NUREG-1073

Draft Environmental Statement
related to the operation of River Bend Station

Docket No. 50-458

Gulf States Utilities Company
Cajun Electric Power Cooperative

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

July 1984

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ABSTRACT

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of River Bend Station, pursuant to the National Environment Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations, Part 51, as amended, of the Nuclear Regulatory Commission regulations. This statement examines the environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Comments on this statement should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this statement is published in the Federal Register.

Further information may be obtained from

Edward J. Weinkam III
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555
301 492-7000

SUMMARY AND CONCLUSIONS

This Draft Environmental Statement (DES) was prepared by the staff of the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (staff).

(1) This action is administrative.

(2) The proposed action is the issuance of an operating license to Gulf States Utilities Company (GSU) for construction of River Bend Station (Docket No. 50-458), located near St. Francisville, West Felciana Parish, Louisiana.

The unit will employ a boiling water reactor to produce up to 2894 megawatts thermal (MWt). A steam turbine generator will use this energy to provide 936 megawatts (net) of electrical power capacity (MWe). The exhaust steam in this closed-cycle system will be cooled by four mechanical draft cooling towers, using water from the Mississippi River. Cooling tower blowdown water will be mixed with nonconsumed station water and discharged to the Mississippi River.

(3) The information in this statement represents the second assessment of the environmental impacts pursuant to the Commission's regulations as set forth in Title 10 of the Code of Federal Regulations, Part 51 (10 CFR 51), which implements the requirements of the National Environmental Policy Act of 1969 (NEPA). After receiving, on July 8, 1973, an application to construct River Bend Station, Units 1 and 2, the staff reviewed impacts that would occur during station construction and operation. That evaluation was issued as a Final Environmental Statement-Construction Permit Phase (FES-CP) in September 1974. After this environmental review, a safety review, and an evaluation by the Advisory Committee on Reactor Safeguards, the U.S. Nuclear Regulatory Commission issued Construction Permits Nos. CPPR-145 and 146 on March 25, 1977. The applicant submitted an application for operating licenses (OLs) by letter dated April 24, 1981. The NRC conducted a predocketing acceptance review and determined that sufficient information was available to start detailed environmental and safety reviews. The applicant's Final Safety Analysis Report (FSAR) was docketed on August 25, 1981.

On January 5, 1984, GSU announced the cancellation of River Bend Station Unit 2. As a result, this report will address the environmental impact of a single unit.

(4) The NRC staff has reviewed the activities associated with the proposed operation of the station and the potential impacts, both beneficial and adverse. The NRC staff's conclusions are summarized as follows:

(a) The River Bend Station will provide approximately 4.5 billion kWh of electrical energy annually (assuming that the unit will operate at an annual average capacity factor of 55%). The addition of the station will add 940 MW of operating capacity to the GSU system, resulting in increased system and regional reliability (Chapter 6).

(b) Alteration of about 304 ha (751 acres) of land and associated wildlife habitats has been necessary, including 195 ha (482 acres) that will be devoted to permanent plant facilities. About 126 ha (311 acres) of prime farmland have been permanently lost. Although construction has had adverse effects on land and wildlife, these effects have not been particularly significant. Vacant areas on the site, including 288 ha (711 acres) of bottom-land hardwood forest, will be preserved and devoted to conservation uses (Sections 4.2.2 and 4.3.4).

(c) A maximum of about 0.96 m^3/s (33.8 ft^3/s) of cooling water will be withdrawn from the Mississippi River, of which 0.14 m^3/s (5.4 ft^3/s) will be returned to the river via a pipeline as blowdown, with the concentration of dissolved solids increased over that in the river by a factor of about 6. About 0.72 m^3/s (25.4 ft^3/s) will be evaporated to the atmosphere by the cooling towers (Section 4.2.3.2).

(d) Two 500-kV and four 230-kV transmission lines totaling 169 circuit km (105 circuit miles) will connect the River Bend Station with the existing power system (Section 4.2.7).

(e) Cooling tower salt drift will not adversely affect native vegetation or agricultural crops in the vicinity of the plant (Section 5.5.1).

(f) Evidence found to date by the staff indicates that operation of the River Bend transmission lines will have no effect on the health of humans, animals, and plants (Section 5.5.1.3).

(g) Losses of aquatic organisms by impingement on the intake structure and entrainment in the makeup water withdrawn from the Mississippi will be small in magnitude and have negligible impacts on riverine populations (Section 5.5.2).

(h) The thermal discharge from the plant during operation is expected to result in a plume of heated water extending across less than one-fifth of the river width, remaining attached to the near shore of the river and extending more than 1.6 km (1 mile) downstream. However, no tributary stream mouths would be blocked by the plume (Section 5.5.2.2).

(i) Thermal and chemical discharge effects will be small in magnitude and result in negligible impacts on riverine populations (Section 5.5.2).

(j) There are no endangered species of aquatic organisms in the vicinity of the site. The American alligator, Federally listed as threatened in Louisiana, appears to be a permanent resident on the site. Because most of the alligator's primary habitat (wetlands in bottom-land forest) will be preserved on the site, the site should continue to provide a suitable habitat for this threatened species. No other terrestrial species with Federal or state-listed endangered or threatened status occur regularly or breed on the site (Section 5.6).

(k) Noise levels off the site during plant operation are predicted by the staff to be above ambient levels. Examination of the predicted broadband noise and the potential for annoyance as a result of audibility of tones indicates that adverse community reaction would be expected from noise of operation of the plant (Section 5.12). A monitoring program to identify the extent of impacts and the mitigation actions necessary, if any, will be required (Section 5.14).

(l) The operation and maintenance of the River Bend Station will have no impact on archeological resources or historic sites (Section 5.7).

(m) Socioeconomic impacts of the project are anticipated to be minimal (Section 5.8).

(n) The risk to public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operations will be very small (Section 5.9.3).

(o) The environmental impact of River Bend Station as a result of the uranium fuel cycle is very small when compared to the impact of natural background radiation (Section 5.10).

(5) This statement assesses various impacts associated with the operation of the facility in terms of annual impacts, and balances these impacts against the anticipated annual energy production benefits. Thus, the overall assessment and conclusion would not be dependent on specific operating life. Where appropriate, however, a specific operating life of 40 years was assumed.

(6) The Draft Environmental Statement is being made available to the public, to the Environmental Protection Agency, and to other agencies, as specified in Chapter 8.

(7) The personnel who participated in the preparation of this statement and their areas of responsibility are identified in Section 7.

(8) On the basis of the analyses and evaluations set forth in this statement, and after weighing the environmental, economic, technical, and other benefits against environmental and economic costs at the operating license stage, the NRC staff concludes that the action called for under NEPA and 10 CFR 51 is the issuance of operating licenses for River Bend Station, subject to the following conditions for the protection of the environment. (Section 6.1):

(a) Before engaging in additional construction or operational activities that may result in a significant adverse impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

(b) The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement, as modified and approved by the NRC staff, and implemented in the Environmental Protection Plan and Technical Specifications that will be incorporated in the operating license for River Bend Station. Monitoring of the aquatic environment shall be as specified in the National Pollution Discharge Elimination System (NPDES) permit.

(c) If adverse environmental effects or evidence of irreversible environmental damage develops during the operating life of the plant, the applicant shall provide the NRC staff an analysis of the problem and a proposed course of action to alleviate it.

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FOREWORD

This draft environmental statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (the staff), in accordance with the Commission's regulations in Title 10 of the Code of Federal Regulations, Part 51 (10 CFR 51), which implements the requirements of the National Environmental Policy Act of 1969 (NEPA).

This environmental review deals with the impacts of operation of the River Bend Station. Assessments relating to operation that are presented in this statement augment and update those described in the Final Environmental Statement-Construction Phase (FES-CP) that was issued in September 1974 in support of issuance of construction permits for River Bend Station Units 1 and 2.

The information to be found in various sections of this statement updates the FES-CP in four ways by

(1) evaluating changes in facility design and operation that will result in environmental effects of operation (including those that would enhance as well as degrade the environment) different from those projected during the preconstruction review

(2) reporting the results of relevant new information that has become available since the issuance of the FES-CP

(3) factoring into the statement new environmental policies and statutes that have a bearing on the licensing action

(4) identifying unresolved environmental issues or surveillance needs that are to be resolved by license conditions

Introductions (résumés) in appropriate sections of this statement summarize both the extent of updating and the degree to which the staff considers the subject to be adequately reviewed.

Copies of this statement and the FES-CP are available for inspection at the Commission's Public Document Room, 1717 H Street NW, Washington, DC, and at the Government Document Room, Louisiana State University, Baton Rouge, Louisiana. The documents may be reproduced for a fee at either location. Copies of this draft statement may be obtained free of charge by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Edward J. Weinkam III is the NRC Project Manager for the environmental review of this project. Should there be any questions regarding this statement, Mr. Weinkam may be contacted by telephone at (301) 492-7000 or by writing to the following address:

Edward J. Weinkam III
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

1 INTRODUCTION

The proposed action is the issuance of an operating license (OL) to Gulf States Utilities Company (GSU, the applicant) for startup and operation of River Bend Station near St. Francisville, Louisiana, in West Feliciana Parish.

The generating system consists of a boiling water reactor, a steam turbine generator, a heat-dissipation system, and associated auxiliary facilities and engineering safeguards. Waste heat will be dissipated to the atmosphere by four mechanical draft cooling towers, using water from the Mississippi River.

The rated thermal capability of the unit is 2894 MWt (ER-OL* Section 3.2); the design electrical rating is 965 MWe; and the design thermal (stretch) capability is 3015 MWt (ER-OL Section 3.2).

1.1 Administrative History

On July 8, 1973, Gulf States Utilities Company filed an application with the Atomic Energy Commission (AEC), now the Nuclear Regulatory Commission (NRC), for permits to construct River Bend Station Units 1 and 2. The conclusions resulting from the AEC staff's environmental review were issued as a Final Environmental Statement-Construction Phase (FES-CP) in September 1974. Following reviews by the AEC regulatory staff and its Advisory Committee on Reactor Safeguards (ACRS), public hearings were held before an Atomic Safety and Licensing Board (ASLB). Construction permits for Units 1 and 2 were issued on March 25, 1977.

On April 24, 1981, the applicant submitted applications for OLs for River Bend Station Units 1 and 2. The OL applications were docketed on August 25, 1981. The River Bend Station applicant now estimates that Unit 1 will be ready for fuel loading in April 1985. The applicant announced the cancellation of Unit 2 on January 5, 1984.

This draft environmental statement contains the second assessment of the environmental impact associated with the operation of River Bend Station, pursuant to the National Environment Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations, Part 51, as amended, of the Nuclear Regulatory Commission regulations. This statement examines the environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Comments on this statement should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this statement is published in the <u>Federal Register</u>.

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*"River Bend Station Environmental Report, Operating License Stage," issued by Gulf States Utilities Company in April 1981. Hereinafter this document is cited in the body of the text as ER-OL, usually followed by a specific section, page, figure, or table number. The "Final Safety Analysis Report" issued by Gulf States Utilities Company is similarly cited herein as FSAR, followed by the section, paragraph, figure, or table number.

Appendix A of this statement is reserved for copies of public comments received, and they will be addressed in Chapter 9 of the final environmental statement. Appendix B contains the NEPA population dose assessment, Appendix C discusses impacts of the uranium fuel cycle, and Appendix D contains examples of site-specific dose assessment calculations. Material concerning historic and archeologic sites is in Appendix E. The National Pollution Discharge Elimination System (NPDES) Permit is in Appendix F. Appendix G is a copy of a report on the estimate of fisheries harvest downstream of the River Bend Station.

1.2 Permits and Licenses

ER-OL Table 1.2-1 lists the status of environmentally related permits, approvals, and licenses required from Federal and state agencies in connection with the proposed project. The staff has reviewed the listing and other information and is not aware of any potential non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the station. Pursuant to Section 401 of the Clean Water Act of 1977, the issuance of a water quality certification, or waiver therefrom, by the Louisiana Office of Environmental Affairs, Division of Water Pollution Control (formerly the Stream Control Commission), is a prerequisite to the issuance of an operating license by the NRC. On October 25, 1974, the State of Louisiana issued its opinion that operational discharges from the River Bend Station would not violate state water quality standards and certified that the station operation complied with Section 21(b) of the Federal Water Quality Improvement Act of 1970. The Section 401 certification, covering the operational discharge into the Mississippi River, was requested by the applicant on December 2, 1974 (ER-OL Table 1.2-1). On December 13, 1974, the Louisiana Stream Control Commission indicated it did not intend to take any action on this request. No action was taken by the State within a year of the applicant's request. This inaction constituted a waiver of the Section 401 requirements under the provisions of the Clean Water Act. The NPDES permit for operation, pursuant to Section 402 of the Clean Water Act of 1977, was originally issued by the U.S. Environmental Protection Agency (EPA) on August 4, 1978. The NPDES permit, as modified on May 4, 1983 and reissued by the Louisiana Department of Natural Resources, is reproduced as Appendix F of this environmental statement.

2 PURPOSE OF AND NEED FOR ACTION

The Commission has amended 10 CFR 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection," effective April 26, 1982, to provide that need for power issues will not be considered in ongoing and future operating license proceedings for nuclear power plants unless a showing of "special circumstances" is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). Need for power issues need not be addressed by OL applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with OL applications (10 CFR 51.53, 51.95 and 51.106(c)).

This policy has been determined by the Commission to be justified whether or not the additional capacity to be provided by the nuclear facility may be needed to meet the applicant's load responsibility. The Commission has determined that the need for power is fully considered at the CP stage of the regulatory review where a finding of insufficient need could factor into denial of issuance of a CP. At the OL review stage, the proposed plant is substantially constructed and a finding of insufficient need would not, in itself, result in denial of the operating license. The Commission was further influenced by the substantial information that supports the conclusion that nuclear plants are lower in operating costs than conventional fossil plants. If conservation or other factors lower anticipated demand, utilities remove generating facilities from service according to their costs of operation, with the most expensive facilities removed first. Thus, a completed nuclear plant would serve to substitute for less economical generating capacity (47 FR 12940; 46 FR 39440, August 3, 1981).

Accordingly, this environmental statement does not consider "need for power." Section 6 does, however, consider the savings associated with operation of the nuclear plant.

3 ALTERNATIVES

The Commission amended it regulations in 10 CFR 51, effective April 26, 1982, to provide that issues related to alternative energy sources will not be considered in ongoing and future OL proceedings for nuclear power plants unless a showing of special circumstances is made under 10 CFR 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). In addition, these issues need not be addressed by OL applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications (10 CFR 51.53, 51.95, and 51.106(c) and (d)).

In promulgating this amendment, the Commission noted that alternative energy source issues are resolved at the CP stage and the CP is granted only after a finding that, on balance, no obviously superior alternative to the proposed nuclear facility exists. The Commission concluded that this determination is unlikely to change even if an alternative is shown to be marginally environmentally superior in comparison to operation of the nuclear facility because of the economic advantage that operation of the nuclear plant would have over available alternative sources (47 FR 12940; 46 FR 39440, August 3, 1981).

By earlier amendment (46 FR 28630, May 28, 1981), the Commission also provided that consideration of alternative sites will not be undertaken at the OL stage, except upon a showing of special circumstances under 10 CFR 2.758. Accordingly, this environmental statement does not consider alternative energy sources nor alternative sites.

4 AFFECTED ENVIRONMENT

4.1 Résumé

This résumé highlights changes in the plant operating characteristics and design that have occurred as well as new information on the local environment that has been obtained since the FES-CP was issued in 1974.

In addition to changes as a result of the cancellation of Unit 2, the general plant layout will change as a result of the addition of a training center, which will contain an Emergency Operations Facility, at the intersection of U.S. Highway 61 and the North Access Road (see Section 4.2.1). The size of the site owned by the applicant has increased, as discussed in Section 4.2.2, because of the acquisition of property for an access road from U.S. Highway 61. Volumetric flow rates for the various water systems have been revised, as discussed in Sections 4.2.3 and 4.2.6. The anticipated groundwater use has changed, as addressed in Section 4.2.3.3. Settled solids will be discharged to the Mississippi River instead of being used as landfill (Sections 4.2.3.4 and 4.2.6.2). The biocide treatment scheme of the cooling water and the makeup water pH has been changed; it is addressed in Section 4.2.3.4. The number of pumps and the intake structure design have changed, as discussed in Section 4.2.4.1. The unit heat dissipation system will use multicell circular mechanical draft cooling towers instead of linear mechanical draft towers as originally proposed (Section 4.2.4.2). There have been changes in the power transmission system, such as shortening the total circuit length but increasing the area of the land originally estimated that needed to be cleared (Sections 4.2.7 and 4.3.4.1). The road crossing of Alligator Bayou has been changed to a culverted road, as discussed in Section 4.3.1.1.1. Although the biota of the area have not changed, construction may have permanently eliminated habitat and permanently reduced populations of plant and animal species (Section 4.3.4.1). Section 4.3.7 gives the updated information on historic and archaeologic sites.

4.2 Facility Description

4.2.1 External Appearance and Station Layout

A general description of the external appearance and plant layout is provided in FES-CP Sections 2, 3, and 4, and an artist's sketch of the proposed layout for River Bend Station is shown in Figure 4.1.

Since publication of the FES-CP, the major change that has occurred is the cancellation of Unit 2. As a result, only Unit 1 structures will be visible. Other changes that have occurred include the addition of a training center. This center, which will contain the Emergency Operations Facility, will be located near the intersection of U.S. Highway 61 and the North Access Road.

4.2.2 Land Use

The uses of onsite land areas are shown in Table 4.1. Of the 1352 ha (3342 acres) on the site, 195 ha (482 acres) will be devoted to permanent plant facilities. Before construction, the site contained 449 ha (1110 acres) of prime farmland and an additional 122 ha (301 acres) of farmland of statewide importance. As a result of construction, 126 ha (311 acres) of prime farmland were permanently lost and 5 ha (12 acres) temporarily disturbed. About 27 ha (67 acres) of farmland of statewide importance were lost and 2 ha (5 acres) temporarily disturbed (ER-OL Sections 2.4.1.1 and 4.3.1.1). Areas that were not affected by construction and construction support areas will be preserved and devoted to conservational uses such as recreation and education (see Section 4.3.4.1 below).

The size of the site originally owned by the applicant and assessed in the FES-CP was 1084 ha (2679 acres) (FES-CP Section 4.1.1 and Table 4.2). Although the site is now larger because of the acquisition of property for an access road from U.S. Highway 61 in the northern part of the site, less acreage will be affected by construction (304 ha or 751 acres, compared with 344 ha or 850 acres described in FES-CP Section 4.1.1). Properties and facilities on the site that are not owned by the applicant include State Road 965, Police Jury Road, River Road, the Illinois Central Gulf Railway tracks and right-of-way, and the Starhill Microwave Radio Tower and its 0.7-ha (1.7-acre) lot owned by American Telephone and Telegraph.

4.2.3 Water Use and Treatment

4.2.3.1 General

The overall water use scheme for the River Bend Station is similar to the water scheme in FES-CP, although the volumetric flow rates for the various water systems have changed as a result of the cancellation of the second unit (Figure 4.2). Condenser cooling water and normal service water are cooled by a closed-cycle system with four mechanical-draft cooling towers. The standby service water system operates in conjunction with one mechanical-draft tower for standby cooling and the water storage facilities of the ultimate heat sink. The River Bend Station has two water sources and treatment systems, one for station makeup water and one for cooling tower makeup water. During normal operating conditions, the plant's cooling tower makeup water will come from the Mississippi River. Water for station makeup requirements, domestic use, and standby cooling towers will come from two onsite wells.

4.2.3.2 Surface Water Use

Under normal operating conditions, water will be pumped from the Mississippi River at an average rate of 0.875 m^3/s (13,870 gpm) with a maximum rate of 0.96 m^3/s (15,150 gpm). It will be used for makeup to the condenser and service water cooling systems and to the clarifier sludge dilution tank in the cooling tower makeup water treatment system. This is a slight increase in water use for one unit because in the FES-CP the maximum withdrawal per unit was reported at a rate of 0.885 m^3/s (14,000 gpm). However, this represents an overall reduction for the station.

Makeup water is needed to replace water lost via cooling tower evaporation, drift, and blowdown releases. Cooling tower evaporation and drift losses at an average rate of 0.72 m^3/s (11,400 gpm) are consumptive water uses, whereas blowdown will be returned to the Mississippi River at a constant rate of

0.14 m^3/s (2200 gpm). The cooling system concentration factor is expected to range between 4.7 and 6.7, with an average of 6.2. The estimated average consumptive use given in the FES-CP was 40.5 x 10^3L/min (10,700 gpm) per unit, while the blowdown range was estimated at 3.8 x 10^3 to 12.1 x 10^3 L/min (1000 to 3200 gpm) per unit. The estimated average and maximum concentration factors given in the FES-CP were 5.0 and 6.7, respectively. Normal station service water is pumped from the cooling tower basins to the various station service water heat exchangers and then recirculated to the cooling towers.

4.2.3.3 Groundwater Use

Water for station domestic use, makeup for the station water treatment system, and makeup to the station standby cooling towers is supplied by two onsite deep wells. A third well, shallower than the other wells, is used to supply water to the station fire protection system storage tanks. Maximum pumping rates from the deep wells and the shallow well are 568 L/m (150 gpm) each and 3028 L/min (800 gpm), respectively. Except for periods of high station water demand, pumping from these wells will be intermittent, replenishing the water storage tanks when needed. In the FES-CP, station groundwater use was estimated at 3028 L/min (800 gpm).

4.2.3.4 Water Treatment

The station makeup water treatment system provides high quality demineralized water for use in the reactor condensate cycle and for other station services. The system treats well water and is composed of two demineralizer trains, each designed to produce 9 x 10^{-3} m^3/s (150 gpm). Each train consists of a serial arrangement of a cation exchange unit, a vacuum deaerator, an anion exchange unit, and a mixed-bed ion exchange unit.

The cooling tower makeup water treatment system is designed to clarify the river water necessary for makeup to the heat dissipation system. One full-flow clarifier will remove suspended solids. Polyelectrolyte will be added to enhance removal of suspended solids (to a final concentration of 1 to 2 ppm). Settled solids are removed as underflow from the clarifiers and discharged to a sludge dilution tank. Final discharge is to the Mississippi River. In the FES-CP, settled solids were to have been thickened, dewatered, and disposed of in an approved landfill. An acid feed system is used to prevent scaling on heat exchanger surfaces. An average of 538.8 kg/hr (1188 lb/hr) of 93% sulfuric acid will be added to the circulating water system to maintain the pH range of 6.5 to 7.5.

As described in the FES-CP, hydrogen ion concentration (pH) will be adjusted in the makeup water leaving the clarifiers to prevent scaling condenser circulating water system to maintain the pH within the range of 6.5 to 7.5, rather than a pH of 8.2, as reported in the FES-CP.

Sodium hypochlorite will be used for biofouling control in the condenser cooling water and service water systems. It is estimated that the circulating water in the heat dissipation system will be chlorinated for approximately 60 minutes a day to a level of about 5 ppm at the point of application. (The FES-CP reported a maximum concentration of 3 ppm.) Residual chlorine will be monitored at the discharge from the condensers and sampled at the cooling tower blowdown. The chlorination cycle will be controlled to prevent discharge of either free available chlorine or total residual chlorine at concentrations that exceed the limitations of Federal new source effluent standards for the steam electric power generating point source category. Average and maximum free available chlorine will not exceed 0.2 mg/L and 0.5 mg/L, respectively. The discharge duration of either free available or total residual chlorine will not exceed 2 hours in any 1 day.

4.2.4 Cooling System

4.2.4.1 Intake Structure

The intake screens and piping are located in an embayment that was constructed on the Mississippi River near river mile 262 (Figure 4.3). As discussed in the FES-CP, the embayment is approximately 182.9 m (600 feet) long along the river and 137.2 m (450 feet) wide, with a dredged bottom at elevation -3.6 m (-12 feet) msl. The embayment design is based on model studies (FSAR Appendix 2E). The intake structure design has changed somewhat from the one described in the FES-CP. The pumphouse structure is on the shore at an elevation of +18.3 m (+60 feet) msl and houses two pumps sized for 1.0 m^3/s (16,000 gpm). River water is conveyed to the pumps by two suction pipelines with wedge-wire intake screens mounted at the entrance to each pipeline at elevation -1.1 m (-3.5 feet) msl. The intake screens and suction piping are supported by steel piles.

In the FES-CP, the intake structure design was described as consisting of three 0.88-m^3/s (14,000-gpm) pumps supported from a platform in the embayment at elevation of +18.3 m (+60 feet) msl. A 19-mm mesh, 1.5 m-diameter basket screen was designed to protect each suction intake. The current design calls for octagonal-shaped intake screens that are sized to give an average entrance velocity of less than 0.15 m/s (0.5 fps). The velocity of the water flowing by the intake screens will be approximately 0.03, 0.06, and 0.21 m/s (0.1, 0.2, and 0.7 fps) at low, average, and high water stages, respectively. If fouling occurs, the screens will be cleaned by backwashing. The shoreline protrusion at the upstream side of the intakes should minimize the amount and rate of sediment deposition and trash carried into the embayment.

4.2.4.2 Unit Heat Dissipation System

The design performance characteristics for the heat dissipation system are similar to those described in FES-CP Table 4.2. The main condenser and four multicell mechanical draft cooling towers provide the heat dissipation system for the unit. The station design currently uses circular mechanical draft cooling towers rather than linear mechanical draft towers proposed in the FES-CP. About 1950 MWt of waste heat will be dissipated to the atmosphere from the unit.

4.2.4.3 Discharge System

The design of the blowdown discharge system is similar to that described in the FES-CP. The 76-cm (30-inch) diameter pipe for this outfall is located 185.9 m (610 feet) downstream of the intake structure (Figure 4.3). The pipe is buried in the bank protection material with the center line of the opening at elevation

-0.9 m (-3 feet) msl. Studies conducted by Colorado State University indicate that the blowdown will not recirculate to the intake pumps. At a blowdown flow rate of 0.14 m^3/s (2200 gpm), the exit jet velocity is approximately 0.6 to 0.9 m/s (2 to 3 fps). The discharge facility has been designed to minimize the thermal effects during times of maximum temperature differential.

Diluted sludge from the cooling tower makeup water treatment system is discharged via a 15.2-cm (6-inch) diameter pipe near the cooling tower blowdown discharge (Figure 4.3). The diluted sludge flow will average 0.03 m^3/s (540 gpm).

4.2.5 Radioactive Waste Management System

Under requirements set by 10 CFR 50.34a, an application for a permit to construct a nuclear power reactor must include a preliminary design for equipment to keep levels of radioactive materials in effluents to unrestricted areas as low as reasonably achievable (ALARA). The term ALARA takes into account the state of technology and the economics of improvements 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 50 provides numerical guidance on radiation dose design objectives for light-water-cooled nuclear power reactors (LWRs) to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept ALARA.

To comply with the requirements of 10 CFR 50.34a, the applicant provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents ALARA within the requirements of Appendix I to 10 CFR 50. In addition, the applicant provided an estimate of the quantity of each principal radionuclide expected to be released annually to unrestricted areas in liquid and gaseous effluents produced during normal reactor operations, including anticipated operational occurrences.

The NRC staff's detailed evaluation of the radwaste systems and the capability of these systems to meet the requirements of Appendix I were presented in Chapter 11 of the staff's Safety Evaluation Report, which was issued in May 1984. The quantities of radioactive material that the NRC staff calculates will be released from the plant during normal operations, including anticipated operational occurrences, are in Appendix D of this statement, along with examples of the calculated doses to individual members of the public and to the general population resulting from these effluent quantities.

The staff's detailed evaluation of the solid radwaste system and its capability to accommodate the solid wastes expected during normal operations, including anticipated operational occurrences, is in Chapter 11 of the SER. As part of the operating license for this facility, the NRC will require Technical Specifications limiting release rates for radioactive material in liquid and gaseous effluents and requiring routine monitoring and measurement of all principal release points to ensure that the facility operates in conformance with the radiation-dose-design objectives of Appendix I.

4.2.6 Nonradioactive Waste Management Systems

4.2.6.1 General

Nonradioactive effluents will result from the operation of the River Bend Station water treatment systems, evaporative cooling water system, and waste water treatment system. Some changes have occurred in the design and operating characteristics of the cooling water system since the FES-CP was issued. The chemical waste treatment systems and sanitary waste treatment system have not changed significantly. A general description of these systems and any changes is given below.

4.2.6.2 Cooling Water System

The cooling tower makeup water treatment system will treat a larger amount of water on the average than that reported for one unit in the FES-CP (see Section 4.2.3), but, overall, the amount treated will be less. Suspended solids will be removed by chemical flocculation and clarification, enhanced by the addition of polyelectrolyte. Settled solids will be removed as underflow from the clarifiers and discharged to a sludge dilution tank. Raw river water at a rate of approximately 1893 L/min (500 gpm) will be used to dilute the sludge to a solids concentration of 0.5% to 4.0% by weight. The diluted mixture will be discharged to the Mississippi River under NPDES Permit No. LA0042731. The method for disposal of settled solids has changed since the FES-CP was issued. Previously, settled solids were to have been thickened, dewatered, and disposed of in an approved landfill.

Within the circulating water system, evaporation of water is the main heat transfer mechanism and results in an increased concentration of suspended solids. A quantity of water will be continuously released from the circulating water system to control the dissolved solids concentration in the circulating water at an average concentration factor (ratio of total dissolved solids in circulating water to total dissolved solids in makeup water) of 6.2 (range of 4.7 to 6.7). This is higher than the concentration factor of 5 reported in the FES-CP. The expected concentrations of substances in cooling tower blowdown are given in Table 4.3. The standby cooling tower will use well water, and its blowdown will flow into the main cooling tower blowdown pipeline.

The River Bend Station design does not require the use of corrosion inhibitors in any closed-loop fluid system; however, sodium nitrite is used to inhibit corrosion in the diesel generator cooling jackets. Corrosion rates are controlled, where necessary, by the use of noble metals, protective coatings, inert gas blanketing, or other established techniques. Corrosion and erosion of the tubes in the main condensers will result in an increase in the concentration of copper, zinc, nickel, and tin in the cooling tower blowdown above the level naturally occurring in Mississippi River water or the circulating water (Table 4.4). The quantity of heavy metals discharged in the cooling tower blowdown attributable to corrosion inhibitors is below the Federal New Source Effluent Limitations and Standards for the Steam Electric Power Generating Point Source Category of 1 ppm for zinc, 0.2 ppm for chromium, and 5 ppm for phosphorus.

4.2.6.3 Chemical Waste Systems

Chemical wastes associated with the makeup water treatment system consist of regenerant storage tank spillage and spent acid and caustic solutions, all resulting from ion exchange resin regeneration. No significant changes have occurred in the makeup water treatment system since the FES-CP was issued. Well water is treated by two demineralizer trains. Periodic regeneration of the ion exchange units occurs with a 3% to 6% solution of sulfuric acid and a 3% solution of sodium hydroxide. Drainage from the regeneration process flows to the acid and caustic waste sump and is discharged to the waste neutralization tanks. After neutralization, the contents of the waste neutralization tank will be discharged to the cooling tower blowdown pipe at a maximum rate of 1515 L/min (400 gpm). The pH of the contents of the neutralization tanks will be monitored before discharge. Table 4.3 compares the concentrations of chemical constituents in blowdown mixed with neutralized demineralizer regeneration waste to cooling tower blowdown and river water.

The design of the auxiliary boiler system has not changed since the FES-CP was issued. The auxiliary boiler will operate an average of 8 weeks a year and will have a maximum blowdown rate of 0.76 L/min (0.2 gpm). Boiler blowdown will be conveyed to the acid and caustic waste sump for pH adjustment and then mixed with cooling tower blowdown before discharge to the Mississippi River. The composition and concentration of substances in the boiler blowdown has changed since the FES-CP was issued; however, this blowdown will not appreciably affect the composition of the cooling tower blowdown (Table 4.5).

Nonradioactive floor and equipment drainage, storm water runoff, and excess well water are conveyed to the storm sewer system and discharged to Grants Bayou via East and West Creeks. As indicated in the FES-CP, all drainage that may contain oil will pass through an oil/water separator before discharge, and the oil will be trucked off the site for disposal. Spills in the transformer yard will be contained and will also pass through an oil separator.

4.2.6.4 Sanitary Waste Treatment System

The sanitary waste treatment system for River Bend has not changed since the FES-CP was issued. The waste from all sanitary fixtures in the power station is conveyed to one of two package treatment plants with a total treatment capacity of 83.3 L/d (22,000 gpd). An extended aeration modification of the activated sludge process is used. Effluent from the treatment plant is chlorinated to produce a free chlorine residual of 1 ppm and discharged to the storm sewer at an average rate of 27.6 L/min (7.3 gpm). The treatment plant produces effluent that meets the Federal standards for secondary treatment and operates in accordance with the requirements of the State of Louisiana Board of Health.

4.2.7 Power Transmission System

The power transmission system currently required to connect the River Bend Station with the applicant's existing system includes six different power lines on three routes: I, II, and III (routes B, C, and A in the FES-CP) (see Table 4.6). Routes D and E (FES-CP Section 4.3.1.2) have been deleted since the FES-CP was issued. Routes I and III each have one 500-kV line, and Route II has four 230-kV lines, only one of which extends along the entire route. The circuit length is 91 km (56 miles) for the 500-kV lines and 78 km (49 miles) for the 230-kV lines, for a total of 169 circuit km (105 circuit miles).

The lines were constructed in accordance with the National Electric Safety Code, and are accommodated by a single switchyard 1220 m (4000 feet) southwest of the power plant. Since the FES-CP was issued, several minor changes were made in the transmission line routes and termination points. The total circuit length is less than initially proposed. For the 500-kV lines, the total circuit length is 91 km (56 miles), rather than 97 km (60 miles) as given in the FES-CP, and for the 230-kV lines, it is 78 km (49 miles) rather than 127 km (79 miles) as given in the FES-CP.

Additional 230-kV lines may be constructed along these routes. Only Routes II and III, however, would be used for the River Bend Station. On Route I, future lines would be associated with other power stations. Future 230-kV lines for which provisions have been made include two lines on portions of Route I, three on Route II, and two on Route III. These provisions include towers that will accommodate additional circuits on all three routes and a wide right-of-way that will accommodate an additional line (set) of towers on Route II.

The 500-kV conductors are supported by steel lattice towers that have provision for 230-kV conductors beneath the 500-kV conductors. Most of the structures used to support the 230-kV conductors are of the steel H-frame type, both single and double circuit. A smaller number of single steel pole structures will be used for the 230-kV lines. Right-of-way widths vary greatly, depending on the number of rows (sets) of towers (i.e., the number of parallel lines) present. ER-OL Section 3.7 provides detailed descriptions of the power line routes, structures, conductors, and clearances.

4.3 Project-Related Environmental Descriptions

4.3.1 Hydrology

4.3.1.1 Hydrologic Description

4.3.1.1.1 Surface Water

The surface water descriptions in Section 2.5 of the FES-CP are still valid with the additions and discussions below. In addition, Section 5.3.2.2 of this report discusses the hydrologic effects of alterations in the floodplain as required by Executive Order 11988, Floodplain Management.

The River Bend Station is located on a terrace above the Mississippi River floodplain at approximately river mile 262. The plant facilities are on a gently sloping terrain about 3.2 km (2 miles) east of the river. The floodplain on the east side of the river varies from 930 to 1240 m (3000 to 4000 feet) wide and is at an elevation of about 35 feet msl. A natural levee borders the floodplain along the river bank line. The buildings with safety-related equipment are located on the upper terrace area that has an average elevation exceeding 100 feet msl. The finished plant grade will be at elevation 95 feet msl.

Plant makeup water will be withdrawn from the Mississippi River through an intake system located in an embayment that was constructed near river mile 262. The embayment is approximately 186 m (600 feet) long and 140 m (450 feet) wide with a dredged bottom at elevation -12 feet msl. The blowdown discharge line is located downstream from the embayment to prevent recirculation.

Mississippi River

The Mississippi River drainage basin encompasses about 41% of the conterminous United States. The drainage area upstream from the Bayou Sara gaging station (river mile 265.4) is about 2,925,100 sq km (1,129,400 mi^2). Variations in river flow are mostly seasonal, with the flood flows expected during the spring. Annual low flows usually occur during late summer to early fall.

The construction of various diversion structures along the Mississippi River since 1956 has resulted in changes in the seasonal river discharges. River discharge data from 1956 to 1978 show that the mean monthly discharge of the river near the site varies so that 25,470 m^3/sec (900,000 cfs) is exceeded less than 5% of the time and 4950 m^3/sec (175,000 cfs) is exceeded 95% of the time. The monthly mean discharge for the period 1956 to 1978 was about 12,650 m^3/sec (447,000 cfs).

The major floods on the Mississippi coincide with floods on its major tributaries. The flood season extends from January to July. The most severe flood of record near the site occurred during the spring of 1927 when an estimated confined discharge of 66,360 m^3/sec (2,345,000 cfs) passed the Red River Landing gaging station, which is about 64 km (40 miles) upstream from the plant site. The estimated water level at the site for this flood was 55.5 feet msl. A large portion of any major flood is now diverted from the Mississippi River upstream of the River Bend site. The diversions occur at the Old River Control Structure (river mile 314.5) and at the Morganza Floodway (river mile 285). The project design flood (PDF) discharge, as determined by the Corps of Engineers, at Red River Landing is 85,750 m^3/sec (3,030,000 cfs). The diversions would control the PDF to the extent that only 42,250 m^3/sec (1,500,000 cfs) would pass the site, with a resultant stage of 54.5 feet msl. This is about 12.4 m (40 feet) below plant grade (95.0 feet msl). Thus, the staff concludes that inundation of the plant by the Mississippi River is not a credible event.

Gage records maintained by the Corps of Engineers from 1930 to 1963 at Red River Landing (19 km (12 miles) below the Old River Control Structure) and from 1963 to the present at Tarbert Landing (9.5 km (6 miles) below the Old River Control Structure) indicate a minimum daily discharge of 2122 m^3/sec (75,000 cfs) on November 4, 1939. Flow through the diversion on that day was 380 m^3/sec (13,400 cfs). Because of the construction of the diversion structures, the applicant states that it is doubtful the daily flow downstream of the diversion would ever be less than 2830 m^3/sec (100,000 cfs).

River stage data at Bayou Sara, Louisiana (about river mile 265) for the period 1956 to 1979 indicate that the mean annual river stage is 20.4 feet msl. The mean annual flood stage is about 38.9 feet msl, and the mean low water level is 7.0 feet msl. River stages at the plant site are approximately 0.4 feet lower than Bayou Sara stages. Table 4.7 is a summary of peak flood stages on the Mississippi at the River Bend Station embayment based on historical stages (1956 to 1979) at Bayou Sara.

The Mississippi River channel at the station site is about 530 m (1700 feet) wide increasing to more than 1240 m (4000 feet) 6.4 km (4 miles) downstream. River current velocities measured at the site by the applicant varied from slack bank currents to 2.6 m/sec (8.3 fps) in the main channel. The measurements were made at a stage of 2.5 m (8 feet) above the average annual stage. Measured velocities at the Tarbert Landing gaging station from 1966 to 1970 compare closely with those measured by the applicant. Velocities at that location varied from 0.9 to 3.0 m/sec (3.0 to 9.5 fps).

Local Streams

The plant site lies within the watershed of Grants Bayou. The power plant facilities are located within the watershed of West Creek, which is a small tributary of Grants Bayou. Grants Bayou has a drainage area of 39.6 sq km (15.3 mi^2) and joins Alligator Bayou in the Mississippi River flood plain south of the site. Alligator Bayou drains into Thompson Creek about 4.75 km (3 miles) upstream from its confluence with the Mississippi River.

Plant runoff is collected by West Creek, an intermittent stream with a drainage area of approximately 2.6 sq km (1.0 mi^2). West Creek has been rerouted past the plant facilities by an 800-m (2850-foot)-long Fabriform* channel that is 34 m (110 feet) wide at the top and 15.5 m (50 feet) wide at the base. The channel was constructed to minimize potential plant flooding during heavy rainfalls.

Alligator Bayou is located on the Mississippi River floodplain and flows roughly parallel to the Mississippi. Above the floodplain, the channel flows through a narrow, entrenched valley with relatively steep slopes and is known as Alexander Creek. Alligator Bayou is subject to short periods of high runoff and extended low flow periods of zero discharge. Inundation by overbank flows of the Mississippi River occurs during major floods and can last up to 3 months. Increased sedimentation occurs during flood flows from Alexander Creek resulting in considerable sediment deposition in the flood plain area.

A river access road connecting the plant facilities with the Mississippi River has been constructed across Alligator Bayou to provide access to the barge slip and intake structure. In the FES-CP the bridge to be built across Alligator Bayou was described as a 500-foot-long, 40-foot-wide roadway with a reinforced concrete deck and precast concrete piles. The hydrologic effects of this bridge were not discussed in the FES-CP. The road crossing that was constructed consists of 14 corrugated barrel culverts that are 1.83 m (6 feet) in diameter and an earth embankment. The purpose of the culverts is to allow Mississippi River flood flows and local runoff from Alligator Bayou to pass through the Bayou in nearly the same way as it did under preconstruction conditions. A hydrologic analysis performed by the applicant (Section 5.3.2.1) shows that the primary impact of the culverts is to increase the length of time over which the levee between Alligator Bayou and the Mississippi River is overtopped. This intermittent overtopping may increase erosion of a section of River Road located on top of the levee, producing gullies between the road and the Mississippi River.

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*Fabriform is a grout-filled nylon fabric.

Local Ponds

Several small farm ponds are located in the site vicinity. Before construction, 24 ponds with a total surface area of about 11.6 ha (28.6 acres) existed within the site boundaries. Five ponds were removed during construction, decreasing the total surface area by 0.69 ha (1.7 acres). To offset removal of these ponds, a Wildlife Management Lake will be constructed at the site. The water level will be controlled by a concrete spillway that will provide a water surface elevation of 50 feet and a surface area of about 13.8 ha (34.2 acres).

There are approximately 212 ponds within a 10-km (6.3-mile) radius of the River Bend property. Their sizes range from 0.10 to 4.05 ha (0.25 to 10 acres). The nearest pond used for catfish harvesting is more than 30 km northeast of the site. The only public recreation lake (12.1 ha (30 acres)) is at Audubon Lake Camping Resort, approximately 3 km (1.9 miles) northwest of the site. Within a 5-km (3.1-mile) radius of the site, there are three residences that use rainwater tanks for their water supply.

4.3.1.1.2 Groundwater

Groundwater at the River Bend site is present and available from Holocene Mississippi River aluvium, Holocene and Lower Pleistocene alluvial deposits that make up the terraces in the upland areas, and Tertiary sands. These units form three distinct hydrogeologic systems.

The alluvial aquifer of the Mississippi River is restricted to the valley of the river. It unconformably overlies the deposits that form the Upland Terrace and Tertiary aquifers. The alluvial aquifer is in direct hydraulic connection with the Mississippi River, and water levels in wells respond readily to changes in river stage. Test borings at the River Bend site show that the aquifer has an upper zone consisting predominantly of clay extending for 26 m (85 feet) underlain by sand and gravel for an additional 20 m (65 feet).

The Upland Terrace Aquifer consists of sediments ranging in size from clay to gravel. These deposits are overlain by a layer of loess that averages 3 m (10 feet) in thickness. Water-level measurements made in this unit typify an unconfined flow system. Near the contact of the Upland Terrace and Mississippi River Alluvial aquifers, the Upland Terrace Aquifer responds to changes in river stage, indicating hydraulic connection. Underlying the Upland Terrace aquifer is a thick section of clay (over a hundred meters) and interspersed sand layers that serve to isolate it from the Tertiary Aquifer system below. The Tertiary Aquifer is divided into three zones in the vicinity of the site. Each of the three zones represents a separate, confined aquifer. These units comprise the major groundwater resource in the area. As a result of heavy pumping for public water supplies from the lower Tertiary zones, there is decreasing head with depth in this aquifer.

A groundwater dewatering system has been temporarily installed at the site; it was last operated in October 1981. The system is being maintained in a standby mode. After final use of the system, it will be abandoned according to appropriate Louisiana law.

The groundwater gradient in the Upland Terrace Aquifer is toward the Mississippi River at a slope of 2.7 m/km (0.0027 foot/foot).

4.3.2 Water Quality

The Mississippi River carries the largest quantity of water of any U.S. rivers and drains over a million square miles by the time it reaches the site. The water in the Lower Mississippi River at the site is well-buffered, hard, and fairly homogeneous because of the river's large volume. High sediment concentrations (10 to 2,500 mg/L) characterize water quality in the Mississippi River. Vertical temperature variations are generally less than 1.1C° (2F°). Dissolved oxygen and chemical constituents in the Lower Mississippi River usually vary as a function of physical rather than biological influences. Dissolved oxygen levels in the Mississippi River are usually greater than 5 mg/L throughout the year. Water quality data on the Mississippi River near St. Francisville from the applicant's interim water quality monitoring program do not show significant differences in the data from this location from that presented in the FES-CP. Seasonal variations in the water quality of the surface waters near the River Bend site are in ER-OL Tables 2.3-14 through 2.3-17. An overall summary of this information is in Table 4.8. The designated uses for the river segment at the River Bend site are secondary contact recreation, propagation of fish and wildlife, and domestic raw water supply (Louisiana Stream Control Commission, 1977). Specific criteria for this segment are in Table 4.9.

