issue (10 CFR Part 51, Subpart A, Appendix B, Table B-1). Table B-1 of 10 CFR Part 51 Subpart A,

Appendix B, notes that “significant changes in land use may be associated with population and tax revenue changes resulting from license renewal.” Entergy has not identified any increases in plant staffing related to the license renewal application; consequently, there are no corresponding increases in direct or indirect workers in Pope County.

Section 4.7.4 of the GEIS (NRC 1996a) defines the magnitude of land use changes during the license renewal term as follows:

- SMALL, where there is very little new development and minimal changes to the area’s land-use pattern.
- MODERATE, where there is considerable new development and some changes to land-use patterns.
- LARGE, where there is large-scale new development and major changes to land-use patterns.

Section 4.7.4.1 of the GEIS (NRC 1996a) states that the assessment of tax-driven land-use impacts during the license renewal term should consider (1) the size of the plant's payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) the extent to which the community already has public services in place to support and guide development. If the plant's tax payments are projected to be small relative to the community's total revenue, new tax-driven land-use changes by the plant during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development. If the plant's tax payments are projected to be medium-to-large relative to the community's total revenue, new tax-driven land-use changes would be MODERATE. This is most likely to be true where the community has no pre-established patterns of development (i.e., land-use plans or controls) or has not provided adequate public services to support and guide development in the past, especially infrastructure that would allow industrial development. If the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development in the past.

Pope County is the only jurisdiction that taxes ANO directly, and it is the principal jurisdiction that receives direct tax revenue as a result of ANO’s presence. Because there are no major refurbishment activities and no new construction as a result of the license renewal, no new sources of plant-related tax payments are expected that could significantly influence land use in Pope County. During the license renewal term, however, new land-use impacts could result from the use by local governments of the tax revenue paid by Entergy for ANO-1. As discussed

in Section 2.2.8 of this report, Entergy paid Pope County $8.66 million in utility and property taxes for ANO-1 and ANO-2 in 1999. This amount represented 34.4 percent of the Pope County tax revenue.

Residential development is expected to continue around Lake Dardanelle because of the availability of desirable lakefront property. Pope County has experienced moderate population growth and moderate land-use changes in the last 10 years. Although recent population growth is not directly related to the presence of ANO, future lakefront development would be facilitated by the presence of roads and water service, which are an indirect impact of the ANO site. Continuation of Pope County's tax receipts from ANO keeps tax rates below what they otherwise would have to be to fund the county government and also provides for a higher level of public infrastructure and services than otherwise would be possible. This enhances the county's attractiveness as a place to live and may tend to accelerate the conversion of open space to residential and commercial uses.

The ANO plant site was one of the case studies examined in the GEIS (NRC 1996a). Section C.4.1.5.2 of the GEIS concluded that the indirect land-use impacts associated with the license renewal term are expected to be MODERATE. The GEIS case study, however, assumed a certain level of refurbishment activity. Entergy stated that it will not conduct any refurbishment activities for ANO-1. Therefore, there are no land use changes planned during the renewal period, and the staff concludes that the land-use impact will be SMALL. Additional mitigation for land-use impacts during the license renewal term does not appear to be warranted.

- **Public Services: Transportation Impacts During Operations**

On October 4, 1999, 10 CFR 51.53(c)(3)(ii)(J) and 10 CFR Part 51, Subpart A, Appendix B, Table B-1, were revised to clearly state that "Public Services: Transportation Impacts During Operations" is a Category 2 issue (see NRC 1999b for more discussion of this clarification). This issue is treated as such in this Supplemental Environmental Impact Statement (SEIS).

Moderate population growth is expected in all three counties in the study area by 2034, as was discussed in Section 2.2.8 of this report. However, none of this expected growth will be due directly to increases in employment at ANO. It may be argued that the industrial tax base afforded by ANO makes the county a more affordable and pleasant place to live and indirectly increases population, but even this indirect impact is likely to be fairly small and difficult to predict. Future general population increases likely will increase highway congestion at specific locations, but the magnitude of impact of ANO-1 on this service degradation is likely to be SMALL and will not require mitigation.

- **Historic and Archaeological Resources**

Because the Entergy license renewal application (Entergy 2000a) covering an additional 20 years of operation of ANO-1 does not include plans for future land disturbances or structural modifications beyond routine maintenance activities at the plant, there would be no identifiable adverse effects to known historic and archaeological resources.

During the site visit, the staff became aware of the following information and activities at the ANO site, unrelated to license renewal, that may have jeopardized potentially significant cultural resources.

- Entergy reported that archaeological site 3PP66 was potentially damaged during construction, in the early 1990s, of the Entergy office building (NRC 2000a). However, the location of site 3PP66, as plotted by the 1969 archaeological survey, appears to be somewhat south of the building location, closer to the edge of Lake Dardanelle. The original plotting of the archaeological site's location was also just outside of the ANO property line boundary.

- The 1969 archaeological survey of the ANO site did not identify at least 35 Historic-era Euroamerican properties. To date, these properties have not been recorded or evaluated for their inclusion on the National Register of Historic Places.

- It appears that archaeological sites 3PP63 and 3PP65, as well as at least 15 undocumented potential Historic-era sites, have recently been impacted by ground disturbances unrelated to NRC-licensed activities at the ANO site. These activities include tree-thinning, clear cutting, plowing, and replanting of trees across portions of the ANO property.

The staff initiated discussions with the Arkansas State Historic Preservation Officer (SHPO), and notified it of the results of the site visit (NRC 2000b). In addition, the Tribal Historic Preservation Officer for the Caddo Tribe of Oklahoma expressed concern that the area in which ANO is located has the potential to produce important historic properties that could be associated with the Tribe. His concerns were forwarded to the Arkansas SHPO (NRC 2000b). In a letter dated September 21, 2000, Entergy committed to continue to work with the SHPO in order to identify additional sites that should be included with those that currently require an evaluation for land disturbances (Entergy 2000b). In a letter dated February 2, 2001, Entergy stated that it has implemented an administrative-level environmental procedure to provide additional control over future land disturbances at the ANO site (Entergy 2000c).

As discussed in Section 2.2.9.1, the water route of the 1838 Trail of Tears National Historic Trail near the plant has been inundated by earlier development of the McClellan-Kerr Navigation System, Lake Dardanelle in this case. Bell's Route of the Trail of Tears passes in the vicinity (within 0.9 km [0.5 mi]) of the ANO northern property boundary, close to the paths occupied today by U.S. Highway 64 and the Union Pacific Railroad. Based on separation

distance from the ANO site, the staff concludes that the potential for impacts to the adjacent elements of the Trail from continued operation of ANO-1 is SMALL.

Entergy indicated in its application for license renewal that it has performed an evaluation of structures and components pursuant to 10 CFR 54.21 to identify activities that are necessary to continue operation of ANO-1 during the requested 20-year period of extended operation. These activities include replacement of certain components as well as new inspection activities (Entergy 2000a). However, Entergy stated that the replacements of these components and the additional inspection activities are within the bounds of normal plant component replacement and inspections; therefore, they are not expected to affect the environment outside the bounds of plant operations as evaluated in the FES (AEC 1973). In addition, Entergy's evaluation of structures and components did not identify any major plant refurbishment activities beyond the period for which the existing operating license was issued. Had Entergy anticipated the need for refurbishment activities and, if such refurbishment activities would have adverse effects on historic properties, then it would be expected that Entergy would seek ways to avoid or reduce the effects on such properties.

Additional care should be taken during normal operational or maintenance conditions to ensure that potential historic properties are not inadvertently impacted. These activities may include not only operation of the plant itself, but also land management-related actions such as recreation, wildlife habitat enhancement, or maintaining/upgrading access roads throughout the plant site. Based on the finding that Entergy did not identify any major refurbishment activities related to the renewal of the ANO-1 operating license and that operations will continue within the bounds of plant operations as evaluated in the FES (AEC 1973), and the steps taken by Entergy to preclude adverse impacts to cultural resources in the future, it is the staff's conclusion that the potential impacts on historic and archeological resources are expected to be SMALL, and mitigation is not warranted.

- **Environmental Justice**

Environmental justice refers to a Federal policy in which Federal actions should not result in disproportionately high and adverse impacts on minority or low-income populations. A minority population is defined to exist if the percentage of minorities individually or in combination within the census blocks near the site exceeds the corresponding percentage of minorities in the entire State of Arkansas by 20 percentage points, or if the corresponding percentage of minorities within the census block is at least 50 percent. Executive Order 12898 (59 FR 7629) directs Federal executive agencies to consider environmental justice under the National Environmental Policy Act of 1969 (NEPA), and the Council on Environmental Quality has provided guidance for addressing environmental justice under NEPA (CEQ 1997). Although it is not subject to the Executive Order, the Commission has voluntarily committed to undertake environmental justice reviews. Specific guidance is provided in Attachment 4 to Nuclear

Reactor Regulation (NRR) Office Letter No. 906, Revision 2: "Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues" (NRC 1999a).

The scope of the review as defined in NRR Office Letter No. 906, Revision 2, should include an analysis of impacts on minority or low-income populations, the location and significance of any environmental impacts during operations on populations that are particularly sensitive, and any additional information pertaining to mitigation. The descriptions to be provided by this review should be of sufficient detail to permit subsequent staff assessment of whether these impacts are likely to be disproportionately high and adverse and to evaluate the significance of such impacts.

Air, land, and water resources within about 80 km (50 mi) of ANO were examined. Within that area, a few potential environmental impacts could affect human populations; all of these were considered SMALL. These include

- groundwater use conflicts
- electric shock
- microbial organisms
- postulated accidents
- surface water use conflicts.

To decide whether any of these impacts could be disproportionate, the staff examined the geographic distribution of minority and low-income populations within 80 km (50 mi) of the site that was recorded during the 1990 Census (USCB 1991) and supplemented by field inquiries to the local planning departments and social service agencies in Pope County.

In general, minority populations are small and dispersed in the study area's population. Figure 4-1, taken from the 1990 Census (USCB 1991), shows the geographic distribution of minority populations within the 80-km (50-mi) radius of the plant. Minority populations are located primarily in the surrounding towns of Russellville, Clarksville, Conway, and in the outskirts of Morrilton in Conway County. An additional census block group (0311-1) shows a significant concentration of minority individuals northwest of Little Rock. Figure 4-1 indicates that outside of the town centers, minority populations in general are either relatively well-mixed into the majority population, or concentrations of minority individuals are too small to be identified in the census detail. This is consistent with the results of field interviews. Several

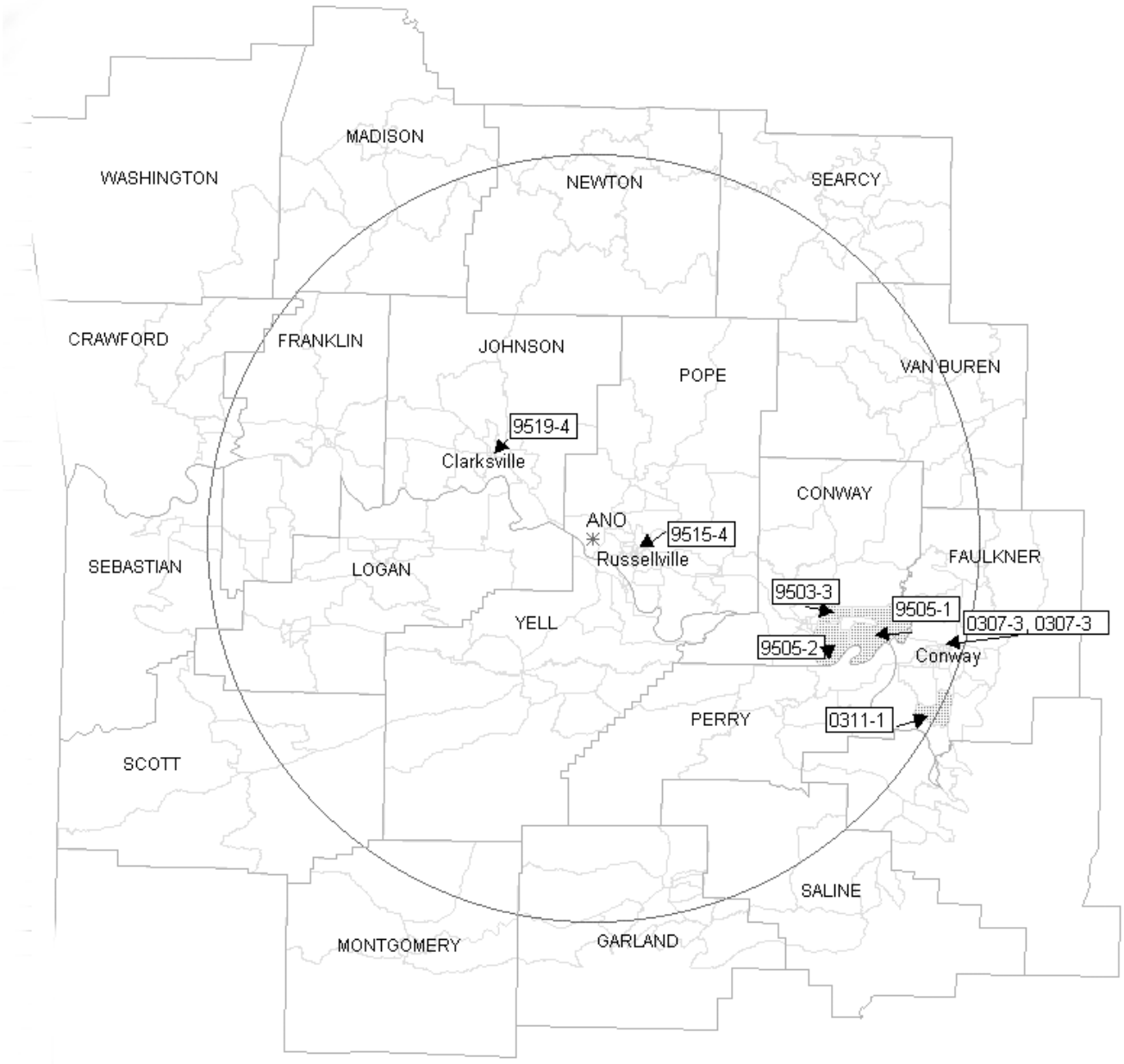

Figure 4-1. Geographic Distribution of Minority Populations (shown in shaded areas) Within 80 km (50 mi) of ANO

people affiliated with social services in Pope County indicated that the Hispanic population has increased significantly in recent years, particularly at Dardanelle and in rural areas surrounding Russellville and Morrilton that have large poultry farms.

Figure 4-2, also taken from the 1990 Census (USCB 1991) shows the geographic distribution of low-income populations within the 80-km (50-mi) radius of the plant. The cross-hatched census blocks show areas where the percentage of households below the poverty level is 20 percentage points or more greater than the percentage of households below the poverty level in the entire State of Arkansas for those census blocks within the State of Arkansas. The largest concentrations of low-income populations within the 80-km (50-mi) radius are located in Russellville and to the west of Morrilton in Conway County. Some small groups are scattered throughout the rural areas of Pope, Newton, and Van Buren Counties, although none is within 16 km (10 mi) of ANO.

Examination of the various environmental pathways by which minority or low-income populations could be disproportionately affected reveals no unusual resource dependencies or practices through which these populations could be disproportionately affected. Specifically, no pathways were found through which subsistence agriculture or fishing was significantly affected. In general, the prevailing atmospheric transport direction from the ANO site is toward the west, thus missing most of the census blocks showing minority and low-income populations. Therefore, the impact is SMALL, and no mitigation actions are warranted.

4.5 Groundwater Use and Quality

A Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, is applicable to ANO-1 groundwater use and quality and is listed in Table 4-8. Entergy stated in its ER (Entergy 2000) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review.

