Draft Supplement
to the

NUREG-0428

final environmental statement

related to construction of

ALLENS CREEK NUCLEAR GENERATING STATION UNIT NO. 1

HOUSTON LIGHTING & POWER COMPANY

FEBRUARY 1978

Docket No. 50-466

U. S. Nuclear Regulatory Commission • Office of Nuclear Reactor Regulation

NUREG-0428

DRAFT SUPPLEMENT

to the

FINAL ENVIRONMENTAL STATEMENT

Related to the Construction of
Allens Creek Nuclear Generating Station
Unit No. 1

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U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION

SUMMARY AND CONCLUSIONS

This Supplement to the Final Environmental Statement (FES) for the Allens Creek Nuclear Generating Station (ACNGS), Units 1 and 2, which was issued in November 1974, was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation. The probable environmental impacts and adverse effects of constructing and operating a two-unit nuclear station at the Allens Creek site, as described in the FES, are reconsidered because of project changes resulting from the deferral and subsequent rescheduling of Unit 1 and the cancellation of Unit 2.

1. This action is administrative.

2. The proposed action is the issuance of a construction permit to the Houston Lighting and Power Company for the construction of ACNGS, located in Austin County, Texas (Docket No. 50-466), with one unit instead of the originally proposed two units.

   The facility will employ an identical boiling water reactor (BWR) and similar cooling systems to those originally proposed for the two-unit station. Accordingly, at the 3579-MWt power level initially to be licensed (the maximum expected thermal power level is 3758 MW), a steam turbine generator will use the generated heat to provide a net electrical output capacity of 1146 MW. The exhaust steam will be cooled by the flow of water pumped from and discharged to a newly constructed lake, which is now designed with a surface area of about 2072 ha (5120 acres), representing a 38% reduction in the original design. The Brazos River will serve as the source of the makeup water and as the receiving body for the cooling lake discharges.

3. Major changes in the station design include: (1) a reduction in gross electrical generating capacity from 2400 to 1200 MW; (2) a reduction in the number and size of associated facilities; (3) a reduction in the cooling lake surface area from 3339 to 2072 ha (8250 to 5120 acres); (4) the addition of an external dam along the northern lake perimeter; (5) a significant reduction in the estimated water use requirements (i.e., a reduction in the makeup water requirements from 90,000 to 30,000 acre-ft/year; a reduction in the total evaporative loss from 70,500 to 40,400 acre-ft/year; and a reduction in discharge from 71,000 to 26,200 acre-ft/year); and (6) a redesign of the radioactive and nonradioactive waste systems to meet regulations now in effect.

   Appendix S.B of this Supplement to the FES contains the summary and conclusions of the FES which, in part, summarize the environmental impacts and adverse effects (item 3) of constructing and operating two 1200-MWe nuclear units, a 3339-ha (8250-acre) cooling lake, and associated facilities at the Allens Creek site. Similarly, the following summary describes the environmental impacts and adverse effects that will occur for the construction and operation of the proposed one-unit station at the Allens Creek site. Changes in the station design as enumerated here will not modify the nature and types of impact. In fact, many of the environmental effects described here (f through k) will occur for either station design. However, because these effects are only amenable to qualitative assessments, the degree to which they will differ for the construction and operation of either station as designed cannot be quantified. The remaining environmental effects (a through e, and l) will also occur in either station design; however, the degree to which they will occur is more readily quantified.

   a. Construction-related activities on the site will disturb about 2315 ha (5720 acres) of pasture and cropland, including the 2072 ha (5120 acres) of land inundated by the Allens Creek cooling lake, which will be constructed in conjunction with the station (Sect. S.4.1).

   b. About 104 km (65 miles) of transmission-line corridors will require about 749 ha (1851 acres) of land for the rights-of-way (Sect. S.4.1.4).

   c. Relocation of the current pipelines as proposed will involve about 12 ha (30 acres). An access road and a railroad spur, which is less than 1.6 km (1 mile) long, will affect about 16 ha (40 acres).

d. Station construction will involve less extensive community impacts than those described in the FES. However, 16 familes will be displaced from the site. Also, traffic on local roads will increase due to construction and commuting activities. The influx of construction workers' families and the peak work force of 2400 persons will result in a demand for increased services in Austin County (Sect. S.4.4).

e. The total flow of circulating water will be 55 m^3/sec (1940 cfs), which will be taken from and returned to Allens Creek cooling lake. The Allens Creek cooling lake will receive about 30,000 acre-ft/year from the Brazos River, 16,600 acre-ft/ year as direct rainfall, and 20,600 acre-ft/year as runoff. About 40,400 acre-ft/ year will be evaporated, 26,200 acre-ft/year will be returned to the Brazos River, and 600 acre-ft/year will be lost as seepage. During the annual drawdown, the concentration of total dissolved solids (TDS) in Allens Creek cooling lake will increase by a factor of 1.8 to 2.2, and the water returned to the Brazos River will cause an 11% increase in TDS concentrations in the river during low-flow conditions. However, increases in TDS concentration will not significantly affect the aquatic productivity of Allens Creek cooling lake or the Brazos River. In addition, the thermal alteration of the Brazos River is not anticipated to have an adverse effect on aquatic productivity. However, the thermal alteration of Allens Creek cooling lake is expected to partially restrict the range of most game fish species and have an adverse effect on their productivity (Sect. S.5.3.2.2).

f. The overall impact of construction activities on Allens Creek prior to filling of the cooling lake will be a reduction in aquatic populations in the lower half of the creek. When the cooling lake is filled, about 13.7 km (8.5 miles) of Allens Creek will be lost as running-water aquatic habitat. The loss of aquatic biota in this section of Allens Creek will be more than compensated for by the establishment of aquatic biota in the cooling lake through natural colonization and the introduction of game fish. Construction activities may temporarily reduce aquatic populations in the Brazos River near the ACNGS site. Such reductions will probably be temporary and near the site (Sect. S.4.3.2).

g. Entrainment of phytoplankton, zooplankton, and ichthyoplankton in the circulating-water system may reduce the overall productivity of the cooling lake, although the extent of this reduction cannot be determined. Some mortality of juvenile and adult fish in the cooling lake will result from impingement on traveling screens of the circulating-water intake structure. The low approach velocities to the screens should minimize impingement losses (Sect. S.5.3.1.2). Chemical discharges during operation of the ACNGS should not significantly affect aquatic biota in the cooling lake or in the Brazos River provided that the discharge of total residual chlorine to the cooling lake is maintained at a peak concentration of 0.1 ppm (Sect. 5.3.2.2).

h. Phytoplankton, zooplankton, and ichthyoplankton will be subject to entrainment in the makeup-water intake system, although entrainment mortality is not expected to significantly reduce these populations in the Brazos River.

i. The proposed cooling lake should provide a valuable recreational fishery. There is a strong probability of high phytoplankton densities in the cooling lake which may reduce water contact activity for certain periods during spring and summer months.

j. The proposed cooling lake will displace white-tailed kites which are considered endangered by the Texas Organization for Endangered Species. However, the lake may provide suitable habitat for southern bald eagles and American alligators which are considered endangered by the U.S. Department of the Interior. The lake will also attract waterfowl, possibly in large numbers.

k. The risk associated with accidental radiation exposure is very low.

l. No significant environmental impacts are anticipated from normal operational releases of radioactive materials. The estimated dose to be received by the offsite population within 80 km (50 miles) of station would be less than 39 man-rems/year. This value is less than the normal fluctuations in the 260,000 man-rems/year background dose that this population would receive (Sect. S.5.4).

4. The following principal alternatives were reconsidered:

   a. purchase of power
   b. alternative energy systems,
   c. alternative sites, and
   d. alternative heat dissipation methods.

5. The following Federal, State, and local agencies were asked to comment on this Supplement to the FES:

   Advisory Council on Historic Preservation
   Department of Agriculture
   Department of the Army, Corps of Engineers
   Department of Commerce
   Department of Health, Education, and Welfare
   Department of Housing and Urban Development
   Department of the Interior
   Department of Transportation
   Department of Energy
   Environmental Protection Agency
   Federal Energy Regulatory Commission
   Houston Lighting and Power Company
   Office of the Governor, State of Texas
   County Judge, Austin County, Texas
   Houston-Galveston Area Council
   Mayor, City of Wallis
   Sierra Club

6. This Supplement was made available to the public and to other specified agencies in February 1978.

7. On the basis of the analysis and evaluation set forth in this Supplement, in the original FES, and in hearings before NRC's Atomic Safety and Licensing Board, and after weighing the environmental, economic, technical, and other benefits of ACNGS, Unit 1, against environmental and other costs, and after considering available alternatives, it is concluded that the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of a construction permit for the station subject to several conditions for the protection of the environment. In order to minimize confusion, the conditions contained in the Summary and Conclusions in the FES (Appendix S.B of this Supplement) are hereby vacated and are replaced in their entirety by the following:

   a. The applicant will submit a lake management program, including a development plan for the State parks, which will ensure that the Allens Creek cooling lake will be a recreational asset with benefits equivalent to those given in the FES (Sect. 5.6.4). In this plan, consideration should be given to making the lakeshore buffer zone, which will connect the two State parks on the south edge of the lake, into a hiking and fishing area; to modifying the character of the diversion dike by creating a more natural-looking land form; and to planting trees. The staff's approval of the program shall be obtained prior to start of construction of the cooling lake, of the dam, or of structures directly associated with the lake.

   b. The applicant will control the addition of chlorine to the circulating-water system so that the concentration of total residual chlorine at the point of discharge to Allens Creek cooling lake will be 0.1 ppm or less at all times.

   c. The applicant will not discharge chlorine upstream of the traveling screens for the circulating-water intake structure because significant fish impingement rates and fish kills may result.

   d. The applicant will not withdraw makeup water from the Brazos River during the spring spawning season (April to July) unless sufficient data on ichthyoplankton densities near the makeup pumping station to support the contention that this restriction is unnecessary to protect the Brazos River fishery are provided and approved by the staff.

e. The applicant will take the necessary mitigating actions, including those summarized in Sect. S.4.5 of this Supplement, during construction of the station and associated transmission lines in order to avoid unnecessary adverse environmental impacts from construction activities.

f. In addition to the preoperational monitoring program described in Sect. S6.1 of the Environmental Report Supplement, the staff recommendations in Sect. S.6.1 of this Draft Supplement will be followed.

g. The applicant will establish a control program that shall include written procedures and instructions to control all construction activities as prescribed herein and shall provide for periodic management audits to determine the adequacy of implementation of environmental conditions. The applicant will maintain sufficient records to furnish evidence of compliance with all the environmental conditions herein.

h. Before engaging in a construction activity not evaluated by the Commission, the applicant will prepare and record an environmental evaluation of such an activity. If the evaluation indicates that the activity may result in a significantly adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in this Supplement or the FES, the applicant will provide a written evaluation of such activities and obtain prior approval from the Director of Nuclear Reactor Regulation for the activities.

i. If unexpected harmful effects or evidences of irreversible damage are detected during facility construction, the applicant will provide the staff with an acceptable analysis of the problem and a plan of action for eliminating or significantly reducing the harmful effects or damages.

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FOREWORD

This Supplement to the FES was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, in accordance with the Commission's regulations in 10 CFR Part 51, that implement the requirements of the National Environmental Policy Act of 1969 (NEPA). The Act specifies, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice.
- Achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA calls for the preparation of a detailed statement on the following:

(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented;

(iii) alternatives to the proposed action;

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Pursuant to 10 CFR Part 51, the NRC Office of Nuclear Reactor Regulation prepares a detailed statement on the foregoing considerations with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or an operating license, the applicant submits an Environmental Report (ER) to the NRC. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the ER, to seek new information from the applicant that might be necessary for an adequate assessment, and generally to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information that will assist in the evaluation from other sources and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing and on the basis of other such activities or inquiries as are deemed useful and appropriate, the staff independently assesses the considerations specified in Section 102(2)(C) of NEPA and in 10 CFR Part 51.

This environmental review deals with the impacts of construction and operation of Allens Creek Nuclear Generating Station (ACNGS), Unit 1. The scope of this review, however, is limited by the fact that an extensive review, which resulted in the issuance of a partial initial decision by the Atomic Safety and Licensing Board (ASLB), was made for a nuclear facility consisting of two units at the Allens Creek site. The purpose of this Supplement is to identify the project changes resulting from the deferral and subsequent rescheduling of Unit 1 and the cancellation of Unit 2 of the initially proposed two-unit station for the Allens Creek site, and to assess the associated changes in the environmental impact and adverse effects that were evaluated in the FES and in staff testimony at the ASLB hearing. This environmental review is largely based upon an ER Supplement submitted by the applicant for the purpose of reactivating the construction permit application for the ACNGS, Unit 1. The ER Supplement consists of updated information that reflects changes in the ER resulting from the reduction in project scope and changes in schedule for construction and operation.

Single copies of this Supplement may be obtained by writing to the Director, Division of Document Control, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, D.C., 20555. Frederick J. Hebdon is the NRC Environmental Project Manager for this Draft Supplement. He may be contacted (301-492-8433) if there are questions regarding the contents of this Draft Supplement.

Effective January 19, 1975, activities under the U.S. Atomic Energy Commission's regulatory program were assumed by the Nuclear Regulatory Commission in accordance with the Energy Reorganization Act of 1974. Any references to the Atomic Energy Commission (AEC) contained herein or in the FES should be interpreted as referring to the Nuclear Regulatory Commission (NRC).

S.1. INTRODUCTION

S.1.1 BACKGROUND

Pursuant to the Atomic Energy Act of 1954, as amended, and the Nuclear Regulatory Commission's (NRC) regulations in Title 10, *Code of Federal Regulations* (CFR), an application was filed by Houston Lighting and Power Company (HL&P) for construction permits for two generating units designated as the Allens Creek Nuclear Generating Station (ACNGS) Units 1 and 2 (Docket Nos. 50-466 and 50-467). The application was accepted for docketing on August 24, 1973. If approval of the applicant's request had been given in accord with their schedule, construction of Units 1 and 2 would have proceeded so that Unit 1 would begin commercial operation in 1980 and Unit 2 would begin commercial operation in 1982. Each of the proposed nuclear units was to use a boiling-water reactor (BWR) designed for initial operation at approximately 3579 MWt. Condenser cooling was to be accomplished by the flow of water pumped from and discharged to a newly constructed 3339-ha (8250-acre) cooling lake utilizing makeup water from the Brazos River. Effluents from the cooling lake were to be discharged into the Brazos River. The proposed facility was to be located on the utility-owned site of 4513 ha (11,152 acres) located in Austin County, Texas, approximately 6.4 km (4 miles) northwest of Wallis, 11.3 km (7 miles) south-southeast of Sealy, and approximately 72.4 km (45 miles) west of the center of Houston.

Following an environmental review by the NRC staff for compliance with the provisions of the National Environmental Policy Act (NEPA), a Final Environmental Statement (FES) for the Allens Creek Nuclear Generating Station was issued in November 1974, and public hearings on environmental and site suitability matters were held in Wallis, Texas, on March 11 and 12, 1975, before an Atomic Safety and Licensing Board (hereafter ASLB or Board). On September 25, 1975, HL&P delayed construction of the two-unit station indefinitely but requested the Board to make certain findings regarding environmental and site suitability matters not likely to change. On November 12, 1975, the Board issued a partial initial decision which constituted a portion of the initial decision that was to be issued upon completion of the remaining environmental and site suitability matters and the radiological health and safety phase of the proceeding. On December 21, 1976, HL&P announced plans to reactivate the construction permit application for a one-unit station at the Allens Creek site. In addition, the size of the cooling lake would be reduced to 2072 ha (5120 acres), and project changes other than those directly associated with the reduction in project scope from a two-unit to a one-unit initial development at the station would be necessitated in order to comply with regulations now in effect and to accommodate state-of-the-art advances in design engineering concepts. Consequently, on August 1, 1977, the applicant submitted a Supplement to the original Environmental Report (ER) consisting of updated information reflecting changes in the ER which resulted from the deferral and subsequent rescheduling of Unit 1 and the cancellation of Unit 2. If approval of the applicant's request is given in accord with the revised schedule, construction of the station will commence in late 1978, and will have an anticipated commercial operation date of March 1985.

S.1.2 SCOPE OF ENVIRONMENTAL REVIEW

The Director of Nuclear Reactor Regulation or his designee is required in 10 CFR Part 51 to analyze the applicant's ER and to prepare a detailed statement of environmental considerations. Within this framework, this Supplement to the FES related to the construction of ACNGS, Unit 1, has been prepared by the Office of Nuclear Reactor Regulation of the NRC.

In view of the staff's documentation of detailed environmental considerations for a two-unit facility at the Allens Creek site, the primary objective of this Supplement is to focus on those elements of the previous analyses and considerations that have changed in the FES (as so amended by staff testimony at the ASLB hearing), and to identify the impact of these changes. Hence, the scope of this environmental review is limited to new information which indicates that a construction or operational activity may result in a significant adverse environmental impact that was not evaluated in the earlier proceedings, or that is significantly greater than that evaluated in the FES or during the environmental hearings. Also, state-of-the-art analytical methods were employed to reassess the various environmental effects and, where appropriate, to determine compliance with regulations now in effect.

Major documents used in the preparation of this Supplement are the applicant's Environmental Report (ER);[1] Environmental Report Supplement[2] and supplements thereto; the Final Environmental Statement (FES),[3] and the transcript of the ASLB hearings.[4] In this Supplement, these documents are cited extensively; however, their full titles and documentation are given only in the list of references for Sect. S.1. Elsewhere in this statement, references to Environmental Report, Final Environmental Statement, and Transcripts of the ASLB hearings will appear as the abbreviations ER, FES, and ASLB (or the Board) hearings, followed by the number(s) of specific sections, pages, tables, figures, exhibits, and appendices.

Independent calculations and sources of information have also been used as a basis for the assessment of environmental impacts resulting from the proposed project. In addition, information was gained from a visit by the staff to the Allens Creek site and surrounding areas in September 1977.

To provide for a single coordinated environmental review, the NRC has entered into agreements, each published as a Memorandum of Understanding, with the Environmental Protection Agency (EPA)[5] and the U.S. Army Corps of Engineers[6] regarding the issuance of permits for the discharge of pollutants to waters of the United States from point sources as defined in the Federal Water Pollution Control Amendments of 1972 (Public Law 92-500). Under each Memorandum of Understanding, the NRC acts as the lead agency to evaluate and consider environmental impacts of the proposed actions for nuclear power plants.

During the comment period on the Draft Supplement, the participating agencies will review and comment on the Supplement pursuant to Sect. 1500.7(b) of the Council of Environmental Quality Guidelines for Preparation of Environmental Impact Statements (August 1, 1973). These agencies will also participate with the staff in the review of comments on this Draft Supplement and in the preparation of the Final Supplement to the FES. Other appropriate agencies will also be requested to review and comment on the Draft Supplement. The views of these agencies will be set forth as an appendix in the Final Supplement, and concerns that they may raise will be addressed by the staff in the Final Supplement.

As part of its safety evaluation, the Commission conducts a detailed evaluation of the applicant's plans and equipment for minimizing and controlling the release of radioactive materials under both normal operating conditions and potential accident conditions, including the effects of natural phenomena. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated environmental effects are repeated in this Draft Supplement to the FES.

Copies of this Draft Supplement and the applicant's Environmental Report Supplement are available for public inspection at the Commission's Public Document Room, 1717 H Street N.W., Washington, D.C.; and at the Sealy Public Library, Atchison Street, Sealy, Texas, 77474.

S.1.3 STATUS OF REVIEWS AND APPROVALS

The reduction in the ACNGS generating capacity from two 1200-MWe nuclear units to one unit, and the reduction in the size of the associated cooling lake from 3339 to 2072 ha (8250 to 5120 acres) have resulted in significant changes with regard to environmentally related permits, approvals, and licenses. The U.S. Army Corps of Engineers has determined that Allens Creek is a navigable water and therefore, a permit under Section 402 of the Federal Water Pollution Control Act (FWPCA) will be required. Based in part on the Corps of Engineers determination, the EPA has decided that Allens Creek Lake is a cooling lake and not a cooling pond. Consequently, a permit under Section 402 of the FWPCA will be required for discharges to the lake, including the circulating water system. In addition, EPA has decided that ACNGS will be a new source as defined in Section 306 of the FWPCA. Therefore, new source performance standards are applicable to ACNGS. All of these decisions are subject to continued review and/or appeal and could be revised at a later date. The analyses contained in this Supplement assume that these decisions will not be significantly modified. The staff believes that these issues will not preclude construction of ACNGS at the Allens Creek site. The applicant has provided a status listing of these environmentally related approvals and consultations required from Federal, State, regional, and local agencies in connection with the proposed project (ER Suppl., Sect. S12). The staff has reviewed this listing and has consulted with the appropriate agencies in an effort to identify significant environmental issues of concern to the reviewing agencies. No such issues have been identified. The staff is aware of no potential non-NRC licensing difficulties that would preclude construction of a nuclear station at the Allens Creek site.

REFERENCES FOR SECTION S.1

1. Houston Lighting and Power Company, *Environmental Report, Allens Creek Nuclear Generating Station, Units 1 and 2*, Docket Nos. 50-466 and 50-467, August 24, 1973.

2. Houston Lighting and Power Company, *Supplement to the Environmental Report, Allens Creek Nuclear Generating Station, Unit 1*, Docket 50-466, August 1977.

3. Directorate of Licensing, U.S. Atomic Energy Commission, *Final Environmental Statement, Allens Creek Nuclear Generating Station, Units 1 and 2*, Docket Nos. 50-466 and 50-467, November 1974.

4. U.S. Nuclear Regulatory Commission, *In the matter of: Houston Lighting and Power Company, Allens Creek Nuclear Generating Station, Units 1 and 2 — Hearings at Wallis, Texas, March 11-12, 1975*, transcript of evidentiary hearings before the Atomic Safety and Licensing Board, Docket Nos. 50-466 and 50-467.

5. *Fed. Regist.* 40(251): 60115 (1975).

6. *Fed. Regist.* 40(165): 37110 (1975).

S.2. THE SITE

The site of ACNGS is located in the southern part of Austin County, Texas, immediately west of the Brazos River and about 72.4 km (45 miles) west of the center of Houston (Fig. S.2.1). The site consists of the same nominal 4513 ha (11,152 acres) of land that were originally proposed for the two-unit station (FES, Sect. 2.1). Of this 4513 ha (11,152 acres), the exclusion area and cooling lake will occupy 2315 ha (5720 acres), and an additional 259 ha (640 acres) will be used as a recreational area.

With few exceptions, the baseline descriptions of the Allens Creek site and environs and the regional characteristics given in the FES (Sect. 2) have not changed. The ER Supplement does, however, reflect changes in the population projections and land-use characteristics within the site vicinity (ER Suppl., Sect S2). Also, additional onsite meteorological data and the final results of the Allens Creek area biological monitoring program, which was initiated in October 1973 and covered a one-year period, are available. Previously, the staff based its analyses on an interim biological report covering the first six-month period. These descriptive ecological data as well as descriptions of the site and the regional characteristics are updated in the following sections. Site information which has not changed substantively is not addressed in this supplement.

S.2.1 REGIONAL DEMOGRAPHY

The 1970 population estimates and population projections given in the FES (Sect. 2.2.1) were based in part on data from the 1970 U.S. Census. The applicant's current (1977) estimates are made on the basis of a site reconnaissance conducted during March 1977, on U.S. Bureau of the Census county and city population estimates for 1975, and on estimates and projections published by various State agencies since the FES was developed (ER Suppl., Sect. S2.2 1).

Tables S.2.1 and S.2.2 present the 1970 cumulative populations and the projected populations for the years 1985, 2000, and 2020 up to an 80-km (50-mile) radius of the Allens Creek site. Within a 16-km (10-mile) radius of the plant site, the 1970 cumulative population was 7999 persons. The applicant has reported, however, that the 1977 population within this same area is 8840, which represents an increase of approximately 841 persons, or 10.5%, during the seven-year period (ER Suppl., S.2.2.1). Similarly, the 1970 cumulative population of 1,470,000 (Table S.2.2) within 80 km (50 miles) of the plant site increased to an estimated 1,676,000 persons (a 14% increase) by 1977. Tables S.2.3 and S.2.4 present 1975 populations of communities within 16 and 80 km (10 and 50 miles) of the site.

S.2.2 LAND USE

S.2.2.1 <u>The site</u>

The major change in land use in the vicinity of the Allens Creek property since publication of the FES has been the discontinuance of farming on the land owned by the applicant. Prior to this change, an estimated 1740 ha (4300 acres) of the bottomland were farmed.[1] Most of this area was planted with sorghum (1173 ha) and hay (405 ha), but small amounts of corn and cotton were also grown. Soils supporting these crops have been assigned to soil capability unit IIs-4 in the Soil Conservation Service system of land capability groupings.[1] This designation indicates that the soils are well suited for crops and pasture but have management limitations because they drain very slowly, and if the soil is worked when it is too wet a clay pan will form. The remainder of the property was used for pasture (1105 ha), rangeland (1611 ha), and miscellaneous purposes, such as homesites and roads (57 ha).

S.2.2.2 <u>The region</u>

Within a 48-km (30-mile) radius of the Allens Creek property, the major land use is agricultural, with approximately 85% of the land used for either cropland or pasture. The remaining 15% is mainly wooded or heavily forested, and less than 3% of the whole region is developed land. To the east, beyond a 48-km (30-mile) radius, the urban development of Houston is displacing the dominant agricultural land use.

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Fig. S.2.1. Site location. Source: FES, Fig. 2.1 (modified).

Table S.2.1. Cumulative 1970 and projected population totals within a 16-km (10-mile) radius of the proposed site

Year	Distance from site		
	Within 3 km (2 miles)	Within 8 km (5 miles)	Within 16 km (10 miles)
1970	72	1,844	7,999
1985	80	2,150	9,900
2000	110	2,450	12,030
2010	120	2,710	13,840
2020	130	3,000	16,060

Source: ER Suppl., Table S2.2-3.

Table S.2.2. Summary of 1970 cumulative and projected population totals within an 80.5-km (50-mile) radius of the proposed site

Year	Radial distance from site			
	Within 32 km (20 miles)	Within 48 km (30 miles)	Within 64 km (40 miles)	Within 80 km (50 miles)
1970	34,000	94,000	525,000	1,470,000
1985	43,000	122,000	719,000	2,037,000
2000	55,000	156,000	967,000	2,784,000
2010	66,000	186,000	1,187,000	3,422,000
2020	79,000	226,000	1,464,000	4,237,000

Source: ER Suppl., Table S2.2-6.

Table S.2.3. Population estimates of all communities of 100 or more inhabitants within 16.1 km (10 miles) of the site

Community	Distance from site		Direction	Population estimates[a]			Growth from 1970–1975 (%)
	(km)	(miles)		1970	1973	1975	
Orchard	16	10	ESE	292	377	411	40.8
San Felipe	13	8	N	422	432	477	5.9
Sealy	11	7	NNW	2685	2801	3211	19.6
Simonton	13	8	E	150	*b*	*b*	
Valley Lodge	8	5	E	*b*	*b*	*b*	
Wallis	6	4	SE	1033	1055	1108	7.3

[a]Source: ER Suppl., Table S2.2-4.
[b]Unincorporated area; data not available.

S.2.2.3 Transmission line rights-of-way

The applicant originally planned to build three transmission lines having a total length of 130.5 km (81.1 miles) and covering 890 ha (2200 acres). As a result of the reduced generating capacity of ACNGS, current plans are to construct only two transmission lines totalling 104 km (65 miles) in length and covering 749 ha (1851 acres). Route 1A from the site to W. A. Parish substation is essentially the same as described in the FES; Route 2C from the site to the Obrien substation replaces Route 2A; and Route 3A connecting the site, the Addicks substation and the Obrien substation is being deleted.

Land use along the proposed transmission line rights-of-way is described in the ER (p. 3.9-8) and in the ER Supplement (p. S3.9-1). Both transmission line routes run over cropland and rangeland. Rice fields comprise 37% (280 ha) of the rights-of-way; other types of cropland comprise 33% (243 ha); rangeland comprises 30% (223 ha); and heavily wooded land comprises less than 1% (2 ha). The transmission lines have routed to avoid developed land as much as possible.

Table S.2.4. Estimated 1975 population of all unincorporated communities which have 1000 or more inhabitants and all incorporated communities within 16 to 80.5 km (10 to 50 miles) of the site

Community	Population	Distance from site (km)	Distance from site (miles)	Direction	Change from 1970–1975 (%)
Hempstead	2,011	47	29	N	6.3
Navasota	4,993	77	48	N	−2.3
Prairie View	4,045	47	29	NNE	6.6
Waller	1,192	45	28	NNE	6.1
Brookshire	2,165	19	12	NE	9.4
Tomball	4,651	68	42	NE	70.1
Hilshire Village	789	63	39	ENE	25.8
Jersey Village	828	58	36	ENE	8.2
Katy	4,993	31	19	ENE	70.8
Spring Valley	3,473	60	37	ENE	9.6
Houston	1,326,809	56–88	35–55	E and ENE	5.9
Bellaire	17,057	61	38	E	−10.3
Brookside Village	1,597	79	49	E	6.0
Bunker Hill Village	4,241	58	36	E	6.6
Hedwig Village	3,746	60	37	E	15.1
Hunters Creek	4,395	60	37	E	11.0
Pearland	9,734	80	50	E	61.1
Piney Point Village	2,729	60	37	E	7.1
South Side Place	1,263	68	42	E	−13.8
Stafford	5,167	53	33	E	77.8
Sugar Land	7,306	50	31	E	120.2
West University Place	14,434	68	42	E	8.4
Missouri City	8,873	56	35	E and ESE	114.5
Richmond	8,452	35	22	ESE	46.3
Rosenberg	14,995	32	20	ESE	14.8
Needville	1,662	40	25	SE	62.3
West Columbia	3,330	74	46	SE	−0.1
East Bernard	1,159	18	11	SSE	*a*
Sweeny	3,025	80	50	SSE	−5.2
Van Vleck	1,051	76	47	SSE	*a*
Bay City	13,567	79	49	S	0.9
Wharton	7,744	42	26	S	−1.7
El Campo	9,334	55	34	SSW	0.0
Ganado	1,749	80	50	SSW	6.6
Eagle Lake	3,515	24	15	WSW	−2.0
Columbus	3,161	42	26	W	−5.4
Weimar	1,935	66	41	W	−8.0
Schulenburg	2,313	76	47	W	0.8
La Grange	3,060	76	47	WNW	−1.0
Fayetteville	422	60	37	WNW	5.5
Bellville	2,632	34	21	NNW	11.0
Round Top	100	71	44	NNW	6.4
Brenham	10,329	56	37	NNW	15.8

[a] Not recorded separately in 1975 population estimates.
Source: ER Suppl., Table S2.2-5.

S.2.2.4 Prime and unique farmlands

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture has expressed concern over the loss of some of the Nation's lands best suited for production of food, forage, and timber.[2] To mitigate this loss, the SCS has adopted a policy of making an up-to-date inventory of designated prime and unique farmlands. Prime farmlands are lands best suited and available for producing food, feed, forage, fiber, and oilseed crops; unique farmlands are those other than prime farmlands which are used for the production of high value food-and-fiber specialty crops.[2,3] The Soil Conservation Service has not yet completed a detailed inventory of prime and unique farmlands in Texas, and no published soil survey of Austin County is available.

However, the SCS has provided the staff with field survey sheets of the site and immediate vicinity, and a listing of those soils on the property which are rated as prime-1 and prime-2 farmlands.[4] Prime-1 farmlands are those wich meet the criteria of prime farmland based on inherent soil properties, while prime-2 farmlands meet these criteria following installation of specific management practices such as irrigation or drainage.[3] Based on the information provided by the SCS, the staff has determined that most of the bottomland portion of the property is Brazoria clay, occasionally flooded, which is rated as prime-1 farmland. Although a diversity of soil types occurs on the upland portions of the site, the uplands area is dominantly prime-2 farmland.

The transmission lines traverse a large area of rice fields and other agricultural land. The applicant estimates that 405 ha (1001 acres) of the transmission line corridor is prime farmland, and 107 ha (264 acres) is unique farmland (ER Suppl., pp. SH-S7, S8).

S.2.3 METEOROLOGY

The discussion of regional climatology, severe weather, and local meteorology, except for the discussion of wind characteristics at the Allens Creek site, remains unchanged from that presented in the FES (Sect. 2.6). Only one year (August 1, 1972 to July 31, 1973) of onsite meteorological data were available for inclusion in the FES; however, three years (August 1, 1972 to July 31, 1975) of onsite data are now available.

Wind data from the Allens Creek site for the 10-m level, representing the period August 1, 1972 to July 31, 1975 (Fig. S.2.2), indicate predominant winds from the southeast through south, occurring about 34% of the time. Winds from the south were most frequent, occurring 12.2% of the time. Winds from the west and west-northwest were least frequent, each occurring less than 2% of the time. There were only 0.3% calm conditions reported. The onsite wind roses for the 10-m and 60-m levels for the period August 1, 1972 to July 31, 1975 are shown in Fig. S.2.2.

S.2.4 ECOLOGY OF THE SITE AND ENVIRONS

The FES (Sect. 2.7) gives a general description of the ecology of the Allens Creek site and environs based in part on data collected in a biological monitoring program which was incomplete at the time the FES was issued. Subsequently, the biological monitoring program spanning a one-year period (October 11, 1973, through October 10, 1974) was completed and later documented in the *Biological Monitoring Program Report*.[1] (Hereafter in this Draft Supplement, the applicant's final biological monitoring report will be cited as BMPR, followed by a specific page number or section.) The following description updates the FES based on new information contained in the completed monitoring report.

S.2.4.1 Terrestrial biota

During the monitoring program, the applicant recognized two unique plant communities occurring on the site. The first is a native hay meadow, approximately 20 ha (50 acres) in extent, located in the area being proposed as a State park. This meadow is unique in having a species composition similar to that of the original climax coastal prairie. Less than fifty remnants of such communities exist today, and many of these have been modified by man's activities. The second unique community occurs along the bluff that will form the western edge of the cooling lake. A variety of woody plant species having restricted distributions in eastern Texas are present in this community, including the Texas persimmon (*Diospyros texana*), Mexican buckeye (*Aesculus pavia*), Durand oak (*Quercus durandii*), laurel oak (*Q. laurifolia*), and bur oak (*Q. macrocarpa*).

Since the FES was written, the number of plant species identified as occurring on, or in close proximity to, the site has increased from 108 to 258 species. None of these plants has been proposed for either threatened or endangered status.

A preliminary list of fauna occurring on the site is included in Appendix B of the FES. At the completion of the monitoring program, 21 species of mammals, 36 species of reptiles and amphibians, 95 species of birds (32 resident species), and 700 species of insects had been observed on the site or in close proximity to it. (A more complete list is given in the BMPR.) No animal species listed as endangered or threatened by the U.S. Fish and Wildlife Service[5] has been observed on the Allens Creek property.

Table S.2.5 lists critical fauna with ranges that overlap the Allens Creek property. Section 2.7.1 of the FES discusses the status of those endangered species that are most likely to occur on the site. Additional observations by the applicant during the monitoring program have shown

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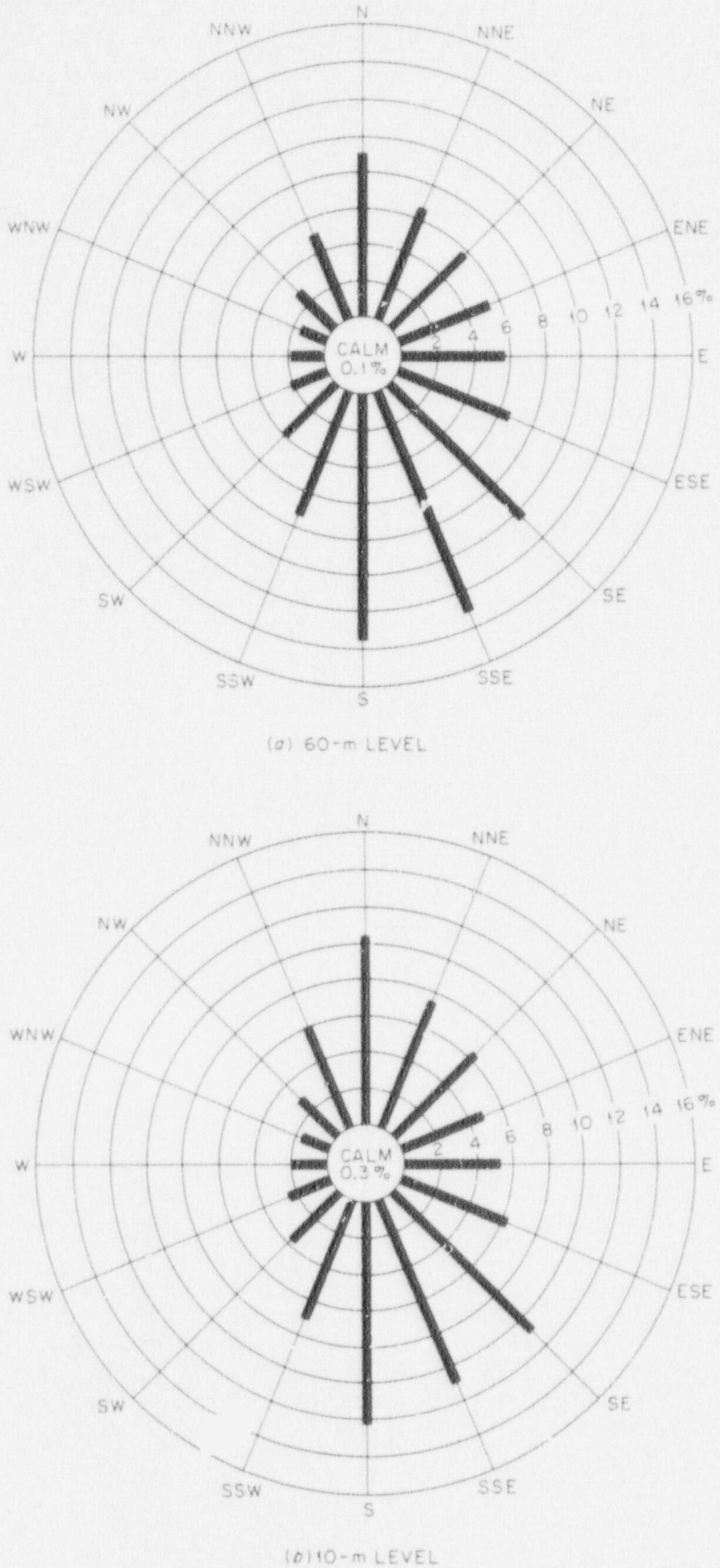

Fig. S.2.2. Allens Creek Nuclear Generating Station wind roses for period August 1972 through July 1975. (*a*) 60-m level and (*b*) 10-m level.

Table S.2.5. Critical fauna whose ranges include the Allens Creek area

Common name	Scientific name	Status
	Mammals	
Red wolf	*Canis rufus*	Endangered[a,b]
Black bear	*Ursus americanus luteolus*	Endangered[b]
Ringtail	*Bassariscus astutus flavus*	Uncommon; along river bottoms[c]
River otter	*Lutra canadensis*	Rare in east Texas[c]
Jaguar	*Felis onca veracrucis*	Peripheral; threatened with extinction[a,c]
Mountain lion	*Felis concolor stanleyana*	Peripheral; nowhere common[c]
Ocelot	*Felis pardalis albescens*	Extinct or endangered in Texas[a,c]
	Reptiles and Amphibians	
American alligator	*Alligator mississippiensis*	Endangered[a,b]
Texas horned lizard	*Phrynosoma cornutum*	Protected nongame species[d]
Western smooth green snake	*Opheodrys vernalis blanchardi*	Threatened[b]
Houston toad	*Bufo houstonensis*	Endangered[a,b]
	Birds	
Southern bald eagle	*Haliaeetus leucocephalus*	Endangered[a,b]
Attwater's prairie chicken	*Tympanuchus cupido attwateri*	Endangered[a,b]
Osprey	*Pandion haliaetus*	Endangered[b]
White-tailed kite[e]	*Elanus leucurus*	Endangered, peripheral[b]

[a]Department of the Interior, Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42: 36420–31 (1977).

[b]Texas Organization for Endangered Species, *TOES Watch List of Endangered, Threatened, and Peripheral Vertebrates of Texas,* Publication 1, Temple, Texas, 1975.

[c]G. E. Lowman, *A Survey of Endangered, Threatened, Rare, Status-Undetermined, Peripheral, and Unique Mammals of the Southeastern National Forests and Grasslands,* USDA Forest Service, Southern Region.

[d]Texas Parks and Wildlife Department, Regulation 127.70, in *Regulations for Taking, Possessing, and Transporting Protected Nongame Species,* effective July 18, 1977.

[e]Species which have been observed on the Allens Creek site during the biological survey.

that at least four adult white-tailed kites (*Elanus leucurus*), a species which is considered endangered (peripheral) by the Texas Organization for Endangered Species,[6] are frequently present on the property. However, no evidence of nesting activity by this species has been observed.

Twenty-two species of birds that are considered to have declining populations in all or a significant part of their range[7] occur in the general vicinity of the ACNGS property, and nine of these species were seen on the plant site during the monitoring program. Although the FES indicates that practically no habitat for aquatic birds exists at the site, hundreds of geese and dabbling ducks were observed feeding on crop residues on the bottomland fields of the site during the monitoring program.

S.2.4.2 Aquatic biota

As described in Sect. 2.7.2 of the FES, the proposed construction and operation of ACNGS will affect two existing aquatic environments: Allens Creek, which will be impounded to form the Allens Creek cooling lake; and the lower portion of the Brazos River, which will provide makeup water for, and will receive discharges from, the cooling lake. The following supplemental description of these aquatic environments deals only with significant seasonal changes in aquatic biota community composition and water quality, based on new data presented in the 3MPR which is not included in the FES. It is further noted that no species listed as endangered or threatened by the U.S. Fish and Wildlife Service[5] has been observed in Allens Creek or in the Brazos River near Allens Creek. Moreover, based on a September 1977 inspection of the proposed site and surrounding region, the staff concludes that no observable qualitative change in these aquatic habitats has occurred between 1974 and 1977.

S.2.4.2.1 Allens Creek

A general description of the Allens Creek aquatic habitat is given in the FES (pp. 2-12 to 2-15). As discussed, Allens Creek receives sewage effluents from the towns of Sealy and Wallis. Sealy discharges its sewage into the upper Allens Creek channel, and Wallis discharges into a southern arm of the creek near its confluence with the Brazos River (Fig. S.2.3). Additional organic and nutrient loading to the Allens Creek watershed occurs along its channel from a number of cattle operations on permanent pasture. Nutrients and organic matter are added to the stream by runoff from these pastures or by direct addition to the stream channel from cattle during low-flow periods. Data presented in the BMPR (Sect. 3.6) suggest that nutrient and organic loading from cattle operations may exceed those from sewage outfalls. Quantitative estimates of seasonal and yearly nutrient loading in the Allens Creek watershed are not available. However, data given in the BMPR (Sect. 3.6) show Allens Creek to be highly nutrient-enriched (nitrate, as N: 2.73 mg/liter and phosphate, as P: 2.4 mg/liter) with low concentrations of dissolved oxygen (1 ppm).

Fig. S.2.3. Allens Creek Nuclear Generating Station cooling lake.

The yearly cycle of heavy-metal concentrations in Allens Creek water is given in the BMPR (Sect. 3.6). This data shows that the creek in the winter months is relatively free of heavy-metal contamination except for copper and iron, but that concentrations of cadmium, cobalt, manganese, mercury, nickel, strontium, and zinc are all roughly of the order of parts per billion during summer and fall.

Table S.2.6. Heavy-metal concentrations in Brazos River water (station B1)[a]

Date	Concentration of element (ppb)									
	Cadmium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Strontium	Zinc
12/7/73	<1.0	<10.0	28.2	2,400[b]	18.0	2.0	0.27	<1.0	120.0	8.0
1/2/74	<1.0	10.0	24.0	6,000[b]	<2.0	<2.0	36.0	<1.0	500.0	30.0
2/1/74	<1.0	<10.0	48.0	18,200[b]	<2.0	<2.0	12.0	<1.0	470.0	2,000.0
3/1/74	<1.0	<10.0	27.0	1,100[c]	<2.0	<2.0	<0.1	<1.0	<5.0	37.0
3/27/74	<1.0	<10.0	23.0	1,200[c]	<2.0	<2.0	<0.1	<1.0	<5.0	14.0
4/23/74	<1.0	10.0	1.0	5,000[c]	<2.0	<2.0	3.0	<1.0	<5.0	2.0
5/7/74	<1.0	<10.0	5.0	4,400[b]	<2.0	<2.0	2.1	<1.0	<5.0	2.0
6/4/74	<1.0	<10.0	<1.0	2,700[b]	<2.0	120.0	1.0	<1.0	<5.0	9.0
7/2/74	<1.0	10.0	15.0	1,900[b]	<2.0	120.0	5.0	12.0	820.0	2.0
8/1/74	5.0	70.0	<1.0	3,600[b]	<2.0	220.0	2.0	55.0	1,380.0	22.0
9/3/74	15.0	73.5	17.5	40,500[b]	<2.0	995.0	1.8	54.0	300.0	58.0
10/3/74	12.0	42.0	3.0	11,300[b]	<2.0	190.0	0.5	40.0	400.0	5.0

[a] Station location is above intake structure location (see BMPR, Sect. 3.1, and ER Suppl., Fig. S2.4).
[b] Total iron.
[c] Soluble iron.
Source: BMPR, Sect. 3.6.

Phytoplankton

As stated in the FES (p. 2-13) the observed phytoplankton community of Allens Creek is dominated by diatoms (Bacillariophyceae) and green algae (Chlorophyta). Although the proportions of the taxa (FES, Table 2.3) shift according to season, the general species composition remains the same. Seasonal phytoplankton densities, however, fluctuate greatly where the numbers of organisms per liter show an increase from a winter low of approximately 8×10^2 cells per liter to a seasonal high of 5.3×10^6 cells per liter in mid-June. Species diversity in Allens Creek is inversely related to turbidity (BMPR, Fig. 3.3-2), and the species diversity increases somewhat near the confluence of Allens Creek with the Brazos River.

Macrophytes

No aquatic macrophytes have been reported in Allens Creek. A complete list of macrophyte species reported in the area or suspected to be prime invaders of the proposed cooling lake are given in the BMPR (Table 3.2-1).

Periphyton

Thirty-one species were found during this period which were numerically dominated by pennate diatom forms. Seasonal increases in periphyton biomass were positively correlated with higher light intensities and temperatures during the summer months. Blue-green algae appeared during the summer months but apparently did not become dominant. Quantitative data on all species reported is lacking; therefore, only presence-absence data can be compared for the whole community. Due to water turbidity and stream shading, Allens Creek is not expected to sustain a large standing crop of periphyton, except possibly in scattered pools during intermittent low-flow periods (ER, p. 2.7-14A).

Zooplankton

Zooplankton community composition by major taxa for Allens Creek is approximated in the FES (Table 2.4). Rotifer and crustacean zooplankton exhibited alternate numerical dominance during the course of the sampling year and only on occasion did the crustacean zooplankton become dominant as is characteristic of slower flowing creeks and streams.[8] Zooplankton densities over a yearly cycle ranged from normally less than 5 to 7 organisms per liter to as high as 150 to 200 organisms per liter in late May and early August respectively (BMPR, Figs. 3.3-5 and 3.3-7).

Benthic macroinvertebrates

A general discussion of the benthic macroinvertebrate fauna found in Allens Creek is given in the FES (p. 2-14). Subsequent to publication of the FES, additional data on benthic community composition has indicated that Allens Creek suffers light to moderate pollution except in riffle areas (BMPR, Sect. 3.4). Low dissolved-oxygen conditions and associated physical-chemical changes are postulated as factors that control community development. Most of the benthos collected are characterized as being pollutant tolerant.[9] As stated in the BMPR (p. 3.4-42) and the FES (p. 2-14), macroinvertebrate growth in Allens Creek is probably limited by the lack of suitable bottom substrate due to the intermittent-flow regime.

Adult and juvenile fish

The BMPR (Sect. 3.5) reports fish data from only four sampling dates during the year: November 1973, February 1974, June 1974, and September 1974. The Allens Creek fish community is composed of mosquitofish, other cyprinids, centrarchids, and ictalurids. A total of 36 species of fish have been reported and are listed in the BMPR (Table 3.5-4) with the general taxa-abundance distribution pattern shown in the FES (Table 2.6). From the initial November 1973 fish collection reported in the FES, winter sampling revealed an increase in both the number of species present and in the total number of individuals caught. The numbers of individuals collected decreased during the spring sampling period. The summer data revealed a drastic decline in number and diversity of species and individuals near the Allens Creek confluence with the Brazos River and showed an increase in fish numbers dominated by mosquitofish in areas upstream of the stream mouth (BMPR, Tables 3.5-6 and 3.5-8). The summer fish community is probably controlled by water-level fluctuations and limiting environmental variables, such as dissolved oxygen (BMPR, Sect. 3.6). Many of the species collected are habitual small-stream dwellers and complete their life cycle within Allens Creek. Other species (e.g., channel catfish) collected primarily near the confluence of the Brazos River utilize small tributaries as spawning habitat and nursery grounds. Fish found in a breeding condition in Allens Creek were gizzard shad, river carpsucker, carp, channel and blue catfish (spent females) (BMPR, p. 3.5-34). However, due to the general low number of ripe individuals collected (BMPR, p. 3.5-64), it is concluded that Allens Creek does not appear to be a major spawning area for Brazos River fish, although it may function in this capacity to a limited degree. Deeper portions of Allens Creek near its confluence with the Brazos River may be used as a nursery area for juvenile fish spawned in Allens Creek, as may be the case for the river carpsucker. Trophic relationships within the fish community of Allens Creek and with other biological components are given in the BMPR (Fig. 3.5-2). Stomach analysis revealed that freshwater shrimp (*Palaemonetes kadiakensis*), hydropsychid caddisflies (*Tricoptera*), mayfly numphs (*Ephemeroptera*) and small cyprinids and poeciliids comprise the major food items for adult fish (BMPR, p. 3.5-30). Parasitism of adult fish did not appear to be significant during the sampling period.

Larval fish

Mosquitofish (*Gambusia affinis*) were the most common larval fish collected in Allens Creek. Although other larval fish species were collected during the spring and summer sampling periods, only a relatively low number of individuals was observed (BMPR, p. 3.5-35).

S.2.4.2.2 Brazos River

The FES (pp. 2-15 to 2-18 and Sect. 2.5.3) presents a general description of the Brazos River watershed and habitat near Allens Creek and discusses general surface-water quality for the Brazos River. Yearly water-quality data presented in Table S.2.6 show that the concentrations of heavy metals vary seasonably.

Macrophytes

The Brazos River is known for its unstable bottom and relative lack of aquatic macrophyte development (BMPR, p. 3.5-22). Of these species found in the Brazos River, only arrowhead (*Sagittaria* sp.) is considered common (BMPR, Appendix B, Table 3.2-1).

Periphyton

Periphyton in the Brazos River were collected primarily from three limb scrapings. Twenty-five species of the benthic algae were identified during the year-long survey (BMPR). These were numerically dominated by pennate diatoms. The periphyton community consisted of pennate diatoms

(Bacillariophyceae, 13 species), centrate diatoms (Bacillariophyceae, 2 species), green algae (Chlorophyta, 5 species), and blue-green algae (Cyanophyta, 5 species). According to the BMPR, most diatom densities are relatively constant in the Brazos River throughout the year. Blue-green algae are evident only during the summer and fall months. Green algae species were not observed until April during the survey. The low number of organisms found indicate a relatively poor periphyton habitat in the Brazos River, probably due to the shifting substrate environment and poor shoreline stability.

Phytoplankton

A general description of phytoplankton community composition in the Brazos River is given in the FES (pp. 2-15 and 2-16). Phytoplankton density was maximal in September, with total concentrations varying between 8×10^2 cells per liter to 5×10^7 cells per liter from winter to summer. Phytoplankton diversity is inversely proportional to turbidity and rate of flow in the Brazos. During periods of low turbidity and low flow, diversity increases and a more truly planktonic phytoplankton association is evident in the river. During periods of high flow, (presumably) meroplankton consisting primarily of diatoms dominates the phytoplankton.

Zooplankton

The general zooplankton taxa distribution found in the Brazos River is given in the FES (Table 2.8). The depression of crustacean zooplankters in favor of rotifer populations is characteristic of large rivers. Zooplankton population densities were found to decline through the winter months and remain low during the spring. An increase in zooplankton density was observed through August and September, and a decline reappeared in October (BMPR, p. 3.3-28).

Benthic macroinvertebrates

A general description of the Brazos River benthic macroinvertebrates and their approximate distribution is given in the FES (Table 2.9). The observed benthic community is characteristic of a moderately polluted, low-gradient stream. The oligochaete *Ophiderais serpetina* is numerically dominant in the Brazos below its confluence with Allens Creek, and several species of chironomids (Diptera) are numerically dominant above this area. Species diversity is difficult to estimate in the Brazos River due to the low number of benthic organisms collected. The Brazos is generally characterized by a shifting sand substrate, which presents poor habitat for the benthic community and highly fluctuating benthic community with both species and numbers fluctuating inversely with the yearly flow-velocity regime.

Adult and juvenile fish

A description of the Brazos River adult fish community is given in the FES (p. 2-17). Thirty-one species were eventually identified during the one-year sampling period (BMPR, Sect. 3.5). Catch-per-unit-effort data indicate that relatively low numbers of sport fish exist in the river. Three sport fishes were found, all catfish (blue, channel, and flathead). Fish shelter in the Brazos is provided primarily by fallen trees, tree roots from shore, and their detrital accumulations. The distribution of these shelter areas is sparse, and the majority of the benthic area is intermittently scoured during high-flow periods. Spawning habitat is found in areas of fast water over gravel substrate. Such areas exist both upstream [at a distance somewhat greater than 500 m (1640 ft)] of the proposed intake location and downstream of the proposed cooling lake discharge. A large number of red shiners in breeding condition were collected below the outfall area in the spring. As water levels rise in the Brazos River during late spring and early summer, inundated vegetation also becomes available as spawning habitat for minnows. Such an area exists approximately 500 m (1640 ft) above the proposed intake location. Juvenile fish (primarily shiners) were observed in this area during the summer. Young-of-the-year fish, consisting of gizzard shad and various shiners (*Notropis* spp.) were also found in eddies and in slower water near the river shore. Stomach analyses of Brazos River fish indicate that aquatic insects are the principal food; occasional cyprinids are also found in the stomach contents. Parasitism in adult fish was not considered significant during the sampling period. An evaluation of the Brazos River recreational fishery shows it to be of poor yield (FES. p. 2-17).

Larval fish

Larval fish collected in the Brazos River riffle areas include those of spotted gar, flathead catfish, and various cyprinids. In slower current stretches over gravel substrate, early juvenile stages of channel catfish and river carpsucker have been collected during routine fish sampling using seines (0.32 cm mesh size). No special ichthyoplankton data using fine mesh net collection are reported.

REFERENCES FOR SECTION S.2

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3. U.S. Department of Agriculture, Soil Conservation Service, *Land Inventory and Monitoring Memorandum TX-5, Re: Prime and Unique Farmlands*, Temple, Texas, Jan. 31, 1977.

4. James M. McGuire, Area Conservationist, Soil Conservation Service, letter to Dr. Robert M. Reed, Dec. 2, 1977, Docket No. 50-466.

5. U.S. Department of the Interior, Fish and Wildlife Service, "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42: 36420-31 (1977).

6. Texas Organization for Endangered Species, *TOES Watch List of Endangered, Threatened, and Peripheral Vertebrates of Texas*, Publication 1, Temple, Texas, 1975.

7. R. Arbib, "The Blue List for 1977," *Am. Birds* 30: 1031-39 (1976).

8. H. B. N. Hynes, *The Ecology of Running Water*, University of Toronto Press, 1970.

9. C. I. Weber, *Biological Field and Laboratory Methods for Measuring the Quality of Surface Water Effluents*, EPA-670/4-73-001, Environmental Protection Agency, U.S. Environmental Research Center, Office of Research and Development, Cincinnati, Oh., 1973.

S.3. THE STATION

Changes in various components of the station design were necessitated by the reduction in generating capacity from two 1200-MW units to one 1200-MW unit, by the promulgation of new regulations, and by technological advances in design engineering concepts. Basically, design changes in the components of the heat-dissipation system included reducing the size and configuration of the cooling lake (Fig. S.3.1), the size of the circulating-water intake structure and the discharge canal, and the size of the makeup-water intake in order to accommodate smaller flows; thus, these design changes are directly associated with the reduction in project scope to a one-unit station. Flows in the circulating-water intake and discharge canal are reduced from 107 to 55 m^3/sec (3780 to 1940 cfs); details of plant water use requirements are depicted in Fig. S.3.2. Moreover, the makeup-water requirement from the Brazos River is reduced from 90,000 to 30,000 acre-ft/year. Other station design changes, such as changes in the radwaste, sanitary-waste, and chemical- and biocide-waste systems, are essentially due to the promulgation of new regulations and technological advances.

The external appearance of the proposed Allens Creek station also changes considerably. Figure S.3.1 shows the arrangement of the structures which are now found on a correspondingly smaller plant island. Notable in this figure are (1) the reduction in the surface area of the cooling lake from 3339 to 2072 ha (8250 to 5120 acres); (2) the omission of the 100-m (328-ft) stack; and (3) the emergence of the cylindrical domed containment structure as the dominant structure in the complex. The reactor and steam-electric system consists of one (instead of two, as called for in the original design) General Electric boiling-water reactor (BWR-6), a turbine generating unit, a heat dissipation system and associated equipment; this system is essentially the same system as that described in the FES (Sect. 3.2).

Detailed descriptions of the station design, which in most cases is a scaled-down version of the original design, are included in the following sections.

S.3.1 HEAT DISSIPATION SYSTEM

The ACNGS, Unit 1, will employ an open-cycle cooling system to remove the excess heat from the main condenser and other related cooling systems (see FES, Sect. 3.4, for design of original heat dissipation system). Condenser cooling water will be withdrawn from a newly constructed cooling lake (Fig. S.3.3); will be circulated through the various cooling systems, whereby its bulk temperature will increase 10.8°C (19.5°F) above the inlet temperature; and then will be discharged into the cooling lake via a discharge canal to complete the cycle. Makeup water in the cooling lake to replace evaporative losses and to maintain water quality will be derived from precipitation in the form of direct rainfall and runoff in the Allens Creek watershed and from water pumped from the Brazos River. To help minimize the amount of suspended material flowing into the cooling lake, makeup water pumped from the Brazos River will flow through a sedimentation basin before entering the lake. The discharge from the cooling lake will be returned to the Brazos River via a spillway.

S.3.1.1 Makeup-water pumping station

The makeup-water pumping station, which will deliver water to the sedimentation basin of the cooling lake, will be located as shown in Fig. S.3.3. The intake structure has been designed as a shoreline intake in contrast to earlier designs that included a 152-m (500 ft) approach canal. As Fig. S.3.4 shows, the intake structure consists of two intake bays, with each bay housing a 2.3-m^3/sec (82.4-cfs or 37,000-gal/min) pump. Each bay is also fitted with trash racks and fine screen guides. (Although guides for fine screens will be installed, fine screens will not be installed).

Makeup water for the cooling lake will be withdrawn from the Brazos River at an annual rate of 3.7×10^7 m^3 (30,000 acre-ft) during either a three-month or a six-month period (ER Suppl., Sect. S3.4.2.2.3). Although the logic for using either pumping scheme is based on ecological considerations, the applicant is not under contractual obligation to use any particular pumping scheme (FES, Sect. 5.2.1). To withdraw makeup water uniformly over the various pumping periods, both pumps must be employed for the three-month period, whereas only one pump is required for

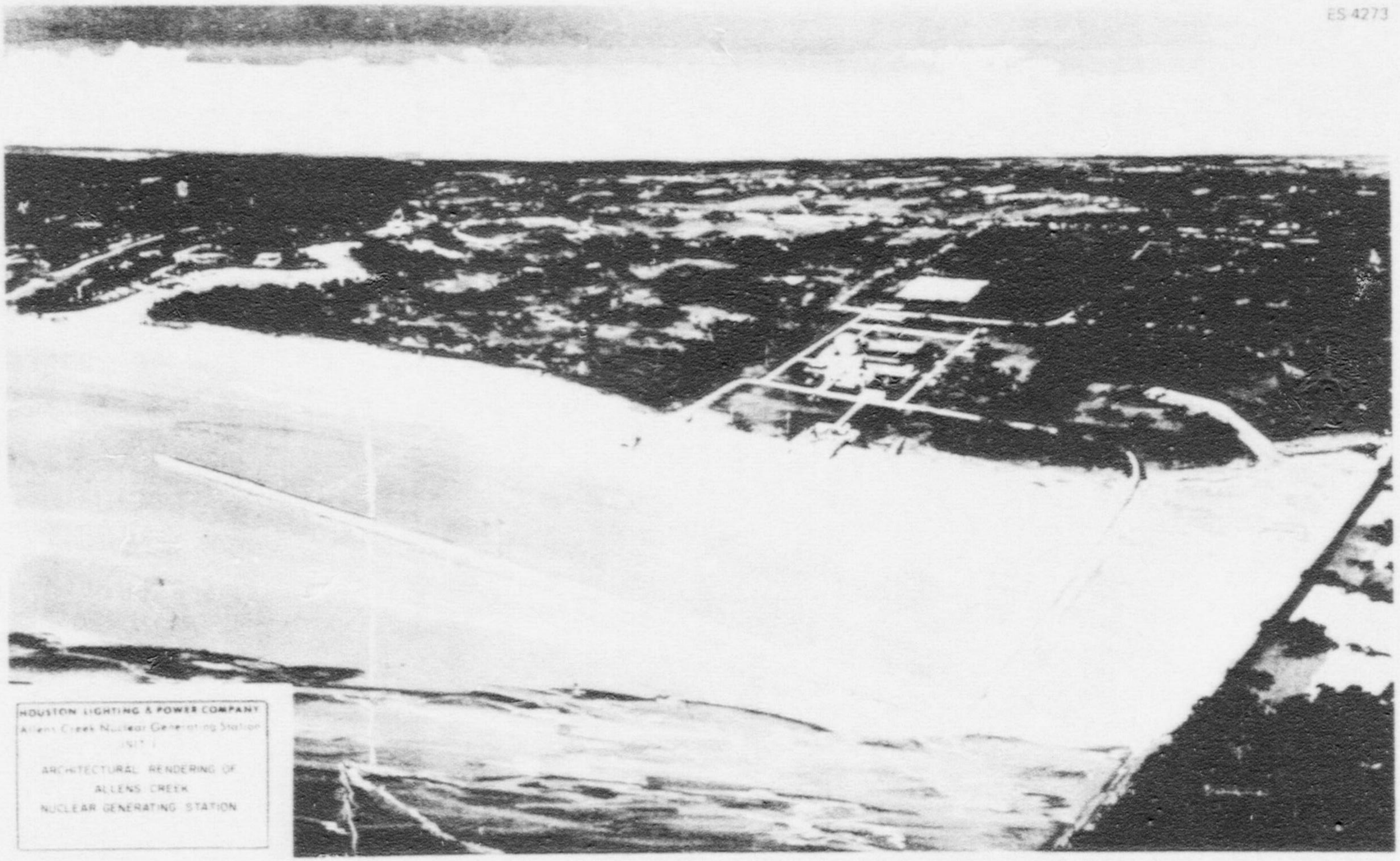

Fig. S.3.1. Allens Creek Nuclear Generating Station site. Source: ER Supplement, Fig. S3.1-1.