Water quality in Alligator Bayou and Grants Bayou is similar. Dissolved oxygen levels often fall below 5 mg/L during summer months, and conductivity and turbidity in these areas is lower than in the Mississippi River.

4.3.2.1 Water Use

4.3.2.1.1 Surface Water

The principal users of surface water in Louisiana are industry and thermoelectric power plants. Local surface waters near the site are used mostly for livestock watering and industrial processing. When both the River Bend Station and the Big Cajun No. 2 Plant (Units 1, 2, and 3) directly across the river are in operation, the principal local water users will be industry and power plants.

The closest municipal water intake using Mississippi River water is at Donaldsonville, Louisiana downstream at river mile 175.5. The Peoples Water Service Company, Inc. pumps water from the river into Bayou Lafourche at a maximum rate of 979.8×10^6 L/day (259.2 mgd). This pumping station is about 139 km (87 miles) downstream from the River Bend discharge, and the withdrawal rate is less than 0.1% of the average flow. The closest municipal water intake directly on the river is that of the St. James Parish Utilities Company at Convent, Louisiana, about 172.8 km (108 miles) downstream (river mile 154.1).

The nearest industrial user is the Crown Zellerbach papermill, about 3.2 km (2 miles) downstream from the River Bend site. The average daily intake in 1978 was 112.6×10^6 L/day (29.8 mgd). The Big Cajun No. 2 Units 1, 2, and 3, which are coal-fired units, have recently gone into operation. The intake and discharge locations for Units 1 and 2 are about 186 m (600 feet) upstream from the River Bend embayment. Units 1 and 2 require an intake flow of 113.4 x 10^6 L/day (30 mgd), with a discharge of 41.6 x 10^6 L/day (11 mgd). The cooling system for Unit 3 requires about 1,410 x 10^6 L/day (374 mgd) for intake and discharge flow. The intake for Unit 3 is directly across the river from the River Bend embayment, and the discharge is about 124 m (400 feet) downstream.

The Mississippi River is the main navigation artery for Louisiana and connects with the Gulf Intracoastal Waterway. The navigation requirement for all waterways in Louisiana is 3.67 x 10^{11} L/day (97,080 mgd) steady for each month, and more than 99% of this requirement is for the Mississippi River. A 12.4-m (40-foot)-deep navigation channel is maintained by the Corps of Engineers up to Baton Rouge, Louisiana. Upriver from there, a 3.7-m (12 foot)-deep channel is authorized and a 2.8-m (9-foot)-deep channel maintained. The Port of Baton Rouge is located about 56 km (35 miles) downstream from the River Bend site.

Navigation traffic past the River Bend site has been increasing annually. In 1977 almost 162,000 vessels passed the site. Dock facilities near the site are the coal dock to be used by Big Cajun No. 2 across the river at river mile 263, and the Crown Zellerbach Paper Company dock at river mile 260.

There are four, free, state-run ferry crossings [illegible]ississippi River within 80 km of the River Bend Station. The crossing l[illegible]e at river miles 300.5, 266.0, 202.6, and 191.4. The nearest ferry c[illegible]ng to the station site is at river mile 266.0, which is serviced by the New Roads Ferry (continuous) and the St. Francisville Ferry (5 days a week).

As noted above, the only known public water recreation within 10 km of the site is at the 12.1-ha (30-acre) lake at Audubon Camping Resort. Activities include fishing and boating. Swimming is restricted to a 22-m by 103-m (71 foot by 332 foot) pool just outside the 10-km (6.3-mile) radius in an oxbow lake, False River. The Mississippi River is not extensively used for recreational purposes in the River Bend area because of constant barge traffic and a lack of riverside recreational facilities such as parks and marinas.

4.3.2.1.2 Groundwater

Three wells on the site will be used during normal operations. Two of these wells tap the Tertiary Zone 3 aquifer at depths of 555 m (1790 feet) and 553 m (1780 feet). These wells are designed to provide normal plant domestic and makeup water. Before plant startup, these wells will supply water to fill the ultimate heat sink (UHS) basin. The wells are capable of supplying 9.4 L/sec (150 gpm) each, and, in case of an emergency, will supply makeup water to the UHS system at a maximum calculated rate of 13.4 L/sec (214 gpm).

The third well taps the Upland Terrace Aquifer at a depth of 46 m (150 feet). It is equipped with a 50-L/sec (800-gpm) pump and is designed to provide water for fire protection.

Groundwater use downgradient of the River Bend site is limited to two domestic users; all other wells were annexed when the station property was acquired. Station use of groundwater is limited and will not affect or be affected by the small users remaining. Extensive pumping by the City of Baton Rouge from the tertiary aquifers has resulted in a cone of depression that has reached

St. Francisville. It is estimated that drawdown in this aquifer as a result of pumpage from the two River Bend wells will be less than 0.5 m (1.5 feet) after 40 years of continuous operation.

4.3.3 Meteorology and Air Quality

The regional climatic information in FES-CP Section 2.6 is still applicable, as are the local meteorology description in Section 2.6.2 and the description of severe weather in Section 2.6.3.

An onsite meteorological measurements program has been in place since 1971. In 1977, new sensors were installed at the same levels (10 and 50 m (30 and 150 feet)) where the original sensors were located. The onsite meteorological measurement program, which was implemented in accordance with Regulatory Guide (RG) 1.23, has provided 2 years (March 1977 to March 1979) of joint frequency data of wind speed by direction by atmosphere stability to describe conditions at the site. Wind speed and direction are measured at the 10- and 50-m levels on the onsite meteorology tower. Wind direction frequencies for these two levels are presented in Figures 4.4 and 4.5, respectively.

The stability determination is based on the vertical temperature difference between 10 and 30 m. Precipitation is measured with a tipping bucket rain gage, near the tower, on top of the instrument building about 5 m above ground level. The joint recovery of wind speed and direction measured at the 10-m level and the temperature difference between 10 and 50 m was 98% during the 2-year data period.

4.3.4 Terrestrial and Aquatic Resources

4.3.4.1 Terrestrial Resources

Terrestrial biota of the River Bend site were described in detail in FES-CP Section 2.7.1 and ER-OL Section 2.4. The biota of the area have not changed significantly since the FES-CP was issued in 1974, except that clearing and construction have eliminated habitat and permanently reduced the populations of the affected plant and animal species.

As a result of additions to the site, the site land area is now 1352 ha (3342 acres) compared to the 1084-ha (2679-acre) site assessed in FES-CP Section 4.3.1.1. The acreages of the various forest types on the site before and after construction are given in Table 4.10. Bottomland hardwood forests, which are very productive and important to a relatively large number of wildlife species, comprised 297 ha (734 acres) of the site. Because of construction of the river access road, the area of these forests experienced a small loss (3.2%). Losses of prime farmland and farmland of statewide importance total 153 ha (378 acres) (see Section 4.2.2).

The applicant will manage many areas on the site in cooperation with university, state, and Federal forestry and wildlife specialists. The management program will include studies of procedures for reforestation of spoil areas, methods for the management of unharvested deer herds, maintenance of old-growth stands of loblolly pine and bottomland hardwoods, the preservation of Needle Lake, creation of the Wildlife Management Lake, and habitat management for waterfowl (ER Supplement 8, Q&R 2.4-2). Most of the bottomland forest (288 ha, 712 acres) will be preserved. This preservation is important, because most bottomland forests in the region will probably eventually be converted to agricultural uses (Johnson and McCormick, 1978).

Descriptions of terrestrial resources along the transmission lines and summaries of the changes in vegetation types and land uses because of construction of the lines are in FES-CP Section 4.3.1.2 and ER-OL Section 4.3.1.2. Briefly, 234 ha (577 acres) of forest were cleared (ER-OL Tables 2.2-6 to 2.2-8), which represents 57% of the 411 ha (1014 acres) needed for the transmission corridors. The 234 ha (577 acres) cleared is 21 ha (52 acres) greater than that estimated in the FES-CP (213 ha or 526 acres) (Table 4.11).

4.3.4.2 Aquatic Resources

The aquatic resources potentially affected by construction and operation of the River Bend Station were described in FES-CP Section 2.7.2. The 1972-1974 baseline study by Louisiana State University (LSU) provided data for the FES-CP. An interim study, which began in the spring of 1974, was designed to continue the monitoring from the baseline study at an increased frequency but for fewer stations (Figure 5.7 below). Special studies of the floodplain have also been conducted. Figures 5.6 and 5.7 below show aquatic sampling stations for these studies, and Section 5.14 of this report discusses the aquatic monitoring program in more detail.

Information discussed in this section is from the ER-OL, the LSU monitoring reports (LSU, 1978a and b), the Report on Special Floodplain Studies (Conner, 1981), and the scientific literature. Emphasis is placed on describing aquatic resources that are most likely to be impacted by operation of the plant and new data available since the FES-CP was issued in 1974. Habitats near the intake and discharge areas in the Mississippi River, Alligator Bayou, and Grants Bayou are of special interest (Figure 4.6). The Mississippi River has a better ability to assimilate changes than other aquatic systems on the site because it is large, deep, and fast flowing. The Alligator Bayou system, because of its periodic inundation by the Mississippi River, has high organic and low dissolved oxygen concentrations. Grants Bayou is usually not more than a few centimeters deep, with continuous flows in the winter and spring. The water temperature in Grants Bayou ranges from 12° to 29°C (53.6° to 84.2°F), and dissolved oxygen concentrations range from 3.6 to 12.6 mg/L. The hydrology of these aquatic systems is described in Section 4.3.1.

Nineteen small ponds exist on the site. Three of these are natural and contain clear but darkly stained water with submerged, emergent, and floating plants. These ponds are not discussed further because station operation is not expected to affect them.

Mississippi River

Attached aquatic vegetation is limited to filamentous algae. Since 1972, more than 115 taxa of planktonic algae have been collected from the river. Although the green algae (Chlorophyta) are the most diverse algal division, the diatoms (Bacillariophyceae) often dominate the phytoplankton biomass of the Mississippi. The greatest phytoplankton densities usually occur along the western shore where river currents are lowest, especially during low river stages (ER-OL Section 2.4.2).

Zooplankton include the permanent plankters (holoplankton), the temporary plankters (meroplankton), and insects. Ichthyoplankton (fish eggs and larvae) and adult fish are discussed later in this section. More than 170 invertebrate taxa have been identified at the site. Rotifers, copepods, and Daphnidae are the most common holoplankters. Meroplankton at the site include eggs and larvae of: river shrimp, annelids, molluscs, mayflies, true bugs, beetles, and caddisflies. River shrimp eggs and larvae were present only from late April to September. Based on one sampling date, densities of zooplankton found near the western shore (12% of total numbers) were considerably lower than those at midstream (42%) or along the eastern shore (46%).

The benthic community is composed of organisms living on or near the sediment/water interface, with more than 70 taxa of benthic invertebrates having been identified from the river at the site. Low densities of benthic invertebrates occur at midchannel. The most abundant benthic organisms are aquatic oligochaetes or worms (58% of total by number) and mayfly larvae (30%). The Asiatic clam (Corbicula sp.) is the principal bivalve in the area, despite its fairly recent invasion of the lower Mississippi. Adult river shrimp (Macrobrachium ohione) are an important food source for many predaceous fish and are harvested commercially.

Forty-five taxa have been identified in ichthyoplankton samples since 1973. The drums (Sciaenidae), herrings (Cluplidae), minnows (Cyprinidae), and suckers (Catostomidae) account for approximately 95% of the ichthyoplankton by number. Only two fish species--the freshwater drum (Aplodinotus grunniens) and the goldeneye (Hiodon alosoides)--have eggs that float and are therefore found with the plankton. Drum, carp, minnow, and shiner larvae are more abundant along shorelines.

In the site area, 88 species of fish have been collected; 39 of these are considered common to the area. The ecologically dominant fishes in the Lower Mississippi River are listed in Table 4.12. In general, the number of fish collected was greatest in the summer, while the greatest number of species were present during the spring and summer. Populations of fish in the Mississippi River have exhibited considerable variation during the monitoring program. This variation is the result of intrinsic factors, such as migrations and spawning success, and extrinsic factors such as food availability, river flooding, turbidity, currents, and temperature. The fish community shows spatial variability by habitat preference in this reach of the river. The ecology and life history of representative fish species for this portion of the Mississippi River are in ER-OL Section 2.4.2.

Alligator Bayou

In the section of Alexander Creek just above the tramline at the entrance to Alligator Bayou and in shallow embayments along the bayou, dense stands of rooted aquatic vegetation are common.

The zooplankton of Alligator Bayou are dominated by protozoans and rotifers, with both groups tending to increase during summer months. Alligator Bayou has a considerably more diverse benthic community than the river; more than 150 taxa have been collected since 1972. Dominant benthic forms are aquatic oligochaetes and dipteran (midge) larvae. Several species of crayfish occur in the bayou areas.

Sixty-four species and three hybrid sunfishes have been collected in Alligator Bayou, and about half of these are judged to be common. The buffalos and white bass use the bayou as spawning and nursery habitat.

Since the FES-CP was issued, a river access road has been built across Alligator Bayou and the adjacent Mississippi River floodplain. The earthen-filled road crosses Alligator Bayou over 14 1.8-m (6-foot)-diameter metal culverts that are 73.2 m (240 feet) in length. (The FES-CP stated that a bridge was to have been constructed across Alligator Bayou.) Studies were initiated in 1978 to evaluate the effects of this access road on the aquatic habitat of the floodplain (Conner, 1981).

The literature on riverine ecology suggests that floodplain migrations are important to the reproductive success of some fishes. Experience has shown that under natural conditions some movement of fishes occurs at times along the floodplain (according to a personal communication from J. V. Conner of LSU to J. E. Booker of GSU, on August 31, 1977). The area affected by the access road is about one-third of the total floodplain along the 16-km (10-mile) reach of the Mississippi River between Bayou Sara and Thompson Creek (Conner, 1981).

Ichthyoplankton sampling data emphasize the greater diversity and abundance of larval and early juvenile fishes in the inundated floodplain compared to the main river channel. These data support the hypothesis that floodplains tend to be relatively more important as spawning and/or nursery areas than main stream channels. Bowfin, gizzard shad, and carp were caught traversing the culverts. Nine more species and three times as many fishes occurred below the access road than above it. Besides shads, the migratory shortnose gar, skipjack herring, common carp, buffalo, and white bass were found less often and in much lower numbers per unit of effort above the access road (Conner, 1981).

Grants Bayou

Twenty-three fish species and one hybrid have been recorded in Grants Bayou. The ichthyofauna of Grants Bayou in the study area is transient. Some or all of the 10 common species may maintain small populations in isolated pools during dry periods.

Commercial and Sport Fisheries

The total commercial and recreational harvest of finfish, turtles, crayfish, river shrimp, and frogs from the lower Mississippi River below the River Bend Station is conservatively estimated by the staff to be 9.85×10^5 kg/yr (2.16×10^6 lb/yr). Details of the estimation procedures and results are in Appendix G of this report.

4.3.5 Endangered and Threatened Species

4.3.5.1 Terrestrial

FES-CP Section 2.7.1.1 and ER-OL Section 2.4.1.1.14 discuss the occurrence of endangered and threatened terrestrial species at the River Bend site. One such species is the threatened American alligator (50 CFR 17.11 and 17.12), which appears to be a permanent resident at the site. The alligator's primary habitat at the site is wetlands in bottomland forest areas. Because most of this habitat is being preserved (Section 4.3.4.1), the site should continue to provide the alligator with suitable habitat over the long term. Two endangered species--the bald eagle and the peregrine falcon--do not occur regularly or breed at the site, but may occur as rare visitors. The bald eagle is known to nest in the Atchafalaya swamps more than 65 km (40 miles) south of the River Bend site (Kroodsma, 1983). The endangered ivory-billed woodpecker and Bachman's warbler have not been recorded in the Louisiana area or anywhere in years, and may be extinct. The endangered red-cockaded woodpecker occurs in many areas in the Southeast, but is not known to occur regularly at or near the site. There are currently no stands of pine at the site that appear to be suitable for supporting a colony of these red-cockaded woodpeckers (Kroodsma, 1983). Finally, the site is within the former geographic range of the endangered red wolf and Florida panther or eastern cougar. These species, however, apparently no longer occur in the region.

No Federally endangered or threatened plants occur in Louisiana (50 CFR 17.11 and 17.12). The Louisiana state list of endangered species does not include any other species than those above that would occur near the site (U.S. Fish and Wildlife Service, 1982).

4.3.5.2 Aquatic

There are no aquatic species (fish or invertebrates) in the site vicinity that are included on Federal or state lists of endangered or threatened species.

4.3.6 Socioeconomic Characteristics

The general socioeconomic characteristics of the region, including demography and land use, are in FES-CP Section 2. As indicated in the FES-CP, the plant is in the southeastern corner of West Feliciana Parish, Louisiana, about 6.4 km (2 miles) east of the Mississippi River and about 38.6 km (24 miles) north-northwest of Baton Rouge.

The 16-km (10-mile) area surrounding the plant site includes portions of West Feliciana Parish, East Feliciana Parish, Pointe Coupee Parish, and East and West Baton Rouge Parishes. They are predominantly agricultural land, forest land, and wetlands. Industry and business are located largely in the nearby towns of St. Francisville (1980 population 1471), which is about 4.8 km (3 miles) northwest of the site; New Roads (1980 population 3924), which is about 10 km (6.7 miles) southwest of the site; and Jackson (1980 population 3133), which is about 14 km (9.2 miles) northeast of the site. The Cajun Electric Power Cooperative's Big Cajun No. 2, Units 1, 2, and 3 coal-fired generating plants are located directly across the Mississippi River in Pointe Coupee Parish. The Army Corps of Engineers casting yard is about 2.4 km (1.5 miles) from the site, south of St. Francisville (ER-OL Figure 2.2-2).

West Feliciana Parish grew from 10,761 persons in 1970 to 12,186 persons in 1980, a growth of 1425 persons. The population of St. Francisville declined during this decade from 1603 persons in 1970 to 1471 in 1980, according to data from the U.S. Bureau of the Census. According to the applicant, the 1980 population within 16 km (10 miles) of the site is estimated to be about 22,500 persons. About 13,500 of these persons are in the 8- to 16-km (5- to 10-mile) area around the plant; of these, more than one-half are in the south, south-southwest, southwest, and west-southwest sectors (ER-OL Table 2C-1). It is estimated that population within 16 km (10 miles) of the plant will be about 29,100 in the year 2000 (ER-OL Table 2C-4). The staff has compared the applicant's demography data estimates with independent data sources and maps, and has found the applicant's estimates reasonable.

4.3.7 Historic and Archeological Sites

FES-CP Section 2.3 discusses historic and archeological sites and names the sites in the region surrounding the plant site that are listed on the National Register of Historic Places. At present there are six listed properties in the vicinity of Jackson in East Feliciana Parish and five in the vicinity of New Roads in Pointe Coupee Parish. In the vicinity of St. Francisville in West Feliciana Parish, there are eight listings. In addition, there are two property listings in the vicinity of Hardwood and one in the vicinity of Wakefield.

In 1978, in consultation with the State Historic Preservation Office (SHPO), a cultural resource survey was conducted of the transmission line routes. After a review of the survey findings and consultation with the SHPO, a Memorandum of Agreement (MOA) was signed by the Advisory Council on Historic Preservation, the Louisiana State Historic Preservation Office, and the NRC. During construction, the MOA protected breastworks that had been identified along an existing transmission line corridor that was being expanded. (The line traverses the Port Hudson Battlefield, a National Historic Landmark, located 11.8 km (7.4 miles) south-southwest of the River Bend Station.) The work required by the MOA was completed in May 1982, and a report on it was transmitted to NRC November 2, 1982 (Booker).

4.4 References

Booker, J. E. (GSU), letter to R. L. Tedesco, (NRC), transmitting "Report on Transmission Line Construction Activities Within the Port Hudson National Historic Land Mark by Gulf States Utilities Company," November 2, 1982.

Conner, J. V., "Report on Special Floodplain Studies, LSU Phase II Interim Ecological Monitoring Program, River Bend Units 1 and 2," Louisiana State University, Baton Rouge, 1981.

Johnson, R. R. and J. F. McCormick, "Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems," General Technical Report WO-12, U.S. Forest Service, Washington, DC, 1978.

Louisiana State University (LSU), "River Bend Station Interim Ecological Monitoring, 1976 Annual Report," School of Forestry and Wildlife Management, Baton Rouge, March 3, 1978a.

---, "River Bend Station Interim Ecological Monitoring, 1977 Annual Report and Summary Overview," School of Forestry and Wildlife Management, Baton Rouge, March 3, 1978b.

Lousianna Stream Control Commission, "State of Lousianna Water Quality Criteria," Baton Rouge, 1977.

U.S. Fish and Wildlife Service, "Endangered and Threatened Species of the Southeastern United States," Region 4, Atlanta, 1982.

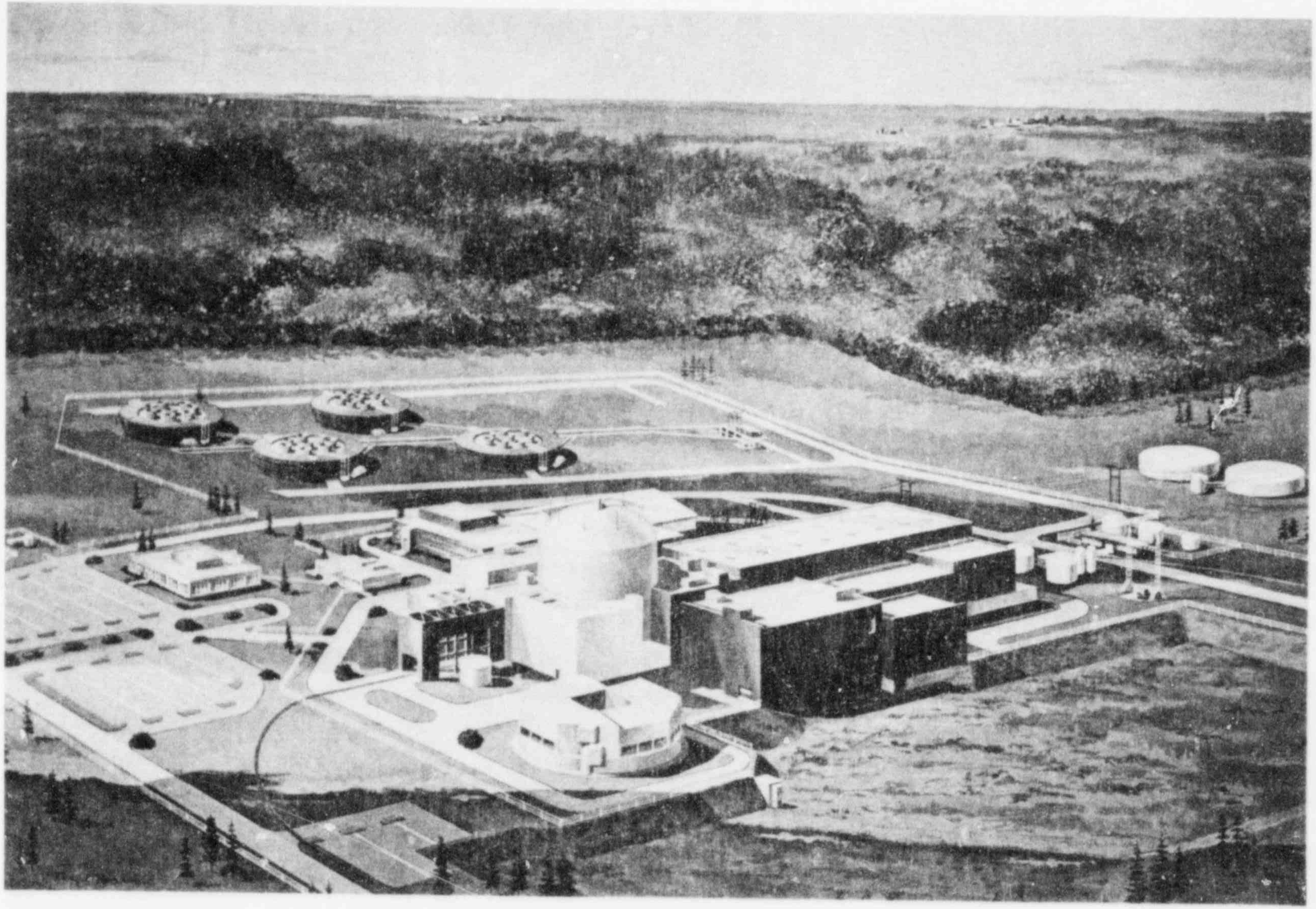
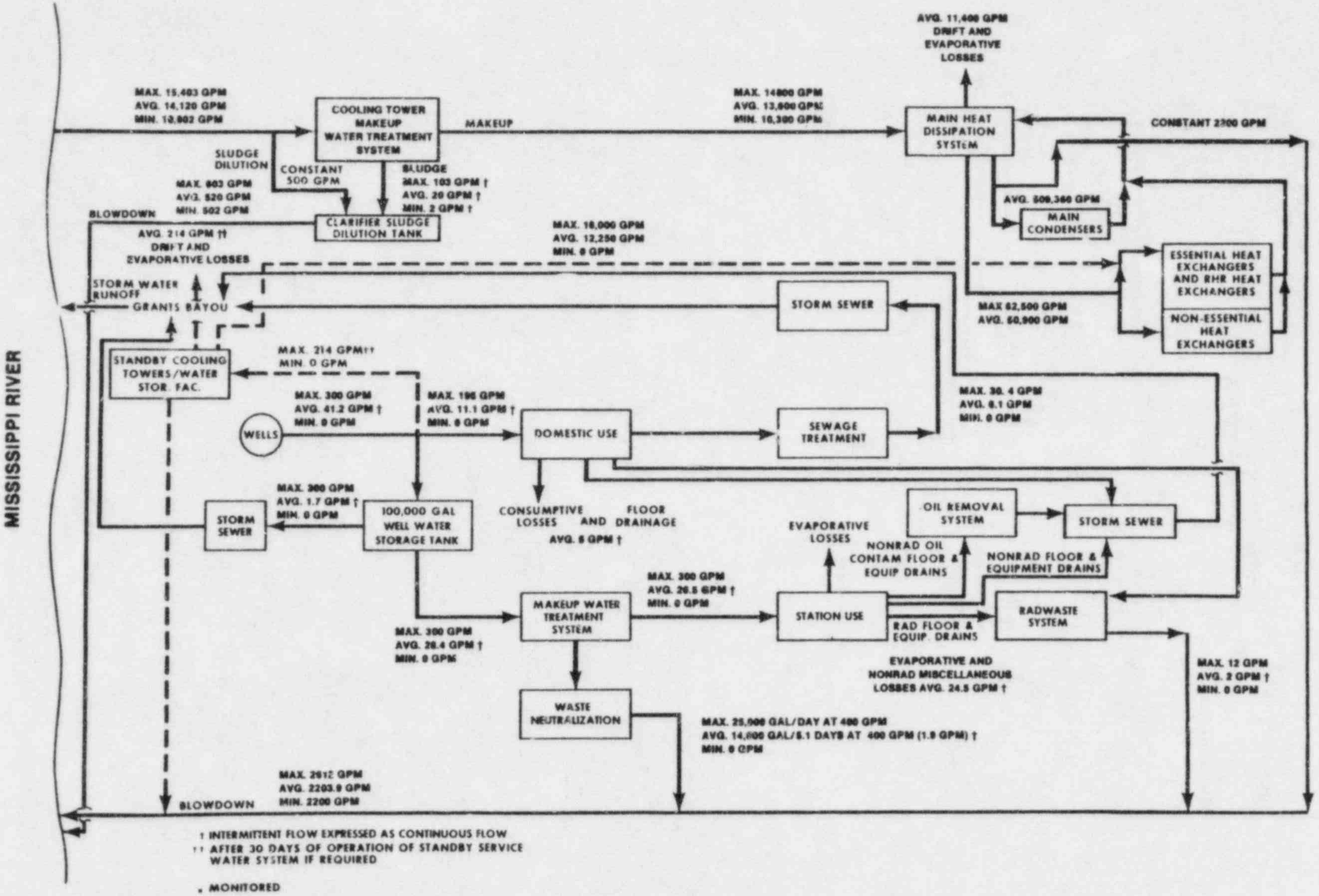


Figure 4.1 Artist's sketch of River Bend



† INTERMITTENT FLOW EXPRESSED AS CONTINUOUS FLOW
†† AFTER 30 DAYS OF OPERATION OF STANDBY SERVICE WATER SYSTEM IF REQUIRED
. MONITORED

Figure 4.2 Water use diagram

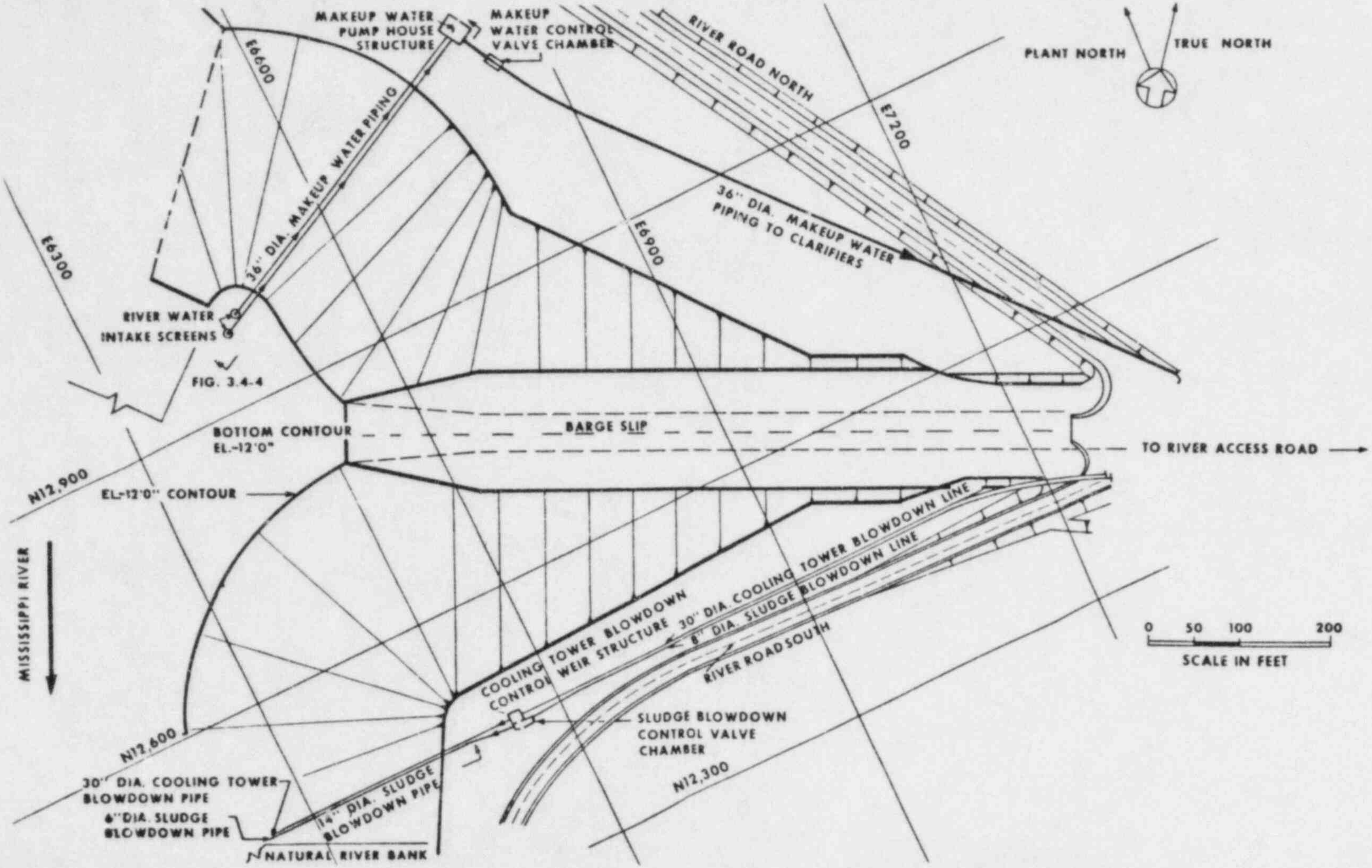


Figure 4.3 Intake-discharge area embayment development

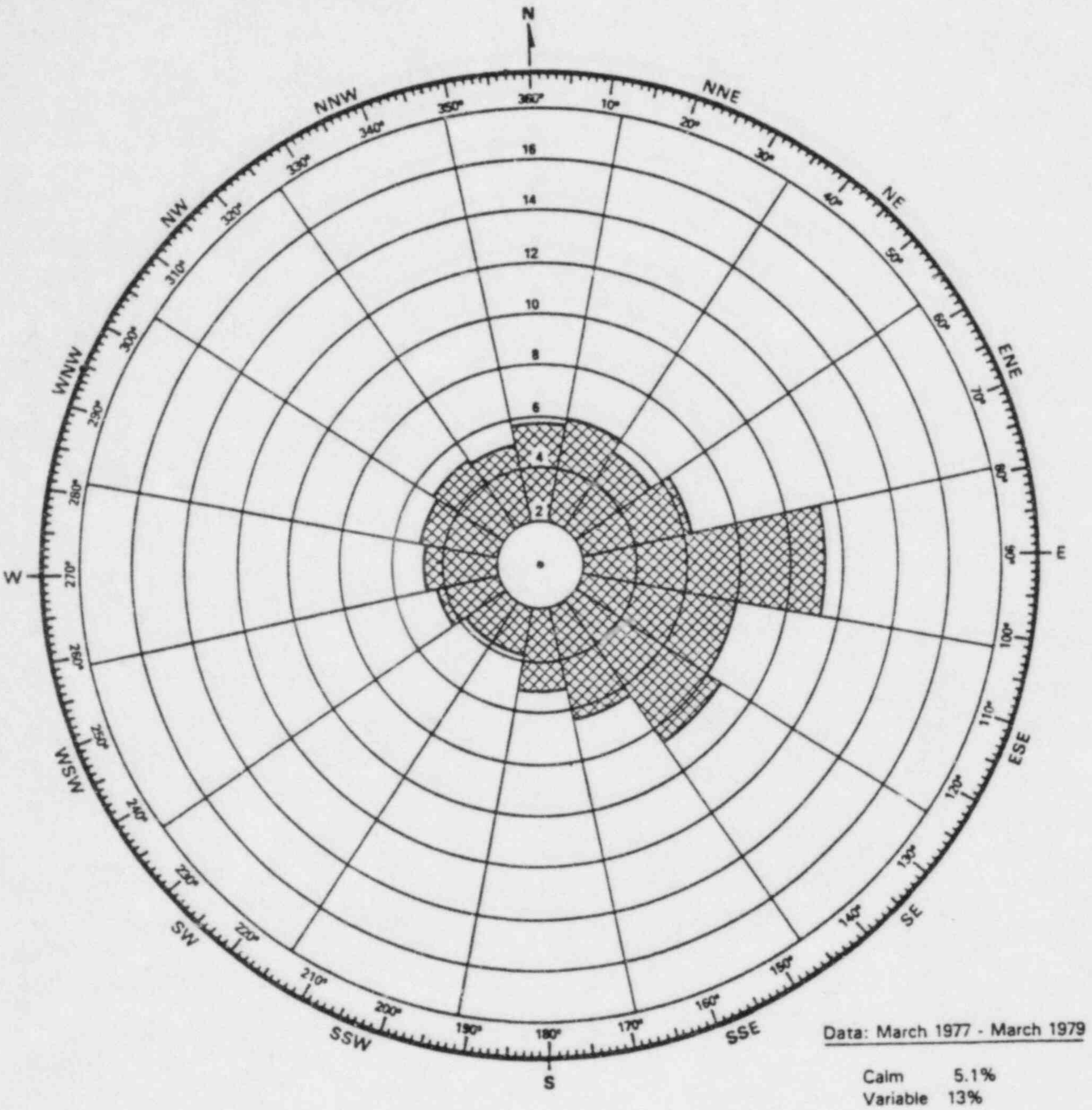
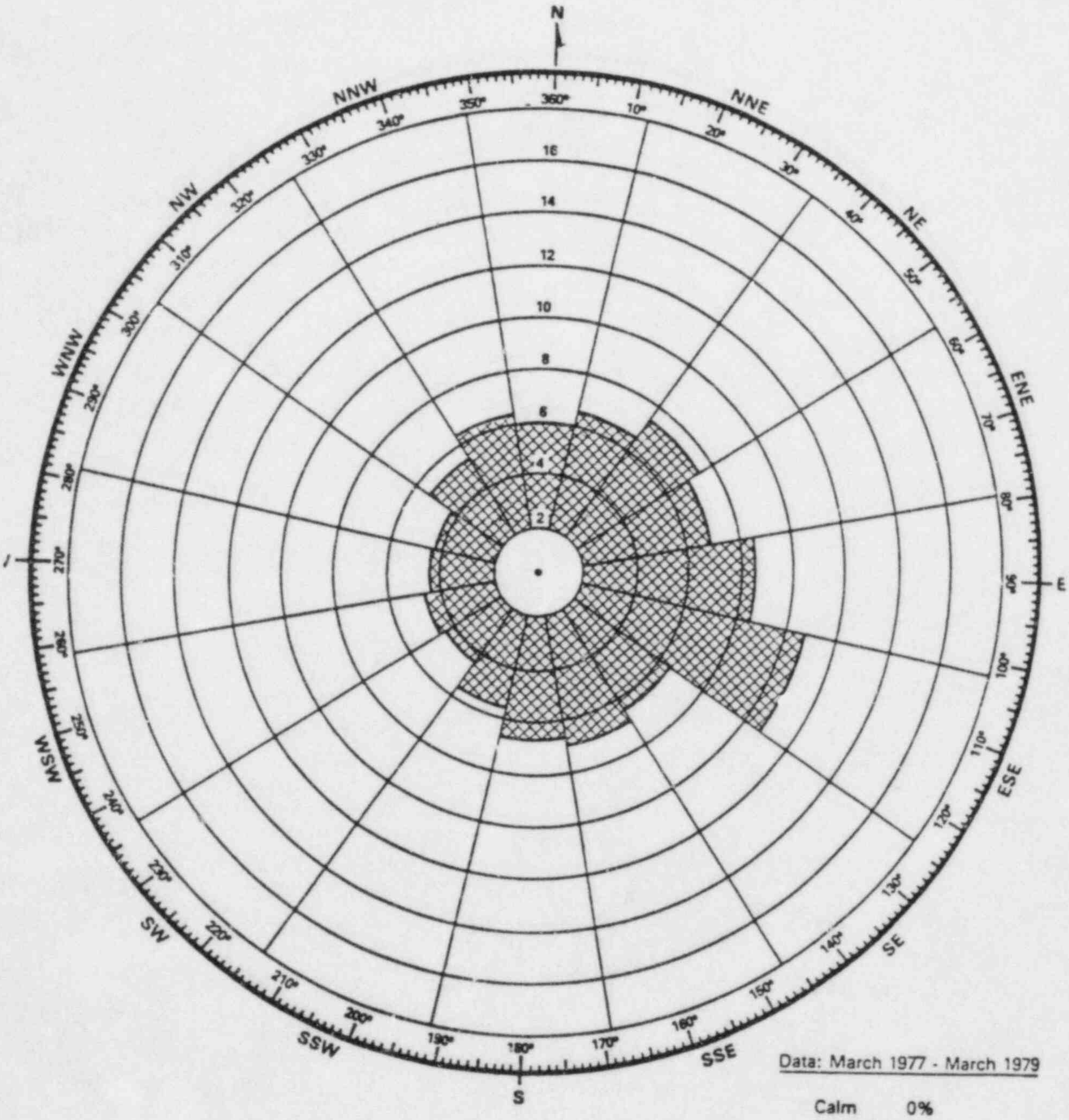


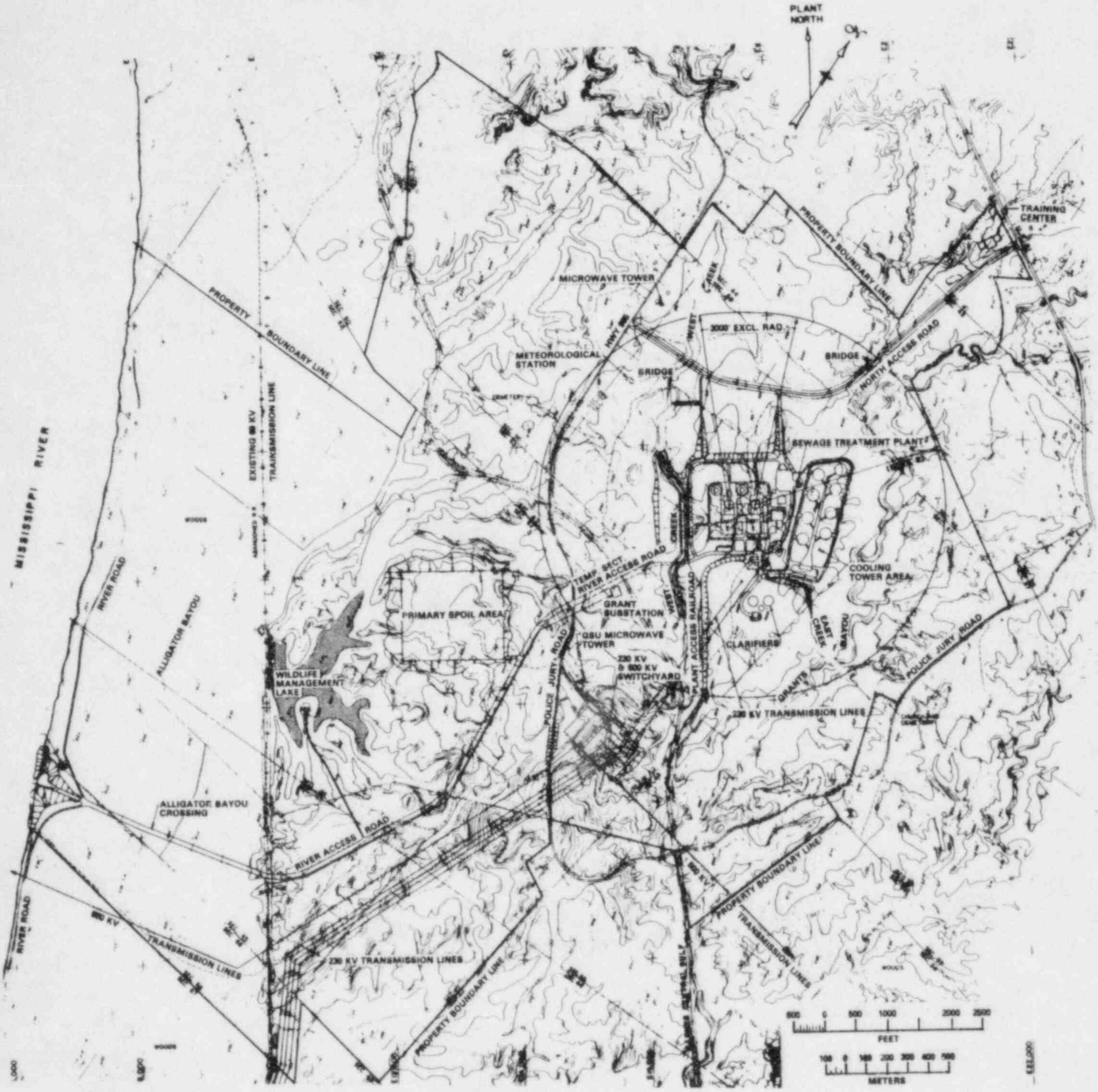
Figure 4.4 10-m windrose, showing percent of time wind blows from each direction



Data: March 1977 - March 1979

Calm 0%
Variable < 1%

Figure 4.5 50-m windrose, showing percent of time wind blows from each direction



NOTES
1. VERTICAL DATUM
MEAN SEA LEVEL AS ESTABLISHED BY U.S. CO. AND GEODETIC SURVEY
2. DISTANCE FROM CENTERLINE REACTOR NO. 1 TO PROPERTY BOUND = 3035 M

Figure 4.6 Site vicinity showing Mississippi River, Alligator Bayou, Grants Bayou

Table 4.1 Onsite area land use

Facility	Area ha	 acres	Status
Main plant	35.6	88.0	Under construction
Cooling towers	15.4	38.1	Under construction
Roads	37.2	91.9	Completed
Switchyard	13.2	32.6	Completed
Transmission lines	63.1	155.9	Completed
Wildlife management lake and classroom area	15.2	37.6	Construction not begun
Relocated creeks	14.8	36.6	Completed
Training center	0.6	1.6	Completed
TOTAL OPERATING PLANT AREA	195.1	482.2	
Construction support facilities	109.6	270.8	In use
Unaffected area	1047.3	2587.8	
TOTAL SITE AREA	1352.0	3340.8	

Source: ER-OL Table 4.3-1

Table 4.2 Heat dissipation system characteristics

Component	Capacity
Heat load	
Main condenser (100% load)	6.72×10^9 Btu/hr
Service water (maximum conditions)	0.19×10^9 Btu/hr
Circulating water flow	1.936×10^6 L/m (511,560 gpm)
Main condenser	1.928×10^6 L/m (509,360 gpm)
Service water	1.927×10^5 L/m (50,900 gpm) (2.366×10^5 max) (62,490 max)*
Total flow	2.139×10^6 L/m (565,000 gpm)
Cooling towers	
Number of tower blocks	4
Number of fans per tower	8
Tower dimensions	Approximately 60.96 m (200 feet) in diameter
Tower basin dimensions	Approximately 60.96 m (200 feet) in diameter x 1.83 m (6 feet) deep
Tower height (from curb)	Approximately 12.5 m (41 feet) to fan deck Approximately 17.98 m (59 feet) to top of stack
Stack diameter	Approximately 9.45 m (31 feet)
Cooling tower operation (at design point)	
Design wet bulb	27.2°C (81°F)
Temperature range	-3.6°C (25.5°F)
Approach	-11.0°C (12.14°F)
Exit air velocity	548.6 m/m (1,800 fpm)
Exit air temperature	41.1°C (106°F)
Maximum drift rate	208.2 L/m (55 gpm)
Evaporation loss	43,153 L/m (48,423 max) (11,400 gpm (12,792 max))
Condenser	
Temperature rise	-2.8C° (27F°)
Surface area	57298 m^2 (616,750 ft^2)
Tube material	Admiralty/70-30 Cu-Ni
Tube length	13.7 m (45.0 feet)
Tube diameter	1.9 cm (0.75 inch)

*236,550 L/m (62,490 gpm) occurs after turbine trip when condenser heat load is smaller.