Therefore, the staff concludes that there are no impacts related to this issue beyond those discussed in the GEIS. For this issue, the GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, follows:

- Groundwater use conflicts (potable and service water; plants that use less than 0.068 m^3/s [100 gpm]): Based on information in the GEIS, the Commission found: "Plants using less than 100 gpm are not expected to cause any groundwater use conflicts." ANO-1 does not

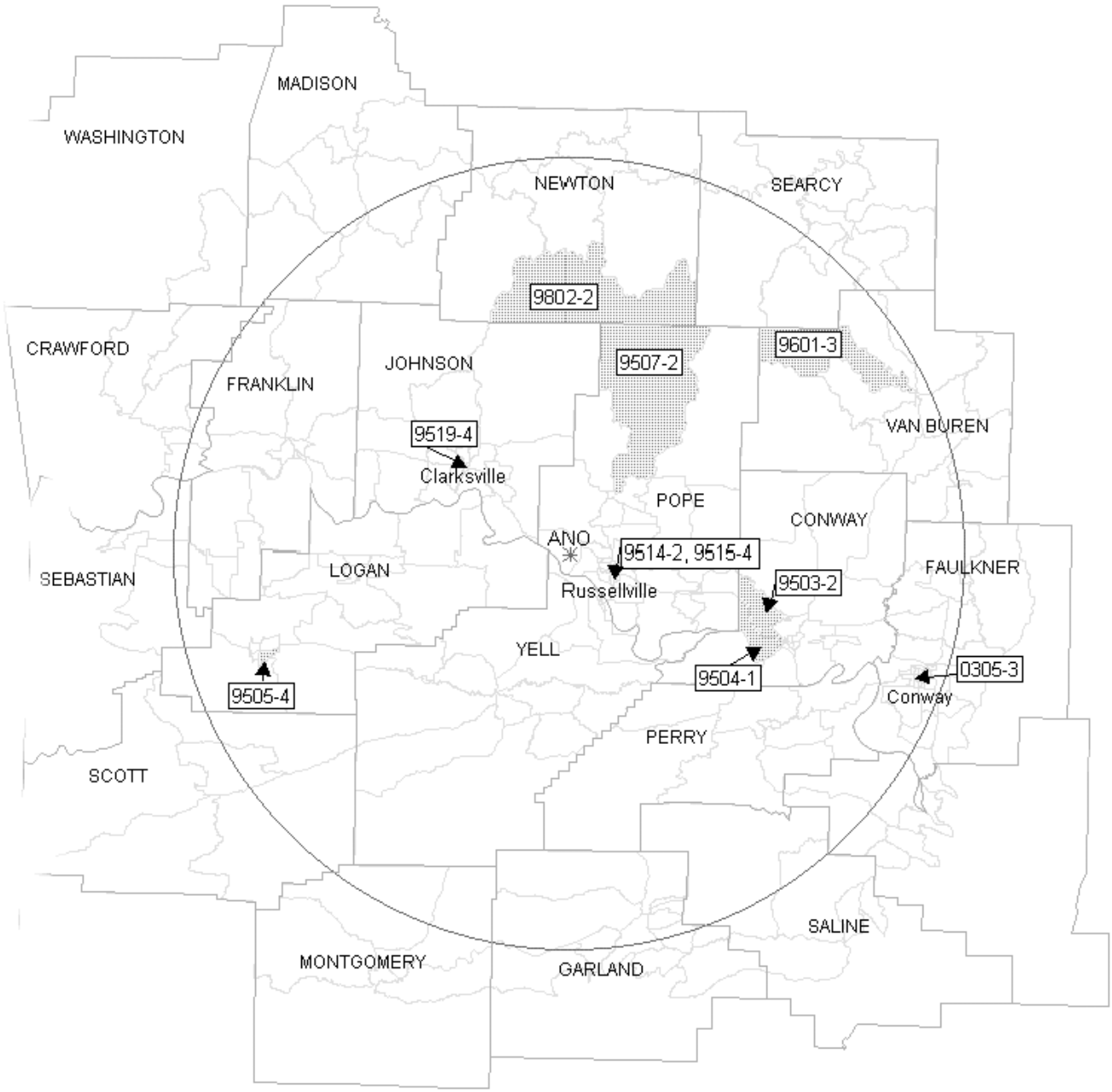

Figure 4-2. Geographic Distribution of Low-Income Populations (shown in shaded areas) Within 80 km (50 mi) of ANO

Table 4-8. Category 1 Issue Applicable to Groundwater Use and Quality During the Renewal Term

ISSUE -- 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
GROUNDWATER USE AND QUALITY	
Groundwater use conflicts (potable and service water; plants that use less than 100 gpm [0.068 m^3/s]).	4.8.1.1

use groundwater. The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no groundwater use conflicts during the renewal term.

There are no Category 2 issues related to groundwater use and quality.

4.6 Threatened or Endangered Species

Threatened or endangered species is listed as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The issue is listed in Table 4-9.

The applicant contacted the Arkansas Natural Heritage Commission regarding the presence of state-listed species at the ANO site and along the transmission rights-of-way. No species listed by Arkansas were identified in the area (ANHC 1999).

Table 4-9. Category 2 Issue Applicable to Threatened or Endangered Species During the Renewal Term

ISSUE – 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
THREATENED OR ENDANGERED SPECIES (FOR ALL PLANTS)			
Threatened or endangered species	4.1	E	4.6

Informal consultation with the FWS was initiated on June 13, 2000, under Section 7 of the Endangered Species Act of 1973 regarding the presence of Federally protected species within the ANO site and the four transmission line rights-of-way. Based on its analysis, the FWS concluded that no listed species, candidates for listing, or protected habitats are known to occur in the project area (FWS 2000). No refurbishment is planned; therefore, no impacts to habitats are expected. However, there are species located in the vicinity of the project area:

The gray bat (*Myotis grisescens*) is listed as endangered by the FWS. It is known to occur downstream of ANO, where it resides in caves upstream of the Dardanelle Lock and Dam. However, these caves are 16 km (10 mi) from the ANO facility and 3.2 km (2 mi) from the transmission line rights-of-way and, therefore, continued operation of the facility and the transmission lines will not adversely affect this species.

The interior least tern (*Sterna antillarum*) is listed as endangered by the FWS. It breeds on sandbars in the Arkansas River near Atkins and Clarksville, Arkansas. These nesting locations are beyond a 16-km (10-mi) radius from the ANO facility and the transmission line rights-of-way. Relicensing will not involve changes in water levels of Lake Dardanelle, nor will any nesting habitat be otherwise directly or indirectly disturbed by power plant operations or transmission line rights-of-way maintenance. Because no refurbishment is planned for license renewal, no adverse effects on interior least terns are expected.

The staff has completed consultation with the FWS relative to potential impacts to listed and proposed threatened or endangered species or critical habitats from operations during the renewal term and has analyzed operations under relicensing for impacts to listed species in the ANO area. Based on this consultation and analysis, the staff concludes that the impact is SMALL, and mitigation is not needed.

4.7 Evaluation of Potential New and Significant Information on Impacts of Operations During the Renewal Term

The staff has not identified significant new information on environmental issues listed in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, related to operation during the renewal term. The staff has reviewed the discussion of environmental impacts associated with operation during the renewal term in the GEIS and the licensee's program for determining new and significant information and has conducted its own independent review, including the public scoping meetings, to identify issues with significant new information. Processes for identification and evaluation of new information are described in Section 1.0 under "License Renewal Evaluation Process."

4.8 Summary of Impacts of Operations During the Renewal Term

Neither Entergy nor the staff is aware of significant new information related to any of the applicable Category 1 issues associated with the ANO-1 operation during the renewal term. Consequently, the staff concludes that the environmental impacts associated with these issues are bounded by the impacts described in the GEIS. For each of these issues, the GEIS concluded that the impacts would be SMALL and that "plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation."

Plant-specific environmental evaluations were conducted for 12 Category 2 issues applicable to ANO-1 operation during the renewal term and for environmental justice. For all 12 issues and environmental justice, the staff concluded that the potential environmental impact of renewal term operations of ANO-1 would be of SMALL significance in the context of the standards set forth in the GEIS and that mitigation would not be warranted.

In addition, the staff determined that a consensus has not been reached by appropriate Federal health agencies that there are adverse effects from electromagnetic fields. Therefore, no evaluation of this issue is required.

4.9 References

10 CFR 51.53, "Postconstruction environmental reports."

10 CFR Part 51, Subpart A, Appendix B, Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants."

10 CFR 54.21, "Contents of application – technical information."

59 FR 7629-7633. 1994. Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority and Low-Income Populations." Washington, D.C.

Arkansas Game and Fish Commission (AGFC). 1995. Letter from A. Carter Chief Fisheries Division to Jerry Yelverton, Vice President, Entergy Operations, Inc. March 8, 1995.

Arkansas Natural Heritage Commission (ANHC). 1999. Letter ANHC No.: P-CF-99-079, Cindy Osborne (ANHC) to Dr. Gary Tucker (FTN Associates, Ltd.), September 29, 1999.

Arkansas Power and Light Company (APLC). 1982. *Summary of Entrainment at Arkansas Nuclear One from 1977 through 1982*, Little Rock, Arkansas.

Arkansas Power and Light Company (APLC). 1984. *Summary Report of Environmental Impact of Thermal Discharge.* October 30, 1984. Little Rock, Arkansas.

Arkansas Power and Light Company (APLC). 1985. *Appendix to Summary Report of Environment Impact of Thermal Discharge*. May 6, 1985.

Arkansas Power and Light Company (APLC). 1987. *Summary of Entrainment at Arkansas Nuclear One from 1982 through 1987*, Little Rock, Arkansas.

Chance, C.J. and M. Miller. 1952. Fish sampling with Rotenone in TVA reservoirs. *J. Tenn. Acad. Sci*. **27**:214-222.

Council on Environmental Quality (CEQ). 1997. *Environmental Justice: Guidance Under the National Environmental Policy Act*. Council on Environmental Quality, Executive Office of the President, Washington, D.C.

Endangered Species Act of 1973, as amended, 16 USC 1531 et seq.

Entergy Operations, Inc. 2000a. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

Entergy Operations, Inc. 2000b. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, to U.S. Nuclear Regulatory Commission. Subject: Arkansas Nuclear One, Unit 1, Environmental Report RAIs (TAC No. MA8054). Dated September 21, 2000.

Entergy Operations, Inc. 2000c. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, to U.S. Nuclear Regulatory Commission. Subject: Arkansas Nuclear One, Unit 1, Additional SEIS Comments (TAC No. MA8055). Dated February 2, 2001.

National Electrical Safety Code (NESC). 1997. Institute of Electrical and Electric Engineers, Inc., New York.

National Environmental Policy Act of 1969, as amended, 42 USC 4321 et seq.

National Institute of Environmental Health Sciences (NIEHS). 1999. *NIESH Report on Health Effects from Exposure to Power Line Frequency and Electric and Magnetic Fields*. NIH Publication No. 99-4493, National Institutes of Health, Research Triangle Park, North Carolina.

Rickett, J.D. 1982. *Dardanelle Reservoir - Illinois Bayou Embayment Survey*, University of Arkansas Little Rock, Department of Biology, Little Rock, Arkansas.

Strawn, K. 1965. "Resistance of threadfin shad to low temperatures." *Proc. Annu. Conf. Southeast Assoc. Game and Fish Comm.* **17**:290-293

Texas Instruments, Inc. 1976. Evaluation of potential impact of impingement on fishing resources and dissolved oxygen Dardanelle Reservoir. Annual Report prepared for Arkansas Power and Light Company, Russellville, Arkansas.

U.S. Atomic Energy Commission (AEC). 1973. *Final Environmental Statement Related to the Arkansas Nuclear One Unit 1*, Arkansas Power & Light Company, Docket No. 50-313, Directorate of Licensing.

U.S. Bureau of the Census (USCB). 1991. 1990 Census-Population and Housing; Public Law 94-171 Data, Bureau of the Census. Washington, D.C.

U.S. Fish and Wildlife Service (FWS). 2000. Letter, Allan J. Mueller (USFWS) to Dr. Charles Brandt (PNNL), June 30, 2000.

U.S. Nuclear Regulatory Commission (NRC). 1979. *Impingement Dynamics and Age and Growth of Selected Species at Lake Dardanelle, a South Central Reservoir*, NUREG-0601, Office of Nuclear Reactor Regulation. Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 1999a. Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues, Attachment 4 to NRR Office Letter No. 906, Revision 2. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999b. 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, NUREG-1437, Volume 1, Addendum 1. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2000a. *Summary of Site Audit to Support Review of License Renewal Application of Arkansas Nuclear One Unit 1.* Dated May 1, 2000. Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2000b. Letter from Cynthia A. Carpenter (NRC) to Cathy Buford Slates (Arkansas State Historic Preservation Officer). Dated August 10, 2000.

5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents were discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996, 1999a).[(1)] The GEIS included 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 were 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 of Category 1, and, therefore, additional plant-specific review for these issues is required.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

A Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, related to postulated accidents that is applicable to Arkansas Nuclear One, Unit 1 (ANO-1) is listed in Table 5-1. Entergy Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2000a) that it is not aware of any new and significant information associated with the renewal of the ANO-1

(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 5-1. Category 1 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE--10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
Postulated Accidents	
Design-Basis Accidents (DBAs)	5.3.2; 5.5.1

operating license. No significant new information has been identified during the staff's review. Therefore, the staff concludes that there are no impacts related to this issue beyond those discussed in the GEIS. For this issue, the GEIS concluded that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, follows.

Design-Basis Accidents (DBAs): Based on information in the GEIS, the Commission found: "The NRC staff has concluded that the environmental impacts of design basis accidents are of small significance for all plants." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of DBAs beyond those discussed in the GEIS.

A Category 2 issue related to postulated accidents that is applicable to ANO-1 is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE–10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
Postulated Accidents			
Severe Accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	L	5.2

Severe Accidents: Based on information in the GEIS, the Commission found:

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

The staff has not identified any significant new information with regard to the consequences from severe accidents during its independent review of the Entergy ER (Entergy 2000a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMAs) for ANO-1. The results of its review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives (SAMAs)

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for ANO-1; therefore, the following addresses those alternatives.

- **Introduction**

Entergy submitted an assessment of SAMAs for ANO-1 as part of the ER (Entergy 2000a). This assessment was based on the ANO-1 Probabilistic Safety Assessment (PSA) for core damage frequency estimation and containment performance, and a supplemental analysis of offsite consequences and economic impacts for risk determination. While identifying and evaluating potential SAMAs, Entergy took into consideration the insights and recommendations from the ANO-1 plant-specific risk study, several recent SAMA analyses for other plants, and other U.S. Nuclear Regulatory Commission (NRC) and industry documents discussing potential plant improvements. Entergy considered 169 SAMAs and concluded that only one SAMA involving increased emphasis on timely recirculation swap-over in operator training would be cost-beneficial. However, Entergy further evaluated this SAMA from a training perspective and concluded that this operator action was already adequately addressed in the operations training cycle.

Based on a review of the SAMA assessment, the NRC issued a request for additional information (RAI) to Entergy by letter dated April 12, 2000 (NRC 2000). Key questions concerned the process used by the license renewal applicant to identify potential SAMAs, the exclusion of external events in the risk profile, the determination of the offsite risks, and the inclusion of the proper elements of averted onsite costs in Entergy's value impact analysis. Entergy submitted additional information by letters dated June 26 and July 31, 2000 (Entergy 2000b; 2000c). Additional information on the treatment of recirculation swap-over in the operations training cycle was provided by letter dated January 4, 2001 (Entergy 2001). These responses addressed the staff's concerns and reaffirmed the conclusions of the study.

An assessment of SAMAs for ANO-1 is presented below.

• Estimate of Risk for ANO-1

Entergy's estimates of offsite risk at ANO-1 are summarized below. The summary is followed by an analysis of Entergy's risk estimates.

• Entergy's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the ANO-1 PSA model, and (2) a supplemental analysis of offsite consequences and economic impacts for risk determination developed specifically for SAMA analyses. The ANO-1 PSA is an update of the ANO-1 Individual Plant Examination (IPE) (Entergy 1993), incorporating new information on equipment performance, plant configuration changes, and refinements in PSA modeling techniques. It contains a Level 1 analysis to determine the core damage frequency (CDF) from internally initiated events and a Level 2 analysis to determine containment performance during severe accidents. The total CDF for internal events is about 1.1×10^{-5} per year. A breakdown of the CDF is provided in Table 5-3.

The Level 2 model (which includes plant damage state descriptors, the containment event tree, and the source term binning and containment release categories) is essentially the same as in the original IPE submittal. However, new Level 1 sequences were binned into the existing plant damage states to update the Level 2 results. The breakdown of core damage events in terms of containment release mode is provided in Table 5-4 (second column).

The offsite consequences and economic impact analyses use the MELCOR Accident Consequence Code System 2 (MACCS2) code, Version 1.12, to determine the offsite risk impacts on the surrounding environment and public. Inputs for this analysis include plant/site-specific input values for core radionuclide inventory and release fractions, meteorological data, projected population distribution, emergency response evacuation modeling, and economic data.

Table 5-3. ANO-1 Core Damage Frequency (CDF)

Initiating Event	Frequency (per reactor year)
Transients	5.4×10^{-6} (49%)[(a)]
Loss-of-coolant accident (LOCA)	4.5×10^{-6} (42%)
Anticipated transient without scram (ATWS)	5.7×10^{-7} (5%)
Steam generator tube rupture (SGTR)	3.2×10^{-7} (3%)
Station blackout (SBO)	5.0×10^{-8} (0.5%)
Interfacing system LOCA	4.5×10^{-8} (0.4%)
Total CDF from internal events	1.1 x 10-5[(b)]

(a) Numbers in parentheses reflect the contribution to CDF for internal events.
(b) Although not included in the total CDF from internal events, the CDF associated with flooding events is $<1.0 \times 10^{-6}$

Table 5-4. Risk Profile

Containment Release Mode	Core Damage Frequency (%)	Contribution to Population Dose (%)
Containment intact	81.1	2
Late containment failure	12.2	31
Early containment failure	6.3	32
Containment bypass	0.4	35

Entergy estimates the dose to the population within 80 km (50 mi) of the ANO site from internal initiators at ANO-1 to be 0.55 person-rem per year. Table 5-4 (third column) shows the contributions to population dose by containment release mode. Although containment failures account for the majority of the containment failure/bypass frequency, containment bypass, late containment failure, and early containment failure are nearly equal contributors to risk.

- **Review of Entergy's Risk Estimates**

Entergy's estimate of offsite risk at ANO-1 is based on the ANO-1 PSA and a separate MACCS2 analysis to determine the offsite risk impacts. This review considered the following major elements:

- the Level 1 and 2 risk models that form the bases for the April 1993 IPE submittal
- the major modifications to the IPE model that have been incorporated in the ANO-1 PSA
- the MACCS2 analyses performed to translate fission product release frequencies from the Level 2 PSA model into offsite consequence measures.

Each of these analyses was reviewed to determine the acceptability of Entergy's risk estimates for the SAMA analysis, as summarized below.