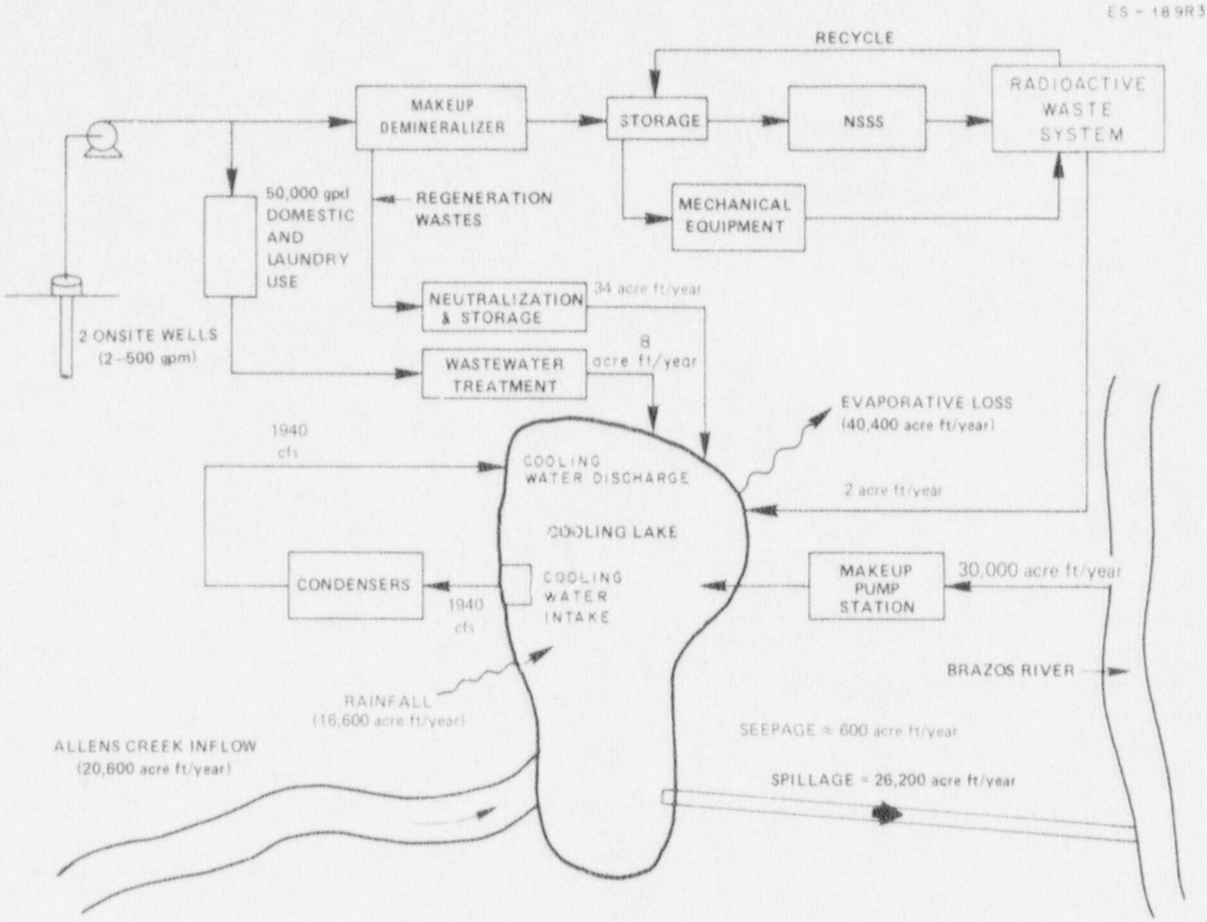

Fig. S.3.2. Predicted water use at Allens Creek Nuclear Generating Station. (Note: 1 cfs = 450 gpm = 725 acre-ft/year.) Source: FES, Fig. 3.3 (modified); and ER Supplement, Fig. S3.3-1.

six-month period. In any event, for both pumping schemes, the staff has estimated that [based on a Brazos River elevation of 70 ft above mean sea level (MSL)] the approach velocity of water entering the intake will be 17.7 cm/sec (0.58 ft/sec). This value of the approach velocity is in accord with the values given in the ER Supplement (Fig. S3.4-6).

S.3.1.2 Allens Creek cooling lake

Figure S.3.3 shows the present design of the cooling lake. Major changes from the previous design include a reduction in cooling lake area from 3339 ha [8250 acres (a 7600-acre effective cooling area)] to 2072 ha [5120 acres (a 4800-acre effective cooling area)]; the addition of a compacted-earth dam along the northern lake perimeter; a reduction in the size of, and a change in the configuration of, the sedimentation basin; and a reduction in the length of the diversion dike from 6035 to 4206 m (19,800 to 13,800 ft). The baseline description of the cooling lake area is otherwise accurately described in the FES (Sect. 3.4.3).

When the external dam is extended to include the northern as well as the eastern lake perimeter, the compacted-earth dam will be 8687 m (28,500 ft) long and will form a barrier for about 50% of the lake perimeter (the remaining western and southern perimeters will consist of natural boundaries). The crest of the dam will remain at a constant elevation of 40.4 m (132.5 ft) above mean sea level (MSL) (refer to ER [illegible]., Sect. S3.4, for details). Moreover, the northern portion of the dam reduces the periphera[illegible] [illegible]chment area that will drain directly into the cooling lake from 33.4 to 13 km^2 (12.9 to 5 sq miles). Hence, the applicant plans to construct a drainage channel along the northern section of the external dam to intercept the runoff not draining into the lake due to the extension of the dam (ER Suppl., Sect. S2.5.1.1). Thus, runoff in areas contiguous to portions of the dam located above the spillway will be intercepted by the drainage channel and conveyed to the spillway, which discharges into the Brazos River.

Fig. S.3.3. Allens Creek Nuclear Generating Station cooling lake. Source: ER Supplement, S2.1-2 (modified).

The area and capacity curves for Allens Creek cooling lake are shown in Fig. S.3.5; the area curve does not include the 77-ha (190-acre) sedimentation basin area until the water level is greater than 36.6 m (120 ft) MSL. As in the previous designs, the sedimentation basin will be equipped with a separate piping system and overflow weir (ER Suppl., Sect. S3.4.2.2.4). Figure S.3.3 shows the location of the basin. The method of construction of the dikes that form the sedimentation basins remains unchanged (FES, Sect. 3.4.3).

The design of the cooling lake spillway and connecting discharge canal has not changed significantly from the previous design, except for the replacement of the low-level outlet pipe with a 1.8- by 1.8-m (6- by 6-ft) tunnel. The low-level outlet will permit discharge of water into the spillway when the cooling lake water elevation is below 36 m (118 ft) MSL.

S.3.1.3 Circulating-water system

The circulating-water intake structure and discharge canal for the station cooling system will be located as shown in Fig. S.3.3. The circulating-water intake structure will consist of four intake bays, each consisting of four intake cells. The intake cells of each bay will discharge into a common plenum which houses a 12.9-m^3/sec (455.5-cfs) circulating-water pump. Each intake cell will be fitted with trash racks, conventional vertical traveling screens, and fine screen guides (although guides will be available for fine screens, the fine screens will not be installed). As Fig. S.3.6 shows, cooling water will enter each intake cell through a trash rack and then through a traveling screen of 0.95-cm (3/8-in.) mesh before entering the pump for

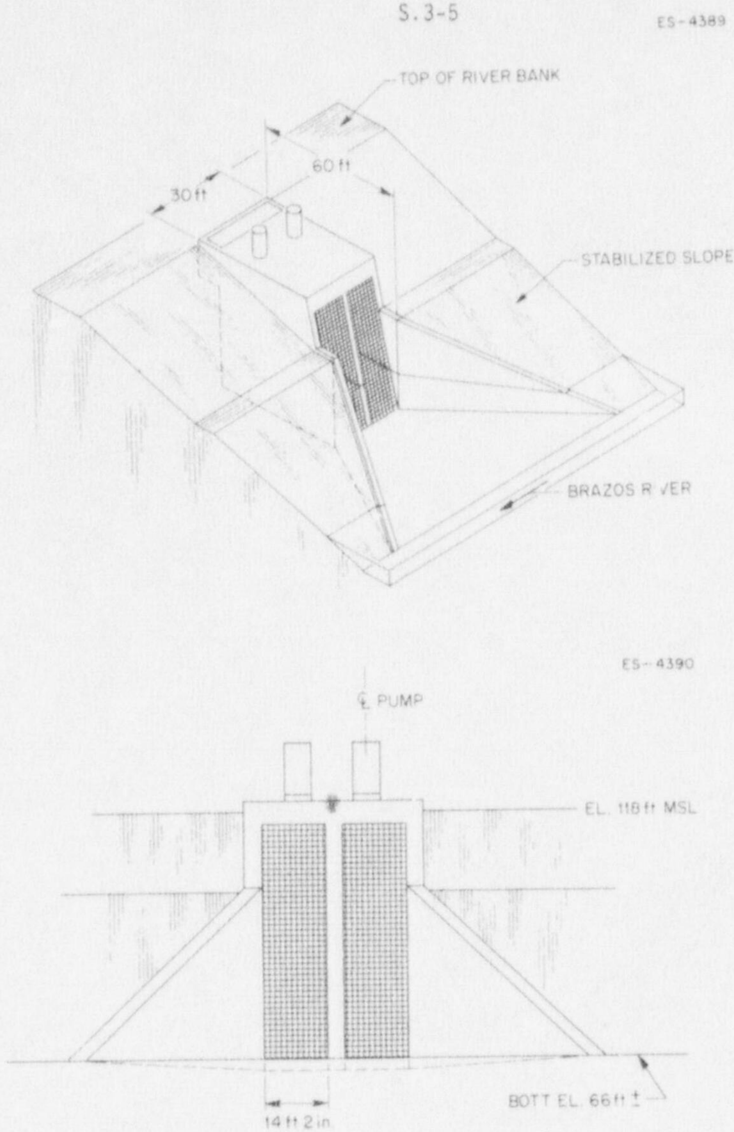

Fig. S.3.4. Makeup intake structure plan and section view. Source: ER Supplement, Fig. S3.4-5.

transmission to the turbine building. The trash racks are designed to prevent large objects, such as logs, from entering the intake structure, whereas the traveling screens are designed to stop most of the small debris and fish. The overall width of the intake structure (measured across the face) will be 62.8 m (206 ft) with each cell having a channel width of about 3.1 m (10.2 ft). Provisions are not made as in the original design for the parallel fish pass (or a window placed in each cell wall immediately behind the trash rack).

The applicant has estimated that during plant operation the cooling lake water level will be greater than 34.4 m (113 ft) MSL at least 95% of the time (refer to Fig. S.3.6). Moreover, the plant will be shut down at lake surface elevations of 33 m (108 ft) MSL and below, for which a decrease in lake surface area takes effect (Fig. S.3.5). Accordingly, the staff's estimates of the intake velocities for selected reservoir levels are given in Table S.3.1.

The condenser cooling water will flow from the circulating-water pumps to an intake block for passage to the ACNGS, Unit 1, condenser via two 3-m (10-ft)-diam concrete pipelines. Upon passage through the main condenser and other cooling systems at a flow rate of about 52 m^3/sec (1823 cfs), the cooling water will absorb 2344 MWt (8.0×10^9 Btu/hr) of waste heat at rated plant capacity, thus increasing the cooling-water temperature by 10.8°C (19.5°F). Then the

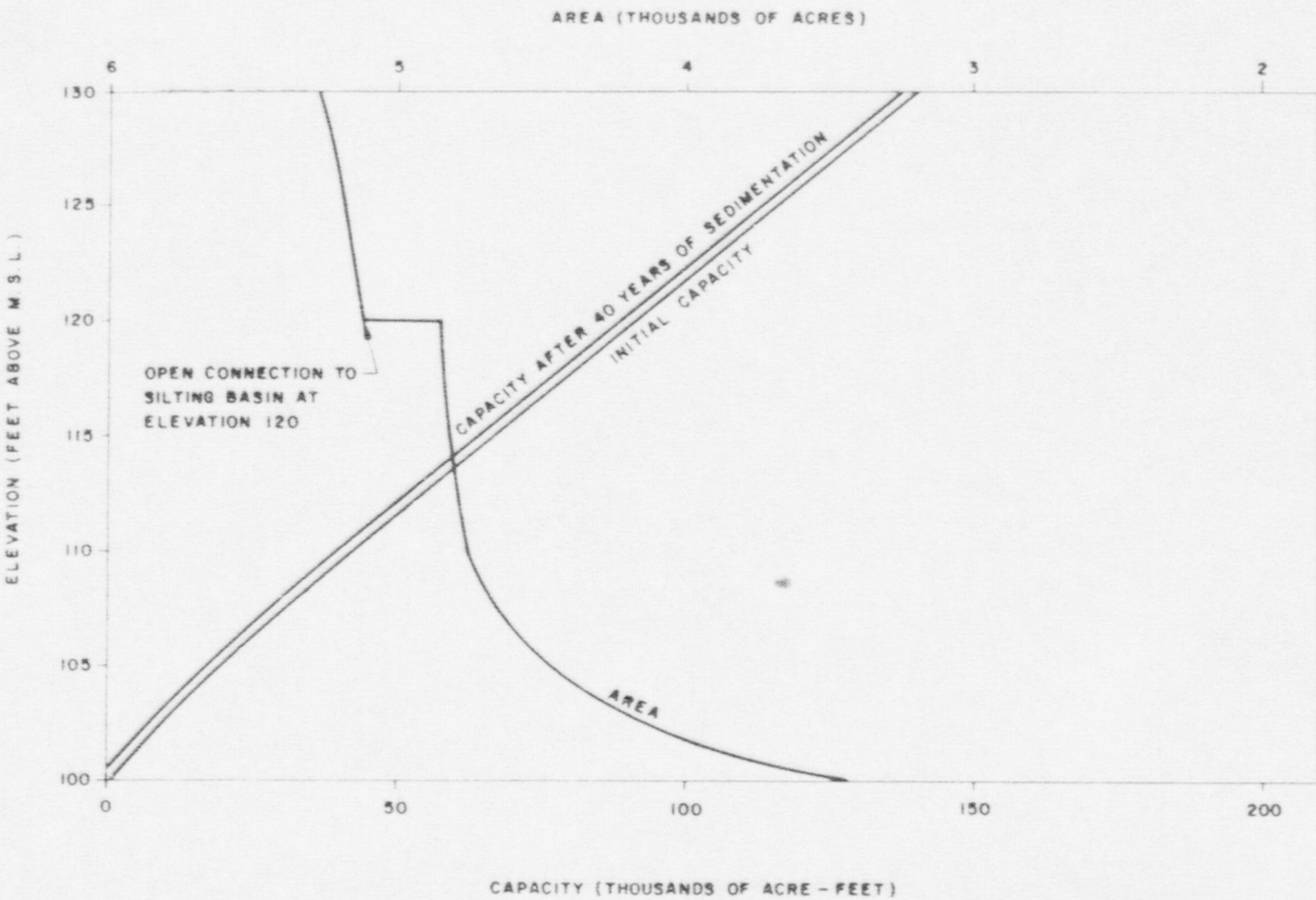

Fig. S.3.5. Area capacity curve of Allens Creek cooling lake. Source: ER Supplement, Fig. S3.4-2.

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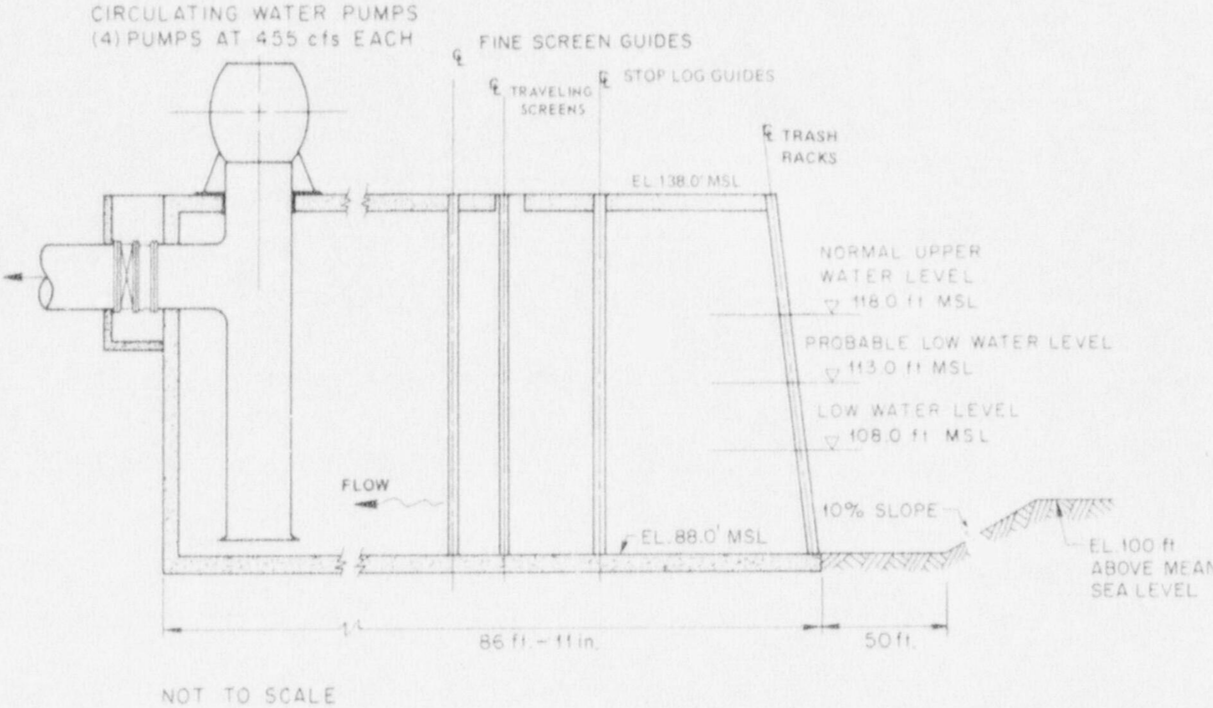

Fig. S.3.6. Circulating-water intake structure: typical cross section. Source: ER Supplement, Fig. S3.4-10 (modified); and Ebasco Services Incorporated, *Allens Creek Nuclear Generating Station Engineering Report*, report prepared for Houston Lighting and Power Company in support of an application to the Texas Water Quality Board, December 1973.

Table S.3.1. Staff's estimates of water velocities in the circulating-water intake structure[a]

Location	Water velocity [cm/sec (ft/sec)] at various cooling lake water levels		
	33m (108 ft)	34.4m (113 ft)	36m (118 ft)
Approaches to intake bays[b]	18.2 (0.60)	14.5 (0.48)	11.8 (0.39)
Through trash racks[c]	20.0 (0.65)	15.9 (0.52)	13.0 (0.43)
Through traveling screens[d]	41.4 (1.36)	32.9 (1.09)	27.0 (0.88)

[a] Based on total intake flow of 1940 cfs (see Fig. S.3.2).
[b] Based on combined channel widths of intake bays.
[c] Based on a 9% reduction in channel area by trash racks.
[d] Based on a 56% reduction in channel area by traveling screens.

heated water will be discharged in two 3-m (10-ft)-diam conduits through a seal well into the cooling-water discharge canal. The total residence time of the circulating water from the intake inlet to the seal well outlet will be about 403 sec.

Figure S.3.7 shows a cross-sectional view of the circulating-water discharge canal. The structure will be about 61 m (200 ft) wide and 549 m (1800 ft) long. The canal floor will be sloped in the streamwise direction from an elevation of 36 m (118 ft) MSL at the seal well to 35.7 m (117 ft) MSL at the point of discharge into the lake. This design concept contrasts with the originally planned design (ER, Fig. 3.4-8) in which the canal floor was sloped from an elevation of 31.7 m (103.9 ft) MSL to 31.4 m (103 ft) MSL. On the basis of a circulating-water flow rate of 55 m^3/sec (1940 cfs) and on the assumption of critical flow at the canal outlet, the staff has estimated a mean discharge velocity of 1.9 m/sec (6.3 ft/sec).

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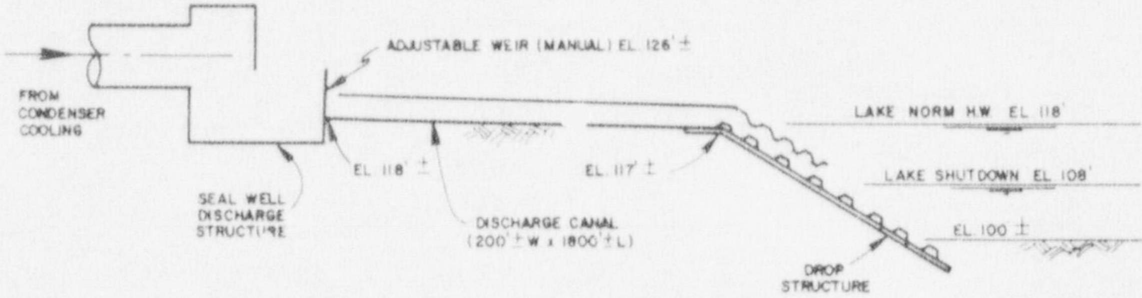

Fig. S.3.7. Circulating-water discharge-canal cross section. <u>Source</u>: ER Supplement, Fig. S3.4-13.

S.3.2 RADIOACTIVE WASTE SYSTEMS

In Part 50.34a of Title 10 of the *Code of Federal Regulations*, an applicant for a permit to construct a nuclear power reactor is required to include a preliminary description of the design of equipment to be installed for keeping levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology and the economics of improvement in relation to benefits to the public health and safety and other societal and socioeconomic considerations and in relation to the utilization of atomic energy in the public interest. Appendix I to 10 CFR Part 50 provides numerical guidance on design objectives for light water-cooled nuclear power reactors to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept as low as is reasonably achievable.

To meet the requirements of 10 CFR Part 50.34a, the applicant has provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable within the requirements of Appendix I to 10 CFR Part 50 and the requirements of the Annex to Appendix I dated September 4, 1975, elected in lieu of performing a cost-benefit analysis as required by Sect. II.D of Appendix I. In addition, the applicant has provided an estimate of the quantity of each principal radionuclide expected to be released annually to unrestricted areas in liquid and gaseous effluents produced from normal operation including anticipated operational occurrences.

The staff's detailed evaluation of the radwaste system and the capability of these systems to meet the requirements of Appendix I are presented in Chapter 11 of the *Safety Evaluation Report*. The quantities of radioactive material calculated by the staff to be released from the plant are also presented in Chapter 11 of the *Safety Evaluation Report* and in Sect. S.5.4 of this Environmental Statement with the calculated doses to individuals and the population that will result from these effluent quantities.

At the time of the operating license, the applicant will be required to submit Technical Specifications which will establish release rates for radioactive material in liquid and gaseous effluents and which provide the routine monitoring and measurement of all principal release points to assure that the facility operates in conformance with the requirements of Appendix I to 10 CFR Part 50.

S.3.3 NONRADIOACTIVE WASTE SYSTEMS

S.3.3.1 <u>Wastes containing chemicals or biocides</u>

The operation of ACNGS will result in chemical wastes that will be discharged into the cooling lake and will eventually reach the Brazos River. The chemical wastes result from the concentrating effect on the dissolved solids in the river water as a result of evaporation in the cooling lake and from the addition of chemicals to the various systems during reactor operation.

A summary of chemicals discharged to the environment and a partial water analysis of makeup water from the Brazos River are presented in Table S.3.2. The relative magnitude of the chemical input to the environment may be judged from this table. It should be noted that the incremental increases in chemical concentrations of these effluents in the Brazos River are, in general, within a few percent of the values given for operation of the originally proposed two-unit station (FES, Table 3.9).

Table S.3.2. Increase in chemical concentration of effluents in Brazos River due to cooling lake concentration

Chemical parameter	Maximum concentration in Brazos River at site[a]	Maximum concentration in cooling lake[b]	Incremental increase in Brazos River[c]
	(ppm)		
Biological oxygen demand	4	8	0.9
Chemical oxygen demand	39	78	8.3
Dissolved oxygen (DO)	7.6		
Sulfate (SO_4^{2-})	71	142	15.1
Chloride (Cl^-)	81	162	17.3
Nitrate (NO_3^-)	0.97	1.9	0.2
Phosphate (PO_4^{3-})	9.6	19.2	2.1
Total dissolved solids (TDS)	681[d]	1362	145

[a] Information based on ER, Table 2.5-3, and FES, Table 3.9.

[b] Based on 2.0 concentration cycle.

[c] Based on 147 cfs spillage flow and 542 cfs Brazos River flow (ER Suppl., Table S3.6).

[d] Dames and Moore, Inc., *Biological Monitoring Program Progress Report: Allens Creek Nuclear Generating Station Site*, for Houston Lighting and Power Company, Docket Nos. 50-466 and 50-467 (March 1, 1974).

S.3.3.1.1 Circulating-water system

To prevent excessive biological fouling in the circulating-water system, chlorine will be injected periodically into the inlet cells of the circulating-water intake structure. The system will be designed to provide two 15-min shock doses per day to the circulating water (55 m^3/sec or 1940 cfs) with doses ranging up to 7 ppm; therefore, the total dosage of chlorine to the system (based on maximum concentrations) will be approximately 692 kg/day (1525 lb/day). The applicant estimates that these doses will be sufficient to maintain the design value of 0.2 ppm of free residual chlorine at the condenser discharge block (ER Suppl., S3.6.3).

In contrast to the design constraints of the one-unit station (0.2 ppm of free chlorine downstream of the condenser), the two-unit station was designed to maintain a free residual chlorine concentration of 0.1 ppm at the condenser discharge block. Additionally, the chlorination system for the two-unit operation was designed for alternate chlorination of each unit, thus (during simultaneous operation) providing for dilution of the chlorinated water with the unchlorinated circulating water while the water would be in the seal well, thereby precluding the discharge of free available chlorine. The mixing of chlorinated and unchlorinated discharges would also reduce the total residual chlorine concentration. However, with the installation of a one-unit station as presently designed, these dilution techniques are no longer achievable.

S.3.3.1.2 Nonnuclear regenerative waste

Makeup water for the nuclear steam supply system (NSSS) will be provided by demineralizing well water. After presedimentation, well water will be pumped at a rate of 581 liters/min (150 gal/min) through the demineralizer trains where regeneration will occur with the addition of NaOH and H_2SO_4. This process will result in the generation of waste at amounts of 114 m^3/day (30,000 gal/day) for normal operation to 261 m^3/day (69,000 gal/day) for maximum design flow. Figure S.3.8 presents a flow diagram of the demineralizer waste treatment system. The applicant states that the system will be designed to assure compliance with Federal Chemical Effluent Limitations Guidelines and with the Texas Water Quality Board's Heavy Metals Board Order.

It is estimated that neutralization of the normal flow will require the addition of approximately 91 kg (200 lb) of lime [$Ca(OH)_2$] per day and approximately 181 kg (400 lb) of lime per day at maximum flow (ER Suppl., Sect. S3.6.6). As Fig. S.3.8 shows, these wastes will be discharged to the cooling lake during normal operation at a rate of 75 gal/min for about 6 hr per day.

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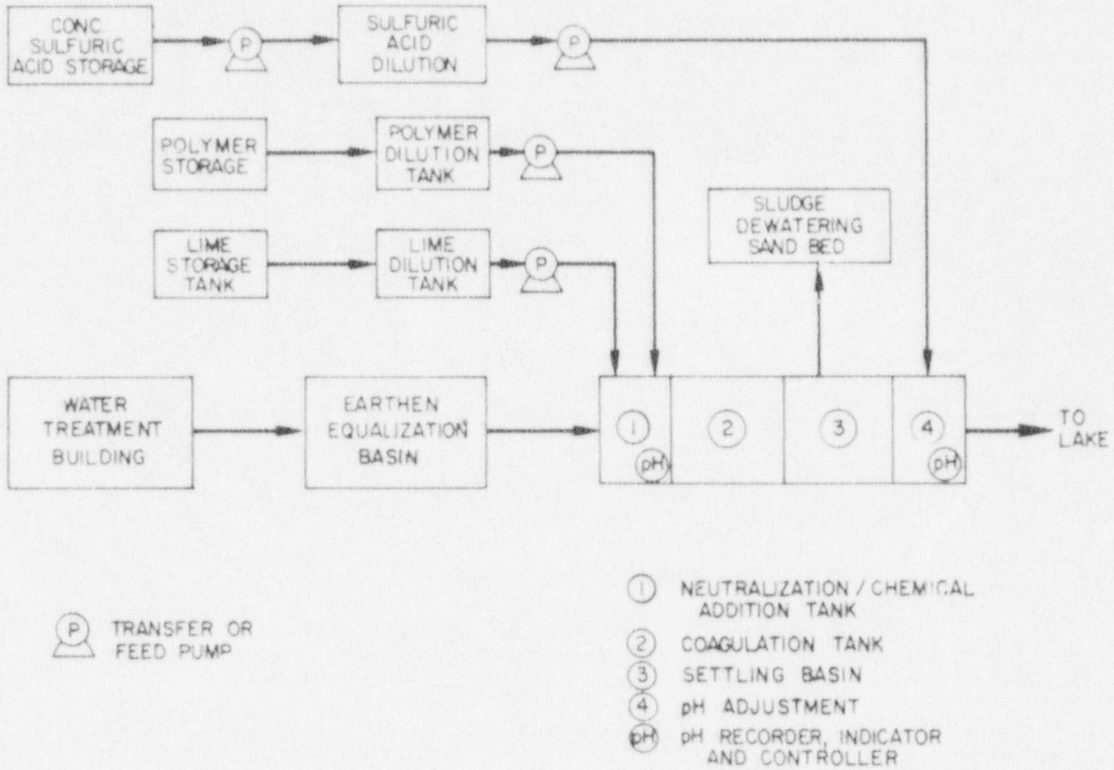

Fig. S.3.8. Flow diagram of the demineralizer waste treatment system. Source: ER Supplement, Fig. S3.6-1.

S.3.3.2 Sanitary system wastes

The design of the permanent sanitary waste treatment system for the two-unit station was based on the anticipated wastewater loadings resulting from the maximum plant population (1[illegible] persons) required to operate and maintain the plant (FES, Sect. 3.7). It is noted, however, that for the present system, the applicant has adopted a concept that includes a design basis for both the construction-stage and operational-stage populations. A contact-stabilization activated-sludge system with effluent filtration and chlorination will be installed for the treatment of sanitary waste during construction, and during the operation stage this system will be converted to an extended-aeration activated-sludge system with effluent filtration and chlorination. The treated wastewater from the treatment plant will be discharged to Allens Creek during the construction stage, and to the circulating-water discharge canal (and then to the cooling lake) during the operating stage. These effluents will be required to meet all applicable water quality standards. The system will meet the requirements of the Texas State Department of Health.

S.3.4 POWER TRANSMISSION SYSTEMS

Several changes to the transmission system have been proposed as a result of the reduced generating capacity of ACNGS. The transmission routes now being planned are Route 1A, connecting Unit 1 to the W. A. Parish substation; and Route 2C, connecting Unit 1 to the new Obrien substation (Fig. S.3.9). Route 3 and that part of Route 2A that is being replaced by Route 2C will not be constructed.

The location of Route 1A remains essentially the same as described in the FES (Sect. 3.8). Some changes have been made in this route so that it will run through a less densely populated zone in the vicinity of Pleak.[1]

ES-183R

Fig. S.3.9. Transmission line routes. Source: ER, Fig. 3.9-1 (modified); and ER Supplement, Fig. S3.9-1 (modified).

The applicant plans to replace a portion of Route 2A with Route 2C, thus adopting the staff's recommendation (FES, p. 9-14) to reroute the transmission lines around the (original) cooling lake perimeter. Route 2C will run in a northerly direction for about 5.3 km (3.3 miles), will turn ENE for about 8.0 km (5.0 miles) crossing the Brazos River, and will then intersect the originally proposed Route 2A, which it will follow to the Obrien substation (Fig. S.3.9). The line is approximately 46 km (28.5 miles) long and follows 18.5 km (11.5 miles) of existing 138-kV transmission lines at its eastern end. It crosses the Brazos River, Brazos Creek, several farm-to-market roads, and the Texas and New Orleans line of the Southern Pacific Railroad. The 345-kV line will be reduced from a double circuit to a single circuit along Route 2C as a result of the reduced generating capacity of ACNGS. Double circuit towers will be used along Route 1A, while single circuit towers will be used in the vicinity of the plant and along Route 2C. The applicant will follow the National Electric Safety Code in locating and constructing these transmission lines.

The Obrien substation will be built in conjunction with the construction of Unit 1 as originally planned, and the W. A. Parish substation will be expanded. The Addicks substation, which was originally planned as part of the Allens Creek distribution system, will no longer be required for that purpose, but will be built in 1980 or 1981 as part of the general system requirements of HL&P.

S.3.5 RAILROAD SPUR, ACCESS ROADS, AND PIPELINE RELOCATIONS

The construction of a railroad spur and access roads remains essentially unchanged from the description in the FES (Sect. 3.9). As a result of the reduction in size of the cooling lake, only one pipeline will need to be relocated. This 61-cm (25-in.) natural gas pipeline, owned by Texas Utilities Company, will be rerouted along the northeast side of the cooling dam for a distance of approximately 8.5 km (5.3 miles) (ER, Suppl., Fig. S2.1-4). The remaining pipelines described in the FES (Sect. 3.10) will not be affected by either the plant or the cooling lake.

REFERENCE FOR SECTION S.3

1. U.S. Nuclear Regulatory Commission, Affidavit of John A. Gill relative to transmission lines, (dated July 14, 1975) Docket Nos. 50-466 and 50-467.

S.4. ENVIRONMENTAL EFFECTS OF CONSTRUCTION

The environmental effects of constructing ACNGS as originally proposed (i.e., a two-unit station with a 3339-ha cooling lake) are described in Chapter 4 of the FES. This section of the Supplement to the FES describes the similar environmental effects of constructing ACNGS as now designed for a one-unit station with a 2072-ha cooling lake.

As described in Sect. S.3, the extension of the cooling lake dam to include the northern lake perimeter and a decrease in the number of structures associated with the station (such as the reactor, the turbine, and radwaste buildings, etc.) constitute the major changes in the station design. Accordingly, construction activities will be confined to correspondingly smaller portions of the site area, however, the estimated number of construction personnel is about 9.1% larger. Moreover, a reduction in the scope of the proposed project will cause a reduction in the associated environmental impacts. However, the nature of the impacts and their qualitative assessment have not changed.

S.4.1 IMPACTS ON LAND USE

Areas associated with construction activities for ACNGS, Unit 1, are shown in Fig. S.4.1. The property and adjacent areas, which are owned by the applicant, comprise approximately 4513 ha (11,152 acres). The applicant estimates that the area affected by construction will total about 2315 ha (5720 acres), including 243 ha (600 acres) for the nuclear reactor and its ancillary structures, and about 2072 ha (5120 acres) inundated by the cooling lake. An update of areas to be affected by various construction activities is shown in Table S.4.1 (compare with the FES, Table 4.1).

S.4.1.1 Station facilities

In general, the construction impacts described in Sect. 4.1.1 of the FES have been reduced as a result of the decreased size of the station and associated facilities. Changes to impacts previously described are (1) a 4% reduction (from 398,000 to 382,000 m^3) in volume of excavated material from the plant area, most of which will be used in the construction of the diversion dike; and (2) an increase in vehicular traffic to the site to more than 1800 vehicles per day, since the peak construction force has been increased by about 9.1%. Moreover, the ASLB has found that the applicant has satisfactorily conducted a review of the archaeological sites present on the property.[1] Archaeological Site 41AU36 was named to the National Register of Historic Places on March 21, 1975, as a result of a survey done by the Texas Archaeological Survey.[2] The Board has found that the applicant has complied with the requirements of the National Historic Preservation Act and the procedures of the Advisory Council on Historic Preservation, and that the impacts of construction on Site 41AU36 have been satisfactorily mitigated. Furthermore, the Board has stated that Condition 7b of the FES (see Appendix S.B in this Supplement) has been satisfied and is no longer required as part of the construction permit.[1]

S.4.1.2 Cooling lake

The Allens Creek cooling lake will have an effective cooling area of approximately 1942 ha (4800 acres) and will be formed by an earthen dam about 8687 m (28,500 ft) long constructed along the northern and eastern perimeters.

The dam will be approximately 10 m (32 ft) high, will be constructed of compacted-earth fill, and will be soil stabilized on the inside slopes and grass covered on the outside slopes. The borrow areas located along the inside dam walls (Fig. S.4.1) will cover approximately 271 ha (670 acres). All construction runoff will be directed to a series of sedimentation basins within the cooling lake basin. The staff requires that the provisions of 40 CFR Part 423 be incorporated in the design of the sedimentation basins. Normal procedures to minimize erosion during construction of the dam will be used (ER Suppl., Sect. S4.4.3.6.1).

The design of the diversion dike is consistent with that described in the FES (Sect. 4.1.2), but the length will be reduced to approximately 4206 m (13,800 ft). The dike will be

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Fig. S.4.1. Areas associated with construction activities at the Allens Creek Nuclear Generating Station site. Source: ER Supplement, Fig. S4.1-1 (modified).

Table S.4.1. Summary of areas affected by construction activities

Land use	Land area Ha	Land area Acres
1. Plant construction (includes parking lots, concrete mix plant, switchyard, and circulating water discharge canal)	61	150
2. Access roads and railroad spur	16	40
3. Construction facilities outside of direct impact area	24	60
4. Dam and interior dike	89	220
5. Borrow pits, heat sink, haul roads, and construction drainage basins (also included in No. 7)	405	1000
6. Spillway, makeup pumping station riverbank stabilization, and drainage land	53	130
7. Lake filling	2072	5120
Total onsite area affected[a]	**2315**	**5720**
8. Transmission line rights-of-way	749	1851
Total land area affected	**3064**	**7571**

[a] An additional 12 ha (30 acres) will be disturbed temporarily by relocation of the 61-cm (24-in.) natural gas pipeline.

approximately 8 m (26 ft) high and will be constructed of compacted earth and stabilized on both sides with riprap.

S.4.1.3 Agricultural impact

Development of ACNGS will directly remove an approximate 2315 ha (5720 acres) of potential agricultural land from production either by construction activities or by inundation of the cooling lake (Table S.4.1). An additional 259 ha (640 acres) will be set aside as a state park. The applicant has made no definite plans for the remainder of the Allens Creek property (about 1939 ha), but is holding it for unspecified future site development.

A lengthy discussion, held during the evidentiary hearings before the ASLB on the ACNGS, Units 1 and 2, construction permit application, concerned the impact of removing both the entire property and only that portion to be inundated by the cooling lake from agricultural production. On the basis of that discussion, the Board stated that the Allens Creek land is only of average productivity, cannot be considered prime farmland when compared to prime farmland in the Iowa-Illinois cornbelt, and has supported no crops which require either soil or climatic conditions unique to the area.[1] Furthermore, the Board stated that this land constituted a small to insignificant percentage of similar land available at the local, state and national levels.[1]

Since the ASLB hearings (1975), the Soil Conservation Service (SCS) has clarified the definition and criteria for recognition of prime and unique farmlands.[3,4] Using these criteria and the information available on soil capability classes present on the Allens Creek property,[5] the bottomlands have been tentatively identified by the applicant as prime farmlands, and the uplands as unique farmlands (ER Suppl., p. SH-60).

The SCS has rated the majority of soils occurring on the ACNGS property as either prime-1 or prime-2 farmlands (Sect. S.2.2.4). Based on the information provided by the SCS, the staff has determined that 1882 ha (4650 acres) of prime-1 farmland will be inundated by the cooling lake and associated structures, and 112 ha (277 acres) of prime-1 and prime-2 farmland and 36 ha (89 acres) of unique farmland will be affected by construction of the station and ancillary structures.

Estimated crop production from the Allens Creek property has been compared to projections of state and national production of similar crops at the ASLB hearings.[1,5,6,7] The Board found that agricultural productivity of the cropland on the site appeared to be above average for the local area (i.e., the five counties immediately surrounding the site) and only average for the State of Texas.[1] The frequency of flooding was estimated to decrease productivity to about 80% of its potential during a normal year. Table S.4.2 compares site crop production estimates (based on land use in 1972)[7] with the most recently available State and county production statistics. This comparison shows: (1) sorghum productivity is slightly below average for the local five-county region and slightly above average for the State; (2) corn productivity

Table S.4.2. Crop production estimates for Allens Creek (1972)[a], the five county region (1972–75),[b] and Texas (1972–75)[c]

Crop	Site	Five county region	Texas
Sorghum			
Yield, kg/ha	3,900	4,300	3,490
Range		4,210 to 4,730	3,260 to 3,770
Area, ha	1,170	68,260	2,587,000
Range		38,620 to 90,900	2,193,000 to 2,914,000
Production, kg × 10^3	4,570	293,500	9,037,000
Range		182,800 to 382,500	7,925,000 to 10,590,000
Corn			
Yield, kg/ha	3,500	4,320	7,520
Range		3,630 to 5,340	6,760 to 8,090
Area, ha	121	15,200	303,500
Range		13,190 to 16,960	186,200 to 445,200
Production kg × 10^3	430	65,620	2,284,000
Range		49,960 to 90,120	1,258,000 to 3,603,000
Cotton			
Yield, kg/ha	448	375	401
Range		242 to 456	301 to 483
Area, ha	40	33,680	1,872,000
Range		17,970 to 45,610	1,578,000 to 2,104,000
Production, kg × 10^3	18	12,640	750,100
Range		6,823 to 20,803	519,300 to 1,019,000
Hay			
Yield, kg/ha	5,600	5,770	5,070
Range		4,650 to 6,840	4,550 to 5,420
Area, ha	405	28,530	897,400
Range		22,220 to 33,140	777,000 to 971,200
Production, kg × 10^3	2,270	164,720	4,549,000
Range		127,730 to 211,830	3,537,000 to 5,269,000

[a] Estimates of yield, area, and production based on 1972 land use on the site; from *Supplemental Direct Testimony Re: Agricultural Impact of Allens Creek Project*, testimony of Dr. Phillip B. Hildebrand, Docket Nos. 50-466, 50-467.

[b] Five county region includes Austin County, Colorado County, Fort Bend County, Waller County, and Wharton County; estimates of yield, area, and production calculated from County Agricultural Statistics, Texas Department of Agriculture, Austin, Texas.

[c] Estimates of yield, area, and production for Texas calculated from data in *Agricultural Statistics*, U.S.D.A., 1975 and 1976.

is considerably below average for both areas; (3) cotton productivity is somewhat better than average for both areas and (4) hay productivity is average for the local area and above average for the State. Cattle and calf production are estimated at 225,000 kg (495,000 lbs) for the property.[7]

Although a detailed inventory of prime farmlands at the local, state, and national levels is not yet complete, it is estimated that 6.8 million ha (16.8 million acres) of prime farmland are present in Texas (ER, Suppl., p. SH-57). Using this figure, the area of prime farmland which would be removed from potential agricultural production during the lifetime of the ACNGS development is approximately 0.029% of the prime farmland in the state. There is little data available on the amount of unique farmland in the State of Texas. The majority of unique farmland in the Houston area is rice land. Assuming that the 36 ha (89 acres) of unique farmland to be lost were used for rice production, the area would represent 0.2% of the total area in Texas planted to rice in 1975.

In summary, the staff has found that (1) construction of the ACNGS and the cooling lake will directly remove 1994 ha (4927 acres) of prime farmland and 36 ha (89 acres) of unique farmland from potential agricultural use for at least the lifetime of the plant; (2) productivity of the site is average for most crops at the state and local levels; (3) the prime and unique farmland directly affected by construction of the station and inundation of the cooling lake represents a very small percentage of the total prime and unique farmland in Texas. The staff concludes from the foregoing analysis that development of ACNGS will have an insignificant impact on the total amount of prime farmland available in Texas, especially since the possibility of draining the cooling lake at some future time could result in at least partial recovery of the land for agricultural purposes.

S.4.1.4 Transmission lines

The transmission lines are described in Sect. S.3.4 and in the ER Supplement (Sect. S3.9). The total area that will be affected by transmission corridors is approximately 749 ha (1851 acres). The transmission tower bases will occupy about 3.2 ha (8 acres). Approximately 70% of the corridors (525 ha) is cropland, and about 30% (225 ha) is rangeland. About 68% of the total area through which the corridors will transverse is prime or unique farmland (ER Suppl., p. SH-57). No permanent access or service roads will be built to the rights-of-way. Temporary disruption of agricultural activities along the rights-of-way will occur during construction of the lines as a result of vehicle movement and storage of materials. Construction will be scheduled to avoid unharvested fields, but if fields are disturbed or destroyed, surface construction marks will be removed, and farmers will be adequately compensated. Vehicle movements along the rights-of-way will be controlled so as to minimize effects that could cause erosion, retard restoration of ground cover, or preclude resumption of agricultural use.

The applicant plans to follow the National Electric Safety Code for locating and constructing the transmission lines. In addition, the staff requires the applicant to follow the U.S. Department of the Interior guidelines[8] for locating transmission lines.

The staff believes that construction of the transmission lines can be carried out without a significant long-term or permanent effect on agricultural production.

S.4.1.5 Other impacts

Impacts of road construction and a railroad spur are essentially the same as those described in Sect. 4.1.4 of the FES. The impact of pipeline relocation has been greatly reduced from that originally anticipated (FES, Sect. 4.1.5) because only one pipeline needs to be moved. This pipeline will run along the eastern side of the dam so that its construction will cause little additional disruption to terrestrial habitat in that area. The pipeline corridor will be fertilized and planted to produce native grass cover.

S.4.2 HYDROLOGICAL AND WATER USE IMPACTS

The construction of a one-unit station and a 2072-ha (5120-acre) cooling lake at the Allens Creek site will not result in significantly fewer environmental effects on water use than those described (FES, Sect. 4.2) for the construction of a two-unit station and a 3339-ha (8250-acre) cooling lake. Because many of the construction impacts on water use can only be assessed qualitatively, the staff cannot determine the degree to which these environmental effects will differ for the construction of either the 1200-MW or the 2400-MW station. It is noted, however, that the one-unit station will require significantly less construction because of the decreased number of structures; however, because this construction impacts mainly groundwater (due to dewatering of excavation), its effect will be minor in any case (ER, Sect. 4.1.5.2).

The staff concludes, therefore, that the environmental effects on water use in the site vicinity that result from the construction of a one-unit station designed for the Allens Creek site, will be essentially the same as those described in the FES (Sect. 4.2). Accordingly, both the groundwater and surface-water regimes will be affected. The groundwater regime will be affected initially by withdrawals of water for use during construction and by dewatering of excavations. The surface-water regime will be affected initially by disturbance and alteration of Allens Creek, by channelization of runoff north of the main dam, and by channel stabilization near the makeup water intake structure in the Brazos River. Ultimate, long-term effects on both groundwater and surface-water regimes will be caused by the inundation of the 2072-ha (5120-acre) cooling lake. Construction activities will also cause increases in turbidity in Allens Creek and the Brazos River; however, because the applicant plans to use the normal erosion control techniques (ER Supp. Sect. S4.4.3.6), these effects should be localized and minimal.

S.4.3 ECOLOGICAL IMPACTS

In consideration of the Fish and Wildlife Coordination Act of 1958, as ammended, the staff has consulted with the U.S. Fish and Wildlife Service and the Texas Parks and Wildlife Department. Comments from the USFWS concerning the ER Supplement are included in Appendix S.E. The staff has considered the comments presented as part of the environmental review of this proposed station.

S.4.3.1 Terrestrial ecosystems

The impacts of construction on terrestrial ecosystems discussed in Sect. 4.3.1 of the FES apply equally well to the current station design. The reduced size of the station and associated facilities will result in the permanent loss of about 61 ha (150 acres) of terrestrial habitat and the loss, at least for the lifetime of the station, of an additional 2072 ha (5120 acres) that will be inundated by the cooling lake. The applicant estimates that 8% (194 ha) of the area affected by construction and the cooling lake is heavily forested with the remaining 92% having been recently used as either cropland or pasture (ER, Suppl., p. S4.1-4). Plants and animals inhabiting the majority of the site are common and representative of the surrounding agricultural region.

A unique community of woody species occurring on the bluff forming the western boundary of the cooling lake (Sect. S.2.1.4.1) probably will be destroyed by construction of the cooling lake (BMPR, p. 4.3-2). Onsite habitat for a resident deer population of approximately 33 individuals will be significantly reduced. Feeding activities of large numbers of wintering geese and ducks on the bottomland fields will be greatly reduced or eliminated by development of the site, although the cooling lake will provide a new resting area for waterfowl moving through the general area.

Development of the site will thus directly destroy 2315 ha (5720 acres) of terrestrial habitat and replace it with 2072 ha (5120 acres) of aquatic habitat. The staff finds that the effect of construction activities on local flora and fauna will probably be minimal in terms of region-wide populations.

Endangered species potentially occurring in the general vicinity of the Allens Creek property are listed in Table S.2.5. Most of these species are unlikely to be present on the site since either appropriate habitat is lacking (e.g., the Houston Toad requires loblolly pine forest), or the species is so rare in the area that it is unlikely to be present where agriculture is the dominant land use. Although no endangered species listed by the USFWS occur on the site itself, the transmission line corridor along Route 1A traverses some habitat of the endangered Attwater's prairie chicken (FES Sects. 2.7.1, 3.8, and 5.5.1). The applicant has found (ER Suppl., p. SH-65) that this population, which is located near the Orchard Dome Oil Fields, has been declining since 1973 due to loss of natural habitat. Apparently, much of the habitat available in 1973 had been converted to rice fields by 1977. The applicant has committed himself to schedule construction to avoid the nesting season of the Attwater's prairie chicken in the area of the Orchard Dome Oil Field (ER Suppl., p. S4.4-8). In accordance with Sect. 7 of the Endangered Species Act of 1973, the staff has requested consultation and assistance with the USFWS concerning this population of the Attwater's prairie chicken. Recommendations made in response to this report will be reviewed and incorporated into the Final Supplement.

S.4.3.2 Aquatic ecosystems

The activities associated with construction of ACNGS will affect the aquatic biota in two existing bodies of water: (1) the lower half of Allens Creek and (2) portions of the Brazos River near the site. In addition, construction activities will create the Allens Creek cooling lake. The scope of construction impacts on existing aquatic systems for the original station design as discussed in the FES (Sect. 4.3.2) is applicable to the new station design. Consequently, only changes or additions to the original analysis are given below.

S.4.3.2.1 Initial impact of construction on Allens Creek

Significant short-term changes in Allens Creek will be similar to those detailed in the FES (Sect. 4.3.2.1). However, the relocation of 1.6 km (1 mile) of the Allens Creek channel to accommodate a borrow area is no longer proposed. In addition, berms, ditches, and sedimentation basins will be used during construction (ER Suppl., Sect. S4.1) to reduce sediment loading of Allens Creek. The reduced size of the plant, switching yard, and other facilities should also decrease the significance of sedimentation problems as given in the FES. The overall impact of siltation, bridge construction, and construction effluents will, however, significantly reduce the aquatic populations in the lower half of Allens Creek during the time between onset of construction and filling of the cooling lake.

S.4.3.2.2 Impacts on Allens Creek due to construction of the cooling lake

A cooling lake of approximately 2072 ha (5120 acres) will be formed by impounding Allens Creek and by constructing an earthen dam 8687 m (28,500 ft) long along the eastern and northern boundary of the site. This proposed cooling lake represents a 38% decrease in surface area from the original design. Construction of the cooling lake for either station design will affect Allens Creek in two ways: (1) approximately 12.9 km (8 miles) of the creek will be inundated when the cooling lake is filled, and (2) the flow in the lower portion of Allens Creek below the cooling lake dam (approximately 0.8 km) will be reduced. The qualitative assessment of the impact resulting from these two events as discussed in the FES (Sect. 4.3.2.2) are not affected by the proposed design changes.

S.4.3.2.3 Predicted limnology of the proposed Allens Creek cooling lake and development of aquatic flora and fauna

The proposed Allens Creek cooling lake will have a surface area of approximately 2070 ha (5120 acres), which represents, as previously noted, a 38% reduction in the originally proposed size. Since the new cooling lake design will have approximately the same average depth, orientation to the wind, propensity for complete mixing of the water column, and other similar physical and chemical characteristics as the original design, the projected aquatic characterization of the cooling lake given in Sect. 4.3.2.3 of the FES is, in general, applicable to the current design of the proposed lake. In this section, the staff's projection of water quality and aquatic flora and fauna are reconsidered based on additional data and on experience acquired subsequent to the original assessments.

Water quality

Quantitative estimates of water quality parameters to be expected in the proposed Allens Creek cooling lake are not amenable to analysis. However, certain qualitative aspects of the probable cooling lake water quality are discernible.

Total nutrient loading to the cooling lake is expected to be high, given nutrient additions from Allens Creek, the Brazos River, and from flooded soils. Although the initial projections made in the FES are conservative, such nutrient levels will be sufficient to support abundant algal growth in the new proposed lake. Since Allens Creek is an ungaged stream, nutrient loading from this source based on concentrations in water and flow rates cannot be estimated. However, the concentration of all major nutrients in Allens Creek were reported to be consistently higher than those found in the Brazos River (BMPR, Sect. 3.6).

Silt loading from Allens Creek may be significant in the flooded channel area, and delta formation is expected where the stream enters the cooling lake. Due to high levels of fecal coliform and fecal streptococci in the upper Allens Creek area (BMPR, Sect. 3.6), which probably originate from cattle and sewage, water quality may be poor where the stream enters the lake. Water quality in the southern arm of the proposed lake, which currently receives sewage outfall from the town of Wallis (Fig. S.2.3), is also expected to be poor. Fecal coliform and fecal streptococci in this area may not be a problem if sewage discharges are chlorinated. Possible levels of indicator bacteria and nutrient concentrations for this arm cannot be estimated as these parameters were not measured during the biological monitoring program.

Total dissolved solids (TDS) are expected to be high in the cooling lake due to reported high levels in the Brazos River and in Allens Creek, and because of evaporative concentration in the lake itself (BMPR, Sect. 3.6 and FES, Sect. 4.3.2). TDS under the original lake design were predicted to range from 875 to 2000 ppm. The staff finds that this range is still somewhat conservative for the smaller lake. However, total dissolved solids in the cooling lake are expected to be well below levels constituting physiological stress to aquatic organisms, which generally is considered to occur in the TDS range of 5000 ppm.[9,10]

High levels of some heavy metals (Table S.2.6) have been measured on a number of occasions in Allens Creek and in the Brazos River (BMPR, Sect. 3.6). Due to the extremely complex aqueous chemistry of trace metals, the uncertainty of the overall water quality in the proposed cooling lake, and the unknown amount of trace element loading to the lake, predictions of possible concentrations in cooling lake water cannot be made a priori. Similarly, little can be predicted about the possible effect of these trace elements on aquatic biota. However, if a concentration factor of two is used for the cooling lake (Table S.3.2) and values given in Table S.2.6 are considered equilibrium dissolved concentrations (worse case assumption), then some seasonally high concentrations of heavy metals may enter the cooling lake through the wier overflow from the sedimentation basins. Of particular concern are mercury, zinc, copper, and cadmium. Analysis of catfish flesh (*Ictalurus punctatus*) taken from the Brazos River in March 1974, however, revealed no mercury contamination. Although these elements are not yet considered a problem in Allens Creek or in the Brazos River, some loading to the proposed cooling lake will occur and could disrupt aquatic food chains or could bioaccumulate and eventually lead to ingestion by man. Additional monitoring (Sect. S.6.1) should provide the necessary data to evaluate the potential long-term effect on the aquatic biota of the proposed cooling lake.

Aquatic flora and fauna

A generic assessment for development of aquatic biota in a new reservoir is presented in the FES (Sect. 4.3.2.3) and is applicable to the proposed cooling lake. Due to the modified design of the cooling lake and new information available in the biological monitoring program, however, the following considerations need to be addressed.

The proposed cooling lake may be susceptible to nuisance algae blooms. This situation may arise because of high intermittent nutrient loading (BMPR, Sect. 3.6), reduced turbidity from the use of settling basins, and high ambient water temperatures in some sections of the lake during summer (ER Suppl., Figs. S.3.4-20 to S.3.4-22), all of which contribute to nuisance algae development. The presence of nuisance algae, especially surface scums of blue-green algae, may limit recreational use of the cooling reservoir during the season of their occurrence (FES, Sect. 5.5.2.1.1) and may present problems to fish due to release of toxins during die-off of algae blooms. Although nuisance algae have not been reported to be a problem in other Brazos River reservoirs[11] and neither the magnitude nor duration of such events can accurately be predicted for the Allens Creek cooling lake, nuisance algae blooms may occur in late summer during low water periods.[12-16]

The growth and maintenance of a viable recreational fishery in Allens Lake will be adversely affected by elimination of the natural shoreline on the northern edge of the site as provided in the original lake design. The exclusion of these shallow zones and backwater areas will substantially reduce spawning and nursery habitat necessary for the development and maintenance of a self-sustaining recreational fishery in the lake. The embayments along the northern shore of the old lake design would have constituted about 25% of the lake perimeter and about 50% of the shallow littoral zone. The originally conceived littoral areas will be replaced with a stabilized earth apron lying at 3:1 slope. Spawning on this apron will be minimal as will the development of periphyton and macrophyte communities due to fluctuating water levels, water turbidity, and unsuitable substrate. Important littoral areas for fish reproduction under the new lake design will be located primarily in the flooded Allens Creek channel and in nearby small bays (Fig. S.2.3). Although this area has a dendritic drainage pattern, it is limited in extent and is subjected to substantial sediment load from Allens Creek runoff during intermittent high flow events. Therefore, it is not considered adequate to sustain the spawning habitat needs for the lake fishery. It is the opinion of Texas Parks and Wildlife Commission[17] that the projected 50 to 60% of the fishery being composed of game fish as stated by the applicant (ER Suppl., Sect. 5.5.1.6.1) is not probable in a shallow, thermally loaded reservoir such as proposed for Allens Creek. Supplemental stocking of game fish species or rearing fingerlings to larger sizes in the sedimentation basins to avoid cannibalism may be necessary to sustain a viable fishery. The staff understands that the actual management plan to provide a recreational fishery will be developed in conjunction with the Texas Parks and Wildlife Commission to maximize recreational potential (applicant's Master Development Plan). Although a sustained yield recreational fishery as originally proposed may not be possible under natural reproduction in Allens Creek Lake, the aquatic environment created in the proposed lake and its biotic resources will more than offset the loss of aquatic biota due to construction and operational impacts in Allens Creek.

S.4.3.2.4 Brush and tree clearing

As discussed in the FES (Sect. 4.3.2.4), brush and tree clearing in the cooling lake basin prior to lake filling will have a potential effect on the future aquatic productivity in the proposed cooling lake. Although a detailed tree-cutting and brush-clearing plan for the lake basin has not been received by the staff, the recommendations given in the FES (Sect. 4.3.2.4) and in the applicant's Master Development Plan for the Allens Creek Lake concerning fish habitat enhancement are applicable to the new lake design.

S.4.3.2.5 Effects of construction on the Brazos River

The major effects of construction of ACNGS on the Brazos River are described in the FES (Sect. 4.3.2.4). A significant change from the original analysis is the addition of approximately 44 km^2 (17 sq miles) of Allens Creek watershed runoff to direct inflow to the Brazos River (ER Suppl., Sect. S4.1). This runoff will be carried in a channel along the eastern and northern perimeters of the proposed cooling lake dam (ER Suppl., Fig. S2.5-1). When the cooling lake dam is completed and the lake begins to fill, a small percentage of direct runoff from Allens Creek watershed will be available to augment flows in the Brazos River. This addition, however, is expected to have little effect on the biota of the Brazos River because the total Allens Creek inflow generally amounts to only 1% of the Brazos River flow. The staff concludes that construction effects on the Brazos River will be localized and minimal and should not persist after construction is completed.

S.4.4 SOCIOECONOMIC IMPACTS

The 1977 estimated populations within 16 and 80 km (10 and 50 miles) of the proposed ACNGS are 8840 and 1,676,000 persons respectively (Sect. S.2.1). The present population of the total Houston metropolitan area is approximately 2.4 million persons.[18] The site is within 60 min of off-peak travel time to the center of downtown Houston and is within 40 min of much of developing, western Houston (ER Suppl., S8.1.3.1). The site is within 20 to 30 min travel of the Richmond-Rosenburg area, an area with an estimated 1975 population of 23,500 persons.

The staff has reassessed the current social and economic condition of communities surrounding the proposed site area and determines that, for analytical purposes, the area within the 16-km (10-mile) radius of the site is appropriately defined as the *local* impact area. This includes the towns of Wallis, Sealy, San Felipe, and Orchard with respective populations of 1055, 3200, 447, and 441. The larger, *regional* impact area is appropriately defined as that area encompassing the Houston-Galveston region, a 13-county area (including Austin County) which is a major service area for much of East Texas (Fig. S.4.2).

The applicant has proposed that nearly 2400 workers (a 9.1% increase from original estimates) will be needed to construct ACNGS during the eight-year construction period 1978 to 1985.

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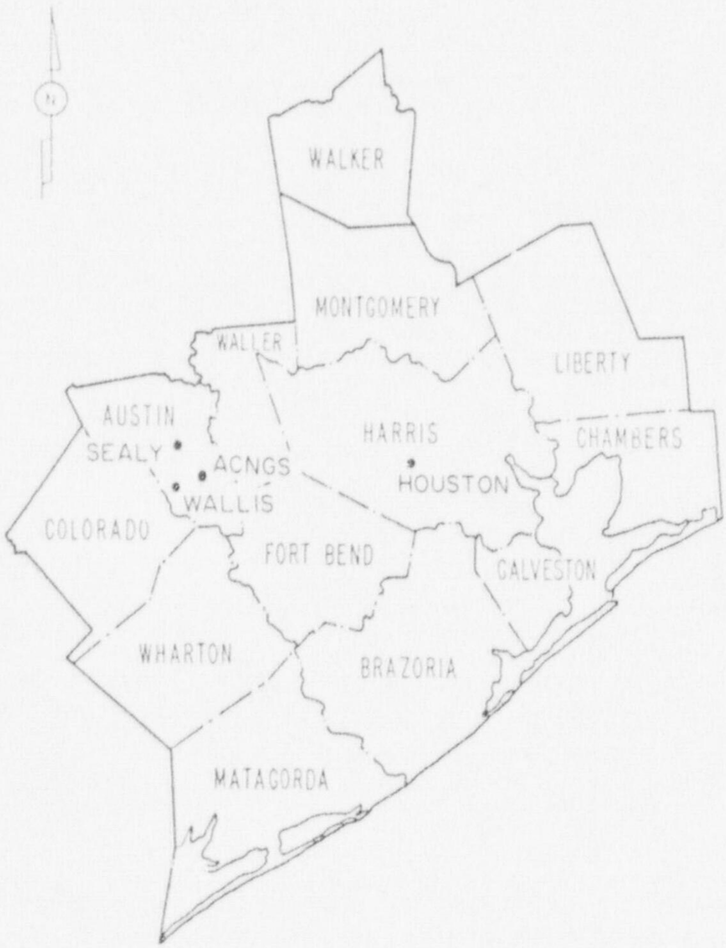

Fig. S.4.2. Houston-Galveston region. Source: Texas Regional Input-Output Study, 1967.