**Based on cooling tower performance curve.

Source: ER-OL

Table 4.3 Expected composition of discharges to Mississippi River

Constituent	River water quality (ppm[1])		Cooling tower blowdown (ppm)		Blowdown with neutralized demineralizer regeneration waste (ppm)	
	Avg[2]	Max[3]	Avg[4]	Max[5]	Avg[6]	Max[7]
Calcium (Ca)	39.4	54 (61)	244.3	365	226	314
Magnesium (Mg)	10.7	18 (24)	66.3	123	61	104
Sodium (Na)	19.5	39 (46)	120.9	261	437	869
Potassium (K)	2.9	5.0 (6.4)	18.0	34	17	29
Bicarbonate (HCO_3)	113.1	174 (204)	78.7	64 (95.5)[8]	87	88 (115)[8]
Sulfate (SO_2)	49.7	90 (90)	798.0	1402	1179	2048
Chloride (Cl)	21.6	50 (68)	133.9	337	128	297
Nitrate (NO_3)	3.4	10 (19)	21.1	66	19	56
Fluoride (F)	0.3	0.7 (1.0)	1.9	4.7	2.6	6.0
Boron (B)	-	-	-	-	1.2	2.8
Silica (SiO_2)	7.7	15 (17)	47.7	100	77	163
Iron (Fe)	0.04	0.24 (0.37)	0.25	1.6	0.3	1.5
Others[9]	1.0	1.5 (-)	6.2	10	5.7	8.5
Total dissolved solids (TDS)	269.34	458	1537.25	2768	2241	3987
Total suspended solids (TSS)	163	446 (463)	<50	<50	<50	<50
pH, units	7.5	8.1 (8.2) 6.8 (6.6)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0
Dissolved oxygen	9.0	12.5 (12.7)	>7	7 (min)	>7	7 (min)
Biocide	-	-	<0.1	0.1	<0.1	0.1

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[1] USGS publication of Mississippi River water quality near St. Francisville, Louisiana, for water years October 1954 to September 1979, expressed as constituent.

[2] Mean of yearly averages.

[3] Mean of each yearly maximum plus one standard deviation. Maximum reported level of each constituent, not necessarily occurring in the same sample, is shown in parentheses.

[4] Based on average river water quality at average concentration factor of 6.2, including pretreatment.

[5] Based on maximum constituent level at maximum concentration factor of 6.7, including pretreatment.

[6] Based on blowdown flow of 4400 gpm, waste flow of 400 gpm (cation-anion and mixed-bed wastes).

[7] Based on operation at full load with blowdown flow of 2200 gpm and maximum solids levels in the river; maximum concentration factor of 6.7; waste flow of 400 gpm (cation-anion wastes).

[8] With acid pretreatment; maximum bicarbonate level (indicated in parentheses) occurs at other than maximum solids concentration.

[9] Including primarily manganese (Mn), phosphorous (P), zinc (Zn), nitrite (NO_2), and phosphate (PO_4), with others in lesser amounts.

Source: ER-OL

Table 4.4 Expected concentration of heavy metals in cooling tower blowdown

Dissolved constituent	River water quality (ppb)[1] Avg	Max	Circulating water (ppb)[2] Avg	Max	Condenser tube metal loss (ppb) Avg	Max	Cooling tower blowdown (ppb) Avg	Max
Copper	5.4	12.0	34	80	721	2164	755	2244
Zinc	13.2	45.5	82	305	262	787	344	1092
Nickel	2.4	7.6	15	51	20	59	35	110
Tin	NR[3]	NR	-	-	10	30	10	30
Arsenic	0.9	2.6	5.6	17	0.3	1.0	6	18
Manganese	19.6	142	121.5	951	0.3	1.0	122	952
Beryllium	1.4	10.0	9	67	-	-	9	67
Cadmium	0.4	3.3	3	22	-	-	3	22
Chromium	1.4	9.5	9	64	-	-	9	64
Cobalt	0.3	2.3	2	15	-	-	2	15
Lead	1.6	6.8	10	46	-	-	10	46
Mercury	0.03	0.14	0.2	0.9	-	-	0.2	0.9
Selenium	0.3	2.0	2	13	-	-	4	25
Vanadium	0.6	3.7	4	25	-	-	4	25

[1] USGS publication of Mississippi River water quality near St. Francisville, Louisiana, for water years October 1974 to September 1979, expressed as constituent.

[2] Based on river water quality with average and maximum concentration factors of 6.2 and 6.7, respectively.

[3] NR = not reported by USGS.

Source: ER-OL

Table 4.5 Expected chemical composition of auxiliary boiler blowdown[1]

Constituent	Concentration reported in ER-OL	Concentration reported in FES-CP
Sodium (Na)	590 ppm	10 ppm
Sulfate (SO_4)	1230 ppm	NA
Total dissolved solids (TDS)	1820 ppm	30 ppm
Hydrazine (N_2H_4)	0.1 to 0.5 ppm	NA[2]
pH (units)	8.0 to 10.0	9.0 to 10.0
Phosphate (PO_4)	NA	10 ppm
Sulfite (SO_3)	NA	5 ppm
Silica (SiO_3)	NA	2 ppm

[1] Based on 4 months' operation per year.

[2] NA = data not available.

Table 4.6 Transmission lines required for the River Bend Station*

Route	Voltage	Termination point	Distance from River Bend to termination point km (miles)
I. Line 746/745	500 kV	Webre Substation	47.0 (29.2)
II.	230 kV	Jaguar Bulk Substation	38.3 (23.8)
Line 352/351	230 kV	Jaguar Bulk Substation	38.3 (23.8)
Line 353	230 kV	Port Hudson Bulk Substation	18.5 (11.5)
Line 354	230 kV	Port Hudson Bulk Substation	18.5 (11.5)
Line 715	230 kV	An existing 230-kV line of the Cajun Electric Power Cooperative	2.9 (1.8)
III. Line 752	500 kV	McKnight Switching Substation	43.9 (27.2)

*Each line is one circuit. Total number of circuit km is 169 (105 miles). Each route will also accommodate future 230-kV lines (see text).

Table 4.7 Mississippi River peak flood stages

Stage	Value
Mean annual stage	20.4 feet msl
Mean annual flood	38.9 feet msl
20-year flood	46.4 feet msl
25-year flood	50.4 feet msl
Project design flood (PDF)	54.5 feet msl
Maximum daily recorded stage	52.1 feet msl
Maximum monthly average recorded stage	49.2 feet msl
Exceeding 40 feet	5% (18 days/year)
Exceeding 45 feet	1% (4 days/year)

Table 4.8 Variations in physiochemical characteristics of the surface waters near the River Bend site

Parameter[1]	Mississippi River near St. Francisville		Mississippi River near River Bend, 1972-1977[3]	Alligator Bayou, 1973-1977[3]	Grant's Bayou, 1972-1977[3]
	1954-1968[2]	1968-1977[3]			
Temperature (°C)	1-31	2-31	3.1-31.5	10.0-29.0	12.0-29.0
Conductivity (µmhos/cm)	173-683	198-567	155-495	40-295	43-238[3]
Dissolved oxygen	-	-	3.3-12.6	0.2-11.0	0.6-12.6
pH	6.7-8.2	6.6-8.2	7.3-8.4	6.5-7.8	6.2-8.4
Turbidity (JTU)[4]	-	-	28-360	22-490	0-188
Alkalinity (as $CaCO_3$)	-	-	23-190	9-106	16-92
Hardness (as $CaCO_3$)	75-204	94-200	70-320	-	42-70
Total iron	-	-	0.00-3.65	-	1.04-3.36[5]
Silica	2.6-15	0.7-9.0	0.0-9.9	-	8.8[6]
Sulfate	28-89	29-90	24.5-86	-	5.0[5]-7.0
Total phosphate	-	-	0.0-2.4	0.0-0.9	0.05-33.0
Nitrate nitrogen	0.2-7.9	0-7	0.0-7.2	0.0-1.6	0.0-1.3

[1] Values in mg/l unless otherwise noted.
[2] As presented in the FES-CP.
[3] As presented in the ER-OL.
[4] JTU = Jackson turbidity unit
[5] No flow; data from isolated pools.
[6] Only one sample.

Sources: ER-OL Tables 2.3-14, 2.3-15, 2.3-16, and 2.3-17

Table 4.9 State of Louisiana water quality criteria for the Mississippi River segment at the River Bend Station

Constituent	Criterion
Chlorides	Not to exceed 75 mg/L
Sulfates	Not to exceed 120 mg/L
Total dissolved solids	Not to exceed 400 mg/L
Dissolved oxygen	No less than 5 mg/L
pH	6.5-9.0
Temperature	Not to exceed 32°C
Total coliform	Monthly arithmetic average of total coliform (most probable number, MPN) not to exceed 10,000 per 100 ml
Fecal coliform	Monthly arithmetic average not to exceed 2000 per 100 ml

Source: Louisiana Stream Control Commission, 1977

Table 4.10 Changes in acreage of forest types as a result of construction on the site

Forest type	Pre-construction		Post-construction		Percentage Loss
	ha	acres	ha	acres	
Upland Forests					
Sweet gum	47.3	116.9	45.7	112.9	3.4
Loblolly pine-sweet gum	86.9	214.7	53.8	132.9	38.1
Sweet gum-lobolly pine	100.8	249.1	37.7	93.2	62.6
Loblolly pine-American beech-sweet gum	10.8	26.7	9.5	23.5	12.0
Sweet gum-cherrybark oak-water oak-winged elm	100.3	247.8	100.3	247.8	0.0
Sweet gum-water oak-green ash-sycamore	64.1	158.4	64.1	168.4	0.0
Sweet gum-water oak-hackberry-Shumard oak	10.9	26.9	0.6	1.5	94.5
Sweet gum-water oak-cherrybark oak-white ash-hackberry-cow oak	129.5	320.0	86.5	213.7	33.2
Sweet gum-American elm-hackberry	23.0	56.8	14.8	36.6	35.7
Box elder-hackberry-sweet gum-sycamore	14.6	36.1	12.9	31.9	11.6
Sweet gum-water oak-cherrybark oak-hickory	96.4	238.2	73.2	180.9	24.1
Loblolly pine	1.4	3.5	1.4	3.5	0.0
Sweet gum-water oak-cherrybark oak-hickory	77.9	192.5	74.5	184.1	4.4
TOTAL	763.9	1887.6	575.0	1420.8	24.7
Bottomland Hardwoods					
Tupelo gum-bald cypress	113.3	280.0	107.5	265.6	5.1
Tupelo gum-hackberry-ash	152.9	377.8	152.9	377.8	0.0
Hackberry-box elder-ash-sycamore	30.9	76.4	27.3	67.5	11.7
TOTAL	297.1	734.1	287.7	710.9	3.2

*Understocked = 11.8 m^2 basal area/ha or 51.3 ft^2 basal area/acre.

**Moderately stocked = 24.1 m^2 basal area/ha or 105 ft^2 basal area/acre.

Source: ER-OL

Table 4.11 Length of transmission line rights-of-way and the amount of forest clearing

Line		Length, km (mi)		Distance through forest, km (mi)		Hectares (acres) cleared	
FES-CP	ER-OL	FES-CP	ER-OL	FES-CP	ER-OL	FES-CP	ER-OL
B	I	51.3 (31.9)	44.7 (27.8)	20.6 (12.8)	19.3 (12.0)	81.5 (201.4)	103.9 (256.7)
C	II	30.9 (19.2)	26.9 (16.7)	7.6 (4.7)	13.0 (8.1)	4.7 (11.6)	41.0 (101.3)
A	III	46.5 (28.9)	42.9 (26.7)	22.0 (13.7)	19.2 (11.9)	109.6 (270.8	88.7 (219.2)
D	none	6.9 (4.3)	- -	3.3 (2.1)	- -	17.3 (42.7)	- -
E	none	4.6 (2.9)	- -	0.8 (0.5)	- -	0.0 (0.0)	- -
	TOTAL	140.2 (87.1)	114.5 (71.2)	54.3 (33.7)	51.5 (32.0)	213.1 (526.6)	233.6 (577.2)

Table 4.12 Ecologically dominant fishes in the lower Mississippi River

Predators (on fishes and larger invertebrates)	Grazers-suckers (on detritus and/or bottom organisms)	Forage fishes (plankton feeders and/or grazers on detritus and bottom organisms)
Shortnose gar	Shovelnose sturgeon	Threadfin shad
Bowfin	Carp	Gizzard shad
Blue catfish	Silver chub	Speckled chub
Channel catfish	River carpsucker	Silvery minnow
Flathead catfish	Smallmouth buffalo	Emerald shiner
White bass	Bigmouth buffalo	River shiner
White crappie	Freshwater drum	Silverband shiner
Black crappie		Shiner hybrids
Sauger		Mimic shiner
		Mosquitofish
		Mississippi silver side

Source: FES-CP Figure 2.6

5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

This section evaluates changes in predicted environmental impacts since the FES-CP was issued September 1974. Section 5.2 describes the impacts of construction of River Bend Station and notes that less acreage is involved than had been predicted in the FES-CP. The estimated evaporative water losses from River Bend Station have decreased from the amount predicted in the FES-CP (Section 5.3.1). The access road connecting the plant area to the intake embayment and the Alligator Bayou crossing was changed from a reinforced bridge to a culverted road (Section 5.3.3.1). Section 5.5.1 discusses the changes in the estimated quantities of chemical constituents in the cooling tower blowdown, and the meteorological data have been updated. Section 5.5.2 addresses aquatic impacts of operation, including intake effects and thermal and chemical discharge effects. Section 5.8 provides the changes in the socioeconomic impacts.

Information in Section 5.9 on radiological impacts has been revised to reflect knowledge gained since the FES-CP was issued. The material on plant accidents contains information that has been revised and updated, including actual experience with nuclear power plant accidents beyond design-basis accidents and the lessons learned from the accident at Three Mile Island Unit 2. Information on the environmental effects of the uranium fuel cycle, decommissioning, noise, and operational monitoring programs is provided in Sections 5.10, 5.11, 5.12, and 5.14.

5.2 Land Use

5.2.1 Plant Site and Vicinity

Impacts on land use at the plant site were evaluated in FES-CP Sections 4.1.1 and 4.1.2 (construction) and 5.1.1 (operation), and current land use on the site is described in Section 4.2.2. The impacts of construction of River Bend Station have generally been as predicted in the FES-CP, except that only 304 ha (751 acres) will be affected by construction instead of the 344 ha (850 acres) indicated in FES-CP Section 4.1.1. The reduced acreage requirement resulted from several factors, including the combining of the 230-kV and 500-kV switchyards into one switchyard, a reduced laydown and spoil area because of the delay and subsequent cancellation of construction of Unit 2, transmission line relocation, and the need for less clearing than expected in some areas. Losses of prime farmland and farmland of statewide importance totaled 153 ha (378 acres) (see Section 4.2.2).

The only aspect of normal plant operation that has potential for land use impact at the site is the emission of drift from the cooling towers and the deposition of this drift on agricultural lands in the vicinity. This potential offsite impact is evaluated in Section 5.5.1 and is expected to be inconsequential. Residential, industrial, highway, and recreational land uses also should not be affected by cooling tower emissions, although the possibility of impacts exists (Section 5.5.1). Some secondary effects on land uses--such as increases in residential and industrial areas--may have resulted from construction of the plant, although such effects have not been documented.

5.2.2 Transmission Lines

Effects of transmission lines on land use were evaluated in FES-CP Section 4.1.3 (construction) and 5.1.2 (operation). Various aspects of transmission line operation (e.g., ozone production) have the potential for impact on land use via effects on biota. These effects are evaluated in Section 5.5.1. None of these potential impacts is expected to be of any consequence to agricultural or other land uses in the area. Cultivation and grazing can continue beneath the lines as they did before construction of the lines, although the tower bases will eliminate a small area of land from these uses, including less than 5 ha (12 acres) of prime farmland (ER-OL Table 4.3-3).

5.3 Water

5.3.1 Water Use Impacts

5.3.1.1 Surface Water Impacts

River Bend Station is located at about river mile (RM) 262. The Mississippi River downstream of the site is used for municipal and industrial water supplies and commercial and sport fisheries. About one million persons receive their domestic water supply downstream of the plant, with the nearest domestic water supply intake located at RM 175.5. The nearest industrial user of river water is a paper mill located about 3.2 km (2 river miles) downstream from the site. Irrigation and livestock watering are not major uses of Mississippi River water in this area.

Under normal operating conditions, Mississippi River water will be withdrawn at an average rate of 0.875 m^3/s (13,870 gpm) maximum rate of 0.96 m^3/s (15,150 gpm). The cooling towers will evaporate an average of 0.72 m^3/s (11,400 gpm); this evaporative loss represents approximately 0.006% of the Mississippi River's average flow rate (about 12,000 m^3/s) and 0.03% of its minimum daily flow rate of record (about 2400 m^3/s).

The estimate for evaporative loss from the River Bend Station has decreased slightly since the FES-CP was issued (Section 4.2.3.2). This consumptive use of Mississippi River water represents less than 0.01% of the river's average flow rate and is not expected to adversely affect any other uses of river water.

Periodic dredging of the intake embayment that was constructed may be necessary. Disposal of dredge spoils will be the same as for embayment construction; material will be placed below the Mississippi River channel bed elevations deemed acceptable by the U.S. Army Corps of Engineers (ER-OL). A temporary increase in turbidity will occur in the Mississippi River near the site during dredging activities, but dredging operations will be in compliance with U.S. Army Corps of Engineers' permit requirements and will not adversely affect long-term water quality.

5.3.1.2 Groundwater

Two 9.4-L/sec (150-gpm) wells approximately 550 m (1800 feet) deep will supply an average of 4.37 L/sec (69.3 gpm) to the plant for domestic water supply. ER-OL Section 2.3.2.1.3 shows that continuous pumping even at abnormally high rates would not seriously impact offsite wells using the same aquifer. The fire protection storage banks will be resupplied by a 50.5-L/sec (800-gpm) well approximately 46 m (150 feet) deep. Pumping from this well will be used only for fire protection requirements, and the cone of depression resulting from pumping will be contained entirely on the site property. Thus, the staff concludes that groundwater use by the plant will not adversely affect other users in the site vicinity. (See also Section 4.3.2.2.2.)

5.3.1.3 Reliability of the Old River Control Structure

The Old River Control Structure, located about 80 km (50 miles) northwest of Baton Rouge, Louisiana, regulates the diversion of flows from the Mississippi River into the Atchafalaya River. The Old River Control Structure was built by and is maintained by the U.S. Army Corps of Engineers.

The Old River Control Structure is not necessary from the standpoint of radiological safety at the River Bend Plant. The plant can lose the Mississippi River as a water supply and still safely shut down.

In regard to reliability of the Old River Control Structure, the Corps of Engineers considers the project to be more than equal to its authorized task for all normal operating conditions, including the design flood, even though the low sill structure was seriously damaged during the flood of 1973. The only remaining weakness in the structure is the ability of the low sill structure to cope with potential emergency situations. A result of the damage to the foundation of the low sill structure during the flood of 1973 is a reduction of the safe maximum differential head that can be placed on the structure from 12 m to 7 m (37 feet to 22 feet). The 7-m (22-foot) limit could be exceeded in a marine accident where barges are drawn into the structure and block the opening. This situation will be remedied in 1985 when an auxiliary control structure that is now under construction is completed (commercial operation of River Bend Station is scheduled to begin in December 1985). In the interim, the Corps of Engineers maintains a 24-hour surveillance of the river and has on station a picket boat to deal with such accidents. Further information may be found in a letter from F. M. Chatry (Corps of Engineers) dated November 22, 1983, to J. E. Booker (GSU) (Booker, 1984).

On the basis of the above discussion, the staff concludes that the probability of failure of the Old River Control Structure in the foreseeable future is very remote and that even if such failure did occur, there would be no significant radiological impacts to the public health and safety.

5.3.2 Water Quality

5.3.2.1 General

Surface water quality is characterized in Section 4.3.2, and the chemical characteristics of blowdown discharges are compared to Mississippi River water in Tables 4.4 and 4.5. The River Bend Station will be discharging cooling tower blowdown, water treatment wastes, and sludge to the Mississippi River, and sanitary and other wastes to Grants Bayou. Effluent limitations and monitoring requirements for the station are specified in NPDES permit LA0042731.

5.3.2.2 Thermal Impacts of Blowdown Discharge

Thermal Discharge

The constant blowdown flow rate of 0.14 m^3/s (2200 gpm) for the station is less than 0.01% of the extreme minimum flow for the Mississippi River near the site (2831 m^3/s). Under winter operating conditions, the greatest temperature difference (ΔT) of 24C° exists between river water at 3.9°C and the blowdown discharge. The staff's predicted far-field thermal plume resulting from the proposed discharge system was modeled for a two-unit discharge using the TWOD computer code (Witten and Long, 1978). As a result of the shallow discharge location, no jet entrainment is expected (Eraslin and Lin, 1982) and, therefore, no near-field dilution is assumed in this analysis. Thermal predictions are made for worst-case winter conditions assuming a discharge rate of 0.4 m^3/s (14.3 ft^3/s), a discharge ΔT of 30.8C° (55F°), an ambient river flow 0.9 m/s (3 ft/s), and an eddy diffusivity of 0.19 m^2/s (2 ft^2/s). It is assumed that the thermal plume is well mixed to a depth of 2.1 m (7 feet) and surface heat transfer is neglected. Results of this model run show a thermal plume attached to the near shore and extending far downstream. The plume is quite narrow, less than 91 m (300 feet) wide or about 17% of the river width, with shoreline excess temperatures up to 2.2C° (4F°) extending more than 1.6 km (1 mile) downstream and with 2.8C° (5F°) excess temperatures occurring up to about 610 m (2000 feet) downstream.

The applicant's two-unit calculations for winter conditions indicated the extent of the thermal plume to be much less than the previous estimate. The extent of the 1C° iostherm at the surface was estimated to be 2.2 m (7.2 feet) wide. The applicant estimated the 1C° isotherm would not reach the river surface in the summer when river water temperatures are the highest (29.4°C) (ER-OL). Although these thermal plume estimates are different, the overall effect on aquatic biota would not be substantially different.

The State of Louisiana Water Quality Criteria (Louisiana Stream Control Commission, 1977) specify a maximum temperature rise of 2.8C° above ambient for streams and rivers and a maximum temperature of 32.2°C. These criteria also require that the mixing zone for waste discharge not exceed 25% of the cross-sectional area and/or volume of flow of a stream. The River Bend thermal discharge would satisfy these criteria.

5.3.2.3 Chemical Impacts of Blowdown Discharge

The normal and standby cooling tower blowdown, auxiliary boiler blowdown, and neutralized chemical waste are combined and discharged to the Mississippi River at a constant rate of 0.28 m^3/s (9.9 ft^3/s). The river flow rate at minimum discharge is 10,000 times the blowdown flow rate, so discharges are rapidly diluted. The NPDES permit for the River Bend Station specifies discharge limitations for the regular and standby cooling tower blowdown, treated chemical waste, and low-level radioactive waste discharges. Chlorine will be controlled to less than 0.1 ppm free residual in the blowdown discharge. Chemicals in the station's blowdown will not impair designated water quality uses.

5.3.2.4 Impacts from Sanitary Wastes

The package sewage treatment plant will treat sanitary wastes to a secondary level of treatment (Table 5.1). Treated effluent at a rate of 39,746 L/day (10,500 gpd) will be discharged to Grants Bayou via the storm drain. Nonradioactive and oil-stripped floor and equipment drainage will add an additional 163 L/min (43 gpm) to this 28-L/min (7-gpm) discharge to the storm sewer. These discharges will usually represent about 1% of the average flow in the upper portion of Grants Bayou; however, these discharges are expected to constitute nearly the total flow in Grants Bayou nearly 70% of the time because of its intermittent nature. Excess well water will also occasionally be discharged to the storm sewer at an average continuous rate of 15 L/min (4 gpm). All of these discharges are controlled by the NPDES permit and are not expected to result in violations of state water quality criteria.

5.3.2.5 Other Waste Discharges

Clarifier sludge from the makeup water treatment system will be diluted to a solids concentration of 0.5% to 4.0% by weight and discharged to the Mississippi River at an average rate of 0.03 m^3/s (1.2 ft^3/s) (ER-OL). The sludge consists of raw river water, coagulated suspended solids, and cationic polymer. Considering the composition of the blowdown, the turbidity of the river, and the river's rapid mixing ability, the applicant estimates the sludge discharge should not be distinguishable beyond 91 m (300 feet) of the outfall and will not adversely impact water quality. The U.S. EPA and the Louisiana Stream Control Commission have approved the discharge of clarifier sludge (White, 1977).

5.3.3 Hydrologic Alterations and Floodplain Effects

5.3.3.1 Effects of Hydrologic Alterations

The principal hydrological alterations related to the construction of the River Bend Station include the relocation and lining of West Creek, the construction of the river access road and berm across Alligator Bayou, and the construction of a barge slip and embayment adjacent to the Mississippi River at the end of the river access road.

West Creek

A portion of West Creek adjacent to the plant area was relocated to an 880-m (2850-foot) Fabriform-lined* channel to reduce the potential for erosion and plant flooding because of local storms. Flows are directed into the lined channel by a drop structure. Riprap has been installed in the stream channel at the downstream end of the lined section to prevent channel undercutting. During the field reconnaissance trip of January 1982, the staff noted that the Fabriform channel supported considerable vegetation. Thus, so the flow-carrying

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*Fabriform is grout-filled nylon fabric.

capacity of the channel is maintained, the deposited sediment will have to be periodically removed from the channel bottom.

River Access Road

An access road connecting the plant area and the intake embayment was constructed across Alligator Bayou. The road was constructed to provide access during construction and operation to the river water intake and the barge slip on the Mississippi. Construction of the road with its 14 culverts has created a flow restriction at about the middle of the bayou. This results in an increase in water levels in Upper Bayou for a given flood event. When water levels in the Upper Bayou reach elevation 37.3 feet msl, water flows directly to the Mississippi over a section of River Road between Alligator Bayou and the Mississippi. Overtopping of this road has occurred naturally in the past, and the increased water levels in the Upper Bayou as a result of the flow restriction increase the potential and duration of road overtopping.

To assess the impact of the river access road, the applicant developed a computer model of the bayou that considered local flows in the watershed, Mississippi River flow into the Bayou upstream from the access road, and backwater effects in the lower portions of Alligator Bayou as a result of high water in the Mississippi River. The model was used to estimate water surface elevations in the Bayou under various flooding conditions, with and without the culverted river access road. Because the culverts can become partially blocked, the model also analyzed culvert blockage.

The staff has reviewed the model and concludes that it appropriately represents the bayou hydrology. However, the staff agrees with the applicant that ultimate verification of the model requires collection of field data and comparison of model results against these data. The applicant set up a monitoring program for this purpose. Gages were placed on both sides of the access road to continuously record upper and lower Bayou water levels. A rain gage was also installed in the Alexander Creek drainage basin, in addition to the existing gage at the onsite meteorological tower. The update of this information is in Attachment A to ER-OL Appendix 2B.

The results of the applicant's analyses are in Table 5.2. The staff's conclusions regarding the effects of the road, based on its evaluation of the applicant's results and field observations are

(1) The river access road has the greatest effect on natural flows having peak stages below the crest of the road.

(2) For natural flows that exceed the crest of River Road, the major effect of the access road construction is increased duration of overtopping.

(3) The only effect of culvert blockage is to increase the duration of overtopping of River Road.

As discussed in Section 4 above, the increased duration of flows that exceed the crest of River Road may be causing increased erosion of the road. To maintain the existing road profile and prevent extension of gullies into Alligator Bayou, the applicant has performed erosion repair work. In the near future, the Corps of Engineers is expected to install a revetment along the levee to stabilize the Mississippi River bank and minimize the impact of levee overtopping.

The staff concludes that the hydraulic effects of the river access road crossing of Alligator Bayou are not significant. In addition, the applicant's policy of repairing erosion caused by overtopping of River Road will alleviate the only flood damage that may, in part, be induced by the road crossing.

Access to the Intake Structure

Of potential concern is the effect of Alligator Bayou and Mississippi River flooding on access to the intake structure. The river access road is the primary access route from the plant to the intake structure. The applicant does not plan to use River Road (along the levee) as an access route to the embayment; therefore, the flooding of River Road is not a concern in this regard. The river access road has a finished grade of 50 feet msl across the bayou and at the intake embayment. Based on the stage information presented in Table 4.7, the crest of the road will be exceeded by Mississippi River flood less than 1% of the time (less than 4 days a year). Four of the most severe floods in the recorded history (in 1973, 1974, 1975, and 1979) are included in the period of record; however, the water level exceeded 50 feet msl only during the 1973 and 1979 floods. It is anticipated that the slight chance for limited access will have no impact on station operation because the intake structure could be accessed by boat during a flood if necessary. The levee along the Mississippi is at a lower elevation than the river access road; therefore, flood flows unable to pass through the culverts would pond in the Upper Bayou and flow over the levee before topping the river access road and preventing access to the intake structure.

Erosion Control

During plant construction, a variety of erosion control measures were implemented at the site. These included stockpiling and use of topsoil, seeding, mulching, drainage channels, and energy dissipators. Despite the control measures taken, some erosion occurred from the primary spoil pile, resulting in sediment deposition in the Wildlife Management Lake. The applicant stated in the ER that this condition will be assessed and appropriate mitigative actions taken before lake construction.

5.3.3.2 Floodplain Effects

Major floodplain construction activities for the River Bend Station include the construction of the barge slip and intake embayment in the Mississippi River and construction of the river access road across Alligator Bayou. The following paragraphs address the floodplain-related effects of these activities.

An excavated embayment containing a barge slip and intake structure is located on the Mississippi River at river mile 262. The Mississippi River has an extensive floodway system that regulates flood flow and level in the site region. The extent of flow storage and diversion as a result of these upstream controls prevents a straightforward probabilistic determination of high flow water levels. For this reason, the Corps of Engineers prepared a project design flood (PDF) study to determine the maximum expected water levels along the river, accounting for floodway system operation and reservoir storage. The PDF water elevation in the vicinity of the site is 54.5 feet msl. The PDF has an estimated return period of greater than 100 years, but an exact determination is not available. The embayment bottom elevation is at -12 feet msl. The entryway to the intake structure is at elevation 60.5 ft msl. The base of each intake screen is at -7.5 feet msl. Therefore, some portion of the structure is in the 100-year floodplain, but because of the relatively small encroachment, it will have no effect on the upstream 100-year flood level. The PDF floodplain for the Mississippi River adjacent to the River Bend plant is shown in Figure 5.1.

The construction of the river access road across Alligator Bayou constricts the bayou flows and increases upstream water levels. However, the results of the applicant's analyses show that when natural flows exceed the River Road crest elevation, the river access road has only minor effect on maximum bayou water levels. For example, for the 10-year recurrence interval rainfall event, assuming the culverts are 75% blocked, the water levels were only 0.4 m (1.3 feet) greater than under natural conditions, and only 0.1 m (0.3 foot) greater than for the 5-year event with the same level of blockage. Therefore, it is the staff's opinion that the effect of the road construction on the 100-year floodplain will not be significant. Furthermore, a major portion of the affected floodplain is within the applicant's property boundary.

Therefore, the staff concludes that the construction of the plant will not have any significant adverse floodplain effects.

5.4 Air Quality

The River Bend site is in a nonindustrial, rural area of Louisiana. It is not subject, on the average, to a great number of poor atmospheric dispersion conditions during the year. (Poor conditions are those characterized by low wind speeds and limited vertical mixing of effluents in the atmosphere and are indicated by the number of days that high air pollution potential is forecast.) In the site area, approximately 10 days in a 5-year period were classified as having high pollution potential (Holzworth, 1972).

The Louisiana Air Control Commission monitors air quality within 50 km of the site. The pollutants monitored are SO_2, TSP, NO_2, and Ox (oxidants). SO_2 and NO_2 levels in the Baton Rouge area from January 1975 to June 1979 complied with Federal and state quality standards; however, the TSP and Ox standards have been exceeded at various times. The instances in which TSP exceeded the standards were highly localized, whereas the instances in which Ox exceeded the standards were region wide.

5.4.1 Emissions

Principal emissions to the atmosphere will result from the operation of the plant's mechanical draft cooling towers. The staff reviewed the applicant's evaluation of the effects of the cooling towers and found that it adequately describes these effects, which are expected to primarily be on the site and near the plant. The principal effect is expected to be a visible plume of water vapor, whose intensity and extent will depend on ambient meteorological conditions. During the winter, in addition to the visible plume, icing on nearby surfaces would be a possibility. However, icing is not expected to be a major impact because temperatures fall below freezing on the average of only 14 hours a year. The effects of cooling tower drift with dissolved salts also are expected to be minimal, and any deposition of dissolved salts should occur primarily near the cooling towers.

5.4.2 Monitoring

The operational meteorological measurement program will be the same as the preoperational program described in Section 4.3.3 of this document and in the FSAR. This program will be reviewed for adequacy with respect to meeting the needs of meteorology monitoring for emergency preparedness, as described in NUREG-0654, and the results will be reported in a supplement to the River Bend Safety Evaluation Report (SER).

5.5 Terrestrial and Aquatic Resources

5.5.1 Terrestrial Resources

5.5.1.1 Cooling Tower Operation

Cooling tower emissions have the potential to cause the following impacts:

(1) Aesthetics may be degraded by cooling tower noise and visible plumes of water vapor emanating from the towers.

(2) Increased ground level fogging and icing resulting from the water droplets in the cooling tower drift may interfere with highway traffic.

(3) Vegetation may be adversely affected by increased icing or by the salts contained in the cooling tower drift deposited on soils or directly on foliage.

(4) Wildlife may be affected by noise and any adverse impacts on vegetation.

(5) Acid vapors may result from the combination of the cooling tower plume with stack releases from nearby industries or fossil fuel power plants.

Section 5.3 of the FES-CP and Section 5.3.3 of the ER-OL analyze these potential impacts.

The applicant calculated the expected salt drift deposition rates in the 16 22.5-degree compass sectors surrounding the cooling tower installation (ER-OL Section 5.3.3), and predicted that the maximum annual average deposition rate will be 16.6 $gm/m^2/yr$ (148 lb/acre/yr), occurring 230 m (750 feet) west of the towers. The FES-CP estimated that 0.8 km (0.5 miles) from the towers the maximum would be 20 $gm/m^2/yr$ (178 lb/acre/yr), occurring in the west-northwest sector. Closer to the towers, the deposition rate was predicted to be higher, but an accurate estimate for short distances could not be obtained with the dispersion model used by the NRC staff.

Some of the difference between the applicant's and the staff's estimates may be because (1) the chemical constituent quantities in the cooling tower blowdown have been reduced since the FES-CP was issued (ER-OL Table 1.3-1), and (2) the meteorological data have been updated. At the nearest site boundary (north sector 805 m or 0.5 mile from the cooling towers), the applicant predicted a deposition rate of about 2.24 $g/m^2/yr$ (20 lb/acre/yr) (ER-OL Figures 5.3-31 to 5.3-34), while the NRC staff predicted a deposition rate of 14 $g/m^2/yr$ (125 lb/acre/yr) (FES-CP Figure 5.3). The applicant predicated that at 1.6 km (1 mile) from the towers an annual average salt deposition rate would be roughly 0.5 $g/m^2/yr$ (4 lb/acre/yr) (ER-OL Figures 5.3-31 to 5.3-34), while the staff predicted a rate of 4.4 $g/m^2/yr$ (40 lb/acre/yr) (FES-CP Figure 5.3).

At the nearest site boundary, the level of deposition predicted by the staff for the more toxic component of the drift, the NaCl, is well below the levels of NaCl that cause leaf damage to sensitive plant species (12 $g/m^2/yr$ or 107 lb/acre/yr (NUREG-0555). About 20% of the drift solids, however, will consist of NaCl; the remainder will consist of the much less toxic ions of sulfate, calcium, bicarbonate, and others.

Therefore, serious impact to vegetation off the site is not anticipated. The applicant will monitor the health of vegetation in the area by the use of infrared photography (ER-OL Section 5.10.6).

Relative humidity was predicted by the applicant to increase by a maximum of 7% on any one day (ER-OL) Section 5.3.3.1.6), and by an annual average of up to 0.14% (ER-OL Table 5.3-3). These changes in humidity are much smaller than the natural variation and should have no effects on terrestrial biota. Noise from the cooling towers and other plant operations will be approximately constant at a low level (a maximum of about 41 to 59 dBA at the site boundary). Wildlife species should quickly become accustomed to this noise, and their population levels should not be adversely affected.

Visible plumes are expected to occasionally extend a distance of 1.6 km (1 mile) from the cooling towers (ER-OL Section 5.3.3.1.5). Ground level fog in areas around the site may occur for an additional 12 hours a year as a result of cooling tower operation (FES-CP Section 5.3.2). This compares with an average of 1150 hours a year of natural fog for the 10-year period 1963-1972. Impacts of increased fogging are, therefore, considered minor. The applicant predicted a maximum increase in icing of 7 hours a year 366 m (1200 feet) from the cooling towers, and no increase beyond 425 m (1400 feet) (ER-OL Table 5.3-2). Although the plumes from natural draft cooling towers at several power plants have been observed to increase cloud cover several thousand feet above the ground, mechanical draft cooling towers are not known to produce such effects (ER-OL Section 5.3.3.1.4). Under certain meteorological conditions, acid aerosols may form from the mixing of the cooling tower plumes with emissions of fossil fuel combustion at the Big Cajun No. 2 power plant about 2.4 km (1.5 miles) southwest of the River Bend Station. The distance separating the two facilities and the much greater height of the Big Cajun stacks (183 m or 600 feet; Olsen, 1978) as compared to the cooling towers (23 m or 75 feet), however, reduces the probability of the occurrence of significant amounts of acid aerosols.

5.5.1.2 Transmission System

The transmission lines will produce small amounts of ozone and nitrogen oxides, electromagnetic fields, and corona noise, and will cause some bird mortality as a result of collisions with structures and conductors. In addition, periodic cutting of vegetation for right-of-way maintenance will affect terrestrial biota.

The electromagnetic fields associated with the lines can cause an induced current in nearby grounded objects, as well as the buildup of voltage on nearby ungrounded objects such as automobiles, electric or nonelectric fences, and rain gutters on buildings. A person or animal who contacts such an object could receive a shock and experience a painful sensation at the point of contact. The strength of the shock depends on the electric field strength, the size of the object, and how well both the object and the person or animal are insulated from the ground.

With constant contact, a person could experience a current level of up to 5 mA (milliamps) under worst case conditions (for a 500-kV line, a large well-insulated vehicle parked under power lines and a well-grounded person). In normal situations, however, conditions that would result in the worst case are rare, and induced currents should be much less than 5 mA. The average let-go level has been estimated as 9 mA for men, 6 mA for women, and 5 mA for children. A current of 4.5 mA has been estimated as a safe let-go level* for children (Lee et al., 1982).

A spark discharge may also occur just before contact is made with the object. This discharge is similar to the static discharge shock a person can experience after walking across a carpet and then touching a metal door knob, although in the case of transmission lines the shock can occur repeatedly at a high frequency (60 times per second) as long as there is a slight space between the person and the object. The energy in a spark discharge can be harmful at levels above 25 J (joules). In the case of 230-kV and 500-kV transmission lines, the energy in a discharge would in the worst case (i.e., for a large vehicle parked under a power line) be usually less than 30 mJ (millijoules) (Lee et al., 1982). To mitigate potential problems with shocks involving induced currents or spark discharges, the NRC staff will require that the applicant provide adequate grounding for objects near the transmission lines in accordance with the National Electric Safety Code (NESC) specification that induced currents not exceed 5 mA. The applicant expects that electric field strength under the power lines will conform with the NESC guidelines (less than 7.5 kV/m maximum within the right-of-way, and less than 2.6 kV/m maximum at the edge of the right-of-way (ER-OL Section 5.6)).

The issue of long-term exposure to electromagnetic fields is of increased concern because higher voltages are utilized. Extensive experience with high voltage lines up to 765 kV and the overall results of numerous studies provide little evidence that transmission lines pose a long-term biological hazard (Lee et at., 1982). With few exceptions, 30 reviews of the literature on biological effects of electromagnetic fields concluded that power-line electromagnetic fields have not been shown to cause harmful effects in plants, animals, or people (ibid). Most of the reviews, however, pointed out the need for further research because of the effects reported in some studies. The applicant has encountered no significant environmental problems associated with electromagnetic fields from its 230-kV and 500-kV power lines (ER-OL Section 5.6.3),

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*The let-go level is the current above which it would not be possible to let go of the ungrounded object.

and should be able to operate the River Bend power lines without significant effect. If problems do arise, it is highly likely that they can be easily eliminated by modifications of the lines or rights-of-way.

Noise, radio and TV interference, and production of ozone and nitrogen oxides result from corona phenomena (electrical discharges in the air around the conductors) associated with the operation of power lines. Corona increases with voltage, adverse weather conditions (e.g., high humidity or fog), and the amount of surface irregularities (e.g., scratches, dirt particles) on the conductors. Modern power lines are designed to limit the occurrence of corona to relatively low levels. Corona noise and possibly some radio and TV interference will be noticeable near the lines. Under adverse weather conditions, a 500-kV line (double circuit) increases the ambient ozone concentration at ground level under the lines by no more than 0.0022 ppm, compared to an average ambient ozone concentration of 0.01 to 0.03 ppm in rural areas (ibid) and a national primary air quality standard of 0.12 ppm. Therefore, ozone production by the power lines is expected to be inconsequential. Production of nitrogen oxides is even less significant (ibid).

Bird mortality will result from collisions of birds with the towers and the conductors. The amount of this mortality cannot be accurately quantified, although Stout and Cornwell (1976) estimated that only 0.07% of the total mortality of waterfowl resulted from collision. Bird collisions with lines are most evident where the lines pass through areas of bird concentration, such as river crossings and wetland areas frequented by large numbers of waterfowl. No such areas are known to exist near the River Bend transmission lines, and the lines should have no greater impact on birds than other transmission lines in the region. Waterfowl are not particularly abundant where the Mississippi River is crossed by the 500-kV line on Route I, according to a personal communication between R. L. Kroodsma (Oak Ridge National Laboratories) and R. E. Noble (LSU) on October 13, 1983.

The power line rights-of-way will be managed by periodic removal of tall-growing trees within the right-of-way and removal or trimming of such trees at the edge of the right-of-way. This maintenance practice is in widespread use among the utilities and should have no unexpected or serious impacts. Population numbers of most of the wildlife species occurring on the right-of-way may fluctuate in accordance with the cutting cycle, with the lows in numbers occurring shortly after the periodic cutting. Pesticides or herbicides will not be used (ER-OL Section 5.6.1), which minimizes the potential for significant impact. Existing roads will be used almost exclusively for right-of-way maintenance (ER-OL Section 5.6.1).

During power line right-of-way maintenance, the primary potential problem is excessive erosion along maintenance roads. The staff will require the applicant, in using existing maintenance roads or construction of new roads, practice appropriate erosion control techniques, such as following contours and constructing appropriately spaced trench drains or water bars to divert water to and off the side of the road.

5.5.2 Aquatic Resources

The potential effects of plant operation on aquatic organisms are of the same type as described in the FES-CP. Since the FES-CP was issued, several changes have occurred in the design of the River Bend Station that could alter the effects of the station's operation on aquatic organisms. These are

- reduction in approach velocities to the intake screens
- constant cooling tower blowdown discharge rate of 0.14 m^3/s (2,200 gpm)
- increased dispersion of cooling tower blowdown and improved dilution characteristics of thermal discharge
- construction of an earth-filled access road rather than a bridge over culverts at Alligator Bayou

5.5.2.1 Intake Effects

The cooling water structure will be inside an embayment that has been constructed (Section 4.2.4.1). Average flow in the Mississippi River channel is 0.1 m/s, while water withdrawal for the plant will create a velocity (perpendicular to the shore) across the embayment of 0.006 m/s (0.02 ft/s). The average velocity in front of the screen face is estimated by the applicant to be 0.15 m/s (0.48 ft/s). The intake structures are designed with low approach velocities during normal operation 0.07 m/s (0.24 ft/s) and backflushing velocities of 0.15 m/s (0.50 ft/s). Wedge-wire screens provide an effective means of minimizing organism mortality from impingement and entrainment (Cannon et al., 1979). The plant requires a small volume of water (0.875 m^3/s) relative to the mean annual river flow of 12,654 m^3/s. The cooling water system for River Bend Station has been designed to minimize the impact to aquatic organisms and is consistent with the EPA recommendations for minimizing the impact relative to the location, design, and capacity of cooling water intake structures (EPA, 1976).