The staff's review of the ANO-1 IPE is described in a staff report dated May 5, 1997 (NRC 1997a). In that review, the staff evaluated the methodology, models, data, and assumptions used to estimate the CDF and characterize containment performance and fission product releases. The staff concluded that Entergy's analysis met the intent of Generic Letter 88-20 (NRC 1988a); that is, the IPE was of adequate quality to be used to look for design or operational vulnerabilities. Although the staff reviewed certain aspects of the IPE in more detail than others, it primarily focused on the licensee's ability to examine ANO-1 for severe accident vulnerabilities and not specifically on the detailed findings or quantification estimates. Overall, the staff believed that the ANO-1 IPE was of adequate quality to be used as a tool in searching for areas with high potential for risk reduction and to assess such risk reductions, especially when the risk models are used in conjunction with insights, such as those from risk importance, sensitivity, and uncertainty analyses.

A comparison of CDF profiles between the original IPE and the current PSA indicates that the estimate of the CDF has been reduced from 4.7×10^{-5} per reactor year to about 1.1×10^{-5} per reactor year. Transients and LOCAs continue to dominate the CDF, although at lower frequencies. Also, station blackout (SBO) events, which were previously the largest contributor to the CDF, now account for less than 1 percent of the CDF. The lower values in the current PSA are attributed to plant and modeling improvements that have been implemented in ANO-1 since the IPE, as discussed below.

The ANO-1 PSA has undergone two major revisions since the IPE submittal. In 1993, the risk model was revised to reflect: (1) better modeling of the full range of LOCA sizes by splitting the IPE small LOCA sequences into small and medium LOCAs, (2) more detail in the modeling of transient-induced LOCAs (reactor coolant pump seals, safety relief valves), (3) installation of a

third totally independent black-start diesel, and (4) additional redundancy in the instrument air system. The impact of these changes was to reduce the overall CDF by being able to more accurately apply success criteria to the LOCA sequences and to credit improved availability of the alternate alternating current (ac) power and instrument air systems.

In 1998, the second revision was made to the ANO-1 PSA. This revision captured several changes to the plant and modified some assumptions made in the model. The major changes included: (1) the addition of a fourth battery charger and four inverters, (2) significant reductions in LOCA-initiating event frequencies based on NUREG/CR-5750 (NRC 1999b), (3) a revision of battery life from 2 hours to 5 hours, based on a reanalysis of battery life that included load-shedding, (4) an addition to the high-pressure injection success criterion to credit two operating pumps and two available injection lines, (5) revisions to several safety and support system models to allow operator selection of system lineups depending upon the application, (6) the inclusion of the service water system as a backup water supply for the emergency feedwater system, and (7) revision of the service water logic models with respect to the discharge paths. The overall impact of these changes was to lower the estimate of the CDF to its present value of 1.1×10^{-5} per reactor year.

Entergy submitted an Individual Plant Examination for External Events (IPEEE) by letter dated May 31, 1996 (Entergy 1996). Entergy chose not to include the results of this analysis in the estimate of CDF and the determination of potential benefits for the SAMAs. Instead, it captured the potential risk benefits associated with external events by doubling the calculated benefits for a given SAMA. In response to an RAI on this topic, Entergy stated that the doubling of the benefit to account for external events provides bounding results because some external events would result in only partial failure of systems or trains, and because the conservative nature of the assumptions used to estimate the risk reduction of each SAMA tends to overestimate the benefits of the SAMA. Additionally, Entergy stated that the major contributor from external risk is expected to come from the risk of a fire. Their review of the unscreened zones revealed that the largest CDF from a fire in a single zone was less than the CDF calculated for the internal events. Because the fire analysis was done as a screening analysis only and not as a determination of the risk value for a fire at ANO-1, the results from the fire analysis are considered to be conservative. Entergy's position is that given the conservative nature of the analysis, there is reasonable assurance that the risk associated with a fire would be bounded by increasing the benefit by a factor of two.

The staff agrees that doubling the benefit analysis results should capture the unknown external event benefits associated with the SAMAs identified and analyzed by Entergy. This is mostly due to the fact that the SAMAs identified and analyzed in the submittal were intended to address internal initiators, and any benefits with regard to external events are only coincidental.

Postulated Accidents

The original IPE Level 2 analysis was characterized by the NRC staff reviewers as a simplified scoping analysis that lacked detailed plant-specific calculations. In response to an RAI on this topic, Entergy supported using the IPE Level 2 analysis, stating that the objective of the ANO-1 Level 2 analysis was to produce a scoping, yet realistic, estimate of the overall ANO-1 reactor building response to severe accident phenomena. As part of that effort, ANO-1-specific features were considered in the analysis of the plant damage states, containment event tree model, and quantification steps. Plant-specific information was used to form conclusions regarding the impact of the identified severe accident response issues on ANO-1. Entergy cited several examples where plant-specific design and test data were used in the Level 2 analysis. Additionally, most of the phenomenological modeling was based on the Surry analysis in NUREG-1150 (NRC 1990a), which was selected for its similarity to ANO-1. The applicant also noted that an independent, formal review of the Level 2 model was conducted subsequent to completing the SAMA analysis, with no major findings or recommendations for changes related to the Level 2 model. The staff concludes that the use of the ANO-1 Level 2 model provides sufficiently detailed characterization of containment response to support license renewal SAMA analysis.

The process used by Entergy to extend the containment performance (Level 2) portion of the PSA to an assessment of offsite consequences was reviewed. This included consideration of the source terms used to characterize fission product releases for each containment release mode and consideration of the major inputs and assumptions used in the offsite consequence analyses. Entergy used an approach that was similar to the methods used in NUREG-1150 (NRC 1990a), NUREG/CR-4551 (NRC 1990b), and NUREG/CR-4881 (NRC 1988b) to analyze postulated accidents and develop radiological source terms for each of 53 containment release modes. The source terms that were reported in the IPE were incorporated as input to the NRC-developed MACCS2 code. For corresponding release scenarios, Entergy's point estimate source terms for sequences that were large contributors to offsite dose were compared with those in the NUREG-1150 Surry analysis (NRC 1990a) and found to be in reasonable agreement.

The MACCS2 input used site-specific meteorological data processed from hourly measurements from 1996. This data was collected at the site meteorological tower, except for precipitation data, which was recorded hourly at Clarksville, about 32 km (20 mi) northwest of the plant site. These data were the most recent available and acceptable set of hourly data. Year-to-year weather variations are not significant in the SAMA analysis because (1) weather variations are diminished in the MACCS2 analyses due to its weather sampling scheme and the relatively low population density near the plant in all directions, and (2) the same meteorological assumptions are used in estimating both the base-case consequences and the SAMA-case consequences.

The population distribution used as input to the MACCS2 analysis is based on 1990 census data. Population growth within a 80-km (50-mi) radius of the site was projected out to 2025 by using the computer program SECPOP90 (NRC 1997b). Projections were benchmarked with 1998 county data. Because the area is a popular recreational area, Entergy included transient populations in the emergency planning zone (exclusion boundary of 1 km out to 16 km [0.65 mi to 10 mi]). Thus, the MACCS2 site file shows a slightly larger population in this zone than may be found elsewhere in tables of population projections for the ANO region. At the request of the NRC, Entergy projected the population growth out to 2034, the end of the license renewal period, assuming the same growth rate for the last 10 years as for the previous 10 years. This resulted in a population 4 percent higher than that used in the SAMA analysis. Correspondingly, a SAMA analysis using this larger population would result in a 4 percent greater benefit. This would not change the conclusions of the SAMA analyses. The methods and assumptions for the population growth estimates are considered reasonable and acceptable for purposes of the SAMA evaluation.

Evacuation modeling is based on a site-specific evacuation study performed by Entergy. It was assumed that 15 percent of the people within the evacuation zone (extending out to 16 km [10 mi] from the plant) would start moving 45 minutes after the alarm is sounded, 80 percent would start moving at 90 minutes, and 5 percent would start moving at 135 minutes. The evacuation times are based on a site-specific evacuation study carried out by Arkansas Power & Light in 1981 (APL 1981). A sensitivity analysis was performed that assumed that only 95 percent of the people within the evacuation zone would participate in the evacuation. The remaining 5 percent were assumed to go about their normal activities. This assumption is conservative relative to the NUREG-1150 study (NRC 1990a), which assumed evacuation of 99.5 percent of the population within the emergency planning zone. The result was only a 1-percent change in population dose and evacuation costs. Evacuation times from the 1981 study were assumed to remain valid for the license renewal period based on the fact that the state would continue to maintain adequate roads in this recreation area and that the population growth was relatively small. The evacuation-sensitivity study indicated that the evacuation costs and exposures were not very sensitive to the population involved in the evacuation. Accordingly, the evacuation assumptions and analysis are deemed reasonable and acceptable for the purposes of SAMA evaluation.

Site-specific economic data were provided by SECPOP90 and used in the MACCS2 analyses. SECPOP90 contains a database extracted from U.S. Bureau of Census CD-ROMs (1990 census data), the 1992 Census of Agriculture CD-ROM Series 1B, the 1994 U.S. Census County and City Data Book CD-ROM, the 1993 and 1994 Statistical Abstract of the United States, and other minor sources. These regional economic values were updated to 1997 using the Consumer Price Index and other data from the U.S. Bureau of the Census and the

Department of Agriculture. Although some of the economic parameter values were based on values quoted in NUREG-1150 (NRC 1990a), some were revised with more recent and/or site-specific data.

The staff concludes that the methodology used by Entergy to estimate the CDF and offsite consequences for ANO-1 provides an acceptable basis from which to proceed with an assessment of risk reduction potential for the candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDF and offsite doses reported by Entergy.

• Potential Design Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by Entergy are discussed in this section.

• Process for Identifying Potential Design Improvements

Entergy's process for identifying potential plant improvements consisted of the following three elements:

- a review of the ANO-1 IPE submittal, the updated PSA, and the IPEEE for plant-specific enhancements
- reviews of SAMA analyses submitted in support of original licensing and license renewal activities for other operating nuclear power plants and advanced light water reactor plants
- reviews of other NRC and industry documentation discussing potential plant improvements.

Entergy's initial list of 169 candidate improvements was extracted from the process and is reported in Table G.2-1 in Attachment G to the ER (Entergy 2000a).

Entergy performed a qualitative screening on the initial list of 169 SAMAs using the following criteria:

- The SAMA is not applicable to ANO-1, either because the enhancement is only for boiling water reactors, the Westinghouse AP600 design, or pressurized water reactor ice condenser containments, or it is a plant-specific enhancement that does not apply at ANO-1, or

- The SAMA has already been implemented at ANO-1 (or the ANO-1 design meets the intent of the SAMA).

Based on the qualitative screening, 81 SAMAs were eliminated, leaving 88 subject to further analysis. These 88 SAMAs are listed in Table G.2-2 of Attachment G to the ER (Entergy 2000a). The further analysis consisted of identifying the costs and benefits for each SAMA and eliminating those whose cost exceeded their benefit. Thirty-eight SAMAs were eliminated because the costs were expected to exceed twice the maximum attainable benefit. The maximum attainable benefit was determined by assuming all risk for internal events is eliminated. Entergy doubled this value to bound additional benefits that might result for external events. For the remaining 50 SAMAs, further analyses were performed as described in Section 5.2.4.

- **Staff Evaluation**

Of the 169 SAMAs compiled and considered for analysis, 21 were based on the ANO-1 plant-specific risk profile as modeled in the IPE and IPEEE. The IPE was referenced as the source for 10 SAMA candidates. Of those, 8 have already been implemented, leaving only 2 for further consideration. The IPEEE was referenced as the source for 11 SAMA candidates, all of which have been implemented at the plant. Thus, of the 21 plant-specific SAMA candidates, only 2 have not been previously implemented: SAMA 18, “Procedures to Stagger HPI Pump Use After a Loss of Service Water,” and SAMA 56, “Reactor Building Liner Protective Barrier.” Both of these SAMAs were later screened out based on a negative cost-benefit value.

At the request of the NRC staff, the applicant examined the results of importance analyses based on the updated PSA to provide additional confidence in the SAMA identification process. A sensitivity analysis was performed on all basic events having risk reduction worths (RRWs) greater than 1.005. This sensitivity study examined the impact on the CDF of a factor-of-10 reduction in the basic event probability. The associated risk benefit for each basic event was estimated by assuming that the change in CDF was directly proportional to the benefit (a large reduction in CDF results in a large increase in benefit). Entergy determined that PSA basic events with RRWs less than 1.2 yielded benefits that, when doubled, were below the $30,000 value selected as the minimum cost for making a procedure change at ANO-1.

There were only two basic events in the ANO-1 updated PSA with RRWs greater than 1.2: (1) operator failure to attempt low-pressure recirculation within 30 minutes of a large LOCA, and (2) operator failure to trip reactor coolant pumps within 30 minutes of a loss of seal cooling. The list of candidate SAMAs addresses these two operator actions. SAMA 129, “Emphasize Timely Recirculation Swapover in Operator Training,” specifically looks at the first operator action. SAMA 2, involving intermediate cooling water (ICW), “Enhance Loss of ICW (or service water) Procedure to Facilitate Stopping Reactor Coolant Pumps,” and SAMA 4, “Additional

Training on the Loss of ICW," both deal with operator actions during a loss of seal cooling.[1] Thus, the follow-on analysis using the updated PSA confirmed that no additional potential SAMAs would have been identified by using the latest plant-specific risk profile.

While many of the SAMAs identified by Entergy involve major modifications and significant costs, less expensive design improvements and procedure changes that provide similar levels of risk reduction are also included. For example, of the 169 SAMAs, about 20 percent involve changes other than hardware changes, and over one-third of those have already been implemented at ANO-1. In general, ANO-1 has been responsive to making improvements where practical solutions were available (i.e., implementation costs were not prohibitive). Thus, many of the procedure changes and training upgrades proposed as potential SAMAs had already been implemented at ANO-1. This is a contributing factor in the overall low CDF at ANO-1.

The staff concludes that Entergy used a systematic and comprehensive process for identifying potential plant improvements for ANO-1 and that the set of potential improvements identified is reasonably complete and, therefore, acceptable.

- **Risk Reduction Potential of Design Improvements**

Entergy evaluated the risk reduction potential for each of the 50 SAMAs remaining after the screening using a bounding technique. Each SAMA was assumed to completely eliminate all sequences that the specific enhancement was intended to address. Nineteen bounding analysis cases were developed to accomplish this effort. Table 5-5 lists these bounding analyses, the respective assumptions, and the applicable SAMAs. Rather than creating an entire external events model to address risks and benefits associated with external initiating events, Entergy doubled the maximum benefit (based on the internal risk) to account for any unmodelled risk reduction that could also occur in external events.

The staff has reviewed Entergy's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction is reasonable and generally conservative (i.e., the estimated risk reduction would be higher than what would actually be realized).

(a) SAMAs 129 and 4 were part of the 88 SAMAs that underwent further analysis. SAMA 2 was screened out early because it had already been implemented at ANO-1.

Table 5-5. SAMA Cost/Benefit Screening Analysis

Case	SAMA	Bounding Analysis	Bounding Analysis Description	Bounding Analysis Assumptions	Screening Conclusion
1	60, Provide additional battery capacity 61, Use fuel cells instead of batteries 64, Alt. battery charging capability 66, Replace batteries	DCGOOD	Direct current (dc) power improvements	Batteries perfect for 24 hours	All SAMAs screened out
2	25, Procedures for temporary heating, ventilation, and air conditioning (HVAC)	DGHVAC	Emergency diesel generator (EDG) temporary ventilation	Removed EDG dependence on HVAC	Screened out
3	156, Add digital large LOCA protection	NO-A	Large LOCA	Initiating event frequency set to zero	Screened out
4	63, Improved bus cross-tie ability 67, Across unit alternating current (ac) power cross-tie 70, Emphasize steps in offsite power recovery after station blackout (SBO) 73, Install gas turbine generators (GTGs) 74, Install tornado protection on GTG 75, Create river water (RW) backup for diesel generator (DG) cooling 76, Use firewater as backup for DG cooling 77, Connect to alt. offsite power source 78, Underground offsite power lines	NO-LOSP	Loss of offsite power (LOSP)	Initiating event frequency set to zero	All SAMAs screened out
5	81, Redundant spray system during steam generator tube rupture (SGTR) 82, Improve SGTR coping abilities 83, Various SGTR coping features 84, Increase secondary pressure capacity	NOSGTR	SGTR	Initiating event frequency set to zero	All SAMAs screened out

Table 5-5. (contd)

Case	SAMA	Bounding Analysis	Bounding Analysis Description	Bounding Analysis Assumptions	Screening Conclusion
5 (contd)	85, New design steam generators (SGs) 87, Flood SG prior to core damage (CD) 88, Inspect 100% of SG tubes	NOSGTR	SGTR	Initiating event frequency set to zero	All SAMAs screened out
6	140, Replace air compressors	INSTAIR1	More reliable instrument air (IA) compressors	IA compressor failures set to zero	Screened out
7	139, emergency operating procedure (EOP) change to align DGs to more IA compressors	INSTAIR2	EDG backup power for IA system	Removed electric power dependency from IA compressors	Screened out
8	10, Add reactor coolant pump (RCP) seal injection system with DG 11, Add RCP seal inj. system w/o DG 12, Use hydro pump for seal injection	RCPLOCA	RCP seal LOCA	Removed seal LOCA from model	All SAMAs screened out
9	89, Locate residual heat remover (RHR) inside containment 92, Increase frequency of valve leak tests 93, Operator training on interfacing system LOCA (ISLOCA) 94, Relief valves in intermediate cooling water (ICW) system 95, Leak test valves in ISLOCA paths 96, EOP upgrade for ISLOCA identification 97, Ensure ISLOCA releases are scrubbed 98, Redundant/diverse limit switches on cont. isolation valves	ISL	Interfacing system LOCA	Initiating event frequency set to zero	All SAMAs screened out
10	155, Add secondary side guard pipes up to main steam isolation valves (MSIVs)	NOSLB	Main steam line break	Initiating event frequency set to zero	Screened out

Table 5-5. (contd)

Case	SAMA	Bounding Analysis	Bounding Analysis Description	Bounding Analysis Assumptions	Screening Conclusion
11	107, Digital feedwater control system upgrade	FW	Main feedwater control system	Main feedwater - induced transient initiating event frequency set to zero	Screened out
12	1, Cap ICW vent and drain telltale pipes 3, Improve loss of ICW procedure 4, Training on loss of ICW 22, Improve ability to cool RHR heat exchangers (HXs)	ICW1	Loss of ICW	Initiating event frequency set to zero	All SAMAs screened out
13	15, Add third ICW pump	ICW2	Additional ICW pump	Added pump to ICW fault tree	Screened out
14	69, Procedure to fix 4-kV breakers	BREAKER	Circuit breaker repair upgrade	Set failure probability of circuit breakers to zero	Screened out
15	57, Training on inadvertent actuations	SPURIOUS	Operator training on spurious actuations	Spurious actuation initiating event frequencies set to zero	Screened out
16	151, Enhance reactor coolant system (RCS) depressurization 152, Improve depressurization procedure	PDSRCD	Improve depressurization capability	Power operated relief valve (PORV) failure probabilities set to zero	All SAMAs screened out
17	129, Emphasize timely swapover to recirculation 138, Automatic swapover to recirculation	PDSHPROA	Improve recirculation capability	Set operator failure probability for recirculation to zero	129 did not screen out 138 screened out
18	114, Connect portable generator to auxiliary feedwater (AFW) turbine driven pump after battery depletion	PDSTDPDC	dc power to emergency feedwater (EFW) turbine-driven pump	Removed dc power dependency for EFW turbine-driven pump	Screened out
19	7, Increase makeup pump lube oil capacity	LOSWTOMU	Makeup pump cooling	Removed cooling water dependency for makeup pumps	Screened out

The use of a factor of two to implicitly account for the risk benefits associated with both internal and external events is deemed to be conservative because a SAMA generally is most effective in either internal events or external events, but not both. When the internal event risk is greater than the external event risk as it is at ANO-1, doubling the internal event risk is a conservative upper bound for the overall risk. The staff considers this bounding technique reasonable for the purposes of SAMA evaluation for ANO-1 because it would overstate somewhat the benefits of the SAMAs, although this technique may not be applicable for another plant that has a different overall risk profile.