Based on the staff's review of other nuclear plant sites that are within daily commuting distance of metropolitan areas,[19] as well as an assessment of the capacity of the Houston metropolitan area to provide an adequate supply of labor and access to and from the plant site, the staff estimates that most construction workers will be drawn from the Houston regional labor pool and will commute daily from their places of residence within the Houston-Galveston area rather than relocate to the more remote plant site. Most of those workers who will be drawn from outside the area, and those workers who do choose to relocate from within the areas closer to the plant site, will, in the staff's opinion, relocate within the rapidly growing western and southwestern suburban communities adjacent to Interstate 10 and State Highway 36. These newer suburban communities are becoming increasingly able to provide the needed economic, social, and political infrastructure to accommodate new populations. The community of Katy, for example, located 31 km (19 miles) east of the site on I-10, grew 71% from 1970-1975. Richmond and Rosenberg, two communities approximately 32 km (20 miles) ESE of the site on State Highway 36, grew 46% and 15% respectively from 1970 to 1975.[20]

Based on past experience at other plant sites,[19] recent metropolitan growth trends within the Houston area and the size of the labor force (Sect. S.4.4.3), the staff believes that a reasonable estimate of the total peak in-migration of workers to the local area will be within the range from 10 to 15% of the total work force, or 240 to 360 workers. This assumption is a significant departure from the original FES estimate of 25%, or 520 workers (FES, p. 4-10). If 10 to 15% of the total work force move to within 16 km (10 miles) of the plant site and if it can be assumed that one-half of these workers are married and bring their families (estimating 3.5 persons per family), an increase of approximately 420 to 630 persons would be anticipated for the local area. The staff's review has determined that the local area, and primarily the nearby communities of Wallis and Sealy, will be able to provide needed services and facilities for the incoming workers and their families. It is the staff's opinion that the local area will not be severly impacted. Most construction-related impacts will be dispersed throughout the Houston metropolitan area.

It is within this framework that the staff has reconsidered the possible social and economic impacts of constructing ACNGS. The following section updates and revises the staff's original analysis in the FES (Sect 4.4).

S.4.4.1 Public services and housing

Although an increase over the originally estimated size of the work force is planned, a decrease in the estimated percentage of workers who will relocate within the local impact area will result in fewer workers relocating within the local impact area (240 to 360 workers). Tables S8.2-1 and S8.2-4 in the ER Supplement describe the available services, revenue, sources, and financial obligations of Wallis and Sealy. The staff concludes that some public services may be overburdened, but in most instances present services will be adequate to meet demand.

There may be a need for the addition of two professional police officers in Wallis during construction. The daily influx of such a large number of people to the city and its environs may increase the possibility of traffic problems or public disruption during this time.

A possible addition of approximately 120 to 180 children to the Wallis and Sealy school districts during peak construction may occur. This is a decrease from the staff's original FES estimate of 300 pupils. The consolidated Wallis-Orchard Independent School District (ISD) is presently constructing a new high school to be completed in August 1978. With an increased capacity of almost 500 students, this school will be more than adequate to meet the demand. Increased property taxes paid to the Wallis-Orchard ISD by the applicant will more than compensate for any additional students (see Sect. S.4.4.5). The Sealy ISD may also increase their enrollment. Sealy officials state that their public school system is presently at peak enrollment; they are scheduled to open ten new classrooms in September 1978. The Sealy ISD will also receive property tax payment from the applicant. The staff is unaware at this time when payments will begin to each of the jurisdictions.

An increased work force will mean increased transportation problems in the local area. However, the level of congestion problems due to the slightly increased vehicular traffice is not expected to change significantly. The staff requires that the applicant work with local and State officials and undertake all possible measures to see that transportation problems, particularly those occurring around shift changes, are alleviated. The staff further requires that all necessary agreements be arranged accordingly between the applicant and the State to ensure adequate maintenance of local roads.

The staff understands that most construction workers will commute to the plant site via Interstate 10 (approximately 11 km north of the site), State Highway 36 (adjacent to the site), and several area farm-to-market roads (ER Suppl. S2.1-3). To ensure adequate protection of the local road system, the applicant has proposed to (1) ship all materials by rail when practical, (2) schedule truck traffic around local traffic flows, (3) implement traffic control measures to alleviate congestion in local communities, and (4) to construct haul roads on the site to minimize offsite transport of materials.

The staff understands that relatively few housing vacancies exist within the Wallis-Sealy-San Felipe area. In Wallis, building permits were first issued in 1975; since that time, 21 new homes, 14 businesses, and 5 mobile home permits have been issued.[21] Similar information was not available for Sealy or San Felipe. The staff believes that most construction workers who choose to relocate near the plant site will do so in mobile home parks. Mobile home parks are permitted in Wallis, Sealy, and isolated areas of Austin County.

The staff reaffirms its position, however, and states that relatively few workers will relocate to the local area. Most workers will probably choose to reside closer to the confines of the Houston area where more adequate services and facilities currently exist. Some local demand may exist for additional housing or rental property, but this should be relatively small.

S.4.4.2 Income effects

Table S8.1-2 in the ER Supplement displays the direct, indirect, induced, and total income effects of construction of ACNGS. The applicant projects a direct income of over $54.9 million at the peak of activity in 1980, and a total income effect of approximately $149.4 million for the same period. The staff believes that these are reasonable estimates of increased income, and that most of the direct income effect will be dispersed throughout the greater Houston metropolitan area instead of being concentrated within the local impact area.

S.4.4.3 Employment effects

Construction labor force estimates and indirect and induced employment figures are provided in Table S.4.3. These show that construction employment will peak at approximately 2400 workers in 1983. Secondary employment is projected to generate approximately three jobs within the economy for every construction worker employed. The staff concurs with the applicant's employment estimates, but suggests that the secondary employment yielded by the construction of ACNGS will be generated not only in the local area, but also in the greater Houston metropolitan area and in the State of Texas. Very little secondary employment may be generated locally from construction activity.

Table S.4.3. Estimated statewide employment effects of ACNGS construction

Year	Direct Employment[a]	Indirect Employment[b]	Induced Employment[c]	Total Employment[d]
1978	100	60	120	280
1979	950	600	1,110	2,660
1980	2,400	1,510	2,810	6,720
1981	2,185	1,380	2,560	6,125
1982	1,690	1,060	1,980	4,730
1983	945	600	1,100	2,645
1984	·00	250	470	1,120
1985	160	100	190	450
Total	8,830	5,560	10,340	24,730

[a] Estimate by Ebasco Services, Inc.
[b] 0.631 times direct income (from Ref. S8.1-2).
[c] 1.170 times direct income (from Ref. S8.1-2).
[d] Sum of direct, indirect, and induced income streams.
Source: ER Supplement, Table S8.1-4.

The staff has reviewed employment statistics for both Austin County and the Houston Standard Metropolitan Statistical Area (SMSA), which includes Brazoria, Ft. Bend, Harris, Montgomery, Liberty, and Waller counties.[22] Recent estimates of employment in Austin County show that the number of employed persons ranged from 5,544 in January 1977, to 5,785 in July 1977. Unemployment for the same period remained stable at approximately 1.8%. This was the same as the average unemployment rate for 1975 and 1976. Most recent breakdowns of statistics by sector show that in 1975, 700 persons, or almost 14% of the total work force, were unemployed in construction activity. In the Houston SMSA, approximately 1,168,200 persons were employed in the labor force in May 1977. This represents an increase of approximately 84,100 employed persons from May 1976. The unemployment rate of May 1977 was 4.8%. This rate compares favorably with the national adjusted unemployment rate of 6.9%. Of the estimated 1,146,400 wage-and-salary jobs in nonagricultural industries in the Houston SMSA in May 1977, approximately 123,100 persons, or 11% of the total labor force, were employed in contract construction. According to U.S. Census information, the Houston SMSA is one of the largest labor markets in the Nation and ranks near the top in numbers of people employed in construction-related activities.[23]

One of the major benefits of the construction activity may be the provision of new employment opportunities for local area residents. Residents who are employed or who are working within the greater Houston metropolitan area may choose to work locally if the opportunity arises. The staff believes that joint participation in planning programs between the applicant and local school systems may enable graduating students to enter the work force through various trades and crafts at ACNGS.

S.4.4.4 Local purchases of materials

The applicant estimates that the Allens Creek project will purchase in the range of $22 to $55 million worth of material goods from vendors in Austin, Fort Bend, and Harris counties during the construction period. The staff believes a sale volume of this magnitude is very significant. The degree to which businesses are able to provide these items will depend upon their ability to supply the goods on a timely basis at competitive prices.

S.4.4.5 Estimated taxes

The estimates of taxation have been considerably revised from the original FES. A reduction in the number of ACNGS units from two to one, as well as changes in construction costs and general inflation, have been the prime factors for taxation revisions. Property taxes from ACNGS will be paid directly to Austin County, to the Wallis-Orchard ISD, and, during construction and operation, to Austin County Road District 3. The ACNGS will almost triple the total assessed property valuation within Austin County in 1985. Without ACNGS, Austin County's total property valuation in 1985 would be approximately $160 million. At a cost of over $1 billion, the assessed value of ACNGS at the current Austin County (33.3%) assessment ratio would be $333 million (ER Suppl., Sect. S8.1.5.1). The construction of ACNGS within Austin County thus represents a substantial impact on the county's property taxes.

The Wallis-Orchard ISD's assessed valuation will increase dramatically upon completion of ACNGS. The 1985 assessed valuation of the school district without ACNGS would be approximately $94 million. The ISD's assessed valuation with ACNGS would be approximately $744 million, an increase of almost $650 million. The ACNGS may account for over 85% of the total assessed valuation in the school district. The staff believes that this increase in total assessed valuation will more than compensate for any increase in student enrollment due to the nuclear plant construction. The Sealy ISD will also receive some money from construction of ACNGS, but the amount as yet is undetermined.

The ACNGS will also pay State and municipal sales taxes as well as franchise, gross receipts, and Federal income taxes. Table S.4.4 shows that the total taxes to be paid over the lifetime of the plant would be almost $974 million. The annualized value of this total equals roughly $94.6 million.

S.4.4.6 Impact of construction noise, aesthetic impact, and displacement of residents

The discussion of the physical impacts of construction (noise, aesthetics, and displacement of residents located in the upland areas of the site) included in the FES (Sect. 4.4.6) are not affected by the proposed design changes. Accordingly, noise from some of the construction activities will cause disturbance to some of the residents along State Highway 36, FM road 1458, FM road 1093, and the city of Wallis. The applicant plans, however, to select or treat equipment to avoid levels that will be objectionable to residents. Also, the aesthetic impacts associated with the earthmoving activities will not be visible except to users of FM road 1458 and from the bluff overlooking the cooling lake area, and the construction activities will displace a total of 16 families occupying site dwellings.

Table S.4.4. Lifetime tax benefit from Allens Creek Nuclear Generating Station (in thousands of dollars)

Tax	Fiscal year 1985	Lifetime value discounted to 1985	Annualized value	Estimation procedure
Ad valorem taxes				
Austin County	$ 1,500	$ 36,200	$ 3,500	a
Wallis-Orchard Independent School District	2,600	62,900	6,100	a
Sales taxes				
State of Texas	8,000	124,000	[illegible]	59.6% of revenue; 4% tax rate
Municipal	1,600	24,700	2,400	47.5% of revenue; 1% tax rate
Other taxes				
Franchise	8,900	139,000	13,500	Estimated at 2.67% of gross revenue
Gross receipts	4,300	67,000	6,500	Estimated at 1.29% of gross revenue
Federal income	33,500	520,000	50,600	Estimated at 10% of gross revenue
Total estimated taxes	$60,400	$973,800	$94,600	

[a] ER Supplement, Sect. S8.1.5.1.
Source: ER Supplement, Table S8.1-7.

S.4.5 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

S.4.5.1 Applicant commitments

Section 4.5.1 of the FES contains a summary of commitments made by the applicant to limit adverse effects during construction of ACNGS as originally proposed. In order to minimize confusion, the commitments described in Sect. 4.5.1 of the FES are hereby withdrawn and are replaced in their entirety by the following:

1. Measures to minimize erosion and sedimentation during site preparation and construction

   a. Erosion control berms, ditches, and sedimentation basins will be constructed prior to, or simultaneously with initiation of clearing, grubbing, and stripping operations (ER Suppl., Sect. S4.4.3.6.1).

   b. Erodible slopes will be mulched or seeded with native grasses to provide short- and long-term cover if the slope is left undisturbed for an extended period, or permanently. Particular attention will be given to creek bank areas and steep slopes. Where excavation causes topsoil removal and replacement by subsoil, organic matter or selected fertilizers will be added to promote revegetation (ER Suppl., Sect. S4.4.3.6.1).

   c. All construction runoff will be routed to sedimentation basins until completion of the dam. Thereafter runoff from the plant area construction activities will be routed to the cooling lake. There will be no discharge of construction runoff to Allens Creek or the Brazos River except in the event of an abnormally wet year, and then only if the ponded runoff is of acceptable quality (ER Suppl., Sect. S4.4.3.6 2).

2. Disposal of waste materials

   a. Metal scrap will be collected in a trash disposal area for pickup by local scrap dealers (ER Suppl., Sect. S4.4.3.4).

   b. Liquid wastes (chemicals, fuels, etc.) will be deposited or discharged into containers for salvage or subsequent removal to offsite locations (ER Suppl., Sect. S4.4.3.4).

   c. Washings from concrete transporting equipment will be collected in a settling basin and covered with fill upon completion of construction (ER Suppl., Sect. S4.4.3.4).

d. Combustible materials including wastepaper, scrap wood, workmen's lunch leftovers, etc., will be burned in an incinerator approved under Texas Air Control Board Regulation 1. Ashes and other incombustible materials will be buried at designated, regulatory-approved landfill areas on the site (ER Suppl., Sect. S4.4.3.4).

e. Merchantable logs and pulpwood removed by clearing operations may be collected and held for commercial sale. Brush and trees of no value for either commercial sale or use in creating aquatic habitat will be burned using methods given under the Texas Air Control Board Regulation 1 (ER Suppl., Sect. S4.4.3.4).

f. Sanitary wastes of construction personnel will be treated onsite. Plans call for a sanitary waste collection system requiring the trucking of wastes on a regular basis from the approximately 100 portable toilets scattered throughout the construction area to the onsite treatment plant. This plant will have a contact-stabilization activated sludge system with effluent filtration and chlorination. The design of the system will be in accordance with the Texas Department of Health Resources and in accordance with Texas Water Quality Board Regulations. Approximately 3790 liters (1000 gal) of waste will be trucked to the treatment plant daily. It is designed to handle wastes of the peak construction force (approximately 2400) and will be converted into an extended aeration-activated sludge treatment system for use during operation of the station (ER Suppl., Sects. S3.7.3.1 and S4.4.3.5).

g. The concrete mix plant will be kept free of refuse and accumulative debris (ER Suppl., S4.4.3.4).

3. Traffic and dust control

a. Incoming materials will be shipped by rail whenever practical (ER Suppl., Sect. S4.4.3.1).

b. Truck operations will be handled and scheduled whenever practical to minimize impacts on, or interference with, local traffic patterns (ER Suppl., S4.4.3.1).

c. Traffic control measures will be implemented as necessary to control truck traffic and to assure safe operations in the vicinity of small local communities (or concentrations of houses), currently uncontrolled intersections in rural areas, and school bus pickup points (ER Suppl., Sect. S4.4.3.1).

d. Haul roads will be constructed onsite to minimize offsite transport of construction equipment and materials between work areas (ER Suppl., Sect. S4.4.3.1).

e. Entrance roads and parking lots will be paved, and haul roads will be periodically watered to minimize dust dispersal (ER Suppl., Sect. S4.4.3.2).

f. Dust control systems will be installed at the concrete batch plant to avoid excessive releases of cement dust (ER Suppl., S4.4.3.2). Regulations to be followed are those specified in Texas Air Control Board Regulation 1.

4. Measures to minimize the effects of transmission line construction

a. Routes were specifically selected to avoid populated recreational, forested, and visually sensitive areas as much as possible (ER, Sect. 3.9.4).

b. Construction will be scheduled to avoid unharvested fields whenever possible. When disturbance or destruction of field crops is necessary, all surface construction marks will be removed by disking, and farm operators will be adequately compensated (ER Suppl., Sect. S4.4.3.11).

c. Construction will be scheduled to avoid the nesting season of the Attwater's prairie chicken in the areas near which it has been sighted (ER Suppl., Sect. S4.4.3.11).

d. Vegetation clearing along transmission line rights-of-way will be limited and selective (ER Suppl., Sect. S4.4.3.11).

e. Vehicle movements along transmission line rights-of-way will be controlled to minimize effects that could cause erosion, retard restoration of ground cover, or preclude resumption of agricultural use (ER Suppl., Sect. S4.4.3.11).

f. During transmission line construction and operation, no widespread chemical spraying will be done. Herbicides will be used only at the base of structures where brush and vines make inspection and maintenance a problem. No herbicides will be used in the rights-of-way near the Attwater's prairie chicken nesting ground (ER Suppl., Sect. S4.4.3.11 and Appendix SH, p. SH-63).

g. Limbs and other clearing debris will either be burned under conditions specified in Texas Air Control Board Regulation 1 or chipped and spread to provide mulch (ER Suppl., Sect. S4.4.3.11).

h. Denuded areas subject to erosion will be planted to native grass species to accelerate succession and to prevent erosion (ER Suppl., Sect. S4.4.3.11).

5. Other mitigative measures

a. Most of the surface area of the plant site will be replanted following construction (ER, Sect. 3.1).

b. Sound suppression mufflers and emission controls on trucks and other equipment will be required in accordance with applicable State and Federal laws (ER Suppl., Sect. S4.4.3.3).

c. Night shift work, if implemented, will exclude high noise level work (ER Suppl., Sect. S4.4.3.3).

S.4.6.2 Staff evaluation

Based on a review of the anticipated construction activities and the expected environmental effects, the staff concludes that the measures and controls to which the applicant is committed, as summarized here, are adequate to ensure that adverse environmental effects will be kept at the minimum practical level if combined with the following additional precautions:

1. A more detailed tree-cutting plan shall be prepared which will include the consideration of navigation hazards and the visual aesthetics of trees that may appear above the surface as the lake is drawn down.

2. The applicant shall follow the U.S. Department of the Interior guidelines entitled "Environmental Criteria for Electric Transmission Systems" in designing, locating, and constructing the transmission lines.

3. The applicant shall follow guidelines for construction runoff as specified in 40 CFR Part 423.

REFERENCES FOR SECTION S.4

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4. USDA, Soil Conservation Service, "Proposed Rules: Prime and Unique Farmlands," *Fed. Regist.* 42(163): 42359-61.

5. Dames and Moore, *Agricultural Impact of the Allens Creek Nuclear Generating Station, Report for Houston Lighting and Power Company*, Nov. 22, 1974.

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16. J. K. G. Silvey, Dept. of Biology, North Texas State University, personal communication.

17. R. Bounds, Texas Parks and Wildlife Department, Austin, Tx., personal communication.

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19. R. J. Purdy et al., *A Post Licensing Study of Community Effects at Two Operating Nuclear Power Plants*, ORNL/NUREG/TM-22, Oak Ridge National Laboratory, Oak Ridge, Tenn.

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21. M. Noel, Dames and Moore, Inc., and B. Gregar, Mayor's Office, Wallis, Texas, Sept. 2, 1977, personal communication.

22. Texas State Employment Commission, *Special Monthly Labor Market Information Report*, Austin, Texas, 1976.

23. U.S. Department of Commerce, Bureau of Census, *1970 Census of Population and Housing, Census Tracts: Houston, Texas, Standard Metropolitan Statistical Area*, 1972.

S.5. ENVIRONMENTAL EFFECTS OF OPERATION OF THE STATION AND TRANSMISSION FACILITIES

The environmental effects of operating ACNGS as originally proposed [i.e., a two-unit station with a 3339-ha (8250-acre) cooling lake] are described in the FES (Sect. 5). In this section, similar environmental effects of operation of a one-unit (1200-MWe) station with a 2072-ha (5120-acre) cooling lake at the Allens Creek site are described. Table S.5.1 summarizes the cooling lake operating characteristics of both station designs. The water balance (i.e., makeup requirements, inflow, outflow, etc.) for the 2072-ha (5120-acre) lake involves significantly smaller quantities of water than the 3339-ha (8250-acre) lake although the total dissolved solids (TDS) concentrations and spillway temperatures are not significantly different.

Table S.5.1. Summary of cooling lake operating characteristics[a]

	ACNGS, Unit 1[b]	ACNGS, Units 1 & 2[c]
Makeup requirements, acre-ft/year	30,000	90,000
Inflow, acre-ft/year	20,600	24,000
Precipitation, acre-ft/year	16,600	28,500
Seepage, acre-ft/year	600	1,000
Evaporation, acre-ft/year		
Natural	27,300	46,144
Forced	13,100	24,403
Discharge, acre-ft/year		
Spillage	24,900	64,500
Controlled releases	1,300	6,500
Annual average cooling lake TDS concentration, mg/liter	897	840[d]
Annual average TDS concentrations in cooling lake discharges, mg/liter	891	
Monthly average spillway temperature range, °C (°F)	12.6–30.6 (54.7–87.0)	12.3–31.0 (54.1–87.9)[e]
Monthly average range of ΔT in spillway, °C (°F)	0.3–1.6 (0.6–2.9)	0.3–1.3 (0.6–2.4)[e]

[a] Applicant's estimate based on a six-month pumping mode (October–March) and on meteorological data for the period January 1952–December 1968, and on 80% plant factor.

[b] Nominal effective cooling area is 1942 ha (4800 acres).

[c] Nominal effective cooling area is 3076 ha (7600 acres).

[d] Staff estimates based on ER, Sect. 3.4.3.

[e] Based on 100% plant factor; ER, Table 3.4-3.

Basically, major changes in the operational impacts from those of the two-unit station design are associated with the aquatic effects on the ecosystem of the cooling lake, radiological impacts, and socioeconomic effects. With respect to the ecology of the cooling lake, the most significant parameters for comparative purposes in assessing the changes in operational effects are (1) the number of acres of effective cooling area per unit megawatt (electrical) for thermal loading and (2) the effective cooling volume available for dilution of each quantity of discharged effluent, both radiological and nonradiological (Table S.5.1). Other parameters are equally important when either size station is considered, but the factors that influence many of these effects (such as entrainment, impingement, etc.) remain unaffected by the project changes or may be evaluated from these parameters. Because these gauging parameters in each case are roughly equal or larger for the design of the one-unit station, the related operational impacts will be about the same or less than those for the two-unit station. These conclusions are reached in the following sections. In any case, the nature of the impacts and their qualitative assessment have not changed; consequently, updates are provided as appropriate.

S.5.1 IMPACTS ON LAND USE

S.5.1.1 Station operations

The major land-use impact of station operation will be the loss of agricultural production from the site during the lifetime of the station (Sect. S.4.1.3). The applicant estimates that the present worth of agricultural production over the lifetime of the station would be approximately $34 million (ER Suppl., p. S8.2-3). The beneficial impacts of establishing two State parks along the shores of the cooling lake are discussed in Sects. 5.1.1 and 5.6.4 of the FES.

S.5.1.2 Transmission lines

The 104 km (65 miles) of transmission line corridors will traverse 280 ha (692 acres) of rice-land, 243 ha (601 acres) of other cropland, and 223 ha (552 acres) of rangeland (ER, p. 3.9-8, and ER Suppl., p. S3.9-1). Only 2.4 ha (6 acres) of heavily wooded land will be included in the corridors. The 345-kV lines have been routed as much as possible to avoid populated areas, parks, scenic areas, highways, and extensively wooded areas (ER, p. 3.9-6). The visual impact of Route 2A, which was routed over the cooling lake (FES, Sect. 5.1.2), has been eliminated by the applicant's selecting Route 2C as the preferred alternative. The transmission towers will occupy about 3.2 ha (8 acres) of land which will thus be lost to production. Herbicides (Banvel pellets) will be used at the base of towers where brush and vines make inspection and maintenance a problem. No herbicides will be used in the vicinity of the Attwater's prairie chicken nesting grounds (ER Suppl., p. SH-63). Transmission line circuits will be designed to minimize induced voltage and ground currents. Insulator strings proven to give adequate performance with respect to corona effects will be used (ER, Sect. 3.9.7). The staff concludes that the transmission lines will not interfere with agricultural operations or production to a significant extent. However, the staff requires the applicant to follow the Rural Electrification Administration guidelines (REA Bull. 62-4)[1] for minimizing the electrostatic and electromagnetic effects of overhead transmission lines.

S.5.2 HYDROLOGICAL AND WATER-USE IMPACTS

Operation of ACNGS will result in impacts on the local hydrology and, consequently, on water users downstream. Groundwater characteristics, including flow patterns and water level distributions, will be altered to some extent because of onsite well use and seepage losses from the cooling lake. Surface-water hydrology will also be affected because of the consumptive (or evaporative) losses of the heat dissipation system and the alteration of runoff characteristics in the site vicinity. These effects were considered in detail in the FES (Sect. 5.2) and in the ER (Sects. 5.1.8.2 and 5.1.8.3) for the two-unit station, and the staff found that these effects would not be appreciable. Because both the seepage and consumptive losses are estimated to be substantively less for the one-unit station (40 and 43% less) than the losses for the two-unit station, the associated impacts will be less.

The staff described in detail (FES, Sect. 5.2.1) the applicant's contractual agreements with the Brazos River Authority for the withdrawal of makeup water from the Brazos River. To date, the contract is in effect.

S.5.3 COOLING SYSTEM IMPACTS

The operation of the station heat dissipation system as described in Sect. S.3.1 will potentially affect the aquatic ecosystems of both the Allens Creek cooling lake and the Brazos River and to some extent the terrestrial ecosystem of the Allens Creek cooling lake. The nature of the impacts and adverse effects may be categorized or identified with those resulting from operation of the cooling water intake system, from operation of the cooling-water discharge and blowdown systems, and from the overall operational characteristics of the station in relation to the terrestrial ecosystem. Impacts associated with the cooling-water intake system include (1) the physical alteration of flow patterns in the various water bodies which result from the mere presence of the intake structures and from the hydrodynamic effects of withdrawing relatively large volumes of cooling water and (2) the phenomena of the entrainment of organisms into the circulating-water system and the impingement of fish and other biota against the intake screens, both of which are related to the withdrawal of cooling water. Impacts associated with the cooling-water discharge and blowdown systems include the effects of increased temperatures and concentration of chemicals (both above ambient values) of the discharged effluents, which alter certain water quality parameters and result in a stressed aquatic ecosystem (although localized here). Finally, because the newly created reservoir will create a suitable habitat for some animals, the terrestrial ecosystem will be impacted as a result of the station operation.

The environmental assessments of the effects of operation of the cooling system for the original station design (2400-MWe facility) are given in Sects. 5.3 and 5.5 of the FES. Most important, detailed consideration was given to the characterization of the above enumerated impacts in view of extant information for related systems. The qualitative assessments of these effects for the design now under consideration remain unchanged. Consequently, in the following sections, numerical updates of the corresponding cooling-system impacts in the FES are provided.

S.5.3.1 Cooling-water intake systems

S.5.3.1.1 Physical impacts

Brazos River

As described in Sect. S.3.1.1, 30,000 acre-ft of makeup water for the cooling lake will be withdrawn from the Brazos River each year during either a three- (November to January) or six-month (October to March) period. The conventionally designed intake structure (Fig. S.3.4) will be located along the shoreline of the Brazos River (see Fig. S.3.3 for location).

The staff has reviewed the design of the makeup-water pumping station in relation to the way in which its location and proposed operation characteristics may influence the local hydraulics of the Brazos River flow. Of chief concern were (1) the alteration of the local flow patterns to the extent that increases in local turbidity or other related phenomena occur and (2) the zone of influence of the intake flow (or the offshore extent of water entering the intake), which may be a factor associated with intake-related phenomena, such as impingement and entrainment (Sect. S.5.3.1.2).

Inspection of the intake design and location reveals that localized increases in turbidity caused by well-defined eddy motion and turbulence are not likely to occur. The extent of the zone of influence, however, is not readily determined without the use of appropriate flow models and knowledge of the flow data in the Brazos River. Thus, for boundary conditions, the staff assumes that the intake structure (when in operation) will pump at the maximum capacity of about 164 cfs and that the monthly average river flows will be those in Table S.5.2. From October through March (the months of tentative operation), the intake flows will be less than 10% of the Brazos River flow (i.e., if river flows of less than 1100 cfs are not considered, as stipulated in the contractual agreements between the applicant and the Brazos River Authority). This aspect of the flow analysis is important in relation to the entrainment of organisms in the intake. With these data and the river bathymetry given in Table S3.4-10 of the ER Supplement, the staff made conservative estimates of the zone of influence of the intake flow by employing potential flow approximations. At an intake flow of 10% of the river flow, with the magnitudes given in Table S.5.2, the staff estimates that water columns extending beyond 9.4 m (31 ft) offshore will not enter the intake. These estimates are considered below in the staff's assessment of entrainment effects.

Table S.5.2. Brazos River flow

Month	Monthly flow (cfs)																
	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
January	542	4,487	2,252	582	962	682	9,529	1,411	16,516	38,378	3,996	3,656	875	7,842	3,872	1,159	18,155
February	953	1,974	960	4,826	2,078	914	14,654	5,806	12,274	34,782	3,911	3,930	2,068	18,289	7,581	853	12,596
March	1,287	4,243	445	458	1,053	3,630	13,887	2,177	6,331	14,107	2,391	1,791	3,478	6,233	6,526	539	15,161
April	5,620	1,260	828	4,504	893	18,073	5,986	14,531	2,576	5,696	1,898	2,750	1,646	7,345	1,416	2,109	16,187
May	5,784	26,724	7,075	4,111	5,197	77,169	26,443	3,544	7,767	2,829	3,097	1,304	2,654	38,073	36,697	2,842	36,335
June	3,578	1,913	2,886	6,545	786	58,350	4,773	5,354	6,999	15,568	5,715	3,122	2,500	19,945	5,469	2,906	25,053
July	913	994	866	1,700	716	15,922	6,322	4,335	5,352	16,720	2,936	1,950	1,349	5,260	1,944	1,373	17,100
August	600	800	926	1,212	636	3,282	1,861	2,263	1,802	5,375	4,428	549	550	3,707	3,711	1,304	2,717
September	609	1,949	414	899	602	1,656	4,994	1,308	1,168	12,661	7,502	572	2,450	1,832	11,229	1,255	3,898
October	202	3,447	590	10,898	642	28,762	4,097	23,658	7,619	5,960	4,886	852	2,952	2,082	5,047	1,039	3,160
November	433	3,353	866	1,120	1,283	17 592	2,188	10,075	17,785	6,580	2,459	1,069	4,165	7,017	1,513	4,606	2,975
December	3,740	3,565	480	783	1,021	7,200	1,696	10,690	20,203	6,746	6,184	1,079	2,770	7,835	1,380	2,580	8,981

Source: Ebasco Services, Inc., Allens Creek Nuclear Generating Station Engineering Report, Ebasco Services, Inc., New York, 1973.

Allens Creek cooling lake

Section S.3.1.3 contains a description of the circulating-water intake structure, and Fig. S.3.3 shows its location. Circulation patterns in the proposed Allens Creek impoundment will be derived from (1) wind shear due to the prevailing meteorology, (2) the driving force of the condenser water intake-discharge system, and (3) intermittent inflows from Allens Creek. Of these, the prevailing meteorology and the source-sink (or intake-discharge) systems will be the dominant mechanisms influencing circulation patterns in the lake.

Section S.5.3.2.1 describes the applicant's method of calculating the flow patterns caused by the various driving forces. The circulating-water intake system (namely, the intake structure) is an integral part of the forces that cause the flow. Therefore, this system cannot be treated in a manner similar to that given to the installation of intakes on water bodies with existing flow patterns. In any case, it is the staff's opinion that the condenser intake system as proposed will not have any significant physical impacts on the cooling lake.

S.5.3.1.2 Aquatic impacts

Because the operation of ACNGS will require the withdrawal of water from both the Brazos River and the Allens Creek cooling lake, the aquatic ecosystems of both water bodies may be adversely affected by the potential intake effects, which include the entrainment of phytoplankton, zooplankton, and ichthyoplankton; and, in the case of the intake from Allens Creek Lake, the impingement of fish on the intake screens. The assessment of these effects follows that given in the FES (Sect. 5.5.2).

Brazos River

Water is to be withdrawn from the Brazos River to provide makeup to the Allens Creek cooling lake at a volume level of 3.7×10^7 m^3 (30,000 acre-ft) from November through January (three-month pumping mode) or from October through March (six-month pumping mode) during each year of operation (Sect. S.3.1.1). This water will be withdrawn under the terms of a contract with the Brazos River Authority (FES, Sect. 5.2.1). The makeup pumping station will be located as shown in Fig. S.3.3. The detailed design of the makeup-water intake structure — which will consist of two bays, each fitted with trash racks, stop log guides, fine screen guides (fine screens will not be installed), and a 2.3 m^3/sec (37,000-gpm) pump — is discussed in Sect. S.3.1.1. Significant changes from the original design of the makeup-water intake structure include (1) a reduction in the total pump capacity from 7.0 to 4.6 m^3/sec (250 to 164 cfs); (2) the addition of fine screen guides; and (3) an intake located at the shoreline as opposed to one recessed in a canal. The maximum approach velocity to the trash racks remains approximately the same as for the original design [18.3 cm/sec (0.6 fps)]. Although fine screen guides are included in the makeup intake design, the applicant does not plan to install fine mesh screens. Consequently, the makeup water intake effects will consist of the entrainment of fish as well as plankton.

Entrainment of planktonic organisms. In the staff's assessment of entrainment effects for the original intake design (FES, p. 5-32), for which the pumping rates were about 33% higher than for the design now under consideration, it was concluded that the entrainment of phytoplankton and zooplankton would not significantly alter food chains in the Brazos River. The reduction in the pumping capacity by about 33% which will potentially reduce the entrainment of planktonic organisms by an equivalent amount further supports this conclusion. Therefore, it is staff's opinion that entrainment of phytoplankton and zooplankton from the Brazos River will not significantly alter the biotic productivity of the river, especially in light of nutrients and organic matter in the spillway discharges (Sect. S.4.3.2.3).

New information presented in the BMPR (Sect. 3.5) and discussed in this Supplement (Sect. S.2.4.2) shows that fish spawning habitat is located upstream of the proposed intake structure location. As shown in Table S.5.3, makeup water withdrawal from the Brazos River under a 12-month pumping mode and maximum pumping rate during the worst-case flow conditions could result in substantial entrainment of ichthyoplankton during March through June (16 to 19% of total flow if uniform cross-sectional distribution of ichthyoplankton is assumed), and may create an unacceptable impact on the Brazos River fishery and on aquatic biota in general. However, under average-flow conditions, an extension of makeup-water pumping beyond the six-month pumping mode from October through March would be acceptable except during low-flow periods in late summer from the standpoint of entrainment. If a six-month pumping mode is used (October through March), only March spawning occurrences would be susceptible to entrainment effects. Under worst-case low-flow conditions (Brazos River flow at 1100 cfs, makeup-water pumping rate at 164 cfs), and with water released from upstream reservoirs (164 cfs), 13% of the total Brazos River water would be entrained. This would significantly alter the success of early spring (March) spawning in the Brazos River, especially if the ichthyoplankton were concentrated in the current near the intake shoreline.

Table S.5.3. Twelve-month pumping-mode water withdrawal from the Brazos River

Month	Percentage of total flow removed[a]	
	Worst case[b]	Average case[c]
January	15	2
February	7	2
March	13	3
April	16	2
May	3	1
June	17	2
July	19	4
August	21	8
September	21	5
October	20	3
November	11	4
December	14	3

[a] Assuming maximum pumping rate of 164 cfs where

$$\text{Percentage of Brazos River water pumped} = \frac{\text{makeup flow}}{\text{Brazos flow}}$$

[b] Using applicant's worst-case yearly low flows in 1956.

[c] Using applicant's average-flow data, 1951 to 1970.

Source: ER Suppl., p. SH-46, and ER, Fig. 2.5.3.

Without a complete ichthyoplankton study for the Brazos River, the amount of ichthyoplankton entrained — if pumping occurs during the spring spawning period (March through July) — cannot be determined. If ichthyoplankton densities are not uniformly distributed over the river cross section, which may be expected if spawning activity occurs on the same side of the river as the intake structure location, then ichthyoplankton entrainment probably will exceed the 0.5% figure given in the ER Supplement (Sect. S5.1.6.4). Because this exact figure is unknown, no assessment can be made on the probable impact of entrainment mortalities on the Brazos River fish populations. The staff therefore requires that makeup-water pumping not be done during the spring spawning season (March to July) unless sufficient data are provided to support the contention that this restriction is unnecessary to protect the Brazos River fishery (refer to Sect. S.6.1 for monitoring program). With respect to ichthyoplankton entrainment, the staff finds a six-month pumping mode from September through February to be acceptable.

Entrainment of fish. The staff has considered in detail the factors that influence entrainment of the fish species present in the Brazos River (FES, p. 5-33), and what bearing these factors (namely, fish swimming speeds; Table 5.20 of the FES) would have on entrainment in view of makeup-water intake velocities of 15 cm/sec (0.5 ft/sec). Although juvenile fish have been found upstream of the makeup-water intake site (Sect. S.2.4.2), the magnitude of juvenile fish entrainment cannot be estimated due to a lack of information on their seasonal downstream movement past the proposed intake location. However, the staff concludes that the low intake velocities will be an important factor in minimizing the number of fish entrained.

An important modification to the original intake design is the elimination of a long intake canal and substitution of an intake structure located closer to the shoreline. Elimination of the long intake canal which might have attracted fish should, in general, reduce the potential for fish entrapment and entrainment into the intake structure. However, from the intake structure drawings in Fig-5.3.4, it is apparent that a small embayment or intake canal will still exist within the concrete apron in front of the trash racks. As small embayments or canals also serve to entrap or assess fish in an otherwise unidirectional current environment, the presence of this area will increase the entrainment of juvenile fish. The staff therefore recommends that the applicant design the make-up water intake structure to minimize the embayment and take advantage of the natural river flow to sweep fish past the intake structure.

Allens Creek cooling lake

The circulating-water intake system is described in Sect. S.3.1.3. The intake structure will consist of four intake bays, each fitted with trash racks, conventional vertical traveling screens, and fine screens. Each bay will also house a 12.9-m^3/sec (455-cfs) circulating-water pump (Fig. S.3.6). The location of the structure will be about the same as in the original design (Fig. S.3.3). Basically, the design is consistent with the intake design of the two-unit station, except that the intake flow is reduced by about 49% (from 3780 to 1940 cfs). Approach velocities in front of the traveling screen will be 0.5 fps (Sect. S.3.1.3).

Entrainment. A general description of entrainment problems associated with the two-unit station design employing the 3339-ha (8250-acre) cooling lake is given in the FES (p. 5-30). Most of the organisms that enter the intake structure with lengths greater than 20 to 30 mm will probably be impinged against the 1-cm (3/8-in.) mesh screens.[2] With small organisms being entrained, mortality should be high (FES, Sect. 5.5.2).

Although phytoplankton and zooplankton will be continuously entrained into the circulating-water system, under the circulation patterns outlined in the ER Supplement (Appendix SH, p. SH-138) adequate refuge areas will exist for plankton production towards the edge of the cooling lake. Due to the short generation time of most planktors and the long travel (or circulation) time around the outer areas of the lake (Sect. 5.5.3.2.1), only a small overall effect from plankton entrainment is expected. Because nutrients will be returned to the lake in the discharge, available nutrients and resulting algal or macrophyte growth may be found to be somewhat higher near the discharge area. The staff has reviewed the proposed design changes as they relate to the entrainment of phytoplankton and zooplankton, into the circulating-water intake system and concludes (as in the FES) that, although the extent of reduction cannot be quantified entrainment will not significantly reduce the planktonic productivity of the cooling lake.

The extension of the cooling lake dam along the northern lake perimeter is a significant change in the cooling lake design and eliminates the potential aquatic breeding areas (FES, Fig. 3.4) that would have been located north of this dike. These areas would have been embayments and would have constituted about 25% of the lake perimeter (also about 50% of the littoral zones). Consequently, the spawning area of the flooded Allens Creek channel which is located immediately south of the proposed intake area is now of chief concern because it is the major littoral spawning area under the new design. Probable circulation patterns resulting from cooling water uptake and prevailing wind directions suggest that ichthyoplankton spawned in the southern and western areas of the lake may migrate towards the intake location, especially during periods of low flow in Allens Creek. Although the travel time (or drift) of organisms from the flooded channel spawning area to the intake location cannot currently be estimated, a potential exists for significant entrainment of ichthyoplankton from this area. Since this area represents the main littoral spawning habitat in the lake under the new design, any entrainment will serve to debilitate further the natural reproduction prospects for the reservoir fishery. Fish that may use the inner face at the rip-rapped diversion dike as spawning habitat, such as white crappie, may also have their larvae entrained as a result of the circulation patterns. In general, for those fish suspected to be present in the cooling lake (FES, Sect. 4.3.2.3), clupeids (shads) have planktonic eggs and larvae that are susceptible to entrainment. Also, perches and temperate basses (white, yellow, and striped bass and white perch) have planktonic larvae that are susceptible to entrainment losses. However, ictalurids (catfish) and centrachids (sunfish) which undertake parental care of eggs and young are not as susceptible to entrainment.[3] Although entrainment of ichthyoplankton cannot be quantitatively predicted, some reduction in fish reproductive success will result. However, it is the staff's opinion that this reduction via entrainment is not as significant as the loss of spawning habitat due to the reduced lake size.

Impingement. Potential impingement of fish at the circulating-water intake structure is discussed in the FES (p. 5-30). Current design changes allow for the elimination of the parallel fish passages and the retention of a fish return system. In addition, the chlorine injection system is located upstream of the travelling screens. The intake velocities remain essentially the same (15 cm/sec; 0.5 fps).

Of the fish that enter the intake structure, those individuals larger than 20 to 30 mm will be susceptible to impingement on the intake screens.[2] Juvenile fish which are too small or weak to overcome the approach velocity to the intake screens are most readily impinged. Although most adult fish can usually avoid impingement, stressed and weakened individuals will also suffer impingement if they enter the intake structure. By injecting chlorine a few feet in front of the travelling screens, additional stress on fish in the vicinity of the intake will occur and their susceptibility to impingement will increase. The staff therefore requires that the chlorine injection system be placed downstream of the travelling screens to minimize fish impingement.

The FES (Table 5.20) gives data on the effect of swimming speed and temperature on possible impingement of juvenile fish. It is evident that increasing temperature will have an adverse effect on swimming speed above some optimal temperature which varies between fish species. Although juvenile fish impingement will be minimized by the low approach velocities, summer water temperatures above 30-31°C (86-88°F) may have an adverse effect on the ability of juvenile fish to avoid impingement.

From previous experience in reservoirs, it is suspected that gizzard shad will constitute a sizable percentage of the fish impinged in the circulating-water intake structure. Therefore, it is the staff's opinion that a fish return system may not be appropriate if large numbers of clupeids (such as gizzard shad) which have low survivorship after impingement are impinged and returned to the lake in dead or dying condition. Alternative disposal should be made available for these impinged fish. The staff also concurs with the applicant that a fish by-pass system based on tangential velocities just past the trash racks is not appropriate for the circulating-water intake structure. As the technical specifications for plant operation will require impingement monitoring, the staff recommends that a fish return system be used only if monitoring demonstrates that game or sport fish are impinged in significant numbers and that a fish return system would be advantageous to their productivity in the cooling lake. If significant numbers of fish are impinged, other mitigating measures may also be necessary.

The staff concludes that some juvenile fish will be impinged on the travelling screens of the circulating-water intake structure, and that impingement will be increased due to high temperatures and releases of chlorine upstream of the travelling screens (if the chlorination injection system is not relocated). However, fish impingement will not significantly alter fish production in the cooling lake.

S.5.3.2 Cooling-water discharge and blowdown systems

S.5.3.2.1 Cooling lake operating characteristics and physical impacts on Brazos River

The operating characteristics of the proposed Allens Creek cooling lake as originally designed (for a two-unit station) and the design now under consideration are summarized in Table S.5.1. Inspection of these data reveals that the effluents that would be discharged into the Brazos River for both systems would have similar total dissolved solids (TDS) concentrations (within a few percent), and excess temperatures (spillway temperatures above Brazos River temperatures). Accordingly, it can be concluded that physical impacts on the Brazos River which would result from operation of the one-unit station employing the 2072-ha (5120-acre) cooling lake would be substantially less than those for the two-unit station employing the 3339-ha (8250-acre) cooling lake because the two-unit station requires significantly larger quantities of makeup water, and its spillway discharges are also much larger.

To compare the effectiveness of each cooling lake design qualitatively (Table S.5.1), the number of hectares of effective cooling area per unit megawatt of (gross) electrical capacity, and the quantity of chemical effluents (both radiological and nonradiological) released into the cooling lake per unit volume of the cooling lake should be considered. For thermal loading, these gauging parameters are 1.6 and 1.3 ha/MWe (4.0 and 3.2 acres/MWe), respectively, for the one-unit (2072-ha cooling lake) and the two-unit (3339-ha cooling lake) stations. Although the gauging parameter for chemical loading of the cooling lake is not as easily calculated, it can be concluded that since the volume of chemical effluents is reduced by roughly one-half for the one-unit station whereas the volume of the cooling lake is reduced by less than one-half, the quantity of chemical effluents released into the cooling lake per unit of cooling lake volume is less for the one-unit station. Consequently, with respect to thermal and chemical loading, the Allens Creek cooling lake is relatively larger as designed for the one-unit station than the one originally proposed for the two-unit station.

The effects of operation of the heat-dissipation system for the initially proposed two-unit station are described in detail in the FES (Sect. 5.3); a similar description for the proposed one-unit station is given here. The analytical methods used by both the applicant and the staff for the assessments that follow are essentially identical to those delineated in the FES.

Applicant's analysis

Details of the applicant's computational procedures and results of the operating characteristics of the cooling lake and associated physical impacts on the Brazos River are given in Sects. S3.4.3 and S5.1.2 of the ER Supplement. First, a one-dimensional reservoir-yield model was used to make predictions of condenser intake temperatures, evaporation rates, cooling lake volume and operating levels, and TDS concentrations. These calculations were made for meteorological data consisting of surface observations taken at Victoria, Texas, from January 1952 through December 1968. Both the three-month and six-month pumping schemes were considered; however, the applicant is not under contractual obligation to employ either scheme (FES, Sect. 5.2.1).

Tables S.5.4 and S.5.5 show the cooling lake operating characteristics as calculated from the reservoir-yield model for the six-month pumping mode. It is noted that a hydrodynamic model was also employed to estimate the spillway temperatures (Table S.5.5). The results for the three-month pumping mode, when considered on a total or yearly average basis, for the study period data (1952 to 1968) are essentially identical to those for the six-month pumping mode (Tables S.5.4 and S.5.5) except for the respective TDS concentrations. The resulting cycles of TDS concentration were larger for the three-month pumping scheme by about 11%.

Table S.5.4. Cooling-lake evaporative-water loss, discharge, and total dissolved solids (TDS) concentration

Design basis:
One-unit operation at 1,200 MWe
Heat load = 6.4 X 10^9 Btu/hr (80% capacity)
Makeup-water pumping rate = 5,000 acre-ft/month for six months
Study period: 1952 to 1968

Month	Average evaporative water loss[a] (acre-ft)	Number of Years discharge occurred	Average discharge[b] (acre-ft)	Average Brazos River TDS concentration[a]	Average discharge-water TDS concentration (ppm)	Maximum monthly discharge-water TDS concentration	Cycles of TDS concentration[c]
January	1,805	16	4,857	469	844	1,173	1.8
February	2,148	15	6,173	432	843	1,503	2.0
March	2,940	17	3,000	561	834	1,281	1.5
April	3,591	6	5,333	424	982	1,214	2.3
May	4,310	5	3,746	400	827	961	2.1
June	4,874	4	9,695	464	772	1,307	1.7
July	4,897	4	2,001	525	882	1,044	1.7
August	4,496	6	1,703	667	1,070	1,516	1.6
September	3,910	5	1,175	613	1,055	1,631	1.7
October	3,243	8	2,704	561	1,018	1,718	1.8
November	2,358	8	4,566	444	815	1,120	1.8
December	1,824	10	5,771	405	751	1,095	1.9
Total or average	40,396		26,203[d]	489	891	1,297	1.8

[a] Average based upon 1952 to 1968 study-period data.
[b] Based upon months when discharges occur.
[c] Cycles based upon average discharge of TDS and upon TDS in the Brazos River.
[d] Average total annual discharge over the entire 17-year study period.
Source: ER Suppl., Table S3.4-7 (modified).

Table S.5.5. Cooling-lake condenser-intake and spillway temperature

Design basis:
One-unit operation at 1200 MWe
80% plant capacity
Condenser rise = 15.3°F at 80% capacity
Heat load = 6.4 X 10^9 Btu/hr
Study period: 1952 to 1968

Month	Average equilibrium temperature[a]	Average equilibrium temperature[b]	Condenser intake temperature[a]	Average spillway temperature[b]	Temperature rise at spillway[c]
January	52.0	51.8	55.5	54.7	2.9
February	55.2	55.6	58.1	57.9	2.3
March	62.7	62.7	64.[illegible]	64.4	1.7
April	71.8	69.2	73.2	70.2	1.0
May	78.8	78.3	79.8	79.0	0.7
June	84.5	84.2	85.5	84.9	0.7
July	86.7	86.2	87.7	86.9	0.7
August	85.7	86.4	86.8	87.1	0.7
September	81.0	80.8	82.3	81.6	0.8
October	71.6	72.5	73.5	73.9	1.4
November	60.9	60.6	63.5	62.7	2.1
December	53.6	53.3	57.0	56.2	2.9

[a] Based upon meteorology for the 1952 to 1968 study period.
[b] Based upon data for months when discharges occur for six-month pumping.
[c] Rise above equilibrium temperature.
Source: ER Suppl., Table S3.4-2 (modified).

To estimate the temperatures of the spillway discharge, the applicant used a two-dimensional hydrothermal model that provides estimates of the trajectory of the fluid particles (or streamline patterns) in the cooling lake. The temperature of each fluid particle along the various streamlines (see Fig. S.5.1 for typical streamline patterns) is then assumed to dissipate heat only to the atmosphere, making the particle temperature a function of position only along the streamlines (ER, Sect. 5.1.2.2). Consequently, the spatial temperature distribution over the surface of the cooling lake (and over the depth also, because the model is depth-averaged) is obtained for the prevailing meteorological conditions. Figure S.5.1 shows these calculations for data judged to represent five-day critical meteorology. The applicant has also estimated (ER, Suppl., p. SH-139) that for average meteorological conditions, travel times of particles along the diversion dike and the cooling lake dam will be 12.3 and 65.4 days respectively.

Table S.5.5 presents the applicant's estimate of spillway temperatures and excess temperatures for monthly average meteorological conditions (80% plant load factor; 1952 to 1968 study period). The average monthly spillway temperatures range from a low of 12.6°C (54.7°F) in January to a high of 30.6°C (87.1°F) in August, with excess temperatures of 1.6°C (2.9°F) and 0.39°C (0.70°F) respectively. Additionally, the applicant calculated a maximum monthly average summer discharge temperature of 31.2°C (88.2°F) at a plant load factor of 100%, as opposed to 31.1°C (88°F) which was previously predicted for the two-unit, 3339-ha (8250-acre) lake design During December (the period of maximum ΔT), the excess temperature is expected to be about 2.2°C (4°F). Although the results in Tables S.5.4 and S.5.5 are presented in terms of monthly averaged meteorology, various causes were considered for which daily and hourly data were employed. For example, excess temperatures for three-hourly meteorological data calculations (December 1963) were figured at a 100% capacity factor, with a resulting maximum discharge ΔT of 5.9°C (10.6°F) (ER Suppl., S3.4-27).

The applicant's thermal analysis also included an investigation of the mixing characteristics of the thermal effluents discharged into the Brazos River. Table S.5.6 presents the results of the cases investigated for the six-month pumping mode. In nearly all cases, the discharge flow was less than 10% of the Brazos River flow, and the maximum ΔT was 1.9°C (3.5°F). The greatest plume penetration downstream for the 1.1°C (2°F) excess temperature isotherm is 381 m (1250 ft), and the corresponding maximum offshore extent is 6.4 m (21 ft). Similar results were found for the three-month pumping mode; however, due to different flow conditions, the plumes were much larger. These results are for monthly averaged conditions, and the plumes may on occasion cover significantly larger portions of the Brazos River (i.e., for larger discharge excess temperatures).

Staff's analysis

The estimates of cooling lake behavior in Tables S.5.4 and S.5.5 are based on a plant capacity factor of 80%. To assess the cooling lake operation characteristics (from the applicant's model) for a plant capacity factor of 100%, the staff compared the results of the respective cases for the 3076-ha (7600-acre) cooling lake simulations (ER, Tables 3.4-1A and 3.4-1B). The plant capacity factor was increased from 80 to 100% during the months of May through October for the average year of meteorological data (1964). The results show that during this period, forced evaporation increased by an average of 20%, and the cooling lake TDS concentration increased by an average of 2%.

To make an independent assessment of the cooling lake operating characteristics, the staff used the model of Ryan and Harleman.[4] The various pumping modes were not simulated; instead, the surface level of the cooling lake was assumed to remain constant. Calculations were made for the cooling lake gross evaporation rates, equilibrium temperatures, and circulating-water intake temperatures, all on a monthly averaged basis for meteorological observations recorded at Houston, Texas, during the 20-year period January 1952 through December 1971. It was also assumed that the plant would operate at a full load (100% plant capacity factor), thus discharging about 2490 MWt (8.5 x 10^9 Btu/hr) of excess heat into the cooling lake.

In the staff's previous analysis of the operating characteristics of the 3339-ha (8250-acre) cooling lake design (FES, Sect. 5.3.2), the simulations were based on meteorological data recorded at Victoria, Texas (the applicant's choice of data for both analyses), instead of at Houston, Texas. For these data, the staff's and the applicant's results were in close agreement. In particular, the staff's estimate of gross water-evaporation rates (yearly average) from the cooling lake was about 4% larger than the applicant's estimate. This was attributed to the slightly higher heat load used in the staff's analysis. Similar trends were also found in the staff's simulations employing the smaller cooling lake design. Table S.5.7 shows that the average evaporative-water loss is estimated to be 43,855 acre-ft/year, which is about 8.6% higher than the applicant's estimate (Table S.5.5). It is the staff's opinion that this increase is mainly due to the higher heat load used by the staff and not due to differences in the meteorological data.

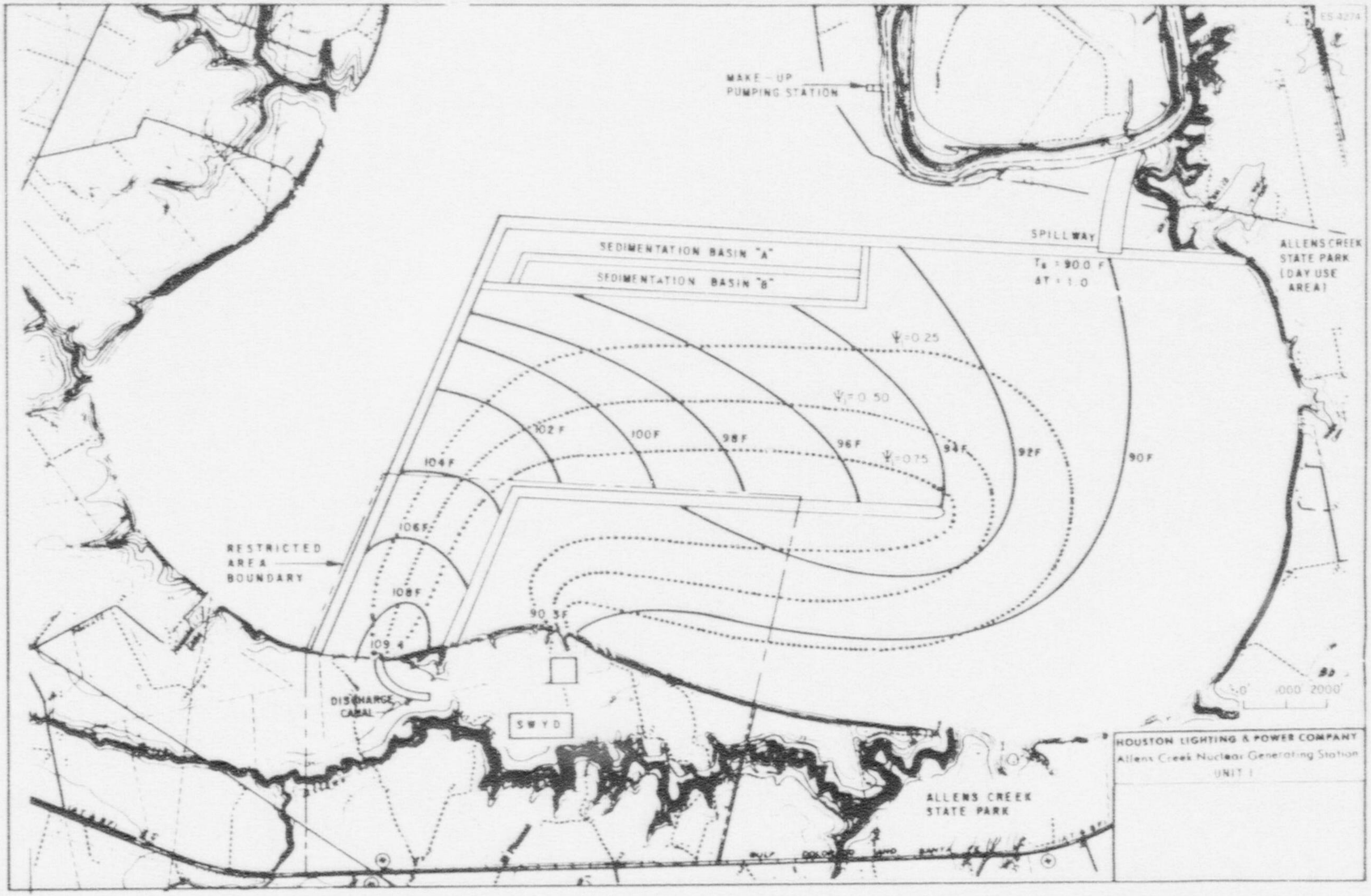

Fig. S.5.1. Isothermal patterns and streamlines for one-unit ACNGS operation at 100% capacity (five-day critical meteorology). Source: ER Supplement, p. SH-138.

Table S.5.6. Temperature effects on the Brazos River one-unit operation for six-month pumping mode

Month	Year	Discharge temperature rise (°F)	Flow (cfs)		Average ft		Brazos River lateral diffusivity (ft^2/sec)	Mixed temperature rise (°F)	Plume			
			Discharge	Brazos River	Brazos River depth	Brazos River width			Brazos River isotherm (°F)	Maximum downstream extent (ft)	Maximum offshore extent (ft)	surface area (acres)
January	1952	2.2	66	542	2.61	203	0.071	0.24	2	1,250	21	0.28
January	1963	3.5	136	3,656	5.23	309	0.200	0.13	2	1,150	11	0.20
									3	350	10	0.04
December	1953	2.7	1.0	3,565	5.19	307	0.197	0.12	2	900	14	0.16
January	1967	3.[illegible]	60	1,159	3.17	221	0.095	0.15	2	1,250	11	0.20
									3	250	10	0.03
February	1967	2.8	66	853	2.92	211	0.083	0.20	2	1,750	15	0.35

Source: ER Suppl., Table S3.4-10.

Table S.5.7. Staff estimate of cooling lake operating characteristics[a,b]

Month	Average evaporative water loss (acre-ft)	Average equilibrium temperature		Condenser intake temperature		Temperature rise at spillway[c]	
		°C	°F	°C	°F	Δ°C	Δ°F
January	2,168	11.5	52.8	14.5	58.2	3.0	5.4
February	2,346	13.4	56.2	15.8	60.5	2.4	4.3
March	2,952	17.3	63.2	19.3	66.7	2.0	3.5
April	3,570	22.3	72.2	23.6	74.5	1.3	2.3
May	4,227	26.4	79.5	27.5	81.6	1.1	2.1
June	4,776	30.0	86.1	31.3	88.3	1.3	2.2
July	4,885	32.2	90.0	33.1	91.5	0.9	1.5
August	4,748	31.4	88.5	33.0	91.4	1.[illegible]	2.9
September	4,546	28.3	83.0	29.9	85.9	1.6	2.9
October	4,019	23.0	73.4	25.1	77.2	2.1	3.8
November	3,159	16.6	61.9	19.3	66.7	2.7	4.8
December	2,459	12.9	55.3	16.0	60.8	3.1	5.5
Total or yearly average	43,855						

[a]Design basis: One-unit operation at 1200 MWe, ΔT = 10.8°C (19.5°F), circulating water flow = 55 m^3/sec (1940 cfs).

[b]Based upon meteorology (monthly average) recorded at Houston, Texas, for the period 1952–1971.

[c]Approximated as value of condenser intake temperature above the average equilibrium temperature.

The staff's estimates of circulating-water intake (or condenser) temperatures and cooling lake equilibrium temperatures (Table S.5.7) are also in agreement with the applicant's results (Table S.5.5). Although the staff's estimates are slightly higher for each month, they agree reasonably well in the relative variations on a monthly basis. As in the design of the 3339-ha (8250-acre) cooling lake, July is the month of highest intake temperatures.

The staff's method of determining the spillway temperatures was to construct graphically a flow net (or streamline patterns) in the cooling lake by employing potential flow theory and neglecting the driving forces due to wind shear. After determination of the streamlines, the flow rates in each cell are obtained, allowing for an estimate of travel times for fluid particles through the various flow circuits. Because it is assumed that the temperature of the fluid particles along each streamline varies with travel time in exactly the same fashion, estimates of spillway temperatures can be made. This method, although approximate and crude, is essentially identical in theory to the applicant's model (ER Suppl., Sect. S5.1.2.2).

Moreover, by employing this method for the larger cooling lake design, the staff concluded that, within the accuracy of the method, the spillway temperatures were about the same as the circulating-water temperatures. Similar results were also obtained for this case. Inspection of the applicant's calculations (Table S.5.5) reveals that, on the average, the condenser intake temperatures are slightly higher. Consequently, the staff calculated the excess temperatures of the effluents discharged via the spillway by equating the spillway temperatures to the condenser intake temperatures. Table S.5.7 shows that the excess temperatures range from 0.9 to 3.1°C (1.5 to 5.5°F).

Rather than perform an independent set of calculations to determine the extent of the thermal plume in the Brazos River, the staff reviewed in detail the applicant's method and assumptions used for these calculations (Table S.5.6). The nature of the discharge and the flow conditions are either ill defined or too dependent on the applicant's mode of operating the cooling lake for the staff to make precise estimates with reasonable confidence. Therefore, the staff believes that for the cases solved, the applicant's results (Table S.5.6) are conservative in that near-field or jet-type mixing was not included at the discharge to the Brazos River.

S.5.3.2.2 Aquatic impacts

The operation of ACNGS potentially will affect two aquatic ecosystems — the Allens Creek cooling lake and the Brazos River. As in the FES (Sect. 5.5.2.1), the staff concludes that operation of the plant will not have any significant impact on the biota of Allens Creek.

Allens Creek cooling lake

Sources of impact on the proposed cooling lake from the cooling water discharge system are (1) temperature alterations, (2) chemical discharges, and (3) water quality changes. A general discussion of the potential impacts resulting from these effects is given in Sect. 5.5.2.1.1 of the FES.