As stated in the FES-CP, impingement of organisms on the intake screens is not likely to be a problem because of low intake velocities. The location of the intake structure in the embayment means it will not block fish movement past the site and it is not located in an important biological area.

Planktonic organisms will be drawn into (entrained in) the intake system. Because phytoplankton densities are greater on the western side of the river, less than 0.01% of the total phytoplankton population at the site will be withdrawn by the cooling system (cooling water intake is less than 0.01% of the average Mississippi River flow at the site). About 46% of the zooplankton population occurs at the eastern side of the river (ER-OL). If one assumes that flow is equally proportioned across the river's width, approximately 0.09% of the total zooplankton population will be withdrawn under average operating conditions. During worst case conditions (low river flow and maximum intake volume), about 0.5% of the total zooplankton population could be entrained.

The freshwater drum and goldeneye have eggs that float and are, therefore, the most likely ichthyoplankton to be entrained. Shad larvae and freshwater drum eggs and larvae constitute about 75% of the ichthyoplankton collected at the site, and both are of commercial importance in the area. Based on 1976 and 1977 collection data for the Mississippi River, the applicant estimated an annual loss to the adult fish population. These estimates are conservative for shad because data for shad fecundity in Lake Erie (Bodola, 1964) are three times the numbers used in these calculations and mortality rate assumptions are high. The 1976 commercial fish landings for Pointe Coupee and West Feliciana parishes were 110,835 kg (244,400 lb) of shad and 16,916 kg (37,300 lb) of freshwater drum (ER-OL), or approximately 733,000 shad and 37,000 drum. The estimated effect of entrainment on the adult fish populations is small, representing a small fraction of the commercial harvest and probably a very small fraction of the normal annual fluctuation in population size of these species in this area of the river.

5.5.2.2 Thermal and Chemical Discharge Effects

Thermal Discharge

As discussed in the FES-CP and Section 5.3.3.2 above, the thermal discharge should not adversely affect aquatic organisms in the Mississippi River. The staff has assessed the facility design and discharge and their relationship to the flow characteristics of the river and concludes that Louisiana state water quality criteria for thermal discharge will be met. Even under worst case conditions, the River Bend thermal plume will allow more than a 75% area and flow as a free zone of passage for organisms. As stated in the FES-CP, there will be no blockage of tributary streams, and the thermal discharge is not expected to adversely impact adult fish, fish spawning, or plankton.

Chemical Discharge

Nonradioactive liquid wastes discharged from the station are identified in Section 4.2.6. The normal and standby cooling tower blowdown, auxiliary boiler blowdown, and neutralized chemical waste are combined and discharged to the Mississippi River. Clarifier blowdown enters the river through a separate pipeline adjacent to the plant blowdown. The remainder of the wastes is combined with storm water runoff and is discharged, via the storm sewer system, to East and West Creeks.

River Bend Station must comply with the discharge limitations assigned by NDPES permit (LA0042731). The State of Louisiana has designated the river reach adjacent to the site for propagation of fish and wildlife and has set appropriate criteria to ensure protection of this use. Sections 4.3.2 and 5.3.3 above describe water quality criteria and water quality impacts associated with operation of the plant.

Sanitary wastes that have been treated to at least secondary standards and have a free available chlorine concentration of less than or equal to 1 mg/L will be discharged to Grants Bayou (ER-OL). This discharge should not adversely affect aquatic life in Grants Bayou because of the degree of treatment for the waste, the intermittent flow of the bayou, and the low discharge flow rate.

Discharge of clarifier sludge (clay, silt, sand, and a neutralized polymer floc) to the Mississippi River will not adversely affect aquatic organisms because of the naturally high levels of suspended solids in this river and rapid dilution. Spoil from periodic maintenance dredging of the embayment will be discharged to the river but will not adversely impact aquatic resources in the area because this is an occasional and short-term activity.

Chlorine, as free and combined available residuals from biocide used in the cooling water system, is toxic to aquatic organisms (Brungs, 1976). Residual biocide in the blowdown will not exceed an average concentration of 0.2 mg/L (ppm) as free available chlorine at the point of discharge or a maximum concentration of 0.5 mg/L. The presence of an additional, but presently unpredictable amount of combined available chlorine in the blowdown will make the total residual chlorine concentration higher than these values. (The EPA Effluent Guidelines and the NPDES permit control the concentration of only free available chlorine in the blowdown from closed cycle cooling water systems.) Chlorination will not exceed 2 hours a day (ER-OL).

Mitigating the potential for adverse effects that this intermittent discharge of residual chlorine may have on receiving water biota are the rapid dilution of the blowdown by the river (which contains no residual chlorine); the small volume and cross-sectional area of the river affected by the discharge; and the lack of interference with tributary stream mouths by the discharge. These characteristics of the station discharge will allow fish and other motile aquatic organisms to avoid any adverse conditions in the discharge plume because of the presence of residual chlorine. Planktonic life forms entrained by the discharge plume could be adversely affected. However, the small volume of the river flow affected by the discharge and the distribution of planktonic forms throughout the river's cross-sectional area will reduce adverse impact.

A comparison of chemical constituent concentrations in the cooling tower blowdown stream with concentrations known to produce toxic effects shows that most constituents are well below toxic levels (ER-OL). Tables 4.3 through 4.5 list chemical concentrations for various discharges. Although maximum calcium and iron concentrations exceed toxic levels, average concentrations do not. Maximum copper concentrations as Cu^{++} (2240 μg/L) occur because of high initial erosion/corrosion rates for condenser tubing. Average copper concentrations are expected to be 760 μg/L. Copper concentrations of 710 μg/L were toxic to bluegill in 96-hour bioassays (EPA, 1976). Even under worst case conditions (low river flow and maximum copper discharge concentrations) and assuming incomplete mixing because of the river's width, copper concentrations after mixing with river waste would be approximately 14 μg/L (Mills et al., 1982). Copper concentrations in the blowdown discharge will not adversely affect aquatic organisms because of rapid dilution and high water velocities (0.44 m/s) in which fish would probably not stay for long periods of time.

The blowdown discharge will be nearly constant at 0.14 m^3/s (2200 gpm) and the minimum flow rate in the Mississippi River at the site is 2830 m^3/s (100,000 cfs). The river flow rate at minimum discharge is 10,000 times the blowdown flow rate; therefore, chemical discharges to the Mississippi River are not expected to adversely affect aquatic resources.

River Access Road over Alligator Bayou

The applicant conducted a floodplain study (Conner, 1981) from 1978 to 1980 to determine if the existing culvert crossing at Alligator Bayou would inhibit migratory fish behavior and to determine the relative importance of periodically inundated areas for fish spawning and/or nursery habitat.

The low catch rates and absence of certain species suggest that the culverts are a partial barrier to migratory fish. A few species, including apparent spawning migrants, did move through the culverts in both directions. The greater diversity and number of adult fish found below the culverts probably indicate that the culverts act as a bottleneck and that fish are attracted to areas of turbulence created by the culverts. Ichthyoplankton sampling data support the hypothesis that floodplains are more important as spawning and/or nursery areas than main stream channels. No clearcut evidence exists for marked differences in quality (productivity) of spawning and/or nursery habitats in comparable areas on opposite sides of the access road.

At the plant site, the Mississippi River overtops its banks at a river stage of +11.3 m (+37 feet) msl. Once this occurs, adult fish can enter the Alligator Bayou system for spawning without crossing through the culvert system. Monitoring data indicate that some fish will cross through the culverts; however, frequent blocking of the culverts by debris would inhibit fish migration. A flood with a low peak stage (less than +11.3 m msl) will cause inundation of the upper floodplain, yet the road embankment and culverts would limit access to potential spawning adults of certain main channel fish (e.g., skipjack herring, smallmouth buffalo, bigmouth buffalo, white bass, shortnose gar, gizzard shad, threadfin shad, and common carp). This worst case flood stage condition occurred once from 1959 to 1980. The frequency of years with no floodplain inundation is greater (about one in seven).

The loss of one-third of the annual reproductive potential of some species in the 16-km (10-mile) reach in question would probably not be detectable in terms of later recruitment to adult populations by the individual year-classes affected, because a low flood stage would also result in a relatively weak year-class. Most of the fish in question are capable of sustaining an occasional year of complete reproductive failure (Conner, 1981). The lowering of the river's levee by natural processes and the U.S. Army Corps of Engineers will increase the frequency of overbank flooding, and thereby reduce the magnitude of an occasional year when productivity in the upper floodplain might be reduced because of the culverts in Alligator Bayou.

5.6 Endangered and Threatened Species

5.6.1 Terrestrial

As described in Section 4.3.5.1, most of the threatened or endangered species potentially occurring in the region do not actually occur regularly at the site. Potential impacts on these species are, therefore, not significant. The threatened American alligator is a permanent resident of wetlands on the site. The use of the site as proposed for the River Bend Station is likely to enhance the status of the alligator in the area, because virtually all of the bottomland habitat on the site will be preserved. In addition, the applicant proposes to create a 13.8-ha (34-acre) lake adjacent to the bottomland area, which might further enhance the alligator population.

5.6.2 Aquatic

No aquatic species of fish or invertebrates in the site vicinity are included on Federal or state lists of endangered or threatened species. Therefore, no impacts on protected species are predicted.

5.7 Historic and Archeologic Sites

The NRC and the State Historic Preservation Office agree that the operation and maintenance of the plant will have no effect on any sites or properties listed on, or eligible for, the National Register of Historic Places (see Appendix E).

5.8 Socioeconomic Impacts

Socioeconomic impacts of the operation of River Bend Station are in FES-CP Section 5.6. It is estimated that 300 workers will be required for station operation, 50 of whom are already at the site. The remaining workers, who will be hired from now until 1985, are likely to reside in locations similar to those where existing plant employees live. Thus, about 4% are expected to reside in Point Coupee, and about 4% in East Feliciana Parish. About 20% are expected to reside in West Feliciana Parish, with the remainder expected to live in East Baton Rouge Parish. Because of the relatively small number of workers required to operate the station, the impact on the communities in which they will reside and on traffic is expected to be minimal.

Scheduled station outages, which are about 3 months long, occur every 12 to 18 months; they normally involve about 400 craft workers and 100 temporary vendor workers. The distribution of these workers' residences is expected to be similar to that of the operating workers' residences (ER-OL page 5.8-5).

The annual payroll for the operating workers is projected to be $15.6 million (1985 dollars). The payroll for temporary contract workers for a scheduled station refueling outage is estimated to be $3.2 million (1985 dollars).

Local purchases of materials and supplies relating to station operation is expected to total about $1 million annually (1985 dollars). Local purchases are expected to be made within an 80-km radius of the station.

According to the applicant, the River Bend Station has qualified for an exemption from ad valorem taxes for 10 years after the plant begins operation. This exemption does not pertain to the property on which the plant is situated (ER-OL page 5.8-3). Table 5.3 shows the estimated ad valorem taxes after the exemption period. The projected taxes are shown for the first 5 years after the exemption period. Table 5.4 shows the estimated sales tax to be paid during the first 5 years of station operation.

5.9 Radiological Impacts

5.9.1 Regulatory Requirements

Nuclear power reactors in the United States must comply with certain regulatory requirements in order to operate. The permissible levels of radiation in unrestricted areas and of radioactivity in effluents to unrestricted areas are recorded in 10 CFR 20, Standards for Protection Against Radiation. These regulations specify limits on levels of radiation and limits on concentrations of radionuclides in the facility's effluent releases to the air and water (above natural background) under which the reactor must operate. These regulations state that no member of the general public in unrestricted areas shall receive a radiation dose, as a result of facility operation, of more than 0.5 rem in 1 calendar year, or if an individual were continuously present in an area, 2 mrems in any 1 hour or 100 mrems in any 7 consecutive days to the total body. These radiation-dose limits are established to be consistent with considerations of the health and safety of the public.

In addition to the Radiation Protection Standards of 10 CFR 20, there are in 10 CFR 50.36a license requirements that are to be imposed on licensees in the form of Technical Specifications on Effluents from Nuclear Power Reactors to keep releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, as low as reasonably achievable (ALARA). Appendix I of 10 CFR 50 provides numerical guidance on dose-design objectives for LWRs to meet this ALARA requirement. Applicants for permits to construct and for licenses to operate an LWR shall provide reasonable assurance that the following calculated dose-design objectives will be met for all unrestricted areas: 3 mrems per year to the total body or 10 mrems per year to any organ from all pathways of exposure from liquid effluents; 10 mrads per year gamma radiation or 20 mrads per year beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems per year to the total body or 15 mrems per year to the skin from gaseous effluents; and 15 mrems per year to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and particulates.

Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with these design objectives will keep average annual releases of radioactive material in effluents at small percentages of the limits specified in 10 CFR 20 and, in fact, will result in doses generally below the dose-design objective values of Appendix I. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to ensure that the public is provided a dependable source of power, even under unusual operating conditions that may temporarily result in releases higher than such small percentages but still well within the limits specified in 10 CFR 20.

In addition to the impact created by facility radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR 51 there are generic treatments of environmental effects of all aspects of the uranium fuel cycle. These environmental data have been summarized in Table S-3 and are discussed in Section 5.10 of this report. In the same manner the environmental impact of transportation of fuel and waste to and from an LWR is summarized in Table S-4 and presented in Section 5.9.3 of this report.

Recently an additional operational requirement for uranium fuel cycle facilities including nuclear power plants was established by the EPA in 40 CFR 190. This regulation limits annual doses (excluding radon and daughters) for members of the public to 25 mrems total body, 75 mrems thyroid, and 25 mrems other organs from all fuel-cycle facility contributions that may impact a specific individual in the public.

5.9.2 Operational Overview

During normal operations of the River Bend Station, small quantities of radioactivity (fission, corrosion, and activation products) will be released to the environment. As required by NEPA, the staff has determined the estimated dose to members of the public outside of the plant boundaries as a result of the radiation from these radioisotope releases and relative to natural-background-radiation dose levels.

These facility-generated environmental dose levels are estimated to be very small because of both the plant design and the development of a program that will be implemented at the facility to contain and control all radioactive emissions and effluents. Radioactive-waste management systems are incorporated into the plant and are designed to remove most of the fission-product radioactivity that is assumed to leak from the fuel, as well as most of the activation and corrosion-product radioactivity produced by neutrons in the reactor-core vicinity. The effectiveness of these systems will be measured by process and effluent radiological monitoring systems that permanently record the amounts of radioactive constituents remaining in the various airborne and waterborne process and effluent streams. The amounts of radioactivity released through vents and discharge points to areas outside the plant boundaries are to be recorded and published semiannually in the Radioactive Effluent Release Reports for the facility.

Airborne effluents will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, waterborne effluents will be diluted with plant waste water and then further diluted as they mix with the Mississippi River beyond the plant boundaries.

Radioisotopes in the facility's effluents that enter unrestricted areas will produce doses through their radiations to members of the general public in a manner similar to the way doses are produced from background radiations (that is, cosmic, terrestrial, and internal radiations), which also include radiation from nuclear-weapons fallout. These radiation doses can be calculated for the many potential radiological-exposure pathways specific to the environment around the facility, such as direct-radiation doses from the gaseous plume or liquid effluent stream outside of the plant boundaries, or internal-radiation-dose commitments from radioactive contaminants that might have been deposited on vegetation, or in meat and fish products eaten by people, or that might be incorporated into milk from cows at nearby farms.

These doses, calculated for the "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure), form the basis of the NRC staff's evaluation of impacts. Actually, these estimates are for a fictitious person because assumptions are made that tend to overestimate the dose that would accrue to members of the public outside the plant boundaries. For example, if this "maximally exposed" individual were to receive the total body dose calculated at the plant boundary as a result of external exposure to the gaseous plume, he/she is assumed to be physically exposed to gamma radiation at that boundary for 70% of the year, an unlikely occurrence.

Site-specific values for various parameters involved in each dose pathway are used in the calculations. These include calculated or observed values for the amounts of radioisotopes released in the gaseous and liquid effluents, meteorological information (for example, wind speed and direction) specific to the site topography and effluent release points, and hydrological information pertaining to dilution of the liquid effluents as they are discharged.

An annual land census will identify changes in the use of unrestricted areas to permit modifications in the programs for evaluating doses to individuals from principal pathways of exposure. This census specification will be incorporated into the Radiological Technical Specifications and satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR 50. As use of the land surrounding the site boundary changes, revised calculations will be made to ensure that the dose estimate for gaseous effluents always represents the highest dose that might possibly occur for any individual member of the public for each applicable foodchain pathway. The estimate considers, for example, where people live, where vegetable gardens are located, and where cows are pastured.

An extensive radiological environmental monitoring program, designed specifically for the environs of the River Bend Station, provides measurements of radiation and radioactive contamination levels that exist outside of the facility boundaries both before and after operations begin. In this program, offsite radiation levels are continuously monitored with thermoluminescent detectors (TLDs). In addition, measurements are made on a number of types of samples from the surrounding area to determine the possible presence of radioactive contaminants that, for example, might be deposited on vegetation, be present in drinking water outside the plant, or be incorporated into cow's milk from nearby farms. The results for all radiological environmental samples measured during a calendar year of operation are recorded and published in the Annual Radiological Environmental Operating Report for the facility. The specifics of the final operational-monitoring program and the requirement for annual publication of the monitoring results will be incorporated into the operating license Radiological Technical Specifications for the River Bend facility.

5.9.3 Radiological Impacts from Routine Operations

5.9.3.1 Radiation Exposure Pathways: Dose Commitments

The potential environmental pathways through which persons may be exposed to radiation originating in a nuclear power reactor are shown schematically in Figure 5.2. When an individual is exposed through one of these pathways, the dose is determined in part by the amount of time he/she is in the vicinity of the source, or the amount of time the radioactivity inhaled or ingested is retained in his/her body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. The annual dose commitment is calculated to be the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing 20 years after the station begins operation. (Calculation for the 20th year, or midpoint of station operation, represents an average exposure over the life of the plant.) However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure because of the turnover of the nuclide by physiological processes and radioactive decay.

There are a number of possible exposure pathways to humans that are appropriate to be studied to determine the impact of routine releases from the River Bend facility on members of the general public living and working outside of the site boundaries, and whether the releases projected at this point in the licensing process will in fact meet regulatory requirements. A detailed listing of these exposure pathways would include external radiation exposure from the gaseous effluents, inhalation of iodines and particulate contaminants in the air, drinking milk from a cow or eating meat from an animal that feeds on open pasture near the site on which iodines or particulates may have deposited, eating vegetables from a garden near the site that may be contaminated by similar deposits, and drinking water or eating fish caught near the point of discharge of liquid effluents.

Other less important pathways include: external irradiation from radionuclides deposited on the ground surface, eating animals and food crops raised near the site using irrigation water that may contain liquid effluents, shoreline boating and swimming activities near lakes or streams that may be contaminated by effluents, drinking potentially contaminated water, and direct radiation from within the plant itself. For the River Bend site there is no drinking water pathway of concern because the first drinking water intake is 139 km (87 miles) downstream of the station and dilution of the station effluent makes any effect of liquid released radioactivity completely negligible.

Calculations of the effects for most pathways are limited to a radius of 80 km (50 miles). This limitation is based on several facts. Experience, as demonstrated by calculations, has shown that all individual dose commitments (>0.1 mrem/year) for radioactive effluents are accounted for within a radius of 80 km from the plant. Beyond 80 km, the doses to individuals are smaller than 0.1 mrem/year, which is far below natural-background doses, and the doses are subject to substantial uncertainty because of limitations of predictive mathematical models.

The NRC staff has made a detailed study of all of the above important pathways and has evaluated the radiation-dose commitments both to the plant workers and the general public for these pathways resulting from routine operation of the facility. A discussion of these evaluations follows.

5.9.3.1.1 Occupational Radiation Exposure for Boiling Water Reactors (BWRs)

Most of the dose to nuclear plant workers results from external exposure to radiation coming from radioactive materials outside of the body rather than from internal exposure from inhaled or ingested radioactive materials. Experience shows that the dose to nuclear plant workers varies from reactor to reactor and from year to year. For environmental-impact purposes, it can be projected by using the experience to date with modern BWRs. Recently licensed 1000-MWe BWRs are operated in accordance with the post-1975 regulatory requirements and guidance that place increased emphasis on maintaining occupational exposure at nuclear power plants ALARA. These requirements and guidance are outlined primarily in 10 CFR 20, Standard Review Plan Chapter 12 (NUREG-0800), and RG 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable."

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

Average collective occupational dose information for 177 BWR reactor years of operation is available for those plants operating between 1974 and 1981. (The year 1974 was chosen as a starting date because the dose data for years prior to 1974 are primarily from reactors with average rated capacities below 500 MWe.) These data indicate that the average reactor annual collective dose at BWRs has been about 790 person-rems, although some plants have experienced annual collective doses averaging as high as about 1660 person-rems/year over their operating lifetime (NUREG-0713, Volume 3). These dose averages are based on widely varying yearly doses at BWRs. For example, for the period mentioned above, annual collective doses for BWRs have ranged from 44 to 3626 person-rems per reactor. However, the average annual dose per nuclear plant worker of about 0.8 rem (ibid) has not varied significantly during this period. The worker dose limit, established by 10 CFR 20, is 3 rems per quarter if the average dose over the worker lifetime is being controlled to 5 rems per year) or 1.25 rems per quarter if it is not.

The wide range of annual collective doses experienced at BWRs in the United States results from a number of factors such as the amount of required maintenance and the amount of reactor operations and inplant surveillance. Because these factors can vary widely and unpredictably, it is impossible to determine in advance a specific year-to-year annual occupational radiation dose for a particular plant over its operating lifetime. There may on occasion be a need for relatively high collective occupational doses, even at plants with radiation protection programs designed to ensure that occupational radiation doses will be kept ALARA.

In recognition of the factors mentioned above, staff occupational dose estimates for environmental impact purposes for River Bend Station are based on the assumption that the facility will experience the annual average occupational dose for BWRs to date. Thus the staff has projected that the collective occupational doses for the River Bend site will be 790 person-rems, but annual collective doses could average as much as twice this value over the life of the plant.

The average annual dose of about 0.8 rem per nuclear-plant worker at operating BWRs and PWRs has been well within the limits of 10 CFR 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear-power-plant workers and compared it in Table 5.5 to published risks for other occupations. Based on these comparisons, the staff concludes that the risk to nuclear-plant workers from plant operation is comparable to the risks associated with other occupations.

In estimating the health effects resulting from both offsite (see Section 5.9.3.2) and occupational radiation exposures as a result of normal operation of this facility, the NRC staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information. Specifically, the staff's estimates are based on information compiled by the National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR I). The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number). The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer-mortality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this report. The staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because there may be biological mechanisms that can repair damage caused by radiation at low doses and/or dose rates. The number of potential cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980 report of the National Academy of Sciences Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR III).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (BEIR I). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology.

The preceding values for risk estimators are consistent with the recommendations of a number of recognized radiation-protection organizations, such as the International Commission on Radiological Protection (ICRP, 1977), the National Council on Radiation Protection and Measurement (NCRP, 1975), the National Academy of Sciences (BEIR, III), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 1982).

The risk of potential fatal cancers in the exposed work-force population at the River Bend facility is estimated as follows: multiplying the annual plant-worker-population dose (about 800 person-rems) by the somatic risk estimator, the staff estimates that about 0.11 cancer deaths may occur in the total exposed population. The value of 0.11 cancer death(s) means that the probability of one cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 11 chances in 100. The risk of potential genetic disorders attributable to exposure of the work force is a risk borne by the progeny of the entire population and is thus properly considered as part of the risk to the general public.

5.9.3.1.2 Public Radiation Exposure.

Transportation of Radioactive Materials

The transportation of "cold" (unirradiated) nuclear fuel to the reactor, of spent irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to waste burial grounds is considered in 10 CFR 51.52. The contribution of the environmental effects of such transportation to the environmental costs of licensing the nuclear power reactor is set forth in Summary Table S-4 from 10 CFR 51.52, reproduced herein as Table 5.6. The cumulative dose to the exposed population as summarized in Table S-4 is very small when compared to the annual collective dose of about 60,000 person-rems to this same population or 26,000,000 person-rems to the U.S. population from background radiation.

- Direct Radiation for BWRs

Radiation fields are produced around nuclear plants as a result of radioactivity within the reactor and its associated components, as well as a result of radioactive-effluent releases. Although the components are shielded, dose rates observed around BWR plants from these plant components have varied from undetectable levels to values on the order of 100 mrems per year at onsite locations where members of the general public were allowed. For newer BWR plants with a standardized design, dose rates have been estimated using special calculational modeling techniques. The calculated cumulative dose to the exposed population from such a facility would be much less than 1 person-rem per year per unit, insignificant when compared with the natural background dose.

Low-level radioactivity storage containers outside the plant are estimated to make a dose contribution at the site boundary of less than 1% of that due to the direct radiation from the plant.

- Radioactive-Effluent Releases: Air and Water

Limited quantities of radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Plant-specific radioisotope-release rates were developed on the basis of estimates regarding fuel performance and descriptions of the operation of radwaste systems in the applicant's FSAR, and by using the calculative models and parameters described in NUREG-0016.

These radioactive effluents are then diluted by the air and water into which they are released before they reach areas accessible to the general public.

Radioactive effluents can be divided into several groups. Among the airborne effluents, the radioisotopes of the fission product noble gases, krypton and xenon, as well as the radioactivated gas argon, do not deposit on the ground nor are they absorbed and accumulated within living organisms; therefore, the noble gas effluents act primarily as a source of direct external radiation emanating from the effluent plume. Dose calculations are performed for the site boundary where the highest external-radiation doses to a member of the general public as a result of gaseous effluents have been estimated to occur; these include the total body and skin doses as well as the annual beta and gamma air doses from the plume at that boundary location.

Another group of airborne radioactive effluents--the fission product radioiodines, as well as carbon-14 and tritium--are also gaseous but these tend to be deposited on the ground and/or inhaled into the body during breathing. For this class of effluents, estimates of direct external-radiation doses from deposits on the ground, and of internal radiation doses to total body, thyroid, bone, and other organs from inhalation and from vegetable, milk, and meat consumption are made. Concentrations of iodine in the thyroid and of carbon-14 in bone are of particular interest.

A third group of airborne effluents, consisting of particulates that remain after filtration of airborne effluents in the plant prior to release, includes fission products such as cesium and strontium and activated corrosion products such as cobalt and chromium. The calculational model determines the direct external radiation dose and the internal radiation doses for these contaminants through the same pathways as described above for the radioiodines, carbon-14, and tritium. Doses from the particulates are combined with those of the radioiodines, carbon-14, and tritium for comparison to one of the design objectives of Appendix I to 10 CFR 50.

The waterborne-radioactive-effluent constituents could include fission products such as nuclides of strontium and iodine; activation and corrosion products, such as nuclides of sodium, iron, and cobalt; and tritium as tritiated water. Calculations estimate the internal doses (if any) from fish consumption, from water ingestion (as drinking water), and from eating meat or vegetables raised near the site on irrigation water, as well as any direct external radiation from recreational use of the water near the point of discharge.

The release rates for each group of effluents, along with site-specific meteorological and hydrological data, serve as input to computerized radiation-dose models that estimate the maximum radiation dose that would be received outside the facility via a number of pathways for individual members of the public, and for the general public as a whole. These models and the radiation-dose calculations are discussed in the October 1977 Revision 1 of RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," and in Appendix B of this statement.

Examples of site-specific dose assessment calculations and discussions of parameters involved are given in Appendix D. Doses from all airborne effluents except the noble gases are calculated for individuals at the location (for example, the site boundary, garden, residence, milk cow, and meat animal) where the highest radiation dose to a member of the public has been established from all applicable pathways (such as ground deposition, inhalation, vegetable consumption, cow milk consumption, or meat consumption.) Only those pathways associated with airborne effluents that are known to exist at a single location are combined to calculate the total maximum exposure to an exposed individual. Pathway doses associated with liquid effluents are combined without regard to any single location, but they are assumed to be associated with maximum exposure of an individual through other than gaseous-effluent pathways.

5.9.3.2 Radiological Impact on Humans

Although the doses calculated in Appendix D are based primarily on radioactive-waste treatment system capability and are below the Appendix I design objective values, the actual radiological impact associated with the operation of the facility will depend, in part, on the manner in which the radioactive-waste treatment system is operated. Based on its evaluation of the potential performance of the ventilation and radwaste treatment systems, the NRC staff has concluded that the systems as now proposed are capable of controlling effluent releases to meet the dose-design objectives of Appendix I to 10 CFR 50.

Operation of the River Bend facility will be governed by operating license Technical Specifications that will be based on the dose-design objectives of Appendix I to 10 CFR 50. Because these design-objective values were chosen to permit flexibility of operation while still ensuring that plant operations are ALARA, 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 for the member of the public subject to maximum exposure will still be very small when compared to natural background doses (~100 mrems per year) or the dose limits (500 mrems per year, total body) specified in 10 CFR 20 as consistent with considerations of the health and safety of the public. As a result, the staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of the River Bend facility.

Operating standards of 40 CFR 190, the Environmental Protection Agency's Environmental Radiation Protection Standards for Nuclear Power Operations, specify that the annual dose equivalent must not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials (radon and its daughters excepted) to the general environment from all uranium-fuel-cycle operations and radiation from these operations that can be expected to affect a given individual. The NRC staff concludes that under normal operations the River Bend facility is capable of operating within these standards.

The radiological doses and dose commitments resulting from a nuclear power plant are well known and documented. Accurate measurements of radiation and radioactive contaminants can be made with very high sensitivity so that much smaller amounts of radioisotopes can be recorded than can be associated with any possible observable ill effects. Furthermore, the effects of radiation on living systems have for decades been subject to intensive investigation and consideration by individual scientists as well as by select committees that have occasionally been constituted to objectively and independently assess radiation dose effects. Although, as in the case of chemical contaminants, there is debate about the exact extent of the effects of very low levels of radiation that result from nuclear-power-plant effluents, upper bound limits of deleterious effects are well established and amenable to standard methods of risk analysis. Thus the risks to the maximally exposed member of the public outside of the site boundaries or to the total population outside of the boundaries can be readily calculated and recorded. These risk estimates for the River Bend facility are presented below.

The risk to the maximally exposed individual is estimated by multiplying the risk estimators presented in Section 5.9.3.1.1 by the annual dose-design objectives for total-body radiation in 10 CFR 50, Appendix I. This calculation results in a risk of potential premature death from cancer to that individual from exposure to radioactive effluents (noble gases or liquid) from 1 year of reactor operations of less than one chance in one million.* The risk of

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*The risk of potential premature death from cancer to the maximally exposed individual from exposure to radioiodines and particulates would be in the same range as the risk from exposure to the other types of effluents.

potential premature death from cancer to the average individual within 80 km (50 miles) of the reactors from exposure to radioactive effluents from the reactors is much less than the risk to the maximally exposed individual. These risks are very small in comparison to natural cancer incidence from causes unrelated to the operation of the River Bend facility.

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation of this facility (that is, 38 person-rems) by the preceding somatic risk estimator, the staff estimates that about 0.005 cancer deaths may occur in the exposed population. The significance of this risk can be determined by comparing it to the natural incidence of cancer death in the U.S. population. Multiplying the estimated U.S. population for the year 2000 (~260 million persons) by the current incidence of actual cancer fatalities (~20%), about 52 million cancer deaths are expected (American Cancer Society, 1978).

For purposes of evaluating the potential genetic risks, the progeny of workers are considered members of the general public. Multiplying the sum of the U.S. population dose from exposure to radioactivity attributable to the normal annual operation of the plant (that is, 38 person-rems), and the estimated dose from occupational exposure (that is, 800 person-rems) by the preceding genetic risk estimators, the staff estimates that about 0.22 potential genetic disorder may occur in all future generations of the exposed population. Because BEIR III indicates that the mean persistence of the two major types of genetic disorders is about 5 generations and 10 generations, in the following analysis the risk of potential genetic disorders from the normal annual operation of the plant is conservatively compared with the risk of actual genetic ill health in the first 5 generations, rather than the first 10 generations. Multiplying the estimated population within 80 km of the plant (~1 million persons in the year 2000) by the current incidence of actual genetic ill health in each generation (~11%), about 550,000 genetic abnormalities are expected in the first 5 generations of the 80-km population (BEIR III).

The risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of the facility are very small fractions of the estimated normal incidence of cancer fatalities and genetic abnormalities. On the basis of the preceding comparison, the staff concludes that the risk to the public health and safety from exposure to radioactivity associated with the normal operation of the facility will be very small.

5.9.3.3 Radiological Impacts on Biota Other Than Humans

Depending on the pathway and the radiation source, terrestrial and aquatic biota will receive doses that are approximately the same or somewhat higher than humans receive. Although guidelines have not been established for acceptable limits for radiation exposure to species other than humans, it is generally agreed that the limits established for humans are sufficiently protective for other species.

Although the existence of extremely radiosensitive biota is possible and increased radiosensitivity in organisms may result from environmental interactions with other stresses (for example, heat or biocides), 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 facility. Furthermore, at all nuclear plants for which radiation exposure to biota other than humans has been analyzed (Blaylock, 1976), there have been no cases of exposure that can be considered significant in terms of harm to the species, or that approach the limits for exposure to members of the public that are permitted by 10 CFR 20. Inasmuch as the 1972 BEIR Report (BEIR I) concluded that evidence to date indicated that no other living organisms are very much more radiosensitive than humans, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this facility.

5.9.3.4 Radiological Monitoring

Radiological environmental monitoring programs are established to provide data where there are measurable levels of radiation and radioactive materials in the site environs and to show that in many cases no detectable levels exist. Such monitoring programs are conducted to verify the effectiveness of inplant systems used to control the release of radioactive materials and to ensure that unanticipated buildups of radioactivity will not occur in the environment. Secondarily, the environmental monitoring programs could identify the highly unlikely existence of releases of radioactivity from unanticipated release points that are not monitored. An annual surveillance (land census) program will be established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs or of the Technical Specifications conditions that relate to the control of doses to individuals.

These programs are discussed generically in greater detail in RG 4.1, Revision 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and in the Radiological Assessment Branch Technical Position, Revision 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program."*

5.9.3.4.1 Preoperational

The preoperational phase of the monitoring program should provide for the measurement of background levels of radioactivity and radiation and their variations along the anticipated important pathways in the areas surrounding the facility, the training of personnel, and the evaluation of procedures, equipment, and techniques. The applicant proposed a radiological environmental-monitoring program to meet these objectives in the ER-CP, and it was discussed in the FES-CP. This early program has been updated and expanded; it is presented in ER-OL Section 6.1.2 and is summarized here in Table 5.7.

The applicant states that the preoperational program will have been implemented at least 2 years before initial criticality of the station to document background levels of direct radiation and concentrations of radionuclides that exist in the environment. The preoperational program will continue up to initial criticality of River Bend Station, at which time the operational radiological monitoring program will commence.

The staff has reviewed the preoperational environmental monitoring plan of the applicant and finds that it is generally acceptable as presented.

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*Available from the Radiological Assessment Branch, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

5.9.3.4.2 Operational

The operational, offsite radiological monitoring program is conducted to provide data on measurable levels of radiation and radioactive materials in the site environs in accordance with 10 CFR 20 and 50. It assists and provides backup support to the effluent-monitoring program recommended in RG 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants."

The applicant states that the operational program will in essence be a continuation of the preoperational program described above. The proposed operational program will be reviewed prior to plant operation. Modification will be based upon anomalies and/or exposure pathway variations observed during the preoperational program.

The final operational-monitoring program proposed by the applicant will be reviewed in detail by the NRC staff, and the specifics of the required monitoring program will be incorporated into the operating license Radiological Technical Specifications.

5.9.4 Environmental Impacts of Postulated Accidents

5.9.4.1 Plant Accidents

The staff has considered the potential radiological impacts on the environment of possible accidents at the River Bend plant site, in accordance with the June 13, 1980, Statement of Interim Policy issued by the NRC. The discussion below reflects the staff's considerations and conclusions.

Section 5.9.4.2 deals with general characteristics of nuclear power plant accidents, including a brief summary of safety measures to minimize the probability of their occurrence and to mitigate the consequences should accidents occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and societal impacts associated with actions to avoid--such health effects as a result of air, water, and ground contamination from accidents--also are identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are described. This is followed by a summary review of safety features of the River Bend facility and of the site that acts to mitigate the consequences of accidents.

The results of calculations of the potential consequences of accidents that have been postulated within the design basis are then given. Also described are the results of calculations for the River Bend site using probabilistic methods to estimate the possible impacts and the risks associated with severe accident sequences of exceedingly low probability of occurrence.

5.9.4.2 General Characteristics of Accidents

The term "accident," as used in this section, refers to any unintentional event not addressed in Section 5.9.3 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Normal release limits are specified in the Commission's regulations in 10 CFR 20 and 10 CFR 50, Appendix I.

There are several features that combine to reduce the risk associated with accidents at nuclear power plants. Safety features in design, construction, and operation, comprising the first line of defense, are to a very large extent devoted to the prevention of the release of these radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defense that are designed to mitigate the consequences of failures in the first line. Descriptions of these features for the River Bend plant are in the applicant's FSAR. The most important mitigative features are described in Section 5.9.4.4(1).

These safety features are designed taking into consideration the specific locations of radioactive materials within the plant; their amounts; their nuclear, physical, and chemical properties; and their relative tendency to be transported into and for creating biological hazards in the environment.

(1) Fission Product Characteristics

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the reactor core in the form of fission products. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent-fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials are also normally present in the water that circulates in the reactor coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant. Table 5.8 lists the inventories of radionuclides that could be expected in a River Bend reactor core.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment depends not only on mechanical forces that might physically transport them, but also on their inherent properties, particularly their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids, and a few are gaseous in nature. These characteristics have a significant bearing on the assessment of the environment radiological impact of accidents.

The gaseous materials include radioactive forms of the chemically inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are low-frequency but credible events (see Section 5.9.4.3). For this reason the safety analysis of each nuclear power plant incorporates a hypothetical design-basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment structure. If these gases were further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure is designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process, and in some chemical forms they may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release from the fuel. If the radionuclides are released to the environment, the principal radiological hazard associated with the radioiodines is ingestion into the human body and subsequent concentration in the thyroid gland. Because of this, the potential for release of radioiodines to the atmosphere is reduced by the use of special systems designed to retain the iodine.

The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperatures, so they have a strong tendency to condense (or plate out) on cooler surfaces. In addition, most of the iodine compounds are quite soluble in, or chemically reactive with, water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release from containment structures that have large internal surface areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may escape into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces (e.g., dew), the radioiodines will show a strong tendency to be absorbed by the moisture.

Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and, therefore, by comparison with the noble gases and iodines, have a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes very high. By the same token, such materials, if they escape by volatilization from the fuel, tend to condense quite rapidly to solid form again when they are transported to a lower temperature region and/or dissolve in water when it is present. The former mechanism can result in production of some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surface features by gravitational settling (fallout) or by precipitation (washout or rainout), where they will become contamination hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years. Many of them decay through a sequence or chain of decay processes, and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes renders the radioactive materials hazardous.

(2) Exposure Pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive materials, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways for radiation and the transport of radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Figure 5.2. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 5.2. One of these is the fallout, onto open bodies of water, of radioactivity initially carried in the air. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This creates the potential for the release of radioactive material into the hydrosphere via groundwater. These pathways may lead to external exposure to radiation and to internal exposure if radioactive material is contacted, inhaled, or ingested from contaminated food or water.

It is characteristic of these pathways that, during the transport of radioactive material by wind or by water, the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The result of these natural processes is to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but they also tend to increase the number who may be exposed. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere, which vary considerably with time and from place to place. This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time.

(3) Health Effects

The cause-and-effect relationships between radiation exposure and adverse health effects are quite complex (National Research Council, 1979; Land, 1980), but these relationships have been more exhaustively studied than have any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rems for a few persons and about 25 rems for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable shortly thereafter. Doses about 10 to 20 times larger, also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in the close proximity of such accidents, if measures are not or cannot be taken to provide protection, such as by sheltering or evacuation.

Lower levels of exposures may also constitute a health risk, but the ability to define a direct cause-and-effect relationship between any given health effect and a known exposure to radiation is difficult, given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necessary to assess such effects on a statistical basis. Such effects include randomly occurring cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. Occurrences of cancer in the exposed population may begin to develop only after a lapse of 2 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), occurrences of cancer may begin to develop at birth (no latent period) and end at age 10 (the plateau period is 10 years). The occurrence of cancer itself is not necessarily indicative of fatality. The health consequences model currently being used is based on the 1972 BEIR Report of the National Academy of Sciences (BEIR I) (National Academy, 1972). Most authorities agree that a reasonable--and probably conservative--estimate of the randomly occurring number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths (although zero is not excluded by the data) per million person-rems. The range comes from the NAS BEIR III report (National Academy, 1980), which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the current NRC health-effects models. In addition, approximately 220 genetic changes per million person-rems would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million person-rems currently used by the staff.

(4) Health-Effects Avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is slow, however, and where the material becomes relatively fixed in its location as an environmental contaminant (such as in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible environmental societal impact of severe accidents is the avoidance of the health hazard rather than the health hazard itself, by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential economic impacts that this can cause are discussed below.

5.9.4.3 Accident Experience and Observed Impacts

The evidence of accident frequency and impacts in the past is a useful indicator of future probabilities and impacts. As of April 1984, there were 79 commercial nuclear power units licensed for operation in the United States at 52 sites, with power-generating capacities ranging from 50 to 1180 MWe. The River Bend unit is designed for an electric power output of 1040 MWe (stretch power). The combined experience with these operating units represents approximately 700 reactor-years of operation over an elapsed time of about 22 years. Accidents have occurred at several of these facilities (Bertini, 1980; NUREG-0651; Thompson and Beckerley, 1964). Some of these accidents have resulted in releases of radioactive material to the environment ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience does not provide a large enough base for a reliable statistical inference. It does, however, suggest that significant environmental impacts caused by accidents are very unlikely over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these units, during the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979. It has been estimated that approximately 2.5 million curies of noble gases (about 0.9% of the core inventory) and 15 curies of radioiodines (about 0.00003% of the core inventory) were released to the environment at TMI-2 (Rogovin, 1980).

No other radioactive fission products were released in measurable quantity. It has been estimated that the maximum cumulative offsite radiation dose to an individual was less than 100 millirems (Rogovin, 1980; President's Commission, 1979). The total population exposure has been estimated to be in the range from about 1000 to 5000 person-rems (this range is discussed on page 2 of NUREG-0558). This exposure could produce between 0 and 1 additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 person-rems, and approximately a half-million cancers are expected to develop in this group over its lifetime (Rogovin, 1980; President's Commission, 1979), primarily from causes other than radiation. Trace quantities (barely above the limit of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were affected.

Accidents at nuclear power plants have also caused occupational injuries and a few fatalities, but none attributed to radiation exposure. Individual worker exposures have ranged up to about 4 rems as a direct consequence of reactor accidents (although there have been higher exposures to individual workers as a result of other unusual occurrences). However, the collective worker exposure levels (person-rems) are a small fraction of the exposures experienced during normal routine operations; these exposures average about 440 to 1300 person-rems in a PWR and 740 to 1650 person-rems in a BWR per reactor-year.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries (Bertini, 1980; Thompson and Beckerley, 1964). Because of inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at Enrico Fermi Atomic Power Plant Unit 1. Fermi Unit 1 was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power 4 years after the accident. It operated successfully and completed its mission in 1973. The Fermi accident did not release any radioactivity to the environment.

A reactor accident in 1957 at Windscale, England, released a significant quantity of radioiodine, approximately 20,000 Ci, to the environment (United Kingdom, 1957). This reactor, which was not operated to generate electricity, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor (characteristic of a graphite-moderated reactor), the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-foot) stack. Milk produced within a 518-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. The United Kingdom National Radiological Protection Board (Crick and Linsley, 1982) estimated that the releases may have caused as many as 260 cases of thyroid cancer, about 13 of them fatal, and as many as 7 deaths from other cancers or hereditary diseases. This kind of accident is unique to an air-cooled reactor and cannot occur in a water-moderated-and-cooled reactor like River Bend.

5.9.4.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, as amended, the NRC conducted a safety evaluation of the application to operate the River Bend Station. Although the

SER contains more detailed information on plant design, the principal design features are presented in the following section.

(1) Design Features

The River Bend unit contains features designed to prevent accidental release of fission products from the fuel and to lessen the consequences should such a release occur. These accident-preventive and mitigative features are referred to collectively as engineered safety features (ESFs). To establish design and operating specifications for ESFs, postulated events referred to as design-basis accidents are analyzed.

An emergency core cooling system (ECCS) is provided to supply cooling water to the reactor core during an accident to prevent or minimize fuel damage. Means of removing heat energy from the containment to prevent its overpressurization following an accident are also provided. The containment system itself is a passive ESF, designed to prevent direct escape of released fission products to the environment.