• Cost Impacts of Candidate Design Improvements

Entergy estimated the costs of implementing each SAMA through the application of engineering judgment, estimates from other licensees' submittals, and site-specific cost estimates. The cost estimates conservatively did not include the cost of replacement power during extended outages required to implement the modifications. Estimates based on modifications implemented or estimated in the past were presented in terms of dollar values at the time of implementation and were not adjusted to present-day dollars.

Because the base-case CDF and public risk calculated by Entergy are relatively low, the maximum attainable benefit is also very low. As a result, a conservative cost estimate was used in most cases to screen the SAMAs from further consideration.

The cost estimates that were cited in Table G.2-2 of Attachment G to the ER (Entergy 2000a) were compared to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors and advanced light-water reactors. The Entergy estimates were found to be consistent and reasonable for the SAMAs under consideration.

• Cost-Benefit Comparison

The cost-benefit comparison as evaluated by Entergy and the staff evaluation of the cost-benefit analysis are described in the following sections.

• Entergy Evaluation

The methodology used by Entergy was based primarily on NRC's guidance for performing cost-benefit analysis, i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook*

(NRC 1997c). The guidance involves determining the net value for each SAMA according to the following formula:

$$\text{Net Value} = (\text{APE} + \text{AOC} + \text{AOE} + \text{AOSC}) - \text{COE}$$

where APE = present value of averted public exposure ($)
AOC = present value of averted offsite property damage costs ($)
AOE = present value of averted occupational exposure ($)
AOSC = present value of averted onsite costs ($)
COE = cost of enhancement ($).

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and it is not considered cost-beneficial. Entergy's derivation of each of the associated costs is summarized below.

Averted Public Exposure (APE) Costs

The APE costs were calculated using the following formula:

APE = Annual reduction in public exposure (Δperson-rem/reactor year)
x occupational exposure per core damage event
x monetary equivalent of unit dose ($2000 per person-rem)
x present value conversion factor (10.76, based on a 20-year period with a 7-percent discount rate).

As stated in NUREG/BR-0184 (NRC 1997c), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss due to a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value.

Averted Offsite Property Damage Costs (AOC)

The AOCs were calculated using the following formula:

AOC = Annual CDF reduction
x offsite economic costs associated with a severe accident (on a per-event basis)
x present value conversion factor.

Entergy cited an annual offsite property economic risk monetary equivalent of $956 per year based on the Level 3 risk analysis. This value, which corresponds to the frequency-weighted sum of the base offsite economic costs in Table G.1-4 of the ER (Entergy 2000a), appears to be lower than comparable values for other sites and those presented in NUREG/BR-0184 (NRC 1997c). This lower value is primarily due to the low population in the 80-km (50-mi) radius zone around the plant and the low CDF estimated for ANO-1.

Averted Occupational Exposure (AOE) Costs

The AOE costs were calculated using the following formula:

AOE = Annual CDF reduction
x occupational exposure per core damage event
x monetary equivalent of unit dose
x present value conversion factor.

Entergy derived the values for averted occupational exposure based on information provided in Section 5.7.3 of NUREG/BR-0184 (NRC 1997c). Best estimate values provided for immediate occupational dose (3300 person-rem) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in NUREG/BR-0184 in conjunction with a monetary equivalent of unit dose of $2000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license-renewal period.

Averted Onsite Costs (AOSC)

The AOSCs include averted cleanup and decontamination costs (ACC), and averted power replacement costs (U_{RP}). Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. Entergy derived the values for AOSC based on information provided in Section 5.7.6 of NUREG/BR-0184 (NRC 1997c).

The ACC are calculated using the following formula:

ACC = Annual CDF reduction
x present value of cleanup costs per core damage event
x present value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in NUREG/BR-0184 (NRC 1997c) as $\$1.5 \times 10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension.

The U_{RP} are calculated using the following formula:

U_{RP} = Annual CDF reduction
x present value of replacement power for a single event
x factor to account for remaining service years for which replacement power is required
x reactor power scaling factor.

Entergy calculated an averted replacement power cost of $81,065. In the analysis provided in the ER (Entergy 2000a), Entergy originally did not include replacement power costs in its cost-benefit evaluation, as recommended in NUREG/BR-0184 (NRC 1997c), but did include these costs as a sensitivity study. In view of the significant impact of these costs on the estimated benefit for a SAMA, the staff requested that Entergy include these costs in the cost-benefit analysis which forms the baseline for subsequent sensitivity analyses. By factoring in the averted replacement power costs in response to the RAI, the SAMA benefits increased between 20 and 65 percent over the original ER submittal values for those SAMAs where a reduction in CDF was expected.

In Entergy's original SAMA analysis, only one SAMA (129, "Emphasize Timely Recirculation Swapover in Operator Training") was found to be cost-beneficial. Based on the updated analysis (including replacement power costs), Entergy reevaluated the value impact of the 88 candidate SAMAs that passed the initial screening. No additional cost-beneficial SAMAs were identified through this reevaluation.

Entergy performed several sensitivity analyses to evaluate the impact of parameter choices on the analysis results. The sensitivity analyses included:

- calculation of each SAMA benefit using a 3-percent discount rate
- calculation of each SAMA benefit assuming the baseline discount rate and assuming that external events contributed an amount equivalent to internal events to the CDF
- calculation of each SAMA benefit assuming averted onsite costs, including the cost of replacement power and the baseline discount rate (only applicable to the original submittal because this became the baseline for the updated analysis)

- calculation of each SAMA benefit, assuming averted onsite costs including the cost of repair/refurbishment, and assuming the baseline discount rate

- calculation of each SAMA benefit assuming a discount rate that Entergy believes to be more realistic (15 percent).

The sensitivity analyses indicated that the results of the SAMA analysis (i.e., only SAMA 129 being cost-beneficial) would not change for the conditions analyzed.

- **Staff Evaluation**

In response to an RAI (Entergy 2000b), Entergy recalculated the value impacts for the 88 SAMAs that passed the initial screening. Entergy also recalculated the sensitivity cases, except for case number three above as this case was no longer applicable as a sensitivity. The cost calculations were based primarily on NUREG/BR-0184 (NRC 1997c). The changes in the results did not invalidate the conclusions of the original SAMA cost-benefit evaluation.

Of the 88 SAMAs analyzed, 87 were found to have negative net values when bounding risk-reduction benefits are assumed. The one remaining SAMA 129, "Emphasize Timely Recirculation Swapover in Operator Training," was found to be potentially cost-beneficial. This SAMA addresses the single most dominant contributor to the CDF in the ANO-1 updated PSA, i.e., failure of the operators to swapover from injection from the borated water storage tank to low pressure recirculation using the containment sump within 30 minutes during a large LOCA. This operator action appears in only one accident sequence, but accounts for over 33 percent of the CDF.

The failure probability assigned to this operator action by the ANO-1 PSA is 7.67×10^{-2}. This value is relatively high in comparison to the results of various human reliability screening methods that would generate values in the 1.0×10^{-2} to 1.0×10^{-3} range for high-stress operator actions. This being the case, an order of magnitude decrease in this operator action through improved training and greater awareness of this dominant risk contributor is not unreasonable. Reducing this operator action by a factor of 10 would result in reducing the CDF by about 30 percent (i.e., by 3.1×10^{-6}). Elimination of all large LOCA accident sequences (as modeled in the bounding analysis for SAMA 129) reduces the CDF by about 35 percent. Thus, the bounding analysis represents a reasonable expectation of the potential benefit from implementation of SAMA 129. It should be noted that the contribution of a large LOCA to the CDF is also due, in part, to the large LOCA initiating event frequency used in the ANO-1 PSA, 4.5×10^{-5} per reactor year. This value is consistent with the large LOCA frequencies used in most IPEs, but the latest information (NUREG/CR-5750, NRC 1999b) indicates that this could be too high by about a factor of 10. This tends to negate the benefit of SAMA 129.

Including replacement power costs, Entergy estimated the benefit of this SAMA to be in the range of $51,000 to $77,000 without doubling for external events. Entergy did not provide a formal cost estimate for this SAMA, but indicated that the cost would be less than twice the benefit. If the costs associated with this training are comparable to implementing a procedure change (estimated by Entergy to be $30,000 or more), then this action would have a positive net value.

Although not age-related, Entergy further evaluated this SAMA from a training perspective and concluded that this operator action was already adequately addressed in the operations training cycle (Entergy 2001). Specifically, the task of shifting the ECCS suction to the reactor building sump is already included in ANO's operator training program. The task is covered in the Reactor Operator Program in the simulator malfunction guide for LOCAs, and is intrinsic in the performance of the Emergency Operating Procedure for an ESAS actuation as part of the requalification process. There is also a Job Performance Measure for specifically evaluating the performance of shifting the ECCS suction to the sump, to evaluate the trainee's performance of the task. Although this task is not drilled routinely due to time constraints, ANO does perform training on the task as part of the coverage of different portions of the Emergency Operating Procedures as necessary.

Based on the updated cost-benefit and sensitivity analyses, the staff finds the cost-benefit comparison methods sound and the results reasonable.

• Conclusions

Entergy completed an extensive effort to identify and evaluate potential cost-beneficial plant enhancements to reduce the risk associated with severe accidents at ANO-1. A list of candidate SAMAs was compiled from a review of the ANO-1 IPE submittal, the updated PSA, and the IPEEE for plant-specific enhancements, reviews of SAMA analyses submitted in support of original licensing and license renewal activities for other operating nuclear power plants and advanced light water reactor plants, and reviews of other NRC and industry documentation discussing potential plant improvements. The staff concluded that the SAMA candidate identification efforts were reasonable and that the list of candidate SAMAs was sufficient.

After screening out SAMA candidates that were not applicable to ANO-1 or had already been implemented, Entergy performed a second screening based on the potential costs and benefits. The risk-reduction benefits were determined using the ANO-1 PSA (an updated version of the ANO-1 IPE) supplemented with a MACCS2 analysis to determine the offsite consequences and economic impacts. The ANO-1 PSA does not include an analysis of the risk associated with external initiating events. To compensate for this situation, Entergy bounded the potential

benefits by doubling the results from the ANO-1 PSA. While unorthodox, the NRC staff concluded that this method was sufficient for the purposes of SAMA evaluation.

The original risk-reduction benefit analysis followed the guidance of NUREG/BR-0184 (NRC 1997c), except that Entergy did not include replacement power costs as part of the averted onsite costs. In this analysis, Entergy concluded that only one SAMA was marginally cost-beneficial. Replacement power costs can have a significant influence on the cost-benefit analysis.

At the request of the staff, Entergy provided a revised assessment of the appropriate SAMAs with replacement power costs included. As a result of this reassessment, the "marginally" cost-beneficial SAMA 129 became more cost-beneficial. All other SAMA candidates retained negative net values. SAMA 129 involves improvements in training and awareness associated with operator actions required to swapover from the injection phase to low-pressure recirculation during a large LOCA. This SAMA does not relate to adequately managing the effects of aging during the period of extended operation and based on further information provided by Entergy, appears to be adequately addressed within the current operations training cycle. Therefore, no further action is necessary as part of license renewal pursuant to 10 CFR Part 54.

5.3 References

10 CFR Part 51, Subpart A, Appendix B, Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants."

10 CFR 51.53(c), "Operating license renewal stage."

10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

Arkansas Power and Light (APL). 1981. *ANO Emergency Plan*. Russellville, Arkansas.

Entergy Operations, Inc. 1993. Letter from James J. Fisicaro (Entergy) to U.S. Nuclear Regulatory Commission, Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, Individual Plant Examination for Severe Accident Vulnerabilities, Generic Letter 88-20 (TAC No. M74376), April 29, 1993.

Entergy Operations, Inc. 1996. Letter from Dwight C. Mims (Entergy) to U.S. Nuclear Regulatory Commission, Subject: Individual Plant Examination of External Events (IPEEE) and Unresolved Safety Issue A-46 Summary Reports for Arkansas Nuclear One, Unit 1 (ANO-1), May 31, 1996.

Entergy Operations, Inc. 2000a. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

Entergy Operations, Inc. 2000b. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, to U.S. Nuclear Regulatory Commission. Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, Environmental Report RAIs. Dated June 26, 2000.

Entergy Operations, Inc. 2000c. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, to U.S. Nuclear Regulatory Commission. Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, Environmental Report RAIs. Dated July 31, 2000.

Entergy Operations, Inc. 2001. Letter from Jimmy D. Vandergrift, Director, Nuclear Safety Assurance, to U.S. Nuclear Regulatory Commission. Subject: Arkansas Nuclear One - Unit 1, Docket No. 50-313, License No. DPR-51, Draft SEIS Comments. Dated January 4, 2001.

U.S. Nuclear Regulatory Commission (NRC). 1988a. Generic Letter 88-20, “Individual Plant Examination for Severe Accident Vulnerabilities,” November 23, 1988.

U.S. Nuclear Regulatory Commission (NRC). 1988b. *Fission Product Release Characteristics into Containment Under Design Basis and Severe Accident Conditions*. NUREG/CR-4881, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1990a. *Severe Accident Risks - An Assessment for Five U.S. Nuclear Power Plants*. NUREG-1150, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1990b. *Evaluation of Severe Accident Risks: Surry Unit 1*. NUREG/CR-4551, Volume 3, Revision 1, Part 1, Washington, D.C..

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

U.S. Nuclear Regulatory Commission (NRC). 1997a. Letter from George Kalman (NRC) to C. Randy Hutchinson (Entergy), Subject: Safety Evaluation Report (SER) and Technical Evaluation Report (TER) for Arkansas Nuclear One, Units 1 and 2, Individual Plant Examination (IPE) Submittals - Internal Events, May 5, 1997.

U.S. Nuclear Regulatory Commission (NRC). 1997b. *SECPOP90: Sector Population, Land Fraction, and Economic Estimation Program*. NUREG/CR-6525, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1997c. *Regulatory Analysis Technical Evaluation Handbook*. NUREG/BR-0184, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999a. *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*. NUREG-1437, Vol. 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999b. *Rates of Initiating Events at U.S. Nuclear Power Plants*. NUREG/CR-5750, Idaho National Engineering and Environmental Laboratory, February 1999.

U.S. Nuclear Regulatory Commission (NRC). 2000. Letter from U.S. NRC to C. Anderson, Entergy Operations, Inc. Subject: Request for Additional Information for the Review of Arkansas Nuclear One Unit 1 Environmental Report Associated with License Renewal—SAMA. Dated April 12, 2000.

6.0 Environmental Impacts of the Uranium Fuel Cycle and Solid Waste Management

Environmental issues associated with the uranium fuel cycle and solid waste management were discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996; 1999[(1)]). The GEIS included 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 were 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 (HLW) 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 of Category 1, and, therefore, additional plant-specific review for these issues is required.

This chapter addresses those issues that are related to the uranium fuel cycle and solid waste management during the license renewal term that are listed in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to Arkansas Nuclear One, Unit 1 (ANO-1). The generic potential impacts of the radiological and non-radiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in the GEIS, based in part on the generic impacts provided in 10 CFR 51.51(b), Table S-3, "Table of Uranium Fuel Cycle Environmental Data," and in 10 CFR 51.52(c), Table S-4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear

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

Power Reactor." The GEIS also addresses the impacts from radon-222 and technetium-99. There are no Category 2 issues for the uranium fuel cycle and solid waste management.