Temperature. The yearly thermal regime of the proposed cooling lake will be somewhat modified from the original analysis because of (1) the reduction of effective cooling area of the lake, (2) the redesign of the circulating-water discharge canal to achieve less near-field mixing, and (3) the reduction in volume of the discharged effluents. As in the original analysis (FES, Sect. 5.5.2.1.1), the circulating-water system of ACNGS will discharge heated water into Allens Creek cooling lake with a maximum ΔT of 10.8°C (19.5°F). Figure S.5.1 shows that elevated temperatures will exist near the condenser discharge canal during worse case conditions. No substantial differences due to three- or six-month makeup pumping modes are revealed in the isothermal patterns in the lake (ER Suppl., p. S5-16). During an average year, lake temperatures will be highest in July. Moreover, during the summer months of an "average" year, the 35.5°C (96°F) isotherm will include about 20% of the lake surface and the 31-32°C (86-88°F) isotherms will include about 85% of the total lake surface (ER Suppl., Figs. S3.4-21 and S3.4-22). These conditions will prevail for at least one month and probably somewhat longer during the period July to August.

Fish. References reviewed and presented in the ER Supplement (Sect. S5.1) and in the FES (Sect. 5.5.2.1) provide evidence for the lack of substantial impact to fish populations resulting from releases of heated water into those Texas reservoirs which have been studied to date. However, as stated in the FES (p. 5-24), many factors other than temperature influence fish production in heated reservoirs and these factors have not been adequately addressed in the various studies. In addition, no information has been found on fish production in these systems prior to receiving heated effluents. Consequently, this literature review is of limited value in the current assessment (FES, p. 5-24).

Under the original cooling lake design, the zone of exclusion resulting from high temperatures could have covered approximately 30% of the lake surface (FES, Table 5.7). As given above, the present zone of exclusion for fish [35.5°C (96°F)] under worse case thermal conditions will be 20% of the total lake surface (Fig. S.5.1). This zone of exclusion under the current design will not prevent a fishery from being established and maintained. When these high-temperature areas occur, they will probably be avoided by fish. Shallow cooling reservoirs like the proposed Allens Creek cooling lake may, however, reach sufficiently high temperatures throughout the water body during an abnormally warm summer to stress fish and other biota.[3] Table S.5.8 gives spawning, growth, and preferred temperatures for some important reservoir fishes, and Table 5.17 of the FES gives incipient lethal temperature thresholds for selected fish. From comparisons of these data and the results of the applicants thermal analysis (ER, Suppl. Figs. S3.4-14 to S3.4-26), more than 50% of the total reservoir surface area will be above 32

Table S.5.8. Spawning, growth, and preferred temperatures of some important reservoir fishes

Species	Temperature at which spawning occurs °C	Temperature for optimum growth °C	Preferred temperature range °C	Sources
Golden shiner	15.6–21.0		17.0–24.0	*a, b, c*
Threadfin shad	14.0–21.0			*c*
Bluegill	20.0		27.0–32.0	*b, d, e*
White crappie	14.0–23.0		16.0–23.0	*a, b*
Largemouth bass	20.0–24.0	27.0	27.0–32.0	*a f*
White bass	12.0–24.0		10.0–31.0	*b, g*
Striped bass	13.0–20.0			*f*
Channel catfish	21.0–27.0	30.0	26.0–30	*a, b, h*

Sources:

[a] J. S. Hart, "Geographic Variations in Some Physiological and Morphological Characters in Certain Freshwater Fish," *Publication of the Ontario Fish Research Laboratory, vol. 72*, University of Toronto Biological Series No. 60, Ontario, Canada, 1952.

[b] J. M. Reutter and C. E. Herdendorff, "Laboratory Estimates of Fish Response to the Heated Discharge from the Davis-Besse Erie, Ohio," Center for Lake Erie Area Research, Ohio State University, Columbus, 1975.

[c] K. D. Carlander, *Handbook of Freshwater Fishery Biology, vol. 1: Life History Data on Freshwater Fishes of the United States and Canada, Exclusive of the Perciformes*, Iowa State University Press, Ames, 1969.

[d] F. B. Cross, *Handbook of Fishes of Kansas*, Museum of Natural History, University of Kansas, Lawrence, 1967.

[e] C. C. Coutant, "Temperature Selection by Fish: A Factor in Power Plant Impact Assessments", *in Environmental Effects of Cooling Systems at Nuclear Power Plants*, International Atomic Energy Commission, Vienna, 1975.

[f] A. J. McClane, *McClane's New Standard Fishing Encyclopedia*, Holt, Rinehart, and Winston, Inc., N.Y.

[g] C. C. Riggs, "Reproduction of the White Bass: *Morone chrysops*," *Invest. Indiana Lakes Streams*, 4: 87–110. (1955).

[h] J. W. Andrews, L. H. Knight, and T. Murai, "Temperature Requirements for High Density Rearing of Channel Catfish from Fingerling to Market Size," *Prog. Fish-Cult.* 34: 240 1972.

(90°F) during July and August. Approximately 15 to 50% of the lake surface will be at 32°C (90°F) or above during the summer period of June to September. Although many species of fish likely to inhabit the Allens Creek cooling lake have been collected in high-temperature areas (FES, Table 5.16), growth and spawning will be adversely affected and the incident rate of disease may increase if temperatures above 32°C (90°F) prevail for more than a month.[3,5] Adverse effects from the summer temperature regime will be especially evident for those fish species which may be forced, in the absence of any thermal refuges, to inhabit lake water above their preferred temperature range. Although some refuges of cooler water temperatures below 32°C (90°F) will exist in the lake, the one- to two-month period of restriction of this area during summer months (July and August) will have an adverse effect on the maintenance of the reservoir game fish populations. Rough fish to game fish ratios in the lake will also be affected by extreme summer temperature because rough fish will have a competitive advantage due to their generally higher optimal temperature regime.[6] In addition, since the temperature increase in the condenser cooling water will be 10.8°C (19.5°F) above ambient, dissolved gases present in the cooling water will become supersaturated and may lead to problems of gas bubble disease in fish.[7] However, the incident rate of gas-bubble disease in fish near the discharge canal is not currently amenable to prediction and the staff believes that this occurrence will not significantly alter fish production in the cooling reservoir.

Cold shock stress on resident fish populations is another potential problem in thermally loaded reservoirs. The probability of cold shock occurring in the original station design was reduced by the low probability that both units of the station would be shut down simultaneously (FES, p. 5-24). However, using the one-unit operating design, thermal cold shock may be an occurrence of significance in the cooling lake during winter months in the event of plant shutdown. During winter months, fish tend to seek preferred temperatures in thermal plumes; therefore, sudden loss or dissipation of these plumes by storms or plant shutdowns can result in severe physiological stress or death. The staff was unable to find any evidence of cold shock occurring in Texas reservoirs, probably because of the subtropical climate and mild winter conditions allowing for more gradual acclimation of fish populations to lower temperatures. In this climate, cold shock may be possible only during a combination of rare cold weather and plant shutdown.

The staff concludes that thermal loading of Allens Creek cooling lake by plant operation will adversely affect productivity of those fish with temperature optima of 30°C (86°F) or less but that direct fish mortality will not result. Rough fish populations will probably be enhanced at the expense of game fish populations due to high summer water temperatures in the lake. Fish mortality due to cold shock should be negligible since it would only occur when severe winter cold weather is coupled with plant shutdown. Gas-bubble disease may be present in fish but should not significantly affect fish production.

Benthic macroinvertebrates. The analysis of temperature effects on benthic macroinvertebrates presented in the FES (p. 5-24) is appropriate for the current cooling lake design and operation. Although localized differences in benthic macroinvertebrate biomass and diversity are expected, no significant effect of temperature on total lake benthic productivity is probable for the expected yearly isotherm cycles given in the ER Supplement (Sect. S3.4).

Zooplankton and phytoplankton. The impact of elevated temperatures on plankton in Texas reservoirs is considered in the FES and in Sect. S.4.3.2.3 of this supplement. Algal bloom occurrences are considered probable in the high-nutrient Allens Creek cooling lake. These algal blooms may be enhanced somewhat by thermal releases from plant operation. The impacts from these blooms are considered in Sect. S.4.3.2.3.

Pathogenic amoebae. During the review of this proposed facility, the staff reviewed information concerning primary amoebic meningoencephalitis (PAME). Three cases of PAME were reported in the United States in 1977, one each in North Carolina, Georgia, and Texas. All of these cases involved individuals who had reportedly been swimming in waters with elevated temperatures and each case resulted in death. This disease has been attributed to pathogenic amoeba of the genus *Naegleria* and *Acanthamoeba*. Since the cooling lake may at times be at elevated temperatures, both naturally and during operation, and *Naegleria fowleri*, one of the primary causal pathogens, has been identified in some thermally loaded Texas reservoirs,[8] the staff did a detailed survey of current ecological and epidemeological literature relative to the potential presence of pathogenic amoeba in the Allens Creek cooling lake. The survey revealed that: (1) *Naegleria* and *Acanthamoeba* are ubiquitous in nature and can be free-living in fresh water without an apparent need for an intermediate host; (2) *Naegleria* and *Acanthamoeba* can live on bacterial populations present in fresh water; (3) bacteria populations are stimulated by organic nutrient loading and heat input to freshwater bodies; (4) amoeba undergo interspecific competition such that pathogenic forms seem to be favored over nonpathogenic forms at higher temperatures [above 35-37°C (95-97°F) but especially above 42°C (108°F)].

In the preceding analysis (Sect. S.4.4.2), the staff has shown that Allens Creek cooling lake will be a thermally loaded eutrophic system with high bacterial populations during warm water seasons. The staff therefore concludes that it is possible for the cooling lake to provide appropriate habitat for *Naegleria* and *Acanthamoeba*. However, as revealed by the literature survey, there presently exists no capacity to predict whether amoeba that may develop in the lake will be pathogenic; and, if pathogenic amoeba do develop, what, if any, will be the rate of contraction of the amoebic diseases in individuals coming in contact with the lake waters.

Chemical discharges

Chlorine. During normal plant operation, chlorine will be injected into the inlet cells of the circulating-water intake structure as a biocide to prevent fouling in the cooling system. Chlorine will be discharged to the Allens Creek cooling reservoir at a maximum rate of 692 kg/day (1525 lbs/day). The applicant states that chlorine will be discharged in two daily doses of 15 min each at a concentration sufficient to maintain a 0.2 mg/liter free chlorine residual at the condenser discharge block (ER approximately Suppl., Sect. 3.6.3). This level corresponds with EPA's chemical effluent limitations guidelines. This will result in a maximum total residual chlorine (TRC) discharge of approximately 2.2 mg/liter to the lake (during two 15 min periods each day) if no loss of free chlorine along the discharge canal occurs. Unlike condenser operation for the two-unit operation originally proposed in the FES, no dilution will occur in the condenser system. Although some of the free residual chlorine will undoubtedly be taken up by the biological chlorine demand of the discharge canal,[9] dilution will only occur when chlorine enters the lake. The proposed total residual chlorine release of 2.2 ppm is greater than the projected release of 1.0 ± 0.5 ppm TRC estimated for the original plant design (testimony of Hildebrand and Zittel)[9]. Consequently, further discussion of the effect of chlorine releases into the cooling lake is warranted.

Total residual chlorine will enter the lake with the thermal effluent and will be dispensed by circulation patterns in the cooling lake. These circulation patterns will be affected by cooling-water intake and discharge, by the prevailing wind, and by the inflow from Allens Creek. Due to the uncertainties of the water chemistry of the proposed cooling lake (Sect. S.4.4.2.3) and the unknown amount of atmospheric losses, the dispersion of TRC in the lake cannot be properly simulated.[9,10]

Because the cooling lake will be eutrophic and organically rich, much of the TRC will be in the form of combined residual chlorine, which has a slower reaction time with the chlorine demand of the lake water (estimated at 2 mg/liter for the original lake plan).[9] Although the instantaneous chlorine demand of the cooling lake water will eliminate the free residual chlorine when it enters the lake, the combined residual chlorine compounds consisting primarily of chloramines will be dispersed to a much greater degree. Because chloramines are toxic to aquatic biota,[10] some effect from the discharge of 2.2 ppm TRC on the biota of the cooling lake will occur.

Chlorine effects on biota through short-term exposure. The general toxicity considerations of chlorine to aquatic biota are discussed in the FES (Sect. 5.5.2.1.1). Figure S.5.2 is an update of Fig. 5.6 given in the FES.

All organisms entrained into the cooling system during chlorination events should suffer 100% mortality. Although overall plankton productivity in the lake will be reduced, no significant effects are expected from this occurrence.

Benthic macroinvertebrates in the vicinity of the discharge canal will be affected by the total residual chlorine releases. Because the cooling lake will be eutrophic, which usually means that chironomids and oligochaetes will dominate the benthos, only these organisms are considered. Since chironomids are relatively resistant to chlorine poisoning, their distribution will not be affected as much as that of the more sensitive oligochaetes (Table S.5.9).[10] The areal extent of the probable shift in relative population densities cannot be estimated, but the overall benthic macroinvertebrate productivity in the cooling lake will not be severely affected by the chlorine releases.

At the discharge area, any fish found in the thermal plume dispersion path may swim out of the area during periods of chlorination if given an appropriate warning.[11] However, fish kills have been reported to occur in discharge plumes during intermittent chlorination events.[7,12] The applicant's projected TRC discharge of 2.2 mg/liter will therfore cause fish distress if avoidance does not occur in the discharge area. From fig. S.5.2 it follows that the acute toxicity threshold for aquatic biota (0.15 mg/liter for 15 min) will be exceeded twice a day in some area near the discharge canal. Further, the staff's analysis predicts that dispersion by diffusion concentration by the time the dischaaged water reaches the bend in the diversion dike (Sect. S.5.3.2.1). Thus, a substantial area of the upper lake will be affected by high TRC concentrations. This may be especially detrimental to resident fish populations during winter months if fish exhibit a preference for the thermal plume.[7,11] Also, if white crappie or other fish species spawn along the rip-rapped diversion dike shoreline in the discharge canal area, their spawn will be subjected to high TRC levels. It is the staff's opinion that although the areal extent and magnitude of TRC effects on fish populations in the cooling lake cannot be predicted with certainty, the applicant's proposed chlorine release of 2.2 mg/liter TRC will adversely affect fish populations in the cooling lake.

Chlorine effects on biota through long-term exposure. As stated in the FES (p. 5-25) total residual chlorine discharged to the lake in the thermal effluent will be composed primarily of chloramines which are generally more persistent than but with apparently the same order of magnitude toxicity (to aquatic organisms) as free available chlorine. Long-term exposure to chloramines may therefore produce some negative effects on the biota of the Allens Creek cooling lake in the vicinity of the discharge canal. From inspection of Fig. S.5.2 and from the previous discussion of the dispersion of TRC in the cooling lake, it is apparent that TRC discharges of 2.2 ppm will greatly exceed the suggested conservative limit for continuous exposure of 0.0015 ppm[10] over some area near the discharge location. As previously stated, neither the areal extent nor concentration or duration of the exposure to TRC compounds can currently be predicted. Consequently, the magnitude of the effects upon the aquatic biota of Allens Creek cooling lake from long-term exposure to TRC cannot be estimated. It should be pointed out that many non-game fishes, which will probably dominate the Allens Creek cooling lake fishery, are more resistant to chlorine than are most of the cold water species used to develop the conservative estimate of TRC concentration for protection on a continuous basis (ER, Suppl., p. S5.4-6). It is the staff's opinion that some effect of long-term exposure to TRC compounds will be evident in the Allens Creek aquatic biota due to the applicant's projected release of 2.2 ppm TRC during two 15-min daily periods.

Based on the above analysis of both short- and long-term potential impacts from the release of 0.2 mg/liter of TRC during two 15-min daily periods, the staff concludes that the predicted levels of impact would significantly alter the biotic productivity of the cooling reservoir. The staff therefore recommends that the applicant be required to meet the 0.1 mg/liter TRC discharge limit agreed to by the applicant during the hearing before the ASLB (transcript page 14). As stated in the FES (p. 5-25) and in the hearing transcript page 161), dilution of this concentration in the cooling lake should be sufficient to protect the aquatic biota.

The limit of 0.1 mg/l TRC is more restrictive than EPA's Chemical Effluent Limitation Guidelines (CELG). However, the staff is hopeful that the above discussion of the potential harm associated with the high levels of chlorine release that would be permitted by the CELG will convince EPA to incorporate the more restrictive limit of 0.1 mg/l TRC in the NPDES for ACNGS. If EPA decides on a limit of greater than 0.1 mg/l TRC, it is the staff's opinion that significant adverse impacts on the aquatic biota of Allens Creek Lake may result.

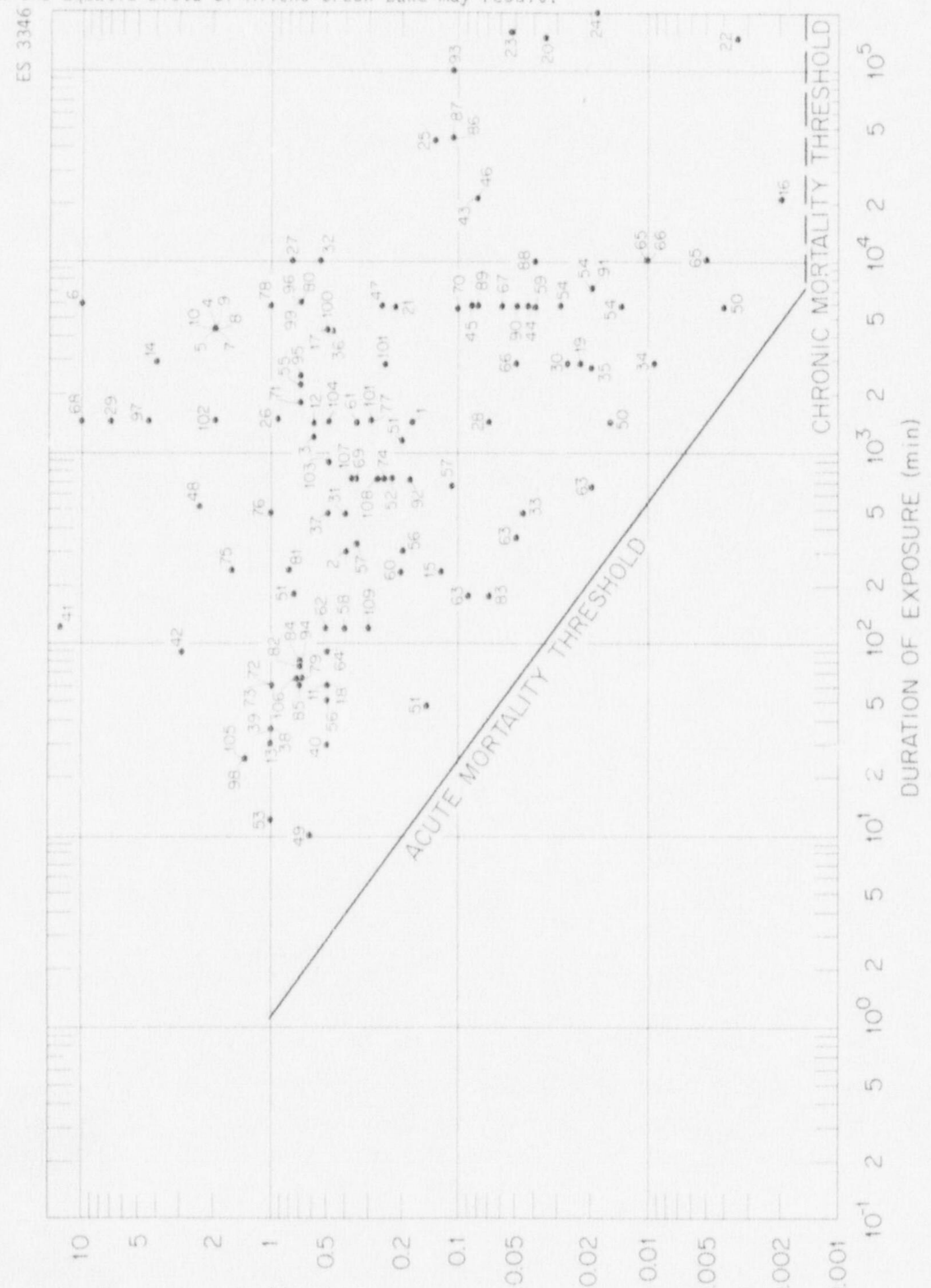

Fig. S.5.2. Toxicity of chlorine to freshwater organisms. Source: J. S. Mattice and H. E. Zittel, "Site-Specific Evaluation of Power Plant Chlorination," *J. Water Pollut. Control Fed.* 48(10): 2284-2308 (1976).

Table S.5.9. Summary of toxicity of chlorine to freshwater organisms

Data point and scientific name	Descriptive name	Concentration (mg/liter)[a]	Duration of exposure (min)	Effect
Plants				
Chlorophyta				
1. *Chlorella pyrenoidosa*		0.18	1,440	50% decrease in growth
2. *Chlorella pyrenoidosa*		0.4	300	50% decrease in growth
3. *Chlorella pyrenoidosa*		0.6	1,200	43% mortality
4. *Chlorella variegata*		2	4,320	Decreased growth
5. *Scenedesmus obliquus*		2	4,320	Decreased growth
6. *Scenedesmus* sp.		10	5,760	Mortality threshold
Chrysophyta				
7. *Gomphonema parvulum*		2	4,320	Decreased growth
8. *Nitzschia palea*		2	4,320	Decreased growth
Cyanophyta				
9. *Cylindrospermum licheniforme*		2	4,320	Decreased growth
10. *Microcystis aeruginosa*		2	4,320	Decreased growth
Miscellaneous				
Not given	Phytoplankton	0.4	Not given	Stops growth
Invertebrate animals				
Protozoa				
(many species)		2–8	<1	Some mortality
Arthropoda-crustacea				
11. *Asellus aquaticus*	Water louse	0.5	60	No reproduction
12. *Asellus racovitzai*	Isopod	0.613	1,440	50% mortality (15°C)
13. *Cyclops* sp.		1	30	Some mortality
14. *Daphnia magna*	Water flea	4	2,880	Mortality threshold
15. *Daphnia magna*	Water flea	0.125	240	100% mortality
16. *Daphnia magna*	Water flea	0.002	20,160	Decreased reproduction[b]
17. *Daphnia magna*	Water flea	0.5	4,320	100% mortality
18. *Daphnia* sp.	Water flea	0.5	60	Some mortality
19. *Gammarus minus*	Scud	0.023	2,880	50% mortality (15°C)
20. *Gammarus pseudolimnaeus*	Scud	0.035	151,200	80% mortality
21. *Gammarus pseudolimnaeus*	Scud	0.22	5,760	50% mortality
22. *Gammarus pseudolimnaeus*	Scud	0.0034	151,200	Almost no reproduction
23. *Gammarus pseudolimnaeus*	Scud	0.054	161,280	Decreased survival[b]
24. *Gammarus pseudolimnaeus*	Scud	0.019	201,600	Decreased reproduction[b]
25. *Gammarus pseudolimnaeus*	Scud	0.135	43,200	No effect[b]
26. *Gammarus pseudolimnaeus*	Scud	0.900	1,440	50% mortality[b]
27. *Orconectes virilis*	Crayfish	0.780	10,080	50% mortality[b]
Arthropoda-insecta				
28. *Centroptilium* sp.	Mayfly	0.071	1,440	50% mortality (6°C)
29. *Chironomus* sp.	Midge larvae	7	1,440	80% mortality
30. *Ephemerella lata*	Mayfly	0.027	2,880	50% mortality (15°C)
31. *Hydropsyche bifida*	Caddisfly	0.396	480	50% mortality (25°C)
32. *Hydropsyche* sp.	Caddisfly	0.55	10,080	50% mortality[c]
33. *Iron humeralis*	Mayfly	0.046	480	50% mortality (15°C)
34. *Isonychia* sp.	Mayfly	0.0093	2,880	50% mortality (6°C)
35. *Peltoperla maria*	Stonefly	0.020	2,880	50% mortality (15°C)
36. *Pterynarcys* sp.	Stonefly	0.480	4,320	50% mortality[b]
37. *Stenonema ithaca*	Mayfly	0.502	480	50% mortality (25°C)
Annelida				
38. *Nais communis*	Oligochaete worm	1.0	35	95% mortality
39. *Nais* sp.	Oligochaete worm	1.0	34	100% mortality
40. *Nais* sp.	Oligochaete worm	0.5	30	Disintegration
Nematoda				
Cheilobus quadrilabiatus	Nematode worm	91	30	50% mortality
41. *Diplogaster nudicapitatus*	Nematode worm	13.0	120	50% mortality
42. *Trilobus gracilis*	Nematode	20.0	150	100% mortality
42. *Trilobus gracilis*	Nematode (immature)	3.0	90	100% mortality
Mollusca				
43. *Campeloma decisum*	Operculate snail	>0.810	20,160	50% mortality[b]
44. *Goniobasis virginica*	Operculate snail	0.044	5,760	50% mortality (25°C)
45. *Nitocris (Anculosa) carinata*	Operculate snail	0.086	5,760	50% mortality (25°C)
46. *Physa integra*	Pulmonate snail	>0.810	20,160	50% mortality[b]
47. *Physa heterostropha*	Pulmonate snail	0.258	5,760	50% mortality (25°C)

Table S.5.9 (continued)

Data point and scientific name	Descriptive name	Concentration (mg/liter)[a]	Duration of exposure (min)	Effect
Vertebrate animals				
Amphibia				
48. *Rana catesbiana*	Tadpole	2.4	510	100% mortality
Fish				
Clupeidae				
49. *Dorosoma cepedianum*	Gizzard shad	0.62	10	Some mortality
Salmonidae				
50. *Oncorhynchus kisutch*	Coho salmon	0.016	1,440	Mortality threshold
50. *Oncorhynchus kisutch*	Coho salmon	0.004	5,760	Mortality threshold
51. *Oncorhynchus kisutch*	Coho salmon fingerlings	0.2	1,152	76% mortality (free OCl)
51. *Oncorhynchus kisutch*	Coho salmon fingerlings	0.75	180	100% mortality (NH_2Cl)
51. *Oncorhynchus kisutch*	Coho salmon fingerlings	0.15	<48	100% mortality ($NHCl_2$)
Oncorhynchus kisutch	Coho salmon fingerlings	0.2	<1	Immediate distress
52. *Oncorhynchus kisutch*	Coho salmon	0.230	720	50% mortality[b]
53. *Oncorhynchus tshawytscha*	Chinook salmon fry	1.0	12	100% mortality
54. *Salmo gairdnerii*	Rainbow trout	0.02	7,200	50% mortality[b]
54. *Salmo gairdnerii*	Rainbow trout	0.014	5,760	50% mortality[b]
54. *Salmo gairdnerii*	Rainbow trout	0.029	5,760	50% mortality[b]
55. *Salmo gairdnerii*	Rainbow trout	0.7	2,220	100% mortality
56. *Salmo gairdnerii*	Rainbow trout	0.2	300	50% mortality
56. *Salmo gairdnerii*	Rainbow trout	0.5	50	50% mortality
57. *Salmo gairdnerii*	Rainbow trout	0.108	672	60% mortality
57. *Salmo gairdnerii*	Rainbow trout	0.354	330	40% mortality
58. *Salmo gairdnerii*	Rainbow trout	0.4	120	100% mortality
59. *Salmo gairdnerii*	Rainbow trout	0.04	5,760	50% mortality (20–80 mm)
60. *Salmo gairdnerii*	Rainbow trout fingerlings	0.2	240	100% mortality
61. *Salmo trutta*	Brown trout	0.35	1,440	Mortality[c]
62. *Salmo trutta*	Brown trout	0.5	120	50% mortality
63. *Salmo trutta*	Brown trout	0.09	180	50% mortality
63. *Salmo trutta*	Brown trout	0.05	360	50% mortality
63. *Salmo trutta*	Brown trout	0.02	660	50% mortality
64. *Salmo trutta*	Brown trout fingerlings	0.5	90	50% mortality
65. *Salvelinus fontinalis*	Brook trout	0.01	10,080	Mortality threshold
65. *Salvelinus fontinalis*	Brook trout	0.005	10,080	Activity depressed
66. *Salvelinus fontinalis*	Brook trout	0.01	10,080	Mortality threshold
66. *Salvelinus fontinalis*	Brook trout	0.05	2,880	100% mortality
67. *Salvelinus fontinalis*	Brook trout	0.06	5,760	50% mortality
68. *Salvelinus fontinalis*	Brook trout	10.0	1,440	100% mortality
69. *Salvelinus fontinalis*	Brook trout	0.360	720	50% mortality[b]
70. *Salvelinus fontinalis*	Brook trout	0.102	5,760	50% mortality (20°C)
Esocidae				
71. *Esox lucius*	Northern pike	0.7	1,800	100% mortality (temp 4.5°–7°C)
72. *Esox vermiculatus*	Grass pickerel	1	60	100% mortality (after 24 hr)
Catastomidae				
73. *Catastomus commersoni*	White sucker	1	60	100% mortality
74. *Catastomus commersoni*	White sucker	0.248	720	50% mortality[b]
Cyprinidae				
75. *Carrassius auratus*	Goldfish	1.6	240	100% mortality
76. Not given	Goldfish	1.0	480	Some mortality
77. Not given	Goldfish	0.3	1,440	100% mortality
78. *Carrassius auratus*	Goldfish	1.0	5,760	100% mortality
79. *Cyprinus carpio*	Carp	0.72	65	Some mortality
80. *Cyprinus carpio*	Carp	0.7	6,000	80% mortality
Notemigonus crysoleucas	Golden shiner	>3,000	0.17	Death
81. *Notemigonus crysoleucas*	Golden shiner	0.8	240	100% mortality
82. *Notropis cornutus*	Common shiner	0.7	76	100% mortality
83. *Notropis rubellus*	Roseyface shiner	0.07	180	100% mortality
84. *Notropis rubellus*	Roseyface shiner	0.7	79	100% mortality
85. *Pimepheles notatus*	Minnow bluntnose	0.7	51	100% mortality
86. *Pimepheles promelas*	Fathead minnow larvae	0.108	43,200	60% mortality
87. *Pimepheles promelas*	Fathead minnow larvae	0.108	43,200	68% decreased growth

Table S.5.9 (continued)

Data point and scientific name	Descriptive name	Concentration (mg/liter)[a]	Duration of exposure (min)	Effect
88. *Pimepheles promelas*	Fathead minnow	0.043	10,080	50% decreased spawning
89. *Pimepheles promelas*	Fathead minnow	0.08–0.19	5,760	50% mortality
90. *Pimepheles promelas*	Fathead minnow	0.05	5,760	Threshold mortality
91. *Pimepheles promelas*	Fathead minnow	0.02	7,200	50% mortality
92. *Pimepheles promelas*	Fathead minnow	0.185	720	50% mortality[b]
93. *Pimepheles promelas*	Fathead minnow	0.110	100,800	No spawning[b]
94. *Rhinichthys atronaus*	Minnow	0.7	79	100% mortality
95. *Scardinius erythrophthalmus*	Rudd	0.7	2,460	100% mortality
96. *Tinca tinca*	Tench	0.7	6,000	20% mortality
Ictaluridae				
97. *Ictalurus melas*	Black bullhead	~4.5	1,440	50% mortality
98. *Ictalurus melas*	Black bullhead	1.36	25	Some mortality
Anguillidae				
99. *Anguilla anguilla*	Eel	0.7	6,000	Mortality threshold
Poeciliidae				
100. *Gambusia affinis*	Mosquitofish	0.5–1.0	4,320	Mortality threshold
Serranidae				
101. *Morone saxatilis*	Striped bass	0.3	1,440	50% mortality
101. *Morone saxatilis*	Striped bass	0.25	2,880	50% mortality
Centrarchidae				
102. *Lepomis cyanellus*	Green sunfish	2	1,440	60% mortality
Lepomis cyanellus	Green sunfish	0.4	Not given	Eventual mortality
103. *Micropterus dolomieui*	Smallmouth bass	0.5	900	50% mortality
104. *Micropterus salmoides*	Largemouth bass	0.494	1,440	50% mortality[b]
105. *Pomoxis nigromaculatus*	Black crappie	1.36	25	Some mortality
Percidae				
106. *Perca flavescans*	Yellow perch	0.72	65	Some mortality
107. *Perca flavescans*	Yellow perch	0.365	720	50% mortality[b]
108. *Stizostedion vitreum vitreum*	Walleye	0.267	720	50% mortality[b]
Miscellaneous				
109. Not given	Freshwater minnows "killies"	0.3	120	No distress

[a]Milligrams per liter and parts per million were treated as equivalent units.

[b]Wastewater chlorination.

[c]Measured time of first "agitation," but death occurred about 1 min later.

Source: J. S. Mattice and H. E. Zittel, "Site-specific evaluation of power plant chlorination," *J. Water Pollut. Control Fed.* 48(10) (1976).

Water quality

Chemical discharges from the sanitary waste system to the Allens Creek cooling lake are given in Table S.3.2 and the ER Supplement (Sect. S5.5-1). None of the chemical concentrations remaining after 1.7 x 10^5 dilution in the discharge canal (ER Suppl., Sect. S5.5.1) are expected to have any significant impacts on the aquatic biota as they will be below known toxic levels. The discussion of enrichment effects of the nutrients released given in the FES is applicable for either station design.

The maximum concentration of TDS in the cooling lake has been estimated to approach 1800 ppm (ER Suppl., Fig. S3.4-31). Monthly averages will be within 800 to 1200 ppm, which are well within the range of acceptable concentrations for the protection of aquatic life (FES, Table 5.18).

High levels of some trace elements have been reported in Brazos River (Table S2.6). Heavy metal concentrations by element do not show consistent seasonal behavior during the one year of data given. Consequently, makeup water pumping during any time of year will lead to some heavy metal contamination of the cooling lake. Further heavy metal inputs to the cooling lake will come from runoff from the Allens Creek drainage (BMPR, Sect. 3.6). The aquatic biota of Allens Creek cooling lake may therefore experience impacts from some toxic trace elements. Of special significance and concern is the potential for bioaccumulation of toxic trace elements such as mercury, cadmium, and lead leading to ingestion by man. However, due to the uncertainty of heavy metal water chemistry in the proposed cooling lake and the uncertainty of the yearly concentration cycle by element for Brazos River water (which cannot be confirmed by one year's data), the staff cannot make an accurate assessment of possible impacts from either a three- or six-month pumping mode relative to heavy metal loading. Continuing analysis of the possible extent of heavy metal pollution in the Brazos River as it may affect the Allens Creek cooling lake is necessary. The staff therefore requires additional sampling (Sect. S.6) for the presence of heavy metal accumulation in adult fish in the Brazos River because sampling to date has been limited (BMPR, Sect. 3.6) and because adult fish serve as important integrators of environmental conditions.

High fecal coliform and fecal streptococci numbers have also been reported in Allens Creek. Some seasonal restriction in the recreational use of the Allens Creek embayment may result. However, an adequate data base for a detailed assessment of the probable levels of the bacteria is not available. The staff has therefore suggested a monitoring program (Sect. S.6) because of possible health hazards due to the potential occurrence of fecal indicator bacteria in the Allens Creek embayment from upstream cattle operations and domestic sweage inflows.

<u>Brazos River</u>

The major sources of impact on the Brazos River from operation of the cooling-water discharge system will include (1) temperature changes, (2) chemical discharges, and (3) water quality changes. Releases from the cooling lake to the Brazos River will result from spillage during high-water periods in the lake and from controlled low-level releases to augment low flows in the Brazos (ER, Suppl., Sect. S3.4). The effects of these discharges are discussed in general in the FES (Sect. 5.5.2.1.2). The following section contains data on the effects of a three- or a six-month pumping mode only. The staff recommends against use of a twelve-month pumping mode due to potentially high entrainment losses of ichthyoplankton (Sect S.5.3.1.2).

<u>Temperature</u>. Predicted spillway temperatures are compared to ambient Brazos River temperatures in Sect. S.5.3.2.1. Table S.5.5 shows that average spillway temperatures will be maximum in July [30.6°C (87.1°F)] and minimum in January [13.4°C (56.2°F)], with a predicted maximum ΔT of 1.9°C (3.5°F) (Table S.5.6). Maximum excess temperatures will occur in January and December. These results will essentially be the same for either a three- or six-month pumping mode (Sect. S.5.3.2.1). Based on these data, the staff concludes that the operation of ACNGS will not result in significant thermal impacts on Brazos River biota.

Chlorine will be used as a biocide and will be discharged to the cooling lake. Although TRC discharges to the Brazos River from the Allens Creek cooling lake cannot be accurately simulated, it is the staff's opinion that due to the long travel time between the discharge canal and the Brazos River spillway (Fig. S.5.1) and the subsequent high dilution, the TRC discharge to the Brazos River will be no greater than 0.001 ppm. This concentration is less than the recommended TRC discharge limit to the Brazos River at 0.01 ppm given in the original analysis (FES, p. 5-31). Dilution of this concentration in the Brazos River should be sufficient to protect aquatic life (Fig. S.5.2 and Table S.5.9).

<u>Water quality</u>. A general description of dissolved oxygen in spillage water and its organic and nutrient content as it may affect the Brazos River is presented in Table S.3.2 and in the FES (p. 5-32). A situation similar to that described in the FES will probably exist under the new lake design and power plant operation, and no adverse impact resulting from the oxygen demand and nutrient content of spillway discharges to the Brazos River is expected.

Spillage from the Allens Creek cooling lake will contain relatively high concentrations of total dissolved solids compared to the ambient concentration in the Brazos River (Table S.5.4). As shown in Table S.5.4, the maximum discharge of TDS to the Brazos River will be 1820 mg/liter during October of an average year. Because this TDS concentration is below known toxic levels to aquatic biota reported in the Brazos River (FES, Table 5.[illegible]8), the staff concludes as in the FES (p. 5-32) that little impact, other than some possible movement of biota away from the discharge area during high TDS releases, will occur in the Brazos River.

TDS concentrations in the cooling lake are estimated to be less than 1500 ppm about 95% of the time (ER Suppl., Sect. S3.4.3.1). The applicant's permit from the TWQB permits a maximum monthly average discharge concentration of 1850 ppm from the cooling lake (ER Suppl., Sect. S3.4.3.3). The applicant's analysis (ER Suppl., Table S3.4-11) shows that this limit will not be exceeded. Based on these data, the staff concludes that TDS concentrations of the spillway discharges will not significantly affect existing aquatic biota of the Brazos River.

The staff has evaluated the effect of upstream water impoundment on the supply of sediment and suspended silt load to the Brazos River estuary. As the Allens Creek cooling lake impoundment will not be on the main river channel, only the suspended silt load from that fraction of total river flow pumped into the cooling reservoir would potentially be lost and unavailable for downstream enrichment of the estuary. If water levels are maintained in the Brazos River by upstream releases from reservoirs, then total bed load transport should not be affected to any significant degree by the Allens Creek cooling lake system. Since water enriched with nutrients and particulate organic matter will be released from the cooling lake to the Brazos River, some return of entrained silt load is expected. A quantitative comparison between the present silt load of the Brazos River and that occurring during plant operations is not available due to the qualitative nature of the data on the proposed Allens Creek cooling lake. However, operation of upstream main stem reservoirs such as Lake Granberry should have a much greater impact on the transport of sediment and silt to the Brazos River estuary than will operation of the proposed cooling lake. Consequently, it is the staff's opinion that, although some nutrients will probably be retained by the cooling lake, the level of impact on the Brazos River estuary production should be small.

S.5.3.2.3 Water quality standards

Liquid effluents from ACNGS will be required to comply with appropriate State of Texas and Federal standards. Water quality criteria for Texas streams are established and enforced by the Texas Water Quality Board (TWQB). The EPA is kept informed of TWQB activities on all matters affecting EPA functions as promulgated under the Federal Water Pollution Control Act Amendments (FWPCA) of 1972.

As described in Sect. S.3.1, the plant cooling system will employ a newly constructed cooling lake to dissipate the excess heat, and the lake will discharge into the Brazos River. The TWQB[13] designates the following water uses that are known and suitable for the Brazos River near the ACNGS site: (1) contact and noncontact recreation waters, (2) domestic raw water supply, (3) propagation of fish and wildlife, and (4) irrigation waters. The following criteria apply to the specific waters of the Brazos River Basin (identified as segment 1202) which lie above the tidal zone and extend to Whitney Dam (and therefore include the portions of the Brazos River that will receive effluents from ACNGS):

1. chloride, average not to exceed 600 mg/liter;
2. sulfate, average not to exceed 225 mg/liter;
3. total dissolved solids, average not to exceed 1500 mg/liter;
4. dissolved oxygen, not less than 5.0 mg/liter;
5. pH range, 6.5 to 8.5;
6. fecal coliform, logarithmic average not more than 200 per 100 ml; and
7. temperature, maximum upper limit 35°C (95°F), or a 2.8°C (5°F) rise above ambient temperature.

However, the Texas Water Quality Standards[13] make allowances for mixing zones for which these criteria are applicable only outside of these designated regions. Because of varying local physical, chemical, and biological conditions, no single criterion for determining the mixing zones is applicable in all cases. Consequently, mixing zones are established by the TWQB on a case-by-case basis. Guidelines are established, however, in cases for which fishery resources are considered significant. These guidelines state that the allowed mixing zone shall not preclude the passage of free-swimming and drifting aquatic organisms to the extent that their populations would be significantly affected. Normally, mixing zones should be limited to no more than 25% of the cross-sectional area and/or the volume of flow of the stream or estuary, leaving at least 75% free as a zone of passage, unless otherwise defined by a specific Board order or permit.

With respect to the discharge of effluents into the Brazos River, HL&P obtained a permit from the TWQB which permits a TDS concentration of 1850 mg/liter in the cooling lake discharge. Although the permit is based on the two-unit operation of a 3339-ha (8250-acre) cooling reservoir, the applicant's cooling lake simulations for the one-unit design (ER Suppl., Table S3.4-11) do not exhibit any months in which this limit is exceeded. However, if a flow release were required during a period when the lake water TDS concentration exceeded the permit limitation or when Allens Creek flow is needed for operation, HL&P could draw on upstream water storage to supplement the Brazos River flow as required.

Additionally, the applicant has shown that the maximum monthly average temperature differential between spillway temperature and ambient temperature of the Brazos River during December (in 1963 study period, the period of predicted maximum ΔT) will be about 2.2°C (4°F); consequently, a mixing zone would not be required. The st ff's results, although not conclusive, show slightly higher excess temperatures in the spillway discharges. It is the staff's opinion, however, that a mixing zone may be required because (Sect. S.5.3.2.1) ΔTs greater than 2.8°C (5°F) will occur on a daily basis if the same meteorological conditions were to persist that occurred in the simulations for the study period (1952 to 1968). Moreover, the staff has concluded that in any event, discharges from ACNGS could not have any significant environmental impact (in relation to thermal alterations) on the aquatic biota of the Brazos River (Sect. S.5.3.2.2).

Also notable in the Texas Water Quality Standards, which have applicability to ACNGS, are temperature requirements and other numerical criteria pertaining to freshwater impoundments (Allens Creek cooling lake). For offstream or privately owned reservoirs constructed principally for industrial cooling purposes, there are no temperature requirements. The EPA, however, has determined that Allens Creek is a navigable water body, and its impoundment as proposed for the ACNGS will qualify the reservoir as a cooling lake; therefore, the circulating-water system will be considered a component of a once-through, instead of a closed-cycle system. If, in fact, the EPA's current classification of the proposed Allens Creek impoundment is the final classification effluent limitations (temperature and chamicals) will be est lished at the outlet of the circulating water discharge canal.

S.5.3.3 Impacts to terrestrial ecosystems

The impacts of operation of the Allens Creek station have been discussed in Sect. 5.5.1 of the FES and are essentially the same for the reduced size of the plant and cooling lake. The selection of transmission line Route 2C has reduced the concern for waterfowl collision with power lines as discussed in the FES. The decline in the population of Attwater's prairie chicken along Route 1A may be irreversible, but the staff suggests that the applicant make every effort to provide and maintain tall-grass prairie habitat along his rights-of-way in this area, consistent with recommendations which may be made by the USFWS (Sect. S.4.3). The applicant is holding approximately 1939 ha (4792 acres) of his property for future development and intends either to lease them for agricultural purposes or to allow them to undergo secondary succession until the time that they are needed for other purposes. The staff considers either type of land use acceptable.

The applicant has identified a unique native hay meadow (BMPR, pp. 4.2-1 to 4.2-3) within the area of the proposed state park. The staff considers this meadow to be one of the most valuable terrestrial habitats present on the site. The Master Development Plan for the proposed State Park[15] states that this meadow will be preserved and no development will take place within it.

S.5.4 RADIOLOGICAL IMPACTS FROM ROUTINE OPERATION

S.5.4.1 Exposure pathways

The environmental pathways that were considered in preparing this section are shown in Fig. S.5.3. The specific pathways evaluated were:

1. Direct radiation from the plant.
2. For gaseous effluents,
   a. Immersion in the gaseous plume;
   b. Inhalation of iodines and particulates;
   c. Ingestion of iodines and particulates through the milk cow, goat, meat animal and vegetation pathway;
   d. Radiation from iodines and particulates deposited on the ground.
3. For liquid effluents,
   a. Drinking water;
   b. Ingestion of fish and invertebrates;
   c. Shoreline activities, boating and swimming in water containing radioactive effluents;

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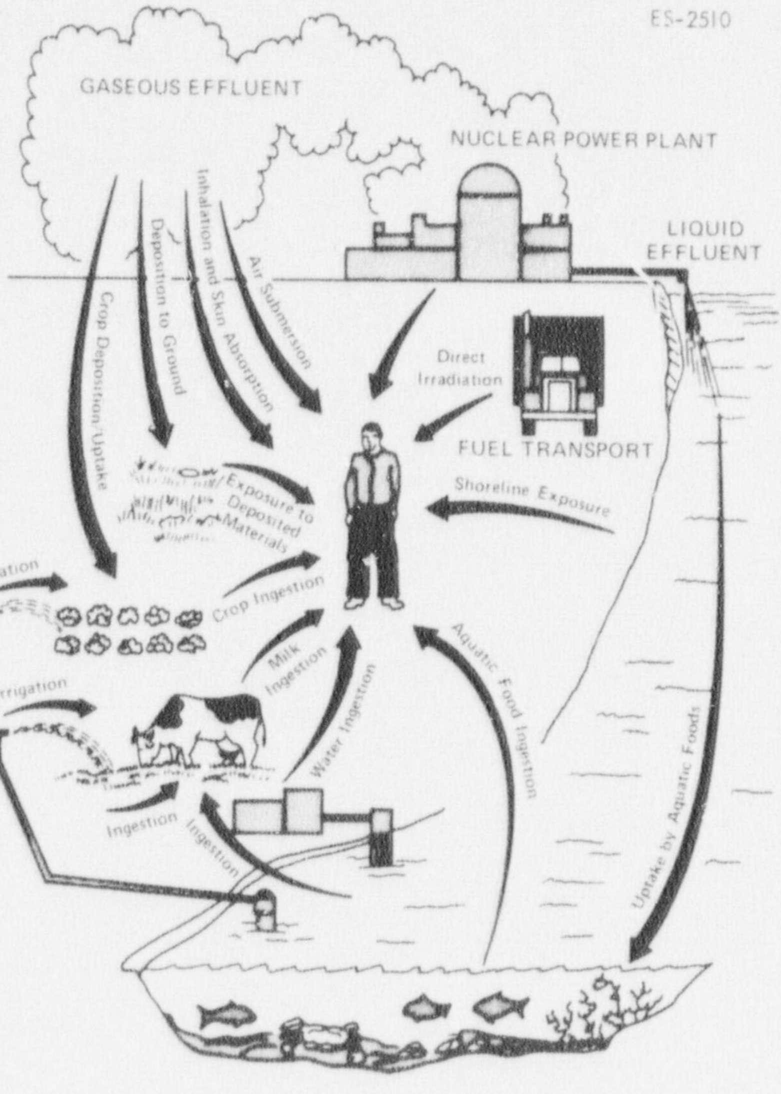

Fig. S.5.3. Generalized pathways for radiation exposure to man.

d. Irrigated foods.

Only those pathways associated with gaseous effluents that were reported to exist at a single location were combined to calculate the total exposure to a maximally exposed individual. Pathways associated with liquid effluents were combined without regard to location but were assumed to be associated with a maximally exposed individual other than the individual from gaseous effluent pathways.

The models and considerations for environmental pathways leading to estimates of radiation doses to individuals near the plant and to the population within an 80-km radius of the plant resulting from plant operations are discussed in detail in Regulatory Guide 1.109. Use of these models with additional assumptions for environmental pathways leading to exposure to populations outside the 80-km radius are described in Appendix S.C of this statement.

S.5.4.2 Dose commitments

The quantities of radioactive material that may be released annually from the plant are estimated based on the description of the radwaste systems given in the applicant's ER and PSAR and using the calculational model and parameters described in NUREG 0016 and 0017. The applicant's site and environmental data provided in the ER and in subsequent answers to the staff's questions are used exter [illegible] in the dose calculations. Using these quantities of radioactive materials released and exposure pathway information, the dose commitments to individuals and the population are estimated. Population doses are based on the projected population distribution of the year 2000.

The dose commitments in this statement represent the total dose received over a period of 50 years following the intake of radioactivity for one year under the conditions existing 15 years after the station is started up. For the younger age groups, changes in organ mass with age after the initial intake of radioactivity are accounted for in a stepwise manner.

In the analysis of all effluent radionuclides released from the plant, tritium, carbon-14, radiocesium, radiocobalt, and radioiodine inhaled with air and ingested with food and water were found to account for essentially all total-body dose commitments to individuals and the population within 80 km of the plant.

S.5.4.2.1 Dose commitments from radioactive releases to the atmosphere

Radioactive effluents released to the atmosphere from the Allens Creek Unit 1 facility will result in small radiation doses to individuals and populations. The staff's estimates of the expected gaseous and particulate releases listed in Table S.5.10, and the site meteorological considerations discussed in Sect. S.2.3 of this Supplement and summarized in Table S.5.11 were used to estimate radiation dose to individuals and populations. The results of the calculations are discussed below.

Table S.5.10. Calculated releases of radioactive materials in gaseous effluents from ACNGS (curies per year per reactor)

Radionuclides	Reactor building	Turbine building	Auxiliary building	Radioactive waste building	Air ejector waste gas	Mechanical vacuum pump	Total
Kr-83m	*a*	*a*	*a*	*a*	3,300	*a*	3,300
Kr-85m	3	68	3	*a*	29,000	*a*	29,000
Kr-85	*a*	*a*	*a*	*a*	290	*a*	290
Kr-87	3	130	3	*a*	5,300	*a*	5,400
Kr-88	3	230	3	*a*	50,000	*a*	50,000
Xe-131m	*a*	*a*	*a*	*a*	170	*a*	170
Xe-133m	*a*	*a*	*a*	*a*	820	*a*	820
Xe-133	66	250	66	10	62,000	2,300	65,000
Xe-135m	46	650	46	*a*	*a*	*a*	740
Xe-135	34	630	34	45	17	350	1,100
Xe-138	7	1,400	7	*a*	*a*	*a*	1,400
I-131	1.7(−1)[b]	1.9(−1)	1.7(−1)	5(−2)	*a*	3(−2)	6.1(−1)
I-133	6.8(−1)	7.6(−1)	6.8(−1)	1.5(−1)	*a*	*a*	2.3
Cr-51	3(−4)	1.3(−2)	3(−4)	9(−3)	*c*	*c*	2.3(−2)
Mn-54	3(−3)	6(−4)	3(−3)	3(−2)	*c*	*c*	3.7(−2)
Fe-59	4(−4)	5(−4)	4(−4)	1.5(−2)	*c*	*c*	1.6(−2)
Co-58	6(−	6(−4)	6(−4)	4.5(−3)	*c*	*c*	6.3(−3)
Co-60	1(	2(−3)	1(−2)	9(−2)	*c*	*c*	1.1(−1)
Zn-65	2(−3)	2(−4)	2(−3)	1.5(−3)	*c*	*c*	5.7(−3)
Sr-89	9(−4)	6(−3)	9(−5)	4.5(−4)	*c*	*c*	6.6(−3)
Sr-90	5(−6)	2(−5)	5(−6)	3(−4)	*c*	*c*	3.3(−4)
Zr-95	4(−4)	1(−4)	4(−4)	5(−5)	*c*	*c*	9.5(−4)
Sb-124	2(−4)	3(−4)	2(−4)	5(−5)	*c*	*c*	7.5(−4)
Cs-134	4(−3)	3(−4)	4(−3)	4.5(−3)	*c*	*c*	1.3(−2)
Cs-136	3(−4)	5(−5)	3(−4)	4.5(−4)	*c*	*c*	1.1(−3)
Cs-137	5.5(−3)	6(−4)	5.5(−3)	9(−3)	*c*	*c*	2.1(−2)
Ba-140	4(−4)	1.1(−2)	4(−4)	1(−4)	*c*	*c*	1.2(−2)
Ce-141	1(−4)	6(−4)	1(−4)	2.5(−3)	*c*	*c*	3.4(−3)
C-14	*a*	*a*	*a*	*a*	9.5	*a*	9.5
H-3	39		39				78
Ar-41	25	*c*	*c*	*c*	*c*	*c*	25

[a] Less than 1.0 Ci/year for noble gases, less than 10^{-4} Ci/year for iodine.

[b] Exponential notation: $7.0(-3) = 7.0 \times 10^{-3}$.

[c] Less than 1% of total for radionuclide.

Radiation dose commitments to individuals

Individual receptor locations and pathway locations considered for the maximum individual are listed in Table S.5.12. The estimated dose commitments to the maximum individual from radioiodine and particulate releases at selected offsite locations are listed in Tables S.5.13 and S.5.14. The maximum individual is an infant who consumes 330 liters of milk per year and resides at a residence for the entire year.

The maximum annual beta and gamma air dose and the maximum total body and skin dose to an individual, at the maximum site boundary, are presented in Tables S.5.13 and S.5.14.

Table S.5.11. Summary of atmospheric dispersion factors and deposition values for ACNGS[a]

Location	Source	χ/Q (sec/m^3)	Relative deposition (m^{-2})
Nearest[b] site boundary (1.2 miles S)	*c*	2.4×10^{-7}	4.6×10^{-9}
	d	5.5×10^{-7}	1.1×10^{-8}
	e	6.5×10^{-7}	1.3×10^{-8}
	f	2.9×10^{-6}	1.2×10^{-8}
Nearest farm residence, milk animal, and meat animal (3.2 miles NW)	*c*	9.3×10^{-8}	3.4×10^{-10}
	d	1.9×10^{-7}	8.9×10^{-10}
	e	2.2×10^{-7}	1.0×10^{-9}
	f	5.2×10^{-7}	1.3×10^{-9}

[a]The dose presented in the following tables are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Rev. 1 "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

[b]"Nearest" refers to that type of location where the highest radiation dose from all appropriate pathways is expected to occur.

[c]Plant vent stack (continuous).

[d]Plant vent stack (intermittent 4 times per year for 24 hr).

[e]Plant vent stack (intermittent 24 times per year for 2 hr).

[f]Radioactive waste building vent (continuous).

Table S.5.12. Receptor and pathway locations selected for maximum individual dose commitments

	Sector	Distance
Site boundary[a]	S	1.2 miles (1900 m)
Residence[b]	NW	3.2 miles (5200 m)
Milk cow	NW	3.2 miles (5200 m)
Meat animal	NW	3.2 miles (5200 m)

[a]Beta and Gamma air doses, total body doses, and skin doses from noble gases are determined at site boundaries.

[b]Dose pathways including inhalation of atmospheric radioactivity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences.

Radiation dose commitments to populations

The estimated annual radiation dose commitments to the population within 80 km of the Allens Creek nuclear plant from gaseous and particulate releases are shown in Table S.5.14. Beyond 80 km the doses were evaluated using average population densities and food production values discussed in Appendix S.C. Estimated dose commitments to the U.S. population based on the projected population distribution for the year 2000 are shown in Table S.5.15. Background radiation doses are provided for comparison. The dose commitments from atmospheric releases from the Allens Creek facility during normal operation represent a small increase in the normal population dose from background radiation sources.

Table S.5.13. Maximum annual dose commitments to an individual near ACNGS[a]

Location	Pathway				
		Radioiodine and particulates in gaseous effluents			
			Total body		Thyroid
Nearest[b] farm residence, milk cow, and meat animal (3.2 miles NW)	Ground deposit		0.092 millirem		0.092 millirem
	Inhalation		<0.01 millirem		0.057 millirem
	Milk		0.024 millirem		3.2 millirems
Total (to an infant)			0.12 millirem		3.4 millirems
		Liquid effluents			
		Total body		Bone	Liver
Nearest drinking water – cooling lake	Water ingestion	<0.1 millirem		<0.1 millirem	<0.1 millirem
Nearest fish at cooling lake	Fish ingestion	1.2 millirems		0.7 millirem	1.6 millirems
Irrigated foods	Vegetation, milk, and meat	<0.1 millirem		<0.1 millirem	<0.1 millirem
Total (to an adult)		1.4 millirems		1.0 millirem	1.8 millirems
		Noble gases in gaseous effluents			
		Total body	Skin	Gamma air dose	Beta air dose
Nearest[c] site boundary (1.2 miles S)		4.3 millirems	6.8 millirems	6.4 millirads	2.6 millirads

[a] Based on annual dose per reactor unit.

[b] "Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways has been estimated.

[c] "Nearest" refers to that site boundary location where the highest radiation doses due to gaseous effluents have been estimated to occur.

S.5.4.2.2 Dose commitments from radioactive liquid releases to the hydrosphere

Radioactive effluents released to the hydrosphere from the Allens Creek Unit 1 facility during normal operation will result in small radiation doses to individuals and populations. The staff's estimates of the expected liquid releases listed in Table S.5.16 and the site hydrological considerations discussed in the FES (Sect. 2.5) and summarized in Table S.5.17 were used to estimate radiation dose commitments to individuals and populations. The results of the calculations are discussed below.

Radiation dose commitments to individuals

The estimated dose commitments to the maximum individual from liquid releases at selected offsite locations are listed in Tables S.5.13 and S.5.14. The maximum individual has been estimated to be an adult, who consumes fish harvested from the cooling lake, drinks water from the cooling lake, and uses the shoreline of the lake for recreation.

Radiation dose commitments to populations

The estimated annual radiation dose commitments to the population within 80 km of the Allens Creek Unit 1 nuclear plant from liquid releases, based on the use of the cooling lake and Brazos River water (recreation, sport fishing, commercial fishing, and irrigated foods) are shown in Table S.5.14. Dose commitments beyond 80 km were based on the assumptions discussed in Appendix S.C. Estimated dose commitments to the U.S. population are shown in Table S.5.15. Background radiation doses are provided for comparison. The dose commitments from liquid releases from the Allens Creek facility during normal operation represent a small increase in the normal population dose from background radiation sources.

Table S.5.14. Calculated maximum dose commitments to an individual and the population from ACNGS operation

Comparison of ACNGS Unit 1 with Appendix I to 10 CFR Part 50, Sections II.A, II.B, and II.C (May 5, 1975) and Section II.D, Annex (Sept. 4, 1975)

Criterion	Appendix I Design Objectives[a]	Annex Design Objectives[b]	Calculated doses Unit No. 1
Individual doses			
Liquid effluents			
Dose to total body from all pathways	3 millirems per year per unit	5 millirems per year per site	1.4 millirems per year per unit
Dose to any organ from all pathways	10 millirems per year per unit	5 millirems per year per site	1.8 millirems per year per unit
Liquid releases (except tritium and dissolved noble gases)	No limit specified	5 Ci per year[c]	0.25 Ci per year
Noble gas effluents (at site boundary)			
Gamma dose in air	10 millirads per year per unit	10 millirads per year per site	6.4 millirads per year per unit
Beta dose in air	20 millirads per year per unit	20 millirads per year per site	2.6 millirads per year per unit
Dose to total body of an individual	5 millirems per year per unit	5 millirems per year per site	4.3 millirems per year per unit
Dose to skin of an individual	15 millirems per year per unit	15 millirems per year per site	6.8 millirems per year per unit
Radioiodines and particulates[d]			
Dose to any organ from all pathways	15 millirems per year per unit	15 millirems per year per site	3.4 millirems per year per unit
Releases (I-131)	No limit specified	1 Ci per year per unit	0.61 Ci per year per unit

Population doses within 80 km (50 miles)

	Total Body	Thyroid
Natural radiation background[e]	260,000. man-rems per year per unit	
Liquid effluents	28. man-rems per year per unit	28. man-rems per year per unit
Noble gas effluents	10. man-rems per year per unit	10. man-rems per year per unit
Radioiodines and particulates	1.2 man-rems per year per unit	7.4 man-rems per year per unit

[a] Appendix I Design Objectives from Sect. II.A, II.B, II.C, and II.D of Appendix I, 10 CFR Part 50, considers maximum doses to individual and population per reactor unit. From Fed. Regist. 40: 19442, (May 5, 1975).

[b] Guides on Design Objectives proposed by the NRC staff on Feb. 20, 1974; considers doses to individuals from all units on site. From *Concluding Statement of Position of the Regulatory Staff*, Docket No. RM-50-2, Feb. 20, 1974, pp. 25–30, U.S. Atomic Energy Commission, Washington, D.C.

[c] Excluding tritium and dissolved noble gases.

[d] Carbon-14 and tritium have been added to this category.

[e] *Natural Radiation Exposure in the United States*, U.S. Environmental Protection Agency, ORP-SID-72-1 (June 1972); using the average Texas State background dose (92 millirems per year) and year 2000 projected population of 2,780,000.

Table S.5.15. Annual total body population dose commitments in the year 2000

Category	U.S. population-dose commitment for the site
Natural background radiation[a] (man-rems per year)	27,000,000
ACNGS operation (man-rems per year per site)	
Plant workers	500
General public	
Radionuclides and particulates	42
Liquid and effluents	41
Noble gas effluents	33
Transportation of fuel and waste	7

[a]Using the average U.S. background dose (102 millirems per year) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Dept. of Commerce, Bureau of the Census, Series P-25, No. 541 (February 1975).

Table S.5.16. Calculated releases of radioactive materials in liquid effluents from ACNGS Unit 1

Radionuclide	Curies per year	Radionuclide	Curies per year
Corrosion and activation products		**Fission products (continued)**	
Na-24	8.5(-3)[a]	Rh-103	6(-5)
P-32	5.2(-4)	Ru-105	3.7(-4)
Cr-51	1.4(-1)	Rh-105*m*	3.7(-4)
Mn-54	1.2(-1)	Rh-105	3.3(-4)
Mn-56	3.2(-3)	Ru-106	2.4(-3)
Fe-55	3(-3)	Ag-110	4.4(-4)
Fe-59	8(-5)	Te-129*m*	1.1(-4)
Co-58	4.6(-3)	Te-129	7(-5)
Co-60	9.9(-3)	Te-131*m*	1.5(-4)
Ni-65	2(-5)	Te-131	3(-5)
Cu-64	2.4(-2)	I-131	4.5(-2)
Zn-65	6(-4)	Te-132	2(-5)
Zn-69*m*	1.7(-3)	I-132	1.8(-3)
Zn-69	1.9(-3)	I-133	2.8(-2)
Zr-69	1.4(-3)	I-134	2(-4)
Mb-95	2(-3)	Cs-134	1.4(-2)
W-187	4(-4)	I-135	8.7(-3)
Np-239	1.4(-2)	Cs-136	5(-4)
Fission products		Cs-137	2.6(-2)
Br-83	2(-4)	Ba-137*m*	1.8(-3)
Sr-80	2.9(-4)	Cs-138	2(-5)
Sr-90	2(-5)	Ba-139	1.2(-4)
Sr-91	2.4(-3)	Ba-140	1(-3)
Y-91*m*	1.5(-3)	La-140	3.5(-4)
Y-91	1.7(-4)	La-141	9(-5)
Sr-92	7.1(-4)	Ce-141	9(-5)
Y-92	2.3(-3)	La-142	9(-5)
Y-93	2.5(-3)	Ce-143	5(-5)
Zr-95	2(-5)	Pr-143	1.1(-4)
Nb-95	2(-5)	Ce-144	5.2(-3)
Mo-99	4.1(-3)	**All Others**	6(-5)
Tc-99*m*	9.4(-3)	**Total except H-3**	0.25
Ru-103	2(-5)	**H-3**	15

[a]Exponential notation: 8.5(-3) = 8.5×10^{-3}.