The River Bend containment systems consist of an inner primary containment and an outer secondary containment. The primary containment is designed to withstand internal pressures resulting from reactor accidents. The secondary containment surrounds all equipment outside primary containment that could handle fission products in the event of an accident. The secondary containment is designed to collect, delay, and filter any leakage from the primary containment prior to its release to the environment.

The secondary containment encloses plant areas that are accessible and, therefore, ventilated during normal operation. Upon detection of a release of radioactivity, normal ventilation is automatically isolated, and an ESF--the standby gas treatment system (SGTS)--assumes control of air flow within and from the secondary containment. The SGTS filters the secondary containment atmosphere and exhausts sufficient filtered air to establish and maintain an internal pressure less than the outside atmospheric pressure. This negative pressure is sufficient to prevent unfiltered air leakage from the building. Radioactive iodine and particulate fission products would be substantially removed from the SGTS flow by safety-grade activated charcoal and high-efficiency particulate filters. The filtered exhaust system also encloses the spent fuel pool.

The main steamlines pass through the secondary containment in going from the reactor to the turbine building. Any leakage of the main steamline isolation valves, therefore, could pass through those lines without being intercepted by the SGTS. To prevent this passage, a main steam positive leakage control system is designed to prevent main steamline isolation valve leakage.

All mechanical systems mentioned above are designed to perform their functions given single failures, and are supplied with emergency power from onsite diesel generators if normal offsite and station power is interrupted.

Much more extensive discussions of these design features may be found in the applicant's FSAR. In addition, the implementation of the lessons learned from the TMI-2 accient--in the form of improvements in design, procedures, and operator training--will significantly reduce the likelihood of a degraded core accident that could result in large releases of fission products to the containment. The applicant will be required to meet the TMI-related requirements specified in NUREG-0737. As noted in Section 5.9.2.1.4, no credit has been taken for these actions and improvements in discussing the radiological risk of accidents in this statement.

(2) Site Features

The NRC reactor site criteria, 10 CFR 100, require that the site for every power reactor have certain characteristics that tend to reduce the risk and potential impact of accidents. The discussion that follows briefly describes the River Bend site characteristics and how they meet these requirements.

First, the site has an exclusion area, as required by 10 CFR 100. The total site area is about 13.5 km^2 (3342 acres). The exclusion area, located within the site boundary, has a minimum radius of 914 meters (3000 feet) from the reactor center to the exclusion area boundary. There are no residents within the exclusion area. The applicant owns all surface and mineral rights in the exclusion area, and has the authority in this area, required by 10 CFR 100, to determine all activities in this area. Two roads traverse the area, allowing access to the plant. One railroad line traverses the exclusion area.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR 100. The LPZ for the River Bend site is a circular area with a 4-km (2.5-mile) radius. Within this zone, the applicant must ensure that there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents in the event of a serious accident. The applicant has projected a population of 855 persons within a 4-km radius in 1985, and estimates that this population will increase to 1613 in the year 2030. Industries, schools and recreational areas are the major sources of transients within a 4.9-km (3-mile) radius of the site. The total number of transients within the LPZ for 1980 was approximately 850. In case of radiological emergency, the applicant has made arrangements to carry out protective actions, including evacuation of personnel in the vicinity of the plant (see also the following section on emergency preparedness).

Third, 10 CFR 100 also requires that the distance from the reactor to the nearest boundary of a densely populated area containing more than about 25,000 residents be at least one and one-third times the distance from the reactor to the outer boundary of the LPZ. Because accidents of greater potential hazards than those commonly postulated as representing an upper limit are conceivable although highly improbable, it was considered desirable to add the population center distance requirement in 10 CFR 100 to provide for protection against excessive doses to people in large centers. The city of Baton Rouge, Louisiana, with a 1980 population of 219,419, and located 27.4 km (17 miles) south of the site, is the nearest population center. The population center distance is at least one and one-third times the LPZ distance. The population density within a 48.3-km (30-mile) radius of the site was 59.1 people/km^2 (153 people/mi^2) in 1980 and is projected to increase to about 120 people/km^2 (311 people/mi^2) by the year 2030.

The safety evaluation of the River Bend site has also included a review of potential external hazards (that is, activities offsite that might adversely affect the operation of the nuclear plant and cause an accident). The review encompassed nearby industrial and transportation facilities that might create explosive, fire, missile, or toxic gas hazards.

The risk to the River Bend station from such hazards has been found to be negligible. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards is in the SER.

(3) Emergency Preparedness

Emergency preparedness plans including protective action measures for River Bend Station have been developed by the applicant and, for offsite areas, by state and local authorities. The onsite plans are being reviewed by the NRC, while the Federal Emergency Management Agency (FEMA) is reviewing the offsite plans. In accordance with 10 CFR 50.47, effective November 3, 1980, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plans are provisions for two emergency planning zones (EPZs). A plume exposure pathway EPZ of about 16 km (10 miles) in radius and an ingestion exposure pathway EPZ of about 80 km (50 miles) in radius are required. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

The NRC and FEMA have agreed that FEMA will make a finding and determination as to the adequacy of state and local government emergency response plans. The NRC will determine the adequacy of the applicant's emergency response plans with respect to the standards listed in 10 CFR 50.47(b), the requirements of Appendix E to 10 CFR 50, and the guidance in NUREG-0654. After the above determinations by the NRC and FEMA, the NRC will make a finding in the licensing process as to the overall and integrated state of preparedness. The NRC staff findings were reported in the River Bend SER. It is the staff's judgment that adequate and tested emergency plans, when implemented, can mitigate the consequences to the public if an accident should occur.

5.9.4.5 Accident Risk and Impact Assessment

(1) Design-Basis Accidents

As a means of ensuring that certain features of the station meet acceptable design and performance criteria, the applicant and the NRC staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment, and calculations have been performed to estimate the potential radiological consequences to persons offsite. For each postulated initiating event, the potential radiological consequences cover a considerable range of values, depending upon how the accident develops and the relevant conditions prevailing during the accident--including wind direction and weather.

In the safety analysis of the River Bend plant, three categories of accidents have been considered. These categories are based upon their probability of occurrence and include (1) incidents of moderate frequency (events that can reasonably be expected to occur during any year of operation), (2) infrequent accidents (events that might occur once during the lifetime of the plant), and (3) limiting faults (accidents not expected to occur but that have the potential for significant releases of radioactivity). The radiological consequences of incidents in the first category, also called anticipated operational occurrences, are discussed in Section 5.9.1. Some of the initiating events postulated in the second and third categories for the River Bend Station are shown in Table 5.9. To evaluate the potential environmental risk inherent in the operation of the River Bend Plant, the applicant has analyzed a variety of accidents, in a more realistic manner, using the guidance of Regulatory Guide 4.2, Revision 2, "Preparation of Environmental Reports for Nuclear Power Plants." The accidents presented in Table 5.9 are similar to some events evaluated in the SER. The applicant's estimates of the radiation doses to individuals at the nearest boundary of the plant during the first 2 hours are also shown in Table 5.9.

These results reflect the expectations that certain engineered safety features designed to mitigate the consequences of the postulated accidents would function as intended. Important assumptions in these evaluations are that the releases considered are limited to noble gases and radioiodines and that other radioactive materials are not released in significant quantities.

The staff does not perform an independent assessment of the potential offsite consequences using realistic assumptions. Instead, the staff estimates potential upper bound exposures to individuals for the same accidents shown in Table 5.9 for the purpose of implementing the provisions of 10 CFR 50 and 100. For the staff evaluations, much more pessimistic assumptions are made as to the course taken by the accident and the prevailing plant conditions. The assumptions used for the "design-basis" accidents include much larger amounts of radioactive material released, additional single failures in equipment, operation of engineered safety features in a degraded mode,* and poor meteorological dispersion conditions. Although not discussed herein, the results of the staff's evaluation are described in detail in the SER.

For comparison with the dose values of Table 5.9, the results taken from the SER show that the limiting whole body exposures are not expected to exceed 17 rems to any individual at the exclusion area boundary. They also show that radioiodine releases have the potential for offsite exposures ranging up to about 54 rems to the thyroid. For such an exposure to occur, an individual would have to be located at a point on the site boundary where the radioiodine concentration in the plume has its highest value and inhale at a breathing rate characteristics of a person jogging for a period of 2 hours. The health risk to an individual receiving such an exposure to the thyroid is the potential

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*The containment system, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR 100.11(a).

appearance of benign or malignant thyroid nodules in about 2 out of 100 cases, and the development of a fatal thyroid cancer in about 1 out of 1000 cases.

None of the calculations of the impacts of design-basis accidents described in this section takes into consideration possible reduction in individual or population exposures as a result of any protective action.

(2) Probabilistic Assessment of Severe Accidents

In this and the following three subsections, the probabilities and consequences of accidents of greater severity than the design basis accidents identified above (in Section 5.9.4.5(1)) are evaluated. As a class, they are considered less likely to occur, but their environmental consequences could be more severe. These more severe accidents, heretofore frequently called Class 9 accidents, can be distinguished from design-basis accidents in two primary respects: they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment.

The assessment methodology employed is that described in the Reactor Safety Study (RSS) (NUREG-75/014), which was published in 1975.* The River Bend Station incorporates a General Electric-designed BWR having similar design and operating characteristics to the Grand Gulf Unit 1 BWR. Therefore, the present assessment for the River Bend Station has used as its starting point the rebaselined accident sequences and sequence groups of the Grand Gulf Unit 1 reactor safety study methodology applications program (RSSMAP), more fully described in Appendix I. Characteristics of the sequences (and sequence groups) used (all of which involve partial to complete melting of the reactor core) are shown in Table 5.10. Sequences initiated by natural phenomena--such as tornadoes, floods, or seismic events--and those that could be initiated by deliberate acts of sabotage are not included in these event sequences. The radiological consequences of such events would not be different in kind from those which have been treated. However, see Section 5.9.2.1.4(7) for discussion of uncertainties.

The calculated probability per reactor-year associated with each accident sequence (or sequence group) used is shown in the second column in Table 5.10. As in the RSS, there are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in the data base on failure rates of individual plant components that were used to calculate the probabilities (see Section 5.9.4.5(7) below). The probability-of-accident sequences from Peach Bottom (the prototype BWR) were used to give a perspective of the societal risk of the River Bend Station because, although the probabilities of particular accident sequences may be substantially different for River Bend, the overall effect of all sequences taken together is likely to be within the uncertainties. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.)

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*Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 5.9.4.5(7).

The magnitudes (curies) of radioactivity releases for each category are obtained by multiplying the release fractions shown in Table 5.10 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 5.8 for a River Bend unit a core thermal power level of 3039 megawatts.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS (NUREG/CR-2300), adapted and modified as described below to apply to a specific site. The essential elements are shown in schematic form in Figure 5.3. Environmental parameters specific to the River Bend site have been used and include the following:

(1) meteorological data for the site representing a full year of consecutive hourly measurements and seasonal variations

(2) projected population for the year 2000 extending throughout regions of 80-km (50-mile) and 563-km (350-mile) radii from the site

(3) the habitable land fraction within a 563-km (350-mile) radius

(4) land-use statistics, on a statewide basis, including farm land values, farm product values including dairy production, and growing season information, for the State of Louisiana and each surrounding state within the 563-km (350-mile) region.

To obtain a probability distribution of consequences, the calculations are performed assuming the releases, as defined by the release categories, at each of 91 different start times throughout a 1-year period. Each calculation used (1) the site-specific hourly meteorological data, (2) the population projections for the year 2000 out to a distance of 563 km (350 miles) around the River Bend site, and (3) seasonal information for the time period following each start time. The consequence model also contains provisions for incorporating the consequence-reduction benefits of evacuation, relocation, and other protective actions. Early evacuation and relocation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage from severe releases. The evacuation model used (see Appendix I) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the River Bend site are estimates made by the staff. There normally would be some facilities near a plant, such as schools or hospitals, where special equipment or personnel may be required to effect evacuation, and there may be some people near a site who may fail to evacuate. Therefore, actual evacuation effectiveness could be greater or less than that characterized, but it would not be expected to be very much less, because special consideration will be given in emergency planning for the River Bend plant to any unique aspects of dealing with special facilities.

The other protective actions include (1) either complete denial of use (interdiction) or permitting use only at a sufficiently later time after appropriate decontamination of food stuffs such as crops and milk, (2) decontamination of severely contaminated environment (land and property) when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels, and (3) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced to such values by radioactive decay and weathering that land and property can be economically decontaminated as in (2) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of, or living in, the contaminated environment.

Early evacuation within the "10-mile" Emergency Planning Zone (EPZ), early relocation of people from outside the EPZ along the plume exposure pathway zone, and other protective actions as mentioned above are considered essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for River Bend include the benefits of these protective actions.

There are also uncertainties in each facet of the estimates of consequences and the error bounds may be as large as they are for the probabilities (see Figure 5.3).

The results of the calculations using this consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions, and costs associated with property damage by radioactive contamination.

(3) Dose and Health Impacts of Atmospheric Releases

The results of the atmospheric pathway calculations of dose and health impacts performed for the River Bend facility and site are presented in the form of probability distributions in Figures 5.4 through 5.9* and are included in the impact summary table, Table 5.11. All of the release categories shown in Table 5.10 contribute to the results, the consequences of each being weighted by its associated probability.

Figure 5.4 shows the probability distribution for the number of persons who might receive bone marrow doses equal to or greater than 200 rems, whole-body doses equal to or greater than 25 rems, and thyroid doses equal to or greater

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*Figures 5.4 through 5.8 are called complementary cumulative distribution functions. They are intended to show the relationship between the probability of a particular type of consequence being equalled or exceeded and the magnitude of the consequence. Probability per reactor-year (r-y) is the chance that a given event will occcur in 1 year for one reactor. Because the different accident releases, atmospheric dispersion conditions, and chances of a health effect (e.g., early fatalities) result in a wide range of calculated consequences, they are presented on a logarithmic plot in which numbers varying over a very large range can be conveniently illustrated by a grid indicated by powers of 10. For instance, 10^6 means one million or 1,000,000 (1 followed by 6 zeroes). The cumulative probabilities of equalling or exceeding a given consequence area also calculated to vary over a large range (because of the varying probabilities of accidents and atmospheric dispersion conditions), so the probabilities are also plotted logarithmically. For instance, 10^{-6} means one millionth or 0.000001.

than 300 rems from early exposure,* all on a per-reactor-year basis. The 200-rem bone marrow dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body dose (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and 300-rem thyroid dose figures correspond to the Commission's guideline values for reactor siting in 10 CFR 100.

Figure 5.4 shows in the left-hand portion that there are approximately 4 chances in 100,000 (4×10^{-5}) per reactor-year that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves initially run almost parallel in horizontal lines shows that if one person were to receive such doses, the chances are about the same that ten to hundreds would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about 5 in 100,000,000 (5×10^{-8}) that 10,000 or more people might receive doses of 200 rems or greater. Virtually all of the exposures reflected in this figure would occur within a 97-km (60-mile) radius.

Figure 5.5 shows the probability distribution for the total population exposure in person-rems; that is, the probability per reactor-year that the total population exposure will equal or exceed the values given. Most of the population exposure up to 1,000,000 person-rems would be expected to occur within 80 km (50 miles), but the more severe releases (as in the first two release categories in Table 5.10) could result in exposure to persons beyond the 80-km range, as shown.

For perspective, population doses shown in Figure 5.5 may be compared with the annual average dose to the population within 80 km of the River Bend site resulting from background radiation of 85,000 person-rems and to the anticipated annual population dose to the general public (total U.S.) from normal plant operation of 38 person-rems (excluding plant workers) (Appendix D, Tables D-7 and D-9).

Figure 5.6 shows the probability distributions for early fatalities, representing radiation injuries that would produce fatalities within about 1 year after exposure. All of the early fatalities would be expected to occur within a 28-km (18-mile) radius and the majority with a 5-km (3-mile) radius. The results of the calculations shown in Figure 5.6 and in Table 5.11 reflect the effect of evacuation within the 16-km (10-mile) plume exposure pathway zone. Figure H.1 in Appendix H shows the sensitivity of the early fatalities to the emergency response variations including (1) no evacuation and relocation after 1 day and (2) no evacuation and relocation after 12 hours.

Figure 5.7 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 80 km are shown separately. Further, the fatal latent cancers

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*Early exposure to an individual includes external doses from the radioactive cloud and the contaminated ground, and the dose from internally deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposure are excluded.

have been subdivided into those attributable to exposures of the thyroid and all other organs.

These complementary cumulative distribution functions are calculated using actual meteorological conditions from a representative 1-year period of record of onsite data. From this 1-year period (8760 consecutive hours) of hourly averaged meteorological observations (wind speed, atmospheric stability, and precipitation), 91 time sequences are used to estimate the dispersion and deposit of radioactive material from each release category into each of 15 sectors corresponding to the 22½° sectors used to report wind direction. The sampling of meteorological data is performed so that all hourly data appear at some time during at least one of the time sequences, and that favorable, unfavorable, and typical atmospheric dispersion conditions are considered. The coupling of 91 time sequences and 16 directions produces 1456 sets of computed consequences for each release category. The probability associated with each set is the product of the probability of the release categories multiplied by the annual probability of the wind blowing into a given sector, divided by 91 to represent the equal likelihood of the meteorological samples. The diversity of meteorological conditions sampled is principally responsible for the general shape of the probability distribution given in Figures 5.4 to 5.8. Combinations of the worst severe accident release category and the most unfavorable meteorological conditions sampled are represented by the extreme of the distribution on the bottom right of each of the plots presented. A detailed description of the atmospheric dispersion model is in WASH-1400, Appendix VI (NUREG-75/014).

(4) Economic and Societal Impacts

As noted in Section 5.9.4.2(4), the various measures for avoidance of adverse health effects, including those resulting from residual radioactive contamination in the environment, are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for the River Bend Station and environs have also been made. Unlike the radiation exposure and health-effect impacts discussed above, impacts associated with adverse health-effects avoidance are more readily transformed into economic impacts.

The results are shown as the probability distribution for costs of offsite mitigating actions in Figure 5.8 and are included in Table 5.11. The factors contributing to these estimated costs include the following:

- evacuation costs
- value of crops contaminated and condemned
- value of milk contaminated and condemned
- costs of decontamination of property where practical
- indirect costs attributable to loss of use of property and incomes derived therefrom

The last-named costs would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 5.8 shows that at the extreme end of the accident spectrum, these costs could exceed several billion dollars, but that the probability that this would occur is exceedingly small (about 1 chance in 1 million per reactor-year).

Additional economic impacts that can be monetized by the RSS consequence model include costs of decontamination of the facility itself. Another cost of impact is the replacement power. Probability distributions for these impacts have not been calculated, but they are included in the discussion of risk considerations in Section 5.9.4.5(6)

(5) Possible Releases to Groundwater

A pathway for radiation exposure to the public and environmental contamination that would be unique for severe reactor accidents could exist from accidents resulting in basemat penetration as indicated in Section 5.9.4.2(2). Consideration has been given to potential environmental impacts of this pathway for River Bend Station. The penetration of the basemat of the containment building can release molten core debris to the strata beneath the plant. The soluble radionuclides in the debris can be leached and transported with groundwater to downgradient domestic wells used for drinking water or the surface water bodies used for drinking water, aquatic food, and recreation. Releases of radioactivity to the groundwater underlying the site could also occur via depressurization of the containment atmosphere or radioactive emergency core cooling water and suppression pool water through the failed containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the liquid pathway generic study (LPGS) (NUREG-0440). The LPGS compares the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for five conventional, generic, land-based nuclear plants and a floating nuclear plant (for which the nuclear reactor would be mounted on a barge and moored in a water body). Parameters for each generic, land-based site were chosen to represent averages for a wide range of real sites and were thus typical, but represented no real sites in particular. The discussion in this section is a summary of an analysis performed to compare the liquid pathway consequences of a postulated accident at the River Bend site with that of the generic, large river, land-based site considered in the LPGS. The comparison is made on the basis of population doses from drinking contaminated water, eating contaminated fish, and shoreline uses such as recreation. The parameters that were evaluated include the amount and rate of release of radioactive materials to the ground, groundwater travel time, sorption on geological media, surface water transport, drinking water usage, aquatic food consumption, and recreation area usage.

All of the reactors considered in the LPGS were Westinghouse pressurized water reactors (PWRs) with ice condenser containments. There are likely to be significantly different mechanisms and probabilities of releases of radioactivity for the River Bend BWR. The staff is not aware of any studies that indicate the probabilities or magnitudes of liquid releases for BWRs. The source term release fractions used for River Bend in this comparison are assumed to be equal to those used in the LPGS.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, alternative sources of water for drinking, irrigation, and industrial uses would be expected to be found, if necessary. Commercial and sports fishing, as well as many other related activities could be restricted. The consequences would, therefore, be largely economic or social, rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

The River Bend site is on the east bank of the Mississippi River at about RM 262. The power block is located on a bluff about 3.05 km (10,000 feet) from and 23 m (75 feet) above the river. Three aquifer systems are found in the immediate vicinity of the site: these are the Mississippi River Alluvial Aquifer, the Upland Terrace Aquifer, and the Tertiary Aquifer system. All of the aquifers are unconsolidated sedimentary deposits, comprised predominantly of sandy materials. Groundwater flow in the Upland Terrace and Alluvial Aquifers is generally toward the Mississippi River.

Should a core melt accident occur at the River Bend site and the leached radionuclides find a path through the concrete basemat, the effluent would move immediately into the Upland Terrace Aquifer and move down gradient toward the Alluvial Aquifer and the Mississippi River.

The applicant performed pumping and laboratory tests of the two aquifers and estimated the permeability of the Upland Terrace aquifer to be 8.8×10^{-4} m/sec (2.9×10^{-3} ft/sec) with an effective porosity of 0.28. Both of these values are within the range of values to be expected for the type of material in the aquifer and are considered reasonable by the staff. The applicant did not present a permeability estimate for the alluvial aquifer, but did present the results of a pumping test on the aquifer by a transmissibility value. The staff used this value and the description of the aquifer characteristics to estimate a permeability of 1×10^{-3} m/sec (3.3×10^{-3} ft/sec). For the transport calculation, the staff assumed the entire pathway to the river to have a permeability of 9.1×10^{-4} m/sec (3×10^{-3} ft/sec) and an effective porosity of 0.28. Using an average gradient of 0.0037, a travel time to the Mississippi River of just over 8 years was calculated.

It was demonstrated in the LPGS that for hold-up times on the order of years, virtually all the liquid pathway population dose results from Sr-90 and Cs-137. Therefore, only these two radionuclides are considered in the remainder of this analysis.

The radionuclides Sr-90 and Cs-137 usually move much slowly than groundwater because of the effects of sorption (ion exchange) on the geologic media. Based on measured distribution coefficients (Kd) for similar soil types (NUREG/CR-0912), a Kd of 2 was selected for Sr-90 and a Kd of 20 for Cs-137. Both Kd values selected are on the low side of representative values and are, therefore, considered to be conservative. From these Kd values, retardation coefficients of 15.3 for Sr-90 and 143.8 for Cs-137 were determined for the transport media. The calculated radionuclide travel times are then 124 years for Sr-90 and 1163 years for Cs-137. The radionuclide travel times for Sr-90 and Cs-137 in the LPGS are 5.7 years and 51 years, respectively. Because of radioactive decay, the estimated amount of Sr-90 entering the Mississippi River will be reduced to about 5% of the amount determined in the LPGS. The amount of Cs-137 will be about 11 orders of magnitude less than that in the LPGS, and its contribution to population dose via the various pathways (drinking water, fish consumption, and recreation activities) need not be considered further.

For the large-river generic site, the contribution of Sr-90 to dose sources other than drinking water is only about 6%. Therefore, if only Sr-90 is present in the Mississippi River in a significant quantity, drinking water will be the only significant large-scale pathway to humans.

The drinking water dose from the River Bend site may be compared to that from the generic site by multiplying the ratios of dilution, water users, and Sr-90 entering the river. Because the dilution flow for each case was the harmonic mean flow in the lower Mississippi River, the ratio of dilution is 1 to 1. The number of drinking water users downstream of the River Bend site is about 1.2 million people, and the number of drinking water users assumed for the generic site is 100,000; hence the ratio of drinking water users is 12 to 1. As stated previously, the ratio of Sr-90 entering the river from the River Bend site to that from the generic site is 1 to 20. The dose due to Sr-90 in drinking water from a core-melt accident at the River Bend site is then determined to be about 60% of the drinking water dose from the generic site (1 x 12 x 0.05 = 0.60). Because the contribution of Sr-90 is about 74% of the total drinking water dose and the drinking water dose is about 88% of the total dose for the generic site, the total dose for River Bend is 39% of the total dose for the generic site (0.74 x 0.88 x 0.60 = 39%). The staff, therefore, concludes that the River Bend site is not unusual in its liquid pathway contribution to risk.

In addition, there are measures that would be taken to minimize the impact of the liquid pathway. The staff estimated that the minimum groundwater travel time from the River Bend Station to the Mississippi River would be about 8 years and that the holdup of much of the radioactivity would be even greater. This would allow ample time for mitigation measures such as slurry walls, well point dewatering, and other measures to be completed in time to protect downstream drinking water and fisheries. A comprehensive discussion of mitigation measures applicable to this type of accident is presented in Harris (1982).

(6) Risk Considerations

Environmental Risks

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Because the ranges of both factors are quite broad, it is also useful to combine them to obtain average measures of environmental risk. Such averages provide a useful perspective and can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with normal operational releases.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time. Such a quantification of risk does not at all mean that there is universal agreement that the peoples' attitudes about risks, or what constitutes an acceptable risk, can or should be governed solely by such a measure. At best, it can be a contributing factor to a risk judgment, but not necessarily a decisive factor.

Table 5.12 shows average values of risk associated with population dose, early fatalities, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Because the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

The population exposures and latent cancer fatality risks may be compared with those for normal operation shown in Appendix D. The comparison (excluding exposure to the plant personnel) shows that the accident dose risks (expressed in person-rems) to the 80-km population are about 5 times higher than the normal operation dose to the entire population.

The latent cancer fatality risks from potential accidents can also be compared to the cancer risk from all other sources. For accidents, this risk, averaged over those within 80 km (50 miles) of the River Bend plant, is 1.9×10^{-8} per year per person, compared with the cancer fatality risk from all other sources of 1.9×10^{-3} per year.

There are no early fatality or economic risks associated with protective actions and decontamination for normal releases; therefore, these risks are unique for accidents. For perspective and understanding of the meaning of the early fatality risk of 6×10^{-5} (with supportive medical treatment) per reactor-year; however, the staff notes that a good approximation of the population at risk is that within about 16 km (10 miles) of the plant--about 28,900 persons in the year 2010. Accidental fatalities per year for a population of this size, based on overall averages for the U.S., are approximately 6.4 from motor vehicle accidents, 2.2 from falls, 0.89 from drowning, 0.84 from burns, and 0.35 from firearms. The average early fatality risk from reactor accidents is thus an extremely small fraction of the total risk from accidents.

Figure 5.9 shows the calculated risk expressed as whole-body dose to an individual from early exposure as a function of the downwind distance from the plant within the plume exposure pathway zone. The values are on a per-reactor-year basis, and all accident sequences and release categories in Table 5.10 contributed to the dose, weighted by their associated probabilities.

Evacuation and other protective actions can reduce the risk to an individual of early fatality or of latent cancer fatality from accidents at River Bend. Figure 5.10 shows lines of constant risk of early fatality per reactor-year to an individual living within the emergency planning zone of the River Bend site as a function of location. Figure 5.11 shows similar curves of constant risk of latent cancer fatality. Directional variation of these plots reflects the variation in the average fraction of the year the wind would be blowing in different directions from the plant. For comparison, the following risks of fatality per year to an individual living in the United States may be noted: automobile accident, 2.2×10^{-4}; falls, 7.7×10^{-5}; drowning, 3.1×10^{-5}; burning, 2.9×10^{-5}; and firearms, 1.2×10^{-5} (National Research Council, 1979).

The economic risk associated with evacuation and other protective actions could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels--coal or oil, for example--would cause substantial quantities of sulfur dioxide and nitrogen oxides to be emitted into the atmosphere and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (ibid, pages 550-560). This effect has not, however, been sufficiently quantified for a useful comparison to be drawn at this time.

Other Economic Risks

There are other economic impacts and risks that can be monetized but that are not included in the cost calculations discussed earlier. These are accident impacts on the facility itself that result in added costs to the public (ratepayers, taxpayers, and/or shareholders). These costs would be for decontamination and repair or replacement of the facility, and replacement power. Experience with such costs is currently being accumulated as a result of the TMI-2 accident. If an accident occurs during the first full year of River Bend operation (1986), the economic penalty associated with the initial year of the unit's operation is estimated at $1650 million for decontamination and restoration, including replacement of the damaged nuclear fuel (recovery costs). This is based on conservative (high) 10% escalation of the $950 million cost in 1980 dollars estimated for TMI-2 (Comptroller General, 1981). Although insurance would cover $300 million or more the recovery costs, the insurance is not credited against this cost because the $300 million times the risk probability should theoretically balance the insurance premium. In addition, staff estimates additional fuel costs of $107 million (1986 dollars) for replacement power during each year the River Bend unit is being restored. This estimate assumes conservatively (high cost) that 67% of the energy that would have been forthcoming from the unit (assuming a 55% capacity factor) will be replaced by gas-fired generation and 33% by coal-fired generation. Assuming the nuclear unit does not operate for 8 years, the total additional replacement power costs would be approximately $856 million in 1986 dollars.

The probability of a core melt or severe reactor damage is assumed to be about 10^{-4} per reactor-year. (This accident probability is intended to account for all severe core damage accidents leading to large economic consequences for the owner, not just those leading to significant offsite consequences.)

Multiplying the previously estimated costs of approximately $2500 million for an accident to the River Bend unit during the initial year of its operation by the above 10^{-4} probability results in an economic risk of approximately $250,000 (in 1986 dollars or $141,000 in 1980 dollars) applicable to River Bend during its first year of operation. This is also approximately the economic risk (in 1986 dollars) to the River Bend unit during the second and each subsequent year of its operation. Although nuclear units depreciate in value and may operate at reduced capacity factors so that the economic consequences as a result of an accident become less as the units become older, this is conservatively (high cost) considered to be offset by a slightly higher escalation rate than discount rate.

Regional Industrial Impacts

A severe accident that requires the interdiction and/or decontamination of land areas could force numerous businesses to temporarily or permanently close. These closures would have additional economic effects beyond the contaminated areas through the disruption of regional markets and sources of supplies. This section provides estimates of these impacts that were made using: (1) the RSS consequence model discussed elsewhere in this section, and (2) the regional input-output modeling system (RIMS II), developed by the Bureau of Economic Analysis (BEA) (NUREG/CR-2591).

The industrial impact model developed by BEA takes into account contamination levels of the physically affected areas defined by the RSS consequence model. Contamination levels define an interdicted area immediately surrounding the plant, followed by an area of decontamination, an area of crop interdiction, and finally an area of milk interdiction. (The industry-specific impacts are estimated for the five levels of accident severity listed in Table 5.13.)

Assumptions used in the analysis include

- In the interdicted area, all industries would lose total production for more than a year.
- In the decontamination zone, there would be a 3-month loss in nonagricultural output; a 1-year loss in all crop output, except no loss in greenhouse, nursery, and forestry output; a 3-month loss in dairy output; and a 6-month loss in livestock and poultry output.
- In the crop interdicted area, there would be no loss in nonagricultural output; a 1-year loss in agricultural output, except no loss in greenhouse, nursery, and forestry output; no loss in livestock and poultry output; and a 2-month loss of dairy output.
- In the milk interdiction zone, there would be a 2-month loss in dairy output.

The estimates of industrial impacts are made for an economic study area that consists of a physically affected area and a physically unaffected area. An accident that causes an adverse impact in the physically affected area (for example, the loss of agricultural output) could also adversely affect output in the physically unaffected area (for example, food processing). In addition to the direct impacts in the physically affected area, the following additional impacts could occur in the physically unaffected area:

- decreased demand (in the physically affected area) for output produced in the physically unaffected area
- decreased availability of production inputs purchased from the physically affected area

Only the impacts occurring during the first year following an accident are considered. The longer term consequences are not considered because they will widely vary depending on the level and nature of efforts to mitigate the accident consequences and to decontaminate the physically affected areas. The estimates assume no compensating effects (such as the use of unused capacity in the physically unaffected area to offset the initial lost production in the physically affected area, or income payments to individuals displaced from their jobs that would enable them to maintain their spending habits). These compensating effects would reduce the industrial impacts. Realistically, these compensating effects would occur over a lengthy period. The estimates using no compensating effects are the best measures of first year economic impacts.

Table 5.13 presents the regional economic output and employment impacts and corresponding expected risks associated with the five different release categories. The estimated overall risk values using output losses as the measure of accident consequences, expressed in a per-reactor-year basis, is $19,719. This number is composed of direct impacts of $11,320 in the nonagricultural sector and $6238 in the agricultural sector, and indirect impacts of $2161 from decreased exports and supply constraints. The corresponding expected employment loss per reactor year is about 0.8 job.

It should be noted that 20% of the expected losses or $3776 results from releases occurring toward the south-southeast. The BWR-2B sequence contributes $2222 of that amount. On an absolute basis, BWR-2A, 2B, and 2C releases to the south-southeast are the greatest and would result in a loss of $1.6 billion and 68,000 jobs. For each release category, for all directions, the minimal expected losses range from $1 to $215 per reactor year. The staff has also considered the health care costs resulting from hypothetical accidents in a generic model developed by the Pacific Northwest Laboratory (Nieves, 1983). Based on this generic model, the staff concludes that such costs may be a fraction of the offsite costs evaluated herein, but that the model is not sufficiently constituted for application to a specific reactor size.

(7) Uncertainties

The probabilistic risk assessment discussed above has been based mostly on the methodology presented in the RSS, which was published in 1975. Although substantial improvements have been made in various facets of the RSS methodology since publication of NUREG-75/014, there are still large uncertainties in the results of the analysis presented in the preceding sections, including uncertainties associated with the likelihoods of the accident sequences and containment failure modes leading to the release categories, the source terms for the release categories, and the estimates of environmental consequences. The relatively more important contributors to uncertainties in the results presented in this environmental statement are as follows:

(a) Probability of occurrence of accident: If the probability of a release category would change by a certain factor, the probabilities of various types of consequences from that release category would also change exactly by the same factor. Thus, an order of magnitude uncertainty in the probability of a release category would result in an order of magnitude uncertainty in both societal and individual risks stemming from the release category. As in the RSS, there are substantial uncertainties in the probabilities of the release categories. This is due, in part, to difficulties associated with the quantification of human error, and to inadequacies in the data base on failure rates of individual plant components and in the data base on external events and their effects on plant systems and components that are used to calculate the probabilities.

Another related area of uncertainty is risks from externally caused accidents (such as earthquakes, floods, and human-caused events--including sabotage). No evaluations of such risks have been made for River Bend.

Some of these types of risks have been evaluated for the Indian Point reactors in New York State, the Limerick reactors in Pennsylvania, and for the Zion reactors in Illinois; such risks were found within a factor of less than 100 times greater than risks from internally initiated accidents at the corresponding plants. Such experiences in plant-specific probabilistic risk assessments cannot be extended directly to River Bend because of site and plant design characteristics. However, the staff judges such risks to be within the uncertainty bounds discussed below.

(b) Quantity and chemical form of radioactivity released: This relates to the quantity of each radionuclide species that would be released, and its chemical form, from a reactor unit during a particular accident sequence.

Such releases would originate in the fuel, and would be attenuated by physical and chemical processes in route to being released to the environment. Depending on the accident sequence, attenuation in the reactor vessel, the primary cooling system, the containment, and adjacent buildings would influence both the magnitude and chemical form of radioactive releases. The source terms used in the staff analysis were determined using the RSS methodology applied to a PWR with a large dry containment. Information available in NUREG-0772 indicates that the best-estimate source terms cannot be much worse than the larger source terms used in this analysis (release categories 2a and 2c of Table 5.10), but they could be substantially lower than the release categories used here for the same types of initiating accident sequences. The impact of smaller source terms would be substantially lower estimates of health effects, particularly early fatalities and injuries.

(c) Atmospheric dispersion modeling for the radioactive plume transport, including the physical and chemical behavior of radionuclides in particulate form in the atmosphere: This uncertainty relates to the differences in modeling the atmospheric transport of radioactivity in gaseous and particulate states and the actual transport, diffusion and deposition or fallout that would occur during an accident (including the effects of condensation and precipitation). The phenomenon of plume rise resulting from heat associated with the atmospheric release, effects of precipitation on the plume, and fallout of particulate matter from the plume all have considerable impact on the magnitudes of early health consequences and on the distance from the reactor to which these consequences would occur. The staff judgment is that these factors can result in substantial overestimates or underestimates of both early and later effects (health and economic).

Other areas that have substantial but relatively less effect on uncertainty than the preceding items are

(a) Duration and energy of release, warning time, and inplant radionuclide decay time: This relates to the differences between assumed release duration, energy of release, and the warning and the inplant radioactivity decay times compared with those that would actually occur during a real accident.

For a relatively long duration of an atmospheric release, the actual crosswind spread (the width) of the radioactive plume that would develop could be larger than the width calculated by the dispersion model in the staff consequence evaluation code (NUREG-0340). However, the effective width of the plume is calculated in the code using a plume expansion factor that is determined by the release duration. For a given quantity of radionuclides in a release, the plume and, therefore, the area that would come under its cover would become wider if the release duration were made longer. In effect, this would result in lower air and ground concentrations of radioactivity, but a greater area of contamination.

The thermal energy associated with the release affects the plume rise phenomenon, which results in relatively lower air and ground concentrations in the closer regions and in relatively higher concentrations as a result of fallout in the regions that are more distant. Therefore, if a large amount of thermal energy were associated with a release containing large fractions of core inventory of radionuclides, it could increase the distance from the reactor over which early health effects may occur. If, on the other hand, the release behavior were dominated by the presence of large amounts of condensing steam, very much the reverse could occur because of the close deposition of radionuclides induced by the falling water condensed from the steam.

Warning time before evacuation has considerable impact on the effectiveness of offsite emergency response. Longer warning times would improve the effectiveness of the response.

The time from reactor shutdown until the beginning of the release to the environment (atmosphere), known as the time of release, is used to calculate the depletion of radionuclides by radioactive decay within the plant before release. The depletion factor for each radionuclide (determined by the radioactive decay constant and the time of release) multiplied by the release fraction of the radionuclide and its core inventory determines the actual quantity of the radionuclide released to the environment. Later releases would result in the release of fewer curies to the environment for given values of release fractions.

The first three of the above parameters (duration and energy of release and warning time) can have significant impacts on accident consequences, particularly early consequences. The staff judgment is that the early consequences and risks calculated for this review could be substantial underestimates or substantial overestimates, because of uncertainties in the first three parameters.

(b) Meteorological sampling scheme used: This relates to the possibility that the meteorological sequences used with the selected 91 start times (sampling) in the CRAC code may not adequately represent all meteorological variations during the year, or that the year of meteorological data may not represent all possible conditions. This factor is judged to produce greater uncertainties for early effects and fewer for latent effects.

(c) Emergency response effectiveness: This relates to the differences between modeling assumptions regarding the emergency response of the people residing near the River Bend site compared to what would happen during an actual severe reactor accident. Included in these considerations are such subjects as evacuation effectiveness under different circumstances, possible sheltering and its effectiveness, and the effectiveness of population relocation. The staff judgment is that the uncertainties associated with emergency response effectiveness could cause large uncertainties in early health consequences. The uncertainties in latent health consequences and costs are considered smaller than those for early health consequences. A limited sensitivity analysis in this area is presented in Appendix H.

(d) Dose conversion factors and dose response relationships for health consequences, including benefits of medical treatment: This relates to the uncertainties associated with estimates of dose and early health effects on individuals exposed to high levels of radiation. Included are the uncertainties associated with the conversion of contamination levels to doses, relationships of doses to health effects, and considerations of the availability of what was described in the RSS as supportive medical treament (a specialized medical treatment program of limited availability that would minimize the early health effect consequences of high levels of radiation exposure following a severe reactor accident). Staff analysis indicates that uncertainty from this last source is less than a factor of 3.

(e) Dose-conversion factors and dose-response relationships for latent health consequences: This relates to the uncertainties associated with dose estimates and latent (delayed and long-term) health effects on individuals exposed to lower levels of radiation and on their succeeding generations. Included are the uncertainties associated with conversion of contamination levels to doses and doses to health effects. The staff judgment is that this category has a large uncertainty. The uncertainty could result in relatively small underestimates of consequences, but also in substantial overestimates of consequences. (Note: radiobiological evidence on this subject does not rule out the possibility that low level radiation could produce zero consequences.)

(f) Chronic exposure pathways, including environmental decontamination and the fate of deposited radionuclides: This relates to uncertainties associated with chronic exposure pathways to humans from long-term use of the contaminated environment. Uncertainty arises from the possibility of different protective action guide levels that may actually be used for interdiction or decontamination of the exposure pathways from those assumed in the staff analysis. Further, uncertainty arises because of lack of precise knowledge about the fate of the radionuclides in the environment as influenced by natural processes such as runoff and weathering. The staff's qualitative judgment is that the uncertainty from these considerations is substantial.

(g) Economic data and modeling: This relates to uncertainties in the economic parameters and economic modeling, such as costs of evacuation, relocation, medical treatment, cost of decontamination of properties, and other costs of property damage. Uncertainty in this area could be substantial.

The state of the art for quantitative evaluation of the uncertainties in the probabilistic risk analysis such as the type presented here is not well developed. Therefore, although the staff has made a reasonable analysis of the risks presented herein consistent with current data and methodology, there are large uncertainties associated with the results shown. It is the qualitative judgment of the staff that the uncertainty bounds could be well over a factor of 10, but not as large as a factor of 100. Within these uncertainty bounds, however, the uncertainties associated with the probability-integrated values of consequences (the risks) are likely to be less (although still large) than uncertainties in the curves in the figures showing probability distribution of consequences, as a result of partial cancellation of uncertainties by integration.

The accident at TMI-2 occurred in March 1979 at a time when the accumulated experience record was about 400 reactor-years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity (National Research Council, 1979, page 553). It should also be noted that the TMI-2 accident has resulted in a very comprehensive evaluation of reactor accidents by a significant number of investigative groups. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island (1979), and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident" (NUREG-0660, Vol 1) collected the various recommendations of these groups and describes them under the subject areas of Operational Safety, Siting and Design, Emergency Preparedness and Radiation Effects, Practices and Procedures, and NRC Policy Organization and Management. The action plan presents a sequence of actions, some already taken, that results in a gradually increasing improvement in safety as individual actions are completed. River Bend is receiving and will receive the benefit of these actions.

(8) Comparison of River Bend Risks with Other Plants

Figures 5.12 to 5.16 illustrate selected risks as computed for other nuclear power plants that are either operating or are receiving staff consideration for issuance of a license to operate. These figures are included to supply a context in which to view the computed River Bend societal risks, although direct comparison among plants is subject to some of the uncertainties discussed above. In light of these uncertainties, these figures can only serve to indicate that the River Bend plant and site pose computed measures of societal risk that are neither the highest nor the lowest of those computed for other plants and sites.

5.9.4.6 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the River Bend facility. They have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and groundwater pathways. Included in the considerations are postulated design-basis accidents and more severe accident sequences that lead to a core melt.

The environmental impacts that have been considered include potential releases of radioactivity to the environment with resulting radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small. This conclusion is based on (1) the fact that considerable experience has been gained as a result of the operation of similar facilities without significant degradation of the environment, (2) the fact that, in order to obtain a license to operate the River Bend facility, the applicant must comply with the applicable Commission regulations and requirements, and (3) a probabilistic assessment of the risk based on the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents, assuming protective actions, shows that this risk is on the same order as the risks from normal operation, although accidents have a potential for early fatalities and economic costs that cannot arise from normal operation. The risks of early fatality from potential accidents at the site are small in comparison with risks of accidental deaths from other human activities in a comparably sized population.

On the basis of the above considerations, the staff concludes that there are no special or unique circumstances about the River Bend site and environs that would warrant consideration of alternatives for the River Bend unit.

5.10 Impacts from the Uranium Fuel Cycle

The Uranium Fuel Cycle rule, 10 CFR 51.51 (49 FR 9388), reflects the latest information relative to the reprocessing of spent fuel and to 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 rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the AEC report WASH-1248, "Environmental Survey of the Uranium Fuel Cycle." The NRC staff was also directed to develop an explanatory narrative that would convey in understandable terms the significance of releases in the table. The narrative was also to address such important fuel cycle impacts as environmental dose commitments and health effects, socioeconomic impacts and cumulative impacts, where these are appropriate for generic treatment. A proposed explanatory narrative was published in the Federal Register on March 4, 1981 (46 FR 15154-15175). Appendix C to this report contains a number of sections that address those impacts of the LWR-supporting fuel cycle that reasonably appear to have significance for individual reactor licensing sufficient to warrant attention for NEPA purposes.

Table S-3 of the final rule is reproduced in its entirety as Table 5.14 herein.* Specific categories of natural resource use included in the table relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the 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 results in the greater impact is used.

Appendix C to this report contains a description of the environmental impact assessment of the uranium fuel cycle as related to the operation of the River

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*The U.S. Supreme Court has upheld the validity of the S-3 rule in Baltimore Gas & Electric Co., et al. v. Natural Resources Defense Council, Inc., No. 82-524, issued June 6, 1983, 51 U.S. Law Week, 4678.