6.1 The Uranium Fuel Cycle

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to ANO-1 from the uranium fuel cycle and solid waste management are listed in Table 6-1. Entergy Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2000) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review. Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of those issues, the staff concludes in the GEIS that the impacts are SMALL (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal, as discussed below), and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of these issues follows:

- Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste): Based on information in the GEIS, the Commission found:

  Offsite impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part [10 CFR 51.51(b)]. Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.

  The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no offsite radiological impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Offsite radiological impacts (collective effects): Based on information in the GEIS, the Commission found:

  The 100 year environmental dose commitment to the U.S. population from the fuel cycle, HLW, and spent fuel disposal is calculated to be about 14,800 person rem [148 person Sv], or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines

Table 6-1. Category 1 Issues Applicable to the Uranium Fuel Cycle and Solid Waste Management During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
URANIUM FUEL CYCLE AND WASTE MANAGEMENT	
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and HLW)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4
Offsite radiological impacts (spent fuel and HLW disposal)	6.1; 6.2.2.1; 6.2.3; 6.2.4
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6
Low-level waste storage and disposal	6.1; 6.2.2.2; 6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4
On-site spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6

> and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years as well as doses outside the U.S. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny doses have some statistical adverse health effect which will not ever be mitigated (for example no cancer cure in the next thousand years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are very small fractions of regulatory limits and even smaller fractions of natural background exposure to the same populations.
>
> Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1.

The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no collective impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Offsite radiological impacts (spent fuel and HLW disposal): Based on information in the GEIS, the Commission found:

  > For the high level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for offsite releases of radionuclides for the current candidate repository site. However, if we assume that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report, "Technical Bases for Yucca Mountain Standards," and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site which will comply with such limits, peak doses to virtually all individuals will be 100 millirem [1 mSv] per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human

environment. The NAS report indicated that 100 millirem [1 mSv] per year should be considered as a starting point for limits for individual doses, but notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem [1 mSv] per year. The lifetime individual risk from 100 millirem [1 mSv] annual dose limit is about 3×10^{-3}.

Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by Department of Energy in the "Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," October 1980 [DOE 1980]. The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure, after 1,000 years, after 100,000 years, and after 100,000,000 years. Subsequently, the NRC and other federal agencies have expended considerable effort to develop models for the design and for the licensing of a high level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve very great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by NAS is a limit on maximum individual dose. The relationship of the potential new regulatory requirements, based on NAS report, and cumulative population impacts has not been determined, although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, EPA's generic repository standards in 40 CFR part 191 generally provide an indication of the order of magnitude of cumulative risk to population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR part 191 protect the population by imposing "containment requirements" that limit the cumulative amount of radioactive material released over 10,000 years. Reporting performance standards that will be required by EPA are expected to result in releases and associated health consequences in the range between 10 and 100 premature cancer deaths with an upper limit of 1,000 premature cancer deaths worldwide for a 100,000 metric tonne (MTHM) repository.

Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR part 54 should be eliminated. Accordingly, while the

> Commission has not assigned a single level of significance for the impacts of spent fuel and high level waste disposal, this issue is considered Category 1.

The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no collective impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Nonradiological impacts of the uranium fuel cycle: Based on information in the GEIS, the Commission found: "The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no nonradiological impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Low-level waste storage and disposal: Based on information in the GEIS, the Commission found:

  > The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional on-site land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

  The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of low-level waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- Mixed waste storage and disposal: Based on information in the GEIS, the Commission found:

> The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of mixed waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- Onsite spent fuel: Based on information in the GEIS, the Commission found: "The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of onsite spent fuel associated with license renewal beyond those discussed in the GEIS.

- Nonradiological waste: Based on information in the GEIS, the Commission found: "No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no nonradiological waste impacts during the renewal term beyond those discussed in the GEIS.

- Transportation: Based on information contained in the GEIS, the Commission found:

  > The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 MWd/MTU and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4—Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in §51.52.

  ANO-1 meets the fuel enrichment and burnup conditions set forth in Addendum 1 to the GEIS. The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of transportation associated with license renewal beyond those discussed in the GEIS.

6.2 References

10 CFR 51.23, "Temporary storage of spent fuel after cessation of reactor operation—generic determination of no significant environmental impact."

10 CFR 51.51(b), Table S-3, " Table of uranium fuel cycle environmental data."

10 CFR 51.52(c), Table S-4, "Environmental impact of transportation of fuel and waste to and from one light-water cooled nuclear power reactor."

10 CFR Part 51, Subpart A, Appendix B, Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants."

10 CFR Part 54, "Requirements for renewal of operating licenses for nuclear power plants."

40 CFR Part 191, "Environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive waste."

Entergy Operations, Inc. 2000. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

National Academy of Sciences (NAS). 1995. *Technical Bases for Yucca Mountain Standards*. Washington, D.C.

National Environmental Policy Act of 1969, as amended, 42 USC 4321 et seq.

U.S. Department of Energy (DOE). 1980. *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste*. DOE/EIS 0046-F, Vols. 1-3, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement to 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*. NUREG-1437, Vol. 1, Addendum 1, Washington, D.C.

7.0 Environmental Impacts of Decommissioning

Environmental issues associated with decommissioning resulting from continued plant operation during the renewal term were discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (GEIS), NUREG-1437 (NRC 1996; 1999).[(1)] The GEIS included 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 were 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 not likely 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 of Category 1, and therefore, additional plant-specific review for these issues is required. There are no Category 2 issues related to decommissioning at Arkansas Nuclear One, Unit 1 (ANO-1).

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to ANO-1 decommissioning following the renewal term are listed in Table 7-1. Entergy Operations, Inc. (Entergy) stated in its Environmental Report (ER) (Entergy 2000) that it is not aware of any new and significant information associated with the renewal of the ANO-1 operating license. No significant new information has been identified by the staff during its review. Therefore, the staff concludes that there are no impacts related to these issues beyond those

(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 7-1. Category 1 Issues Applicable to the Decommissioning of ANO-1 Following the Renewal Term

ISSUES—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
DECOMMISSIONING	
Radiation Doses	7.3.1; 7.4
Waste Management	7.3.2; 7.4
Air Quality	7.3.3; 7.4
Water Quality	7.3.4; 7.4
Ecological Resources	7.3.5; 7.4
Socioeconomic Impacts	7.3.7; 7.4

discussed in the GEIS. For all of those issues, the staff concluded in the GEIS that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, for each of the issues follows:

- Radiation doses: Based on information in the GEIS, the Commission found: "Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem [0.01 person-Sv] caused by buildup of long-lived radionuclides during the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no radiation doses associated with decommissioning following license renewal beyond those discussed in the GEIS.

- Waste management: Based on information in the GEIS, the Commission found: "Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of

other available information. Therefore, the staff concludes that there are no impacts of solid waste associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Air quality: Based on information in the GEIS, the Commission found: "Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of license renewal on air quality during decommissioning beyond those discussed in the GEIS.

- Water quality: Based on information in the GEIS, the Commission found: "The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of the license renewal term on water quality during decommissioning beyond those discussed in the GEIS.

- Ecological resources: Based on information in the GEIS, the Commission found: "Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of the license renewal term on ecological resources during decommissioning beyond those discussed in the GEIS.

- Socioeconomic Impacts: Based on information in the GEIS, the Commission found: "Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth." The staff has not identified any significant new information during its independent review of the Entergy ER (Entergy 2000), the staff's site visit, the scoping process, its review of public comments, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of license renewal on the socioeconomic impacts of decommissioning beyond those discussed in the GEIS.

7.1 References

10 CFR Part 51, Subpart A, Appendix B, Table B-1, “Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants.”

Entergy Operations, Inc. 2000. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plant* (GEIS). NUREG-1437, 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*. NUREG-1437, Vol. 1, Addendum 1, Washington, D.C.

8.0 Environmental Impacts of Alternatives to License Renewal

This chapter examines the potential environmental impacts associated with denying a renewed operating license (i.e., the no-action alternative) for Arkansas Nuclear One, Unit 1 (ANO-1); the potential environmental impacts from electric generating sources other than renewal of the ANO-1 operating license; the potential impacts from instituting additional conservation measures to reduce the total demand for power; and the potential impacts from power imports. The impacts are evaluated using a three-level standard of significance—SMALL, MODERATE, or LARGE—based on Council on Environmental Quality guidelines. These significance levels are 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.

8.1 No-Action Alternative

For license renewal, the no-action alternative refers to a scenario in which the U.S. Nuclear Regulatory Commission (NRC) would not renew the ANO-1 operating license, and the applicant would then decommission ANO-1 when plant operations cease. For the purposes of this review, the staff assumes that ANO-2 continues to operate. Replacement of ANO-1 electricity-generation capacity would be met either by demand-side management and energy conservation (perhaps supplied by an energy service company), imported power, some generating alternative other than ANO-1, or some combination of these. However, due to the influence of the ongoing deregulation of the retail market, Entergy might not be the ultimate power supplier.

Entergy will be required to comply with NRC decommissioning requirements whether or not the operating license is renewed. If the ANO-1 operating license is renewed, decommissioning activities may be postponed for up to an additional 20 years. If the license is not renewed, then Entergy would begin decommissioning activities when plant operations cease, beginning in 2014 or perhaps sooner. The impacts of decommissioning would occur concurrently with the impacts of supplying replacement power. The *Generic Environmental Impact Statement for*

License Renewal of Nuclear Plants (GEIS), NUREG-1437 (NRC 1996) and the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG-0586 (NRC 1988), provide a description of decommissioning activities.

The environmental impacts associated with decommissioning under the no-action alternative would be bounded by the discussion of impacts in Chapter 7 of the GEIS (NRC 1996), Chapter 7 of this *Supplemental Environmental Impact Statement* (SEIS), and NUREG-0586 (NRC 1988). The impacts of decommissioning after 60 years of operation generally would not be significantly different from those occurring after 40 years of operation.

- Socioeconomic: When ANO-1 ceases operation, employment and tax revenues will decrease. This impact would be concentrated in Pope County. Most secondary employment impacts and impacts on population would also be expected in Pope County and to a lesser degree in Johnson and Yell Counties. Table 2-5 shows the current geographic distribution of the residences of all permanent ANO employees by county. Most of the tax revenue losses would occur in Pope County. The no-action alternative results in the loss of these taxes and payrolls 20 years earlier than if the license is renewed (see Table 8-1). Entergy pays taxes on ANO of about $8 million per year to Pope County, as stated in Section 2.2.8. This tax base would be reduced in the no-action alternative. It is expected that energy costs in the area would also be higher in a regulated utility environment. It appears from the staff's interviews with local real estate agents and appraisers that there would be a significant negative impact on housing values as a result of closing ANO-1.

- Historic and Archaeological Resources: The potential for future adverse impacts to known or unrecorded cultural resources at the ANO site following decommissioning will depend on the future land use of the site. Eventual sale or transfer of the land within the plant site could result in adverse impacts to these resources should the land-use pattern change dramatically; however, land sales are unlikely while ANO-2 is still operating (see Table 8-1).

Table 8-1. Summary of Environmental Impacts from No-Action Alternative

Impact Category	Impact	Comment
Socioeconomic	MODERATE to LARGE	Decrease in employment and tax revenues
Historic and Archaeological Resources	SMALL to MODERATE	Sale or transfer of land within plant site limited by continued operation of ANO-2
Environmental Justice	SMALL to MODERATE	Loss of employment opportunities and social programs

- Environmental Justice for No-Action: Current operations at ANO-1 do not have disproportionate impacts on minority and low-income populations of the surrounding counties, and no environmental pathways have been identified that would cause disproportionate impacts. Since closure would result in a decrease in employment and tax revenues in Pope County, it is possible that the County's ability to maintain social services could be reduced at the same time as diminished economic conditions reduce employment prospects for the minority or low-income populations (see Table 8-1). There is some possibility of negative and disproportionate impacts on minority or low-income populations from this source under the no-action alternative.

8.2 Alternative Energy Sources

Nuclear power plants are commonly used for base-load generation; the GEIS states that coal-fired and gas-fired generation capacity are the feasible alternatives to nuclear power generating capacity, based on current (and expected) technological and cost factors. The alternatives of coal-fired generation and gas-fired generation are presented (Sections 8.2.1 and 8.2.2, respectively) as if such plants were constructed at the ANO site, using the existing water intake and discharge structures, switchyard, and transmission lines, or at an alternate location that could be either a current industrial site or an undisturbed, pristine site requiring a new generating building and facilities, new switchyard, and at least some new transmission lines. For purposes of this SEIS, a "greenfield" site is assumed to be an undisturbed, pristine site.

Depending on the location of an alternative site, it might also be necessary to connect to the nearest gas pipeline (in the case of natural gas) or rail line (in the case of coal). The requirement for these additional facilities also likely would increase the environmental impacts relative to those that would be experienced at the ANO site, although this is less certain.

The cooling water needs of a fossil-fired plant of equal capacity to ANO-1 would require the use of either a once-through cooling system located on a large body of water such as Lake Dardanelle or a closed-cycle system using cooling towers. It was concluded that a coal-fired plant would not be a reasonable onsite replacement alternative because there is not enough land at the ANO site to both build a coal-fired unit and have space for a coal yard. The impacts of this alternative, however, are assessed in Section 8.2.1.

The potential for using imported power is discussed in Section 8.2.3. Imported power is considered feasible, but would result in the transfer of environmental impacts from the current region in Arkansas to some other location in Arkansas, another state, or Canadian province. Several other technologies were considered, but were determined not to be reasonable replacements for a nuclear power plant. These options included wind, solar, hydropower,

geothermal, wood energy, municipal solid waste, energy crops, oil, advanced nuclear power, fuel cells, delayed retirement of other generating units, and utility-sponsored conservation, as discussed in Section 8.2.4.

Some of the alternatives discussed in Section 8.2.4 are technically feasible, but could not provide enough power on their own to replace the power from ANO-1. The final subsection considers the environmental consequences of a mix of alternatives. These impacts are the same or larger than the environmental consequences of license renewal.

• Coal-Fired Generation

It was assumed that it would take about 1000 megawatt electric (MW[e]) of coal-fired generation capacity to replace the approximately 836 MW(e) generated by ANO-1. A comparison using a larger-sized coal-fired facility is appropriate considering the additional electrical usage necessary for pollution control and transporting coal or ash. The typical capacity (in MW[e]) and configuration used by the electrical power industry in the application of coal-fired generation technology vary. The staff used information about the Delmarva Power and Light Company's Dorchester Power Plant and the South Carolina Electric and Gas Company's Cope Power Plant, and adjusted the estimates appropriately to develop a representative alternative coal-fired plant (BGE 1998).

• Once-Through Cooling System

This section discusses the environmental impacts of converting part of the current ANO site to a coal-fired generation facility with a once-through cooling system, and building a similar facility on a greenfield site. For the purposes of this comparison, it is assumed that the coal-fired alternative generation plant would use the existing intake and discharge structure of ANO-1 and use a once-through cooling system, similar to the system currently used by ANO-1, rather than a closed-loop cooling tower as is used by ANO-2. The minor environmental differences between the closed-cycle cooling and once-through cooling systems are discussed in Section 8.2.1.2.

Land use in the discussion that follows was based on impacts summarized in the GEIS, Section 8.3.9. The impacts are summarized below in Table 8-2. Construction of the coal-fired plant would take approximately 5 years. The estimated peak workforce during the construction is estimated to be 1200 to 2500 for the construction of a 1000-MW(e) plant (NRC 1996). Additional water would be needed for controlling wet-scrubber sulfur dioxide (SO_2) emissions and for boiler makeup during operation.

Table 8-2. Summary of Environmental Impacts from Coal-Fired Generation—Once-Through Cooling

	ANO Site		Alternative Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE	Approximately 700 ha (1700 acres), (including an additional 217 ha [536 acres] adjacent to existing site)	MODERATE to LARGE	200 ha (500 acres) to 800 ha (2000 acres), including transmission lines
Ecology	MODERATE	Uses undeveloped areas in current ANO site, other nearby land, and rail corridor	MODERATE to LARGE	Impact will depend on ecology of site
Water Use and Quality				
- Surface Water	SMALL	Uses existing intake and discharge structures	SMALL to MODERATE	Impact will depend on volume and other characteristics of receiving water
- Groundwater	SMALL	No groundwater is currently used by ANO-1. This practice likely would continue	SMALL to LARGE	Impact will depend on site characteristics and availability of groundwater
Air Quality	MODERATE	SO_x – 1820 MT*/yr – allowances required NO_x – 850 MT/yr – allowances required Particulate – 120 MT/yr (filterable) – 30 MT/yr (unfilterable) Carbon monoxide – 580 MT/yr Trace amounts of mercury, arsenic, chromium, beryllium and selenium	MODERATE	Same impacts as ANO site, although pollution control standards may vary
Waste	MODERATE	Total waste volume would be estimated around 800,000 MT/yr of ash and scrubber sludge	MODERATE	Same impacts as ANO site; waste disposal constraints may vary
Human Health	SMALL	Impacts considered minor	SMALL	Same impact as ANO site
Socioeconomics	MODERATE	1200 to 2500 additional workers during peak period of the 5-year construction period, followed by reduction from current ANO workforce of 573 to less than 200	MODERATE TO LARGE	Construction impacts would be relocated. Community near ANO would still experience reduction from 573 persons to a minimal maintenance size
Aesthetics	MODERATE to LARGE	Visual impact of large industrial facility and stacks would be significant	MODERATE to LARGE	Alternate locations could reduce aesthetic impact if siting is in an industrial area
Historic and Archaeological Resources	SMALL	Affects previously developed parts of current ANO site, nearby land, and 13 to 16 km (8 to 10 mi) rail corridor	SMALL	Alternate location would necessitate cultural resource studies

Table 8-2. (contd.)