Table S.5.17. Summary of hydrologic transport and dispersion for liquid releases from ACNGS[a]

Location	Transit time (hours)	Dilution factor
Nearest drinking water intake[b] (cooling lake outfall)	0.1	1
Nearest sport fishing location (cooling lake)	0.1	1
Nearest shoreline (cooling lake)	0.1	1
Nearest irrigated crops[b] (cooling lake outfall)	0.1	1

[a]See Regulatory Guide 1.113, *Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases*, (April 1977, Rev. 1).

[b]Assumed for purposes of an upper-limit estimate.

S.5.4.3 Direct radiation

S.5.4.3.1 Radiation from the facility

Radiation fields are produced in nuclear plant environs as a result of radioactivity contained within the reactor and its associated components. Although these components are shielded, dose rates around the plants have been observed to vary from undetectable levels to values of the order of 1 rem/year.

Doses from sources within the plant are primarily due to nitrogen-16, a radionuclide produced in the reactor core. For boiling water reactors, nitrogen-16 is transported with the primary coolant to the turbine building. The orientation of piping and turbine components in the turbine building determines, in part, the exposure rates outside the plant. Because of variations in equipment lay-out, exposure rates are strongly dependent upon overall plant design.

Based on the radiation surveys that have been performed around several operating BWRs, it appears to be very difficult to develop a reasonable model to predict shine doses. Thus, older plants should have actual measurements performed if information regarding direct radiation and sky-shine rates is needed.

For newer BWR plants with a standardized design, dose rates have been estimated using sophisticated Monte Carlo techniques. The turbine island design proposed in the Braun SAR[16] is estimated to have direct radiation and skyshine dose rates of the order of 20 man-rem per year per unit at a typical site boundary distance of 0.64 km (0.4 mile) from the turbine building. This dose rate is assumed to be typical of the new generation of boiling water reactors. The integrated population dose from such a facility would be less than one man-rem per year per unit.

Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 mrem/year at the site boundary.

S.5.4.3.2 Occupational radiation exposure

Based on a review of the applicant's safety analysis report, the staff has determined that the applicant is committed to design features and operating practices that will assure that individual occupational radiation doses can be maintained within the limits of 10 CFR Part 20 and that individual and total plant population doses will be as low as is reasonably achievable.[17] For the purpose of portraying the radiological impact of the plant operation on all onsite personnel, it is necessary to estimate a man-rem occupational radiation dose. For a plant designed and proposed to be operated in a manner consistent with the 10 CFR Part 20, there will be many variables that influence exposure and make it difficult to determine a quantitative total occupational radiation dose for a specific plant. Therefore, past exposure experience from operating nuclear power stations[18] has been used to provide a widely applicable estimate to be used for all light water reactor power plants of similar type and size. This experience indicates a value of 500 man-rems per year per reactor unit.

On this basis, the projected occupational radiation exposure impact of the one-unit Allens Creek station is estimated to be 500 man-rems per year.

S.5.4.3.3 Transportation of radioactive material

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive waste from the reactor to burial grounds is within the scope of the NRC report entitled, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*. The estimated population dose commitments associated with transportation of fuels and wastes are listed in Tables S.5.15 and S.5.18.

Table S.5.18. Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor

Normal conditions of transport

	Environmental impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lb per truck; 100 tons per cask per rail car
Traffic density	Less than one per day
Rail	Less than three per month

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals per reactor year[a] (millirems)	Cumulative dose to exposed population per reactor year[b] (man-rems)
Transportation workers	200	0.01 to 300	4
General public			
Onlookers	1,100	0.003 to 1.3	3
Along route	600,000	0.001 to 0.06	

Accidents in transport

	Environmental risk
Radiological effects	Small[c]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[a]The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5000 millirems/year for individuals as a result of occupational exposure and should be limited to 500 millirems/year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirems/year.

[b]Man-rem is an expression for the summation of whole-body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if two people were to receive a dose of 0.5 rem (500 millirems) each, the total man-rem dose in each case would be 1 man-rem.

[c]Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multi-reactor site.

Source: Data supporting this table are given in the Commission's *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants,* WASH-1238, December 1972, and Supplement I, NUREG 75/038, April 1975.

S.5.4.4 Radiological impact on man

The actual radiological impact associated with the operation of the proposed Allens Creek nuclear power station will depend, in part, on the manner in which the radioactive waste treatment system is operated. Based on the staff's evaluation of the potential performance of the radwaste system, it is concluded that the system as proposed is capable of meeting the dose design objectives of 10 CFR 50, Appendix I. The applicant has elected to meet the requirements of the Annex to Appendix I (dated September 4, 1975) in lieu of performing the cost-benefit analysis required by Sect. II.D of Appendix I. Table S.5.14 compares the calculated maximum individual doses to the dose design objectives. However, since the facility's operation will be governed by operating license technical specifications and since the technical specifications will be based on the dose design objectives of 10 CFR 50, Appendix I, as shown in the first column of Table S.5.14, the actual radiological impact of plant operation may result in doses close to the dose design objectives. Even if this situation exists the individual doses will still be very small when compared to natural background doses (~92 man-rems/year) or of the dose limits specified in 10 CFR 20. As a result, the staff concludes that there will be no measurable radiological impact on man from routine operation of the Allens Creek Unit 1 plant.

S.5.4.5 Radiological impacts to biota other than man

Depending on the pathway and radiation source, terrestrial and aquatic biota will receive doses approximately the same or somewhat higher than man receives. Although guidelines have not been established for acceptable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Experience has shown that it is the maintenance of population stability that is crucial to the survival of a species, and species in most ecosystems suffer rather high mortality rates from natural causes. Although the existence of extremely radiosensitive biota is possible, and whereas increased radiosensitivity in organisms may result from environmental interactions with other stresses (e.g., heat, biocides, etc.), no biota have yet been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding the Allens Creek Unit 1 nuclear power plant. Furthermore, in all the plants for which an analysis of radiation exposure to biota other than man has been made, there have been no cases of exposures that can be considered significant in terms of harm to the species, or that approach the exposure limits to members of the public permitted by 10 CFR Part 20.[19] Since the BEIR Report[20] concluded that the evidence to date indicates that no other living organisms are very much more radiosensitive than man, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this plant.

S.5.5 URANIUM FUEL CYCLE IMPACTS

Section 5.4.3 of the FES summarizes the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low- and high-level wastes. These environmental effects were set out in Table S-3 of 10 CFR Part 51 as it then appeared, which was reproduced as Table 5.15 in the ACNGS FES.

On March 14, 1977, the Commission presented in the *Federal Register* (42FR13803) an interim rule regarding the environmental considerations of the uranium fuel cycle. It is effective through September 13, 1978 and revises Table S-3 of 10 CFR Part 51. Final rulemaking proceedings will be conducted so as to allow for additional public comment and specific details with respect to time, place, and format of such proceedings and shall be presented in a subsequent *Federal Register* notice.

The interim rule reflects new and updated information relative to reprocessing of spent fuel and radioactive waste management as discussed in NUREG-0116, *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle* and NUREG-0216, which presents staff responses to comments on NUREG-0116. The contributions in the new table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that resulted in the greater impact was used. The rule also considers other environmental factors of the uranium fuel cycle including mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the *Environmental Survey of the Uranium Fuel Cycle* (AEC report WASH-1248).

Specific categories of natural resource use are included in Table S-3 of the interim rule and are reproduced in this Draft Supplement as Table S.5.19. These categories relate to land use, water consumption and thermal effluents, electrical energy use, fossil fuel combustion, chemical and radioactive effluents, burial of transuranic and high/low level wastes, and radiation doses from transportation and occupational exposures.

In accordance with the interim rule, the assessment of the environmental impacts of the fuel cycle as related to the operation of ACNGS is based upon the values given in Table S.5.19. For the sake of consistency, the analysis of fuel-cycle impacts other than those due to land use has been cast in terms of a model 1000-MWe light-water reactor (LWR).

The total annual land requirements for the fuel cycle supporting a model 1000-MWe LWR are approximately 405 ha (100 acre) [38 ha (94 acres) temporarily committed and 2.9 ha (7.1 acres) permanently committed]. Over the 30-year operating life of the plant, this amounts to about 1700 ha

Table S.5.19 Summary of environmental considerations for uranium fuel cycle[1]

[Normalized to model LWR annual fuel requirement (WASH-1248) or reference reactor year (NUREG-0116)]

Natural resource Use	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
Land (acres):		
Temporarily committed[2]	94	
Undisturbed area	73	
Disturbed area	22	Equivalent to 110 MWe coal-fired powerplant.
Permanently committed	7.1	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired powerplant.
Water (millions of gallons):		
Discharged to air	159	=2 pct of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	124	
Total	11,373	<4 pct of model 1,000 MWe LWR with once-through cooling.
Fossil fuel:		
Electrical energy (thousands of megawatt-hours)	321	<5 pct of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT)	117	Equivalent to the consumption of a 45 MWe coal-fired powerplant.
Natural gas (millions of scf)	124	<0.3 pct of model 1,000 MWe energy output.
Effluents—chemical (MT):		
Gases (including entrainment):[3]		
SO_x	4,400	
NO_x[4]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F^-	0.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HCl	0.014	
Liquids:		
SO_4^{-}	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3—600 ft^3/s. NO_3—20 ft^3/s. Fluoride—70 ft^3/s.
NO_3^{-}	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to environment.
Solids	91,000	Principally from mills—no significant effluents to environment.
Effluents—radiological (curies):		
Gases (including entrainment):[5]		
Rn-222	74.5*	Principally from milling operations and excludes contributions from mining.
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	0.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	0.83	
Fission products and transuranics	0.203	
Liquids:[6]		
Uranium and daughters	2.1	Principally from milling—included in tailings liquor and returned to ground—no effluents; therefore, no effect on environment.
Ra-226	.0034	From UF_6 production.
Th-230	.0015	
Th-234	.01	From fuel fabrication plants—concentration 10 pct of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low-level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. ~60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^7	Buried at Federal repository.
Effluents—thermal (billions of British thermal units)	3,462	<4 pct of model 1,000 MWe LWR.
Transportation (person-rem): Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

[1] Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); and the "Discussion of Comments Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248). The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the 2 fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in table S-4 of sec. 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of table S-3A of WASH-1248.

[2] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services 1 reactor for 1 yr or 57 reactors for 30 yr.

[3] Estimated effluents based upon combustion of equivalent coal for power generation.

[4] 1.2 pct from natural gas use and process.

[5] Gaseous effluents from waste management contribute about 9 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year for the uranium only recycle option. This contribution for the no recycle option is 170 person-rem. For comparison, all radiological gaseous effluents from fuel cycle operations contribute about 370 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. This dose is <0.002 pct of the average natural background radiation dose to this population. Fuel reprocessing contributes about 330 person-rem (total body) of the total of 370 person-rem to offsite U.S. population. Person-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total person-rem dose in each case would be 1 person-rem. The dose to the offsite U.S. population due to average natural background radiation is about 2×10^7 person-rem per year. The Commission's final environmental statement on use of mixed-oxide fuel in LWR's (NUREG-0002) indicates a maximum release of about 4800 Ci of Rn-222 when contributions from mining are included. NUREG-0002 also indicates that mining contributes about 500 person-rem (total body) and that milling contributes about 100 person-rem (total body) of a total of about 610 person-rem (total body) to offsite U.S. population per annual fuel requirement.

[6] Liquid radiological effluents from reprocessing and waste management activities in the fuel cycle contribute 1.4×10^{-4} person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. For comparison all radiological liquid effluents from fuel cycle operations contribute about 100 person-rem (total body) to offsite U.S. population per annual fuel requirement or reference reactor year. This dose is <0.0005 pct of the average natural background radiation dose to this population.

*In the September 21, 1977 memorandum to the Chairman of the ASLB Panel, Dr. Walter H. Jordan, an ASLB Panel technical member, raised substantial questions as to the correctness of this value. However, the ASLAB subsequently held that absent contrary instructions from the Commission, the present value in this revised Table S-3 must still be given effect. Metropolitan Edison Co. (Three Mile Island Nuclear Station, Unit No. 2), ALAB-456, NRC __ (Jan. 27, 1978).

(4200 acres),* which is slightly smaller than the total land commitment for ACNGS. Considering common classes of land use in the United States, the fu[illegible] land requirement related to the operation of ACNGS does not constitute a significant [illegible]

The annual total water use and thermal effluents assoc[illegible]h fuel-cycle operations to support a 1000-MWe LWR are, respectively, about 4.2×10^7 [illegible] gal) and 3500×10^9 Btu. The corresponding annual water use and thermal outpu[illegible] ACNGS, [illegible]uming an 80% capacity factor, are 8.6×10^7 m^3 (23×10^9 gal) and $56{,}125 \times 10^9$ Btu r[illegible]ectively. The staff finds these quantities of indirect water consumption and thermal loadings to be acceptable relative to the use of water and thermal discharges at the power plant.

Electrical energy and process heat are required during various phases of the fuel-cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. As indicated in Table S.5.19, electrical energy associated with the fuel cycle represents less than 5% of the annual electrical power production of a typical 1000-MWe nuclear plant. Process heat is generated primarily by the combustion of natural gas. As noted in Table S.5.19, this gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from a 1000-MWe plant. The staff finds, therefore, that both the direct and indirect consumptions of electrical energy for fuel-cycle operations are small and acceptable relative to the net power production of the plant.

The quantities of chemical gaseous and particulate effluents associated with fuel-cycle processes are given in Table S.5.19. The principal species are sulfur oxides, nitrogen oxides, and particulates. Based upon data in a CEQ report,[21] the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison to these emissions from the stationary fuel-combustion and transportation sectors in the United States; that is, approximately 0.02% of the annual (1974 base) national releases for each of these species. The staff believes such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel-cycle processes are related to fuel enrichment, fabrication, and reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations so that only small amounts of dilution water are required to reach levels of concentrations that are within established standards. Table S.5.19 specifies the flow of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel-cycle operations will be subject to requirements and limitations set forth in a National Pollutant Discharge Elimination System (NPDES) permit issued by an appropriate Federal regulatory agency.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in sufficient quantities to have a significant impact upon the environment.

Radioactive effluents released to the environment estimated to result from reprocessing and waste-management activities and other phases of the fuel-cycle process are set forth in Table S.5.19. It is estimated that the overall gaseous dose commitment to the U.S. population from the total fuel cycle for a 1000-MWe reference reactor would be approximately 370 man-rems per year. This dose is less than 0.002% of the average natural background dose of approximately 20 million man-rems to the U.S. population. Based on Table S.5.19 values, the additional dose commitment to the U.S. population from radioactive liquid effluents due to all fuel-cycle operations would be approximately 100 man-rems per year for a 1000-MWe reference reactor. Thus, the overall estimated annual involuntary dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle for a 1000-MWe LWR is approximately 470 man-rems.** The occupational dose attributable to the reprocessing and waste-management portions of the fuel cycle is 22.6 man-rems per reference-reactor year.

The quantities of buried radioactive material (including low-level, high-level, and transuranic wastes) are specified in Table S.5.19. For low-level wastes, which are buried at land burial

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*The temporarily committed land at the reprocessing plant is not prorated over 30 years because the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years. (See footnote *b* to Table S.5.19.)

**As noted in Table S.5.19, the entry for radon-222 excludes the contribution from mining. Footnote *e* to Table S.5.19 indicates a maximum release of about 4800 Ci of randon-222 when contributions from mining are considered. This, in turn, would increase the estimated dose commitment for the total fuel cycle by some 600 man-rems per reference-reactor year, maximized for the fuel cycle, it is still small compared to the natural background exposure level of some 20 million man-rems per year.

facilities, the Commission notes in Table S-3 of 10 CFR Part 51.20 that there will be no significant effluent to the environment. For high-level and transuranic wastes, the Commission notes that these are to be buried at a Federal repository, and in accordance with Table S-3 of 10 CFR Part 51.20, no release to the environment is associated with such disposal. NUREG-0116, which provides background and context for the new values established by the Commission, indicates that these buried wastes, which are placed in the geosphere, are not released to the biosphere and no radiological environmental impact is anticipated from them.

The transportation dose to workers and the public is specified in Table S.5.19. This dose is small and is not considered significant in comparison to the natural background dose.

The use of a fuel cycle entailing no recycle (neither plutonium nor uranium) would not affect this discussion because the Commission has considered such a cycle in developing the values given in Table S.5.19 (see footnote *a*) with respect to reprocessing, waste management, and transportation of wastes. The contribution to the impacts described was maximized for either of the fuel cycles; that is, the cycle with the greatest impact was used.*

S.5.6 SOCIOECONOMIC IMPACTS

This section contains updated material to the FES findings associated with the possible local and regional socioeconomic impacts from ACNGS operation. It is concluded that socioeconomic impacts will be minor except for significant increases in the local property tax base (Sect. S.3.4.5) and for the addition of the proposed Allens Creek recreational area.

S.5.6.1 Physical impacts

In Sect. 5.6 of the FES (pp. 5-36 and 5-37), detailed consideration is given to (1) the visual impact of the station design, (2) the effects of station operating noise, and (3) the impact of increased fogging and icing from the cooling lake. With the exception of the elimination of the 100-m stack along the cooling lake shore (FES, Fig. 3.1), the visual impact will be essentially the same for either station design. Similarly, the staff's assessments of station operating noise and the effects of increased fogging and icing from the cooling lake for the station remain valid in view of the proposed design changes.

The staff therefore concludes for either station that (1) although the plant and the cooling lake dam will present an intrusion into an otherwise rural landscape, the creation of a large-surface water body in a region where few lakes exist will mitigate the adverse visual impact; (2) although the noise levels created by the plant may be distinguishable to the nearest residents during nighttime, they will not be disturbing because they will be below the 45- to 65-dB(A) "normally acceptable" level established by HUD; and (3) the total impact of the presence of the cooling lake with regard to average temperature, relative humidity, and frequency of fogs is expected to be minimal.

S.5.6.2 Social and economic impacts

S.5.6.2.1 Employment benefits

The applicant estimates that approximately 100 persons will be needed to operate ACNGS (ER Suppl., Table S8.1-5). After examining operations work forces at other plants, the staff believes this figure is low and that about 125 persons will, in fact, be needed for operation. The applicant further states that secondary employment resulting from ACNGS operation will generate over 300 jobs within the Houston metropolitan region and in the State of Texas (ER Suppl., Table S8.1-5). The staff concurs with this estimate and understands that most of this employment will be generated outside the local area. Only a few local jobs are expected to be created from the operation of ACNGS.

S.5.6.2.2 Estimated income for plant operation

The applicant estimates that the average annual salary of operations workers in 1985 will be $24,500 (ER Suppl., Table S8.1-5). Because the staff assumes that approximately 125 workers will be employed, this represents an estimated first year payroll of $3,062,500, and a 30-year present worth direct income effect of $48 million (5% escalation, 10% discount rate). The

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*As noted in Table S.5.19, the entry for radon-222 excludes the contribution from mining. Footnote *a* to Table S.5.19 indicates a maximum release of about 4800 Ci of radon-222 when contributions from mining are considered. This, the turn, would increase the estimated dose commitment for the total fuel cycle by some 600 man-rems for reference-reactor years, maximized for the fuel cycle, it is still small compared to the natural background exposure level of some 20 million man-rems per years.

staff believes an income level of $24,500 will be considerably higher than that to be paid to most other local area residents in 1985. Income estimates from the U.S. Census show that in 1974, for example, Austin County's per capita income was $3,149, as compared to $4,188 for the State of Texas.[22] Austin County's per capita income estimates in 1974 were also considerably lower than those for the four surrounding counties - Colorado, Fort Bend, Waller, and Sharton. A recent survey of buying power in July 1977 shows that the median household "effective buying income" in Austin County was $8,645 compared to $16,289 for the Houston-Galveston area.

The staff concludes that much of the generated income from operations workers' salaries will be dispersed throughout the Houston metropolitan area and will not accrue directly to the local communities within the vicinity of the plant.

S.5.6.2.3 Recreation benefits

The applicant, in cooperation with the Texas Park and Wildlife Department, is developing plans for a public recreational area at the Allenx Creek site that will include a 640 acre park and the 5000 acre Allens Creek Lake. Only 4000 lake acres will be available for public use, however, because of exclusion zone requirements. The Texas Park and Wildlife Department will have responsibility for operating and maintaining the area. A description of the proposed recreational facitilities can be found in the Water Development Plan, Allens Creek Lake and State Park.[15] Several regional factors indicate that demand for a park/lake area is high and that such demand will likely increase. The proposed park is 45 miles west of metropolitan Houston; the population within a 50 mile radius of the park site is projected to increase over 1970 levels by 39% in 1985 and 89% in 2000 (S.2.1.2, Table S.2.2). Such growth will increase competition for available land; however estimates indicate that less than 9% of the land in metropolitan Houston is currently undeveloped.[15] In such a growing urban center it is unlikely that large recreational parks will be the generated land use for limited developable acreage.

Current availability of recreational areas in the region will also influence the demand for such facilities. The proposed park will be located in the Texas Park and Wildlife Department Planning Region 24 which currently has an average facility unit to population ratio well below the statewide average. Region 24 has 15.3 recretational acres per 1.000 population; and Region 25, which includes metropolitan Houston, has 3.1 recreational acres per 1,000 population.[15] Both Regions are significantly below the statewide average of 148.2 acres per 1.000 population.

Based upon an inventory of visitations at Huntsville, Lake Somerville, Martin Dies, Jr., and Stephen Austin-State Parks during 1973-1974, the Texas Park and Wildlife Department estimated that at least 400,000 visitors annually would use the proposed Allens Creek park/lake facility.[15]

This estimate is also consistent with the staff's testimony accepted by the Atomic Safety and Licensing Board in their Partial Initial Decision.[25] The staff judges this estimate to be conservative yet reasonable. Table 5.5.20 presents two additional estimates of visitor days by the National Economic Research Association of New York which assume a 4000 acre lake and offering amounts of competing recreational acre lake and differing amounts of competing recreational acreage. The predictive model from which these visitor estimates were generated omits the potentially important variable of per capita income and thus probably conservatively estimates the demand for a park.

In light of the projected population growth within the area, the limited supply of recreational acreage and the proximity to Houston, the staff concludes that demand for a lake/park recreation area is relatively high. For the reasons stated above the staff concludes that the projected visitor days in Table 5.5.20 are reasonable if somewhat conservative.

The staff concludes that the construction of the Allens Creek Lake and State Park is one of the most attractive benefits to be gained from construction of the nuclear facility. The proposed reservoir will provide a wide range of water-oriented activities, and the 259-ha (640-acre) state park will provide a much needed area for icking, hiking, and camping. Currently, many Houston residents lack such facilities wi ommuting distance. The development of these recreational facilities will not only b local area residents, but will also provide increased recreational resources for much of egional population.

The staff further concludes that the in-migration of such a large number of visitors into the area may provide new opportunities for economic growth for the local communities. The staff suggests, however, that any economic development which takes place proceed with caution. Rapid and unchecked economic growth accompanying resort development may create problems for the indigenous population if left unplanned (see ref. 24, for example).

Table S.5.20. Predicted visitor days for proposed Allens Creek Lake and State Park: 1985–2014

Year	Visitor days (in thousands)[a]	
	Case 1[b]	Case 2[c]
1985	728	614
1986	731	617
1987	734	619
1988	737	622
1989	739	624
1990	742	626
1991	749	632
1992	755	638
1993	762	644
1994	768	649
1995	774	655
1996	780	660
1997	786	665
1998	791	670
1999	797	675
2000	802	680
2001	809	686
2002	816	693
2003	823	699
2004	829	704
2005	835	710
2006	842	716
2007	848	721
2008	853	727
2009	859	732
2010	865	737
2011	871	743
2012	876	748
2013	882	753
2014	887	759

[a] Estimates are for visitations by persons within 50 miles of the site.

[b] Assumes a competing acreage of 18,050 acres.

[c] Assumes a competing acreage of 518,050 acres.

Source: ER Suppl., Table S8.1-10.

S.5.6.2.4 Conclusions

The staff concludes that the major socioeconomic impacts during plant operation will be an increase in the local tax base (Sect. S.4.4) and in added recreational facilities for the areas. Few operations workers are expected to reside locally; most will probably commute from the western suburban areas of Houston. Very little impact on local institutions or public services will occur. The operation of the facility may indirectly induce some growth in the local area, but most growth will occur from other economic and social activities in the region and from the continued western suburbanization of the greater Houston metropolitan area.

Of the local benefits will be the construction and development of the Allens Creek Lake and State Park. This recreational facility will benefit both local residents and the regional population within the Houston area.

REFERENCES FOR SECTION S.5

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13. Texas Water Quality Board, *Texas Water Quality Standards*, Austin, Tex., February 1976.

14. H. G. Bergman, EPA Region VI, letter to F. W. Conrad, Esquire.

15. Dames and Moore, Inc., *Master Development Plan: Allens Creek Lake and State Park*, for Houston Lighting and Power Company, Houston, Tex., November 1974.

16. *Bryan Safety Analysis Report*, Docket No. STN 50-532, June 27, 1975, p. 12, 1-56.

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18. U.S. Nuclear Regulatory Commission, *Occupational Radiation Exposure to Light Water Cooled Reactors 1969-1974*, NUREG 75/032, June 1975.

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21. Council on Environmental Quality, *The Seventh Annual Report of the Council on Environmental Quality*, September 1976, Figs. 11-27 and 11-28, pp. 238-39.

22. U.S. Bureau of the Census, *Current Population Report*, Series P-25, No. 691, April 1977.

23. Texas Parks and Wildlife Department, Comprehensive Planning Branch, *Texas Outdoor Recreation Plans 1980-1985*, Austin, Tex.

24. J. E. Dobson, *The Changing Control of Economic Activity in the Gatlinburg, Tennessee, Area, 1930-1973*, doctoral dissertation, Department of Geography, University of Tennessee, Knoxville, Tenn., March 1975.

25. U.S. Nuclear Regulatory Commission, Partial Initial Decision as to Some Environmental and Site Suitability Matters in the Matter of Houston Lighting and Power Company, November 1975, Docket Nos. 50-466 and 50-467.

S.6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

The applicant's environmental measurements and monitoring programs are described in the FES (Sect. 6). Since the publication of the ER and the FES, the applicant made available the results of the year-long baseline biological survey[1] conducted on the Allens Creek site between November 1973 and November 1974, and the final results of the meteorological measurements program (consisting of onsite meteorological data for August 1972 through July 1975). These results (which were included in the staff's analyses in Sect. S.4 and S.5) coupled with major changes in the station design (Sect. S.3) provide a basis for further evaluation of the proposed future monitoring (ER, Sect. 6.0).

In the ER Supplement (Sect. S6.1), the applicant provides a description of the modifications to be made to the preoperational environmental program. Notable in the revisions is a reduction in the number of biotic sampling stations as well as the relocation of various stations; both of these revisions were necessitated by the revised lake design. Figure S.6.1 shows the aquatic, surface-water, and groundwater monitoring stations, and Fig. S.6.2 shows the terrestrial monitoring stations. Moreoever, the frequency of measuring the physical and chemical parameters, pesticides, and heavy metals has been modified (ER Suppl., Table S6.1-1).

In addition, the applicant has proposed a radiological environmental monitoring program to meet the objectives discussed in NRC Regulatory Guide 4.1, Rev. 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and in the Radiological Assessment Branch Technical Position, August 1977, "Standard Technical Specification for Radiological Environmental Monitoring Program." The applicant's proposed preoperational radiological environmental monitoring program is presented in Sect. 6.1.5 of the ER and summarized here in Table S.6.1. The applicant proposes to initiate parts of the program two years prior to operations of the facility, with the remaining portions beginning either 6 months or one year prior to operation.

The staff has evaluated the applicant's proposed monitoring (preoperational) programs for the Allens Creek site and concludes that they are generally broad enough in scope for the environmental effects of the site preparation and plant construction, and the potential impacts of plant operation to be assessed adequately. However, the following changes and additions are recommended to improve the effectiveness of the aquatic monitoring program:

1. A one-time adult fish sampling program should be conducted in the Brazos River to gather data on heavy metal bioaccumulation in resident fish species. Trace elements to be analyzed include those shown in Table S.2.6; these are Cd, Cu, Fe, Pb, Ni, Hg, and Zn. Fish tissue analysis should be reported by species and should include both muscle (e.g., axial muscle) and fatty tissue. Replication should be sufficient for adequate statistical treatment of the reported data.

2. Brazos River water should be sampled for an additional year on a monthly basis to determine heavy metal contamination, both particulate and dissolved fractions. Trace elements to be analyzed should include those given in Table S.2.6.

3. Fecal coliform and fecal streptococci should be monitored on a monthly basis for one year in the Wallis sewage discharge area (sampling station A3 of the BMPR or sampling station L8 in ER Supplement, Fig. S6.1-1). This will allow for further assessment of potential impacts of treated sewage discharge into the southern arm of the proposed cooling lake.

4. The applicant has proposed to sample for larval, juvenile, and adult fish entrained during lake filling (ER Suppl., Sect. S6.1.1.2.3) as presented in the FES (Sect. 6.1.3.2). If makeup water pumping is proposed for those months when spawning activity occurs in the Brazos River (approximately March to July), the applicant should include an ichthyoplankton drift study at the makeup water intake structure location. This study should include densities and cross-sectional distributions in the river.

Fig. S.6.1. Aquatic, surface-water, and ground monitoring stations for Allens Creek Nuclear Generating Station. Source: ER Supplement, Fig. S6.1-1.

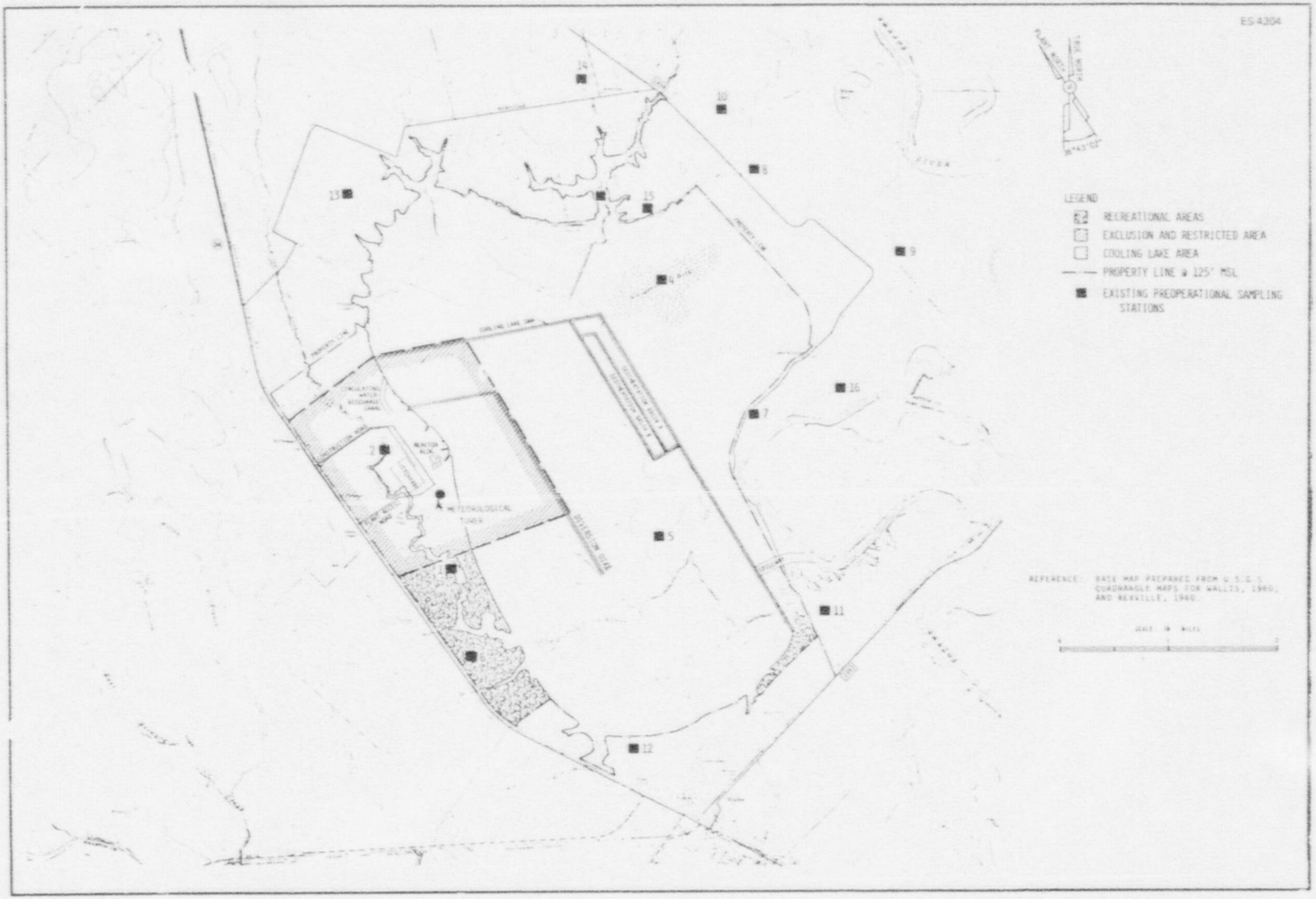

Fig. S.6.2. Terrestrial monitoring stations for Allens Creek Nuclear Generating Station.
Source: ER Supplement, Fig. S6.1-2.

Table S.6.1. Radiological program

Exposure pathway and/or sample	Approximate number and their locations	Collection frequency	Analysis type and frequency
Direct radiation (TLD)	7 – Each air sampling location 3 – Site perimeter 2 – Recreation (shoreline) areas 15 – See ER, Sect. 6.1.5.1	Quarterly and annually	Gamma dose quarterly and annually
Air iodine	3 – 4.5 miles N, 3.5 miles S, 4.5 miles NNW (three sectors with highest χ/Q) 1 – Residence with highest χ/Q 1 – Wallis 1 – Sealy 1 – Approximately 20 miles SE of plant in least-prevalent wind direction)	Weekly	I-131 weekly
Air particulate	Same as air iodine	Weekly	Beta (after 24 hr) weekly; gamma isotopic monthly; Sr-89, Sr-90 quarterly
Surface water	2 – Cooling lake near recreation areas 2 – Brazos River	Monthly	Gamma isotopic monthly; Sr-89, Sr-90, and tritium quarterly
Groundwater	2 – Wells most likely to be affected and used for drinking water	Quarterly	Gamma isotopic and tritium quarterly
Drinking water	1 – Wallis (well water)	Quarterly	Gross beta, gamma isotopic, Sr-89, Sr-90, and tritium quarterly
Milk	1 – Areas within 5 miles with milk cows where highest airborne concentrations are expected 1 – Area about 20 miles SE of plant	Monthly	I-131, Sr-89, Sr-90, and gamma isotopic monthly
Vegetables or cattle forage	1 – Vegetable garden within 5 miles	Monthly during harvest season	Gamma isotopic monthly
Fish	4 – Cooling lake 4 – Brazos River	Semiannually	Gamma isotopic analysis of flesh and Sr-89 and Sr-90 in bones semiannually
Sediment, aquatic plants, and benthic organisms	2 – Cooling lake 2 – Brazos River	Semiannually	Gamma isotopic, Sr-89, and Sr-90 semiannually
Deer and game birds	Within 10 miles of site	When available	Gamma isotopic
Rice	West of site	At harvest	Gamma isotopic
Soil	7 – Each air sampling location 5 – Farms within 5 miles	Prior to startup and every three years thereafter	Gamma isotopic and Sr-90
Meat and poultry	1 – Farm near site where animals drink from cooling lake or eat forage grown within 10 miles downwind	Annually	Gamma isotopic on edible portions

In addition, the following changes and additions are recommended to improve the effectiveness of the radiological monitoring program:

1. The Brazos River water sampling station, located downstream of the cooling pond spillway (B-3), should have sampling equipment capable of collecting hourly aliquot samples relative to the compositing period.

2. The Wallis municipal well water sample should be collected monthly. The composite well water sample should be analyzed monthly for gross beta and gamma isotopic content. The composite water sample should be collected with the same type of equipment as described in 1 above.

3. Milk samples from milking animals when on pasture and in areas where doses are calculated to be greater than 1 mrem/year should be analyzed for radioiodine and gamma isotopic semimonthly.

4. The lower limits of detection (LLD) for the radiological environmental monitoring program should be the same as those listed in Table S.6.2.

Table S.6.2. Detection capabilities for environmental sample analysis

Analysis	Lower limit of detection (LLD)					
	Water[a] (pCi per liter)	Airborne particulate or gas (pCi per m^3)	Fish (pCi per kg, wet)	Milk (pCi per liter)	Food products[b] (pCi per kg, wet)	Sediment (pCi per kg, dry)
Gross beta	2	1×10^{-2}				
^{3}H	330					
^{54}Mn	15		130			
^{59}Fe	30		260			
$^{58,60}Co$	15		130			
^{65}Zn	30		260			
^{95}Zr-Nb	10					
^{131}I	0.5	7×10^{-2}		0.8	25[b]	
$^{134,137}Cs$	15	1×10^{-2}	130	15	80	150
^{140}Ba-La	15			15		

[a]LLD for drinking water.
[b]LLD for leafy vegetables.

Data obtained from these monitoring programs with the staff's recommendations included should be adequate for the staff to reassess or characterize the state of the local environment prior to licensing of the station for operation. The staff also notes that the aquatic, surface water, and groundwater stations (Fig. S.5.1) are suitably located for the implementation of various operational monitoring programs, as recommended by the staff (Sect. S.5), to ensure that the aquatic ecosystems in the site region are not severely impacted.

The operational radiological, chemical-effluent, thermal-effluent, meteorological, hydrological, and ecological monitoring programs will evolve from the combination of the preoperational monitoring programs described in the applicant's ER and ER Supplement and those changes recommended by the staff. Because the present action pertains to the issuance of a construction permit, detailed staff evaluation of the operational program will be done at the time of application for an operating license, and monitoring requirements will be included in the environmental technical specifications of the operating license.

REFERENCE FOR SECTION S.6

1. Dames and Moore, *Final Report, Biological Monitoring Program, Allens Creek Nuclear Generating Station Site, for Houston Lighting and Power Company*, Feb. 15, 1975.

S.7 ENVIRONMENTAL EFFECTS OF ACCIDENTS

A high degree of protection against the occurrence of postulated accidents is provided through correct design, manufacture, and operation of ACNGS, and through the quality assurance program used to establish the necessary high integrity of the reactor system; these factors will be considered in the Commission's Safety Evaluation. System transients that may occur are handled by protective systems to place and hold the plant in a safe condition. Notwithstanding these safeguards, the conservative postulate is made that serious accidents might occur, even though they are extremely unlikely; and engineered safety features will be installed to mitigate the consequences of those postulated events which are judged credible.

In Sect. 7.1 of the FES, the staff considered the probability of occurrence of accidents and the spectrum of their consequences from an environmental effects standpoint, using the best estimates of probabilities and realistic fission-product release and transport assumptions. Table S.7.1 lists the nine classes of postulated accidents and occurrences, ranging in severity from trivial to very serious, that were evaluated. The staff concluded (FES, p. 72) that the environmental risks due to these postulated radiological accidents would be extremely small.

Table S.7.1. Classification of postulated accidents and occurrences

Class	Nuclear Regulatory Commission description	Applicant's examples
1	Trivial incidents	Included under routine releases
2	Small releases outside containment	Included under routine releases
3	Radioactive waste systems failure	Equipment leakage or malfunction; release of waste gas storage tank; release of liquid-waste storage tank inventory
4	Fission products to primary system (BWR)	Fuel-cladding defects and fuel; failures induced by off design transients
5	Fission products to primary and secondary systems (PWR)	Not applicable
6	Refueling accident	Fuel bundle drop; heavy object drop onto fuel
7	Spent fuel handling accident	Fuel assembly drop on fuel storage pool and spent fuel shipping cask drop
8	Accident initiation events considered in design-basis evaluation in the *Safety Analysis Report*	Loss of coolant accident; rod drop accident, steamline break; instrument line break
9	Hypothetical sequence of failures more severe than Class 8	Not considered

Source: FES, Table 7.1 (modified).

The staff has reevaluated these postulated accidents and their probability of occurrence in view of the proposed design changes (Sect. S.3) and has considered advances in analytical methods employed for such calculations. The dose analysis was modified to consider the increase in the projected population for the year 2020, within an 80-km (50-mile) radius (as listed in the PSAR, Table 2.1-4, Amendment 36) and to remove the beta skin-dose component which was included in the earlier dose estimates. As Table S.7.2, shows, these changes have resulted in a general reduction in the estimated individual and population doses contained in Table 7.2 of the FES. These results indicate that the realistically estimated radiological consequences of the postulated accidents to an individual assumed to be at the site boundary would result in exposures that are less than those which would result from a year's exposure to the maximum permissible concentrations (MPC) of 10 CFR Part 20. Table S.7.2 also shows the estimated integrated exposure from each postulated accident of the population within 80 km (50 miles) of the plant. Any of these integrated exposures would be much smaller than those from naturally occurring radioactivity. When considered with the probability of occurrence, the annual potential radiation exposure of the population from the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small and need not be considered further.

Table S.7.2. Summary of radiological consequences of postulated accidents[a]

Class	Event	Estimated fraction of 10 CFR Part 20 limit at site boundary[b]	Estimated dose to population in 80-km (50-mile) radius (man-rems)
1.0	Trival incidents	*c*	*c*
2.0	Small releases outside containment	*c*	*c*
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.007	2.1
3.2	Release of waste-gas storage-tank inventory	0.028	8.7
3.3	Release of liquid-waste storage-tank inventory	<0.001	0.029
4.0	Fission products to primary system (BWR)	<0.001	0.13
4.1	Fuel-cladding defects	*c*	*c*
4.2	Off-design transients that induce fuel failures above those expected	0.001	0.85
5.0	Fission products to pr.mary and secondary systems (PWR)	Not applicable	Not applicable
6.0	Refueling accidents		
6.1	Fuel bundle drop	<0.001	0.046
6.2	Heavy object drop onto fuel in core	0.001	0.38
7.0	Spent-fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.017	0.106
7.2	Heav object drop onto fuel rack	Not applicable	Not applicable
7.3	Fue ask drop	Not applicable	Not applicable
8.0	Accident initiation events considered in design-basis evaluation in the *Safety Analysis Report*		
8.1	Loss-of-coolant accidents		
	Small break	<0.001	0.127
	Large break	0.011	29.1
8.1(a)	Break in instrument line from primary system that penetrates the containment	<0.001	0.006
8.2(a)	Rod ejection accident (PWR)	Not applicable	Not applicable
8.2(b)	Rod drop accident (BWR)	0.0016	1.26
8.3(a)	Steamline breaks (PWRs outsid: containment)	Not applicable	Not applicable
8.3(b)	Steamline break (BWR)		
	Small break	<0.001	0.28
	Large break	0.005	1.46

[a] The doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials resulting in both a direct and an inhalation dose. Staff evaluation of the accident doses assumes that the applicant's environmental monitoring program and appropriate additional monitoring (which could be initiated subsequent to a liquid release incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in a timely manner so that remedial action could be taken if necessary to limit exposure from other potential pathways to man.

[b] Represents the calculated fraction of a whole body dose of 500 millirems, or the equivalent dose to an organ.

[c] These radionuclide releases are considered in developing the gaseous and liquid source terms included in the doses in Sect. S.5.4.

S.8 NEED FOR POWER GENERATING CAPACITY

Major disruptions in the nation's energy markets in the form of precipitous price increases and declining availability of fossil fuels have altered energy demand patterns throughout the United States since the oil embargo of 1973. To some extent, the resulting decline in electricity demand growth in the area served by HL&P is responsible for the decision to delay construction of ACNGS and to reduce the planned generating capacity of the proposed facility. Consequently, substantial revisions have been made in the demand forecasting analysis presented in the FES (Sect. 8). Since the filing of the Allens Creek ER in 1973, HL&P has modified its methodology for forecasting annual peak demand and generation. The new methodology, combined with additional historical data (Sect. S.2.1) not available when the previous forecast was submitted, has produced lower projections of load growth than those contained in the ER. Originally, the applicant had forecasted an average annual growth rate of electricity demand of 6.6% from 1977 through 1984. This forecast has now been reduced to 4.7%, and the applicant now projects that the 1977 system capability of 10,170 MWe must be expanded to 15,560 MWe by 1987 to meet the projected load growth (ER Suppl., Sect. S1.1). The staff concurs with this revision in light of the changed circumstances and additional information available since the original forecast was made.

The results of the revised analysis of the need for additional generating capacity are reported in this section. The staff concludes that in order for HL&P to meet the projected growth rate, an additional generating capacity of about 1200 MWe will be required for the 1985 to 1987 period.

S.8.1 DESCRIPTION OF THE POWER SYSTEM

Figure S.8.1 shows the HL&P service area which occupies a 14,504-km^2 (5600-sq mile) contiguous region on the Gulf Coast of Texas, and which may be roughly described as the Houston-Galveston-Freeport Gulf Coast area. The system covers all or parts of ten counties and serves customers under franchises in 67 incorporated municipalities, including the cities of Houston, Galveston, Freeport, Baytown, and Pasadena. The total population for the area served is estimated at 2,755,000, which is about 20% of the population of Texas. Because of the subtropical climate of the area and the consequent high level of air-conditioning load, the peak-hour demand for the HL&P system normally occurs in June, July, and August. Tables S.8.1 and S.8.2 present information on heating- and cooling-degree days and peak-load fluctuations in the system. In 1972, an estimated 57% of the residential customers within the system had central air conditioning or its equivalent in room air conditioners. This saturation is expected to reach 90% by 1985 and is forecasted to approach 100% by the year 2000. Air-conditioning load is a major factor in the months April through November, and the summer peak has typically been about 140% of the December peak. The system is expected to continue to peak during the summer.

The FES (Sect. 8.1.2) contains a description of the regional relationships within the HL&P service area. The applicant remains a member of the Texas Interconnected System (TIS). No significant changes in operating philosophy or makeup of the group have been reported in the ER Supplement.

S.8.2 POWER REQUIREMENTS

The HL&P serves a large industrial load, which is a major economic base for the area. Kilowatt-hour sales to the industrial class of customers have recently been about 51% of total kilowatt-hour sales. Sales to residential customers have been about 23%; sales to commercial customers have been about 20%; and sales to other public utility distribution systems have been about 6%. The numbers of customers in these various classes are given in Table S.8.3. Some of the more important sectors by percentage of the industrial and commercial market comprising the total kilowatt-hour sales for 1972 included chemicals, 21.4%; refining industry, 7.2%; primary metals, 4.9%; hospitals and health services, 1.5%; and food and beverages, 1.3%.

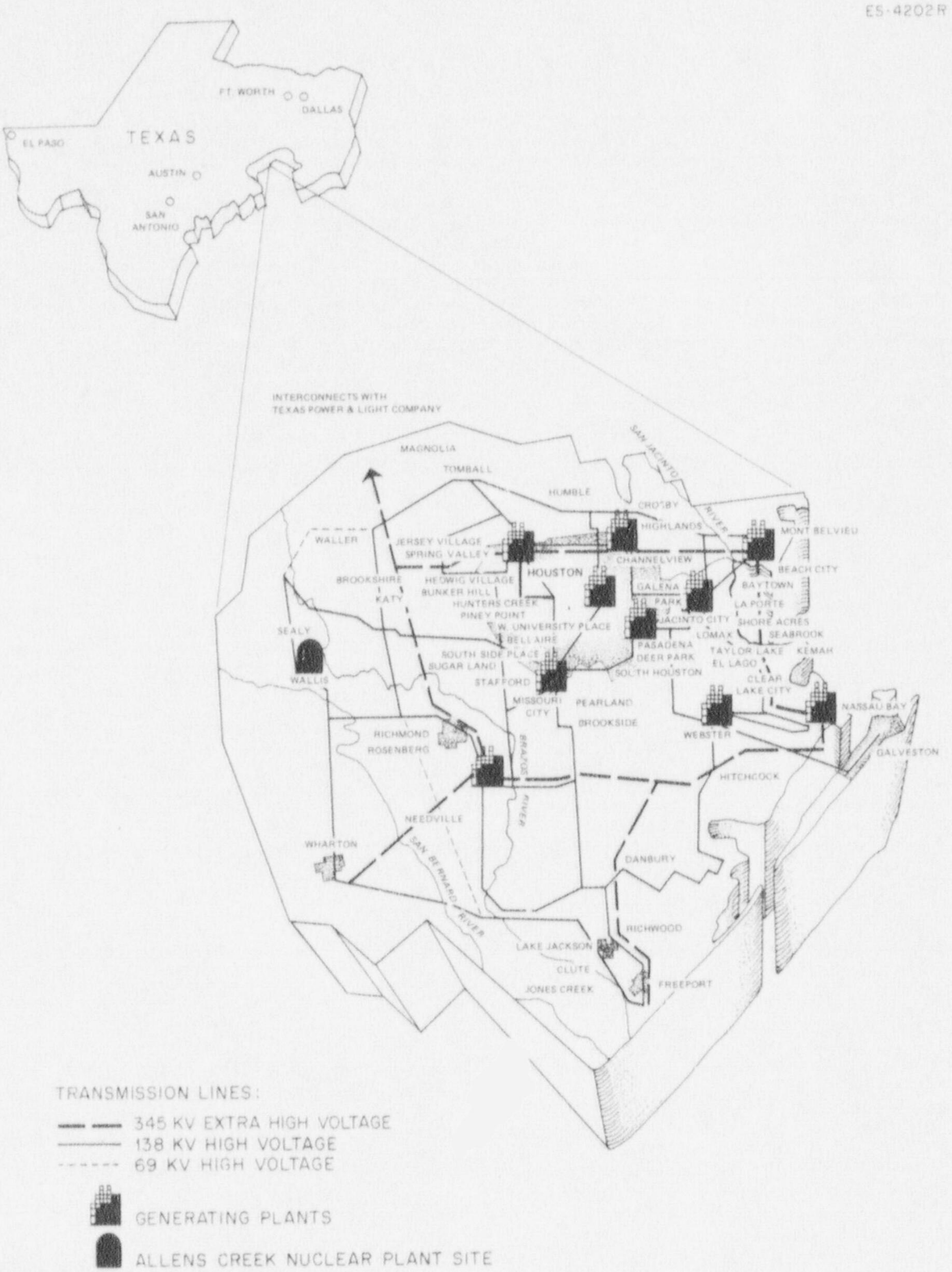

Fig. S.8.1. Houston Lighting and Power Company service area.

Table S.8.1. Weather variables

Year	Cooling-degree hours, annual[a]	Heating-degree hours, annual[b]	High temperature, day of peak		Cooling-degree hours, day of peak
			(°C)	(°F)	
1970	33,804	41,903	35.6	96	281
1971	33,593	30,680	35.0	95	247
1972	37,077	30,713	33.9	93	273
1973	34,831	37,239	35.0	95	299
1974	34,980	31,200	34.4	94	276
1975	33,721	31,544	35.6	96	270
1976	31,550	34,496	33.9	93	289
1977	35,396	37,097	35.0	95	280
1978	35,396	37,097	35.0	95	280
1979	35,396	37,097	35.0	95	280
1980	35,396	37,097	35.0	95	280
1981	35,396	37,097	35.0	95	280

[a] Base temperature = 22.2°C (72°F).
[b] Base temperature = 18.3°C (65°F).
Source: ER Suppl., Appendix SH, p. SH-79.

The applicant has one large-load customer with contract provisions set up on a limited interruptibility basis, with a normal demand of 225 MWe. This customer has a generating capacity of approximately five times its normal demand on the applicant. The applicant can use this load as spinning reserve because the customer can absorb interruptions with his own generation (ER, p. 1.1-3A). Contract provisions allow this load to be reduced to zero demand during an agreed number of hours at the discretion of HL&P.

Table S.8.4 presents historical data on the annual use and peak-hour demand for electricity in the HL&P service area. From 1963 through 1976, annual demand grew from 13,213,000 to 43,355,000 MWhr. Annual growth rates over this period ranged from a low of 4.1% in 1974 to a high of 13.6% in 1965, with the average annual growth rate equal to 9.6%. Prior to 1973, the average annual growth rate was 11.2%, whereas the post-1973 figure is 5.9%. Peak-hour demand grew from 2516 to 8019 MWe from 1963 through 1976, with annual percentage growth rates ranging from a low of 4.6% in 1975 to a high of 15.2% in 1969. The average annual growth rate in peak-hour demand over this period was 9.4%, with a pre-1973 average of 10.2% and a post-1973 average of 7.5%.

Trends of past electricity use are helpful in assessing future use levels. In addition, forecasts of energy demand are influenced by trends in income, population, and employment. Forecasts[1] of these factors in the applicant's service area (Table S.8.5) show continued growth, but at a declining rate. An additional factor affecting future demand is the type of industrial activity; the petrochemical industries, natural gas processing, and petroleum sectors — all heavily represented in the applicant's service area — show some of the highest growth rates of the nation's manufacturing industries.[2]

S.8.2.1 Applicant's forecasts

The applicant currently maintains a forecast of kilowatt-hour energy sales and peak-hour demands extending 20 years into the future; this forecast is reviewed and updated annually. A separate forecast of kilowatt-hour sales is made for each of 11 different groups of customers, who are grouped primarily on the basis of rate schedule.

For one of the forecasted groups, consisting of about 70 of the largest industrial customers, estimates are made individually for the first five years. These estimates are based on data supplied by the customers and are modified using information such as specific market conditions and present and future plant expansions. In forecasting beyond five years, group forecasts are used. Estimates are made on the basis of the long-term trend toward increased electrical use in local industry. Relationships are then established between this trend and that of expected employment trends for the area. For the first five years, estimates of kilowatt-hour use by the public utilities class are obtained directly from the Community Public Service Company. Extrapolation of the historical growth trend was used after five years. For the municipal street lighting class, the number of lamps is derived from the number of households and is then multiplied by kilowatt-hour use.

Table S.8.2. Texas Interconnected-Systems and Houston Lighting and Power Company peak-hour demands: 1963 through 1972

Year		Yearly peak-hour demand[d] (MW)	Monthly peak-hour demands (MW)[d]											
			January	February	March	April	May	June	July	August	September	October	November	December
1963	HL&P[a]	2,516	1,503	1,461	1,637	1,980	2,200	2,378	2,469	2,508	2,516	2,017	1,751	1,617
	TIS[b]	8,501	c	c	c	c	c	c	c	c	c	c	c	c
1964	HL&P	2,778	1,602	1,585	1,621	2,016	2,337	2,576	2,707	2,778	2,756	2,227	2,050	1,909
	TIS	9,367	c	c	c	c	c	c	c	c	c	c	c	c
1965	HL&P	3,039	1,842	1,921	2,023	2,274	2,614	2,875	3,039	3,029	3,031	2,482	2,219	2,084
	TIS	9,896	c	c	c	c	c	c	c	c	c	c	c	c
1966	HL&P	3,338	2,114	2,069	2,171	2,570	2,962	3,157	3,325	3,338	3,268	3,027	2,478	2,393
	TIS	11,087	c	c	c	c	c	c	c	c	c	c	c	c
1967	HL&P	3,752	2,268	2,256	2,611	3,152	3,462	4,712	3,774	3,896	3,558	3,296	2,718	2,842
	TIS	18,308	c	c	c	c	c	c	c	c	9,990	9,535	7,850	8,038
1968	HL&P	4,076	2,620	2,551	2,580	3,066	3,727	4,122	4,152	4,260	4,096	3,834	3,196	2,893
	TIS	13,257	7,788	7,878	7,488	8,498	10,702	c	18,784	13,263	18,854	11,100	9,204	8,863
1969	HL&P	4,701	2,885	2,779	2,806	3,396	4,077	4,686	4,849	4,921	4,756	4,290	3,696	3,253
	TIS	15,680	8,388	c	8,497	9,571	c	14,760	15,581	15,827	14,861	18,609	10,299	9,800
1970	HL&P	5,069	3,230	3,167	3,108	4,230	4,335	4,966	5,134	5,229	5,104	4,577	3,463	3,708
	TIS	16,410	10,087	9,870	9,498	11,790	12,227	15,340	16,240	16,589	15,946	13,361	10,351	10,776
1971	HL&P	5,308	3,625	3,404	3,817	4,481	5,058	5,443	5,530	5,361	5,328	5,163	4,737	4,287
	TIS	17,614	10,785	10,270	10,883	12,943	14,902	16,558	17,584	16,821	17,413	14,938	18,868	11,484
1972	HL&P	6,010	4,092	3,928	4,823	5,110	5,526	6,201	5,982	6,238	6,131	5,662	4,963	4,357
	TIS	19,366	12,115	11,229	12,609	15,606	16,573	19,363	18,667	c	19,150	17,181	13,247	13,188

[a]Houston Lighting and Power Company.

[b]Texas interconnected systems.

[c]Information not available for reference period.

[d]Monthly peak-hour demands include interruptible load, whereas yearly peak-hour demand does not.

Table S.8.3. Number of customers by class: December 1976

Class	Number of customers
Residential	663,095
Commercial	94,556
Industrial	1,353
Government and municipal	75
Public utilities	6
Total	759,085

Source: ER Suppl., Appendix SH, p. SH-70.

Table S.8.4. Historical annual usage and peak-hour demands, 1963–1976

Year (July 1)	Annual demand		Peak-hour demand		
	Annual demand MWhr, in thousands	Annual-demand growth rate (%)	Net peak-hour demand[a] (MWe)	Annual increase (MWe)	Annual increase (%)
1963	13,213		2,516		
1964	14,368	8.7	2,778	262	10.4
1965	16,328	13.6	3,039	261	9.4
1966	18,258	11.8	3,338	299	9.8
1967	20,427	11.9	3,752	414	12.4
1968	22,966	12.4	4,076	324	8.6
1969	25,921	12.9	4,697	621	15.2
1970	27,741	7.0	5,067	370	7.9
1971	30,888	11.3	5,308	241	4.8
1972	34,468	11.6	6,010	702	13.2
1973	36,694	6.5	6,484	474	7.9
1974	38,191	4.1	6,930	446	6.9
1975	40,276	5.5	7,252	322	4.6
1976	43,355	7.6	8,019	767	10.6

[a]Does not include interruptible load.

Source: ER Suppl., modified from Tables S1.1-1 and S1.1-2.

Table S.8.5. Projections of income, population, and employment for the service area

Year	Total personal income		Per capita personal income		Population		Employment[a]	
	Millions of dollars	Average increase (percent per year)	Dollars	Average increase (percent per year)	Millions	Average increase (percent per year)	Millions	Average increase (percent per year)
1960	4.29		2536		1.7		0.6	
1970	7.61	5.9	3308	2.7	2.3	3.1	0.8	4.1
1980	13.12	5.6	4565	3.3	2.9	2.3	1.1	2.5
1990	21.04	4.8	5821	2.4	3.4[b]	1.8	1.3[b]	1.7

[a]For the four major counties, Harris, Galveston, Brazoria, and Fort Bend, in the service area.

[b]The staff changed these projections to be consistent with Series E rather than Series C population projections of the U.S. Water Resources Council's *1972 OBERS Projections*, Washington, D.C., April 1974.

Source: Texas Water Development Board, *Economic Forecasts: Harris County and Vicinity*, Economics Branch, Austin, Texas, March 8, 1974; and FES, Table 8.1.

Equations were developed that model sales for the residential, commercial, and the small industrial groups in these classes. The major elements of these equations are service area population, persons per household, price of electricity, household income, and weather conditions.

The population forecast was constructed from a projection for the nation by the U.S Census Bureau and from assumptions as to the ratio of local area population to the U.S. population. Recent substantial revisions of population growth estimates in the Houston area since the 1970 census were incorporated. A projection of future persons per household was also made, which, when combined with the population, provides an estimate of the number of households for the area. The number of households then provides the basis for the number of customers in each customer group.

Household income is used as a variable to model residential megawatt-hour sales. In combination with the number of customers, household income captures part of the growth trend associated with acquisition and use of appliances, including air conditioning and electric heating. The price of electricity is a variable in the equations of residential, commercial, and small industrial use. This variable is used along with household income to capture variation in the growth trends associated with changes in the relative cost of acquiring and operating electric equipment. Two weather variables — cooling-degree hours and heating-degree hours — are used in forecasting for residential, commercial, and small industrial groups. The projections of megawatt-hour sales are based upon average weather conditions. Assumptions have also been made as to what portion of new dwelling units will be multifamily vs single-family units, and as to the breakdown of future individual- vs master-metered multifamily units. After 1980, it was assumed that all new apartments would be individually metered and would be included in the residential class.

The applicant's original and revised forecasts of annual electricity demand for 1977 through 1987 are presented in Table S.8.6. The original forecast did not contain data for 1985 through 1987. Note that for the 1977 through 1984 period, the average annual-growth-rate forecast for total demand was 6.6% in the original estimate and 4.7% in the revised estimate. By the end of 1984, the revised estimate is 18,163,000 MWhr below the original estimate — a reduction of 22%. Note that the reduced growth rate forecast for 1983 is the result of an anticipated loss of a large industrial user from the HL&P system. This loss also affects the figures reported in Tables S.8.7 and S.8.8.

Table S.8.6. Original and revised forecasts of annual electricity demand, 1977–1987

Year (July 1)	Original forecast		Revised forecast	
	Annual demand (MWhr, in thousands)	Annual-demand growth rate (%)	Annual demand (MWhr, in thousands)	Annual-demand growth rate (%)
1977	53,198		47,246	
1978	57,173	7.5	51,117	8.2
1979	61,354	7.3	53,826	5.3
1980	65,583	6.9	57,318	6.5
1981	69,746	6.3	60,112	4.9
1982	74,042	6.2	62,467	3.9
1983	78,488	6.0	62,536	0.1
1984	83,066	5.8	64,903	3.8
1985			67,769	4.4
1986			70,780	4.4
1987			74,029	4.6

Source: ER Suppl., Table S1.1-2 (modified).

Original and revised forecasts of peak-hour demands for the 1977 through 1987 period are given in Table S.8.7. For the 1977 through 1984 period, the average annual growth rate for peak-hour demand was 7.1% in the original estimate and 5.0% in the revised estimate. At the end of this period, the revised estimate is 2725 MW below the original estimate — a reduction of 18%. Figure S.8.2 shows the growth in peak-hour demand forecast for the 1967 through 1987 period for the four classes of customers.

In obtaining peak demand, class contributions to system peak demand for the residential, commercial, and small industrial groups have been modeled as functions of class energy consumption, number of customers, peak temperature, and degree hours on the day of the peak demand. These equations model the effects on peak demands of changes in weather conditions, calendar-month generation, and number of customers, thereby explaining the changes in demand growth rates.