Bend facility. The environmental impacts are based on the values given in Table S-3, and on an analysis of the radiological impact from radon-222 and technetium-99 releases. The NRC staff has determined that the environmental impact of this facility on the U.S. population from radioactive gaseous and liquid releases (including radon and technetium) due to the uranium fuel cycle is very small when compared with the impact of natural background radiation. In addition, the nonradiological impacts of the uranium fuel cycle have been found to be acceptable.

5.11 Decommissioning

The purpose of decommissioning is to safely remove nuclear facilities from service and to remove or isolate the associated radioactivity from the environment so that the facility site can be released for other uses. Alternative methods of accomplishing this purpose and the environmental impacts of each method are discussed in NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities."

Since 1960, 68 nuclear reactors, including 5 licensed, low-power reactors, have been or are in the process of being decommissioned. Although no large commercial reactor has undergone decommissioning to date, the broad base of experience gained from smaller facilities is generally relevant to the decommissioning of any type of nuclear facility.

Radiation doses to the public as a result of a decommissioning activities at the end of a commercial power reactor's useful life should be small. They will come primarily from the transportation of waste to appropriate repositories. Radiation doses to decommissioning workers should be well within the occupational exposure limits imposed by regulatory requirements.

The NRC is currently conducting a generic rulemaking that will develop a more explicit overall policy for decommissioning commercial nuclear facilities. Specific licensing requirements are being considered that include the development of decommissioning plans and financial arrangements for decommissioning nuclear facilities.

Estimates of the economic cost of decommissioning are provided in Section 6 of this statement.

5.12 Noise Impacts

Sound pressure levels expected to occur from the operation of River Bend Station have been calculated for seven ambient noise survey positions A-G located in the vicinity of the site (Figure 5.21), and the eight nearest residences to the site denoted R1-R8 (Figure 5.22).

Locations A-G were used in both 1972 and 1980 for the measurement of octave band sound pressure levels and A-weighted sound pressure levels. All 15 locations are potential noise-sensitive locations in the community. No significant barriers stand between the major plant associated noise sources (the four circular mechanical draft cooling towers) and these noise-sensitive locations.

5.12.1 Ambient Noise Levels

Ambient measurements in 1972 (Bruce, 1972) were made before construction of Unit 1. These measurements were made at eight positions on June 15 between 1:45 and 4:25 a.m. and on June 16 between 1:58 and 3:45 a.m. The 1980 measurements (Bruce, 1972) were made on January 9 (10:40 a.m. to 3:48 p.m.) and on January 10 (noon to 5 p.m.). During the 1972 measurement period, significant insect noise was present at the higher frequencies. The applicant developed "modified" ambient noise levels (Bruce, 1972) in which each ambient octave band spectrum was corrected to eliminate this high frequency insect noise. In this way, a residual ambient was estimated that should be valid when insects are not present (in winter months). The January 1980 measurements were made while Unit 1 was under construction; however, most of the measurements were made during nonworking hours.

5.12.2 Station Noise Levels During Operation

The major noise sources at the site are the four circular mechanical draft cooling towers and the nine transformers (see Figure 5.22). The latter include two main step-up transformers, three normal station service transformers, and four preferred (offsite power) station service transformers.

The circular mechanical draft towers emit noise of a broadband nature, and the transformers emit noise of a tonal nature at discrete frequencies of 120, 240, 360, and 480 Hz.

A computer model (Dunn et al., 1982), based largely on the Edison Electric Institute (EEI) Environmental Noise Guide (BB&N, 1978), was used to predict the effect of plant noise at these 15 receptors. Calculations were made using only the significant noise sources noted above. Other noise sources at the site lead to insignificant contributions to community noise levels because of their location inside buildings, the intermittent nature of their operation, or their low sound power level. The relatively large distances from these sources to the nearby sensitive areas further underscores their negligible contribution. The four circular mechanical draft cooling towers and nine transformers were assumed to be in operation at a constant level throughout the day and night. Standard day conditions (18°C ambient temperature and 70% relative humidity) were also assumed. Source data on circular mechanical draft tower noise came from the EEI Noise Guide. Data on the noise level of the transformers came from Gordon et al. (1978). Data on transformers of similar megavolt-ampere rating were examined, and the staff chose the data that represented the strongest sources of noise for each transformer. A conservative assumption was also made in neglecting the attenuation of noise offsite by intervening trees between the noise sources and receptors.

Noise level predictions were carried out in two steps. First, the increase in the ambient noise at all 15 receptor points was computed for the four cooling towers alone. Calculations were performed twice, once for the 1972 measured ambient and once for the 1980 ambient. The lowest ambient noise levels measured for each receptor station were used for each period. For the 1972 calculations, the ambient noise levels corrected for insect noise were used. The community impact of the increased broadband was then determined. The second step modeled the increase in noise level at the receptor locations from the transformer core tones employing the "new" ambient represented by the increased broadband noise in the community from the cooling towers.

The octave band analyses of the operation of the cooling towers predict an incremental increase of 10 dB or more for at least one octave band centered in the 63- to 1000-Hz range for all of the nearest residence locations R1-R8, when using the 1972 ambient noise level data (Table 5.15). Similar results but for octave bands centered in the 250- to 2000-Hz range were found when the 1980 ambient noise level data were used (Table 5.16). Community receptor locations B, E, and F were also predicted to have incremental increases of 10 dB or more in some octave bands (Table 5.17). These findings are significant because such incremental noise level increases have been shown to be a cause of annoyance in residential areas (Stevens, Rosenblith, and Bolt, 1953). The resulting overall A-weighted noise level increases at the eight nearest residences as a result of cooling tower operation are predicted to range up to 16 dB. Predicted increases at community locations B, E, and F range from 6 to 14 dB.

The community reactions to these increases in environmental noise levels was estimated using the modified composite noise rating (CNR). This rating is a measure that evaluates community reaction to noise, using octave band sound pressure level data with appropriate corrections for spectral characteristics, background noise interference, and time of day. Figure 5.23 shows the modified CNR rating of the community noise at the receptor locations, denoted by letters ranging from A-1, related to expected community reaction. Tables 5.15 to 5.17 and Figure 5.23 predict that the reaction at each receptor presented by R1-R8 and Receptors B, E, and F would range from "widespread complaints or single threat of legal action" to "several threats of legal action or strong appeals to local officials to stop noise" as a result of operation of the station cooling towers.

The transformer core tones at 120, 240, 360, and 480 Hz were then modeled. The cooling tower noise was found to increase the masking level of the ambient noise and thereby assisted in making the transformer tones inaudible. The results of this modeling predicts that, for all transformer tones and for both the 1972 and 1980 generated ambients, no tone would be audible at any of the 15 receptor locations. The "old" ambient level at each receptor was already in the moderate-to-high range, providing significant masking. The significant increase in the ambient because of the cooling tower fan noise provided considerable incremental masking of the transformer tones at the core tone frequencies.

The above calculations were made employing two important assumptions. First, the sound power level for each tower was taken from the EEI Noise Guide (Bolt Beranek and Newman, 1978) based on the horsepower rating of the fans in the tower. The noise levels obtained agreed identically with those in the ER-OL. However, there is some uncertainty because the noise levels for the circular mechanical draft towers purchased by the applicant may differ from that provided for an "average" circular mechanical draft cooling tower in the EEI Noise Guide. Noise levels made available from the manufacturer might provide the basis for more accurate noise predictions. In the second assumption, noise attenuation because of intervening trees and vegetation between the residences and noise sources has been neglected. During much of the year, the trees will absorb a significant amount of noise. Dunn et al. (1982) provide typical absorption rates because of trees on an octave band basis. The category "very dense trees" probably applies at River Bend much of the year.

Attenuation for this foliage category ranges from about 7 dB/100 m at low frequency to about 15 dB/100 m for the 1000-Hz band frequency. However, the ER-OL (Supplement 2) states: "When the leaves are off the trees during December and January, attenuation may be negligible." Thus, the "bare trees" attenuation (Table 5.18) may be applicable at that time. Attenuation under this foliage condition is much less, ranging from 0 dB for band center frequencies of 20 Hz and below to 3 dB/100 m for the 1000-Hz band center frequency.

Because of the uncertainty in both the cooling tower sound power levels and the amount of noise attenuation because of the trees that will be present between the towers and residences, the applicant will be required to further investigate the potential for noise-related impacts of the station at nearby residences. This effort is to include investigation and resolution of noise-related complaints received by the applicant, as well as a noise monitoring program during the initial period of station operation.

5.13 Emergency Planning Impacts

In connection with the promulgation of the Commission's upgraded emergency planning requirements, the NRC staff issued NUREG-0658, "Environmental Assessment for Effective Changes to 10 CFR Part 50 and Appendix E to 10 CFR Part 50; Emergency Planning Requirements for Nuclear Power Plants." The staff believes the only noteworthy potential source of impacts to the public from emergency planning would be associated with the testing of the early notification system. The test requirements and noise levels will be consistent with those used for existing alert systems; therefore, the staff concludes that the noise impacts from the testing of the system will be infrequent and insignificant.

The emergency operations facility is located in the Station Training Center; as a result, its construction will not involve any additional environmental impacts.

5.14 Monitoring Programs

5.14.1 Terrestrial Monitoring

Extensive field studies of the terrestrial ecology of the River Bend site were conducted by the Louisiana State University (LSU) staff in 1971 and 1972, and a brief site reconnaissance was conducted in October 1979. Available literature was also used to document the ecology of the area. The results of these studies are in ER-OL Section 2.4.1.

The primary source of impact of station operation on terrestrial systems is cooling-tower drift. To monitor the impacts of drift, the applicant will use stereo false color infrared aerial photographs of the site. Photographs will be taken in September or early October, which is the period of maximum theoretical susceptibility of vegetation to salt-induced stress, because of the relatively arid conditions (ER-OL Section 6.5.1.2). Photographs will be taken during the 2 years preceding initiation of cooling tower operation, and during the following first and third years. If adverse effects are observed, the NRC will require the applicant to repeat the study in additional years and to perform examinations of vegetation, both on and off the site, to determine the extent of the damage. Such studies are necessary to determine the need for any corrective action to mitigate the impacts.

5.14.2 Aquatic Monitoring

Operational monitoring of River Bend Station effluents is required by the NPDES permit (Appendix F). The applicant received an NPDES permit effective from August 17, 1981 through August 16, 1986. This permit specifies the measurement frequency and sample type for certain effluent characteristics in the cooling tower blowdown (outfall number 001), standby cooling tower blowdown (002), treated chemical waste (003), low-level radioactive waste (004), excess well water (005), nonradioactive floor drain waste (006), sanitary waste treatment discharge (007), and noncontaminated storm water runoff waste for East and West Creeks (008, 009). There is to be no discharge of polychlorinated biphenyl transformer fluid.

An extensive program that monitors aquatic life in the vicinity of the River Bend site has been conducted by LSU personnel since 1972. The initial baseline study was conducted from spring of 1972 to spring of 1974. Sampling stations for this study are shown on Figure 5.24. The interim study began in the spring of 1974 and will continue to the beginning of the preoperational study. This study continues the baseline monitoring at an increased frequency with fewer stations per area. Aquatic sampling stations for interim monitoring are shown in Figure 5.25.

Two years each of preoperational and operational monitoring will be performed by the applicant. This monitoring will take place in the Mississippi River along the eastern shoreline and in Grants Bayou above and below the plant outfalls (Figure 5.26).

Benthic macroinvertebrates and physiochemical parameters will be sampled in both areas, both ichthyoplankton and nekton will be sampled only in the Mississippi River. The operational monitoring program will be a continuation of the preoperational monitoring and will begin at the start of station operation. Results will be reviewed after the first year. If no unexpected impacts have been detected, the same level of effort will take place during the second year Unless the first two years of operational study show that continued monitoring is required, the applicant could terminate all aquatic sampling.

5.14.3 Operational Noise Monitoring

The staff will require that the applicant conduct a short-term noise monitoring program in the site vicinity during the first year of operation of the station. The purpose of this program will be to quantify operational phase noise levels and the mitigative measures necessary, if any, in the vicinity of the River Bend Station.

Measurements on a one-third octave band basis along with A-weighted and statistical indicators (L_{90}, L_{50}, L_{eg}) are to be made twice a year (for one year), once in winter and once in summer. Data will be collected during daytime and nighttime (midnight to 4 a.m.) periods, and measured noise levels will be compared to the 1972 and 1980 ambients. The applicant also is to provide an evaluation of the community impact (if any) of the fan blade tone from the circular mechanical draft cooling tower. The measurement of one-third octave band spectra (rather than octave band) should now provide sufficient data to isolate the cooling tower blade tone and its impacts (if any). Finally, the applicant will evaluate community impacts from these measurements in terms of incremental broadband noise and blade tonal noise from the cooling towers. The details of this program will be included in the River Bend Environmental Protection Plan.

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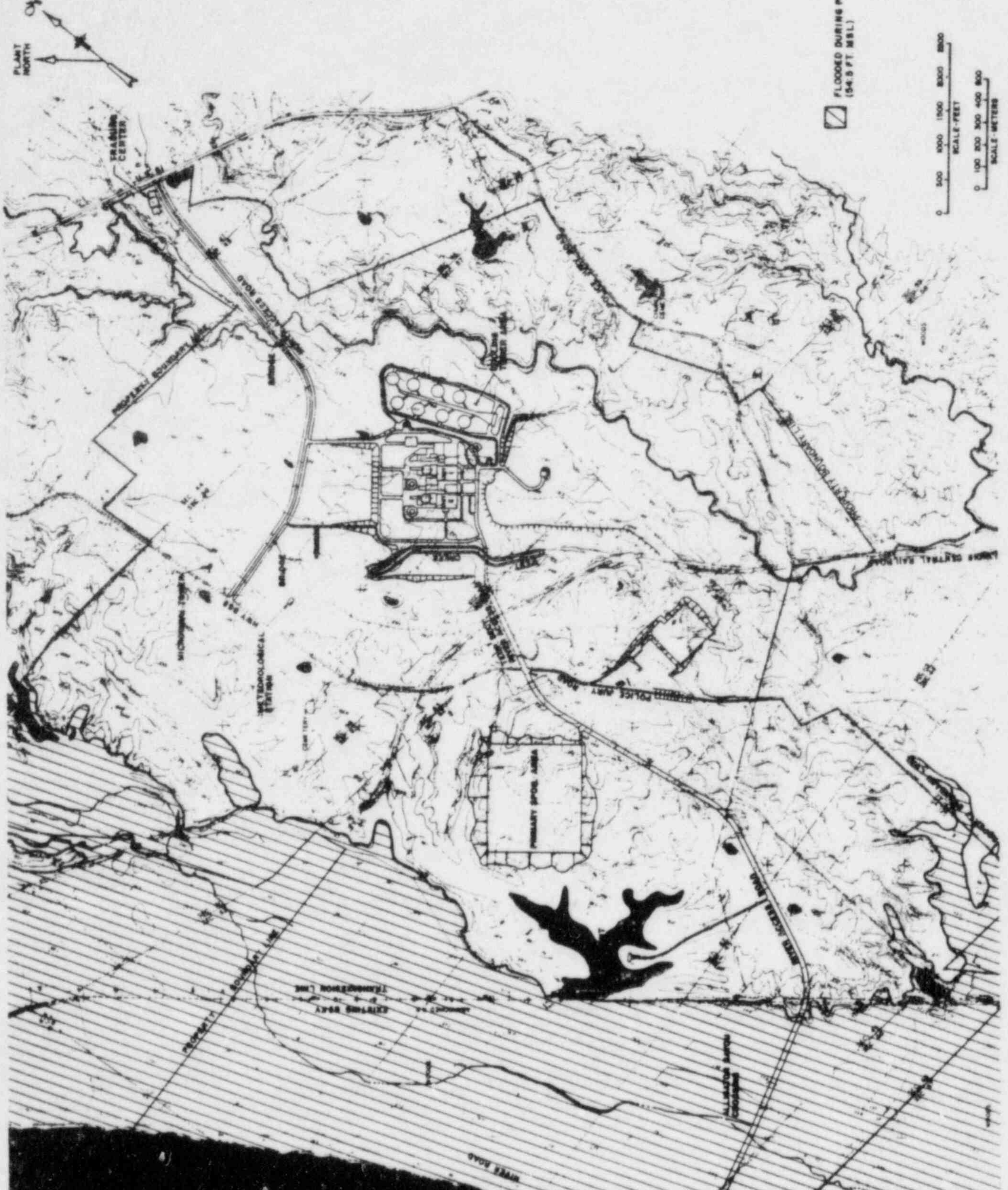


Figure 5.1 Mississippi River floodplain near River Bend Station

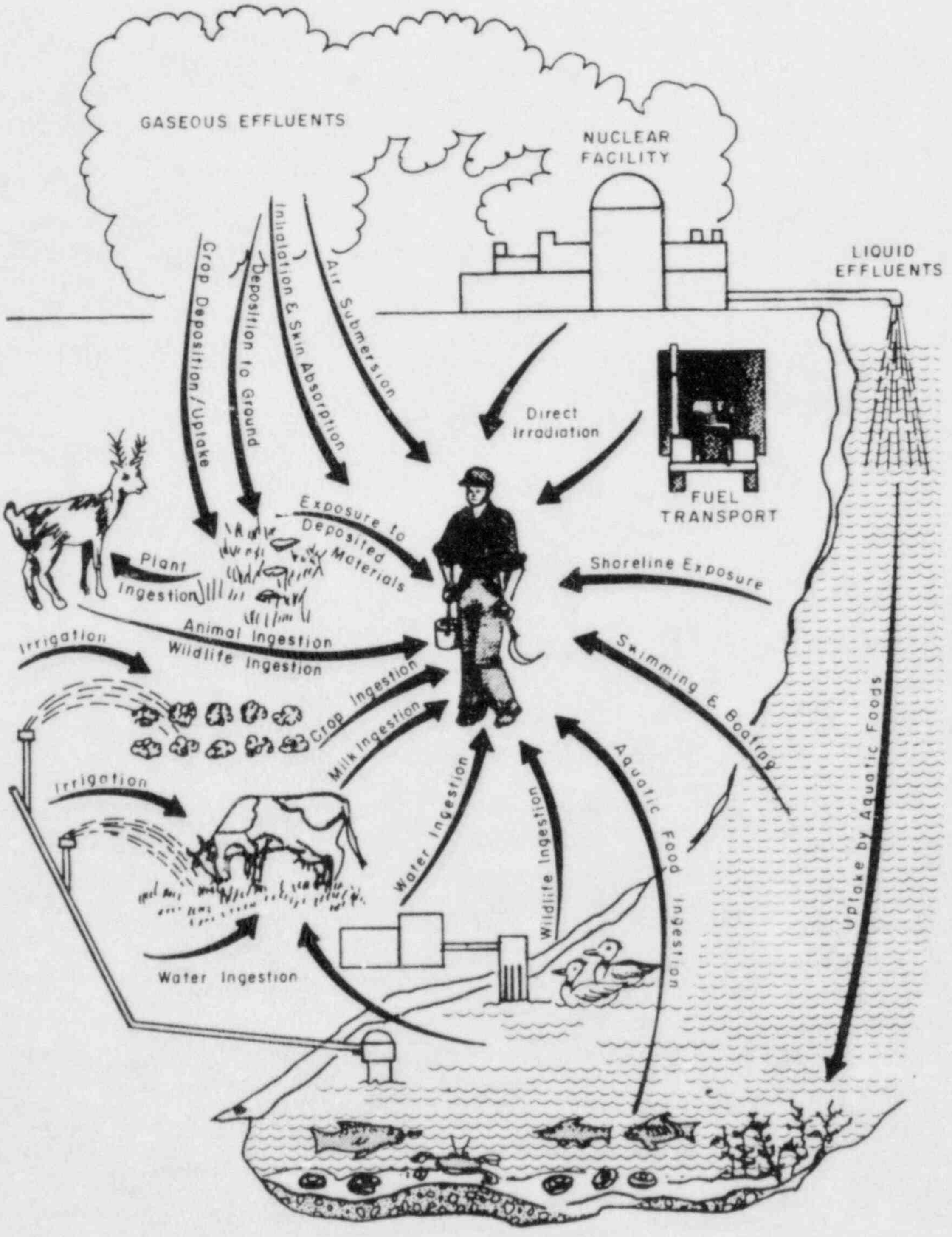


Figure 5.2 Potentially meaningful exposure pathways to individuals

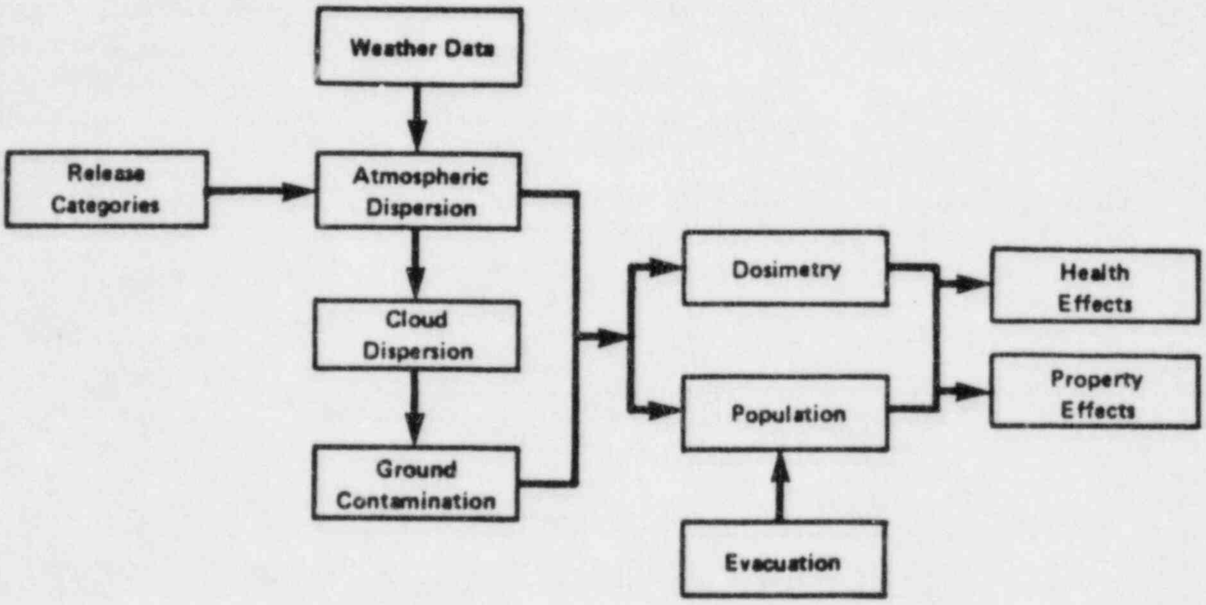


Figure 5.3 Schematic of atmospheric pathway consequence model

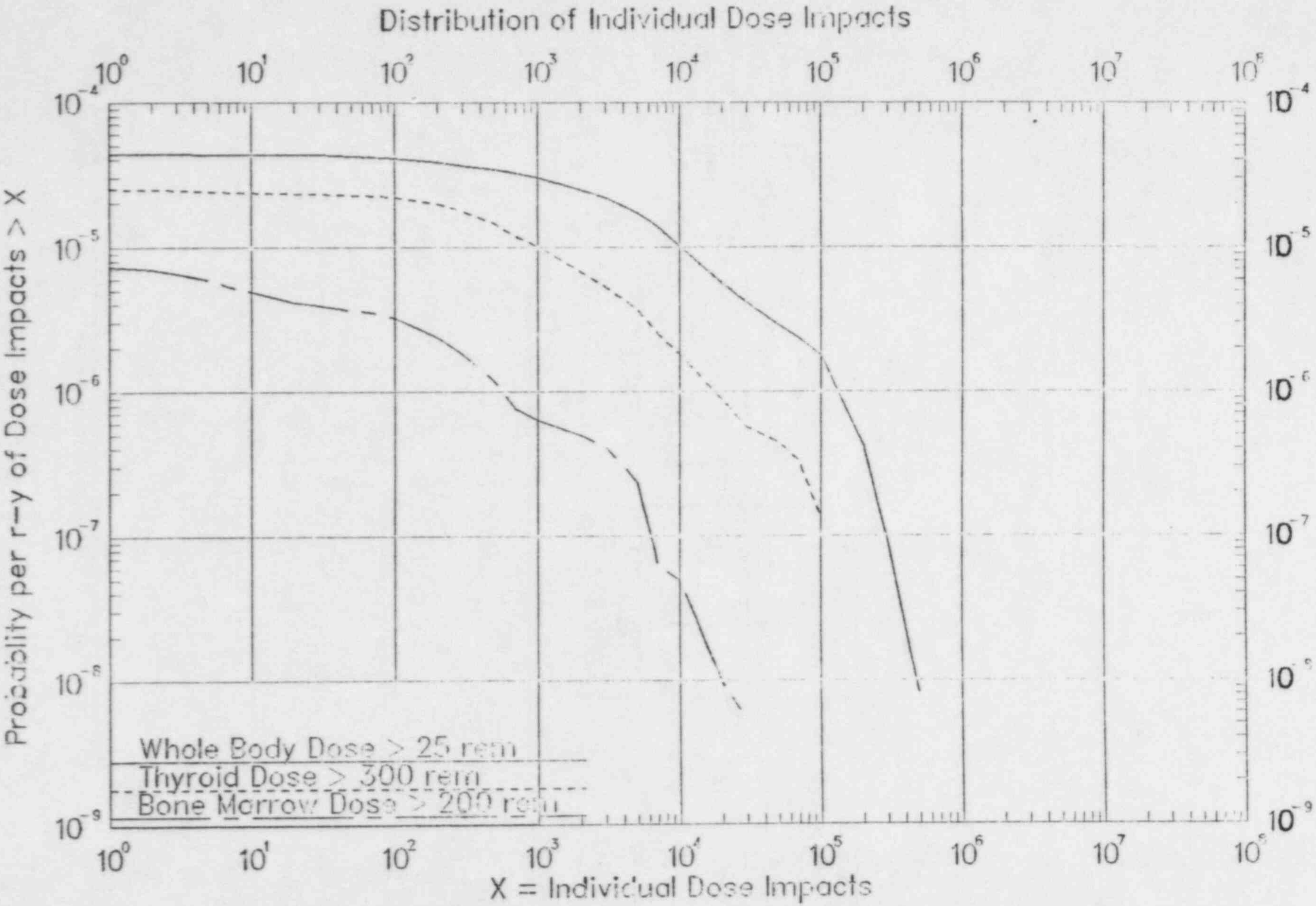


Figure 5.4 Probability distributions of individual dose impacts. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates. Also see footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure.)

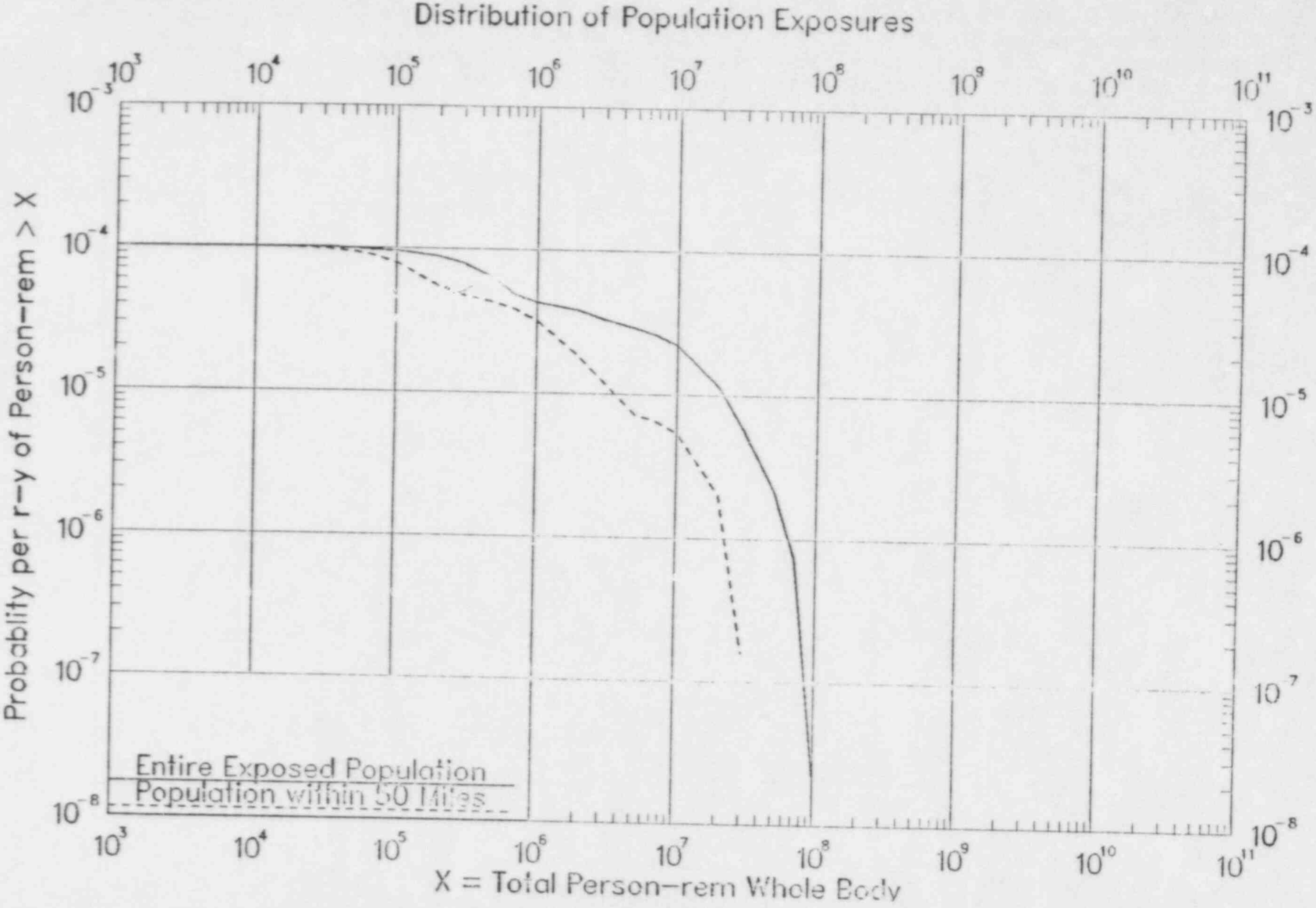


Figure 5.5 Probability distributions of population exposures. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates) (50 mi = 80 km). Also see footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure.)

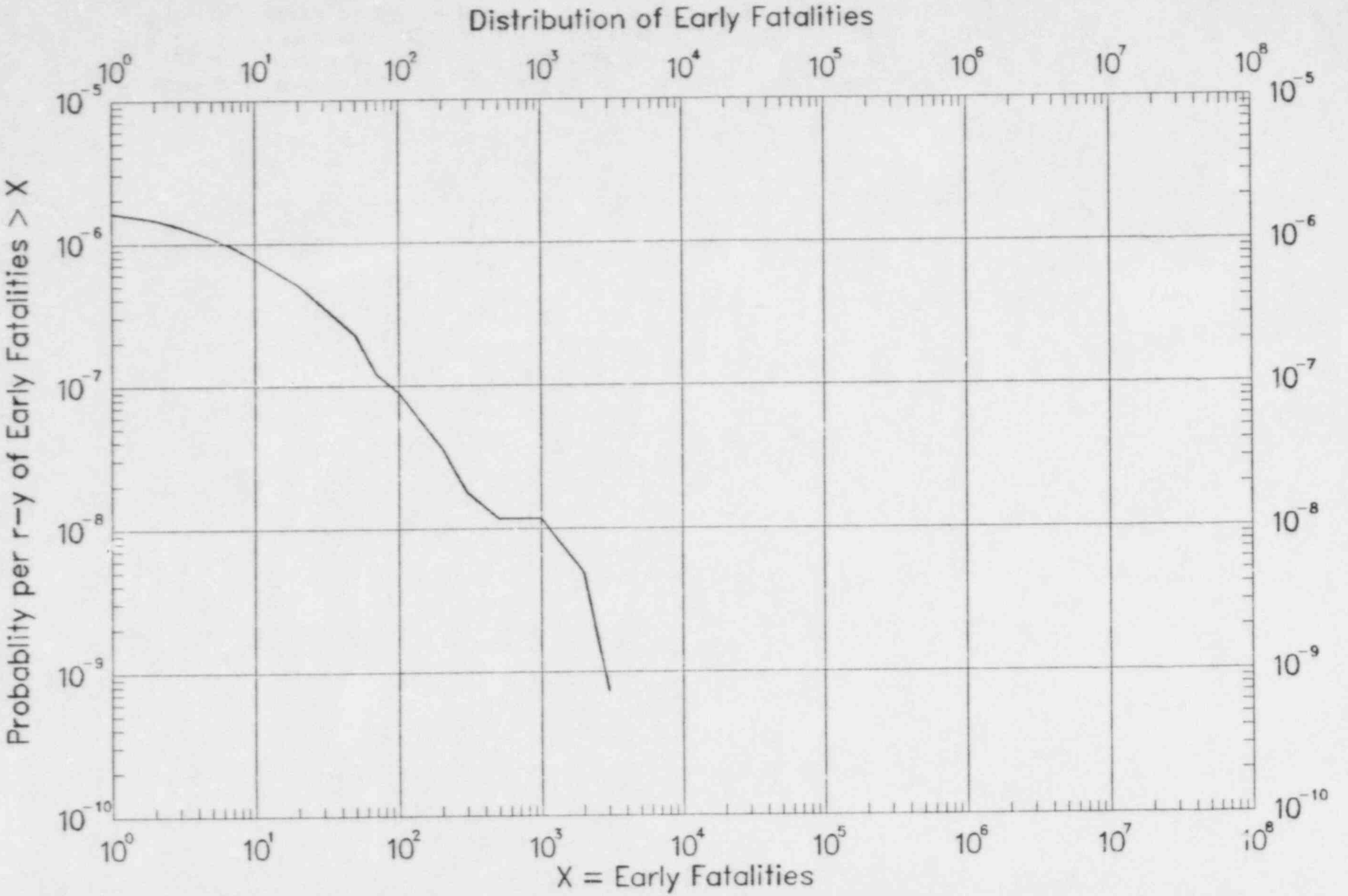


Figure 5.6 Probability distribution of early fatalities (see Section 5.9.4.5(7) for a discussion of uncertainties in risk estimate (50 miles = 80 km). Also see footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure. The hatched area encloses confidence level loci of all points on the uppermost curve.)

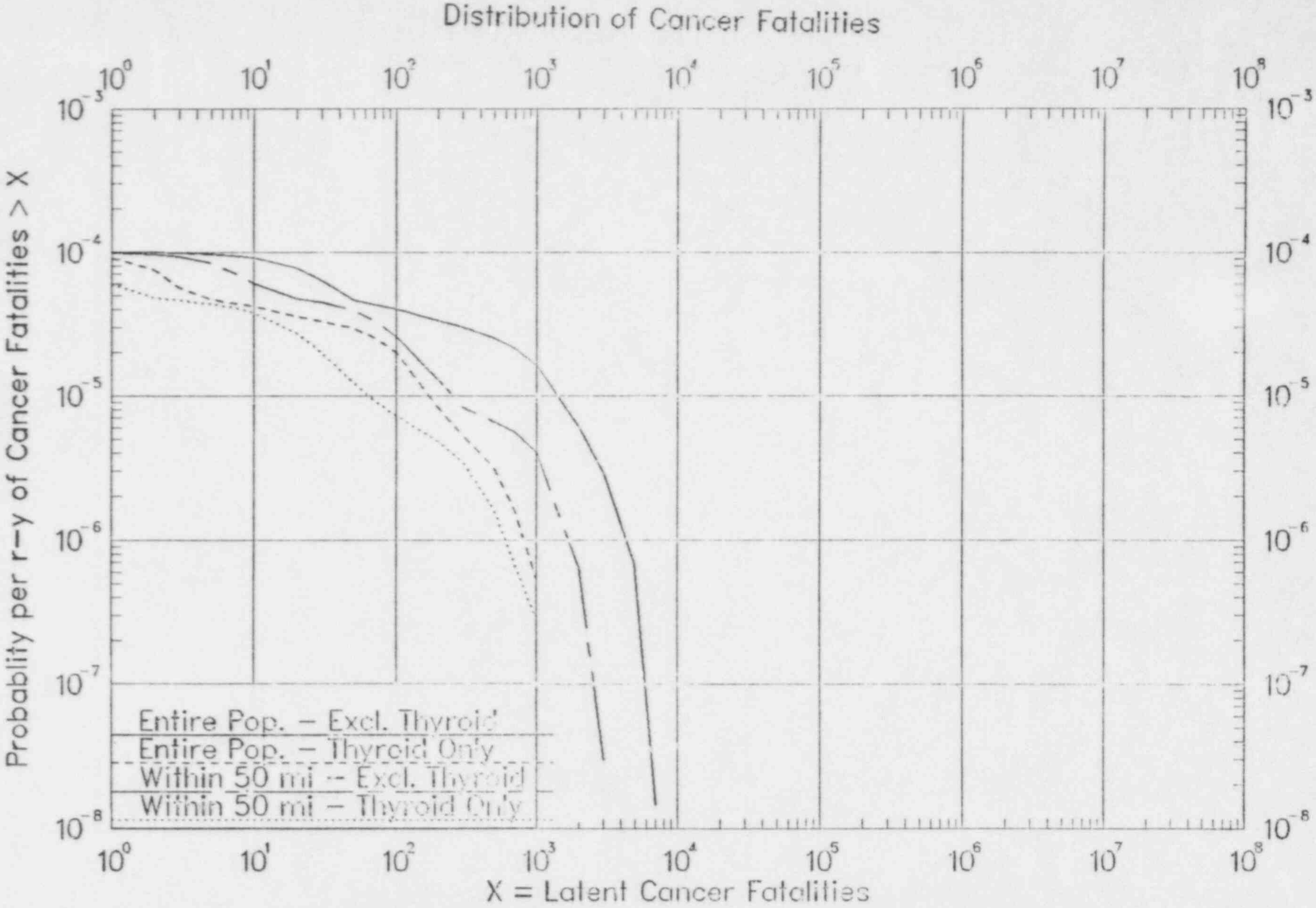


Figure 5.7 Probability distributions of cancer fatalities. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimate (50 miles = 80 km). Also see a footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure.)

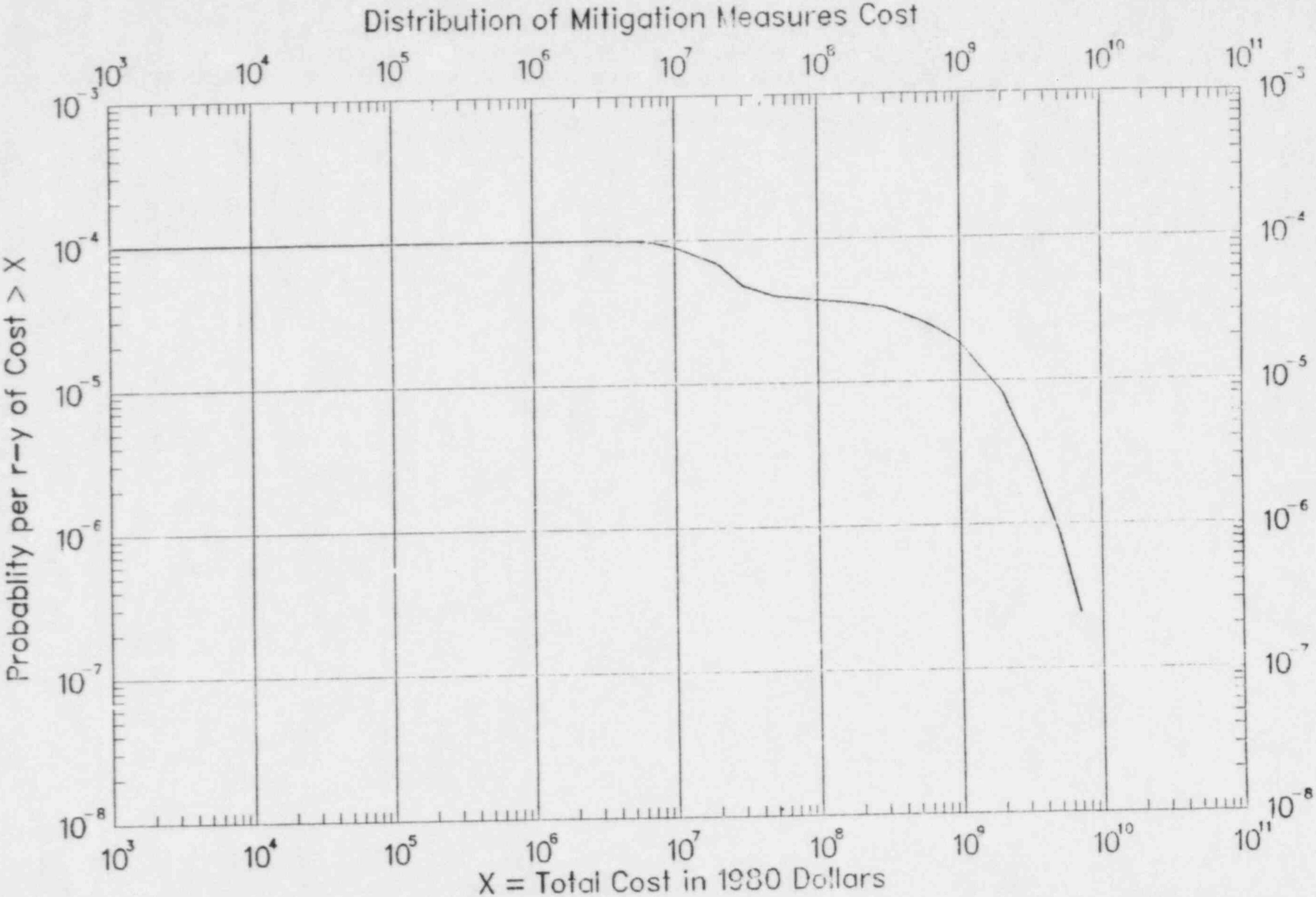


Figure 5.8 Probability distribution of mitigation measures cost. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates. Also see footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure.)

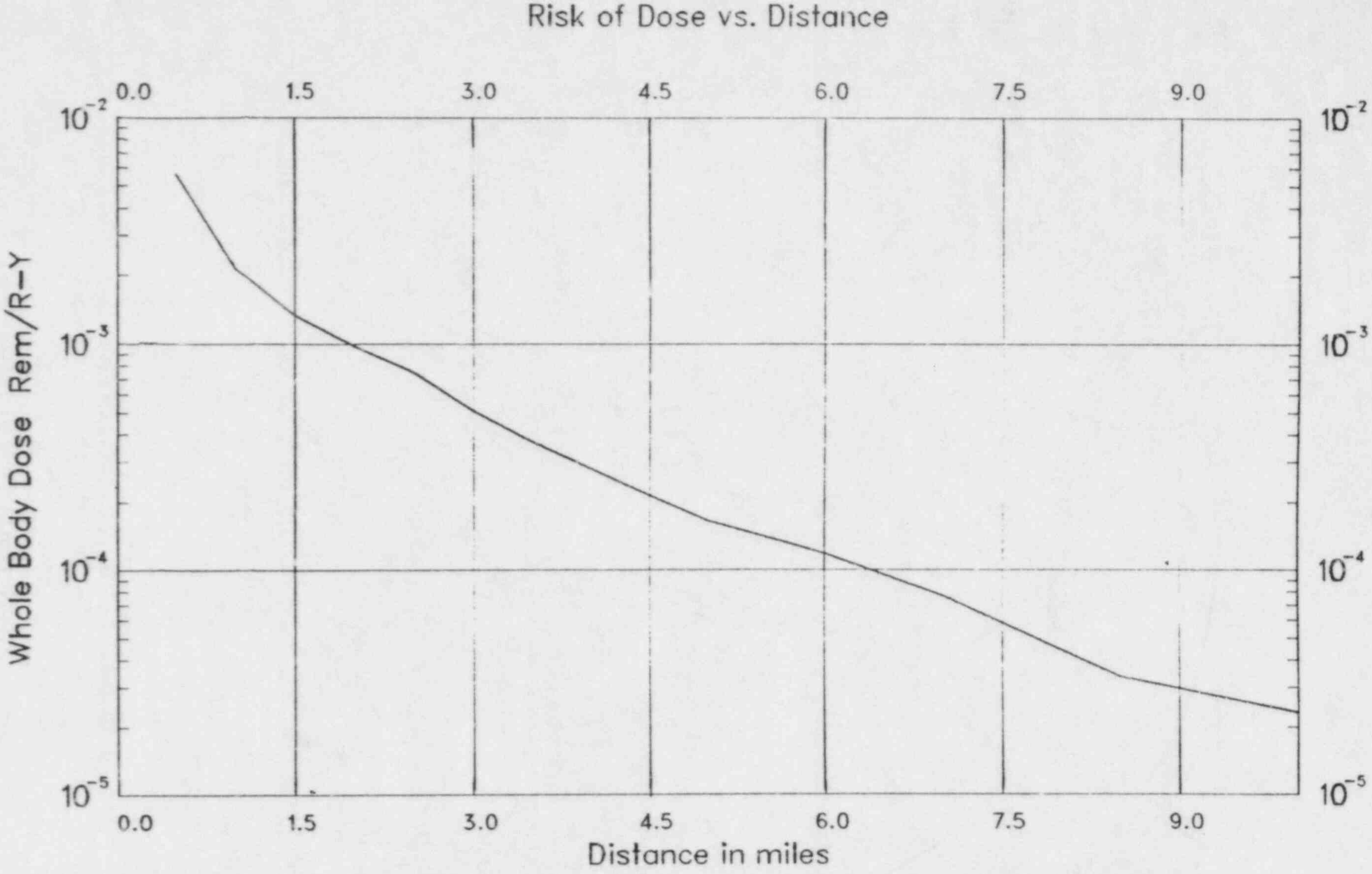


Figure 5.9 Individual risk of dose as a function of distance. (See Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates. To convert miles to km, multiply by 1.6093. Also see footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this this figure.)