		ANO Site	Alternative Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Environmental Justice	MODERATE	Impacts on low income and minority communities should be similar to those experienced by the population as a whole. Some impacts on housing are likely.	SMALL to LARGE	Impacts will vary depending on population distribution and make up

*Metric tons

- **Land Use**

  Based on GEIS estimates for a 1000-MW(e) coal plant, approximately 700 ha (1700 acres) would be needed, which would amount to a considerable loss of natural habitat and/or agricultural land for the plant site alone, excluding that required for mining and other fuel-cycle impacts. Ecological impacts could be large, and important cultural sites could be encountered, particularly near rivers. With this much land being cleared, some erosion and sedimentation would be expected. Considerable fugitive dust emissions would affect air quality temporarily, and the quantity of construction debris also would be substantial. The solid wastes generated by a conventional coal-fired plant would be fly ash, bottom ash, selective catalytic reduction (SCR) catalyst (used for control of oxides of nitrogen [NO_x]), and SO_2 scrubber sludge/waste. A coal facility of this size would generate significant amounts of ash on an annual basis. The SCR would generate spent catalyst material that would have high concentrations of metals that are removed from the fly ash. A new coal-fired facility would also result in the generation of significant amounts of scrubber sludge on an annual basis. Facilities would be constructed to control and treat leachate from ash and from scrubber waste-disposal areas and runoff from coal-storage areas. These facilities are included in the land-use estimates.

  The existing switchyard and transmission system would be used. The staff assumed that approximately 700 ha (1700 acres) would be required, based on the GEIS example of a 1000-MW(e) coal-fired plant. It is assumed that coal-fired generation structures and facilities, including coal storage and waste disposal, would be located in one or more of the unused areas of the ANO site and on adjacent land that would have to be purchased by Entergy.

  The ANO-1 plant is located on 471 ha (1164 acres) of Entergy-owned land. A total of 181 ha (449 acres) of the ANO site is disrupted by industrial activities, and the remaining land is made up of wooded areas, wetlands, shrubs, and open water. A coal-fired plant generating 1000 MW(e) would have a total land requirement of approximately 700 ha (1700) acres. Thus, in addition to disrupting an additional 279 ha (715 acres) of land on the

current ANO site, an additional 217 ha (536 acres) of land, at a minimum, would need to be acquired adjacent to the ANO site to add a coal-fired plant to the site. Acquiring the land surrounding the ANO site may not be feasible. In addition, it is not clear what difficulties would be posed by operating both a coal-fired plant and the remaining nuclear unit (ANO-2) on the same site. The impact of a coal-fired generation alternative on land use is best characterized as MODERATE; its impact would be greater than the proposed action.

In contrast, land use for a coal-fired generation alternative using once-through cooling at an alternative greenfield site would require 700 ha (1700 acres) for offices, roads, generating facilities and cooling structures, coal storage ash basin, and fly ash disposal, as discussed previously. Additional land might be needed for transmission lines, depending on the location of the site relative to the nearest inter-tie connection. Depending on the transmission line routing, these alternatives could result in MODERATE or LARGE land-use impacts consistent with the GEIS characterization of land use at a greenfield site.

- **Ecology**

Locating an alternate energy source at the existing ANO site would noticeably alter ecological resources because of using additional undeveloped areas and modifying the existing intake and discharge system. The impact to the Lake Dardanelle ecology would be expected to remain unchanged because the amount of heat transfer resulting from coal production would be similar to the amount of heat transfer produced by ANO-1. The ecological impacts of a coal-fired generation alternative at the ANO site would be MODERATE; its impact would be greater than the proposed action.

Constructing a coal-fired plant at a greenfield site, particularly one sited in a rural area with considerable natural habitat, would certainly alter the ecology and could impact any endangered or threatened species present at the site. These ecological impacts could be MODERATE to LARGE, consistent with the GEIS characterization of ecological impacts at a greenfield site.

- **Water Use and Quality**

Surface Water: The coal-fired generation alternative is assumed to use the existing ANO-1 intake and discharge structures as part of a once-through cooling system. This alternative would minimize environmental impacts because less construction would be required to adapt the system to the coal-fired alternative. It is assumed that runoff from coal piles and other water-related emissions would be successfully controlled. It is also assumed that the coal-fired alternative cooling water volume and discharge temperature would be approximately the same as for the current nuclear plant. This would comply with the existing ANO National Pollutant Discharge Elimination System (NPDES) permit. The GEIS

analysis determined that surface-water quality, hydrology, and use impacts for license renewal would be SMALL. Because the coal-fired generation alternative is assumed to have the same discharge characteristics as ANO-1, surface-water impacts are expected to remain SMALL; the impacts would be so minor that they would not noticeably alter any important attribute of the resource.

For alternative greenfield sites, the impact to the surface water would depend on the volume associated with the cooling system and characteristics of the receiving body of water. The impacts would be SMALL or MODERATE.

Groundwater: Groundwater use would be unaffected because water used to supply drinking and restroom facilities, as well as irrigation water for site landscaping during the summer months comes from a surface water source. However, the leachate from ash and scrubber waste disposal areas and runoff from coal storage areas would have to be controlled to avoid groundwater and surface-water contamination. For this reason, the appropriate characterization of coal-fired generation groundwater impacts would be SMALL; the impacts would be so minor that they would not noticeably alter any important attribute of the resource.

For alternative greenfield sites, the impact to the groundwater would depend on the site characteristics, including the amount of groundwater available. The impacts would range between SMALL and LARGE.

- **Air Quality**

Air quality impacts of coal-fired generation are very different from those of nuclear power due to emissions of oxides of sulfur (SO_x), NO_x, particulates, and carbon monoxide (CO). The proximity of the ANO site to the Ozark National Forest and Mount Nebo State Park would be of concern for a major coal-fired plant.

The staff assumed that the coal-fired unit could be tangentially fired with dry-bottom boilers. The firing configuration was chosen because it would have moderate uncontrolled emissions of NO_x compared with other applications. The NO_x emissions controls would include low-NO_x burners, overfire air, and post-combustion SCR. The combination of low-NO_x burners and overfire air would achieve an NO_x reduction of 40 to 60 percent from uncontrolled levels. The combustion controls, along with SCR, can achieve the current upper limit of NO_x control (95-percent reduction). Based on an operating capacity factor of 83.9 percent, the resulting annual NO_x emissions would be approximately 850 metric tons (MT). Filters and electrostatic precipitators (99.9-percent particulate removal efficiency), a wet lime/limestone flue gas de-sulfurization system (95-percent scrubber removal efficiency), and an operating factor of 83.9 percent would result in annual emissions per unit

of 120 MT of filterable particulates, 30 MT of particulate matter having a diameter of 10 microns or less (PM_{10}), and 1820 MT of SO_x. CO emissions would be approximately 580 MT per year per unit (EPA 1993; Delmarva Power and Light Co. 1992, adjusted for the smaller scale of the ANO-1 replacement).

The air quality impacts would be considered MODERATE for coal-fired generation. The impacts would be clearly noticeable, but would not destabilize air quality.

Sulfur oxides emissions: Using current SO_x emissions-control technology, the total annual stack emissions would include approximately 1820 MT of SO_x, most of which would be SO_2. Additional reductions could become necessary. The acid rain provision of the Clean Air Act of 1970 (Sections 403 and 404) capped the nation's SO_2 emissions from power plants. Under the Act, affected fossil-fired steam units are allocated a number of SO_2 emission allowances. To achieve compliance, each utility must hold enough allowances to cover its SO_2 emissions annually or be subject to certain penalties. If the utility's SO_2 emissions are less than its annually allocated emission allowances, then the utility may bank the surplus allowances for use in future years. An SO_2 allowances market has been established for the buying and selling of allowances. Entergy could potentially have to purchase additional allowances to operate a coal-fired alternative. Because of allowances, any major new combustion facility in Arkansas would not add SO_2 impacts on a regional basis, though it might do so locally.

Nitrogen oxides emissions: Using current NO_x emissions control technology, the total annual stack emissions would include approximately 850 MT of NO_x. Section 407 of the Clean Air Act of 1970 establishes an annual reduction program for the NO_x emissions program. Putting additional burdens on coal use are the U.S. Environmental Protection Agency (EPA) 8-hour ozone standard, the EPA standard requiring particulate matter to have a diameter less than 2.5 microns ($PM_{2.5}$), and the Regional Haze rules. In addition, modeling for visibility impacts may be required (see Section 2.2.4). A major new combustion facility would likely add to local emissions.

Particulate emissions: The total estimated annual stack emissions would include 120 MT of filterable particulate matter and 30 MT of PM_{10}. In addition, coal-handling equipment would introduce fugitive particulate emissions.

Carbon monoxide emissions: The total CO emissions are estimated to be approximately 580 MT per year.

Mercury: Coal-fired boilers account for nearly one-third of mercury emissions in the U.S. Technologies available to control mercury emissions have varying degrees of success. In response to growing concerns with mercury, the Clean Air Act Amendments of 1990 have

required the EPA to identify mercury emission sources, evaluate the contributions of power plants and municipal incinerators, identify control technologies, and evaluate toxicological effects from the consumption of mercury-contaminated fish. It is likely that these studies will lead to additional restrictions concerning mercury emissions associated with coal-fired power plants, as well as other sources of mercury emissions. Recent studies by the Maryland Power Plant Research Program have indicated that although coal-fired power plants contribute to mercury emissions, the resulting concentrations are not high enough to adversely affect humans or other organisms (MDNR 1999). Therefore, the probable effect of trace mercury emissions on human health would be SMALL.

Summary: The GEIS analysis did not quantify coal-fired boiler emissions, but implied that air impacts would be substantial and mentioned global warming and acid rain as potential impacts. Adverse human health effects from coal combustion have led to important Federal legislation in recent years, and public health risks, such as cancer and emphysema, have been associated with the products of coal combustion. Federal legislation and large-scale concerns, such as acid rain and global warming, are indications of concerns about air resources. SO_x emission allowances, NO_x emission offsets, low-NO_x burners, overfire air, SCR, fabric filters or electrostatic precipitators, and scrubbers may be required as mitigation measures. As such, the appropriate characterization of coal-fired generation air quality impacts would be MODERATE. The impacts would be clearly noticeable, but would not destabilize air quality.

Siting the coal-fired generation at a greenfield site would not significantly change air-quality impacts, although it could result in installing more or less stringent pollution-control equipment to meet applicable standards. Therefore, the impacts would be MODERATE.

- **Waste**

Coal combustion generates waste in the form of ash, and equipment for controlling air pollution generates additional ash and scrubber sludge. This impact could extend well after the operating life because revegetation management and groundwater monitoring for leachate contaminant impacts could be a permanent requirement.

The GEIS analysis concluded that large amounts of fly ash and scrubber sludge would be produced and would require constant management. Disposal of this waste could noticeably affect land use and groundwater quality, but with appropriate management and monitoring it would not destabilize any resources. After closure of the waste site and revegetation, the land would be available for other uses, and regulatory requirements would ensure groundwater protection. For these reasons, impacts from waste generated from burning coal would be MODERATE; the impacts would be clearly noticeable, but would not destabilize any important resource.

Siting the facility on an alternate greenfield site would not alter waste generation, although other sites might have more constraints on disposal locations. Therefore, the impacts would be MODERATE.

- **Human Health**

Coal-fired power generation introduces worker risks from fuel and lime/limestone mining, and worker and public risks from fuel and lime/limestone transportation and stack-emissions inhalation. Stack-emissions impacts can be very widespread and the health risks difficult to quantify. This alternative also introduces the risk of coal-pile fires and attendant inhalation risks.

The GEIS analysis noted that there could be human health impacts (cancer and emphysema) from inhalation of toxins and particulates, but did not identify the significance of this impact. Regulatory agencies, such as the EPA, focus on air emissions and revise regulatory requirements or propose statutory changes, based on human health impacts. Such agencies also impose site-specific emission permit limits as needed to protect human health. Thus, human health impacts from inhaling toxins and particulates generated by burning coal would be SMALL.

Using the same logic, siting the facility at an alternate greenfield site would not alter the possible human health effects. Therefore, the impacts would be SMALL.

- **Socioeconomics**

Construction of the coal-fired alternative would take approximately 5 years**.** It is assumed that construction would take place concurrently while ANO-1 continues operation and would be completed at the time ANO-1 would cease operations. Thus, the peak workforce is estimated to range from 1200 to 2500 additional workers during the 5-year construction period, based on estimates given in the GEIS (NRC 1996). The surrounding communities would experience demands on housing and public services that could have large impacts. After construction, the communities would be impacted by the loss of jobs; construction workers would leave, the nuclear plant workforce (573) would decline through a decommissioning period to a minimal maintenance size, and the coal-fired plant would introduce no more than 200 new jobs (BGE 1998).

The GEIS analysis concluded that socioeconomic impacts at a rural site would be larger than at an urban site because more of the 1200 to 2500 peak construction workforce would need to move to the area to work. Operational impacts could result in moderate socioeconomic benefits in the form of several hundred additional jobs, substantial tax revenues, and plant expenditures.

If the plant was located at the ANO site, the size of the construction workforce for a coal-fired plant and plant-related spending during construction would be noticeable. Operational impacts would include an eventual loss of approximately 400 jobs at the ANO site, however, with a commensurate reduction in demand on socioeconomic resources and contribution to the regional economy. The area's rapid population growth and the replacement industrial tax base resulting from the coal-fired power plant would prevent any destabilization of socio-economic resources. For these reasons, the appropriate characterization of socioeconomic impacts for a coal-fired plant would be MODERATE; the impacts would be clearly noticeable, but would not destabilize any important resource.

Construction at another site would relocate some socioeconomic impacts, but would not eliminate them. The community around ANO-1 would still experience the impact of ANO-1 operational job loss, and the communities around the new site would have to absorb the impacts of a large, temporary workforce and a moderate, permanent workforce. Therefore, the impacts are MODERATE to LARGE, based on the adverse effects on the employment and the tax base in Pope County, which would be similar to those of the no-action alternative.

- **Aesthetics**

  Plant structures would be visible over intervening trees for kilometers around, particularly along Lake Dardanelle. This view would contrast strongly with what is otherwise a natural-appearing wooded area around the lake. Coal-fired generation would also introduce additional mechanical sources of noise (e.g., induced-draft fans and coal-handling equipment) that may be audible offsite due to their proximity to Lake Dardanelle.

  The GEIS concluded that aesthetic impacts from such a large construction project in a rural and forested area could be substantial. Industrial structures that would be located at the ANO site would tower above area vegetation and create a noticeable visual impact for a large area. A coal-fired generating station would contrast strongly with the existing resource. The aesthetic impacts would be MODERATE to LARGE, noticeable but not destabilizing.

  Alternative locations could reduce the aesthetic impact of coal-fired generation if siting was in an area that was already industrialized. In such a case, however, the introduction of such tall stacks and cooling towers would probably still have a MODERATE incremental impact. Other sites could show a LARGE impact.

- **Historic and Archaeological Resources**

The GEIS analysis concluded that impacts to cultural resources would be relatively SMALL unless important site-specific resources were affected. Under this alternative, cultural resource inventories would be required for any lands that have not been previously disturbed to the extent that no historic or archaeological resources might remain. Other lands that are purchased to support the facility would also require an inventory of field cultural resources, identification, and recording of extant historic and archaeological resources, and possible mitigation of adverse effects from subsequent ground-disturbing actions related to physical expansion of the plant site. Therefore, the impacts would be SMALL.

Construction at another site would require studies to identify, evaluate, and mitigate potential impacts of new plant construction on cultural resources. This would be required for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission line, or other rights-of-way). Impacts can generally be managed and maintained as SMALL.

- **Environmental Justice**

No environmental pathways have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement coal-fired plant were built at the ANO site. Some impacts on housing availability and prices during construction might occur, and this could disproportionately affect the minority and low-income populations. Impacts at other sites would depend upon the site chosen. These impacts would be MODERATE.

If the replacement plant was built in Pope County, the County's tax base would be largely maintained, and some potential negative socioeconomic impacts on the minority or low-income populations would be avoided. If the plant were built elsewhere, environmental justice impacts would be SMALL to LARGE, depending on the plant location and nearby population distribution.

- **Closed-Cycle Cooling System**

Cooling for a coal-fired facility could also be accomplished by a closed-cycle system, which would also use the existing intake and discharge structures, but flow requirements would be 80 percent less than the once-through cooling system (Gilbert/Commonwealth 1996). This alternative would use high-draft cooling towers. The closed-cycle cooling system alternative would introduce a cooling-tower blowdown that would be higher in dissolved solids in comparison to Lake Dardanelle. Cooling-tower operation would require more electrical power than the once-through alternative due to the modified pumping systems. Cooling towers would discharge a plume of water vapor and a small amount of cooling-tower drift. The discharge temperature would be lower and volume less than with a once-through cooling system.

The impacts (SMALL, MODERATE, or LARGE) of this alternative are essentially the same as the impacts for a coal-fired plant using a once-through cooling system. There are, however, minor environmental differences between the closed-cycle and once-through cooling system. Table 8-3 summarizes these differences.