Table S.8.7. Original and revised forecasts of peak-hour demands, 1977–1987

Year	Original forecast			Revised forecast		
	Net peak-hour demand[a] (MWhr)	Annual increase (MWhr)	Annual increase (%)	Net peak-hour demand[a] (MWhr)	Annual increase (MWhr)	Annual increase (%)
1977	9,050	750	9.0	8,650		
1978	9,800	750	8.5	9,200	550	6.4
1979	10,600	800	8.2	9,750	550	6.0
1980	11,450	850	8.0	10,375	625	6.4
1981	12,200	750	6.6	10,950	575	5.5
1982	12,950	750	6.1	11,425	475	4.3
1983	13,700	750	5.8	11,700	275	2.4
1984	14,400	700	5.1	12,175	475	4.1
1985				12,675	500	4.1
1986				13,225	550	4.3
1987				13,775	550	4.2

[a]Does not include interruptible load.

Source: ER, Table 1.1-2; and ER Suppl., Table S1.1-1.

Table S.8.8. Annual and peak-hour demands with system-load factors

Year	Annual demand (MWhr, in thousands)	Peak-hour demand[c] (MWe)	System-load factor
1963	13,213 (A)[a]	2,516 (A)	59.9 (A)
1964	14,368 (A)	2,778 (A)	59.0 (A)
1965	16,328 (A)	3,039 (A)	61.3 (A)
1966	18,258 (A)	3,338 (A)	62.4 (A)
1967	20,427 (A)	3,752 (A)	62.1 (A)
1968	22,966 (A)	4,076 (A)	64.3 (A)
1969	25,921 (A)	4,697 (A)	63.0 (A)
1970	27,741 (A)	5,067 (A)	62.5 (A)
1971	30,888 (A)	5,308 (A)	66.4 (A)
1972	34,468 (A)	6,010 (A)	65.5 (A)
1973	36,694 (A)	6,484 (A)	64.6 (A)
1974	38,191 (A)	6,930 (A)	62.9 (A)
1975	40,276 (A)	7,252 (A)	63.4 (A)
1976	43,355 (A)	8,019 (A)	61.7 (A)
1977	47,246 (F)[b]	8,650 (F)	62.4 (F)
1978	51,117 (F)	9,200 (F)	63.4 (F)
1979	53,826 (F)	9,750 (F)	63.0 (F)
1980	57,318 (F)	10,375 (F)	63.1 (F)
1981	60,112 (F)	10,950 (F)	62.7 (F)
1982	62,467 (F)	11,425 (F)	62.4 (F)
1983	62,536 (F)	11,700 (F)	61.0 (F)
1984	64,903 (F)	12,175 (F)	60.9 (F)
1985	67,769 (F)	12,675 (F)	61.0 (F)
1986	70,780 (F)	13,225 (F)	61.1 (F)
1987	74,029 (F)	13,775 (F)	61.3 (F)

[a](A) = Actual.

[b](F) = Forecasted.

[c]Does not include interruptible load.

Source: ER Suppl., Tables S1.1-1 and S1.1-2.

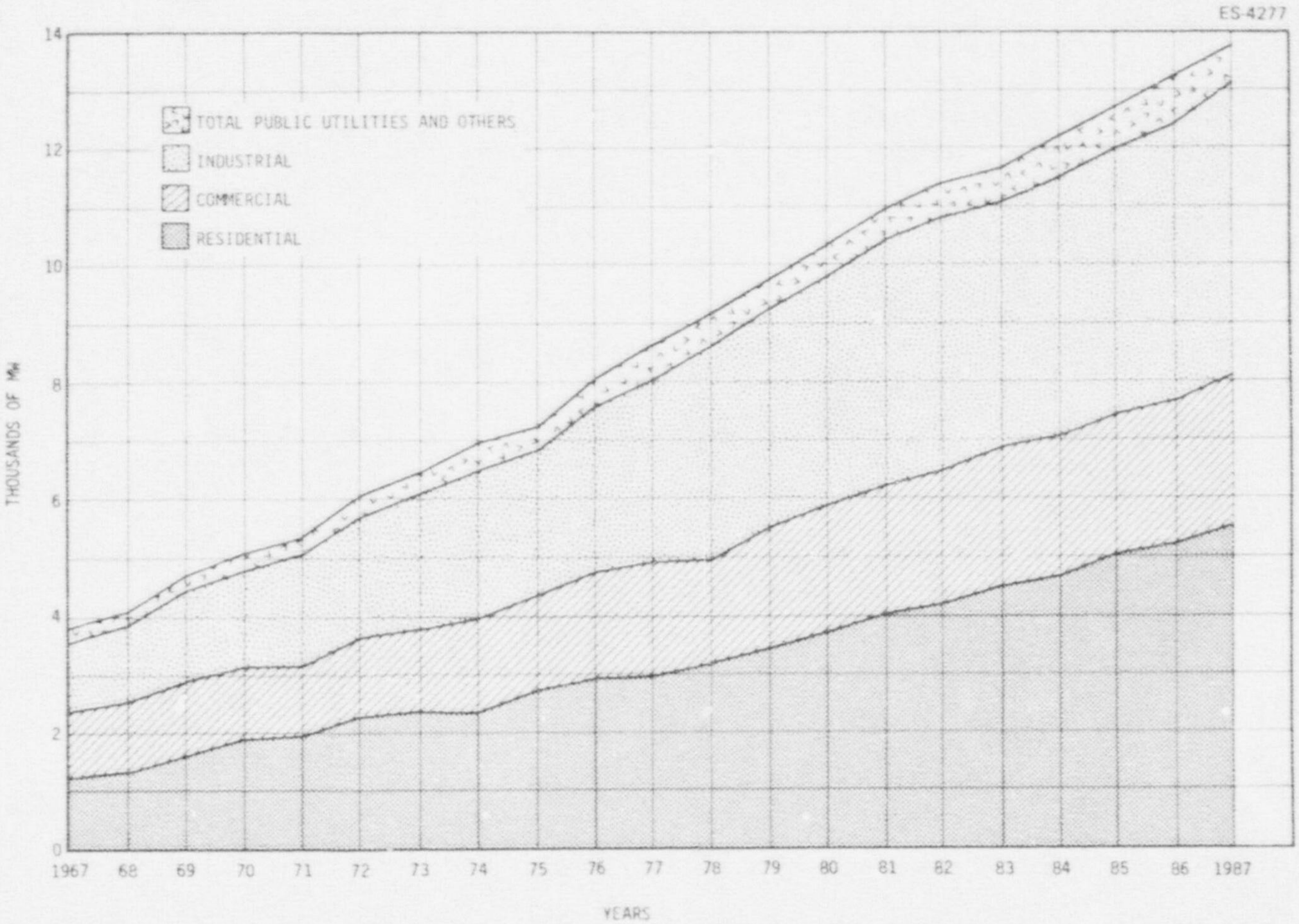

Fig. S.8.2. Peak-hour demand from 1967 to 1987. Source: ER Suppl., Fig. S1.1-1.

The large industrial, government and municipal, and public utilities class demands have been estimated using typical load factors. The overall system load factors, both historical and forecasted, are presented in Table S.8.8. As can be seen in this table, these are predicted to decline slightly in the future. The average load factor observed over the 1963 through 1976 period is 62.7%, whereas that forecast for the 1977 through 1987 period is 62.0%.

The reduced-use and peak-hour-demands forecast in the revised estimate result from two major causes. First, the oil embargo of 1973 and the ensuing energy price increases led to a reduction in the quantity of electricity demanded. Second, the economic recession that followed the embargo led to a reduced rate of growth of many of the factors that influence electricity demand: income, industrial output, and others. Forecasts that were made prior to these occurrences were unable to foresee these events and, as a result, generally overpredicted electricity demand in the postembargo era. A detailed account of the accuracy of the applicant's forecasts in the past is provided in Table S.8.9. Note that the general trend throughout the 1960s was to underestimate demand growth. This tendency was reversed in the early 1970s. Since the embargo of 1973, the applicant's forecasts have tended to err on the high side. This trend, however, may again reverse as economic recovery proceeds in the Houston area.

S.8.2.2 Staff's forecast

A current research project[3] provides an econometric model of electricity demand and supply in the United States capable of generating price and quantity forecasts for three sectors at the state level. The model is a nonlinear simultaneous system of six equations (price and quantity for the residential, commercial, and industrial sectors) which has been estimated with historical data. Rates of growth of primary exogenous variables that were assumed in the forecast for electricity use in Texas are given in Table S.8.10. These growth rates and the forecasts that are generated from them are for the entire State of Texas. To the extent that the HL&P service area experiences growth patterns that diverge from the State average, these assumptions will bias the forecast. Projections made by the U.S. Water Resources Council[4] indicate a 1.10% annual rate of growth in population for the State of Texas over the 1980 through 1990 period and a 1.73% rate of growth in population for the Bureau of Economic Analysis (BEA) area 141 (which roughly corresponds to the applicant's service area). Consequently, the assumptions in Table S.8.10 are likely to lead to an underestimate of electricity demand growth in the relevant geographic area.

Table S.8.11 presents the staff's unadjusted forecasts of annual percentage rates of growth of electricity use over the 1974 through 1990 period for the State of Texas. Separate forecasts are generated for the three consuming sectors for three different fuel price scenarios (Table S.8.10). Overall annual electricity use is predicted to increase at a rate of 3.9 to 4.2% per year from 1974 through 1990. Note that the scenario that incorporates the high-price assumption regarding alternative fuels (natural gas, oil, and coal) results in a reduction in electricity consumption relative to the base case and the low-price case. Higher prices for these fuels lead to an outward shift in the demand curve for electricity, which would tend to increase use. However, generation costs are also increased by such price increases; as a result, the supply curve is shifted inward, tending to reduce consumption of electricity. After equilibrium is established, the net effect is an overall reduction in electricity consumption and an increase in electricity prices caused by rising alternative fuel prices.

Due to the divergent growth rates projected for primary exogenous variables between the State and the applicant's service area, the forecasted growth rates for the State as a whole are likely to provide a downward-biased estimate of the electricity consumption growth rate for the applicant's service area. This effect is due to the faster economic growth expected in the Houston area than that in the rest of the State, and is likely to hold true regardless of the alternative fuel price scenario adopted. Consequently, an adjustment factor has been calculated to correct for the divergent growth patterns likely to occur in the future. This factor is given by the ratio of the Office of Business and Economic Research (OBERS)[4] predicted average rates of growth of total personal income in BEA area 141 and the State as a whole over the period 1970 to 1990. The resulting number is 1.17, which, when multiplied by the growth rates forecast for the State, results in the predicted values given in Table S.8.12. Although this adjustment technique is obviously crude, it is interesting to note that the resulting forecasted growth rates closely bracket the figure of 4.7% obtained with the applicant's methodology.

Table S.8.9. History of forecasts system net maximum hour usage

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1955	1540 (5)[a]																	
1956	2440 (4)	2480 (5)																
1957	2209 (3)	2496 (4)	2820 (5)															
1958	1900 (2)	2100 (3)	2350 (4)	2600 (5)														
1959	1900 (1)	2050 (2)	2200 (3)	2400 (4)	2550 (5)													
1960	1931 (A)[b]	2000 (1)	2130 (2)	2250 (3)	2430 (4)	2600 (5)												
1961		1957 (A)	2160 (1)	2360 (2)	2490 (3)	2630 (4)	2750 (5)											
1962			2338 (A)	2365 (1)	2489 (2)	2672 (3)	2856 (4)	3047 (5)										
1963				2516 (A)	2751 (1)	2975 (2)	3219 (3)	3478 (4)	3729 (5)									
1964					2778 (A)	3000 (1)	3250 (2)	3500 (3)	3800 (4)	4050 (5)								
1965						3039 (A)	3300 (1)	3600 (2)	3900 (3)	4200 (4)	4500 (5)	4900 (6)	5250 (7)	5650 (8)	6350 (9)	6450 (10)	6900 (11)	7350 (12)
1966							3338 (A)	3700 (1)	4000 (2)	4350 (3)	4750 (4)	5150 (5)	5600 (6)	6050 (7)	6500 (8)	7000 (9)	7150 (10)	8000 (11)
1967								3752 (A)	4100 (1)	4450 (2)	4800 (3)	5250 (4)	5700 (5)	6100 (6)	6500 (7)	6950 (8)	7450 (9)	8000 (10)
1968									4076 (A)	4450 (1)	4850 (2)	5300 (3)	5750 (4)	6250 (5)	6800 (6)	7350 (7)	7850 (8)	8450 (9)
1969										4697 (A)	5000 (1)	5550 (2)	6150 (3)	6750 (4)	7400 (5)	8000 (6)	8550 (7)	9150 (8)
1970											5067 (A)	5600 (1)	6150 (2)	6650 (3)	7150 (4)	7750 (5)	8300 (6)	8950 (7)
1971												5308 (A)	6050 (1)	6600 (2)	7200 (3)	7800 (4)	8500 (5)	9250 (6)
1972													6010 (A)	6650 (1)	7250 (2)	8000 (3)	8700 (4)	9450 (5)
1973														6484 (A)	7200 (1)	7950 (2)	8850 (3)	9550 (4)
1974															6930 (A)	7600 (1)	8300 (2)	9050 (3)
1975																7252 (A)	8150 (1)	8700 (2)
1976																	8019 (A)	8650 (1)
1977																		

[a] The number in parentheses indicates how many years the estimate was made prior to the actual.

[b] (A) = Actual net maximum hour (minus interruptible load) in year.

Source: ER Suppl., p. SH-85.

Table S.8.10. Assumed growth rates (in percent) for exogenous variables in the Chern model[a]

Variables	Base case			Low-price case			High-price case		
	1974–1980	1980–1985	1985–1990	1974–1980	1980–1985	1985–1990	1974–1980	1980–1985	1985–1990
Population	0.70	1.10	1.10	0.70	1.10	1.10	0.70	1.10	1.10
Residential customers	1.99	1.72	1.72	1.99	1.72	1.72	1.99	1.72	1.72
Real per capita personal income	3.59	2.67	2.67	3.59	2.67	2.67	3.59	2.67	2.67
Commercial customers	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Industrial customers	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69
Value added in manufacturing	4.91	3.58	3.58	4.91	3.58	3.58	4.91	3.58	3.58
Cost-of-living index	5.20	4.80	3.90	5.20	4.80	3.90	5.20	4.80	3.90
Wholesale price index	5.10	3.40	2.70	5.10	3.40	2.70	5.10	3.40	2.70
Price of natural gas (residential and commercial)	1.91	1.06	2.55				3.82	2.18	5.10
Price of natural gas (industrial)	2.01	2.49	3.75				4.02	4.98	7.50
Price of No. 2 diesel oil (residential and commercial)	0.10	1.39	1.89				0.20	2.78	3.78
Price of No. 6 diesel oil (industrial)	0.15	2.79	3.09				0.30	5.58	6.18
Price of coal	2.26	3.48	3.31				4.52	6.96	6.62

[a] W. S. Chern and B. D. Holcomb, *A Regional Forecasting Model for Electric Energy*, to be published by Oak Ridge National Laboratory.

Table S.8.11. Unadjusted rate of growth forecasts of annual electricity usage in Texas, 1974–1990 (%)[a]

Growth case	Residential	Commercial	Industrial	Total
Base case	4.9	4.7	2.9	4.0
High-price case	5.1	4.6	2.5	3.9
Low-price case	4.8	4.7	3.4	4.2

[a] Generated from the model by W. S. Chern and B. D. Holcomb, *A Regional Forecasting Model for Electric Energy*, to be published by Oak Ridge National Laboratory.

Table S.8.12. Adjusted forecasted rates of growth of annual electricity usage in Bureau of Economic Analysis area 141: 1974–1990 (%)[a]

	Residential	Commercial	Industrial	Total
Base case	5.73	5.50	3.39	4.68
High-price case	5.97	5.38	2.93	4.56
Low-price case	5.62	5.50	3.98	4.91

[a]State-level forecast (Table S.8.11) adjusted by a factor of 1.17.

S.8.2.3 Potential impacts of conservation

The forecasts presented above do not explicitly account for potential effects of future conservation policies or efforts. Consequently, the estimates of electricity demand growth that are obtained may be somewhat biased as a result. This section attempts to at least partially remedy this shortcoming by discussing in qualitative terms the kinds of effects that are likely to be generated by conservation measures in the HL&P service area.

In April 1977, President Carter revealed the details of the National Energy Plan[5] for dealing with the U.S. energy crisis. The Plan has three primary objectives: (1) to reduce dependence on foreign oil and vulnerability to supply disruption, (2) to keep U.S. imports low enough to weather the period when world oil production approaches its capacity limitations, and (3) to have renewable and essentially inexhaustible sources of energy for sustained economic growth. Among elements of the Plan, conservation and fuel efficiency act as the cornerstone; this emphasis reflects in part the fact that conservation is cheaper than the production of new energy supplies and is also an effective means of protecting the environment as well as being compatible with economic growth. The specific goal toward which the conservation elements of the National Energy Plan are directed is a reduction to less than 2% in the annual growth of the total energy demand.[5]

In its broadest sense, energy conservation might be defined as any reduction in energy consumption. Thus, in the context of a static economy, if the United States were to consume less energy tomorrow than it does today, energy would be conserved. More realistically, in the context of a dynamic and growing economy, if the growth rate in energy consumption were to be reduced in the future in comparison to historical trends of increases in consumption, energy also would be conserved. For the purpose of this review, energy conservation is defined as any reduction in the growth rate of energy consumption resulting from the implementation of specific governmental actions that have been adopted for that purpose. Electricity conservation, in turn, is defined as any reduction in the growth rate of electrical energy consumption resulting from governmental action adopted for that purpose.

The staff recognizes, of course, that almost all of the elements of the National Energy Plan are conservation oriented; that is, they are directed toward reducing the United States' consumption of scarce oil and natural gas resources both by directly reducing demand and by developing alternative energy resources. Although many of these proposed elements are directed towards reducing the consumption of oil and natural gas, they could have indirect effects leading to reductions in the consumption of electricity. For example, to the extent that rising oil or natural gas prices increase the costs of electricity generation, or that the development of new, lower-cost energy sources induces consumers to substitute these in lieu of electricity, the consumption of electricity will be reduced if all other factors remain equal. However, for the purposes of this review, such reductions in electricity consumption are not considered to be electricity conservation.

It is possible to define three principal categories of governmental actions designed to reduce the consumption of electricity: (1) programs to encourage electricity-rate reform, (2) programs to encourage changes in the technology of electrical energy use, and (3) programs to encourage and promote electricity-saving changes in life-style through consumer education and appeals for voluntary cooperation. The impact of electrical rate reform is discussed in Sect. S.8.2.4. A review of the potential impact on electricity consumption resulting from the adoption of specific actions in the remaining two categories is presented here. The specific electricity conservation policy proposals presented in the National Energy Plan are found in Sect. S.8.2.3.3.

S.8.2.3.1 Technology-related conservation

Policies relating to the technological conditions of energy consumption focus on the development and implementation of new and existing products or processes that are capable of maintaining a given level of output of some good or service (space heat, refrigeration, lighting, etc.) while simultaneously reducing the level of energy input into the production of that particular good or service. During the past two years, many industries, the Federal government, and state and local governments have made the promotion of energy-conserving technology a priority program. The U.S. Department of Commerce has developed a department-wide effort to (1) encourage businesses to conserve energy in the operation of their own processes and building, (2) encourage the manufacture and marketing of more energy-efficient products, and (3) encourage businessmen to disseminate information on energy conservation. The National Bureau of Standards (NBS) has been given a leading role in promoting the development and implementation of energy-saving standards. Programs include voluntary labeling of household appliances; research, development, and education in energy conservation in buildings; efficient energy use in industrial processes; and improved energy efficiency in environmental control processes.

The potential reduction in energy demand possible through adoption of technology-oriented programs has been the subject of considerable research in recent years. To a large extent, this research has focused on two principal areas in which energy savings appear to be available in the immediate or near-term future.

The first of these areas involves insulation and other building improvements that permit the maintenance of a given level of space conditioning (i.e., both air conditioning and heating) with a reduced level of energy consumption. It appears that substantial energy savings are potentially feasible through the implementation of this class of conservation measures. For example, the seven-story Federal Office Building to be built in Manchester, New Hampshire, illustrates the potential for energy conservation in future commercial buildings using existing technology. For this particular building, energy savings are anticipated at a minimum of 20 to 25% over a conventionally designed building in the same location. Heat savings alone are expected to be 44% because of improved wall insulation, small window areas, the use of efficient heating and heat storage equipment, and the use of solar collectors on the roof.

In 1971, the Federal Housing Administration (FHA) established new insulation standards that would reduce average residential heating losses by one-third. Studies[6] have shown that it is possible to produce even greater reductions in heat loss through improved insulation at economical costs over a period of years. Improved insulation not only conserves energy in winter but also reduces the air-conditioning burden in the summer.

The Federal Energy Administration (FEA) has estimated that voluntary building standards (proposed in ASHRAE 90-75)[7] would result in average reductions (in comparison to 1973 construction and operation practices) in energy consumption in buildings of 11.3% in single-family residences, 42.7% in low-rise apartment buildings, 59.7% in office buildings, 40.1% in retail stores, and 48.1% in school buildings. Finally, a detailed engineering-econometric model of energy use in the residential sector[8] has been used to estimate the effect of a vigorous construction standards program aimed at energy conservation in the residential sector. If energy prices continue to rise at present trends, preliminary results indicate that such a program would, if all other factors remain constant, result in a reduction from 1.7 to 1.5% in the average annual growth rate of residential energy use from 1976 to 2000. Other studies support the conclusion that significant energy savings can be realized through improved insulation and building standards.[9]

The second category of technology-related conservation measures consists of various appliance efficiency standards that might be adopted to reduce the energy input requirements of a variety of household appliances. These measures often result in an economic trade-off between front-end capital costs and lifetime operating costs; as a result, their acceptability often hinges on available and attractive financing arrangements. For example, a recent study[10] has shown that refrigerator electricity use can be reduced by 52% by increasing insulation thickness and improving compressor efficiency. These operating cost savings are obtained, however, only by a 19% increase in initial capital cost. Another study, dealing with room air conditioners, has estimated that an improvement in average efficiency from 6 to 10 Btu per watt-hour could potentially save electric utilities almost 58,000 MW in 1980.[11] Air conditioners capable of achieving such efficiencies require a combination of increased heat-exchanger size and higher-efficiency compressors, resulting in higher initial cost. Lighting, which has accounted for about 24% of all electricity sold nationally, is another area where savings are being realized. Many experts believe recommended lighting levels in typical commercial buildings have been excessive.[12] It has been calculated that adequate illumination in commercial buildings can be achieved at 50% of current levels through various design and operation changes. Another study indicated that if all households in 1970 had changed from incandescent to fluorescent lighting, the residential use of electricity for lighting would have been reduced approximately 2.5%.[13] However, because the majority of residential lighting occurs in off-peak hours, the reduction of peak demand would be less than 1%.

For the residential sector as a whole, the Hirst engineering-econometric model[8] estimates a potential reduction from a baseline of 1.7% to 1.5% in the energy use growth rate if national appliance efficiency standards are implemented. If new construction standards are also implemented, an overall growth rate of 1.3% for the residential sector will result.

In addition to lighting and air-conditioning efficiency, there are many opportunities for electricity conservation in industry. Electric motors should be turned off when not in use, and motors should be carefully sized according to the work they are to perform. Small savings can be realized by de-energizing transformers whenever possible. Fuel requirements for vacuum furnaces can be reduced by 75% if local direct-combustion low-quality heat rather than high-quality electrical-resistance heating is employed.[14]

S.8.2.3.2 Nontechnological conservation

Nontechnological conservation measures are those that encourage a reduction in energy consumption within a given technology framework. This reduction necessarily involves a substitution of non-energy-intensive products or processes for energy-intensive ones. For example, additional clothing or blankets may be purchased instead of space heating, or hand mowers may be employed instead of power mowers. Policy measures designed to encourage this form of conservation may be classified into two basic categories: information-dissemination policies and preference-alteration policies. First, those policies that alter behavioral patterns by providing relevant information on prices and opportunities available enable consumers to make better educated choices among energy sources and conservation measures available. Second, those policies that appeal to social conscience or altruism attempt to alter consumers' preferences through effecting a change in consumer attitudes.

The first category includes such measures as appliance labeling. The NBS is working with an industrial task force from the Association of Home Appliance Manufacturers in a voluntary labeling program that would provide consumers with energy consumption and efficiency values for each appliance and would educate consumers on how to use this information. Room air conditioners are the first to be labeled. The next types of household appliances to be labeled are refrigerators and refrigerator/freezers and water heaters. Also included in the first category are individual metering, peak-load pricing, and other techniques that alter the energy-pricing framework to provide individuals with information concerning the real economic costs of the services provided. The probable result of such measures is an overall decline in average electricity consumption; therefore, these measures constitute potential conservation policies.

The second category makes use of such conservation measures as advertisements and public appeals that are intended to persuade consumers to use less energy within a given technological, price, and information framework. Actually, the potential energy savings achievable through such measures is quite large. A recent study[15] found that an energy savings ranging from 20% in Minneapolis to 40% in Atlanta may be realized if residential indoor temperatures are reduced from 72 to 68°F in the daytime and reduced from 68 to 60°F at night. In practice, however, these potential savings are seldom realized through attempts at moral suasion. A study (1970-1974) of natural gas and liquid propane gas (LPG) users in Indiana reveals that the national conservation ethic is ineffective in reducing consumption except when combined with fuel price increases.[16] Thus, it appears that large energy savings are not likely to be realized through this category of conservation measures.

S.8.2.3.3 Analysis of conservation elements of the National Energy Plan

Among the major elements of the National Energy Plan designed to reduce energy consumption, those having the potential for directly reducing the consumption of electricity include a program to decrease the waste of energy in buildings, a program to establish mandatory appliance efficiency standards, a program to promote industrial conservation and fuel efficiency improvements, and a program to effect utility reform. To implement these programs, a wide variety of policy initiatives are proposed. Those initiatives that attempt to reduce electrical consumption through the manipulating of electricity prices or electricity-use costs include phasing out promotional, declining-block, and other electricity-utility rates that do not reflect cost incidence, requiring electric utilities to offer daily off-peak rates and prohibiting master metering. Those initiatives that attempt to encourage changes in the technology of electrical energy use include giving tax credits for approved industrial conservation measures; requiring utility-provided residential insulation service; facilitating residential conservation loans; providing increased funding for the low-income-household weatherization program; establishing a rural home conservation loan program; giving tax credits for business investments in conservation measures; providing a Federal grant program to assist public and nonprofit schools and hospitals in insulating their buildings; developing mandatory efficiency standards for new buildings; and establishing mandatory minimum energy-efficiency standards for major appliances.

The foregoing energy conservation initiatives can be characterized as those which have the potential for directly reducing the consumption of electricity (and other fuels as well). To the extent that they are eventually adopted, they will probably reduce the demand for electricity and the need for power. In addition, the National Energy Plan also contains a large number of other proposed policy initiatives designed specifically to conserve fuels other than electricity. If these initiatives are adopted, the effect on the demand for electricity will be indirect, and the various initiatives may serve either to reduce or to increase the demand for electricity and the need for power.

S.8.2.3.4 Major initiatives of the National Energy Plan affecting other fuels

A brief review of the major initiatives affecting the use of other fuels and the resulting potential impact on the demand for electricity is outlined here.

Initiatives affecting the prices of other fuels

One of the principal strategies of the National Energy Plan is that the prices of oil and gas should reflect the true cost of replacing these fuels. As a result, the Plan contains several proposals that would have the effect over time of increasing the prices of domestic oil and natural gas. To the extent that such policies would increase the prices of these fuels in relation to the price of electricity, the demand for electricity would, in fact, increase.

Initiatives designed to promote the adoption of new energy technologies

Because one of the objectives of the National Energy Plan is to develop renewable and essentially inexhaustible sources of energy, thereby reducing the Nation's reliance on conventional fuels (e.g., oil and natural gas), the Plan contains several proposals such as removing institutional barriers for co-generation, providing tax credits on the purchase of solar energy equipment, and extending the tax deductions for cost of geothermal energy development. To the extent that such policies may serve to reduce the prices of energy from these sources in relation to the price of electricity, the demand for electricity could decrease.

It is not now possible to forecast the overall impact of the National Energy Plan on the demand for electricity and need for power. Many conservation proposals, particularly those directed specifically toward electricity consumption (Sects. S.8.2.3.1 and S.8.2.3.2), individually would have the effect of reducing electricity demand. However, other elements of the Plan (Sect. S.8.2.3.3) may indirectly lead to increases in the demand for electricity. Thus, while implementation of the Plan may reduce the annual growth of total energy demand to less than 2%, the growth of electricity demand will not necessarily be reduced to that level.

Several studies recently have been published which attempt to evaluate the National Energy Plan.[17,18] Although the authors of these studies express agreement with many of the Plan's initiatives, they also indicate concern that the Plan will in some cases fall short of its goals. Therefore, they recommend, in part, that additional or alternative energy conservation measures be adopted. Until a national energy plan is ultimately adopted, is then analyzed, and its effects are forecasted in a detailed and comprehensive way, it is obviously not possible to predict the impact of such a plan on the consumption of electricity.

S.8.2.4 Change in utility rate structure

At present, utility rate structures are generally designed to encourage increased kilowatt-hour consumption by each customer through the use of declining-block rates. Under this rate structure, the energy charge per kilowatt-hour decreases as the quantity of electricity consumed during the month increases. In the past, under conditions of abundant fuel resources, the economic logic for declining-block rates was never seriously disputed. However, the use of declining-block rates considerably improves the competitive position of electricity for activities which require the largest use of energy in the average home and which represent inefficient uses of electric energy if weighed against the comparative amount of energy required for generation using other types of fuel. This latter point is often cited by critics of the present rate structure. Commonly mentioned alternatives to declining rates are increasing block rates, peak-load pricing, or a flattened rate structure. Under increasing block rates, the energy charge per kilowatt-hour increases at higher levels of consumption; if adopted, this rate structure would, in theory, discourage inefficient uses of electricity and the overall growth of total energy sales.

Pricing systems based on marginal costs, which vary by time of day and season of the year, are generally referred to as peak-load pricing systems. Under this price system, customers would pay a higher rate for all electricity they would demand during peak periods. The establishment of a price differential between peak and off-peak periods would correctly reflect the higher costs of providing electricity during the peak. The higher costs exist because utilities must add capacity (peaking units) to meet this demand. Furthermore, these peaking units are particularly wasteful because they operate infrequently and incur very high operating costs when used. In contrast, consumption shifts to off-peak periods will permit greater utilization of existing base-load units having relatively low operating costs.

Utility companies have generally reacted unfavorably to these new rate designs, mainly because they are uncertain about the effects of such a policy on the demand for electricity and, therefore, about their ability to earn a fair return on existing capital investment. There is little evidence available at the present time to alleviate this uncertainty.

The confusion rests on the definition of price. Economic theory implies that decisions are based on the marginal price of a product, whereas many econometric studies use average price data as a proxy because it is readily available. Both concepts generate inverse relationships between price and quantity of electricity demand; nevertheless, finer distinctions do exist, particularly in the context of analyzing the effect of alternative rate structures.

Under a declining-block rate, the average price paid by any customer will be higher than the marginal price. Consequently, if the marginal price is the correct determinant of demand, the quantity of electricity used by the customer could be reduced by increasing the marginal price, even though the average price would remain constant. This action is equivalent to moving toward (1) flattening the rate structure or (2) inverting the rates for this particular customer. However, even if this relationship holds true for each individual customer, it does not follow that the new rate structures will reduce overall demand for electricity among all customers. Each customer consumes different amounts of electricity; consequently, prices vary between customers. If the rate schedule is flattened and the average price received from the whole group is kept constant, then customers who use relatively small quantities of electricity may now pay a lower marginal price than before, even though large users will pay a higher price. It is the relative importance of these two competing effects that determines whether flattening or inverting the rate schedule will reduce electricity consumption.

An attempt has been made at Cornell University to estimate the impact of such a revision in the rate structure.[19] The methodology used in this analysis consisted of a model for forecasting electricity consumption in which characteristics of both the level and the steepness of the rate schedule were identified as explanatory variables. Results of the study show that there is no evidence to support the contention that flattening rate schedules will lead to drastic reductions in the use of electricity. In fact, investigators found that there might be a slight expansion of consumption, because customers who currently use small quantities of electricity increase consumption at a faster rate than large users make the offsetting reductions.

Other investigations have produced similar results.[20] Studies have shown that the elimination of the differences among industrial, commercial, and residential rates lowers industrial demand and accelerates residential and commercial demand, with aggregate growth remaining unchanged. In some circumstances, rate equalization was shown to cause a slight increase in aggregate growth.

Although these studies suggest that flattening or inverting the rate schedule is not expected to reduce overall electricity demand, this action may still serve as an effective conservation measure in terms of total energy use. For example, flattening the rate schedule for residential customers will tend to discourage the use of electricity for space and water heating for which more efficient alternative fuels exist. Customers using relatively little electricity will provide the offsetting consumption increases related to activities for which no practical substitutes exist, such as lighting and the power source for standard electric appliances.

With respect to peak-load pricing, the staff agrees that the development of a peak-demand surcharge can discourage consumption during peak periods. However, the Allens Creek plant constitutes a base-load unit, and it is base load, not peaking capacity, that must be considered. Although peak consumption may be lowered or its growth rate may be reduced, it is only logical to expect that part of the consumption that is curtailed will not be eliminated but will only be shifted to off-peak periods. Thus, the result of such a rate revision will be to increase the system's base load beyond what would have existed under the prevailing rate structure. Therefore, the proposed rate revision would only enhance the need for base-load units such as the Allens Creek plant.

Furthermore, there is the potential that a "needle peak" would result. That is, even though consumption during the peak period is cut back, the absolute peak will remain relatively unaffected. On a diagram depicting hourly consumption for the entire year, this phenomenon would appear as a needle because the absolute peak remains high for a very short duration, while other peak periods fall back toward base levels. This result would suggest that customers either cannot, or will not, do without electricity during conditions that bring about the absolute peak (e.g., space-conditioning load and extreme weather conditions).

The Governor's Energy Advisory Council of the State of Texas reports that a successful implementation of load-management policies would reduce the need for new generating capacity in the future.[21] It is estimated that a 20% improvement in the average load factor in Texas (from approximately 48 to 68%) would result in a reduction of 20 to 25% in the required capacity by the year 2000. It is pointed out, however, that a reduction of new capacity additions would extend the useful life of the existing capacity, which is fueled primarily by increasingly scarce natural gas. Consequently, the short- and medium-term result would be a continued dependence on high-cost fuel in existing plants; therefore, the price of electricity would be higher than it would be without load management until a substantial portion of the existing gas-fired capacity would be retired or converted. Furthermore, since the HL&P's load factor is currently above 60%, there may be little improvement to be gained from the introduction of additional load management techniques in the Houston area.

In the staff's opinion, it is still too early to judge the extent to which the proposed rate designs will be effective in reducing electricity demand and/or in improving the load factor. With respect to inverted and flat rates, the Cornell study[19] suggests that energy consumption would actually increase under such rate structures. Nevertheless, the staff affirms the general desirability of initiating peak-load pricing by electric utilities. If effective, it should improve the system load factor (i.e., utilization of existing capacity) and reduce the need for peaking units. However, a shift in time of use by electricity customers may actually increase the need for base-load units such as the Allens Creek plant.

S.8.2.5 Substitution of electricity for scarce fuels

Since the new emphasis on energy conservation has resulted principally from the energy crisis, it is equally important to inquire about the extent to which the future substitution of electrical energy for fuels in short supply (namely, oil and natural gas) will tend to increase the demand for electric power, thus offsetting the impacts of conservation measures.

Recognition of this positive stimulus to future electrical demand has been frequently noted in the literature. Preliminary data already indicate shifts by consumer groups toward increased electricity use due to price and supply considerations associated with natural gas. For example, in the residential sector during the first six months of 1973, the sale of gas ranges was down 0.6% from that of the previous year, whereas the sale of electric ranges was up 12.6% over the same time period. Water heater sales suggest a similar trend: gas water heater sales were up 1.2%, whereas electric water heater sales were up 18.4%. Sales of electric dryers increased 17.5%, but gas dryer sales increased only 5.5%. In the space-heating category, gas-fired unit sales were down 9.3%, whereas electric unit sales increased 15%. In 1974, the Electric Energy Association predicted that for the first time, more than half the newly built homes in the United States would be heated electrically.

Recently, in the 50th American Assembly — a symposium attended by 62 experts from government, industry, and the academic community — a general consensus was reached. Although the rate of growth for U.S. electric power demand would probably be less than the historic growth rate, it is unlikely to be less than 5 to 5.5% in view of the need to substitute electrical energy for some of the present uses of oil and gas.[22]

Another study[23] also acknowledges the importance of substitution for oil and natural gas on future electric demand and identifies these shifts as being long-term in nature. These investigators conducted a survey of the major energy-consuming manufacturing industries in the United States to determine the effect of potential short-falls of fossil fuels on future industrial electric energy requirements.

The 15 most energy-intensive manufacturing groups were selected, which represent over 90% of the energy consumed by the industrial sector in the United States. Ten companies from each of these groups were selected for interviews, and, in all, 142 companies and approximately 25 trade associations, electrical equipment manufacturers, and electric utility industry representatives were contacted.

Of the 142 companies surveyed, 80% indicated that they expect a short-fall of certain types of fossil energy, and 61% plan significant changes in their energy mix during the next ten years and have developed contingency plans. Of those companies expecting to make energy use changes in the immediate future, most anticipate greater reliance on oil, apparently due to the ease of conversion. However, although oil will remain the dominant alternate fuel for the two- to five-year immediate period, increased shifts to electricity and to new coal applications are anticipated. This study concluded that "over the long term, the number of companies using coal and electricity is expected to increase significantly."[23]

The staff expects that substitution of electricity for scarce energy sources will probably accelerate in the applicant's service area because of the uncertainty of oil and gas supplies and the outlook for higher prices in relation to the price of electricity produced from coal-fired or nuclear plant[illegible] example, electric space heating is projected to grow nationally from 7.6% for all ho[illegible] to 16% in 1980, and to 27% in 1990. Other increases are forecasted in the growt[illegible]ater heaters and ranges. The advent of electric automobiles or other new uses o[illegible]annot be discounted but are not now quantified in projecting need for power beca[illegible]such items is speculative. It is the staff's evaluation that substitution effect[illegible]egree offset any savings from other conservation of electricity techniques.

A second kind of subst[illegible] is relatively important in considering the applicant's need to add the proposed nuc[illegible] to this system is the desirability of adding nuclear capacity as soon as possible to [illegible]l consumed by gas- or oil-fired units that now form a significant part of the applic[illegible]tem. This addition, in turn, will increase the availability of these scarce material r[illegible]or other uses for which there is no available substitute.

S.8.2.6 Conclusions

The applicant does not believe that any energy conservation measures, substitution effects, or load management techniques (FES, Sect. 8.2.3.4) will be significant enough to change the projection of power needs. Although energy conservation measures have a potential for reducing the future demand for electricity, there is no reliable way at this time to quantify the reduction in power demand resulting from conservation methods which could be implemented either by Federal, state, or local regulating bodies or by voluntary public action. The staff's ability to predict is speculative because of (1) the uncertain nature of the effectiveness of the measures that may be taken, (2) the substitutional effects, and (3) the possible regulations that may require increased electrical demand. Finally, even if conservation of energy measures are effective in reducing the demand for electricity in the 1980s, it is desirable to add nuclear capacity to reduce the amount of fuel consumed by gas- or oil-fired units, thus increasing the availability of these limited resources for which there are no available substitutes.

S.8.3 POWER SUPPLY

S.8.3.1 Existing and planned generating capacity

Houston Lighting and Power Company's installed system shows a total capability of 10,170 MW for 1977, with all units in the system being gas-fired. From March 1978 through March 1984, the company has under construction or has projected a total additional capacity of 4700 MW, including 2730 MW of coal-fired capacity and 1970 MW of nuclear capacity (including the 1200 MW represented by the proposed ACNGS). Table S.8.13 lists all planned and proposed capacity additions of 100 MW or more for the 1978 to 1984 period.

Table S.8.13. Planned and proposed capacity additions of 100 MW or more to base-load systems: 1978 through 1984

Unit name, no.	Rated capacity (MW)	Primary fuel	In-Service date
W. A. Parish 5	660	Coal	3/78
W. A. Parish 6	660	Coal	3/79
W. A. Parish 7	600	Coal	3/81
South Texas Project 1	385	Nuclear	10/80
South Texas Project 2	385	Nuclear	3/82
Allens Creek 1	1200	Nuclear	3/85
Undetermined 1	375	Coal	3/83
Undetermined 2	375	Coal	3/84

[a]HL&P owns 30.8% of the total capacity of the South Texas Project.
Source: ER Suppl., Appendix SH, p. SH-100.

S.8.3.2 Power sales and purchases

The HL&P has no commitments for firm interchanges or purchases of power at this time, nor are any such commitments planned within the foreseeable future.

S.8.4 NEED FOR THE PLANT

The staff's assessment of HL&P's need for new base-load generating capacity consists of three parts: (1) a comparison of planned total capacity in relation to forecasts of peak-load demand (taking into account the need for reserve margins); (2) the results of the applicant's loss-of-load probability (LOLP) analysis; and (3) a comparison of planned base-load capacity with base-load demand.

S.8.4.1 Reserve margin assessment

The *reserve* for a system is defined by the staff as the difference between net generating resources and peak-load demand. *Net generating resources* are defined as installed capacity, plus firm purchases, minus firm sales. Because firm purchases and sales are zero throughout this analysis, net generating resources are equal to installed capacity. The *reserve margin* is then defined as the reserve divided by peak-load demand. Table S.8.14 presents figures for installed capacity, peak demand, reserves, and reserve margin for HL&P from 1963 through 1987.

Table S.8.14. Capacity, peak load, and reserves for the Houston Lighting and Power Company

Year	Power available (MW)			Reserve percentage
	Installed capacity	Peak demand[a]	Amount of reserve	
1963	3,004	2,516	488	19.40
1964	3,004	2,778	226	8.14
1965	3,377	3,039	338	11.12
1966	3,858	3,338	520	15.58
1967	4,401	3,752	649	17.30
1968	5,010	4,076	934	22.91
1969	5,575	4,697	878	18.69
1970	5,575	5,067	508	10.03
1971	6,325	5,308	1017	19.16
1972	7,375	6,010	1365	22.71
1973	7,708	6,484	1224	18.88
1974	8,760	6,930	1830	26.41
1975	9,810	7,252	2558	35.27
1976	9,810	8,019	1791	22.33
1977	10,170	8,650	1520	17.57
1978	10,830	9,200	1630	17.70
1979	11,490	9,750	1740	17.80
1980	11,490	10,375	1115	10.70
1981	12,475	10,950	1525	13.90
1982	12,860	11,425	1435	12.60
1983	13,235	11,700	1535	13.10
1984	13,610	12,175	1435	11.80
1985	14,810	12,675	2135	16.80
1986	14,810	13,225	1585	12.00
1987	15,560	13,775	1785	13.00

[a]Does not include interruptible demand.
Source: ER Suppl., Table S1.1-3.

For a number of reasons, utilities are required to have more capacity than the anticipated peak load. Among these reasons are scheduled maintenance, forced outages, errors in forecasts, and extremes in temperature. Based on a LOLP analysis, most U.S. electrical systems are designed on the assumption of one generating outage in ten years of operation. On a standard percent reserve basis, this requirement is approximately equivalent to a 15 to 25% reserve margin, depending upon individual system characteristics.

As shown in Table S.8.14, the reserve margins for HL&P for 1980 through 1987 are, with one exception, below the 15% level recommended by TIS. Without ACNGS, the company would be in a negative reserve position by 1987 (i.e., generating resources would not be adequate to meet forecasted peak demand). On this basis, it is the staff's opinion that an additional generating capacity at least equal to that of the Allens Creek plant is needed within the proposed time frame.

S.8.4.2 Loss-of-load-probability assessment

System reserve requirements are established, in part, by loss-of-load probability calculations. These calculations make use of demand forecasts, planned capacity, and assumed forced-outage rates. The LOLP program groups outage probabilities, corresponding to classes of megawatt-outage states, into a cumulative outage probability table. The net capability minus the predicted daily peak load is then compared to the outage probability table to determine the probability that a megawatt outage which would exceed this daily margin may occur. The daily probabilities of deficient margins are then accumulated for every weekday of the year to obtain the yearly loss-of-load probability. Figure S.8.3 presents the results of this analysis. Table S.8.15 gives LOLP figures and corresponding reserve margins under three alternative scenarios. As can easily be seen, any delay in the addition of ACNGS would cause serious impacts on reserve margins, thereby jeopardizing system reliability.

Table S.8.15. Loss-of-load probability and system reserves: 1984 through 1986

Year	Loss-of-load probability	Reserve	Time frame
1984	0.043	11.8%	
1985	0.025	16.8%	No delay
1986	0.109	12.0%	
1984	0.043	11.8%	Delay of
1985	0.182	7.4%	one year
1986	0.109	12.0%	
1984	0.043	11.8%	Delay of
1985	0.182	7.4%	two years
1986	0.767	2.9%	

Source: ER Suppl., Appendix SH, p. SH 104.

It should be noted that all LOLP results and reserve margin calculations are based on the assumption that ACNGS will be available for full operating capacity from the proposed date for commercial operation. Historically, however, regulatory restrictions and mechanical considerations have limited the operating capacities of new nuclear units. Also, these results do not reflect any possible fuel oil and natural gas curtailments in future years, although it is certainly possible that such curtailments will occur. Because fuel oil and natural gas are becoming more scarce every day, it is desirable to increase the mix of generating capacity to include nuclear and coal-fired units. Consequently, this analysis, while clearly demonstrating the need for ACNGS, probably understates the real need for this unit.

S.8.4.3 Assessment of base-load generating capacity

The staff has also evaluated the need for base-load capacity in the HL&P system. Essentially, this evaluation consisted of a quantitative approximation of projected base-load demand and base-load capacity from 1984 through 1987. The results are given in Table S.8.16.

Base-load demand was approximated by the average hourly demand for the given year. Base-load capacity was calculated by including all but those units used only for peaking. Both of these approximations would tend to bias the results against demonstration of need for additional base-load capacity. As shown in Table S.8.16, however, base-load capacity will fall short of base-load requirements in 1987, even with the addition of the 1200-MW ACNGS in 1985, and the capacity is only marginally above the required base-load capacity in the three preceding years. On this basis, it is the staff's opinion that the base-load generating capacity proposed by HL&P is needed within the time frame of 1985 to 1987 as proposed by the applicant.

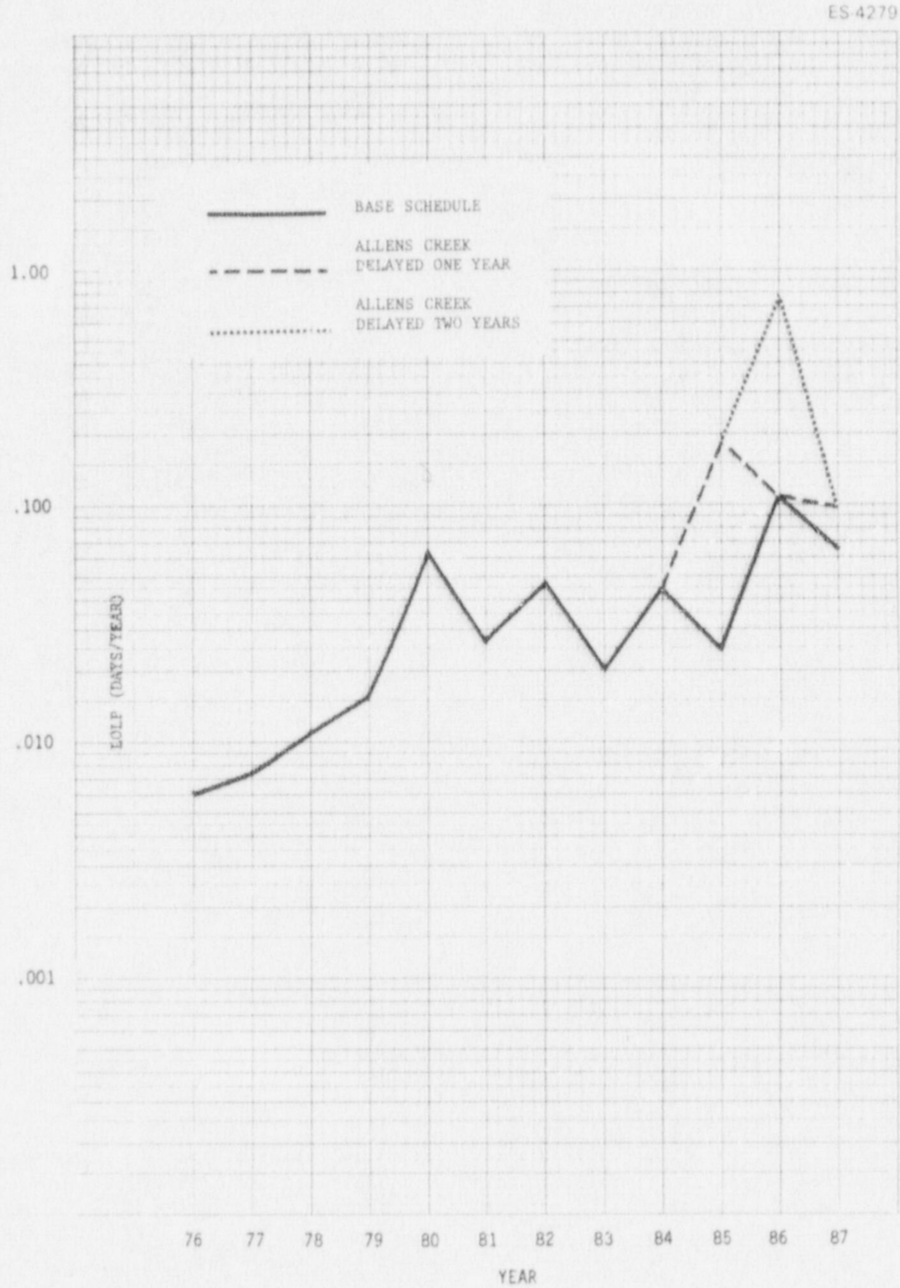

Fig. S.8.3. Loss-of-load probability (LOLP) analysis and results.
Source: ER Supplement, Fig. S1.1-3.

Table S.8.16. Comparison of planned and required base-load capacity (megawatts)

Year	Average hourly demand	Baseload requirement[a]	Baseload capacity[b]
1984	7,409	11,398	11,513
1985	7,736	11,902	12,713
1986	8,080	12,431	12,713
1987	8,451	13,002	12,713

[a] Assumes a 0.65 plant factor for base-load units.
[b] Includes intermediate capacity.

S.8.5 CONCLUSIONS

The foregoing analyses and findings indicate that (1) electricity demand growth within the HL&P service area is likely to create the need for the additional generating capacity represented by ACNGS; (2) a sufficient portion of the overall growth in demand is likely to be of the base-load variety which will justify construction of the proposed 1200-MW nuclear plant; and (3) an additional need exists within the system for diversification of generating capacity away from the present preponderance of gas-fired units. For these reasons, ACNGS, Unit 1, should be constructed within the proposed time frame.

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S.9. BENEFIT-COST ANALYSIS OF ALTERNATIVES

The staff has established (Sect. S.8) that HL&P will need additional generating capacity of about 1200 MWe for the 1985 to 1987 period as opposed to the original forecast of 2400 MWe for the 1980 to 1982 period. In view of the five-year delay and a sizeable reduction in project scope, the staff has reconsidered the alternatives that might be adopted. These include alternative energy sources and systems, alternative cooling systems, and alternative sites.

It is worth noting that, in most cases, the conclusions reached in the FES (Sect. 9) in consideration of these alternatives for the initially proposed two-unit station are equally applicable for the assessments in this section. After reviewing both the conventional and potential energy sources, the staff specifically concludes that only coal is a viable alternative source of energy for the proposed 1200-MWe nuclear power facility. Moreover, because of the lower probable generating costs of nuclear power in the late 1980s and its lesser effects on the health of the general population, the selection of nuclear plants is favored over the coal-fired alternatives. With respect to the selection of the Allens Creek site and the use of the proposed cooling lake as the preferred cooling system, the staff concludes that in view of the new design criteria the applicant has made sound choices and that the criteria used and the methods of analysis are acceptable.

Alternatives to various aspects of the proposed project are considered in detail in this section. Also, the basis for making the above conclusions is considered.

S.9.1 ENERGY SOURCES AND SYSTEMS

S.9.1.1 Alternatives not requiring creation of new generating capacity

In the FES (Sect. 9.1.1), the staff explored the alternatives of purchasing power or diversity exchange, reactivating or upgrading older plants, and the base-load operation of existing peaking facilities as a means of HL&P's meeting increasing load demands without construction of new generating capacity. It was concluded that the purchase or exchange of power was not a viable alternative; deactivated units were not of sufficient size to meet the projected power requirements (which were then 2400 MWe); the upgrading of existing units was not practical for design or engineering reasons; and base-load operation of existing peaking facilities was inadequate to meet future demands.

The staff has reconsidered each of these alternatives in view of the new projected energy requirements of 1200 MWe (Sect. S.8) and concludes that no significant changes have occurred which affect these conclusions. Therefore, construction of new generating capacity remains the only practical alternative to meet future demand requirements.

S.9.1.2 Alternatives requiring creation of new generating capacity

To determine whether the new generating capacity should be nuclear, the staff has evaluated possible alternative energy sources and compared the possible alternative generating systems resulting from its evaluation of energy sources. The energy sources evaluated as possible alternatives to the proposed 1200-MWe nuclear unit can be grouped relative to type in two broad categories: conventional and potential future energy sources.

S.9.1.2.1 Conventional energy sources

The conventional energy sources evaluated include (1) oil, (2) natural gas, (3) water or hydroelectric power, and (4) coal. These sources were evaluated with respect to their availability and possible cost in the applicant's service area.

Oil

In 1973, the United States used about 17,307,000 bbl of oil products per day, but domestic production of crude oil in 1973 was only about 9,203,000 bbl/day.[1] Thus, imports of crude oil and oil products in 1973 totaled about 8,100,000 bbl/day. Total domestic demand for oil during 1974 declined about 3% to 16,735,000 bbl/day.[2] Domestic production was about 10,495,000 bbl/day, while imports total 6,275,000 bbl/day. In 1975, domestic demand for oil products averaged 16,200,000 bbl/day, with total imports of approximately 6.2 million bbl/day.[3]

Annual electrical generation (usually closely proportional to consumption) for 1976 was about 6.3% greater than in 1975,[4] and generation so far in 1977 is about 7% greater than last year.[5] The total U.S. energy demand, which declined for two consecutive years, increased by 4.8% in 1976.[6] This increase was attained by a 6.6% increase in consumption of oil and its products, including a 21.4% increase in imports. These imports amounted to 40.6% of the total U.S. demand for oil and its products in 1976. This dependency on imports, expected to continue for many years,[7,8] necessitates dealing in an international oil market supplied mainly by the Middle East and North African countries, which produce almost half of the world's oil.

The availability and cost of imported oil are subject to the quite often politically motivated production and pricing policies of foreign producers, and the reliability of fuel supplies from such sources cannot be considered dependable over the long term. The national balance-of-payments problem is also aggravated by the importation of large quantities of oil. Further, the petrochemical and fertilizer industries depend on petroleum and its derivatives and have a higher claim to available supplies than the electric utilities when other fuel sources are available.

In summary, the staff believes that the uncertain nature of the oil supplies, their high cost, and their importance in other aspects of the U.S. economy preclude consideration of oil-fired steam-electric base-load power stations as an alternative to the 1200-MWe ACNGS.

Natural gas

From an environmental standpoint, natural gas is the preferred fossil fuel because its sulfur and ash contents are negligible. However, the demand for this energy form has recently exceeded its domestic availability. This situation of excess demand is expected to persist and become nationwide as producing regions are required to export to consuming regions. The total domestic consumption of natural gas increased 72.3% from 1961 through 1970.[9] Electric utility consumption of natural gas increased 113.4% during that period, with natural gas accounting for one-third of the total fossil fuel consumption by electric utilities in 1970.

The results of a 20-year forecast made by the Bureau of Natural Gas for the Federal Power Commission (FPC), published in 1972, indicate that the rate of development of natural gas supplies, both conventional and supplemental, will be inadequate to meet current projections of future demand.[10] This prediction included consideration of future prospects for additions to domestic reserves, imports of pipeline and liquified natural gas, Alaskan gas, and synthetic gas from coal and liquid hydrocarbons. A successful program of development or implementation was assumed for each of these major current or future supply programs.[10]

Early in 1973, shortages of natural gas brought about the issuance of Order No. 467 by the FPC.[11] This order sets forth initial priorities based on end use of gas to be followed by pipeline companies. Users of natural gas with the lowest priority are those with "interruptible requirements of more than 10,000 mcf per day where alternative fuel capabilities can meet such requirements." In view of the shortage, the position taken by the FPC is that the use of natural gas for boiler fuel is an inferior end use and that all large quantity sales of gas for use in boilers should be made under interruptible rather than firm contracts.

By a rule adopted May 5, 1975, the Federal Energy Administration (FEA) established its program to implement Sects. 2(a), (b), and (c) of the Energy Supply and Environmental Coordination Act of 1974 (Public Law 93-319 ESECA) related to prohibiting certain power plants and major fuel-burning installations from burning petroleum products or natural gas as their primary energy source. Utilities have been advised by the FEA that gas use for electric power generation must be phased out and that the use of oil as a power plant fuel is also being restricted.

The failure of natural gas supply to meet demand is due to stimulation of demand and constrained resource discovery and development resulting from regulated prices that have become artificially low when compared with competing fuels.[12] Deregulation of the price of newly developed natural gas supplies is expected to stimulate supply and restrain growth of demand,[8,12] thus eliminating the current shortage problems. However, deregulated prices approaching \$2.00 per 1000 ft^3, which are typical in the unregulated intrastate market, would be equivalent to the current cost of fuel oil and, therefore, too costly for boiler fuel.

The HL&P currently employs natural gas as its primary fuel for generating electricity. Because current restrictions do not permit the use of natural gas as a boiler fuel and because future prices are expected to be too high, the staff does not find natural gas to be a viable fuel for an 1200-MWe base-load power station.

Hydroelectric power

The HL&P does not have any conventional run-of-river hydroelectric generation facilities. Considering the topography and the rivers in the south Texas region, the staff does not expect development of any conventional hydroelectric facilities. Development of pumped-storage facilities may be possible, although currently unplanned, but this type of facility only provides peaking capacity at the expense of increased utilization of base-load facilities. Therefore, hydroelectric power is not an alternative to the proposed ACNGS.

Coal

Coal is the most abundant fossil fuel in the United States, accounting for 73% of the total recoverable fossil fuels.[13] Currently, its primary use is in the manufacture of steel and other goods and in the generation of electricity. Coal supplied 54% of the energy used in thermal power generation in 1970[14] but decreased to about 44% by 1975.[15] In terms of contained energy, electric utilities used about 66% of the coal consumed in the United States in 1975.[15]

The National Petroleum Council Coal Task Group's projected demands for coal produced in the United States for the years 1975, 1980, and 1985 are as follows:[16]

Consumer	Projected demand (millions of tons) 1975	1980	1985
U.S. electric utilities	415	525	654
Total United States	621	734	863
Exports	92	111	138
Subtotal	713	845	1001
Replacement	30	65	70
Total	743	910	1071

The values given as "replacement" in the preceding tabulation are assumed replacement for shortfalls in other fuel supplies.

The FEA forecast of coal consumption in 1985 is approximately the same, assuming continuation of the high price ($13 in 1975 dollars) for imported oil.[8] Expanded use of coal, particularly for generation of electricity and for production of synthetic liquid and gaseous fuels, has been the proposed energy policy goal of both President Ford and President Carter.

The projected demands represent an average annual increase in coal production of 3.7% during the period through 1985. The Coal Task Group concluded that, even under the most favorable circumstances, it is unlikely that coal alone could completely eliminate the nation's dependence on imported fuels prior to 1985.[16] In fact, the FEA studies[8] indicate that favorable development of all domestic fuel resources (coal, oil, natural gas, and nuclear) will only restrain petroleum imports in the mid-1980s to the undesirable 1974 level, with hope for import reductions to begin after 1985.

Because of the adequate availability and reasonable price of coal (compared to other fossil fuels), the staff concludes that coal is the only conventional fuel at present that is a viable alternative to nuclear fuel for a large base-load power station. An environmental and economic comparison of coal-fired and nuclear-fueled power plants is presented in Sect. S.9.1.2.3.

S.9.1.2.2 Potential future energy sources

Potential future energy sources applicable to central-station power generation may be the result of technological developments that either improve energy conversion efficiencies and techniques or unleash energy sources for new applications. Magnetohydrodynamics and fuel cells are examples of energy conversion techniques currently being investigated.

Energy forms from other conversion techniques considered include (1) synthetic fuels and (2) energy released by combustion of refuse. The "new" energy sources considered in this evaluation are (3) geothermal energy, (4) solar energy, and (5) controlled nuclear fusion. These forms and sources are discussed in the following paragraphs.

Magnetohydrodynamics

Magnetohydrodynamics (MHD) is an engineering technique for more efficient conversion of thermal energy from energy sources such as the fossil fuels or nuclear reactors into electrical energy. The MHD generator is a heat engine that combines the features of a conventional turbine-generator into a single apparatus by eliminating the turbine and replacing the rotating conductor of a commercial generator by an electrically conductive plasma or fluid flowing in a conduit through a magnetic field. MHD concepts include both open-cycle and closed-cycle systems. In the open-cycle system, fossil fuel (most likely coal) is burned at sufficiently high temperatures to produce ionized gas plasmas; conductivity is enhanced by seeding with conductive ionized salts.

In the closed-cycle system, ionized gases and/or liquid metals, heated by fossil or nuclear energy, are caused to flow through the MHD generator.

As noted in the Atomic Energy Commission (AEC) draft statement for the Liquid Metal Fast Breeder Reactor Program,[17] all MHD power generation concepts are currently in the development stage. A number of laboratory and pilot-plant-scale plasma MHD generators have produced significant amounts of power (several megawatts) for a few minutes at a time, while those employing liquid metal systems have produced energy on a much smaller scale.

Attention has been directed toward testing various system components; however, until recently, no continuously operating MHD pilot plants have been built. In the spring of 1977, it was announced that the University of Tennessee Space Institute (UTSI) had succeeded in burning high-sulfur coal in an MHD plant to produce electricity while containing more than 95% of the sulfur without using an expensive desulfurization process.[18] The UTSI researchers expect their coal-burning MHD plant to have a conversion efficiency of 55% by combining the high-temperature MHD plasma process with a conventional lower temperature steam-electric turbine generator. A second-stage pilot plant, scheduled for completion in 1978, with a capacity of 3 MWe is currently being built by UTSI. In addition, ERDA reported that Soviet Union researchers have operated a natural-gas-fired MHD plant based on the UTSI model for 250 consecutive hours.[18] These advances in MHD technology are believed by the UTSI researchers to offer significant confidence that MHD may enter the commercial market sometime between 1985 to 1990.

However, this encouraging schedule does not offer much hope for MHD as a reliable alternative for a power plant planned to begin operation in 1985.