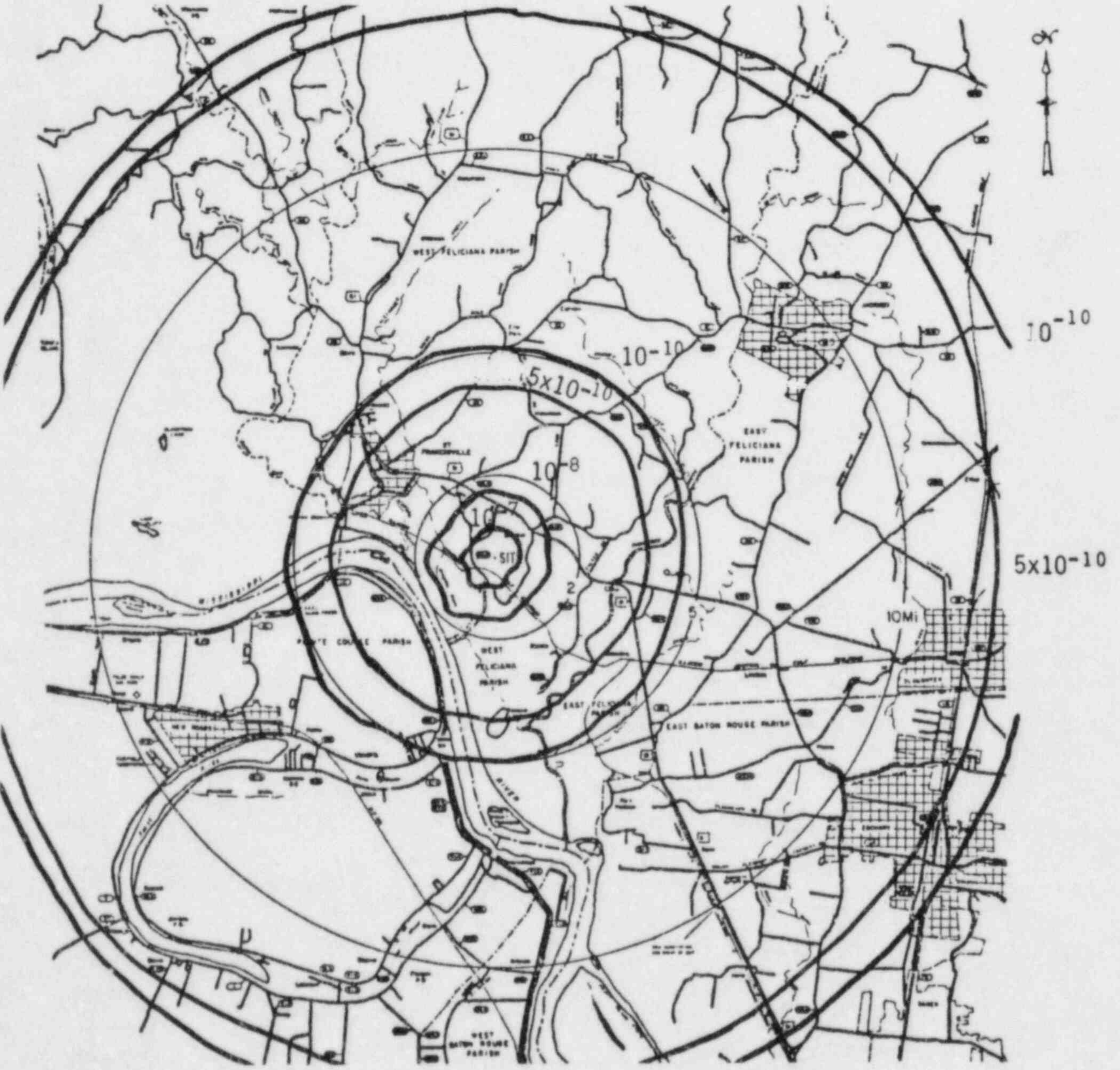


Figure 5.10 Lines of equal risk (isopleths) per reactor-year of early fatality to an individual

Note: See Section 5.9.4.5(7) for a discussion of uncertainties.

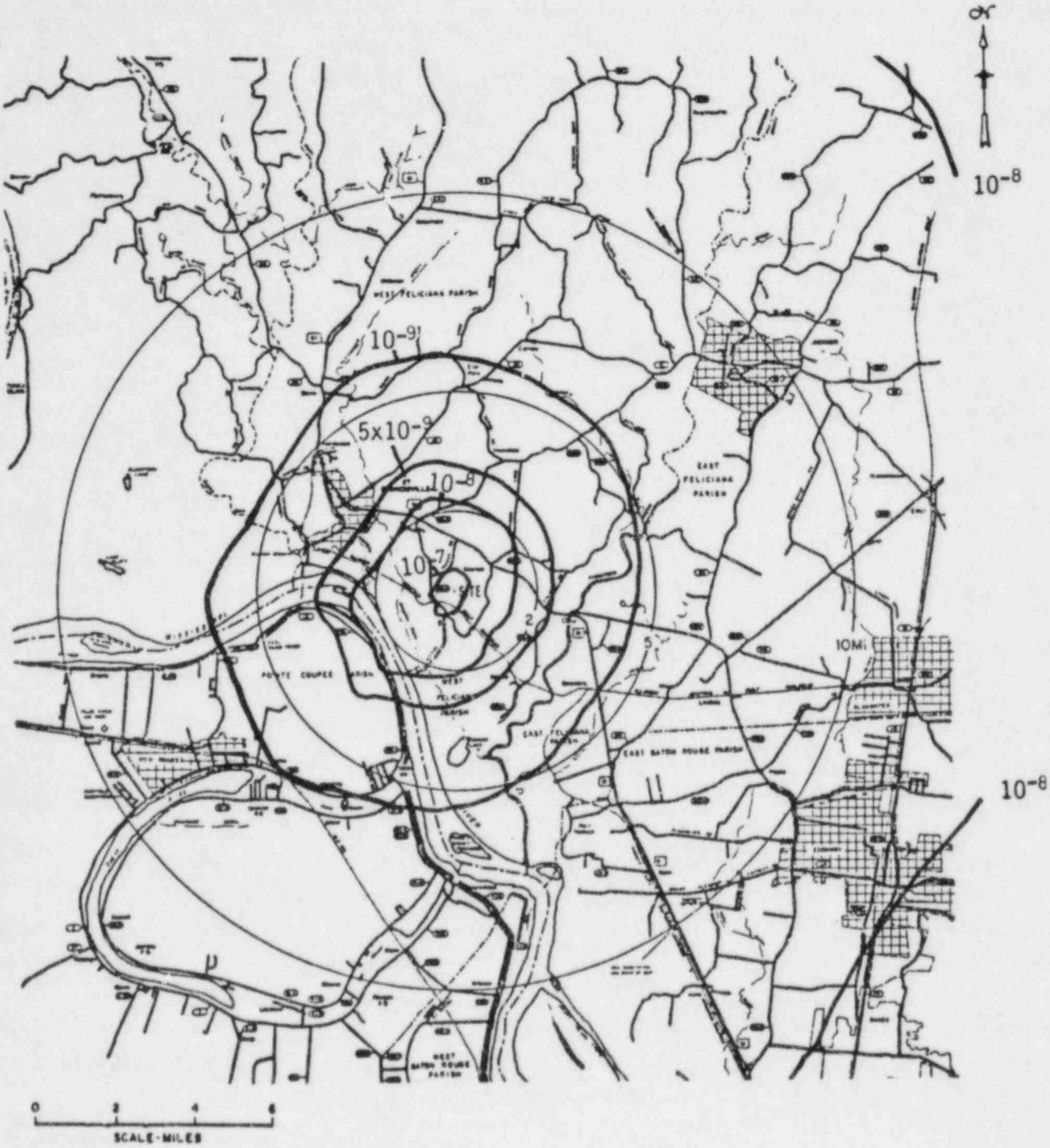


Figure 5.11 Lines of equal risk (isopleths) per reactor-year of latent cancer fatality to an individual

Note: See Section 5.9.4.5(7) for a discussion of uncertainties.

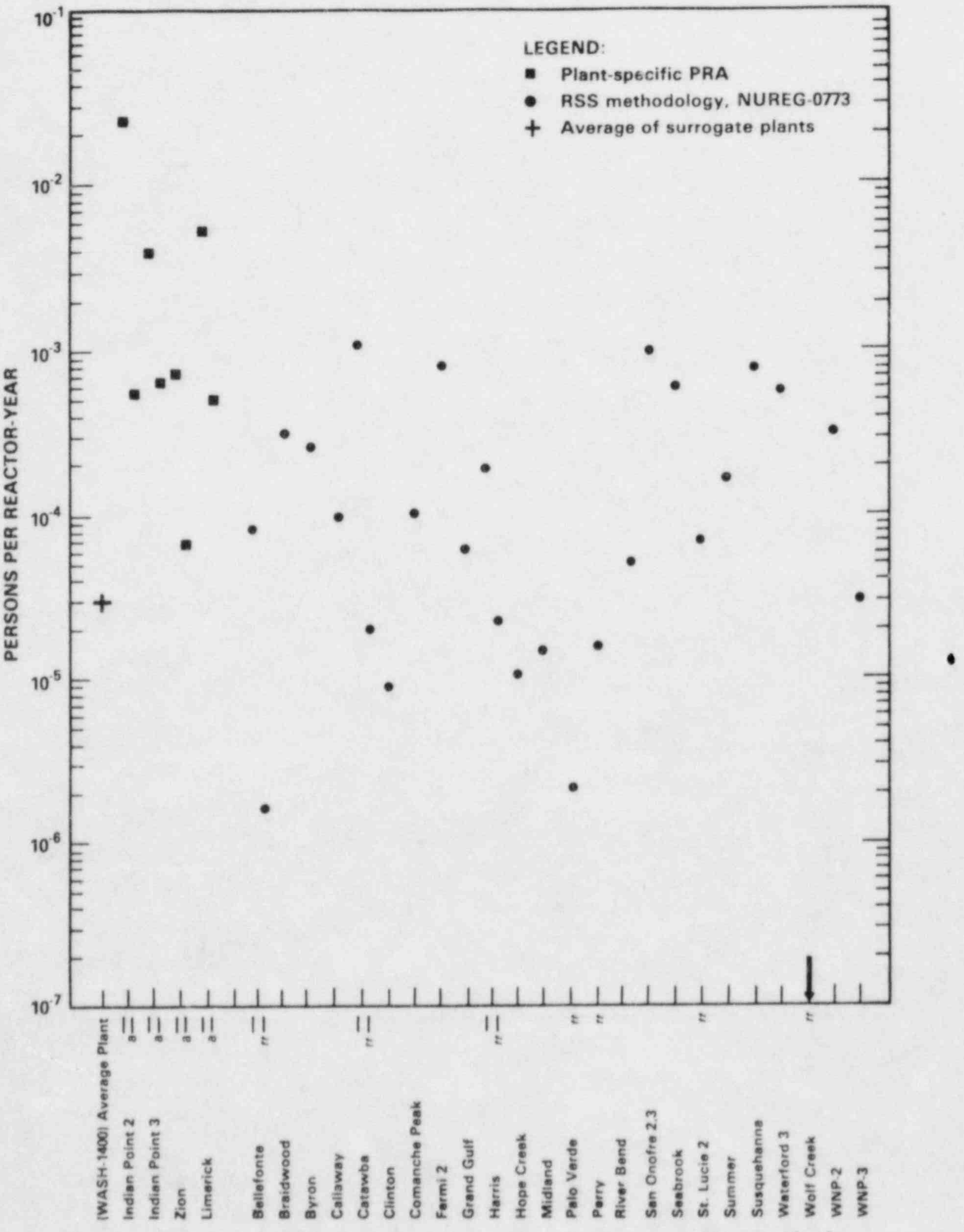


Figure 5.12 Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes following Figure 5.20.

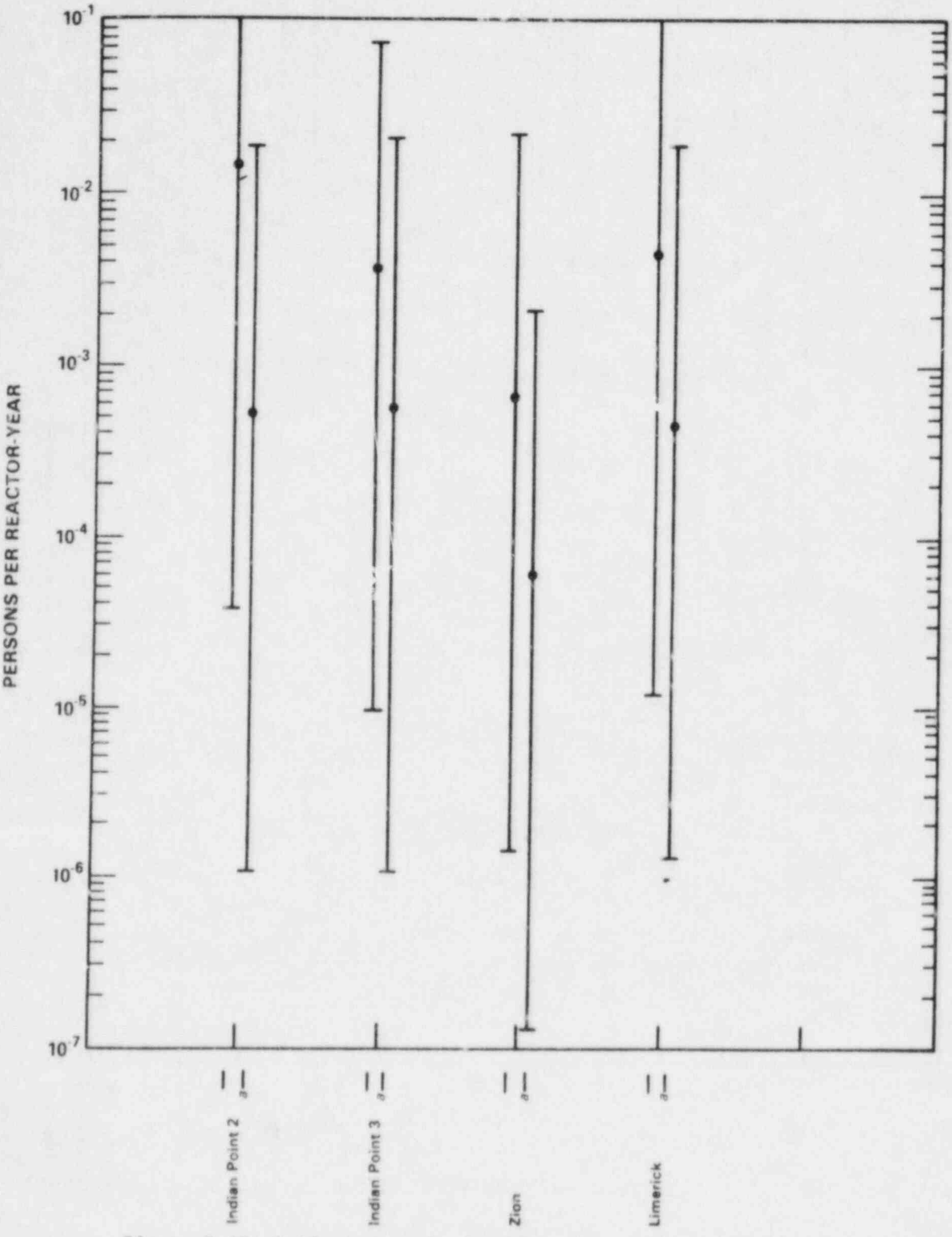


Figure 5.13 Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes following Figure 5.20.

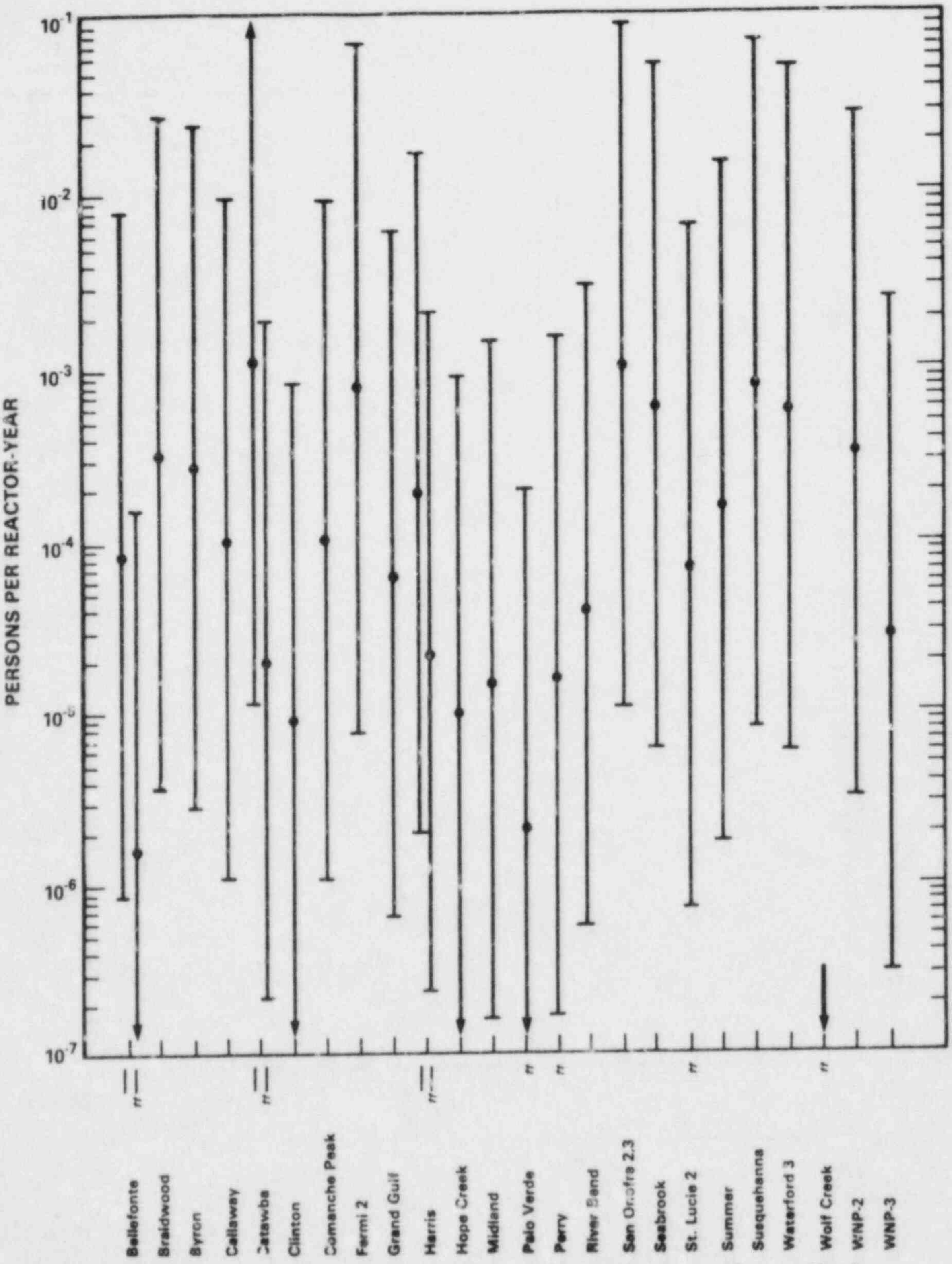


Figure 5.14 Estimated early fatality risk with supportive medical treatment (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideraton for issuance of license to operate for which site-specific applications of NUREG-0773 accident releases have been used to calculate offsite consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes following Figure 5.20.

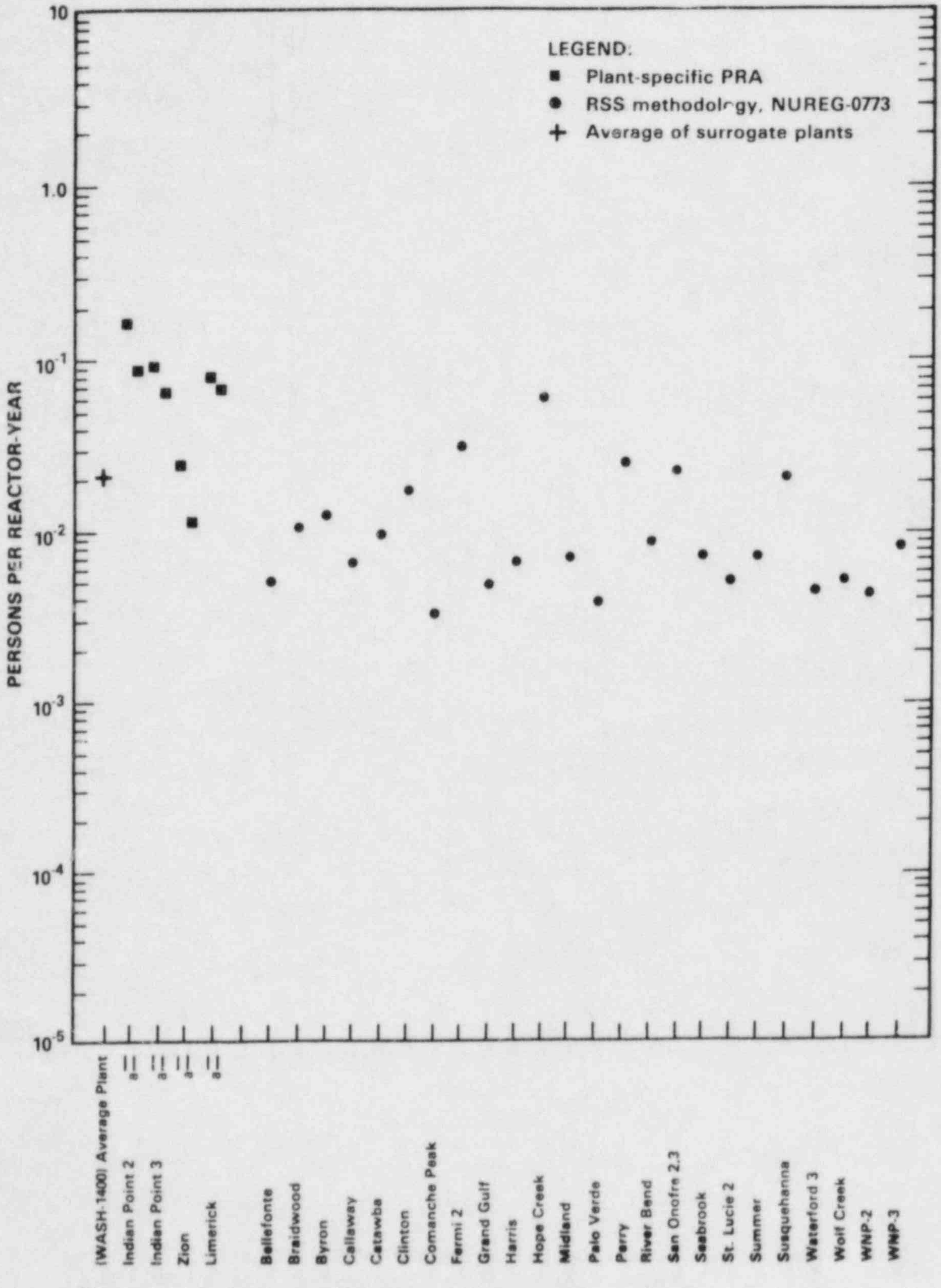


Figure 5.15 Estimated latent cancer fatality risk, excluding thyroid (persons), from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of license to operate. See footnotes at the end of Figure 5.20.

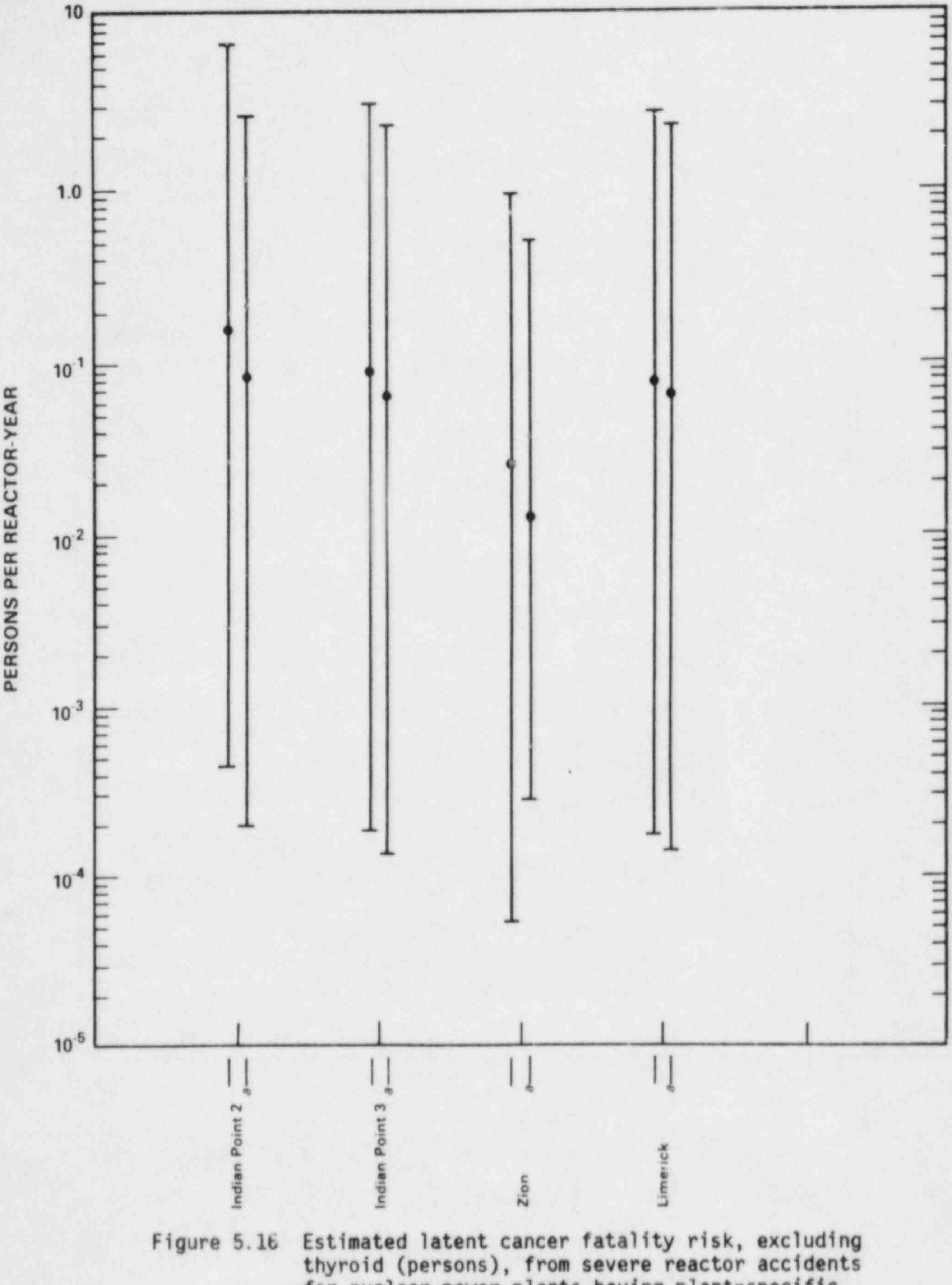


Figure 5.16 Estimated latent cancer fatality risk, excluding thyroid (persons), from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes at the end of Figure 5.20.

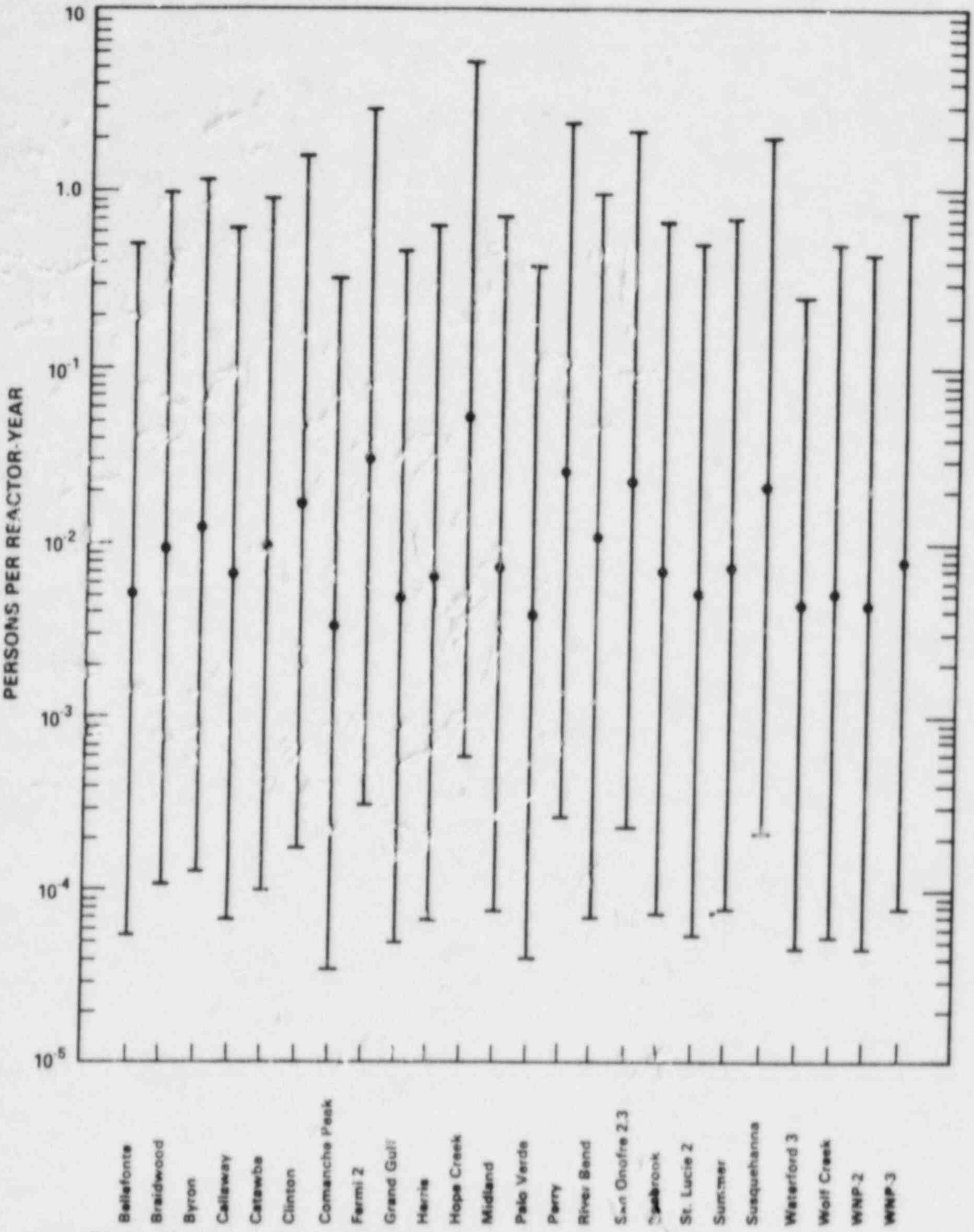


Figure 5.17 Estimated latent cancer fatality risk, excluding thyroid (persons), from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of a license to operate for which site-specific applications of NUREG-0773 accident releases have been used to calculate offsite consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes at the end of figure 5.20.

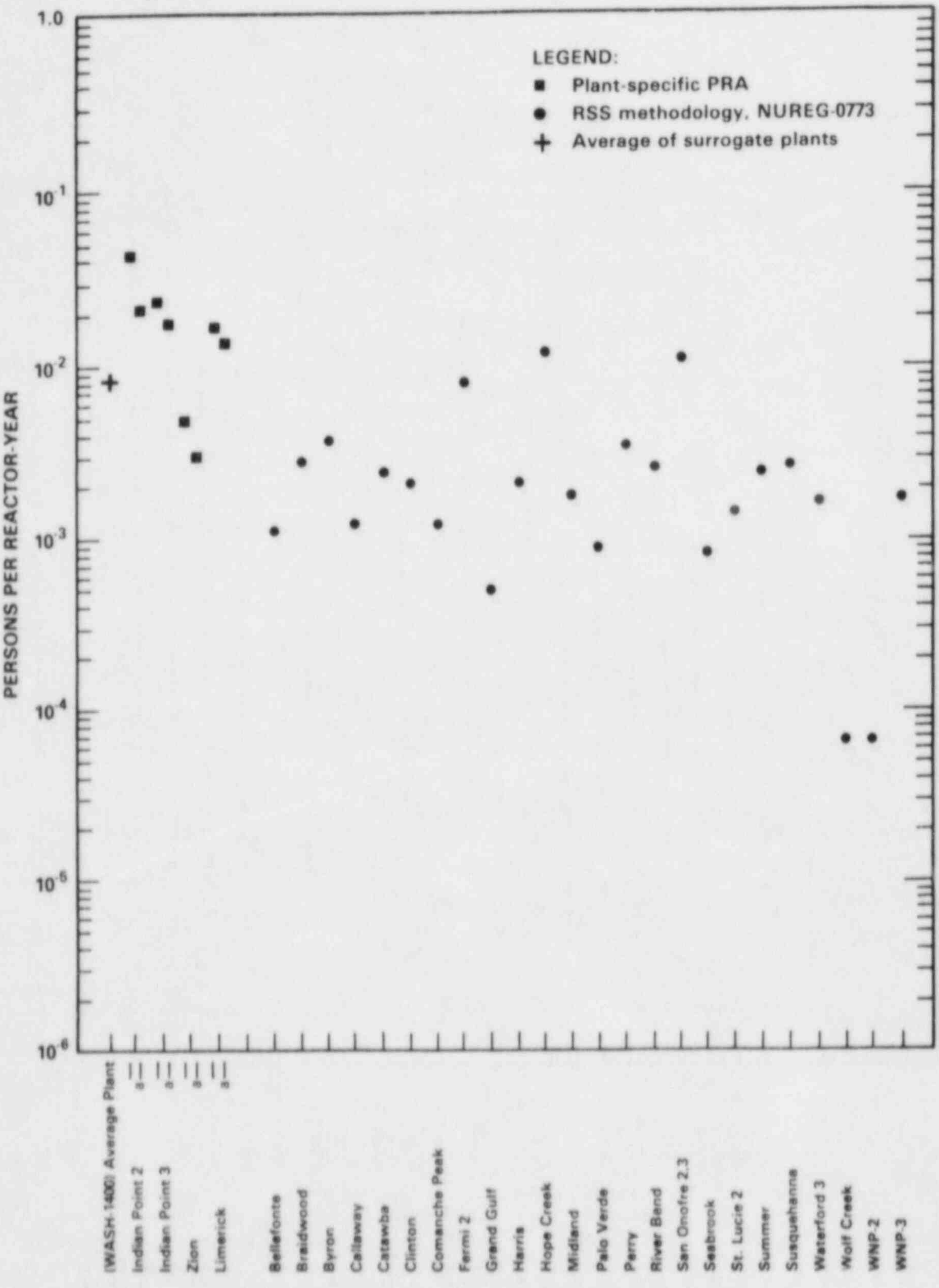


Figure 5.18 Estimated latent tyroid cancer fatality risk (persons) from severe reactor accidents for several nuclear power plants either operating or receiving consideration for issuance of a license to operate. See footnotes at the end of Figure 5.20.

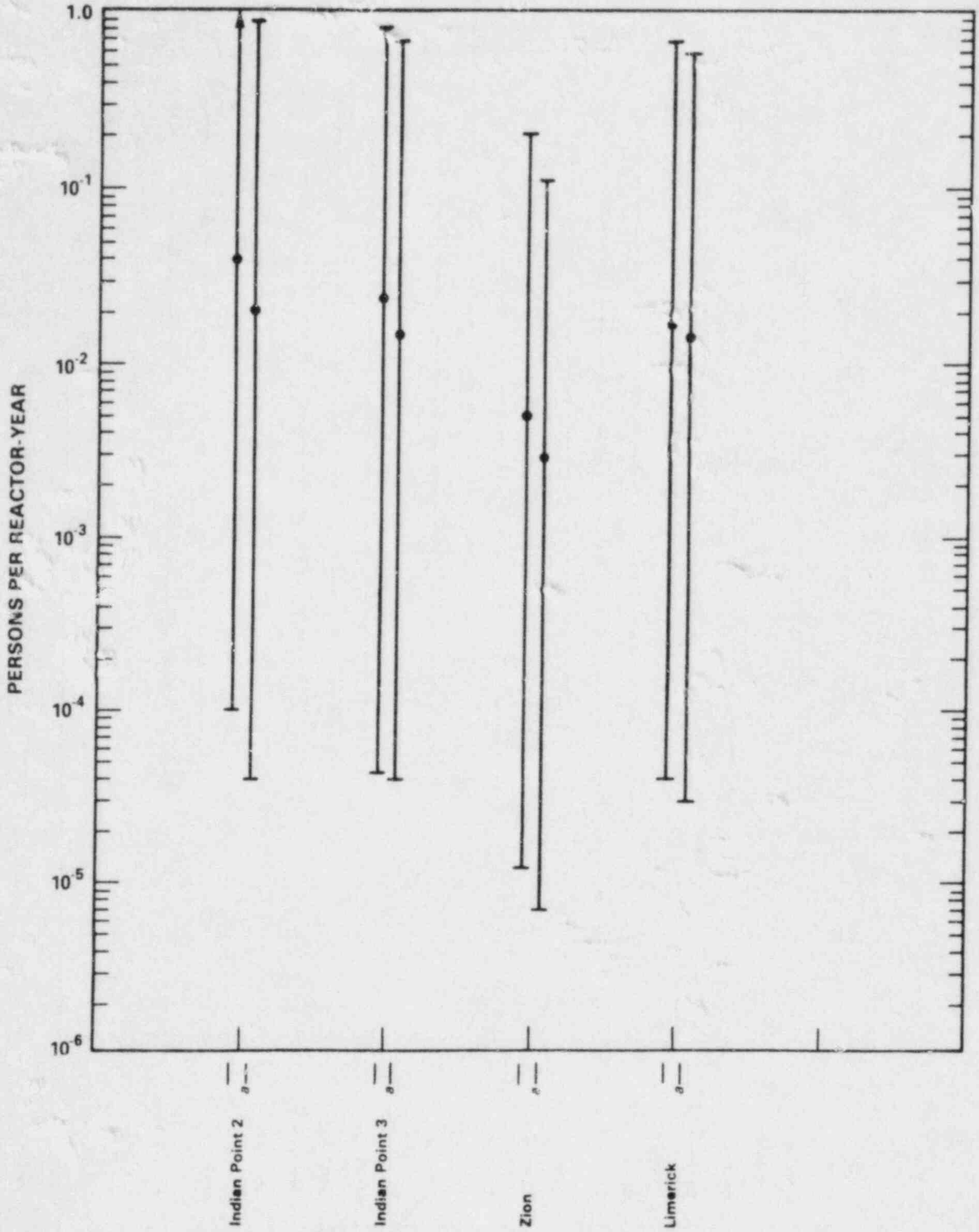


Figure 5.19 Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents for nuclear power plants having plant-specific PRAs, showing estimated range of uncertainties. See footnotes at the end of Figure 5.20.

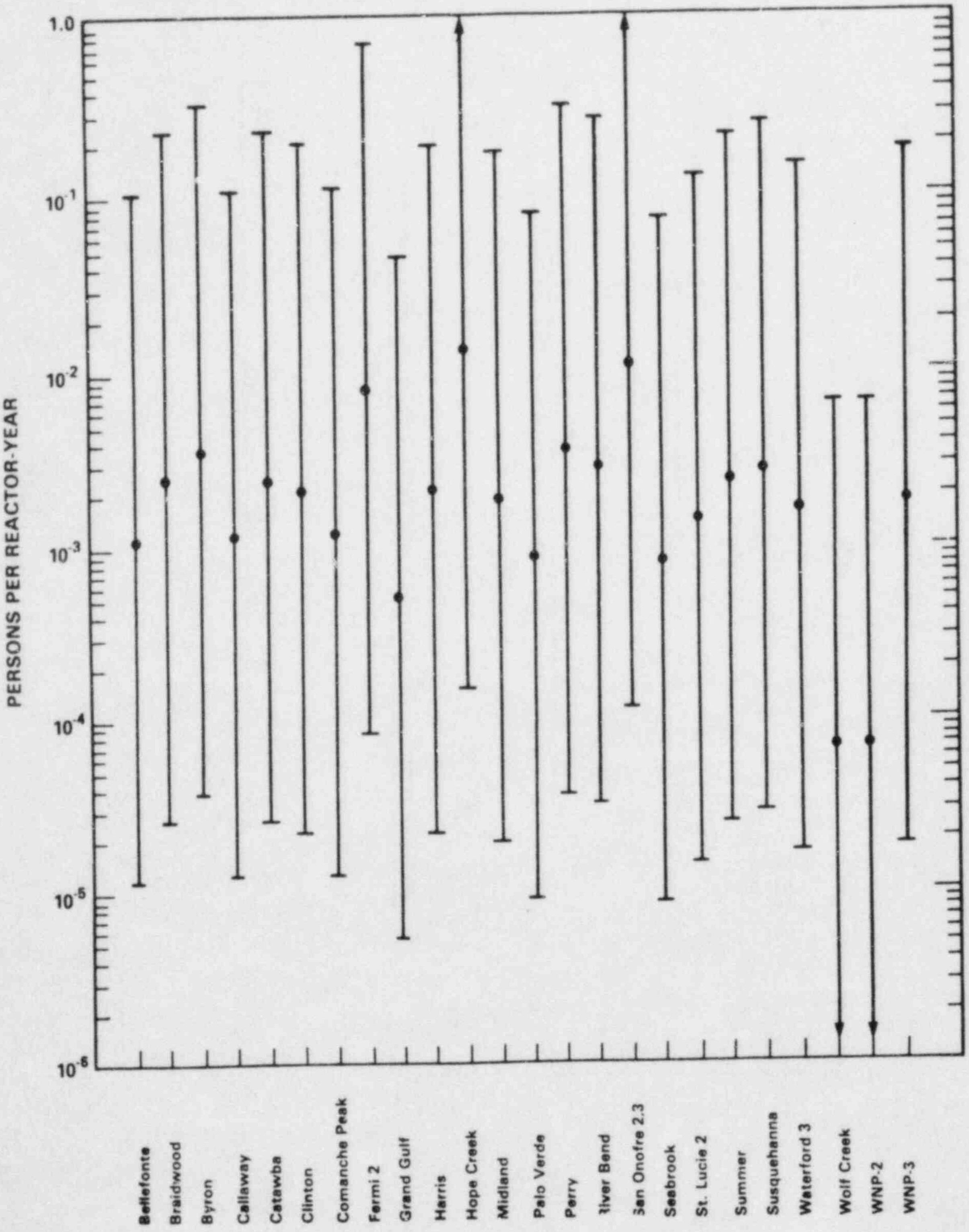


Figure 5.20 Estimated latent thyroid cancer fatality risk (persons) from severe reactor accidents from several nuclear power plants either operating or receiving consideration for issuance of a license to operate for which site-specific applications of NUREG-0773 accident releases have been used to calculate off-site consequences. Bars are drawn to illustrate effect of uncertainty range discussed in text. See footnotes on following page.