• Gas-Fired Generation

It was assumed that a replacement natural-gas-fired plant would use combined cycle technology. In the combined cycle unit, hot combustion gases in a combustion turbine rotate the turbine to generate electricity. Waste combustion heat from the combustion turbine is routed through a heat-recovery steam generator to generate additional electricity. The size, type, and configuration of gas-fired generation units and plants currently operational in the U.S. vary and include simple-cycle combustion and combined-cycle units that range in size from 25 MW(e) to 600 MW(e) (EPA 1994). As with coal-fired technology, units may be configured and combined at a location to produce the desired amount of megawatts, and construction can be phased to meet electrical power needs.

Section 8.2.2.1 discusses the environmental impacts of converting the current ANO site to a natural-gas-fired generation facility with once-through cooling and building a similar facility on a greenfield site. The minor environmental differences between the closed-cycle cooling and once-through cooling systems are discussed in Section 8.2.2.2.

- **Once-Through Cooling System**

Providing 1000 MW(e) of replacement power with a combined cycle system would require 45 ha (110 acres) of land (NRC 1996). Natural gas typically has an average heating value of 3.7×10^7 Joules/cubic meter (J/m^3) (1,000 British thermal unit per cubic foot [Btu/ft^3]) (DOE 1996; EPA 1993), and it would be the primary fuel; the gas-fired alternative plant would burn approximately 1.24 J/m^3-s (100 billion ft^3/yr).

Table 8-3. Summary of Environmental Impacts from Alternate Cooling System—Cooling Towers with Closed-Cycle Cooling

Impact Category	Change in Impact from ANO Once-Through Cooling
Land Use	10 to 12 additional ha (25 to 30 acres) required
Ecology	Additional impact to terrestrial ecology from cooling tower drift Reduced impact to aquatic ecology
Water Use and Quality	
Surface Water	Blowdown has higher dissolved solids Reduced flow/Less thermal load
Groundwater	None
Air Quality	None
Waste	None
Human Health	None
Socioeconomics	None
Aesthetics	Addition of 30-m (100-ft) cooling tower or noise from mechanical draft tower
Historic and Archaeological Resources	Cultural surveys possibly required
Environmental Justice	None

As a surrogate for a similar-sized gas-fired alternative plant, the staff used Baltimore Gas and Electric's Perryman Power Plant and Polk Power Plant (BGE 1989; EPA 1994). The staff assumed that each unit would be less than 30 m (100 ft) high and would be designed with dry, low-NO_x combusters, water injection, and selective catalytic reduction. Each unit would exhaust through a 70-m (230-ft) stack after passing through heat-recovery steam generators. This stack height is consistent with EPA regulations (40 CFR 51.100), which address requirements for determining the stack height of new emission sources.

The staff used an 880-MW(e) surrogate gas-fired generation plant to measure the impacts of replacing the 836-MW(e) ANO-1. The gas-fired generation alternative would consist of two

440-MW combined-cycle units, each consisting of two 155-MW simple-cycle combustion turbines and a 130-MW heat-recovery steam generator. Natural gas would have to be delivered via pipeline. Reliant and Ozark are the two nearest natural gas pipelines, located approximately 8 km (5 mi) from the ANO-1 site. Construction cost of installing a gas line has been estimated to be an average of approximately $1 million per mile (Duke 1999). To the degree existing rights-of-way could be used, the level of impact could be reduced.

Environmental impacts of conversion to the gas-fired generation option at both ANO and a "greenfield" site are summarized in the following text and are listed in Table 8-4.

- **Land Use**

  The gas-fired generation at the ANO site would require converting the existing industrial site to a gas plant. Almost all the converted land would be used for the power block. Additional land would be disturbed during pipeline construction. Some additional land would also be required for backup oil storage tanks. Gas-fired generation land-use impacts at the existing ANO site are SMALL to MODERATE; the impacts would noticeably alter the habitat but would not destabilize any important attribute of the resource. The difficulties of operating a gas-fired plant and the remaining nuclear unit (ANO-2) at the same site are expected to be less than with a coal-fired plant because of the much smaller "footprint" of a gas-fired plant.

  In addition to the land required for the gas-fired plant, construction at a greenfield site would impact approximately 8 to 20 ha (20 to 50 acres) for offices, roads, parking areas, and a switchyard. The power block would require 25 ha (60 acres). Some additional land would also be required for backup oil storage. In addition, it is assumed that another 170 ha (424 acres) would be necessary for transmission lines (assuming the plant is sited 16 km [10 mi] from the nearest inter-tie connection) although this would depend on the actual plant location. Plants of this type are usually built very close to existing natural gas pipelines. Including the land required for pipeline construction, a greenfield site would require approximately 200 ha (500 acres). Depending on the transmission-line routing, the greenfield site alternative could result in SMALL to MODERATE land-use impacts

. The GEIS estimated that land-use requirements for a 1000-MW gas-fired plant at a greenfield site would be SMALL (approximately 45 ha [110 acres] for the plant site), and that co-locating with a retired nuclear plant would reduce these impacts. Therefore, the impacts would be SMALL to MODERATE, depending on the length and routing of required pipelines and transmission lines.

Table 8-4. Summary of Environmental Impacts from Gas-Fired Generation—Once-Through Cooling Alternative

Impact Category	ANO Site		Alternative Greenfield Site	
	Impact	**Comments**	**Impact**	**Comments**
Land Use	SMALL to MODERATE	25 ha (60 acres) required for power block, 60 ha (150 acres) disturbed for pipeline construction, additional land for backup oil storage tanks	SMALL to MODERATE	Up to 200 ha (500 acres) required for site, pipelines, an estimated 16-km (10-mi) transmission line connection, additional land for backup oil storage tanks
Ecology	MODERATE	Constructed on land within ANO site. Possible significant habitat loss due to pipeline construction.	SMALL to MODERATE	Impact depends on location and ecology of the site
Water Use and Quality				
Surface Water	SMALL	70% reduction in required cooling water flow compared with ANO-1	SMALL to MODERATE	Impact depends on volume and characteristics of receiving body of water
Groundwater	SMALL	ANO-1 does not use groundwater nor is expected to use ground water during license renewal period	SMALL to LARGE	Groundwater impacts would depend on uses, available supply
Air Quality	MODERATE	Primarily nitrogen oxides. Impacts could be noticeable, but not destabilizing	MODERATE	Similar impacts as for ANO site
Waste	SMALL	Waste generation is minor	SMALL	Same impacts as for ANO site
Human Health	SMALL	Impacts considered to be minor	SMALL	Same impacts as for ANO site

Table 8-4. (contd.)

Impact Category	ANO Site		Alternative Greenfield Site	
	Impact	Comments	Impact	Comments
Socioeconomics	SMALL to MODERATE	500 to 750 additional workers during 3-year construction period; followed by reduction from 573 to fewer than 100 persons.	MODERATE to LARGE	Construction impacts would be relocated. Community near ANO would still experience reduction from 573 to a minimal maintenance size.
Aesthetics	SMALL to MODERATE	Visual impact of stacks and equipment would be noticeable, but not as significant as coal option	SMALL to MODERATE	Alternate locations could reduce the aesthetic impact if siting is in an industrial area
Historic and Archaeological Resources	SMALL	Only previously disturbed and adjacent areas would likely be affected	SMALL	Alternate location would necessitate cultural resource surveys
Environmental Justice	SMALL to MODERATE	Impacts on low-income and minority populations should be similar to those on the population as a whole. Impacts on housing are possible.	SMALL to MODERATE	Impacts vary depending on population distribution and makeup

- **Ecology**

  Siting gas-fired generation at the existing ANO site would have MODERATE ecological impacts because the facility would be constructed partly on previously disturbed areas and would disturb relatively little acreage at the site. However, significant habitat would be disturbed by approximately 8 km (5 mi) of pipeline construction. Ecological impacts would be reduced by using the existing intake and discharge system. Past operational monitoring of the effects of once-through cooling at ANO-1 has not shown significant negative impacts to Lake Dardanelle ecology, and this would be expected to remain unchanged.

  The GEIS noted that land-dependent ecological impacts from construction would be SMALL unless site-specific factors should indicate a particular sensitivity and that operational impacts would be smaller than for other fossil fuel technologies of equal capacity. The staff

has identified the gas pipeline as a site-specific factor that would make the gas-fired alternative's ecological impacts larger than for the license renewal. Therefore, in this case, the appropriate characterization of gas-fired-generation ecological impacts would be MODERATE.

Construction at a greenfield site could alter the ecology of the site and could impact threatened and endangered species. These ecological impacts could be SMALL to MODERATE.

- **Water Use and Quality**

  Surface Water: The plant would use the existing ANO-1 intake and discharge structures as part of a once-through cooling system; however, because cooling requirements would be less (70-percent reduction; EPA 1994), water quality impacts would continue to be SMALL.

  Water quality impacts from sedimentation during construction was another land-related impact that the GEIS categorized as SMALL. The GEIS also noted that operational water quality impacts would be similar to, or less than, those from other centralized generating technologies. The staff has concluded that water quality impacts from coal-fired generation would be SMALL, and gas-fired alternative water usage would be less than that for coal-fired generation. Surface water impacts would remain SMALL; the impacts would not be detectable or be so minor that they would not noticeably alter any important attribute of the resource.

  For alternative greenfield sites, the impact on surface water would depend on the volume and other characteristics of the receiving body of water. The impacts would be SMALL to MODERATE.

  Groundwater: ANO-1 does not use groundwater. As discussed in Section 4.5, the groundwater impacts would be SMALL; the impacts would be so minor that they would not noticeably alter any important resource.

  For alternative greenfield sites, the impact to the groundwater would depend on the site characteristics, including the amount of groundwater available. The impacts would range between SMALL and LARGE.

- **Air Quality**

  Natural gas is a relatively clean-burning fuel. Because ANO-1 is not in a nonattainment area for ozone, air-quality impacts of gas-fired generation would not be of concern. The GEIS noted that gas-fired air quality impacts are less than other fossil technologies because

fewer pollutants are emitted, and SO_2 is not emitted at all. Emission levels from the gas-fired alternative would be less than emission levels from the coal-fired alternative. However, the gas-fired alternative would contribute NO_x emissions to an area that in the future may become a nonattainment area for ozone. Because NO_x contributes to ozone formation, the reduced NO_x emissions are still of future concern, and low-NO_x combusters, water injection, and SCR could be mitigation measures required by regulatory agencies.

For these reasons, the appropriate characterization of air impacts from a gas-fired plant would be MODERATE; the impacts, primarily NO_x, would be clearly noticeable, but would not be sufficient to destabilize air resources as a whole.

Siting the gas-fired plant elsewhere would not significantly change air-quality impacts because the site could also be located in a greenfield area that was not a serious nonattainment area for ozone. In addition, the location could result in installing more or less stringent pollution control equipment to meet the regulations. Therefore, the impacts would be MODERATE.

- **Waste**

  There will be only small amounts of solid waste products (i.e., ash) from burning natural gas fuel. The GEIS concluded that waste generation from gas-fired technology would be minimal. Gas firing results in very few combustion by-products because of the clean nature of the fuel. Waste generation would be limited to typical office wastes. This impact would be SMALL; waste generation impacts would be so minor that they would not noticeably alter any important resource attribute.

  Siting the facility at an alternate greenfield site would not alter the waste generation; therefore, the impacts would continue to be SMALL.

- **Human Health**

  The GEIS analysis mentions potential gas-fired alternative health risks (cancer and emphysema). The risk may be attributable to NO_x emissions that contribute to ozone formation, which in turn contributes to health risks. As discussed in Section 8.2.1 for the coal-fired alternative, legislative and regulatory control of the nation's emissions and air quality are protective of human health, and the human health impacts from gas-fired generation would be SMALL; that is, human health effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource.

Siting of the facility at an alternate greenfield site would not alter the possible human health effects. Therefore, the impacts would be SMALL.

- **Socioeconomics**

  It is assumed that gas-fired construction would take place while ANO-1 continues operation, with completion of the replacement plant at the time that the nuclear plant would halt operations. Construction of the gas-fired alternative would take much less time than constructing other plants (NRC 1996). During the time of construction, the surrounding communities would experience demands on housing and public services that could have MODERATE impacts. After construction, the communities would be impacted by the loss of jobs, construction workers would leave, the ANO-1 nuclear plant workforce (573) would decline through a decommissioning period to a minimal maintenance size, and the gas-fired plant would introduce a replacement tax base of about 100 new jobs.

  The GEIS concluded that socioeconomic impacts from constructing a gas-fired plant would not be very noticeable and that the small operational workforce would have the lowest socioeconomic impacts (local purchases and taxes) of any nonrenewable technology. Compared to the coal-fired alternative, the smaller size of the construction workforce, the shorter construction time-frame, and the smaller size of the operations workforce would all reduce some of the socioeconomic impacts. For these reasons, the socioeconomic impacts of gas-fired-generation socioeconomic impacts would be SMALL to MODERATE; that is, depending on other growth in the area, socioeconomic effects could be noticed, but they would not destabilize any important attribute of the resource.

  Construction at another site would relocate some socioeconomic impacts, but would not eliminate them. The community around the ANO site would still experience the impact of the loss of ANO-1 operational jobs and the tax base. The communities around the new site would have to absorb the impacts of a moderate, temporary workforce and a small, permanent workforce. Therefore, the impacts would be MODERATE to LARGE, based on net job and tax-base losses in the ANO area. This impact is about the same in the ANO area as in the no-action alternative.

- **Aesthetics**

  The combustion turbines and heat-recovery boilers would be relatively low structures and would be screened from most offsite vantage points by intervening woodlands. The steam turbine building would be taller, approximately 30 m (100 ft) in height, and, together with 70-m (230-ft) exhaust stacks, would be visible offsite.

The GEIS analysis noted that land-related impacts, such as aesthetic impacts, would be small unless site-specific factors indicate a particular sensitivity. As in the case of the coal-fired alternative, aesthetic impacts from the gas-fired alternative would be noticeable. However, because the gas-fired structures are shorter than the coal-fired structures and more amenable to screening by vegetation, the staff determined that the aesthetic resources would not be destabilized by the gas-fired alternative. For these reasons, aesthetic impacts from a gas-fired plant would be SMALL to MODERATE; the impacts would be clearly noticeable, but would not destabilize this important resource.

Alternative locations could reduce the aesthetic impact of gas-fired generation if siting was in an area that was already industrialized. In such a case, however, the introduction of the steam generator building, stacks, and cooling tower plumes would probably still have a SMALL to MODERATE incremental impact.

- **Historic and Archaeological Resources**

The GEIS analysis noted, as for the coal-fired alternative, that cultural resource impacts of the gas-fired alternative would be SMALL unless important site-specific resources were affected. Gas-fired alternative construction at the ANO site would affect a smaller area within the footprint of the coal-fired alternative. As discussed in Section 8.2.1, site knowledge minimizes the possibility of cultural resource impacts. Cultural resource impacts would be SMALL; that is, cultural resource impacts would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource.

Construction at another site could necessitate instituting cultural resource preservation measures, but impacts can generally be managed and maintained as SMALL. Cultural resource surveys would be required for the pipeline construction and any other areas of ground disturbance associated with this alternative.

- **Environmental Justice**

No environmental pathways have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement gas-fired plant were built at the ANO site. Some impacts on housing availability and prices during construction might occur, and this could disproportionately affect the minority and low-income populations. The impacts would be SMALL to MODERATE. Impacts at other sites would depend upon the site chosen. If the replacement plant was built in Pope County, the County's tax base would be largely maintained, and some potential negative socioeconomic impacts on the minority or

low-income populations would be avoided. If the plant was built elsewhere, environmental justice impacts would be SMALL to MODERATE, depending on the population distribution.

- **Closed-Cycle Cooling System**

Cooling for the gas-fired facility could also be accomplished by a closed-cycle system, which would also use the existing intake and discharge structures, but flow requirements would be 90 percent less than the once-through cooling system (Gilbert/Commonwealth 1996). This alternative would use cooling towers. The closed-cycle cooling system alternative would introduce a cooling-tower blowdown that would be higher in dissolved solids in comparison to Lake Dardanelle. Cooling tower operation would require more electrical power than the once-through alternative due to the modified pumping systems. Cooling towers would discharge a plume of water vapor and a small amount of cooling-tower drift. The discharge temperature would be lower and volume would be less than with a once-through cooling system.

The impacts (SMALL, MODERATE, LARGE) of this alternative are essentially the same as the impacts for a gas-fired plant using a once-through cooling system. There are, however, minor environmental differences between the closed-cycle and once-through cooling system. The minor environmental differences are summarized in Table 8-5.

• Imported Electrical Power

"Imported power" means power purchased and transmitted from electric generation plants that the applicant does not own and that are located elsewhere within the region, nation, or Canada. Entergy purchases substantial amounts of capacity on the wholesale market (3.6-million MWh in 1998) (NRC 2000). The majority of the power is purchased on the wholesale market from the Tennessee Valley Authority (TVA). For the purposes of this analysis, it is assumed that replacement of generation by ANO-1 with purchased power would come from the TVA. As approximately 45 percent of electricity from the TVA is generated using fossil fuels, air emissions would be greater from purchased power than from generation by ANO-1. Other large generators in the region would have as high, if not higher, emissions rates, as energy production in the region is generally from older coal-fired plants that have the highest emission per kilowatt-hour of all generation sources.

In theory, importing (purchasing) additional power is a feasible alternative to ANO-1 license renewal. There is less assurance, however, that sufficient capacity or energy would be available in the 2014 through 2034 time-frame to replace the 836 MW(e) net base-load generation. More importantly, regardless of the technology used to generate imported power, the generating technology would be one of those described in this SEIS and in the GEIS (probably coal, natural gas, nuclear, or hydro-electric). The GEIS, Chapter 8, description of the environmental impacts of other technologies is representative of the imported electrical power alternative to ANO-1 license renewal.