Fuel cells

Fuel cells, which are similar to conventional electrolytic batteries, produce electricity through the electrochemical reaction of hydrogen or hydrocarbon fuels (such as oil, gas, or methanol) with oxygen. The electric conversion efficiency is only about 35 to 40%. However, the packaged, modular design of fuel cells permits the application of this technology to dispersed siting at point of use, such as industrial plants, integrated commercial-residential complexes, and utility substations.[19] In the first two siting examples, the reject heat may also be readily applied to process or space heating and cooling systems, thus increasing the overall fuel-use efficiency. In the utility application, the fuel cell can be operated as an unattended load-following device, thus reducing the quantity of centralized base-load capacity required and substituting for the more complex turbine or diesel-type peak capacity generating units.

Fuel-cell research peaked during the early 1960s when the problem of providing electric power for space vehicles was a critical issue. Research and development then declined until the energy crisis developed in 1974, and the Federal government began to expand its interest in developing a greater variety of energy sources.

In 1976, ERDA, the Electric Power Research Institute (EPRI), and United Technologies Corporation announced their intent to construct a 4.8-MWe fuel-cell demonstration plant.[20] This effort is expected to result in a certified module of a fuel cell power plant by about 1980 and to help with the introduction of larger plants shortly thereafter. (Consolidated Edison in New York City has been chosen to operate this demonstration plant beginning sometime in 1978.[21])

Although this technology does offer unique possibilities for increased energy efficiency and environmental advantages associated with dispersed siting and reduced gaseous pollution (fuels are not burned), the question of commercial acceptability and economic viability remain to be shown through demonstrations in the next five years. Thus the staff does not believe that fuel-cell power plants can be considered as an alternative to central-station plants planned for operation beginning in 1985, nor is it likely that sufficient fuel cells will be installed by individual consumers to reduce the growth rate of electrical energy required from the HL&P during the next decade.

Synthetic fuels

Synthetic fuels from domestic coal and oil shale cannot be considered as alternative sources of energy for the period under study because the processes for producing most of the synthetic fuels are in the developmental or prototype stages. In a 1973 study,[16] the National Petroleum Council concluded that production facilities for synthetic liquids and gases from coal could not be developed fast enough to replace the nation's expanding imports of petroleum. Coal gasification and liquefaction plants represent complicated engineering processes not previously tried in the United States. Prototype facilities have been proposed or are under construction to test processes and delineate potential problems, but operation is still in the future. Commercial development leading to a significant production capacity of synthetic fuels is not currently committed, although a gasification plant for 50 million ft^3 of natural gas per day will be built by ERDA and Memphis Light, Gas, and Water Division for operation in the early 1980s.[22] Two important problems are economics and the environment. It has been estimated that synthetic fuels would cost the equivalent of $15/bbl (1975 dollars).[23] A recent information overview has pointed out the environmental hazards, including the potential leakage of cancer-inducing polycyclic aromatic hydrocarbons during the production of synthetic fuels.[24]

In 1976, the Mobil Oil Corporation Senior Vice President, Dayton H. Chewell, stated at the Third Energy Technology Conference in Washington, D.C., that synthetic fuels will supply about 2.5% of the nation's energy needs by 1990.[25] It is the staff's opinion that no significant change in supply or demand has occurred to alter his prediction.

Oil shale is the second most abundant source of energy available in the United States, exceeded only by coal. Vast oil-shale deposits exist in the Green River area of Colorado, Utah, and Wyoming.[23] This area covers some 16,000 to 17,000 sq miles of land and is estimated to contain some 2.6 trillion bbl of potentially recoverable oil. Although not included in the published figures on "proved reserves," the shale oil in the Green River area is much greater than the oil in the entire Middle East.[13] However, shale oil is not expected to play a major supply role between now and the middle 1980s. Production was estimated to start off at about 50,000 bbl/day in the early 1980s and perhaps reach 250 thousand to 500 thousand bbl/day by 1985, if production problems are overcome. However, this estimate now appears overly optimistic because large-scale development has been slowed pending improved commercial economic benefit, particularly Federal guarantees of investment loans in order to limit financial risks. Finally, ARCO's President, Thorton Bradshaw, believes that limited water availability will limit ultimate shale-oil production capacity to near 2.5 million bbl/day unless new technology is developed.[26] This amount will only help to hold the level of imports of petroleum to current levels but not reduce the nation's dependence on imports.[8]

Combustion of refuse

Substantial sources of energy exist in the refuse generated in this nation each year, and many cities and counties in the United States are studying ways to take advantage of garbage as a source of energy. Although processes for converting municipal garbage and sewage sludge into methanol, synthetic natural gas, or fuel gas are being evaluated, the combustion of refuse in steam systems for production of electric power or to provide process or space heat appears to provide the most immediate promise.

Practical and economic considerations make the burning of refuse for power generation more feasible as an auxiliary to the use of more conventional fossil fuels. The primary concern of a utility company is to deliver electricity to its customers, and the fuel necessary for this purpose must be available to follow the load for operation of a power plant. Storage or stockpiling of raw garbage for this purpose is not practical for aesthetic and health reasons. Further, the capital cost of a refuse-burning-only steam-electric plant is very high, the base-load operating and maintenance costs are high, and the cost of the refuse fuel is relatively low.[27]

The model for the design and operation of large dry-materials separation plants being considered is the existing 300 ton/day material separation plant being operated by the city of St. Louis in a cooperative program with the Union Electric Company. The city collects and processes refuse by dry shredding and magnetic separation and delivers the shredded waste to Union Electric, where it is burned in the furnaces of two 125-MWe steam generators. However, pulverized coal is the primary fuel for these boilers, and 10 to 20% of the total heat input is derived from refuse.[28]

Use of the estimated potential energy from refuse as a substitute for electric energy at point of use could reduce the annual electric energy provided by HL&P. Whether this energy is put to use is dependent on factors such as development of technology, economics, institutional and legal encouragement, and governmental support. Examples of energy from refuse can be found in Nashville and Crossville, Tennessee. Nashville has a steam supply system to supply space and process heat to a portion of its downtown area.[29] In Crossville, a boiler is being installed to supply process steam to a small industry while burning the wastes collected by the county-wide collection system.[30]

Wheelabrater-Frye has been involved with two large projects for burning municipal wastes: 1200 tons/day near Boston, Massachusetts,[31] and for Jersey Central Power and Light at a central New Jersey location by 1980.[32] Information gained in current projects will be useful in determining the best ways of utilizing refuse to obtain energy.

The staff believes that refuse should be used to regain lost energy but does not expect that this alternative will be adopted to a sufficient extent during the next decade to lessen the projected need for ACNGS.

Geothermal energy

In the United States, there are basically four types of geothermal energy reservoirs: steam, hot water, abnormal pressure zones, and hot rock. The most convenient and economical form of geothermal energy for electric power production is steam. However, dry steam reservoirs are known only in the Larderello-Mt. Amiata region of Italy and at The Geysers in California.[33] Hot-water reservoirs are the most common type, but the areas in the United States meeting the criteria for classification as known geothermal resource areas are found only in Alaska, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, and Washington.[33] The states containing potentially valuable areas include Arizona, Colorado, South Dakota, and Wyoming.

The only major known abnormal pressure or geopressured strata zones in the United States are in the northern Gulf of Mexico basin.[34] The two main areas of geopressured strata are in southern Texas and southern Louisiana, extending offshore in both areas. However, there are no known areas of geopressured strata in the applicant's service area. Geopressured strata have also been reported in Mississippi.[34]

The greatest promise for large-scale development of geothermal energy lies in the utilization of the heat content of hot rock. The western part of the United States holds excellent prospects for finding enormous hot-rock formations. Work in this area, still in the research stage, is being conducted at the Los Alamos Scientific Laboratory in New Mexico.[13] Because there are no known geothermal sources in the HL&P service area, the staff has concluded that geothermal energy is not an available alternative source of energy for the proposed 1200 MWe of base-load generating capacity.

Solar energy

There are several approaches to the collection and conversion of solar energy with a potential for power generation, and these approaches can be classed as either natural or technological. The natural collection approaches include wind energy, utilization of photosynthetic materials as fuels and methane production from biological wastes, and ocean thermal gradients. The technological collection and conversion approaches include direct conversion of solar energy to electricity (photovoltaic conversion) and solar thermal conversion. Direct solar radiation can also be collected for heating and cooling of buildings.

Wind energy. Wind energy can be converted to electric energy for direct consumption or used to electrolyze water and to produce hydrogen for use in fuel cells or thermal electric generating stations. In a report to Congress, W. L. Hughes, head of the School of Electrical Engineering at Oklahoma State University, stated that wind generation cannot totally replace power plants using oil, gas, coal, or nuclear fuel.[35] The role of wind power in solving the energy crisis depends primarily on the development of economical commercially available energy storage systems. The most significant possible use of wind power would be to pump electricity into existing electric transmission systems when the wind is blowing.[36] The limiting factors in the large-scale direct application of wind power are a combination of available wind energy and possible weather modification.

The current ERDA national solar-electric conversion program includes research and development of three general sizes of wind-energy devices. These are small machines for farm use, large-scale experimental units (over 100 kW), and multiunit facilities (clusters up to MW scale).[37] Under ERDA sponsorship National Aeronautics and Space Administration (NASA) designed and is operating a 100-kWe horizontal-axis wind turbine generator at its Plum Brook Station at Sandusky, Ohio.[38] The capital cost of this first-of-a-kind test model with its 125-ft-diam twin-bladed rotor was $5500/kWe of rated capacity, but the cost of the following 200-kWe test model is estimated at $2340/kWe. A six-story-high vertical-axis wind turbine with an output capacity of 60 kWe is being designed at Sandia Laboratories in Albuquerque, New Mexico, as part of the ERDA wind-energy program.[39] The output from the generator will be 60-cycle ac power that can be synchronized with grid requirements of existing power distribution systems.

These examples illustrate that wind-powered large-scale electrical generation facilities are only now in the stage of design, development, and testing experimental prototypes. Demonstration of megawatt-scale machines (10 to 100 MWe), including site certification and completion of system dynamics studies, may be possible in the early 1980s.[40] Information obtained from such demonstrations would include estimates of the economic, environmental, and operational feasibility of wind-powered power stations.

Because demonstration, acceptability, and commercial availability of wind-powered central power stations are not expected before the middle 1980s, the staff has concluded that wind cannot be considered a viable alternative source of energy for the proposed 1200 MWe of base-load generating capacity.

Photosynthetic materials and organic wastes. Photosynthetically produced organic material (grown specifically for utilization as fuel material) and organic solid wastes (animal wastes and sewage) can either be burned directly to produce steam in equipment similar to that used with coal or can be subjected to anaerobic fermentation to methane.[36] To be burned directly, these fuels must first be dried in order for combustion to be self-sustaining. If the organic material has a high water content, the energy required for drying prior to combustion may equal or exceed the heat content of the material itself. The growing of plants for energy generation is relatively inefficient because the solar conversion efficiency of the photosynthetic process is seldom over 3% during the growing season. Therefore, the amount of land required for a given energy output is very high. Based on a heating value of 7500 Btu/lb of dry plant tissue and yields of 10 to 30 tons of biomass per acre per year, the land required for a 100-MWe organic-fired power plant would be between 25 and 50 sq miles,[36] or 600 to 1200 sq miles for a plant equivalent to the proposed ACNGS.

Based on southern softwood forests and kraft pulp mill operation, Szego and Kemp assumed a softwood growth yield on a sustained basis of 2 cords (5 tons) per acre per year to determine that about 1 sq mile of managed forest would be required per MWe capacity at 55% load factor.[41] These land requirements are greater than the proposed ACNGS [about 4513 ha (11,152 acres)]. The staff does not believe that growing plants for electrical energy production is acceptable in Texas.

The technical feasibility of bioconversion of organic material to methane has been established for many years. The immediate goal is to establish the economics of the process using organic wastes and organic materials resulting from photosynthesis. However, anaerobic fermentation to methane of the entire amount of organic solid wastes believed to be economically recoverable would represent a recovery of 3.6 to 7.8 x 10^{14} Btu/year, or approximately 2 to 3% of the yearly consumption of methane in the United States.[36] Fifteen-year research and development programs are foreseen to make the processes for both direct combustion and conversion to methane of photosynthetically produced material and solid organic wastes economically and technically feasible on a commercial basis.[36] Production of methane on a large scale is not now a reasonable alternative.

Ocean thermal gradients. The difference in water temperature at the surface of the ocean and several thousand feet below the surface can possibly be used to generate electricity in a conventional heat engine. A collection of heat engines moored on 1-mile spacings along the length and across the breadth of the Gulf Stream off the southeastern coast of the United States might provide an annual energy production of 26 x 10^{12} kWhr.[36] If, for economy of energy transport, the electrical power thus generated could be conducted to electrolytic cells, converted and transported as hydrogen gas, and subsequently reconverted to electricity in fuel cells, about one-half to two-thirds of the energy would be recovered.[36] A 15-year research and development program was proposed by the National Science Foundation in 1972 to study the technical and economic problems that could influence large-scale use of ocean thermal differences.[36]

In mid-1975, three separate research teams claimed to have proved the feasibility of building offshore power plants that use natural differences in ocean temperatures to generate electricity and are seeking Federal funding for a pilot power plant off the coast of Florida or Hawaii.[42] However, the estimated costs range from $45 million to $210 million for a 100-MWe plant and $425.6 million for a 160-MWe plant. The current ERDA solar-electric-conversion program includes research and development on components (particularly on heat exchangers and deep-water pipes) for such plants.[37] Other renewable ocean-energy options such as waves, currents, tides, and salinity gradients may also be examined.[37] However, offshore ocean thermal gradient power plants cannot be considered a viable energy source for Texas consumers in the late 1980s.

Photovoltaic conversion. Solar energy can be converted directly to electricity by means of solar cells using photovoltaic conversion, which does not involve moving parts, circulating fluid, or consumption of material. The theoretical maximum conversion efficiency of silicon solar cells is 23%, and efficiencies of 16% have been obtained.[43] However, photovoltaic conversion appears today to be economically quite unattractive because the current purchase price of a silicon solar cell is about $20,000 per kilowatt.[44]

The current ERDA solar-electric conversion program includes research and development directed toward 1- to 4-MWe demonstration plants with array costs under \$500/kWe.[37] Research efforts will be directed toward crystal growth, encapsulation, concentrators, and the production of low-cost silicon arrays, with emphasis on the use of automation and efforts to reduce material cost. However, it is estimated that solar cell costs must be reduced to about \$200/kWe before they will be economically feasible for large-scale power generation.[39] Therefore, power production using photovoltaic conversion devices is not currently economically feasible.

Solar thermal conversion. Solar thermal conversion systems to generate electricity in central stations will possibly be comprised of solar collectors and concentrators, receivers, a means of transferring the heat to a thermal storage facility or to the turbogenerator, and a turbogenerator to produce electricity. As for all approaches involving the use of direct solar radiation, the basic problems associated with central station electric power generation through solar thermal conversion are related to the variability of solar radiation, necessitating either energy storage or backup power, and the low density of solar radiation, requiring large land areas devoted to energy collection. An area of approximately 10 sq miles would be needed for the heat collectors required to operate a 1000-MWe plant in the southwestern part of the United States at an average of 70% of capacity.[36,44] Although the fuel itself is free, the capital investment for collecting, storing, and transforming solar radiation into electricity in thermal conversion power plants with projected efficiencies of 20 to 30% will be high.

The National Science Foundation recommended a 15-year research and development program with an estimated cost of \$1130 million in 1972 that was intended to make a solar-thermal conversion power plant commercially available by 1990.[36] The current ERDA solar-electric conversion program includes research and development on solar thermal energy conversion power plants, with preliminary efforts directed toward central receiver and collector systems.[37] A key goal of the program is cost reduction. Such systems will not be economical unless capital cost estimates can at least be cut in half.[37]

Hot-water heating and the heating and cooling of individual buildings appear to be the most promising near-term applications of solar thermal conversion that might provide a substantial savings in the fuel costs for both individual consumers and electric utilities by the middle or late 1980s. Solar heating and cooling systems could represent 2% of the total U.S. energy use or about 10% of the anticipated heating and cooling energy demand in the year 2000.[45] Economic analyses of solar heating and cooling applications throughout the United States indicate that heat pumps and heat exchangers (vapor compression cooling) are generally more cost competitive with electricity than absorption systems. For solar space heating only, the range of solar effectiveness (fractional energy use from solar) for the most cost competitive systems is 50 to 85% in the southwestern United States, and the homeowner's capital cost (1975 dollars) for a single-family residence would be from \$2000 to \$6000.[45] Solar hot-water heating system energy costs are estimated to be less than for electric hot-water heating in most of the United States, and the solar effectiveness in optimum-cost systems is from 80 to 90%. The system capital cost to the user will range from \$1000 to \$2500 for a single-family residence with an approximate 1/2-day storage capacity.[45]

Significant reductions in the high initial cost of these solar systems, possibly through large-scale production, will be required to make them competitive with electric systems. One approach being investigated, which would alleviate the high initial cost to the consumer, involves entry of utility companies into the distribution market for mass-produced solar heating and cooling systems within five to ten years.[46] A homeowner could rent a supplemental solar energy system from the utility and save about 15%/year on heating, cooling, and hot-water costs after monthly payments for rental of the system. These supplemental solar energy systems would also provide the utility a fuel-cost saving. However, the results of the preceding cost-optimization analyses were based on the assumption that the solar heating and cooling systems involved were equipped with backup sources of electric energy that would be available when required at a cost equal to current residential rates. Even though electric utilities might experience fuel-cost savings as a result of the use of solar systems in individual buildings, they would still need installed generating capacity adequate to meet peak load demands and transmission and distribution networks capable of carrying these loads. The load factor for this backup power would be lower than it would be if there were no individual solar systems in the service area, and the cost of providing this standby capacity would be proportionately higher.

If all of these solar-energy-related research and development programs were to be undertaken now or in the near future, the commercial availability of the forms of solar energy applicable to central-station power generation probably would not be demonstrated until about 1990 or later. The staff therefore concludes that solar energy is not an available alternative source of energy for the proposed 1200-MWe power generating plant. Even if a great many customers have individual solar systems installed in 1986, the applicant would still need generating capacity to meet load demands when these systems switched to their backup supplies of electricity during a period of several cloudy days, although such capacity would be composed of peaking rather than nuclear units. Thus the use of individual solar heating and cooling systems in the service area would not substantially reduce the applicant's overall generating capacity requirements.

Controlled nuclear fusion

There are several concepts currently being investigated for collecting energy from thermonuclear fusion processes. However, fusion power development is in a less advanced stage than solar energy. It is presently estimated that an orderly research and development program might provide commercial fusion power by about the year 2000 and that fusion could then have a significant effect on electrical power production by the year 2020.[47] The staff has therefore concluded that controlled nuclear fusion is not an available alternative source of energy for the proposed power plant.

Conclusions

After reviewing both the conventional and potential future energy sources, the staff concludes that only coal is a viable alternative source of energy for the proposed 1200-MWe nuclear power plant. The uncertainty about the availability of natural gas and oil from either domestic or foreign sources in quantities sufficient for life-time operation of a power plant eliminates oil-fired base-load steam units, combined-cycle units, and gas-turbine units for consideration as alternative energy systems. The lack of available sites eliminates conventional hydroelectric power as an alternative, and the lack of demonstrated technology on a commercial basis eliminates the potential future energy sources from consideration as alternatives for central-station power generation by the late 1980s. Neither the potential energy sources nor the more efficient conversion processes are likely to be in use sufficient to reduce the growth rate of electric energy required from central power stations during the next decade.

S.9.1.2.3 Comparison of alternative energy systems: coal versus nuclear systems

Having concluded that the only viable alternative energy system to the proposed nuclear facility is a coal-fired generating station, the staff has conducted a detailed comparison of the health effects and the direct economic costs of electricity production with these two alternative fuels. The complete analysis is presented in Appendix S.D. The following sections summarize the results of this analysis.

Health effects

In comparing the differing health effects from the use of coal and nuclear fuels, the entire fuel cycle was considered. For coal, this cycle consists of mining, processing, fuel transportation, power generation, and waste disposal. The nuclear fuel cycle includes mining, milling, uranium enrichment, fuel preparation, fuel transportation, power generation, irradiated-fuel transportation and reprocessing, and waste disposal.

For each phase of the respective fuel cycles, excess mortality, morbidity, and injury among both occupational workers and the general public were estimated (the term "excess" is used to mean those effects occurring at a higher than normal rate). Although it is extremely difficult to provide precise quantitative values for these effects, a number of estimates have been prepared on the basis of current knowledge of health effects, and present-day plant design, emission rates, occupational experience, and other data.

Although future technological improvements in both fuel cycles may result in significant reductions in health effects, based on current estimates for present-day systems it must be concluded that the nuclear fuel cycle is considerably less harmful to man than the coal fuel cycle. As shown in Appendix S.D (Tables S.D.15 and S.D.16), the coal fuel-cycle alternative may be more harmful to man by factors of 4 to 260 in an all-nuclear economy, depending on the effect being considered, or by factors of 3 to 22 assuming all electricity used in the uranium fuel cycle is generated by coal-powered plants.

Although there are large uncertainties in the estimates of most of the potential health effects of the coal cycle, the impact of transportation of coal is based on firm statistics. This impact alone is greater than the conservative estimates of health effects for the entire uranium fuel cycle (in an all-nuclear economy), and this impact can be reasonably expected to worsen as more coal is shipped over greater distances. When coal-generated electricity is used in the nuclear fuel cycle, primarily for uranium enrichment and auxiliary reactor systems, the impact of the coal power accounts for essentially all of the impact of the uranium fuel cycle.

However, lest the results of this analysis be misunderstood, it should be emphasized that the increased risk of health effects for either fuel cycle represents a very small incremental risk to the average person. For example, Comar and Sagan[48] have shown that such increases in risk of health effects represent minute increases in the normal expectation of mortality from other causes.

A more comprehensive assessment of these two alternatives and others is anticipated from the National Research Council Committee on Nuclear and Alternative Energy Systems.[49] This study may assist substantially in reducing much of the uncertainty in the analysis presented.

Direct economic costs

The staff has prepared a detailed comparison of the direct economic costs of power generation with a nuclear-fueled power station and a coal-fired power station using western low-sulfur coal. The CONCEPT computer program[50] was used to obtain the staff estimate of capital costs for the proposed nuclear power station and for an equivalent two-unit low-sulfur coal-fired station without flue-gas desulfurization equipment. The recently developed OMCST computer program[51] was used to estimate nonfuel operating and maintenance costs for the two alternative generating stations. The nuclear fuel cycle cost calculations are based on the general procedures outlined in the *Guide for Economic Evaluations of Nuclear Reactor Plant Designs* (NUS-531), using the reference fuel cycle cost components developed in the *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors (GESMO I)* (NUREG-0002). Fuel cost estimates for the coal-fired station were calculated by escalation (at 5%/year) from the current asking price for 0.5% low-sulfur coal (8100 Btu/lb) from Northeastern Wyoming. The calculations for generating-cost estimates are described in detail in Appendix S.D. In the final comparison, the applicant's capital cost estimates and the staff's operating and maintenance and fuel cost estimates were used. Table S.D.14 (Appendix S.D) summarizes the results of these calculations. As seen in this table, nuclear generation costs are less than coal generation costs by 5%, when operating at a 50% capacity factor, to more than 20%, when operating at an 80% capacity factor. Use of the staff-derived capital costs would increase the economic advantage of the nuclear alternative. Also, use of the applicant's suggested fuel costs slightly increases the economic advantage of nuclear-powered generation. The staff's calculations indicate that a coal-fired plant would be cost effective only if the achieved capacity factor under the coal alternative were significantly greater (20% or more) than that of the nuclear alternative (historically, the two have experienced similar capacity factors), or if nuclear fuel costs would increase significantly faster than the cost of coal between 1977 and 1985. Neither of these conditions are thought likely to occur. Therefore, the staff concurs with the applicant that the nuclear generating station is economically preferred.

Conclusions

The staff has concluded that the lower probable generating costs in the late 1980s and lesser effects on the health of the general population of the nuclear plant favor its selection over the coal-fired alternatives. The staff is aware of some uncertainty associated with future construction costs and fuel costs. However, it is generally expected that variation in these costs will be in the upward direction by about the same proportion for all the plant types, in which case the nuclear plant becomes more favorable due to its much lower proportion of fuel costs. Downward changes in costs, if any, are expected to be slight and have little effect on the comparison of nuclear vs coal costs.

S.9.2 SITES

In Sect. 9.1.2.1 of the FES, the staff considered in detail the site-selection process used by the applicant for ACNGS. It was found that two sites (Lower Mill Creek and the Gulf of Mexico) in addition to the Allens Creek site appear to be suitable locations. In conclusion, the staff accepted the recommendation of the Allens Creek site by the applicant, not on the basis of its proven preference over the other two sites, but because there appeared to be no factor or combination of factors that makes any of the alternative sites clearly superior to the Allens Creek site.

The staff has reappraised the applicant's methodology both of selecting candidate sites and of the screening of candidate sites in view of the reduction in project scope from a two-unit to a one-unit station. Of the particular subregions that were identified as candidate site locations and the screening of acceptable sites by the selected criteria, no subregions or sites were rejected on the basis that they were unsuitable because of the size of the initially proposed station (2400 MWe). Moreover, the reductions in generating capacity and cooling-lake size in no way modify the suitability of the Allens Creek site. For these reasons, the staff concludes that the Allens Creek site remains an acceptable choice for the location of the proposed nuclear station.

S.9.3 STATION DESIGN

S.9.3.1 Alternative Cooling Systems

In the FES the staff considered the following alternative cooling systems for the two-unit (2400-MWe) station design: (1) once-through cooling; (2) dry cooling systems; (3) wet-dry cooling towers; (4) mechanical-draft wet (evaporative) towers; (5) natural-draft wet (evaporative) towers; and (6) a spray canal (FES, Sect. 9.2.1).

The once-through cooling system was rejected on the basis of insufficient flow in the Brazos River to provide the continuous flow of 107 m^3/sec (3780 cfs) of water required for dissipating the waste heat of a 2400-MWe station. The reduction in generating capacity to a 1200-MWe facility, which now requires a comparatively smaller circulating-water flow of 55 m^3/sec (1940 cfs), does not provide a premise for the consideration of a once-through system. The Brazos River near the Allens Creek site is not an adequate source of water for the employment of a once-through cooling system for a 1200-MWe generating station.

Of the three generic types of cooling systems that were considered (i.e., the dry, wet-dry, and wet types), only the wet cooling systems were considered to be viable alternatives. Basically, dry cooling systems (which involve no evaporative loss) and wet-dry cooling systems (which have plume-abatement applications) were eliminated from detailed consideration because of economic reasons (FES, p. 9-10). Based on a reappraisal of these systems, the staff concludes that neither the reduction in the project scope nor the recent technological advances provide substantiation for further consideration of these generic cooling systems.

Accordingly, the staff has reviewed the applicant's designs, cost comparisons, environmental impact assessments, and overall comparisons of the mechanical draft, natural draft, and spray canal cooling systems, all on the basis of the current project scope, as alternatives to the proposed cooling lake system (ER, Suppl., Sect. S10.1). The staff is of the opinion that spray canals would not be a preferable alternative because of the lack of experience and the costs of large-sized systems. Furthermore, the staff is unaware of any closed-cycle cooling system employing spray canals that has been constructed for a power station of this size and that has been completely successful in its operation.

For the cooling tower alternatives (natural draft and mechanical draft), the staff concludes as before (FES, Sect. 9.2.1.2) that they are viable alternative cooling systems for the Allens Creek station. The applicant has provided a summary of principal engineering features and a summary of comparative environmental effects and impacts of the cooling tower alternatives (ER Suppl., Tables S10.1-5, S10.1-6, and S10.1-1 respectively). Of particular interest is the water balance for each system. It is shown (ER Suppl., Table S10.1-1) that total evaporation losses from the cooling lake is 40,400 acre-feet/year as compared to about 18,550 acre-feet/year for the cooling towers. However, the induced (or forced) evaporation losses for the cooling towers are higher by about 26%. Also, natural evaporation from the cooling lake accounts for a significant portion of the total evaporation (about 68%). The staff found similar results for the design of the two-unit station. In any event, the differences in the environmental costs of these alternatives as compared to the proposed cooling system are not of sufficent magnitude to indicate a significant environmental advantage for either system. The overriding environmental consideration favoring the cooling lake alternative is the recreational benefit which it, in conjunction with the state park, will provide.

S.9.4 TRANSMISSION SYSTEMS

The applicant has discussed the alternative routes of the two transmission lines in the ER (Sect. 10.9) and in the ER Supplement (S10.9). The major changes to the transmission line routes have been discussed in Sect. S.2.2.3. Route 2C is now the proposed route over Route 2A; Route 3A and its alternatives have been eliminated, and the Addicks substation is no longer needed as part of the Allens Creek distribution system. In addition, minor adjustments have been made in Route 1A to minimize impacts of the transmission lines near the community of Pleak.[52] The staff concurs on the routes chosen by the applicant.

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S.10. EVALUATION OF THE PROPOSED ACTION

In the preceding sections, the staff has described the probable environmental effects and associated impacts of the construction and operation of ACNGS, Unit 1, as set forth in the ER Supplement. This section summarizes the staff's evaluation of the proposed action to construct Unit 1 of the originally proposed two-unit station but with a reduced station size and with a substantially smaller cooling reservoir. Because the conclusions contained in Sect. 10 of the FES may no longer apply or require modifications and in an attempt to minimize confusion, they are hereby vacated and are replaced in their entirety by this section.

S.10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

S.10.1.1 Abiotic effects

S.10.1.1.1 Land use

Construction-related activities on the site will disturb about 2315 ha (5720 acres) of pasture and cropland, including the 2072-ha (5120-acre) area inundated by the Allens Creek cooling lake, which will be constructed in conjunction with the station. The land inundated includes about 13 km (8 miles) of Allens Creek. Approximately 104 km (65 miles) of transmission line corridors will require about 749 ha (1850 acres) of land for the rights-of-way. Relocation of the current pipelines as proposed will involve about 12 ha (30 acres). An access road and a railroad spur, less than 1.6 km (1 mile) long, will affect about 16 ha (40 acres).

S.10.1.1.2 Water use

During construction there will be localized increases in turbidity of surface waters. The concrete batch plant will use about 154 liters/min (40 gpm) from groundwater supplies during the early stages of construction.

During operation about 30,000 acre-ft per year will be pumped from the Brazos River. In addition, the entire runoff of 20,600 acre-ft per year from the Allens Creek catchment area and 16,600 acre-ft per year of direct rainfall will be added to the cooling lake.

Approximately 26,200 acre-ft per year will be returned by spillage to the Brazos River. This will result in a 11% increase in the river water TDS concentration during low-flow conditions. About 40,400 acre-ft per year will be lost by combined forced and natural evaporation.

S.10.1.2 Biotic effects

S.10.1.2.1 Thermal effects

The thermal alteration of the Brazos River is not anticipated to have an adverse effect on aquatic productivity. The thermal alteration of Allens Creek cooling lake is expected to partially restrict the range of most game fish species and have an adverse effect on their productivity. Thermal shock on planktonic forms entrained in the circulating-water intake may reduce the overall productivity of the cooling lake.

S.10.1.2.2 Chemical effects

Chlorine used as a biocide will kill most organisms entrained in the circulating-water intake system of the cooling lake. However, no significant adverse effect on aquatic biota in the cooling lake or the Brazos River due to discharges of chlorine and other chemicals from the plant is anticipated provided that the TRC concentration in the discharge canal is held below 0.1 ppm. High nutrient levels in the cooling lake may lead to high algal densities during certain periods in the spring and summer months.

S.10.1.2.3 Mechanical effects

Impingement and entrainment losses of fish in the cooling lake and in the Brazos River should be minimal due to the low intake velocities. These losses are not expected to result in significant impacts.

S.10.2 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

S.10.2.1 Summary

The National Environmental Policy Act (NEPA) requires the staff to consider specifically the "relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity." On a time scale of several generations, the use of a site during the anticipated life of a proposed nuclear station would be considered a short-term use of the natural resources of land and water. The resources dedicated exclusively to the production of electric power during the life of the plant will be the land itself, the materials used for construction, the materials used for maintenance and operation, the labor effort expended, and the uranium consumed. The commitment of land and water constitutes a significant use of valuable natural resources. The land committed for the 30-year plant life precludes future uses that possibly would be deemed more useful to society than the generation of electric power.

S.10.2.2 Adverse effects on productivity

S.10.2.2.1 Impacts on land use

On a short-term basis (i.e., during construction and operation of the station), 51% of the ACNGS property [2315 ha (5720 acres)] will be removed from potential agricultural use, since it will be covered by the station, its ancillary structures, and the cooling lake. Most of this land [1994 ha (4927 acres)] is classified as prime farmland. During the lifetime of the plant, the loss of agricultural production is estimated by the applicant to be approximately $34 million (1977 price level). On a long-term basis, the 61 ha (150 acres) covered by the station and its ancillary structures will be permanently lost for agricultural purposes. Part of the area covered by the cooling lake, however, could be returned to agricultural use by draining the lake when the station is decommissioned.

Land use in the site vicinity is expected to remain predominantly rural. Construction and operation of the plant and transmission lines will cause only small impairment of current and future land uses. The proximity to Wallis of the proposed Allens Creek State Park and the cooling lake, combined with the large property tax benefits provided by the plant, can be expected to accelerate residential and commercial development of the area.

S.10.2.2.2 Impact of water use

Maximum evaporative losses from operation of ACNGS are not expected to exceed 54.3 x 10^6 m^3 (44,000 acre-ft) annually. These losses combined with the station's other consumptive water uses are not likely to be competitive with other potential water uses in the river basin during the lifetime of the plant.

S.10.2.3 Decommissioning

No specific plan for the decommissioning of the proposed nuclear plant has been developed by HL&P. This policy is consistent with NRC's current regulations that require detailed consideration of decommissioning near the end of the reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan that is submitted to NRC for review. The licensee will be required to comply with the Commission regulations then in effect, and decommissioning of the plant may not commence without authorization from NRC. Under current regulations, the Commission generally requires that all quantities of source, special nuclear, and by-product materials not exempt from licensing under Parts 30, 40, and 70 of Title 10 CFR either be removed from the site or be secured and kept under surveillance.

Experience has been gained with the decommissioning of six nuclear electric generating stations that were operated as part of the AEC's power reactor development program: Hallam Nuclear Power Facility, Piqua Nuclear Power Facility, Boiling Nuclear Superheat Power Station, Elk River Reactor, Carolinas-Virginia Tube Reactor, and Pathfinder Atomic Power Plant. The last two facilities were licensed under 10 CFR Part 50; the others were Commission-owned and operated under the provisions of 10 CFR Part 115.

Several alternative modes of decommissioning have been used in those cases. They may be generally summarized as four alternative levels of restoration of the plant site, each with a distinct level of effort and cost.

1. *Mothballing*: Upon completion of operation, the plant is put into a state of protective storage. In general, the plant will be left intact with the exception of the removal from the site of all fuel, radioactive fluids, and waste. Adequate radiation monitoring, environmental surveillance, and security procedures will be established to provide assurance that the health and safety of the public will not be endangered. Carolinas-Virginia Tube Reactor was decommissioned in this fashion.

2. *Conversion-fossil fuel or nuclear:* The conversion process consists of utilizing the turbine system with a new steam supply system. As in mothballing, all fuel, radioactive fluids, and waste will be removed from the site. The original nuclear steam-supply system will be disposed of upon separation from the electric generating system. Pathfinder Atomic Power Plant was decommissioned in this manner.

3. *In-place entombment*: This consists of sealing most of the radioactive and contaminated components, such as the pressure vessel and internals, within a structure that is integral with the biological shield. The structure must be designed to provide integrity over the period of time in which significant quantities of radioactive material exist in the entombment. All fuels, fluids, and certain selected components will be disposed of offsite. Boiling Nuclear Superheat Power Station, Piqua Nuclear Power Facility, and Hallman Nuclear Power Facility were decommissioned in this manner.

4. *Complete dismantling*: All vestiges of the reactor plant (except subgrade foundations) will be removed and disposed of. All radioactive material above accepted levels will be removed from the site. Upon completion of the dismantling operation, the site will have been returned to the approximate condition that existed prior to the installation of the reactor plant. The areas free of structures are revegetated with a mixture of species indigenous to the area. The revegetation process may also include the planting of various tree and shrub species to allow, as well as to enhance, natural succession and revegetation of the area. This treatment will speed up the revegetation process, whereas a longer period of time would be needed for succession to revegetate the cleared areas. The Elk River Reactor is being completely dismantled in this fashion.

The costs of these procedures have been evaluated recently for the Atomic Industrial Forum.[1] The least expensive alternatives are mothballing or entombing methods which would have 1975 costs (including long-term maintenance and surveillance) of less than $10 million. It appears rather unlikely that the prompt dismantling method will be undertaken because of the necessarily large radiation expousre of personnel. It is also not necessary to dismantle nonradioactive portions of the station. Therefore, if a period of mothballing surveillance is followed by dismantling of the radioactive portions of a boiling-water nuclear power unit, the 1975 cost would be about $39 million.

Nuclear Regulatory Commission regulations [10 CFR Part 50.33(f)] for licensing of production and utilization facilities state: "If the application is for an operating license, such information shall show that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover the estimated costs of operation for the period of the license or for five years, whichever is greater, plus the estimated costs of permanently shutting the facility down and maintaining it in a safe condition." This information is not required in an application for a construction permit, nor is it required at the early site review stage.

S.10.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

S.10.3.1 Scope

Irreversible commitments generally concern changes set in motion by the proposed action that, at some later time, could not be altered to restore the present order of environmental resources. Irretrievable commitments generally involve the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization.

Commitments inherent in environmental impacts are identified in this section, although the main discussions of the impacts are found in Sects. S.4 and S.5. Commitments that involve local long-term effects on productivity are discussed in Sect. S.10.2.

S.10.3.2 Commitments considered

The types of resources of concern in this case can be identified as (1) material resources, such as construction materials, renewable resource materials consumed in operation, and depletable resources consumed; and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources that generally may be irreversibly committed by the operation of ACNGS are (1) the biological species in the vicinity that are destroyed; (2) construction materials that cannot be recovered and recycled using present technology; (3) materials that are rendered radioactive but cannot be decontaminated, and materials consumed or reduced to unrecoverable waste, including the U-235 and U-238 consumed; (4) the atmosphere and water bodies used for disposal of heat and certain waste effluents to the extent that other beneficial uses are curtailed; and (5) land areas rendered unfit for other uses.

S.10.3.3 Biotic resources

S.10.3.3.1 Terrestrial resources

Approximately 61 ha (150 acres) will be covered by the station and will be effectively lost for biological production. Terrestrial habitat supporting 258 plant species, 152 vertebrate species, and 700 insect species will be reduced by approximately 51% due to construction of the station and the cooling lake. A woodland community along the bluff which contains a number of species having restricted distributions in eastern Texas, will probably be destroyed.

S.10.3.3.2 Aquatic resources

The lower 13.7 km (8.5 miles) of Allens Creek will be lost as running-water habitat due to construction of ACNGS. There will be an irretrievable loss of some fish and planktonic organisms from the Brazos River due to the filling of the Allens Creek cooling lake and the withdrawal of makeup water necessary for operation of the plant.

S.10.3.4 Material resources

S.10.3.4.1 Construction materials

Construction materials are almost entirely in the depletable category of resources. Concrete and steel constitute the bulk of these materials, but numerous other mineral resources are incorporated in the physical plant. Some materials are of such value that economic values clearly promote recycling. Plant operation will contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed to reclaim and recycle the constituents. Some parts of the plant will become radioactive by neutron activation. Radiation shielding around the reactor and around other components inside the primary neutron shield constitutes the major material in this category for which separation of the activation products from the base material is not feasible. Components that come in contact with the reactor coolant or with radioactive wastes will sustain various degrees of surface contamination, some of which could be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling are probably very small fractions of the total amount of these resources available that are in broad use in industry. Many materials on the "List of Strategic and Critical Materials"[2] (e.g., aluminum, antimony, asbestos, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, platinum, silver, tin, tungsten, and zinc) are used in nuclear plants.

Construction materials are generally expected to remain in use for the full life of the plant, in contrast to fuel and other replaceable components. A long time will lapse before final disposition must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend on need.

S.10.3.4.2 Replaceable components and consumable materials

Uranium is the principal natural resource irretrievably consumed in plant operation. For practical purposes, other materials consumed are fuel-cladding materials; reactor control elements; other replaceable reactor core components; chemicals used in processes, such as water treatment and ion exchanger regeneration; ion-exchange resins; and minor quantities of materials used in maintenance and operation. Except for the U-235 and U-238, the consumed resource materials have widespread use; therefore, their use in the proposed operation must be reasonable with respect to needs in other industries. The major use of the natural isotopes of uranium is to produce useful energy.[3]

Estimated nuclear fissile-fuel energy-equivalent resources exceed the reserves of fossil fuels, which are also useful raw materials for other industries. The estimates of energy resources and demands for the United States compiled by the Bureau of Mines show that the total recoverable resources, expressed as theoretically available equivalent energy, are 27×10^{21} J for all forms of fossil fuels, 62×10^{21} J for uranium, and 39×10^{21} J for thorium.[4,5]

The quantities of ore that will have to produced and processed and the volume of space that will be required for storage and wastes can be inferred from the Commission's report, *Environmental Survey of the Nuclear Fuel Cycle*.[6] In the long term, the stock of depleted uranium may be used as feed material in breeder reactor fuel cycles. In consideration of the reserves of all depletable fuels, the staff feels that uranium consumption in the proposed operation is a reasonably productive use of this resource.

S.10.3.5 Land resources

About 2315 ha (5720 acres) of land will be completely committed to the construction and operation of this nuclear generating station for the 30 years that it will be licensed to operate. The staff does not expect this land to be returned to present uses after decommissioning of the station, but anticipates that it will either continue to be used as a cooling system or will be developed as an independent recreation area. No commitments have been made by the applicant concerning the use of the remainder of the property [2198 ha (5431 acres)] except for the establishment of a 259-ha (640-acre) state park.

S.10.3.6 Water and air resources

Use of the water consumed by ACNGS can be viewed as an irreversible loss, only in the same sense that natural evaporation from water bodies is an irreversible loss. The staff does not believe that such use will have a long-term effect.

The effect of construction and operation of the proposed ACNGS will have little effect on air resources beyond the minimal impact caused by the various equipment emissions.

S.10.4 COST-BENEFIT BALANCE

S.10.4.1 Benefit description of the proposed plant

S.10.4.1.1 Electricity produced

The electrical energy that will be produced by ACNGS, Unit 1, represents the primary benefit from the proposed project. Operation of this station will result in the annual sale of some 7.9 billion kilowatt-hours of electricity (assuming an annual average capacity factor of 80%). Over the 30 years of assumed plant life, this will total over 200 terawatt-hours. The present value (in 1985 dollars) of the revenue from the sale of this electricity, assuming an even annual flow over 30 years and a 9% rate of discount, is approximately $5.2 billion.

S.10.4.1.2 Local economic and social benefits

Because the ACNGS site is within daily commuting distance of much of Houston, it is anticipated that most construction workers will commute from existing residences, rather than choosing to relocate near the site. Additionally, the site is within commuting distance [less than 90 km (56 road miles)] of a number of rapidly developing suburban areas west of Houston, as well as Richmond, Rosenberg, and Katy. Thus, those project workers who do choose to relocate nearer the site (from more removed sections of Houston or from out of town) will find an ample supply of new housing units for rent or purchase.

During operation, the station will require approximately 125 employees, about half of whom are expected to reside within the local area. The associated direct increase in local population is expected to be in the neighborhood of 200 people. This magnitude of growth should not cause substantial changes in local growth patterns.

S.10.4.1.3 Recreational benefits

The applicant proposes that a 600-acre area along the southwest shore of the lake be developed and operated as a state park, and that a 40-acre area at the southern end of the dam be developed for day use only and for boat access during periods of peak visitation. It is anticipated that the proposed Allens Creek State Park, because of its proximity to the heavily populated areas of the western sections of the Houston metropolitan area only 72 km (45 miles) away, will experience heavy use of its day use and lake facilities as well as its overnight camping facilities.

S.10.4.2 Cost description of the proposed facility

The primary internal costs of ACNGS are (1) the capital cost of the onsite facilities, (2) the fuel costs, (3) the transmission and hook-up costs, and (4) the operating and maintenance costs.

The total construction cost of the facility, including interest during construction, is estimated to be $1.3 billion in 1985 dollars. The 1985 present worth of projected annual fuel costs is estimated at $754 million. The estimated 1985 cost of transmission lines directly related to the Allens Creek station is $29 million, and total operating and maintenance costs are projected to have a 1985 present worth of $208 million.

S.10.4.3 Environmental costs

The major environmental impacts expected to be incurred by construction and operation of the proposed ACNGS, Unit 1, are summarized in Table S.10.1.

S.10.4.4 Decommissioning costs

No specific plan has been developed for decommissioning ACNGS, but estimated decommissioning costs (in 1975 dollars) range from $1 million, plus an annual maintenance charge of about $100,000, to about $39 million for complete restoration of the site (Appendix S.D). In terms of a sinking fund established over the 30-year operation life, the annual cost would be on the order of $100,000.

S.10.4.5 Summary of cost-benefit balance

The staff concludes that the primary benefits of the increased availability of electrical energy and the improved reliability of the applicant's system outweigh the environmental and economic costs of the station.

As indicated in Sect. S.9, the staff believes that there would be no reduction in overall costs by the use of an alternative site, the use of an alternative generating system, or any combination of these. The staff concludes that a nuclear station using the Brazos River as a water source, in conjunction with a cooling lake, is a system that is at least as cost effective as any alternative system.

Table S.10.1. Environmental costs of the proposed Allens Creek Nuclear Generating Station

Effect	Reference	Summary description
	Land use	
Land required for plant	Sect. S.4.1.	61 ha (150 acres)
Land required for transmission	Sect. S.4.1.	749 ha (1850 acres)
Land required for cooling lake	Sect. S.4.1.	2072 ha (5120 acres)
Land required for pipeline relocation	Sect. S.4.1.	12 ha (30 acres)
Land required for access road and railroad spur	Sect. S.4.1.	16 ha (40 acres)
	Water use	
Comsumptive water use	Fig. S.3.2.	Cooling lake evaporation, 40,400 acre-ft/year
Chemical discharges to Brazos River	Sect. S.3.3.	Negligible
Thermal discharges to Brazos River	Table S.5.6.	1.3×10^8 Btu/hr for extreme conditions
Maximum ΔT of discharge to Brazos River	Table S.5.7.	Estimated at 3.1°C (5.5°F)
Chemical discharges to cooling lake	Sect. S.3.3.	Chemicals including biocides released at approved levels
Thermal discharges to cooling lake	Table S.5.4.	8.0×10^9 Btu/hr at full power
Maximum ΔT of discharge to cooling lake	Table S.5.4.	10.8°C (19.5°F) at full power
	Social and economic effects	
During construction	Sect. S.4.4.	Minimal adverse effects are anticipated. Most workers will commute from the Houston metropolitan area.
During operation	Sect. S.5.6.	Minimal adverse effects are anticipated. Allens Creek Lake and State Park will provide added recreational facilities for the local and regional areas.
	Impacts on aquatic life	
Construction	Sect. S.4.3.2.	Siltation, bridge construction, and construction effluents will significantly reduce aquatic populations in the lower half of Allens Creek.
		About 12.9 km (8 miles) of Allens Creek will be inundated by the cooling lake. Temporary reductions in aquatic population in the Brazos River near the site will occur.
Entrainment and impingment	Sect. S.5.3.1.2.	Entrainment of planktonic organisms in the circulating-water system will not significantly reduce the productivity of the cooling lake.
		Some mortality of juvenile and adult fish in the cooling lake will result from impingement on traveling screens of circulating-water intake structure.
		Entrainment mortality in the makeup-intake system should not significantly reduce phytoplankton, zooplankton, or fish populations in the Brazos River.
Chemical discharges	Sect. S.5.3.2.2.	Total residual chlorine should be limited to 0.1 mg/liter in the circulating-water discharge canal.
	Impacts on terrestrial life	
Construction of plant	Sect. S.4.1.1.	Construction-related activities on the site will disturb about 2315 ha (5720 acres) of pasture and cropland, including the 2072 ha (5120 acres) of land inundated by the Allens Creek cooling lake.
Construction of transmission lines	Sect. S.4.1.4.	Some additional stress on the population of the Attwater's prairie chicken is expected.
Operation of plant	Sect. S.5.3.3.	No significant impact is anticipated.
Operation of transmission lines	Sect. S.5.3.3.	No significant impact is expected, but some modification of land use is anticipated.

REFERENCES FOR SECTION S.10

1. National Environmental Studies Project, *An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives: Summary Report*, Atomic Industrial Forum, N.Y., November 1976.

2. G. A. Lincoln, "List of Strategic and Critical Materials," *Fed. Regist.* 37(39): 4123 (1972).

3. U.S. Department of the Interior, Bureau of Mines, *Mineral Facts and Problems*, Washington, D.C., 1970.

4. U.S. Atomic Energy Commission, *Statistical Data of the Uranium Industry: January 1, 1972*, (GJO-100), Grand Junction Office, Grand Junction, Colo., 1972.

5. R. L. Faulkner, "Outlook for Uranium Production to Meet Future Nuclear Fuel Needs in the United States," in *Proc. 4th Int. Conf. Peaceful Uses At. Energy, Geneva, Switzerland, September 6-16, 1971*, (Paper A/Conf. 49/P/059), United Nations, New York, 1972.

6. U.S. Atomic Energy Commission, *Environmental Survey of the Nuclear Fuel Cycle*, Directorate of Licensing, Washington, D.C., November 1972.

Appendix S.A

COMMENTS

(Reserved for comments on the Draft Supplement to the Final Environmental Statement)

Appendix S.B

SUMMARY AND CONCLUSIONS OF THE FINAL ENVIRONMENTAL STATEMENT RELATED TO THE PROPOSED ALLENS CREEK NUCLEAR GENERATING STATION UNITS 1 AND 2, DOCKET NOS. 50-466 AND 50-467, NOVEMBER 1974, UNITED STATES ATOMIC ENERGY COMMISSION, DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Environmental Statement was prepared by the U.S. Atomic Energy Commission, Directorate of Licensing.

1. This action is administrative.

2. The proposed action is the issuance of construction permits to the Houston Lighting and Power Company for the construction of the Allens Creek Nuclear Generating Station, Units 1 and 2, located in Austin County, Texas (Docket Nos. 50-466 and 50-467).

   The station will employ two identical boiling water reactors producing 3579 megawatts thermal (MWt) each. A steam turbine-generator will convert this heat to 1146 MWe (net) of electricity. A design rating of 3758 MWt is anticipated at a future date and has been considered in the assessments contained in this statement.

   The exhaust steam will be cooled by the flow of water in a closed-cycle system incorporating a newly constructed cooling lake utilizing makeup water from the Brazos River. Blowdown from the cooling lake will be discharged into the Brazos River.

3. Summary of environmental impacts and adverse effects:

   a. Construction-related activities on the site will disturb about 9000 acres of pasture and cropland, including the 8250 acres of land inundated by the Allens Creek cooling lake, which will be constructed in conjunction with the station. The land inundated includes about eight linear miles of Allens Creek.

   b. Approximately 81 miles of transmission-line corridors will require about 2200 acres of land for the rights-of-way.

   c. Relocation of the current pipelines as proposed will involve about 60 acres. An access road and a railroad spur, less than one mile long, will affect about 50 acres.

   d. Station construction will involve extensive community impacts. Sixteen families will be displaced from the site. Traffic on local roads will increase due to construction and commuting activities. The influx of construction workers' families (2100 peak work force) is expected to strain the local housing situation. There will be a demand for increased services in Austin County.

   e. The total flow of circulating water will be 3800 cfs which will be taken from and returned to Allens Creek cooling lake. The Allens Creek cooling lake will receive about 90,000 acre-ft/year from the Brazos River, 28,500 acre-ft/year as direct rainfall and 24,000 acre-ft/year as runoff. About 70,500 acre-ft/year will be evaporated, 71,000 acre-ft/year will be returned to the Brazos River, and 1000 acre-ft/year will be lost as seepage. During the annual drawdown the total dissolved solids (TDS) in Allens Creek cooling lake will increase by a factor of 1.3 to 1.9 and the water returned to the Brazos River will cause an average increase in TDS in the Brazos of 0.8%. The thermal alterations and increases in total dissolved solids concentration will not significantly affect the aquatic productivity of Allens Creek cooling lake or the Brazos River.

   f. The overall impact of construction activities on Allens Creek prior to filling of the cooling lake will be a reduction in aquatic populations in the lower half of the creek. When the cooling lake is filled, approximately 8.5 miles of Allens Creek will be lost as running water aquatic habitat. The loss of aquatic biota in this section of Allens Creek will be more than compensated for by the establishment of aquatic biota in the cooling lake through colonization and introductions of game fish. Construction activities may temporarily reduce aquatic populations in the Brazos River near the Allens Creek Nuclear Generating Station site. Such reductions will most likely be temporary and near the site.

g. Entrainment of phytoplankton, zooplankton, and ichthyoplankton in the circulating water system may reduce the overall productivity of the cooling lake although the extent of this reduction cannot be estimated. Some mortality of juvenile and adult fish in the cooling lake will result from impingement on traveling screens of the circulating water intake structure. The low approach velocities to the screens should minimize impingement losses. Chemical discharges during operation of the Allens Creek Nuclear Generating Station should not significantly affect aquatic biota in the cooling lake or the Brazos River.

h. Phytoplankton, zooplankton, and fish in the Brazos River will be subject to entrainment in the makeup water intake system. Entrainment mortality should not significantly reduce phytoplankton and zooplankton populations in the Brazos River. The effect of entrainment on fish populations in the Brazos River cannot be estimated but low approach velocities should minimize fish entrainment mortality in the Brazos River.

i. The proposed cooling lake should provide a valuable recreational fishery. There is a high probability of high phytoplankton densities in the cooling lake which may reduce water contact activity for certain periods during spring and summer months.

j. The proposed cooling lake will displace white-tailed kites but may provide suitable habitat for Southern bald eagles and American alligators. It will attract waterfowl, possibly in large numbers.

k. The risk associated with accidental radiation exposure is very low.

l. No significant environmental impacts are anticipated from normal operation release of radioactive materials within 50 miles. The estimated dose to the offsite population within 50 miles from operation of the station is 9 man-rems/year, less than the normal fluctuations in the 175,000 man-rems/year background dose this population would receive.

4. Principal alternatives considered:

   a. purchase of power;
   b. alternative energy systems;
   c. alternative sites;
   d. alternative heat-dissipation methods.

5. The following Federal, State, and local agencies were asked to comment on this Draft Environmental Statement:

   Advisory Council on Historic Preservation
   Department of Agriculture
   Department of the Army, Corps of Engineers
   Department of Commerce
   Department of Health, Education, and Welfare
   Department of Housing and Urban Development
   Department of the Interior
   Department of Transportation
   Environmental Protection Agency
   Federal Power Commission
   Office of the Governor, State of Texas
   County Judge, Austin County, Texas

The following organizations submitted comments on the Draft Environmental Statement, which was published in July 1974:

   Department of Agriculture (AGR)
   Department of the Army, Corps of Engineers (ARM)
   Department of Commerce (DOC)
   Department of Health, Education and Welfare (HEW)
   Department of the Interior (INT)
   Department of Transportation (DOT), U.S. Coast Guard
   Environmental Protection Agency (EPA)
   Federal Power Commission (FPC)
   Office of the Governor, State of Texas (TEX)
   Houston Lighting and Power (HLP)
   Sierra Club (SC)
   Advisory Council on Historic Preservation (ACHP)

Copies of these comments are in Appendix A of this Final Environmental Statement. The staff has considered these comments and the responses are located in Sect. 11.

6. This Environmental Statement was made available to the public, to the Council on Environmental Quality, and to other specified agencies in July 1974.

7. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical, and other benefits of the Allens Creek Nuclear Generating Station, Units 1 and 2, against environmental and other costs and considering available alternatives, the staff concluded that the action called for under the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 is the issuance of construction permits for the facilities subject to the following conditions for the protection of the environment;

   a. The applicant shall submit a lake management program, including a development plan for the state parks, which assures that the Allens Creek cooling lake will be a recreational asset with benefits equivalent to those given in Sect. 5.6.4 of this Statement. Consideration should be given in this plan to making the lakeshore buffer zone on the south edge of the lake connecting the two state parks into a hiking and fishing area, and also to modifying the character of the diversion dike by creating a more natural looking land form and planting trees. The staff's approval of the program shall be obtained prior to start of construction of the cooling lake, the dam, or associated structures.

   b. The applicant shall complete the investigation, to the satisfaction of the Texas Historical Commission, of the 20 selected archaeological sites in the vicinity of the plant and cooling lake prior to the start of construction activities that could impact these sites.

   c. The applicant shall control the addition of chlorine to the circulating water system such that the concentration of total residual chlorine at the point of discharge to Allens Creek cooling lake is 0.1 ppm or less at all times. The concentration of total residual chlorine discharged to the Brazos River shall be kept below 0.01 ppm.

   d. The applicant shall take the necessary mitigating actions, including those summarized in Sect. 4.5 of this Environmental Statement, during construction of the station and associated transmission lines to avoid unnecessary adverse environmental impacts from construction activities.

   e. The applicant shall modify the monitoring programs in accordance with staff recommendations and complete the preoperational environmental studies (Sect. 6).

   f. A control program shall be established by the applicant to provide for a periodic review of all construction activities to assure that those activities conform to the environmental conditions set forth in the construction permits.

   g. Before engaging in a construction activity which may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this Environmental Statement, the applicant shall provide written notification to the Director of Licensing.

   h. If unexpected harmful effects or evidence of irreversible damage are detected during facility construction, the applicant shall provide to the staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

8. The Draft Environmental Statement, under Section 7, included one additional condition for the protection of the environment:

   "The applicant shall use alternate transmission line route 2C around the north end of the cooling lake, rather than the proposed route 2A which crosses the cooling lake."

   The applicant will use this routing, as stated in Appendix G of the Environmental Report (submitted as Amendment 7 to the ER) and also in comments on the DES which are reproduced in Appendix A of this Statement.

Appendix S.C

NEPA POPULATION DOSE ASSESSMENT

Appendix S.C

NEPA POPULATION DOSE ASSESSMENT

Population dose commitments were calculated for all individuals living within 80 km (50 miles) of the facility by employing the same models used for individual doses (see Regulatory Guide 1.109, Rev. 1). In addition, population doses associated with the export of food crops produced within the 80-km region and with the atmospheric and hydrospheric transport of the more mobile effluent species such as noble gases, tritium, and carbon-14 have been considered.

S.C.1 NOBLE GAS EFFLUENTS

For locations within 80 km of the reactor facility, exposures to these effluents are calculated using the atmosphere dispersion models in Regulatory Guide 1.111, Rev. 1, and the dose models described in Sect. 5.1 and Regulatory Guide 1.109, Rev. 1. Beyond 80 km, and until the effluent reaches the northeastern corner of the United States, it is assumed that all of the noble gases are dispersed uniformly in the lowest 1000 m of the atmosphere. Decay in transit was also considered. Beyond this point, noble gases having a half-life greater than 1 year (e.g., Kr-85) were assumed to mix completely in the troposphere of the world with no removal mechanisms operating. Transfer of tropospheric air between the northern and southern hemispheres, although inhibited by wind patterns in the equatorial region, is considered to yield a hemisphere average tropospheric residence time of about 2 years with respect to hemispheric mixing. Because this time constant is quite short with respect to the expected mid-point of plant life (15 years), mixing in both hemispheres can be assumed for evaluations over the life of the nuclear facility. This additional population dose commitment to the U.S. population was also evaluated.

S.C.2 IODINES AND PARTICULATES RELEASED TO THE ATMOSPHERE

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind, which continuously reduces the concentration remaining in the plume. Within 80 km of the facility, the deposition model in Regulatory Guide 1.111, Rev. 1, was used in conjunction with the dose models in Regulatory Guide 1.109, Rev. 1. Site-specific data concerning production, transport, and consumption of foods within 80 km of the reactor were used. Beyond 80 km, the deposition model was extended until no effluent remained in the plume. Food not consumed within the 80-km distance was accounted for, and additional food production and consumption representative of the eastern half of the country was assumed. Doses obtained in this manner were then assumed to be received by the number of individuals living within the direction sector and distance described above. The population density in this sector is taken to be representative of the eastern United States, which is about 160 people per square mile.

S.C.3 CARBON-14 AND TRITIUM RELEASED TO THE ATMOSPHERE

Carbon-14 and tritium were assumed to disperse without deposition in the same manner as Kr-85 over land. However, they do interact with the oceans. This causes the carbon-14 to be removed with an atmospheric residence time of 4 to 6 years with the oceans being the major sink. From this, the equilibrium ratio of the carbon-14 to natural carbon in the atmosphere was determined. The same ratio was then assumed to exist in man so that the dose received by the entire population of the United States could be estimated. Tritium was assumed to mix uniformly in the world's hydrosphere, which was assumed to include all of the water in the atmosphere and in the upper 70 m of the oceans. With this model, the equilibrium ratio of tritium to hydrogen in the environment can be calculated. The same ratio was assumed to exist in man and was used to calculate the population dose, in the same manner as with carbon-14.

S.C.4 LIQUID EFFLUENTS

Concentrations of effluents in the receiving water within 80 km of the facility were calculated in the same manner as described for the Appendix I calculations. No depletion of the nuclides present in the receiving water by deposition on the bottom of the cooling lake was assumed. It was also assumed that aquatic biota concentrate radioactivity in the same manner as was assumed for the Appendix I evaluations. However, food consumption values appropriate for the average individual, rather than for the maximum individual, were used. It was assumed that all of the sport and commercial fish and shellfish caught within the 80-km area were eaten by the U.S. population.

Beyond 80 km, it was assumed that all of the liquid effluent nuclides except tritium have deposited on the sediments so they make no further contribution to population exposures. The tritium was assumed to mix uniformly in the world's hydrosphere and to result in an exposure to the U.S. population in the same manner as discussed for tritium in gaseous effluents.

Appendix S.D

DETAILED CONSIDERATIONS OF NUCLEAR POWER AND COAL POWER AS ALTERNATIVE ENERGY SOURCES: GENERATING COSTS AND HEALTH EFFECTS

Appendix S.D

DETAILED CONSIDERATIONS OF NUCLEAR POWER AND COAL POWER
AS ALTERNATIVE ENERGY SOURCES: GENERATING COSTS AND HEALTH EFFECTS

S.D.1 COMPARISON OF GENERATING COSTS FOR NUCLEAR FUELED AND WESTERN LOW-SULFUR COAL-FIRED PLANTS

In this section, the staff has prepared an economic comparison of a nuclear-fueled power station and a coal-fired station that uses western low-sulfur coal. This comparison includes a sensitivity analysis for the following variables: construction costs, fuel costs, and plant capacity factors. Included in the discussion are the derivation of each of the cost components and an example illustrating the assembly of these cost components through a standard engineering cost computational procedure into a comparison of generating costs. Because the procedure utilized by the staff is not equivalent to that used by the applicant, the final results cannot be compared for each fuel type. However, the difference in procedure will not affect the ability to make a valid comparison between fuel types.

S.D.1.1 Capital costs

The staff used the CONCEPT computer program[1] (phase V) to obtain a separate staff estimate for the proposed nuclear power station and for a low-sulfur coal-fired station without flue-gas desulfurization equipment. This computer program has access to cost-index data files for 20 major cities in the United States. These files contain wage rate data for 16 construction crafts and unit cost data for 7 site-related materials as reported weekly over the past 15 years in the trade publication *Engineering News-Record*. These data are used to determine historical trends (escalation rates) in costs of site labor and materials and to provide a current base for projecting future costs.

The basic site labor requirement of 9.7 man-hours per kilowatt used by the staff is about the same as that used by the applicant for the nuclear alternative. The staff assumed a slightly lower value of 7.0 man-hours per kilowatt for the coal-fired plant. The staff used escalation rates derived from the CONCEPT data bank, although, on the average, they are not significantly different from the 7% per year used by the applicant. The staff adopted an interest rate for borrowed money that is consistent with current financial considerations: 9% per year compounded.

The basic assumptions used by the staff are summarized in Table S.D.1. The assumption of mechanical draft cooling towers is used since estimates for cooling lakes are not available in the CONCEPT program. The incremental capital costs for cooling lake development is believed to be of the same magnitude as for cooling towers.

Summaries of the estimated capital investment for construction of the nuclear and coal-fired alternatives are given in Tables S.D.2 and S.D.3. The total capital cost of the nuclear alternative is $1104 million, which is about 18% less than the applicant's estimate of $1343 million. The result for the coal alternative is $911 million, or 32% more than the applicant's estimate of $690 million (ER Suppl., Sect. S9.3). The differences will be used to illustrate the sensitivity of total generating cost to variations in construction cost. It is important to note that the range of construction costs given for nuclear and coal-fired plants is not inconsistent with values presented in other reports during the past two years.

S.D.1.2 Operating and maintenance (O&M) costs

The staff used the recently developed OMCST computer program[2] to estimate O&M costs for both the nuclear and the coal-fired stations. The nonfuel O&M costs in 1985 for the two alternatives at a 60% plant capacity factor (approximate industry average) are given in Tables S.D.4 and S.D.5. As shown, the annual O&M costs for the power plants are given by the OMCST program in fixed and variable expenditures. The variable expenditures are only a few percent of the total for both types of plant.

In using the data from Tables S.D.4 and S.D.5 to develop the generation costs, the variable expenditures can be computed as a function of plant capacity factor by recognizing that for each

Table S.D.1. Assumptions used in CONCEPT calculations for Allens Creek Nuclear Generation Station (Revised October 19, 1977)

Plant type	Single-unit BWR with mechanical draft cooling towers
Alternate plant types	Two-unit coal
Unit size	1146 MWe-net, each unit, nuclear plant; 573 MWe-net, each unit, coal-fired plant
Plant location	
Actual	Austin County, Texas
CONCEPT calculations	Dallas
Site labor requirements	9.7 man-hours/kWe – nuclear
	7.0 man-hours/kWe – coal without FGD[a]
Escalation during construction	
Purchased equipment	6.0%/year
Site labor	7.9%/year
Site materials	5.8%/year
Interest during construction	9%/year, compound
Start-of-design date	
NSSS ordered	June 1975
Coal plant	June 1977
Start-of-construction date	
Nuclear plant	November 1978
Fossil alternative	November 1980
Start-of-commercial-operation date	November 1985

[a]FGS = flue-gas desulfurization.

Table S.D.2. Plant-capital investment summary for a single-unit 1146-MWe boiling-water-reactor nuclear power plant for the Allens Creek Nuclear Generating Station (Revised Nov. 17, 1977)

Direct costs (millions of dollars[a]	
Land and land rights	2
Structures and improvements	96
Reactor plant equipment	122
Turbine plant equipment	113
Electric plant equipment	36
Miscellaneous plant equipment	11
Main condenser heat rejection system	21
Subtotal	401
Spare parts allowance	6
Contingency allowance	40
Subtotal (direct costs)	447
Indirect costs (millions of dollars)[a]	
Construction services	73
Home office engineering and services	50
Field office engineering and services	30
Subtotal (indirect costs)	153
Total costs (millions of dollars)[a]	
Total direct and indirect costs[a]	600
Allowance for escalation	153
Allowance for interest	351
Plant capital cost at commercial operation	
Millions of dollars	1104
Dollars per kilowatt	963

[a]In mid-1977 dollars.

Table S.D.3. Plant-capital investment summary for a two-unit, 1146-MWe coal-fired plant as an alternative to the Allens Creek Nuclear Generating Station (Revised Nov. 17, 1977)

	Code esc... tion
Direct costs (millions of dollars)[a]	
Land and land rights	2
Structures and improvements	55
Boiler plant equipment	141
Turbine plant equipment	99
Electric plant equipment	36
Miscellaneous plant equipment	14
Main condenser heat rejection system	17
Subtotal	364
Spare parts allowance	7
Contingency allowance	36
Subtotal (direct costs)	407
Indirect costs (millions of dollars)[a]	
Construction services	42
Home office engineering and services	18
Field office engineering and services	13
Subtotal (indirect costs)	73
Total costs (millions of dollars)	
Total direct and indirect costs[a]	480
Allowance for escalation	184
Allowance for interest	247
Plant capital cost at commercial operation	
Million of dollars	911
Dollars per kilowatt	795

[a] In mid-1977 dollars.

Table S.D.4. Summary of annual nonfuel operation and maintenance costs for base-load steam-electric power plants in 1985

Plant type	BWR
Number of units per station	1
With cooling lake	
Thermal input per unit, MWt	3479
Plant net heat rate, Btu per kWhr	10,660
Plant net efficiency, percent	32.0
Each unit, MWe net rating	1,146
Annual net generation, millions of kWhr	6,023
Plant factor	0.60
Staff (145 persons at $34,000), $1,000/year	4,900
Maintenance material, $1000/year	2300
Fixed – plant	2255
– cooling lake	25
Variable – plant	0
– cooling lake	20
Supplies and expenses, $1000/year	4250
Fixed – plant	1270
– fuel oil	2760
Variable – plant	220
Insurance and fees, $1000/year	580
Commercial liability insurance	350
Government liability insurance	160
Operating fees	70
Administrative and general, $1000/year	1110
Total Fixed costs, $1000/year	12900
Total variable costs, $1000/year	240
Total annual O & M costs, $1000/year	13140
Fixed unit O & M costs, mills/kWhre	2.14
Variable unit O & M costs, mills/kWhre	0.04
Total unit O & M costs, mills/kWhre	2.18

Table S.D.5. Summary of annual nonfuel operation and maintenance costs for base-load steam-electric power plants in 1985

Plant type	Low-sulfur coal
Number of units per station	2
With cooling lake	
Without SO_2 removal	
Thermal input per unit, MWt	1508
Plant net heat rate	9000
Plant net efficiency, percent	38
Each unit, MWe net rating	573
Annual net generation, millions of kWhr	6023
Plant factor	0.60
Staff (230 persons at $34,000), $1000/year	7800
Maintenance material, $1000/year	2750
Fixed – plant	2165
– cooling lake	25
Variable – plant	540
– cooling lake	20
Supplies and expenses, $1000/year	3500
Fixed – plant	850
– fuel oil	2650
Variable – plant	0
Insurance and fees, $1000/year	0
Commercial liability insurance	0
Government liability insurance	0
Operating fees	0
Administrative and general, $1000/year	1150
Total fixed costs, $1000/year	14640
Total variable costs, $1000/year	560
Total annual O & M costs, $1000/year	15200
Fixed unit O & M costs, mills/kWhre	2.43
Variable unit O & M costs, mills/kWhre	0.09
Total unit O & M costs, mills/kWhre	2.25

Table S.D.6. Variable operating and maintenance costs in 1985 as a function of plant factor, in thousands of dollars per year

Fuel-cycle type	Plant factor (%)			
	50	60	70	80
Nuclear	200	240	280	320
Low-sulfur coal	465	560	650	750

type of plant variable cost is constant when expressed in terms of unit energy generation; that is, as mills per kilowatt-hour. The variable costs for these plants are summarized for plant capacity factors of 0.5, 0.6, 0.7, and 0.8 in Table S.D.6. The fixed costs for these plants are $12.9 million for nuclear-power generation and $14.64 million for low-sulfur coal-power generation.

S.D.1.3 Fuel costs

The nuclear fuel cycle cost calculations are based on the general procedures outlined in the *Guide for Economic Evaluations of Nuclear Reactor Plant Designs* (NUS-531). The reference fuel cycle cost components used are those developed in the *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in Light-Water-Cooled Reactors (GESMO)* (NUREG-0002). The fuel-cycle calculations are based on equilibrium conditions. Under current Federal policy, reprocessing and fuel recycle are not included. Without recycle, the spent fuel is stored for five years and then is shipped to a repository for disposal. The assumptions used[3] in the fuel cycle calculations are summarized in Table S.D.7.

Costs for the various components of the fuel cycle are calculated in dollars per kilogram of heavy metal and are converted to mills per kilowatt-hour based on an irradiation level of 27,500 megawatt-days per metric ton of heavy metal (MWD/MTHM). The costs are calculated in 1975

Table S.D.7. Material and service unit costs

Component	Unit cost basis	1975 dollars
Mining and milling[a]	Kilogram of U_3O_8	61.7
Conversion to UF_6	Kilogram of uranium	3.5
Uranium enrichment	Separatable work units (SWU)	75
UO_2 fabrication	Kilogram of heavy metal	95
Spent-fuel transportation	Kilogram of heavy metal	15
Spent-fuel storage	Kilogram of heavy metal per year	5
Spent-fuel disposal[b]	Kilogram	100

[a]Use-weighted average cost (1975–2000) varies with consumption.
[b]Five years' spent-fuel storage costs and shipping to repository are incurred in addition to disposal costs.

dollars, and the total fuel-cycle cost is then escalated at 5% per year to 1985.[4] Table S.D.8 summarizes the nuclear fuel cycle costs excluding carrying charges. It should also be noted that the $61.7/kg for U_3O_8 is a use-weighted average cost (1975–2000) and takes into account the increasing cost of U_3O_8 due to depletion of high-grade ores.

Table S.D.8. Nuclear fuel-cycle cost excluding carrying charges

Fuel-cycle component	No recycle	
	$/kg of heavy metal	Mills/kWhr
U_3O_8 with enrichment	684	3.24
Fabrication	95	0.45
Spent fuel disposal		
Storage (5 years, cost per year)	25	0.12
Shipping	15	0.07
Disposal	100	0.47
Subtotal (1975 dollars)	919	4.35
Escalated to 1986 dollars at 5%	1497	7.09

The carrying charges for the fuel cycle costs are summarized in Table S.D.9. These calculations are based on the following assumptions:

1. The time span for U_3O_8 purchase through conversion to UF_6, enrichment, and fabrication covers a one-year period.

2. Resident time in the reactor is based on plant CFs of 50, 60, 70, and 80%, and on an irradiation level of 27,500 MWD/MTHM exposure.

3. A five-year storage of spent fuel elements is included before final disposal.

4. A 10% interest charge on invested funds is required to support the fuel cycle.

According to staff estimates, the total 1985 nuclear fuel cycle cost including carrying charges ranges from 7.74 to 8.04 mills/kWhr. These estimates are about 30% less than the applicant's estimate of approximately 10.2 mills/kWhr, or $0.99 per million Btu (ER Suppl., p. SH-109). The staff finds that the current contract asking price for 0.5% low-sulfur coal (8100 Btu/lb) from northeastern Wyoming is $7.00 per ton.[5] Long-distance freight costs are estimated to be about one cent per ton per mile, or about $14.00 per ton, to Houston, Texas. The total delivered cost, $21 per ton, is equivalent to about $1.30 per million Btu. Escalating this value by 5% per year, the staff derives a 1985 cost of delivered low-sulfur coal of about $1.92 per million Btu, or about $21 per ton delivered price for 8100 Btu/lb of Wyoming coal. This is about 15% less than the costs used by the applicant for 1985 (ER Suppl., p. SH-109). The $1.92 per million-Btu

Table S.D.9. Carrying charges for nuclear fuel[a]

Cost factor unit	Cost for no recycle at percentage of capacity factor			
	50%	60%	70%	80%
1975 dollars per kilogram of heavy metal	123	105	92	82
Charges escalated to 1985 dollars	205	174	15[illegible]	136
Unit cost, mills per kWhr (1985)	0.97	0.83	0.73	0.65

[a] At 10%.

cost converts to about 17.3 mills/kWhr at a heat rate of 900[illegible] Btu/[illegible]hr. Thus, the first-year cost of coal would be more than twice the cost of nuclear fuel.

S.D.1.4 Power-generation costs

The staff's estimates of capital costs, annual O&M costs, and annual fuel costs were used to determine the probable range of generating costs for the two types of power plants considered. The 1985 present worth (PW) of O&M and fuel costs is calculated by assuming a 5% per year escalation rate and a 10% per year discount rate over an assumed 30-year plant operating life[6] for each alternative type of power plant at capacity factors ranging from 50 to 80%. These PW values are added to the 1985 PW of the capital cost of each alternative, and the sum is divided by the PW factor (without escalation) for 30 years at a discount rate of 10% per year to obtain the levelized cost of station generation. This cost is then converted to mills per kilowatt-hour (levelized) for each capacity factor.

S.D.1.4.1 Nuclear station

The following procedure illustrates the method used to compute the power generation costs for the nuclear station using the staff-derived values and a plant factor of 60%.

The 1985 annual O&M cost estimates used by the staff for the 1146-MWe station were comprised of a fixed component of $12 million and a variable component (Table S.D.6). At a plant factor of 60%, the total 1985 O&M cost for the station is

$$\$12,900,000 \text{ (fixed O\&M)} + \$240,000 \text{ (variable O\&M)} = \$13,140,000 \ . \qquad (1)$$

The PW factor for the prescribed 30-year unit life (n = 30 years) at an escalation rate (e) of 5% per year and a discount rate (i) of 10% per year is

$$\sum_{t=1}^{n} \left[(1+e)^{n-t}\,(1+i)^{t}\right] \left[\frac{i}{(1+i)^{n}-1}\right] = 15.8 \ . \qquad (2)$$

Thus, the PW of the annual O&M cost for the nuclear station operated at a capacity factor of 60% over its 30-year life is

$$PW_{85}O\&M = \$13,140,000 \times 15.8 = \$207,600,000 \ . \qquad (3)$$

At a capacity factor of 60%, the 1985 nuclear fuel cost is 7.92 mills/kWhr, and the annual fuel cost (FC) for the 1146-MWe nuclear station is

$$FC = 1,146,000 \text{ (8760 hr/year)} \cdot (0.6) \cdot (\$0.00792/\text{kWhr}) = \$47,705,000 \ ;$$

the 1985 PW of this cost over the 30-year station life is

$$PW_{85}FC = \$47,705,000 \ (15.8) = \$753,740,000 \ . \qquad (4)$$

The 1985 PW of the total annual cost of the nuclear station at a capacity factor of 60% over its 30-year lifetime is

$$PW_{85}C = PW_{85}O\&M + PW_{85}FC = \$961,340,000 \ . \qquad (5)$$

The estimated levelized annual cost (LC) of capital, O&M, and FCs for the 30-year operating lifetime was determined by adding the staff's estimated capital cost of the station in 1985 dollars to the 1985 PW of the O&M and FC, and multiplying the sum by the capital recovery factor (CR) for 30 years discounted at 10% per year. The CR is the reciprocal of the PW factor, excluding an escalation component, or

$$CR = \frac{i(1+i)^n}{(1+i)^n - 1} = \frac{1}{9.427} . \qquad (6)$$

Thus, at a CF of 60%, the LC of the nuclear station is

$$LC = (\text{capital cost} + PW_{85}C) \times CR = (\$1,104,000,000 + \$961,340,000) \times \frac{1}{9.427}$$

$$= \$2,065,340,000 \times \frac{1}{9.427} = \$219,000,000 . \qquad (7)$$

The levelized unit generating cost (GC) of the nuclear station at a 60% plant factor is

$$GC = \frac{\text{(levelized cost in dollars per year) (mills per dollars)}}{\text{(station capacity in kilowatts) (hours per year) (plant capacity factor)}}$$

$$= \frac{\$219,000,000\ (1000)}{1,146,000\ (8760)\ (0.6)}$$

$$= 36.37 \text{ mills/kWhr} . \qquad (8)$$

The generating costs for the nuclear station operated at capacity factors of 50, 70, and 80% were also computed in the same manner. The effects of potentially higher nuclear fuel costs, due to shortages or higher rates of escalation, were investigated by increasing the fuel cost in two nominal 25% increments, that is, by raising the cost up to 1.5 times the base cost, thus encompassing the applicant's nuclear fuel cost estimates. The generating costs in mills per kilowatt-hour are given in Table S.D.10 as a function of capacity factor and nuclear fuel cost, using the staff's capital cost estimate.

Table S.D.10. Levelized generating costs of Allens Creek Nuclear Generating Station (1146-MWe net output) at the staff's estimated capital cost of $1104 million[a]

Basic nuclear fuel cost[b] (mills/kWhr)	Cost in mills/kWhr at percentage of capacity factor[c]			
	50%	60%	70%	80%
7.09	41.2	36.4[d]	32.9	30.3
8.86	44.6	39.7	36.2	33.6
10.64	48.0	43.0	39.5	36.7

[a]Costs specified in 1985 dollars over a range of capacity factors, for a 30-year plant life.
[b]The carrying charge for nuclear fuel is added to these basic charges.
[c]Rounded to nearest one-tenth mill per kWhr.
[d]Value derived in text.

The sensitivity of generation cost to capital cost is illustrated by the results shown in Table S.D.11, in which the applicant's capital cost estimate was substituted into the computations by the staff.

From Tables S.D.10 and S.D.11, it can be seen that the nuclear plant generation costs can range from a low of about 30.3 mills/kWhr for the low construction cost and low fuel cost assumptions at an 80% CF, to a high of about 53.0 mills/kWhr at a 50% CF when both capital costs and nuclear fuel costs are about 50% higher.

Table S.D.11. Levelized generating costs of Allens Creek Nuclear Generating Station (1146-MWe net output) at the applicant's estimated capital cost of $1343 million[a]

Basic nuclear fuel cost[b] (mills/kWhr)	Cost in mills/kWhr at percentage of capacity factor[c]			
	50%	60%	70%	80%
7.09	46.3	40.6	36.5	33.5
8.86	49.6	43.9	39.8	36.7
10.64	53.0	47.2	43.1	40.0

[a]Costs specified in 1985 dollars over a range of capacity factors for a 30-year plant life.

[b]The carrying charge for nuclear fuel is added to these basic charges.

[c]Rounded to nearest one-tenth mill per kWhr.

After the useful life of nuclear power units is over, a utility must consider methods and costs of decommissioning the nuclear unit. This can be accomplished by one of the following methods: (1) mothballing, (2) entombment, (3) prompt dismantling, (4) mothballing and delayed dismantling, or (5) entombment and delayed dismantling.

The costs of these procedures have been evaluated recently for the Atomic Industrial Forum.[7] The least expensive alternatives are mothballing or entombing methods which would have 1975 costs (including long-term maintenance and surveillance) of less than $10 million. It appears rather unlikely that the prompt dismantling method will be undertaken because of the necessarily large radiation exposure of personnel. It is also not necessary to dismantle nonradioactive portions of the station. Therefore, if a period of mothballing surveillance is followed by dismantling of the radioactive portions of a boiling-water nuclear power unit, the 1975 cost would be about $39 million.

If the delayed dismantling method is selected and a 5% escalation rate is applied to 1975 costs, the 1985 value would be about $36 million per unit; 50 years after the end-of-plant life, the decommissioning cost might be about $1.8 billion. The annualized 30-year cost of generation to cover the decommissioning costs would be about $92,000 with a 10% per year discount rate. Compared to an annual generation cost of about $219 million (Eq. 7), the annualized decommissioning cost is a very small increment.

S.D.1.4.2 Low-sulfur coal-fired station

The generation costs of the coal-fired power station are computed in the same manner as those of the nuclear station, but the estimated values for the fuel and O&M costs for a coal-fired station are used. The staff applied the same variation to the 1985 delivered cost of coal — 25 and 50% greater than the baseline — as they applied previously to the nuclear case. The computed generation costs for this range of coal prices and the 50 to 80% range of CFs are shown in Table S.D.12, using the staff's estimate of $911 million for construction.

Table S.D.12. Levelized generating costs of two-unit low-sulfur coal-fired power station (1146-MWe total output) at the staff's estimated capital cost of $911 million[a]

Coal-fired fuel cost		Cost in mills/kWhr at percentage of capacity factor[b]			
Cents per 10^6 Btu	Mills/kWhr[c]	50%	60%	70%	80%
192	17.3	52.4	49.3	46.4	44.5
240	21.6	60.4	56.5	53.6	51.7
288	26.0	67.8	63.9	61.0	59.1

[a]As a function of fuel cost and capacity factor, assuming a 30-year plant life.

[b]Rounded to the nearest one-tenth mill per kWhr.

[c]Mills per kilowatt-hour obtained by assuming a net heat rate of 9000 Btu/kWhr.

Using the applicant's lower capital cost value of $690 million the staff has computed the generation costs for the coal-fired plant as shown in Table S.D.13 for the same range of fuel costs and capacity factors.

Table S.D.13. Levelized generating costs of two-unit low-sulfur coal-fired power station (1146-MWe net output) at the applicant's construction cost of $690 million[a]

Coal-fired fuel cost		Cost in mills/kWhr at percentage of capacity factor[b]			
Cents per 10^6 Btu	Mills/kWhr	50%	60%	70%	80%
192	17.3	48.6	45.4	43.1	41.3
240	21.6	55.8	52.6	50.3	48.5
288	26.6	63.2	60.0	57.6	55.9

[a] As a function of fuel cost and capacity factor, assuming a 30-year plant life.
[b] Rounded to nearest one-tenth mill per kilowatt-hour.

It can be seen from Tables S.D.12 and S.D.13 that the coal-fired generation costs may vary from 41.3 mills/kWhr for the low fuel cost case and applicant's capital cost estimate at the highest capacity factor, to 67.8 mills/kWhr for the case of low capacity factor, high fuel cost, and the staff's investment-cost estimate.

S.D.1.5 Summary and conclusions

Table S.D.14 summarizes the nuclear and coal-fired generation costs using the applicant's capital cost estimates which favor the fossil fuel option and the probable O&M and fuel costs derived by the staff. These results indicate that nuclear-generation costs are less than those of coal-fired plants, ranging from 5% less at a 50% capacity factor to more than 20% less at an 80% capacity factor. Using the staff-derived capital costs would increase the economic advantage for the nuclear plant alternative as illustrated in Tables S.D.10 and S.D.12. The staff finds that using the applicant's suggested fuel costs also slightly increases the economic advantage of nuclear-powered generation. The staff's calculations indicate that coal-fired plants would be economically competitive only if the achieved capacity factors are significantly greater (20% or more) than those of nuclear-fueled power stations (which has not been the case historically), or if nuclear fuel costs increase significantly faster than coal costs between 1977 and 1985. Neither of these aberrations are thought likely to occur. Therefore, the staff agrees with the applicant that the nuclear-powered generating station is economically preferred.

Table S.D.14. Comparison of generating costs of the proposed nuclear plant with a low-sulfur coal-fired plant at the Allens Creek site (in millions of dollars, unless otherwise specified)

Cost factor	1146-MWe nuclear plant capacity factor (%)				1146 MWe coal-fired plant Capacity factor (%)			
	50	60	70	80	50	60	70	80
1985 capital cost	1343	1343	1343	1343	690	690	690	690
1985 PW[a] operation and maintenance cost	207	207.6	208.2	208.9	238.6	240.2	241.6	243.2
Fuel cost, mills/kWhr	7.09	7.09	7.09	7.09	17.3	17.3	17.3	17.3
Nuclear fuel carrying charge, mills/kWhr	0.97	0.83	0.73	0.65				
Total nuclear fuel cost, mills/kWhr	8.06	7.92	7.82	7.74				
1985 PW fuel cost	639.3	753.7	868.2	982.1	1372.1	1646.4	1920.8	2195.2
1985 PW total cost	2189.3	2304.3	2419.4	2534.0	2300.7	2576.6	2852.4	3128.4
Levelized annual cost	232.2	244.4	250.6	268.8	244.1	273.3	302.6	331.9
Levelized generating cost, mills/kWhr	46.3	40.6	36.5	33.5	48.6	45.4	43.1	41.3

[a] PW = Present worth, assuming a 5% escalation rate and a 10% discount rate during a 30-year operating life.

S.D.2 HEALTH EFFECTS ATTRIBUTABLE TO COAL AND NUCLEAR-FUEL-CYCLE ALTERNATIVES

Differing health effects from using coal and nuclear fuels have been considered in the environmental assessment of each alternative. In making these assessments, the entire fuel cycle rather than just the power generation phase was considered in order to compare the total impacts of each cycle. For coal, the cycle consists of mining, processing, fuel transportation, power generation, and waste disposal. The nuclear fuel cycle includes mining, milling, uranium enrichment, fuel preparation, fuel transportation, power generation, irradiated-fuel transportation and reprocessing, and waste disposal.

In preparing this assessment it has been recognized that there are large uncertainties due to the lack of an adequate data base in certain areas of each fuel cycle alternative. The overall uncertainty in the nuclear fuel cycle is probably about an order of magnitude (increased or decreased by a factor of 10), whereas there is an uncertainty of as much as two orders of magnitude in the assessment of the coal fuel cycle. The much greater uncertainty associated with the coal fuel cycle results from (1) the relatively sparse and equivocal data regarding cause-effect relationships for most of the principal pollutants in the coal fuel cycle and (2) the effect of Federal laws on future performance of coal-fired power plants, mine safety, and culm-bank stabilization.

"Health effects," as the term is used here, is intended to mean excess mortality, morbidity (disease and illness), and injury among occupational workers and the general public. ("Excess" is used here to mean effects occurring at a higher than normal rate. In the case of death, the term is used synonymously with premature mortality.) The most recent and detailed assessments of health effects of the coal fuel cycle have been prepared by the Brookhaven and Argonne national laboratories.[8-13] The most complete and recent assessment of the radiological health effects of the uranium fuel cycle for normal operations was prepared for the *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in Light-Water-Cooled Reactors (GESMO I)*.[14]

However, in accordance with 10 CFR Part 51.20(e), the current impact of the uranium fuel cycle (excluding reactors and mines) is defined by the March 14, 1977, revision of Table S-3, 10 CFR Part 51. Consistent with the Commission's announced intention to reexamine the rule from time to time to accommodate new information [*Fed. Regist.* 39: 14188 (1974); and *Fed. Regist.* 42: 13803 (1977)], staff studies are under way to determine what areas, in addition to waste management and reprocessing, may require updating in Table S-3 [*Notice of Proposed Rulemaking*, Docket No. RM 50-3; and "Environmental Effects of the Uranium Fuel Recycle," *Fed. Regist.* 41: 45849 (1976)]. Using the Table S-3 effluents and the models developed for *GESMO I*, it was possible to estimate the impact on the general public of the uranium fuel cycle for routine plant operations. These values are shown in Tables S.D.15 through S.D.20, and some critical assumptions related to estimates are shown in this Appendix, Sect. S.D.3.

Table S.D.15. Summary of current energy source excess mortality per year per 0.8 GWy(e)

Fuel cycle	Occupational		General public		Totals
	Accident	Disease	Accident	Disease	
Nuclear: U.S. population					
All-nuclear fuel cycle	0.22[a]	0.14[b]	0.05[c]	0.06[b]	0.47
All-coal-fired fuel cycle	0.24 to 0.25[a,d]	0.14 to 0.46[b,e]	0.10[c,f]	0.64 to 4.6[g]	1.1 to 5.4
Coal: regional population	0.35 to 0.65[d]	0 to 7[e]	1.2[f]	13 to 110[g]	15 to 120
Range: ratio of coal-to-nuclear cycles: 32 to 260 All-nuclear-powered cycle; 14 to 22 All coal-powered cycle[h]					

[a] Primarily fatal nonradiological accidents such as falls, explosions, etc.

[b] Primarily fatal radiogenic cancers and leukemias from normal operations at mines, mills, power plants, and reprocessing plants.

[c] Primarily fatal transportation accidents (Table S-4, 10 CFR Part 51) and serious nuclear accidents.

[d] Primarily fatal mining accidents such as cave-ins, fires, explosions, etc.

[e] Primarily coal workers pneumoconiosis (CWP) and related respiratory diseases leading to respiratory failure.

[f] Primarily members of the general public killed at rail crossings by coal trains.

[g] Primarily respiratory failure among the sick and elderly from combustion products from power plants, but includes deaths from waste-coal-bank fires.

[h] With 100% of all electricity consumed by the nuclear fuel cycle produced by coal power; amounts to 45 MWe per 0.8 GWy(e).

Table S.D.16. Summary of current energy source excess morbidity and injury per 0.8-GWy(e) power plant

Fuel cycle	Occupational		General public		Totals
	Morbidity	Injury	Morbidity	Injury	
Nuclear: U.S. population					
All-nuclear fuel cycle	0.84[a]	12[b]	0.78[c]	0.1[d]	14
All-coal-fired fuel cycle	1.7 to 4.1[e]	13 to 14[b]	1.3 to 5.3[f]	0.55[g]	17 to 24
Coal: regional population[j]	20 to 70[e]	17 to 34[h]	10 to 100[f]	10[g]	57 to 210
Range: ratio of coal-to-nuclear cycles: 4.1 to 15 All-nuclear-powered cycle; 3.4 to 8.8 All coal-powered cycle[i]					

[a]Primarily nonfatal cancers and thyroid nodules.

[b]Primarily nonfatal injuries associated with accidents in uranium mines such as rock falls, explosions, etc.

[c]Primarily nonfatal cancers, thyroid nodules, genetically related diseases, and nonfatal illnesses – such as radiation thyroiditis, prodromal vomiting, and temporary sterility – following high radiation doses.

[d]Transportation-related injuries from Table S-4, 10 CFR Part 51.

[e]Primarily nonfatal diseases associated with coal mining such as CWP, bronchitis, emphysema, etc.

[f]Primarily respiratory diseases among adults and children caused by sulfur emissions from coal-fired power plants and waste-coal-bank fires.

[g]Primarily nonfatal injuries among members of the general public from collisions with coal trains at railroad crossings.

[h]Primarily injuries to coal miners from cave-ins, fires, explosions, etc.

[i]With 100% of all electricity consumed by the nuclear fuel cycle produced by coal power; amounts to 45 MWe per 0.8 GWy(e).

[j]Coal effects are based on a regional population of 3.8 million people within 80 km of the coal plant. The 80 km population in the year 2000 near Yellow Creek is about 0.5 million people. Therefore, the health effects related to coal should be reduced by one order of magnitude ($\sim ^1/_{10}$). The coal effects outside an 80-km radius have not been considered by the staff; however, it is the opinion that they would increase those calculated for the 80-km radius.

Table S.D.17. Morbidity and injury per 0.8 GWy(e) for 100% nuclear-powered fuel cycle[a]

Fuel-cycle component	Occupational		General public		Total
	Morbidity	Injury[b]	Morbidity	Injury[c]	
Resource recovery	d	10	e	~0	
Processing[f]	d	0.6	e	~0	
Power generation	d	1.3	e	~0	
Fuel storage	d	g	e	~0	
Transportation	d	<1	e	0.1	
Reprocessing	d	g	e	g	
Waste management	d	g	e	~0	
Total	0.84	12	0.78	0.1	14

[a]Detailed data from summary in Table S.D.16.

[b]L. D. Hamilton, ed., *The Health and Environmental Effects of Electricity Generation: A Preliminary Report*, Brookhaven National Laboratory, July 1974.

[c]Table S-4, 10 CFR Part 51.

[d]Nonfatal cancers are less than or equal to fatal cancers (excluding thyroid), or are about 0.14. Nonfatal thyroid cancers and benign nodules are about 3 times the number of fatal cancers, or are about 0.42. Genetic defects are about 2 times the number of fatal cancers, or are about 0.28.

[e]Reactor accidents: Ten times the number of fatalities, or are about 0.40 nonfatal cases. Normal operations: Nonfatal cancers are less than or equal to fatal cancers or are about 0.064. Nonfatal thyroid cancers and nodules are about 3 times the number of fatal cancers, or are about 0.19. Genetic effects are about 2 times the number of fatal cancers, or are about 0.013.

[f]Includes milling, uranium hexafluoride production, uranium enrichment, and fuel fabrication.

[g]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

Table S.D.18. Excess mortality per 0.8 GWy(e) for 100% coal-fired fuel cycle[a]

Fuel-cycle component	Occupational		General public		Total
	Accident	Disease	Accident	Disease	
Resource recovery	0.3 to 0.6	0 to 7	*b*	*b*	
Processing	0.04	*b*	*b*	10	
Power generation	0.01	*b*	*b*	3 to 100	
Fuel storage	*b*	*b*	*b*	*b*	
Transportation	*b*	*b*	1.2	*b*	
Waste management	*b*	*b*	*b*	*b*	
Total	0.35 to 0.65	0 to 7	1.2	13 to 110	15 to 120

[a]Detailed data from summary in Table S.D.15.

[b]From L. D. Hamilton, ed., *The Health and Environmental Effects of Electricity Generation: A Preliminary Report*, Brookhaven National Laboratory, July 1974.

[c]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

Table S.D.19. Excess mortality per 0.8 GWy(e) for 100% nuclear-powered fuel cycle[a]

Fuel-cycle component	Occupational		General public		Total
	Accident[b]	Disease[c,d,e]	Accident[e,f]	Disease[c]	
Resource recovery	0.2	0.038	~0	*g*	
Processing[h]	0.005[i]	0.042	*j*	0.002	
Power generation	0.01	0.061	0.04	0.011	
Fuel storage	*j*	~0	*j*	~0	
Transportation	~0	~0	0.01	~0	
Reprocessing	*j*	0.003	*j*	0.050	
Waste management	*j*	~0	*j*	0.001	
Total	0.22	0.14	0.05	0.064	0.47

[a]Detailed data from summary in Table S.D.15.

[b]L. D. Hamilton, ed., *The Health and Environmental Effects of Electricity Generation: A Preliminary Report*, Brookhaven National Laboratory, July 1974.

[c]U.S. Nuclear Regulatory Commission, *Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed-Oxide Fuel in Light-Water-Cooled Reactors*, NUREG-0002, August 1976.

[d]10 CFR Part 51, Table S-3.

[e]10 CFR Part 51, Table S-4.

[f]U.S. Nuclear Regulatory Commission, Reactor Safety Study, WASH-1400, NUREG-75/014, October 1975.

[g]These effects are not included in Table S-3, 10 CFR Part 51. Reference cited in footnote *c* above indicates about 0.023 excess deaths per 0.8 GWy(e) due to radon-222 emission.

[h]Includes milling, uranium hexafluoride production, uranium enrichment, and fuel fabrication.

[i]Corrected for factor of 10 error, based on references value given in *The Safety of Nuclear Power Reactors (Light-Water-Cooled) and Related Facilities*, U.S. Atomic Energy Commission, WASH-1250, July 1973.

[j]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

Because Table S-3 (in 10 CFR Part 51) excludes radon releases from uranium mines, the health effects of such releases on the general public are not included in Tables S.D.15 through S.D.20. The effects of such releases would result in some small increases in the total risks of mortality and morbidity as discussed in this Appendix, Sect. S.D.2.3.

In addition, Table S-3 does not generically address releases for light-water-cooled power reactors. The estimated total-body population-dose commitments for both occupational workers and the general public were taken from *GESMO I* (uranium-recycle-only option). In addition, the occupational-dose commitments to workers in uranium mines, mills, uranium hexafluoride plants, uranium fuel plants, and uranium enrichment plants were taken from *GESMO I*, because they are not considered in Table S-3. However, these dose commitments are comparable to those that would result from the radiological releases described in NUREG-0216, which provides background support for Table S-3.

The dose commitments to the public and occupational workers in the March 1977 revision of Table S-3 were used for estimating health effects from the reprocessing and waste management aspects of

Table S.D.20. Morbidity and injury per 0.8 GWy(e) for 100% coal-fired fuel cycle[a]

Fuel-cycle component	Occupational		General public		Total
	Morbidity	Injury	Morbidity	Injury	
Resource recovery	20 to 70	13 to 30	*c*	*c*	
Processing	*c*	3	*c*	*c*	
Power generation	*c*	1.2	10 to 100	*c*	
Fuel storage	*c*	*c*	*c*	*c*	
Transportation	*c*	*c*	*c*	10	
Waste management	*c*	*c*	*c*	*c*	
Total	20 to 70	17 to 34	10 to 100	10	57 to 210

[a]Detailed data from summary given in Table S.D.16.

[b]L. D. Hamilton, ed., *The Health and Environmental Effects of Electricity Generation: A Preliminary Report*, Brookhaven National Laboratory, July 1974.

[c]The effects associated with these activities are not known at this time. Although such effects are generally believed to be small, they would increase the total in the column.

the uranium fuel cycle. The risk estimators used to estimate health effects from radiation dose commitments were taken from *GESMO I* and the *Reactor Safety Study*.[15]

The impact of accidents in fuel cycle facilities[16] and reactors[15] generally does not markedly increase the impact of normal operations for the uranium fuel cycle, but has been included in this assessment for completeness. No comparable analysis of health effects resulting from accidents in coal-fired plants is available at this time.

Estimates of death, disease, and injury from nonradiological causes for the uranium fuel cycle are evaluations from Brookhaven National Laboratory,[8-10] with the exception of transportation-accident-related deaths, which were taken from Table S-4, 10 CFR Part 51. The results of these assessments are shown in Tables S.D.15 and S.D.16. It should be noted that there are two lines under the nuclear fuel cycle: the first assumes all of the electricity used within the uranium fuel cycle is generated by nuclear power (i.e., an all-nuclear economy); the second line asssumes, as shown in Table S-3 (10 CFR Part 51), that 100% of the electricity used within the nuclear fuel cycle comes from coal power. This is equivalent to a 45-MWe coal-fired plant, or 4.5% of the power produced.

S.D.2.1 The uranium fuel cycle

Currently, the NRC estimates that the excess deaths per 0.8 gigawatt-year electric [GWy(e)] will be about 0.47 for an all-nuclear economy. This estimate is probably somewhat high because of the conservatism required in evaluations of generic plants and sites. ("Conservatism" is used here to mean that assumptions regarding atmospheric dispersion, deposition of particulates, bioaccumulation, etc., generally result in estimates of impact that are typically "upper-bound" estimates. In most cases, the estimates would be lower for real plants.) However, this estimate is not greatly different from those made by others, such as Comar and Sagan[17] (0.11 to 1.0), Hamilton[8] (0.7 to 1.6), and Rose et al.[18] (0.50). The uncertainty in the estimate is about an order of magnitude. If, as shown in Table S-3, 100% of the electrical power used by the uranium fuel cycle comes from coal-fired power plants, the NRC estimates there would be about 1.1 to 5.4 excess deaths per 0.8 GWy(e). Of this total, about 0.62 to 4.9 excess deaths per 0.8 GWy(e) would be attributable to coal power (Table S.D.15). The uncertainty in the estimate is about one order of magnitude.

The total number of injuries and diseases that might occur among workers and the entire U.S. population as a result of normal operations and accidents in the uranium fuel cycle was estimated to be about 14 per 0.8 GWy(e) for an all-nuclear economy. Injuries among uranium miners from accidents account for 10 of the 14 cases (Tables S.D.16 and S.D.17). If 100% of the electrical power used by the uranium fuel cycle comes from coal-fired power plants, the NRC estimates there would be about 17 to 24 injuries and diseases per 0.8 GWy(e). Of this total, about three to ten excess events per 0.8 GWy(e) would be attributable to coal power (Tables S.D.16 and S.D.18). The uncertainty in the estimate is also about one order of magnitude.

Although anticipated somatic (nongenetic) effects associated with normal releases of radioactive effluents from the nuclear fuel cycle are limited to potential cancers and leukemias, for the higher doses associated with serious nuclear accidents there is some small risk of various non-fatal somatic effects (footnote *c*, Table S.D.16). At this time, only light-water-cooled power reactors have been thoroughly evaluated.[15] However, it should be noted that power reactors probably account for most of the potential health effects associated with nuclear accidents in the uranium fuel cycle.

This results from the fact that power reactors represent 80% of all fuel cycle facilities expected to be operating for the balance of this century[14] and account for the majority of occupationally exposed individuals. In addition, although the probability of serious accidents is extremely small, if one were to occur, the health effects would be larger than those for any other type of fuel cycle facility. Serious nuclear accidents in power reactors might also contribute about 0.04 excess deaths per 0.8 GWy(e), whereas transportation-related accidents are estimated to contribute about 0.01 excess deaths per 0.8 GWy(e) (footnote *e*, Table S.D.16).

Early and latent nonfatal somatic effects that might be expected after high radiation doses include a variety of effects (footnote *e*, Table S.D.16). It is possible that nonfatal somatic effects could be an order of magnitude greater than excess deaths resulting from accidents;[15] thus, the total number per 0.8 GWy(e) would be about 0.4. This accounts for about one-third of the morbidity shown for the general public and an all-nuclear economy in Table S.D.16. The number of nonfatal thyroid cancers (5 to 10% mortality rate) and benign thyroid nodules would be about 0.6 per 0.8 GWy(e) from routine releases to the public and occupational exposures (primarily external irradiation), whereas other nonfatal cancers would be less than or equal in number to fatal cancers [about 0.2 per 0.8 GWy(e)]; (footnote *e*, Table S.D.16).

It is believed that genetically related diseases (e.g., cystic fibrosis, hemophilia, certain anemias, and congenital abnormalities such as mental retardation, short-limbed dwarfism, and extra digits) and abnormalities in the descendants of workers and the general public from both normal operations and accidents would be perhaps twice the number of excess deaths due to cancer from total-body irradiation;[13,19] this could add another 0.3 health effects per 0.8 GWy(e) among workers, and 0.2 health effects per 0.8 GWy(e) among the general public (compare footnote *e* on Table S.D.16 and footnote *d* on Table S.D.17).

In assessing the impact of coal power used in the uranium fuel cycle, Table S-3 (10 CFR Part 51) was used as the basis for the assumption that 100% of the electricity used in the uranium fuel cycle, primarily for uranium enrichment and reactor operation, came from coal-fired plants. Adding 4.5% of the health effects per 0.8 GWy(e) from the coal fuel cycle significantly increases the health effects per 0.8 GWy(e) from the uranium fuel cycle, as shown on the second lines of Tables S.D.15 and S.D.16.

S.D.2.2. The coal fuel cycle

Current estimates of mortality and morbidity resulting from the coal fuel cycle are quite uncertain; this is the principal reason for the wide range of values reported in the literature. These uncertainties result from the limited number of epidemiological studies and differences in interpretation of the results of such studies. There is additional uncertainty regarding the effects of new Federal laws on coal-cycle facilities in the next decade. Current estimates of excess deaths for the entire coal cycle range from 15 to 120 deaths per 0.8 GWy(e), whereas disease and injury estimates range from 57 to 210 cases per 0.8 GWy(e).

In the case of occupational effects, there is considerable uncertainty because of anticipated reductions in health effects resulting from the implementation of the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173). The provisions of this act should result in significant improvement of the underground work environment, particularly in regard to coal dust. Coal dust is a cause of (1) underground explosions and fires and (2) coal workers' pneumoconiosis (CWP), commonly called black lung disease, and subsequent progressive massive fibrosis (PMF).[8-12] In addition, more coal in the years ahead is expected to be produced by strip mining, which results in lower mortality rates.[8] As a result, the frequencies [per GWy(e)] of both types of events are anticipated to decline in the years ahead. On the other hand [illegible]istics show that new coal miners experience higher mortality and injury rates than experie[illegible].[12] As a result of expected coal production increases, an influx of inexperienced [illegible] end to increase the mortality and injury rates for miners as a group.

For the general public, there is also considerable uncertainty in the estimation of health effects. (In the case of coal plant effluents, consideration of health effects was limited to the population within 80 km of such plants.) For example, although there are estimates of health effects related to burning culm banks (waste banks from coal screening), recent efforts by mine operators have greatly reduced such fires, and future processing activities are expected to avoid fires as a result of new methods of stabilizing the banks to prevent slides.[20] Current estimates of excess deaths in the public from sulfates from such fires range from one to ten per 0.8 GWy(e) (footnote *g*, Table S.D.15). Power generation is estimated to result in 3 to 100 excess deaths per 0.8 GWy(e) (footnote *g*, Table S.D.15), whereas excess morbidity ranges from about 10 to 100 per 0.8 GWy(e) (footnote *e*, Table S.D.16).

The uncertainties are even greater in the power generation phase of the coal cycle, where estimates of health effects range over several orders of magnitude.[17] This is largely due to the lack of a reliable data base for predicting health effects from the various pollutants emitted from coal plants, and the long-term effects of the *EPA New Source Performance Standards* for coal plants regarding particulate and sulfur emissions in future years. There is some uncertainty as to whether these standards can be met in large coal-fired power plants over the life of the plant. The major pollutants emitted include:

1. *Particulates.* These contain large amounts of toxic trace metals in respirable particle size,[21] such as arsenic, antimony, cadmium, lead, selenium, manganese, and thallium;[12] significant quantities of beryllium, chromium, nickel, titanium, zinc, molybdenum, and cobalt;[22] and traces of radium-226, radium-228, thorium-228, and thorium-232.[23]

2. *Hydrocarbons.* These include very potent carcinogens (cancer-causing substances) such as benzo(*a*)pyrene.

3. *Sulfur oxides.*

4. *Nitrogen oxides.*

5. *Other gases.* These include ozone, carbon monoxide, carbon dioxide, mercury vapor, and radon-222.

These pollutants have no well-established epidemiologic cause-effect relationships that can be used to estimate total health effects accurately, either effects resulting from acute exposures during air pollution episodes or those resulting from chronic long-term exposures.

Although definitive cause-effect relationships are lacking, tentative cause-effect relationships for sulfur emissions have been used by numerous groups to estimate health effects from sulfur emissions from coal plants. They are described by the National Academy of Sciences (NAS) in a recent report to the U.S. Senate.[24] The most widely quoted studies are those by Lave and Seskin,[25] Winkelstein et al.,[26] and an unpublished study by the EPA that was used in the NAS/NRC study for the U.S. Senate.[24]

In general, the effects range from excess deaths from cardiovascular failure and increases in asthma attacks during severe air pollution to excess respiratory disease from long-term chronic exposures. Most of the acute deaths are among the elderly and the severely ill, whereas morbidity from long-term exposure also includes children. Although widely accepted cause-effect relationships were not derived from studies of acute air pollution episodes in London in 1952,[27] in Donora, Pennsylvania, in 1948,[28] and in New York,[29] these studies definitely support the conclusions regarding excess death and disease associated with emissions from combustion of coal.

There are no estimates of possible long-term carcinogenic effects by sulfur oxides or associated pollutants. In addition, the recently completed (1976) large-scale EPA Community Health and Environmental Surveillance System (CHESS) study failed to provide any new or definitive cause-effect relationships for any of the pollutants from coal-fired plants that could be used to provide better estimates of health effects than are currently available.[30] The $22 million CHESS study attempted to correlate air pollution data collected from six U.S. cities with a variety of health problems.

If it is assumed that new coal-fired plants in the 1980s can meet *EPA New Source Performance Standards* (which could require 90% sulfur removal for high-sulfur coal and about 99% particulate removal) and can meet other Federal laws regarding mine safety and culm-bank stabilization, the number of deaths should be reduced. Thus, current estimates of 15 to 120 deaths per 0.8 GWy(e), due largely to sulfates from combustion coal, may be reduced by about half.

Recently, Argonne National Laboratory developed a predictive model for deaths from emission of benzo(*a*)pyrene, which indicates about 1 to 4 deaths per 0.8 GWy(e), depending on use of conventional combustion or fluidized-bed combustion.[13] Such effects, although greater than the expected deaths from the entire uranium fuel cycle (all-nuclear economy), do not significantly change the total impact of the coal fuel cycle and were not included in the effects listed in Table 5.D.15.

Probably the most reliable estimates of deaths associated with the coal fuel cycle are those associated with transportation accidents. Because a 1000-MWe coal-fired plant consumes about 2.7 million tonnes (three million tons) of coal per year, there are literally thousands of carloads of coal being transported by rail from mines to plants. It has been estimated that about one out of every ten trains in the United States is a coal train going to a coal-fired power plant.[31] These trains are estimated to travel an average distance of about 480 km (300 miles) from the mine to the plants.[20] As a result, there are about 1.2 deaths per 0.8 GWy(e) among workers and the general public. Further, because most of these deaths occur at railroad crossings, the numbers can be expected to increase as more automobiles are operated and driven greater distances, and as rail transportation distances increase when hauling low-sulfur western coals to eastern markets.

Sickness among coal miners and the general public accounts for most of the nonfatal occurrences in the coal fuel cycle, with most of the remainder due to injuries among coal miners. As a result of implementation of Federal laws, it is probable that future rates among underground miners will be substantially reduced. It is not unreasonable to assume that current estimates of about 57 to 210 cases of sickness and injury among workers and the general public could be reduced in the years ahead, inasmuch as occupational sickness and injury currently account for about half of the total nonfatal health effects.

The overall uncertainty in the estimates of health effects for the coal fuel cycle in this assessment is probably about one order of magnitude because the Brookhaven estimates[8-10] generally fall within the range of estimates in the literature.

S.D.2.3 Other considerations

Although the *Reactor Safety Study*[15] has helped provide a perspective of the risk of mortality or morbidity from potential power reactor accidents (the current experience for serious accidents is zero), there is the additional problem associated with individual perception of risk. Thus, although the study concluded that "all nonnuclear accidents examined in this study, including fires, explosions, toxic chemical releases, dam failures, airplane crashes, earthquakes, hurricanes and tornadoes, are much more likely to occur and can have consequences comparable to, or larger than, those of nuclear accidents," there will continue to be uncertainty associated with such evaluations. Furthermore, there may be a problem of public acceptance of potential accidents, because the consequences can be severe. In fact, it appears that some people more readily accept, for example, having 55,000 people actually killed each year in violent highway accidents, one or two at a time, than they do the unlikely occurrence during their lifetimes of perhaps several thousand possible deaths from a single catastrophic accident.

As noted in the March 1977 revision of Table S-3 (footnote 5) in 10 CFR Part 51, the *GESMO I* radon-222 release increases from 74.5 to about 4800 Ci when releases from mines are included. This would result in a small increase in the total number of excess deaths shown in Table S.D.15, although the mortality per 0.8 GWy(e) for the general public would increase by about 30%.

It is a well-established fact with regard to the coal fuel cycle that the use of coal results in numerous other costs to society that have not yet been adequately quantified. These include:

1. Short- and long-term impacts of sulfur oxides and nitrogen oxides on biota and materials occur. Acid rain, for example, is known to be severely damaging to terrestrial and aquatic habitats. Argonne National Laboratory provides a detailed discussion of these and other effects of sulfur and nitrogen oxide emissions.[12] However, as more coal plants come on line, these effects can be expected to expand to surrounding areas.

2. Materials such as paints, building surfaces, statuary, and metals are damaged by emissions of sulfur oxides, ozone, and nitrogen oxides. A 1976 review of such effects indicates that the costs could range into billions of dollars per year in the United States alone.[32]

3. Soil and vegetation are contaminated to toxic levels by such mechanisms as deposition and bioaccumulation of trace elements present in gaseous emissions.

4. Entire ecosystems in streams and rivers are destroyed by acid mine drainage, and the potential exists for public health effects from downstream use of such water for domestic or agricultural purposes.

5. In addition to the occurrence of excess mortalities, injuries, and morbidities, society suffers medical care costs, lost productivity, and other social losses, which represent a significant consideration that has not been completely evaluated at this time. Some recent studies have attempted to deal with these extremely complex issues,[33,34] and have concluded that social costs from one coal-fired plant may currently be about $50 million per year, not considering the rest of the costs for the coal fuel cycle.

6. There is the possibility of the so-called "greenhouse effect," a phenomenon expected to occur sometime early in the next century as a result of the present and future anticipated production rates of carbon dioxide from the combustion of fossil fuel.[35] Because each 1000-MWe coal plant produces about 6.8 to 9.5 million tonnes (7.5 to 10.5 million tons) of carbon dioxide per year,[8] it is believed these emissions from hundreds of fossil-fueled power plants may result in greater releases of carbon dioxide than the atmosphere and oceans can cycle. As a result, the carbon dioxide concentrations would be expected to increase in the atmosphere. Because carbon dioxide strongly absorbs infrared radiation, it is postulated that the mean atmospheric temperature will rise several degrees. This may cause all or part of the polar ice caps to melt, resulting in inundation of many inhabited areas of the world. At the same time, drought would be expected to prevail in many of the agricultural areas of the temperate zones, resulting in huge crop losses. It is possible

that the particulates emitted by fossil plants will counteract some of the greenhouse effect by reducing the amount of sunlight reaching the surface of the earth.

However, another effect from carbon dioxide released by coal combustion occurs because coal has essentially no carbon-14. In effect, the stable carbon dilutes the carbon-14 in the biosphere, resulting in a reduction in the radiological impact of both naturally occurring and man-made carbon-14.

7. An additional consideration that has not been evaluated for the coal cycle is the radiological impact of mining and burning coal. Of interest is the release of radon-222 from the decay of radium-226 in coal. Not only is the radon released during mining and combustion, but it will continue to emanate from fly ash for millions of years after the coal has been burned. Although Pohl[36] has shown that this is not a problem with most eastern coal (generally of high sulfur content but with a uranium content of 1-3 ppm), the average uranium and radium content of some reserves of low-sulfur western coal is as much as 50 times higher than that of most eastern coal.[37,38] Combustion of the coal and disposal of the remaining ash lead to about the same health effects from radon-222 emissions as do uranium mill-tailings piles. These releases would account for only about 0.02 excess deaths per 0.8 GWy(e) due to fuel cycle activities during the rest of this century. As a result, such releases do not significantly affect the conclusions reached with regard to a comparison of the two alternative fuel cycles. In addition, some believe[39] that if the physical and biological properties of the radium released from conventional coal-powered plants (burning coal with 1 to 2 ppm of uranium-238 and thorium-232) are considered, such plants discharge relatively greater quantities of radioactive materials into the atmosphere than do nuclear plants of comparable size. The EPA has estimated radiation doses from coal and nuclear plants of early designs and has reached similar conclusions.[24]

S.D.2.4 Conclusions

For the reasons cited herein, it is extremely difficult to provide precise quantitative values for excess mortality and morbidity, particularly for the coal fuel cycle. Nevertheless, estimates of mortality and morbidity have been prepared, based on present-day knowledge of health effects and present-day plant design, anticipated emission rates, occupational experience, and other data. These are summarized in Table S.D.15 and Table S.D.16 (footnote j) with some important assumptions inherent in the calculations of health effects listed in this Appendix, Sect. D.3.

Although future technological improvements in both fuel cycles may result in significant reductions in health effects, based on current estimates for present-day technology it must be concluded that the nuclear fuel cycle is considerably less harmful to man than the coal fuel cycle.[8-12,17,18,23,24,39-42] As shown in Tables S.D.15 and S.D.16, the coal fuel cycle alternative may be more harmful to man by factors of 4 to 260 (depending on the effect being considered) if all the electricity used is assumed to come from an all-nuclear economy, or by factors of 3 to 22 if all of the electricity used by the uranium fuel cycle is assumed to come from coal-powered plants.

Although there are large uncertainties in the estimates of most of the potential health effects of the coal cycle, it should be noted that the impact of transportation of coal is based on firm statistics; this impact alone is greater than the conservative estimates of health effects for the entire uranium fuel cycle (all-nuclear economy), and can reasonably be expected to worsen as more coal is shipped over greater distances. In the case where coal-generated electricity is used in the nuclear fuel cycle primarily for uranium enrichment and auxiliary reactor systems, the impact of the coal power accounts for essentially all of the impact of the uranium fuel cycle.

However, lest the results of this be misunderstood, it should be emphasized that the increased risk of health effects for either fuel cycle represents a very small incremental risk to the average public individual. For example, Comar and Sagan[17] have shown that such increases in risk of health effects represent minute increases in the normal expectation of mortality from other causes.

A more comprehensive assessment of these two alternatives and others is anticipated later in 1977 from the National Research Council Committee on Nuclear and Alternative Energy Systems.[43-45] This study may assist substantially in reducing much of the uncertainty in the analysis presented.

S.D.3 ASSUMPTIONS RELATED TO ESTIMATES OF FUEL-CYCLE HEALTH EFFECTS

Some important assumptions in this study affecting evaluations of fuel cycle health effects have been made for both uranium and coal fuel cycles.

S.D.3.1 The uranium fuel cycle[14]

For mine and mill emissions, it was assumed that population density in the United States varies from 2.9 persons/km^2 (7.5 persons/sq mile) in the West to 62 persons/km^2 (160 persons/sq mile) in the East, all uniformly distributed. For all other facilities, density was assumed to be 62 persons/km^2. (It should be noted that most of the calculated health effects would occur outside the 80-km radius of the plant. The mortality rate for the U.S. population is about 2,000,000 per year from all causes.)

"A box" atmospheric dispersion model was used with vertical dispersion limited to 1000-m, 2-m/sec windspeed, and 1-cm/sec deposition velocity for particulates. Resuspension of deposited particulates was considered.

A 50-year dose commitment for one year of operation of each type of fuel cycle facility was calculated. The 50-year commitment considered biological uptake of long-lived radionuclides for 40 years following the year of release. The total impact of the fuel cycle to the U.S. population for 1975 to 2000 was calculated using the needs for all types of facilities in order to meet current projections of power plants. A plant capacity factor of 80% was assumed in these calculations.

Radioactive materials were not considered to be removed from food chains except by radioactive decay. Only in the case of carbon-14 was an environmental sink assumed to be acting on biological availability. Bioaccumulation of radioactivity in food chains was also considered (generally using upper-bound estimates). Krypton-85 and carbon-14 not removed from the plume in the United States were assumed to mix uniformly in the world's atmosphere. Tritium is assumed to be mixed uniformly in the world's circulating water volume.

S.D.3.2 The coal fuel cycle[2-4]

The major impact of the coal fuel cycle results from power-plant emissions; only those critical assumptions are addressed here.

Actual population distributions within 80 km of several nuclear plant sites were used in estimating the impact of the coal fuel cycle. The average population of 3.8 million people has an annual mortality rate of about 26,000 persons from all causes.

Actual meteorological data from the same plants were used to calculate inhalation exposures to sulfates out to 80 km, with the assumption that the oxidation rate for conversion of sulfur dioxides to sulfates would be 10% per hour. A 75% plant capacity factor was assumed. It was also assumed that the plant would have a 1000-ft stack for emissions, and that 99% of the particulates would be removed from plant emissions. Resuspension of deposited particulates was not directly considered, although deposition was.

The dose-response relationships of Lave and Seskin,[25] Winklestein et al.,[26] and others[8,9,46] were used to calculate excess mortality and morbidity; adjustments were made for fractions of sulfates in the total suspended particulates.

Use of 3% sulfur coal with 12% ash and 28 MJ/kg (12,000 Btu/lb) (eastern coal) for an upper-bound estimate of health effects was assumed; use of 0.4% sulfur coal with 3% ash and 28 MJ/kg (eastern coal) for a lower-bound estimate was assumed.

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Appendix S.E

COMMENTS ON THE SUPPLEMENT TO THE ENVIRONMENTAL REPORT
FOR ALLENS CREEK NUCLEAR GENERATING STATION, UNITS 1 AND 2,
FROM THE U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE

ADDRESS ONLY THE DIRECTOR, FISH AND WILDLIFE SERVICE

United St   partment of the Interior

D WILDLIFE SERVICE
HINGTON, D.C. 20240

SEP 22, 1977
U.S. NUCLEAR REGULATORY COMMISSION

In Reply   :
FWS/ES
ER 73/15

SEP 20 1977

Mr. E   . Case
Act   ector, Office of
N   Reactor Regulation
Nu   Regulatory Commission
Wa   ton, D.C. 20555

De   . Case:

ve reviewed the supplement to the environmental report Allens Creek Nuclear Generating Station, Units 1 and 2, in County, Texas (Docket Nos. 50-466/467). Our response is provided in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

General Comments

The project site contains important fish and wildlife habitat and resources. In our August 27, 1974, comments on the Final Environmental Impact Statement prepared for this project, we suggested that a fish and wildlife management and public use plan be developed for the project site through coordination with appropriate Federal, State, and local agencies. Although the applicant has taken important steps to assure recreational use of a major portion of the site, the issue of compensating for significant habitat losses through such means as the preservation and enhancement of remaining habitat on and adjacent to the site has not yet been addressed.

Specific Comments

Page S2.5-1. Reference is made to the construction of a drainage channel to divert runoff from that portion of the Allens Creek Watershed north of the proposed project site to the Brazos River. The channel would be designed to convey peak flows for a ten-year flood. Justification for this should be provided since no flood damage was

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described for that area. In addition, the project applicant should consult with the Corps of Engineers to determine whether a permit is required for the channel.

Page S3. 4-1. Although only one 1200 MW unit is proposed for the power plant, the cooling lake described is designed to handle twice the proposed plant capacity. The feasibility of a smaller or modified impoundment should therefore be discussed. For example, a cooling lake receiving all or part of the runoff from watershed sub-areas I, J, and K (see Figure S2.5-1) and only receiving diverted high-flows from Allens Creek appears to offer the possibility of a cooling system which could preserve important strong bed and riparian habitat along Allens Creek. Additional make-up water might then be required from the Brazos River, but the site's recreational potential could possibly be enhanced and significant fish and wildlife habitat would be preserved.

Page S4. 1-7. An increase in fish production is projected to result from the creation of the cooling lake. The effects of water loss due to evaporation from the cooling lake and the trapping of nutrients at the project site on downstream estuarine life forms should also be addressed in the Environmental Report.

Page S4. 3-1. It is stated that ". . . it would be possible to restore the area to essentially its original condition in the event of plant decommissioning." Because the loss of wildlife habitat and agricultural production is a direct result of project construction, the cost and methods of restoring these site uses should be addressed and the party responsible for restoration should be identified. The costs and methods of perpetually maintaining the cooling lake should also be described in the event that it is to be retained for recreational use beyond the useful life of the power plant.

Page S5. 4-5. The entrainment of fish in the cooling water intake area during chlorination due to the location of the chlorinator diffusers upstream of the traveling screens was identified. The possibility of minimizing or preventing this loss by locating the chlorinator diffusers downstream of the traveling screens should be discussed.

Page S5. 8-1. The effects of mining 5.3 million tons of ore to develop fuel for the proposed plant should be considered in analyzing the impact of the project.

Page S10. 1-12. It is stated that the proposed cooling alternative is the only one associated with major environmental gains. Although the cooling lake would provide significant recreational opportunities, this cooling method would result in far greater wildlife habitat losses than other possible alternatives. It is also stated that the cooling lake would require less Brazos River water than other cooling methods. Not mentioned is the vastly greater use of Allens Creek water associated with the proposed cooling system. Additional factors which have not been adequately addressed in the cited comparison of alternative cooling systems are the reduction in freshwater and nutrient input to the downstream estuarine system, the value of lost agricultural production, and the cost of maintaining or restoring the cooling lake site following the useful life of the proposed power plant.

Page S12 1-1. Reference is made to an application to extend the expiration date of Corps of Engineers Permit Number 10095, issued on January 5, 1975, for the intake structure, spillway, and discharge canal. The Corps of Engineers should be consulted concerning the need for a permit for the proposed cooling lake and the drainage channel referred to earlier. Furthermore, if a permit is required for project implementation, our submission of comments on the Environmental Report does not preclude our providing additional comments on fish and wildlife matters to the Corps of Engineers, pursuant to the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.).

Sincerely yours,

W. J. Olds Jr.

Deputy Associate Director