Table 8-5. Summary of Environmental Impacts of Gas-Fired Generation with Alternate Cooling System—Cooling Towers with Closed-Cycle Cooling

Impact Category	Comparison to Once-Through Cooling
Land Use	Uses an additional 10 to 12 ha (25 to 30 acres) for cooling tower construction
Ecology	Additional impact to terrestrial ecology from cooling tower drift; reduced impact to aquatic ecology
Water Use and Quality	
Surface Water	Blowdown has higher dissolved solids; reduced flow/less thermal load
Groundwater	None
Air Quality	None
Waste	None
Human Health	Impacts considered minor
Socioeconomics	None
Aesthetics	Addition of a 30-m (100-ft) cooling tower or noise from mechanical draft tower
Historic and Archaeological Resources	Minimal studies (if necessary) before construction of cooling towers
Environmental Justice	None

• Other Alternatives

Other commonly known generation technologies considered by NRC are listed in the following paragraphs. However, these sources have been eliminated as reasonable alternatives to the proposed action because the generation of 836 net MW(e) of electricity as a base-load supply using these technologies is not technologically feasible (NRC 1996).

• Wind

The average annual capacity factor for this technology was estimated at 21 percent in 1995 and is projected to be 29 percent in 2010. This low-capacity factor results from the high degree of intermittence of wind energy in many locations (DOE 1993). Current energy storage technologies are too expensive to permit wind power plants to serve as large base-load plants. Wind-energy has a large land requirement, approximately 61,000 ha (150,000 acres) of land to generate 1000 MW(e) of electricity. This eliminates the possibility of co-locating a wind-energy facility with a retired nuclear power plant. A greenfield siting plan would be required. This would have a LARGE impact upon much of the natural environment in the affected areas (NRC 1996).

• Solar

The average capacity factor for this technology is estimated to be between 25 and 40 percent annually. This technology has high capital costs and lacks base-load capability unless combined with natural gas backup. It requires very large energy-storage capabilities. Based upon solar energy resources, the most promising region of the country for this technology is the West. Land-use requirements again are high: 6000 ha (14,000 acres) for 1000 MW(e), which would result in LARGE environmental impacts to the affected area (NRC 1996).

• Hydropower

Hydroelectric power has an average annual capacity factor of 46 percent. The GEIS, Section 8.3.4, indicates that the percentage of the U.S. electrical generation consisting of hydroelectricity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern over flooding, destruction of natural habitat, and destruction of natural river courses. The GEIS, Section 8.3.4, estimates land use of 400,000 ha (1-million acres) per 1000 MW(e) for hydroelectric power, resulting in a LARGE environmental impact. Due to the lack of locations for siting a hydroelectric facility large enough to replace ANO-1, local hydropower is not a feasible alternative to ANO-1 license renewal on its own.

- **Geothermal**

Geothermal has an average capacity factor of 90 percent and can be used for base-load power where available. However, as illustrated by Figure 8.4 in the GEIS, geothermal plants might be located in the western continental U.S., Alaska, and Hawaii where geothermal reservoirs are prevalent. This technology is not widely used as base-load generation due to the limited geographic availability of the resource and the immature status of the technology (NRC 1996). This technology is not applicable to the region where the replacement of 836 MW(e) is needed. There is no feasible location for geothermal generation within the Entergy service area (Entergy 2000).

- **Wood Energy**

A wood-burning facility can provide base-load power and operate with an average annual capacity factor of around 70 to 80 percent and with 20 to 25 percent efficiency. The cost of the fuels required for this type of facility is highly variable and very site-specific. The rough cost for construction of this type of facility in the ANO-1 area, where the replacement of 836 MW(e) is needed, is approximately $800 per kilowatt. Among the factors influencing costs are the environmental considerations and restrictions that are influenced by public perceptions, easy access to fuel sources, and environmental factors. In addition, the technology is expensive and inefficient. Therefore, economics alone eliminate a biomass technology as a reasonable alternative (NRC 1996).

- **Municipal Solid Waste**

The initial capital costs for this technology are much greater than the comparable steam-turbine technology found at wood-waste facilities. This is due to the need for specialized municipal solid waste-handling and waste-separation equipment and stricter environmental emissions controls. The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than by energy considerations. High costs prevent this technology from being economically competitive. Thus, municipal solid waste generation is not a reasonable alternative (NRC 1996).

- **Other Biomass-Derived Fuels**

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive for automotive fuel), and gasifying energy crops (including wood waste). The GEIS points out that none of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a base-load plant such as ANO-1. For these reasons, such fuels do not offer a feasible

alternative to ANO-1 license renewal. In addition, these systems have LARGE impacts on land use (NRC 1996).

- **Oil**

Oil is not considered a stand-alone fuel because it is not cost-competitive when natural gas is available. The cost of an oil-fired operation is about eight times as expensive as a nuclear or coal-fired operation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive than coal-fired generation (DOE 1996). For these reasons, oil-fired generation is not a feasible alternative to ANO-1 license renewal, nor is it likely to be included in a mix with other resources except as a back-up fuel.

- **Advanced Nuclear Power**

Work on advanced reactor designs has continued, and nuclear plant construction continues overseas. However, the cost of building a new nuclear plant and the political uncertainties that have historically surrounded many nuclear plant construction projects are among the factors that have led energy forecasters such as the Energy Information Administration to predict no new domestic orders for the duration of current forecasts (through the year 2010 [(DOE 1996]). For these reasons, new nuclear plant construction is not considered a feasible alternative to ANO-1 license renewal at this time.

- **Fuel Cells**

Phosphoric acid fuel cells are the most mature fuel-cell technology, but they are only in the initial stages of commercialization. Two-hundred turnkey plants have been installed in the U.S., Europe, and Japan. Recent estimates suggest that a company would have to produce 100 MW(e) of fuel-cell stacks annually to achieve a price of $1000 to $1500 per kilowatt (DOE 1999). However, the current production capacity of all fuel-cell manufacturers only totals about 60 MW per year. The use of fuel cells for base-load capacity requires very large energy-storage devices that are not feasible for storage of sufficient electricity to meet the base-load generating requirements. This is a very expensive source of generation, which prevents it from being competitive. This technology also has a high land-use impact, which, like wind technology, results in a LARGE impact to the natural environment. It is estimated that 14,000 ha (35,000 acres) of land would be required to generate 1000 MW(e) of electricity (NRC 1996). Therefore, the staff considers fuel cells not to be a feasible alternative to license renewal at this time.

- **Delayed Retirement**

The delayed retirement of fossil generation sources could not be used to replace the generation capacity of 836 net MW(e) of ANO-1, because the sources facing retirement in the Entergy system are used for peaking and intermediate generation. Additionally, there is no guarantee that these fossil units could economically operate for an additional 20 years after the current decision dates. Entergy does not have plans to retire any of its base-load fossil plants. Therefore, delayed retirement of base-load fossil generation likely could not be used as an alternative to license renewal unless such retiring base-load capacity could be found in a neighboring utility system. (The impact would then be that of imported power.) For these reasons, the delayed retirement of non-nuclear generating units is not considered a reasonable alternative to license renewal for ANO-1.

- **Utility-Sponsored Conservation**

The concept of conservation as a resource does not meet the primary NRC criterion "that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable" (NRC 1996). It is neither single, nor discrete, nor is it a source of generation.

The output of ANO-1, however, could be displaced by reducing energy use through a substantial amount of energy conservation. Entergy currently is reducing emissions and increasing efficiency at its plants in order to decrease greenhouse gas emissions as part of the Federal government's Climate Challenge for utilities. The carbon dioxide (CO_2) emissions reduction in 1998 totaled approximately 5.3 million tons, corresponding to a reduction in fossil generation of approximately 7 million MWh, using the average emissions rate for Entergy's fossil plants. This reduction, however, and future reductions of CO_2 emissions, are already accounted for in Entergy's generation needs.

From a review of the conservation plans at other companies, it is assumed that it would potentially be possible to displace approximately 5 percent of the generation from ANO-1 from a targeted program. The environmental impacts of an energy conservation program would be SMALL, but the potential to displace the entire generation at ANO-1 solely with conservation is not realistic. Conservation is instead used in assessing combinations of alternatives in Section 8.2.4.13.

- **Combination of Alternatives**

Even though individual alternatives might not be sufficient on their own to replace ANO-1 due to the small size of the resource or lack of cost-effective opportunities, it is conceivable that a mix of alternatives might be cost-effective. For example, if some additional cost-effective conserva-

tion opportunities could be found and combined with a smaller imported power or natural-gas-fired alternative, it might be possible to reduce some of the key environmental impacts of alternatives. However, it is unlikely that all of the environmental impacts of such a hypothetical mix could be reduced to SMALL. In comparison, the impacts of renewing the ANO-1 license are SMALL.

By combining conservation, purchase power, and new generation, the output of ANO-1 could be displaced at a lower environmental effect than by using one option alone. Although there is a wide variety of combinations, for this assessment, the staff assumed that the output of ANO-1 could be replaced by 500 MW(e) of gas-fired generation, a conservation rate displacing 5 percent of ANO-1's output, and purchased power. The contributions from these sources would be as follows:

Existing ANO-1 generation	836 MW(e)
Conservation (5 percent of 835 MW[e])	42 MW(e)
Gas-fired generation	500 MW(e)
Purchased power	294 MW(e)

While conservation measures would have very little, or no negative environmental effects, the gas-fired generation and purchased power components of this option would increase emissions and environmental impacts. Table 8-6 provides a summary of the environmental impacts of the assumed combination. The impacts are based on the gas-fired generation impact assumptions discussed in Section 8.2.2 of this report, adjusted for the reduced power generation (880 MW[e] versus 500 MW[e]). The staff then estimated the effect of purchased power on each impact, as discussed in the comments section of Table 8-6. Based on these estimates of the environmental impacts of this combination, the staff concludes that it is unlikely that the environmental impact of such a hypothetical mix could be reduced below SMALL.

8.3 References

40 CFR 51.100, “Definitions.”

Baltimore Gas and Electric (BGE). 1989. *Perryman Power Plant Certification of Public Convenience and Necessity, Environmental Review Document*, Vol. 2. Baltimore, Maryland.

Baltimore Gas and Electric (BGE). 1998. *Applicant’s Environmental Report -- Operating License Renewal Stage -- Calvert Cliffs Nuclear Power Plant, Units 1 and 2.* Baltimore, Maryland.

Table 8-6. Summary of Environmental Impacts of 42 MW(e) Conservation Measures,

Plus 500 MW(e) Gas-Fired Generation, and 294 MW(e) Purchased Power

Impact Category	ANO Site Conservation, Gas-Fired Generation, and Purchased Power		Greenfield Conservation, Gas-Fired Generation, and Purchased Power	
	Impact	**Comments**	**Impact**	**Comments**
Land Use	SMALL to MODERATE	**Gas-Fired**: Additional land required for power block, additional land disturbed for pipeline construction, additional land for backup oil storage. **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.	SMALL to MODERATE	**Gas-Fired**: Additional land required for power block, and additional land disturbed for pipeline construction. An estimated 116-km (10-mi) transmission line connection. Additional land for backup oil storage**.** **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.
Ecology	SMALL to MODERATE	**Gas-Fired**: Constructed on land adjacent to ANO site. Significant habitat loss due to pipeline construction. **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.	SMALL to MODERATE	**Gas-Fired**: Impact depends on location and ecology of the site. **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.
Water Use and Quality				
Surface Water	SMALL to MODERATE	**Gas-Fired**: Reduction in water flow. **Purchased Power**: Impact depends on volume and characteristics of receiving body of water.	SMALL to LARGE	**Gas-Fired**: Impact depends on volume and characteristics of receiving body of water. **Purchased Power**: Impact depends on volume and characteristics of receiving body of water.
Groundwater	SMALL to MODERATE	**Gas-Fired**: No impact on groundwater. **Purchased Power**: Depend on uses, available supply.	SMALL to MODERATE	**Gas-Fired**: Impact depends on uses, available supply. **Purchased Power**: Impact depends on uses, available supply.
Air Quality	SMALL to MODERATE	**Gas-Fired**: Primarily nitrogen oxides for gas-fired plant. **Purchased Power**: Depends on source of power. Moderate impacts potentially produced from coal plants.	SMALL to MODERATE	**Gas-Fired**: Similar impact as for ANO site. **Purchased Power**: Depends on source of power. Moderate impacts potentially produced from coal plants.

Table 8-6. (contd.)

Impact Category	ANO Site Gas-Fired Generation, Conservation and Purchased Power		Greenfield Gas-Fired Generation, Conservation and Purchased Power	
	Impact	**Comments**	**Impact**	**Comments**
Waste	SMALL to MODERATE	**Gas-Fired**: Minor waste generation. **Purchased Power**: Depends on source of power. Moderate impacts potentially produced from coal plants.	SMALL to MODERATE	**Gas-Fired**: Same impact as for ANO site. **Purchased Power**: Depends on source of power. Moderate impacts potentially produced from coal plants.
Human Health	SMALL	**Gas-Fired**: Impact considered to be minor (see discussion of gas-fired alternative). **Purchased Power**: Impact minor for likely sources of purchased power.	SMALL	**Gas-Fired**: Same impact as for ANO site. **Purchased Power**: Impact minor for likely sources of purchased power.
Socio-economics	SMALL to MODERATE	**Gas-Fired**: 250 to 375 additional workers during 3-year construction period; followed by a reduction in employment from 573 persons at ANO to less than 100. **Purchased Power**: Any additional workers employed would be in community from which power is purchased.	SMALL to MODERATE	**Gas-Fired**: 250 to 375 additional workers during 3-year construction period; followed by a reduction in employment from 573 persons at ANO to less than 100. **Purchased Power**: Any additional workers employed would be in community from which power is purchased.
Aesthetics	SMALL to MODERATE	**Gas-Fired**: Visual impact of stacks would be noticeable, but not as significant as coal option. **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.	SMALL to MODERATE	**Gas-Fired**: Alternate locations could reduce the aesthetic impact if siting is in an industrial area. **Purchased Power**: Impact depends on source of power and if expansion of existing plant and/or construction of new plant is required.
Historic and Archeological Resources	SMALL	**Gas-Fired**: Only previously disturbed and adjacent areas would likely be affected. **Purchased Power**: Impact depends on location, would necessitate cultural resource studies.	SMALL	**Gas-Fired**: Alternate location would necessitate cultural resource surveys. **Purchased Power**: Impact depends on location, would necessitate cultural resource studies.
Environmental Justice	SMALL to MODERATE	**Gas-Fired**: Impact on minority and low-income should be similar to those experienced by the population as a whole. **Purchased Power**: Impact depends on population distribution and makeup.	SMALL to MODERATE	**Gas-Fired**: Impact depends on population distribution makeup. **Purchased Power**: Impact depends on population distribution and makeup.

Clean Air Act of 1970, as amended, 42 USC 7401 et seq.

Clean Air Act Amendments of 1990.

Delmarva Power and Light Company. 1992. *Final Site Selection Study; 600 MW Coal-Fired Power Plant.* Wilmington, Delaware.

Duke Energy Corporation (Duke). 1999. Letter from M.S. Tuckman, Duke Energy Corporation to U.S. Nuclear Regulatory Commission. Follow-up to Staff's Request for Additional Information Dated December 29, 1998, Related to the Environmental Portion of the Review of the License Renewal Application for Oconee Units 1, 2, and 3.

Entergy Operations, Inc. 2000. Letter from C. Randy Hutchinson, Vice President, Operations, ANO, to U.S. Nuclear Regulatory Commission. Subject: License Renewal Application - Arkansas Nuclear One, Unit 1. Dated January 31, 2000. (Contains the Entergy Environmental Report [ER]).

Gilbert/Commonwealth. 1996. *Update to Calvert Cliffs Nuclear Power Plant Units 1 and 2 Cooling Tower System Study*. Reading, Pennsylvania.

Maryland Department of Natural Resources (MDNR). 1999. *Maryland Power Plants and the Environment: A review of the impacts of power plants and transmission has on Maryland's natural resources*. PRRP-CEIS-10, Maryland Power Plant Research Program, Annapolis, Maryland.

U.S. Department of Energy (DOE). 1993. *Renewable Resources in the U.S. Electricity Supply*. DOE/EIA-0561, U.S. Department of Energy, Energy Information Administration, Washington, D.C.

U.S. Department of Energy (DOE). 1996. *Annual Energy Outlook; 1996 with Projections to 2015*. DOE/EIA-0383(96), Energy Information Administration, Washington, D.C.

U.S. Department of Energy (DOE). 1999. *Advanced Fuel Cell Systems - A Revolutionary Power Technology*, Fossil Energy-Fuel Cell Power Systems overview. http://www.fe.doe.gov/coal-power/fc_sum.html. (Accessed August 4, 1999).

U.S. Environmental Protection Agency (EPA). 1993. *Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*. EPA AP-42, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1994. *Final Environmental Impact Statement, Volume I: Tampa Electric Company - Polk Power Station*. EPA 904/9-94, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1988. *Final Generic Impact Statement on Decommissioning of Nuclear Facilities*. NUREG-0586, Washington, D.C.

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

U.S. Nuclear Regulatory Commission (NRC). 2000. *Summary of Site Audit to Support Review of License Renewal Application of Arkansas Nuclear One Unit 1*. Dated May 1, 2000. Washington, D.C.