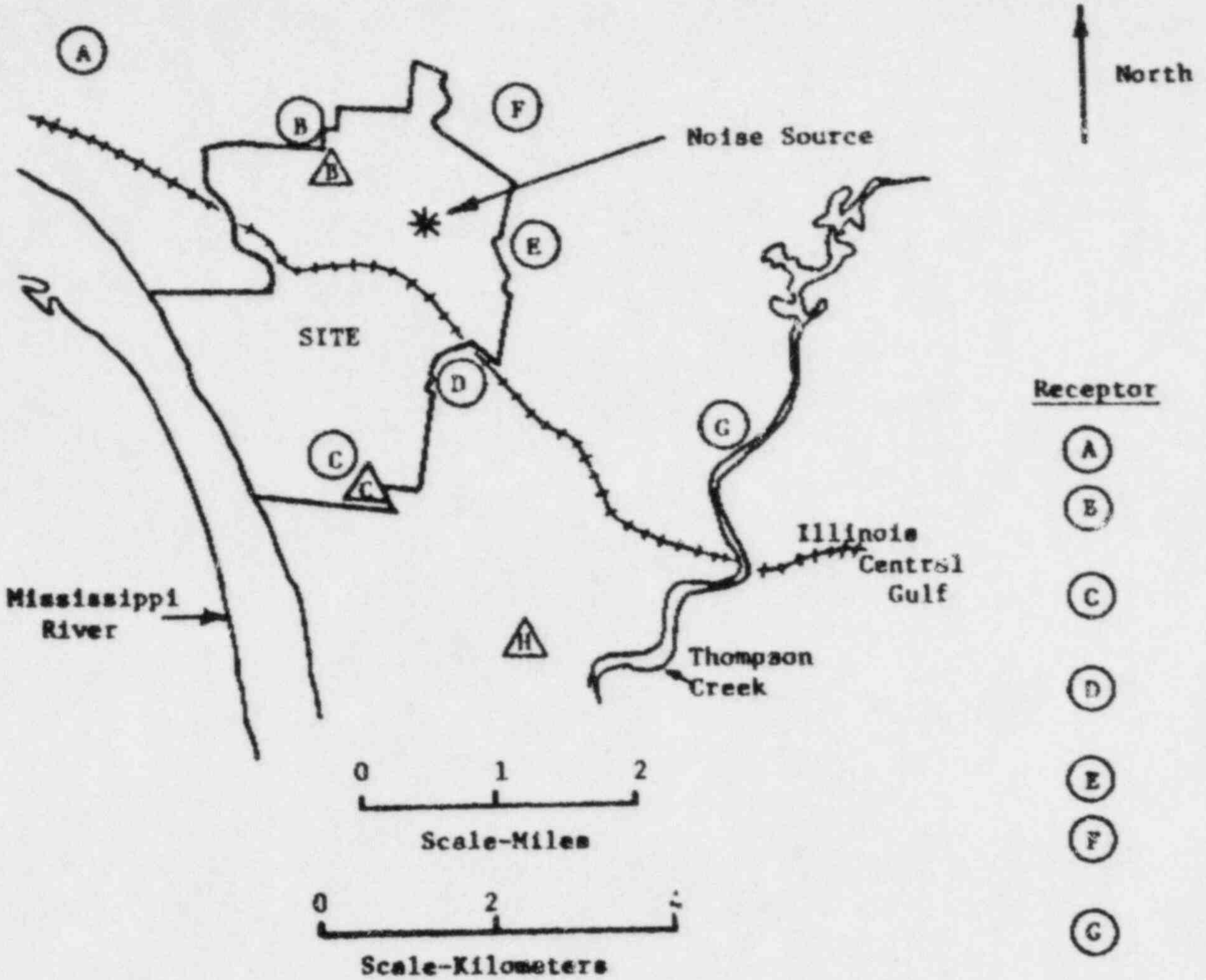
Notes for Figures 5.12 through 5.20

- Except for Indian Point, Zion, and Limerick, risk analyses for other plants in these figures are based on WASH-1400 generic source terms and probabilities for severe accidents and do not include external event analyses.
- 1-01 = 1 x 10^{-1} and so forth.
- Please see Section 5.9.4.5(7) for discussion of uncertainties.

† Assumes evacuation to 40 km (25 miles).

†† With evacuation within 16 km (10 miles) and relocation from 16-40 km (10-25 miles).

[a] Excluding severe earthquakes and hurricanes.



Receptor	Description
Ⓐ	Pecan Grove Drive, St. Francisville
Ⓑ	Route 965, 900 m (3000 ft.) North of Radio Tower
Ⓒ	River Access Road, 30 m (100 ft.) WSW of 69KV Transmission Line
Ⓓ	Police Jury Road, Powell Forest Planation, The Broadbents
Ⓔ	Police Jury Road, Star Hill Church
Ⓕ	Intersection of Route 61, Police Jury Road and Route 966
Ⓖ	Route 964, 1.3 Km (0.8 mi.) North of Illinois Central Gulf RR
△	1972 Survey Positions B, C and H

Figure 5.21 Ambient sound level measurement locations for River Bend site

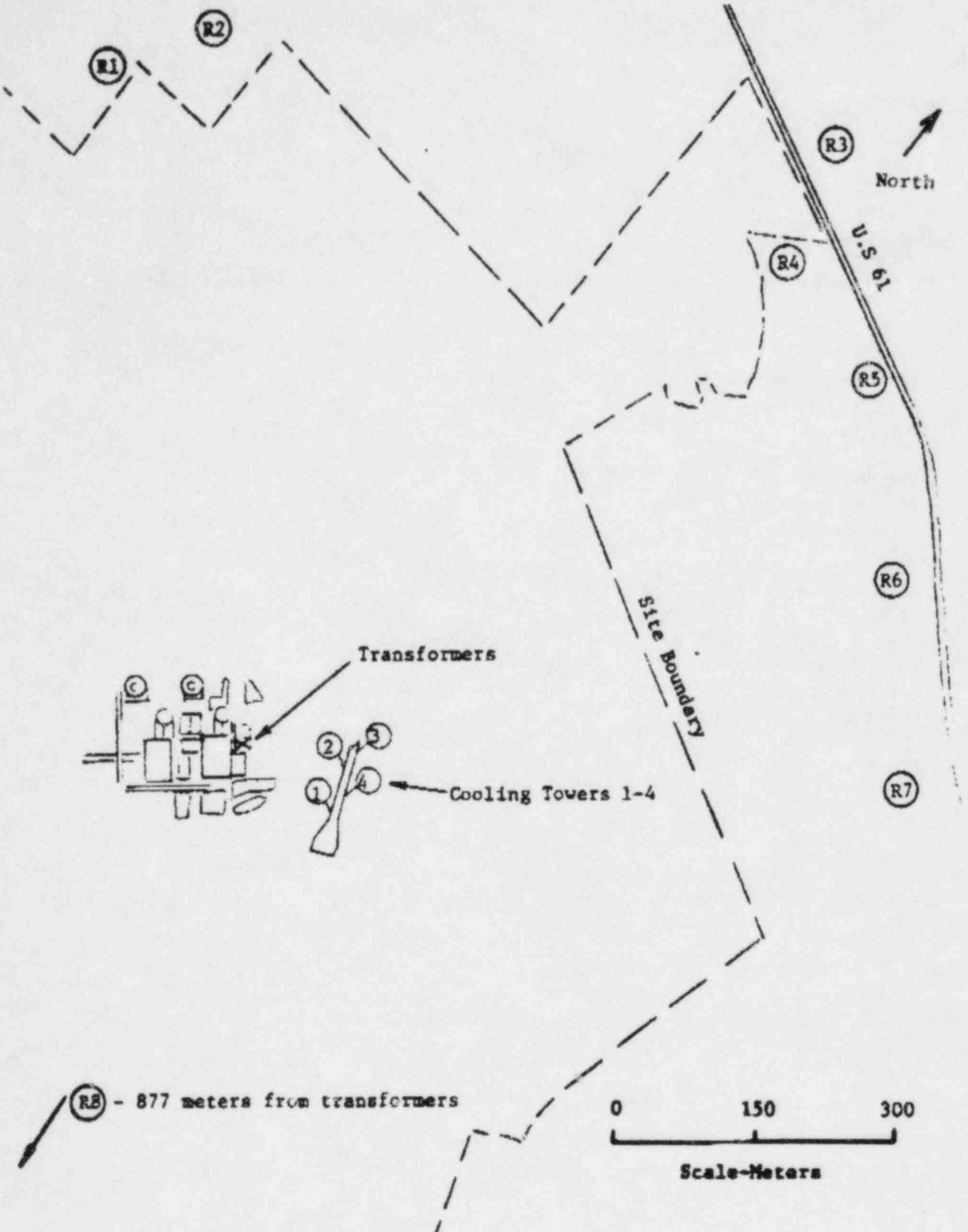


Figure 5.22 Residences nearest River Bend Station

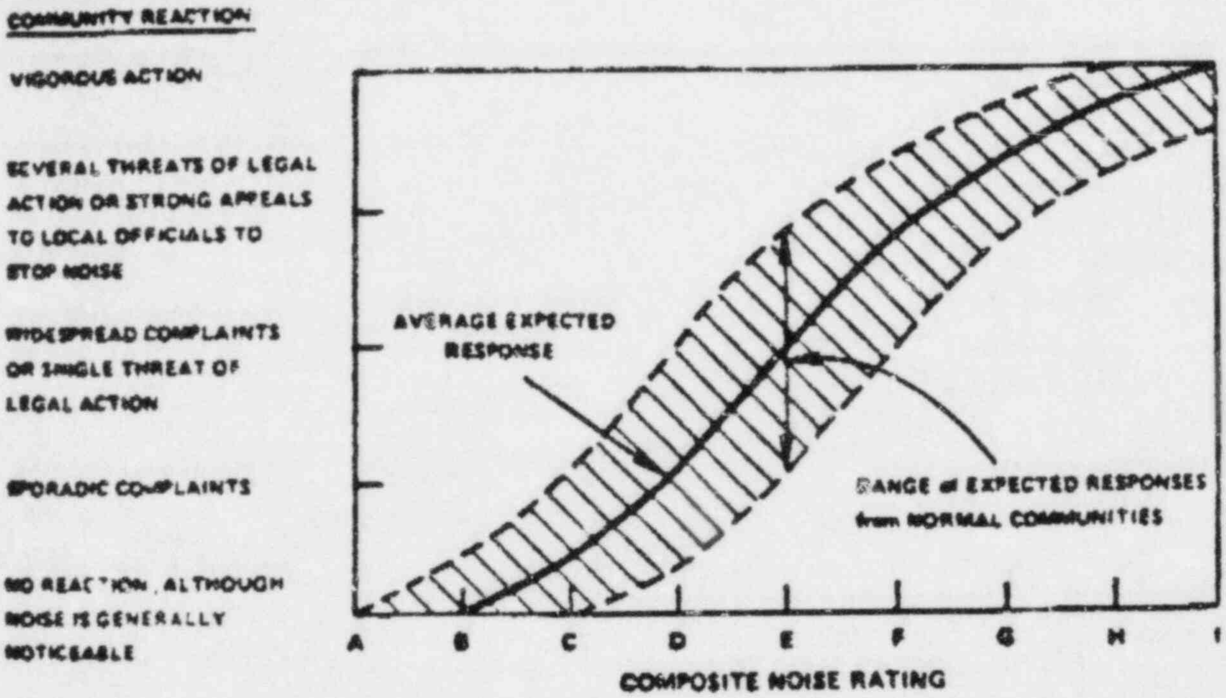


Figure 5.23 Estimated community response versus composite noise rating

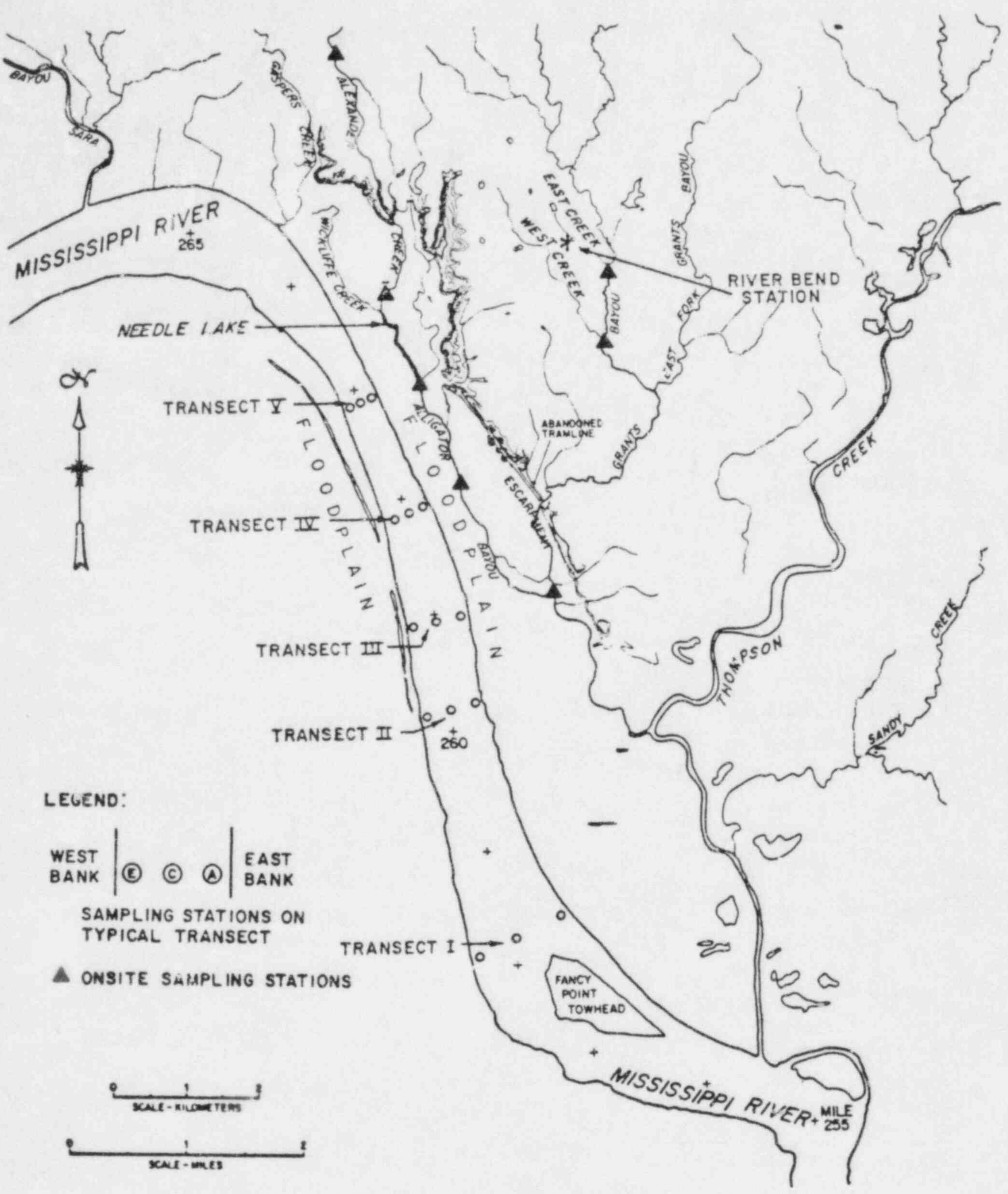


Figure 5.24 Aquatic biology sampling stations established during baseline study
Source: ER-OL Figure 6.5-1

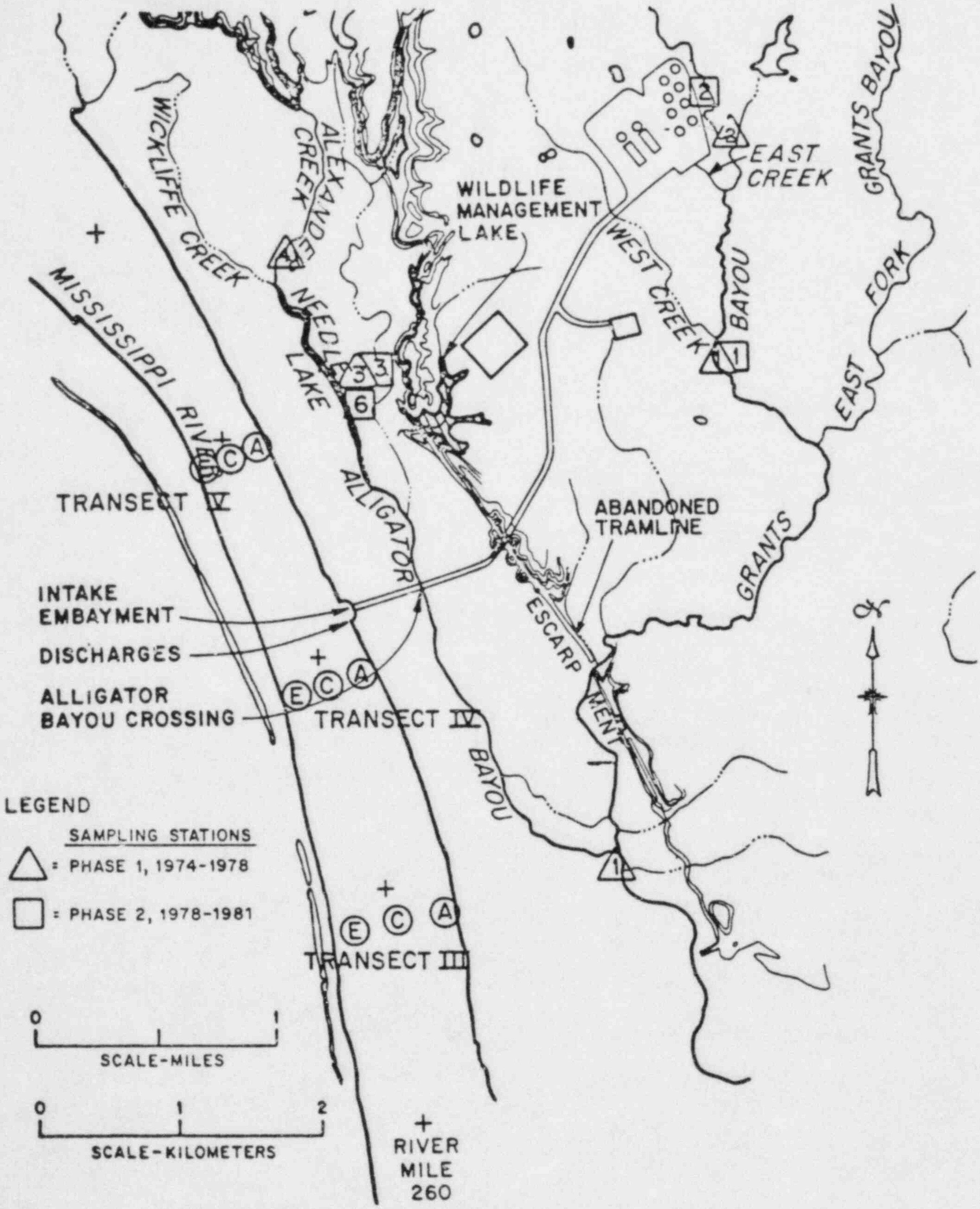


Figure 5.25 Aquatic sampling stations, interim monitoring, 1974-1981
Source: ER-OL Figure 6.5-2

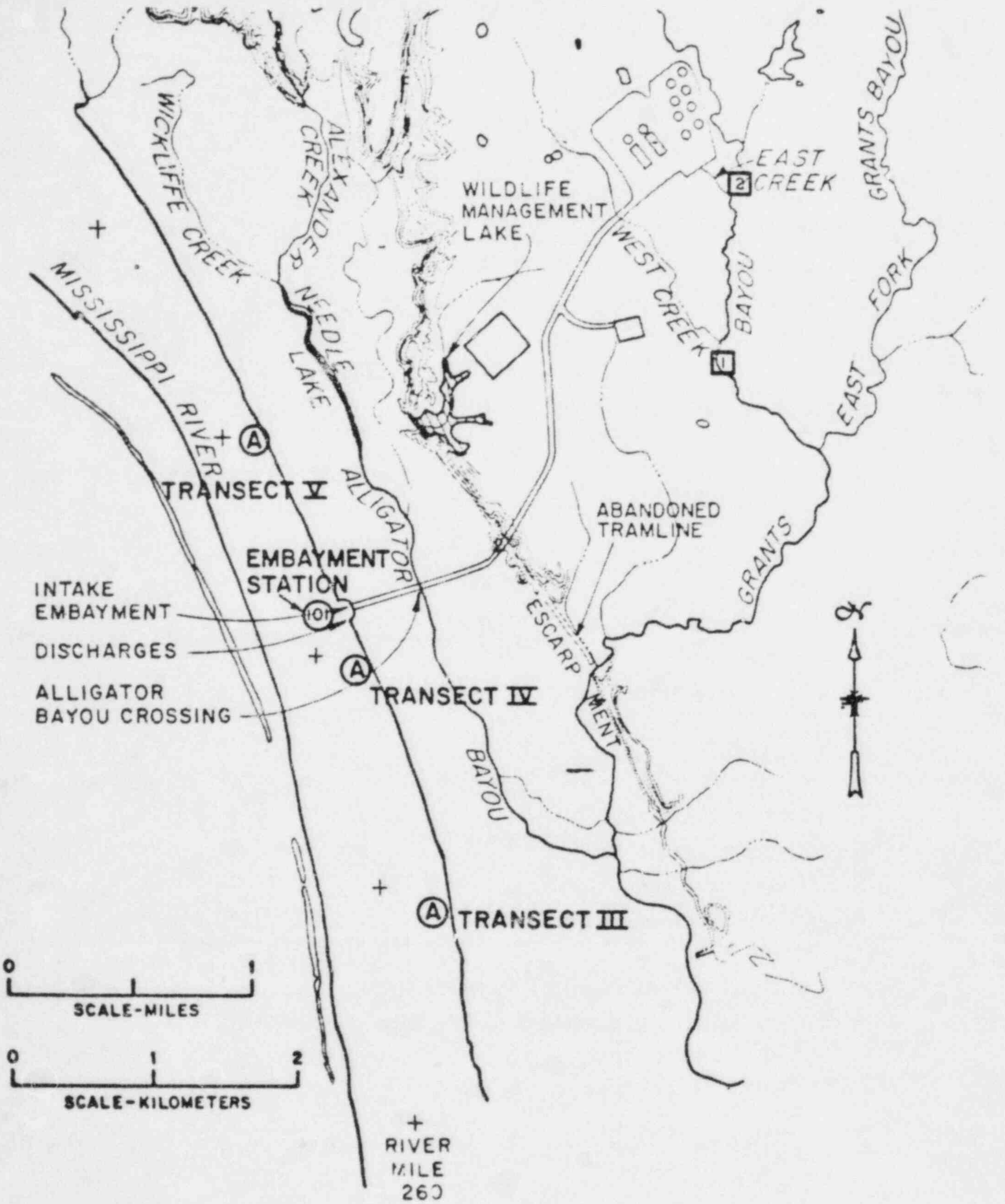


Figure 5.26 Aquatic sampling stations, preoperational and operational monitoring, 1983-1987

Table 5.1 Characteristics of sanitary waste treatment plant effluent

Element	Value
Biological oxygen demand (BOD) (5-day) removal and suspended solids removal	90%
Settleable solids	0.1 mg/L
Chlorination	1 ppm as free residual chlorine
pH	6.0 - 9.0
BOD (5-day) and suspended solids	30 mg/L

Source: ER-OL

Table 5.2 Summary of Alligator Bayou response to rainfall

	Rainfall recurrence interval (years)					
	1		5		10	
Condition	E_1*	T_0**	E_1	T_0	E_1	T_0
Natural condition	34.1	0	37.8	5	39.1	11
0% culvert blockage	38.5	11	39.8	20	40.2	23
25% culvert blockage	38.5	11	39.9	20	40.2	23
50% culvert blockage	38.5	13	39.9	21	40.2	25
75% culvert blockage	38.5	14	40.0	23	40.3	26

*E_1 = maximum water surface elevation in Upper Bayou (feet msl).
**T_0 = hours of flow overtopping River Road

Note: The minimum River Road elevation is approximately 37.3 feet msl.

Table 5.3 Estimated real estate and personal property taxes[1] to be paid to West Feliciana Parish

Year	Total estimated River Bend Station property taxes	Total estimated parish property tax revenue[2]	% of tax revenue attributable to River Bend Station
1986	$32,000[3]	$1,232,000	3%
1987	35,000	1,235,000	3%
1988	38,000	1,238,000	3%
1989	41,000	1,241,000	3%
1990	44.000	1,244,000	4%
1996[4]	$11,968,000[5]	$13,048,000	92%
1997	10,230,000	11,190,000	91%
1998	9,429,500	10,349,000	91%
1999	8,279,000	9,119,000	91%
2000	7,204,000	7,964,000	90%

[1] Dollars are valued in year of expenditure.

[2] The assessed valuation of parish taxable property other than River Bend was assumed to be $30 million for 1986-1990 and $40 million for 1996-2000.

[3] Taxes are for land and nuclear fuel.

[4] River Bend Station has qualified for an exemption from ad valorem taxes for a 10-yr period after the plant is placed in service.

[5] Estimated plant cost is $2.9 billion; CEPO financing costs are unknown.

Source: ER-OL Table 5.8-5

Table 5.4 Estimated sales taxes[1] to be paid during the first 5 years of operation of River Bend Station[1],[2]

Year	State (3%)	School Board (1%)	Parish (1%)	Total (5%)
1986	$ 469,600	$156,550	$156,550	$ 782,700
1987	507,200	169,050	169,050	845,300
1988	547,800	182,600	182,600	913,000
1989	591,600	197,200	197,200	986,000
1990	638,900	212,950	212,950	1,064,800
Total	$2,755,100	$918,350	$918,350	$4,591,800

[1] Dollars are valued in year of expenditure.

[2] Dollars reflect 100% of sales tax. Amounts could be reduced by 30% if CEPCO is granted tax exempt status.

Source: ER-OL Table 5.8-6

Table 5.5 Incidence of job-related mortalities

Occupational Group	Mortality Rates (premature deaths per 10^5 person-years)
Underground metal miners*	~1300
Uranium miners*	420
Smelter workers*	190
Mining**	61
Agriculture, forestry, and fisheries**	35
Contract construction**	33
Transportation and public utilities**	24
Nuclear-plant worker***	23
Manufacturing**	7
Wholesale and retail trade**	6
Finance, insurance, and real estate**	3
Services**	3
Total private sector**	10

*The President's Report on Occupational Safety and Health, "Report on Occupational Safety and Health by the U.S. Department of Health, Education, and Welfare," E. L. Richardson, Secretary, May 1972.

**U.S. Bureau of Labor Statistics, "Occupational Injuries and Illness in the United States by Industry, 1975," Bulletin 1981, 1978.

***The nuclear-plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The estimated occupational risk associated with the industry-wide average radiation dose of 0.8 rem is about 11 potential premature deaths per 10^5 person-years due to cancer, based on the risk estimators described in the following text. The average non-radiation-related risk for seven U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths per 10^5 person-years as shown in Figure 5 of the paper by R. Wilson and E. S. Koehl, "Occupational Risks of Ontario Hydro's Atomic Radiation Workers in Perspective," presented at Nuclear Radiation Risks, A Utility-Medical Dialog, sponsored by the International Institute of Safety and Health in Washington, D.C., September 22-23, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths describes a potential risk rather than an observed statistic.)

Table 5.6 (Summary Table S-4) 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 lbs. per truck; 100 tons per cask per rail car.
Traffic density:	
Truck	Less than 1 per day.
Rail	Less than 3 per month.

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals [2] (per reactor year)	Cumulative dose to exposed population (per reactor year) [3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem.
Along Route	600,000	0.0001 to 0.06 millirem	

ACCIDENTS IN TRANSPORT

	Environmental risk
Radiological effects	Small [4].
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

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[1] 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 Supp. I, NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 1717 H St. NW., Washington, D.C., and may be obtained from National Technical Information Service, Springfield, Va. 22161. WASH-1238 is available from NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microficho, $2.25).

[2] 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 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3] 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 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 man-rem dose in each case would be 1 man-rem.

[4] 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 multireactor site.

Table 5.7 Preoperational radiological environmental monitoring program summary*

Exposure Pathway and/or Sample	Number of Samples and Locations(1)	Sampling and Collection Frequency(1)	Type, Frequency, and Analysis
AIRBORNE			
Radioiodine and Particulates	Samples from 9 locations:	Continuous air sampler operation with filter collection weekly or as required by dust loading, whichever is more frequent	Radioiodine cannister: analysis weekly for I-131
	3 samples from locations near property boundaries (in different directional sectors) with the highest calculated annual average ground-level D/Q (NNE, N, NNW)		
	1 sample from the vicinity of station meteorological tower (approximately 1 km W)		Particulate sampler: gross beta activity following filter change(2), composite (by location) for gamma isotopic(3) quarterly
	1 sample from between the station and the river (near intake embayment) (2.8 km SSW)		
	1 sample from the community having the highest calculated annual average ground-level D/Q (St. Francisville, 5 km WNW)		
	2 samples from major communities 17 km ESE (Zachary) and 40 km SSE (Baton Rouge)		
	1 sample from a control location 20 km SW, in the least prevalent wind direction (Parlange Substation)		
DIRECT RADIATION	Measurements from 45 locations:	Thermoluminescent dosimeters (TLDs) changed monthly or quarterly	Gamma dose monthly or quarterly
	32 stations with two or more dosimeters to be placed in an inner ring near the restricted area boundary (in each of 16 directional sectors) and an outer ring in the 6- to 10-km range (16 sectors)		

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*Adapted from ER-OL Table 6.2-1.

Table 5.7 (continued)

Exposure Pathway and/or Sample	Number of Samples and Locations(1)	Sampling and Collection Frequency(1)	Type, Frequency, and Analysis
	3 stations to serve as control locations, 16, 18, and 20 km distant in the E, N, and SW sectors, respectively		
	10 special interest locations designated in Table 6.2-2		
WATERBORNE			
Surface(4)	1 sample from about 4 km upstream of the plant liquid discharge outfall, near LA Hwy. 10 ferry crossing(5)	Weekly grabs composited over 1-month periods	Gross beta and gamma isotopic analyses monthly; composite for tritium analysis quarterly
	1 sample from about 4 km downstream of the plant liquid discharge outfall, near Crown-Zellerbach paper mill		
Drinking	1 sample from nearest downstream water supply (People's Water Service Co., River Mile 175.5)(5)	Weekly grabs composited over 1-month periods	Gross beta and gamma isotopic analyses monthly; composite for tritium analysis quarterly
Ground	1 sample from Upland Terrace Aquifer well upgradient from site	Quarterly grab	Gross beta, gamma isotopic, and tritium analyses quarterly
	1 sample from Upland Terrace Aquifer well downgradient on site property		
Sediment from River Shoreline	1 sample from along east shore of river near Crown-Zellerbach papermill	Semi-annual grabs (spring and autumn quarters)	Gamma isotopic analysis semi-annually
INGESTION			
Milk	1 sample from McKowen Dairy, 6 km ESE (nearest source of milk for consumption)(6)	Semi-monthly when animals are on pasture monthly at other times	Gamma isotopic and I-131 analyses semi-monthly when animals are on pasture; monthly at other times
	1 sample from animals at a control location (Louisiana State Penitentiary at Angola), 35 km NW		

Table 5.7 (continued)

Exposure Pathway and/or Sample	Number of Samples and Locations(1)	Sampling and Collection Frequency(1)	Type, Frequency, and Analysis
Produce	1 sample of leafy vegetables grown in onsite garden near the site of the highest calculated annual average ground-level D/Q (1 km WNW)	Monthly when available	Gamma isotopic and I-131 analysis on edible portions monthly when available
	2 samples of leafy vegetables grown in offsite gardens in areas of the highest dose potential (N, NW, WNW sectors)(6)		
	1 sample of leafy vegetables grown at a control location (Louisiana State Penitentiary at Angola), 35 km NW		
Fish and Shellfish	1 sample from downstream of plant liquid discharge outfall, near River Mile 260.8, of each of the following: river shrimp, blue catfish, freshwater drum	Seasonally (e.g., summer for shrimp) when available or semi-annually	Gamma isotopic analysis on edible portions seasonally or semi-annually
	1 sample of the same species from an upstream control location		

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(1) The number, medium, frequency, and location of sampling may vary. At times it may not be possible or practical to obtain samples of the medium of choice at the desired location or time. In such cases, suitable alternative media and/or locations will be chosen for the particular pathway in question.

(2) Particulate sample filters will be analyzed for gross beta activity 24 hrs or more after sampling to allow for radon and thoran daughter decay. If gross beta activity in air or water is greater than 10 times the yearly mean of control samples for any medium, gamma isotopic analysis will be performed on the individual samples.

(3) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility or from weapons testing fallout.

(4) The upstream sample will be taken at a distance beyond influence of the plant discharge. The downstream sample will be taken in an area beyond but near the mixing zone.

(5) The upstream surface water sampling location (near LA Hwy. 10 ferry crossing) will be used as a control for drinking water sampling.

(6) If milk-producing animals become available within a 5-km radius of the plant, up to 3 samples from these animals will be analyzed in lieu of the leafy vegetable samples from offsite gardens in high dose-potential areas.

Table 5.8 Activity of radionuclides in a River Bend Station reactor core at 3039 MWt

Group/radionuclide	Radioactive inventory in millions of curies	Half-life (days)
A. <u>NOBLE GASES</u>		
Krypton-85	0.53	3,950
Krypton-85m	23	0.183
Krypton-87	44	0.0528
Krypton-88	65	0.117
Xenon-133	162	5.28
Xenon-135	32	0.384
B. <u>IODINES</u>		
Iodine-131	81	8.05
Iodine-132	111	0.0958
Iodine-133	162	0.875
Iodine-134	179	0.0366
Iodine-135	145	0.280
C. <u>ALKALI METALS</u>		
Rubidium-86	0.02	18.7
Cesium-134	7.2	750
Cesium-136	2.8	13.0
Cesium-137	4.4	11,000
D. <u>TELLURIUM-ANTIMONY</u>		
Tellurium-127	5.6	0.391
Tellurium-127m	1.0	109
Tellurium-129	30	0.048
Tellurium-129m	5.0	34.0
Tellurium-131m	12	1.25
Tellurium-132	111	3.25
Antimony-127	5.8	3.88
Antimony-129	32	0.179
E. <u>ALKALINE EARTHS</u>		
Strontium-89	85	52.1
Strontium-90	3.5	11,030
Strontium-91	102	0.403
Barium-140	153	12.8

Table 5.8 (continued)

Group/radionuclide	Radioactive inventory in millions of curies	Half-life (days)
F. COBALT AND NOBLE METALS		
Cobalt-58	0.74	71.0
Cobalt-60	0.27	1,920
Molybdenum-99	153	2.8
Technetium-99m	136	0.25
Ruthenium-103	102	39.5
Ruthenium-105	68	0.185
Ruthenium-106	24	366
Rhodium-105	47	1.50
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	3.7	2.67
Yttrium-91	111	59.0
Zirconium-95	145	65.2
Zirconium-97	145	0.71
Niobium-95	145	35.0
Lanthanum-140	153	1.67
Cerium-141	145	32.3
Cerium-143	119	1.38
Cerium-144	81	284
Praseodymium-143	119	13.7
Neodymium-147	57	11.1
Neptunium-239	1,534	2.35
Plutonium-238	0.05	32,500
Plutonium-239	0.02	8.9×10^6
Plutonium-240	0.02	2.4×10^6
Plutonium-241	3.2	5,350
Americium-241	0.0016	1.5×10^5
Curium-242	0.48	163
Curium-244	0.02	6,630

Note: The above grouping of radionuclides corresponds to that in Table 5.10.

Table 5.9 Approximate doses from selected design-basis accidents

	Duration of release	2-hr doses at 914 m* Thyroid (rem)	 Whole body (rem)
Infrequent accidents			
Release of liquid waste storage	<2 hr	0.1	-
Fuel handling accident	<2 hr	0.19	0.003
Limiting faults			
Main steamline break	<2 hr	0.88	0.01
Control rod drop	hr-days	0.61	0.003
Large-break LOCA	hr-days	14.0	0.02

*The nearest site (or exclusion area) boundary.

Table 5.10 Summary of atmospheric release in hypothetical accident sequences in a BWR (rebaselined)

Accident sequence or sequence group*	Probability per r-y	Fraction of Core Inventory Released** A	 B	 C	 D	 E	 F†	 G††
BWR-2a	5.30×10^{-6}	1	0.57	0.52	0.31	0.058	0.030	4.40×10^{-3}
BWR-2b	2.28×10^{-5}	1	0.21	0.58	0.55	0.063	0.044	7.20×10^{-3}
BWR-2c	1.00×10^{-5}	1	0.50	0.67	0.25	0.080	0.032	3.90×10^{-3}
BWR-3M	1.14×10^{-6}	1	0.33	0.17	0.49	0.014	0.030	5.8×10^{-3}
BWR-4M	6.08×10^{-5}	1	4.4×10^{-4}	6.2×10^{-3}	0.16	5.1×10^{-4}	9.8×10^{-4}	1.90×10^{-4}

*See Appendix F for description of the accident sequences and sequence groups.

**Background on the isotope groups and release mechanisms is in Appendix VII of WASH-1400 (NUREG-75/014).

†Includes Ru, Rh, Co, Mo, Tc.

††Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

Note: Refer to Section 5.9.4.5(7) for a discussion of uncertainties in risk estimates.

Table 5.11 Summary of environmental impacts and probabilities

Probability of impact per r-y	Persons exposed over 200 rems	Persons exposed over 25 rems	Early fatalities	Population exposure millions of person-rems, 80 km/total	Latent cancers, excluding thyroid total/80 km	Cost of offsite mitigating actions, $ millions
10^{-4}	0	0	0	0.001/0.002	1/0	3
10^{-5}	0	10,000	0	4/20	2000/300	2000
5×10^{-6}	9	20,000	0	10/30	3000/800	3000
10^{-6}	600	200,000	6	30/70	6000/3000	5000
10^{-7}	7,000	300,000	90	30/100	8000/4000	7000
10^{-8}	20,000	500,000	1000	30/100	8000/4000	7000
Related figure	5.4	5.4	5.6	5.5	5.7	5.8

Table 5.12 Estimated values of societal risks from severe accidents per reactor-year

Consequence type	Estimated risk within the 80-km region	Estimated total risk
(1) Early fatalities with supportive medical treatment (persons)	6E-5*	6E-5
(2) Early fatalities with minimal medical treatment (persons)	4E-4	4E-4
(3) Early injuries (persons)	5E-3	5E-3
(4) Latent cancer fatalities (excluding thyroid) (persons)	1E-2	4E-2
(5) Latent thyroid cancer fatalities (persons)	4E-3	7E-3
(6) Total person-rems	2E+2	7E+2
(7) Cost of protective actions (1980 $) and decontamination	5E+4	5E+4
(8) Land area for long-term interdiction (m^2)**	4E+5	4E+5

*6E-5 = 6×10^{-5} = 0.00006.

**About 2.6 million m^2 equals 1 mi^2.

Note: See Section 5.9.4.5(7) for a discussion of uncertainties. Estimated numbers were rounded to one significant digit only for the purpose of this table.

Table 5.13 Regional economic impacts of output and employment

Release categories*	Wind direction	Direct losses, $ millions: Nonagricultural	Direct losses, $ millions: Agricultural	Indirect losses, $ millions	Total, $ millions	Loss in employment, annualized jobs	Expected loss in output/r-y, 1980 $
Maximum losses							
1	SSE	1379	41	175	1595	68000	516
2	SSE	1379	41	175	1595	68000	2222
3	SSE	1379	41	175	1595	68000	974
4	WSW	0	105	13	118	4000	9
5	WSW	0	58	7	65	2000	256
Minimum losses							
1	W	45	64	13	122	4000	62
2	W	45	64	13	122	4000	268
3	W	45	64	13	122	4000	117
4	NW	0	6	1	7	<1000	1
5	NW	0	1	0	1	0	5
Expected losses/r-y							
1	All	1619	721	288	2628	<1	**
2	All	6646	2960	1182	10788	<1	
3	All	3054	1360	543	4957	<1	
4	All	1	44	6	51	<1	
5	All	0	1153	142	1295	<1	
All	All	11320	6238	2161	19719	0.8	

*Release categories include:

1. BWR-2a
2. BWR-2b
3. BWR-2c
4. BWR-3M
5. BWR-4M

**Not applicable, as the expected loss is already expressed in the "Total" column for this portion of the table.

Source: Bureau of Economic Analysis, U.S. Department of Commerce, with assumptions supplied by the NRC.

Table 5.14 (Summary Table S-3) Uranium fuel cycle environmental data[1]

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

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
NATURAL RESOURCES USE		
Land (acres):		
Temporarily committed[2]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant
Water (millions of gallons):		
Discharged to air	160	≈2 percent of model 1,000 MWe LWR with cooling tower
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4 percent of model 1,000 MWe LWR with once-through cooling
Fossil fuel:		
Electrical energy (thousands of MW-hour)	323	<5 percent of model 1,000 MWe LWR output
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant
Natural gas (millions of scf)	135	<0.4 percent 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	.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HCl	.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 cfs. NO_3—20 cfs. Fluoride—70 cfs.
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	.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.

Table 5.14 (continued)

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

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
EFFLUENTS—RADIOLOGICAL (CURIES)		
Gases (including entrainment):		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	.02	
Th-230	.02	
Uranium	.034	
Tritium (thousands)	18.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	.83	
Tc-99		Presently under consideration by the Commission.
Fission products and transuranics	.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling—included 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 percent 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. Approximately 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)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.5	From reprocessing and waste management.

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[1] In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the Table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Radon-222 from the uranium fuel cycle or estimates of Technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

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 Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248); and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two 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 § 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.

[3] 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 one reactor for one year or 57 reactors for 30 years.

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

[5] 1.2 percent from natural gas use and process.

Table 5.15 Summary of noise predictions for four circular mechanical draft cooling towers at community locations R1-R8; 1972 ambient measurements

Receptors	Ambient dBA	Noise sources only, dBA	Total: sources plus ambient, dBA	Modified CNR rating
R1	52	55	57	F
R2	52	55	57	F
R3	46	51	52	E
R4	46	53	54	E
R5	46	53	54	E
R6	46	55	56	F
R7	46	55	53	F
R8	50	49	53	E

Table 5.16 Summary of noise predictions for four circular mechanical draft cooling towers at community locations R1-R8; 1980 ambient measurements

Receptors	Ambient dBA	Noise sources only, dBA	Total: sources plus ambient, dBA	Modified CNR rating
R1	38	52	52	F
R2	38	52	52	F
R3	40	51	51	F
R4	40	53	53	F
R5	40	53	53	F
R6	40	55	55	G
R7	40	55	56	G
R8	38	49	50	E

Table 5.17 Summary of noise predictions for four circular mechanical draft cooling towers at community locations A-H; 1972 and 1980 ambients*

Ambient	Ambient dBA	Noise sources only, dBA	Total: sources plus ambient, dBA	Modified CNR rating
1972				
B	32	46	46	F
E	38	47	47	E
F	37	41	43	E
1980				
E	41	47	48	E

*All predictions revealed less than 10-dB increment on an octave band and dBA basis as shown in the table.

Table 5.18 Attenuation of noise by octave band through various types of trees, dB per meter

Band center frequency, Hz	Average trees	Bare trees	Very dense trees
31.5	0.03	0	0.07
63	0.04	0	0.08
125	0.05	0	0.09
250	0.06	0	0.10
500	0.08	0.02	0.12
1000	0.10	0.03	0.15
2000	0.13	0.05	0.20
4000	0.17	0.06	0.25
8000	0.21	0.08	0.30

Source: ER-OL

6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Impacts

The staff has reassessed the physical, social, biological, and economic impacts that can be attributed to the operation of the River Bend Station. These impacts are summarized in Table 6.1 of this environmental statement.

The applicant is required to adhere to the following conditions for the protection of the environment:

(1) Before engaging in any additional construction or operational activities that may result in any significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant will provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and will receive written approval from that office before proceeding with such activities.

(2) The applicant will carry out the environmental monitoring programs outlined in Section 5 of this statement as modified and approved by the staff and implemented in the Environmental Protection Plan and Technical Specifications that will be incorporated in the operating license.

(3) If an adverse environmental effect or evidence of irreversible environmental damage are detected during the operating life of the plant, the applicant will provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

6.2 Irreversible and Irretrievable Commitments of Resources

There has been no change in the staff's assessment of this impact since the earlier review except that the continuing escalation of costs has increased the dollar values of the materials used for constructing and fueling the plant.

6.3 Relationship Between Short-Term Use and Long-Term Productivity

There have been no significant changes in the staff's evaluation for the River Bend Station since the construction permit stage environmental review.

6.4 Benefit-Cost Summary

6.4.1 Summary

Sections below describe the economic, environmental, and socioeconomic benefits and costs associated with the operation of the River Bend Station.

6.4.2 Benefits

A major benefit to be derived from the operation of the River Bend Station is the approximately 4.5 billion kWh of baseload electrical energy that will be produced annually. (This projection assumes that the unit will operate at an annual average capacity factor of 55%.) The addition of the unit will also improve the applicant's ability to supply system load requirements by contributing 940 MW of capacity to the Cajun and Gulf States systems (282 MW to the Cajun system and 658 MW to the Gulf States system).

The staff estimates that production costs incurred on 4.5 billion kWh of the applicant's existing fossil units will be reduced by approximately 36.2 mills per kWh, resulting in a total cost reduction per year on existing generation of $163 million (1986 dollars).

6.4.3 Economic Costs

The economic costs associated with station operation include fuel costs and operating and maintenance costs, which are expected to average approximately 11.1 mills per kWh and 9.3 mills per kWh, respectively (1986 dollars).

Total production costs for the 4.5 billion kWh per year produced by the nuclear unit will be $92 million per year (1986 dollars).

6.4.4 Socioeconomic Costs

No significant socioeconomic costs are expected from either the operation of the River Bend Station or from the number of station personnel and their families living in the area. The socioeconomic impacts of a severe accident could be large, however, the probability of such an accident is small.

6.5 Conclusion

As a result of its analysis and review of potential environmental, technical, and social impacts, the staff concludes that River Bend Station can be operated with minimal environmental impact.

6.6 Reference

U.S. Nuclear Regulatory Commission, NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning Nuclear Facilities," January 1981.

Table 6.1 Benefit-cost summary

Primary impact and effect on population or resources	Quantity	Impacts*
BENEFITS		
Capacity		
Additional generating capacity	940 MWe	Large
Economic		
Reduction in existing system production costs	4.5 billion kWh/yr @ 36.2 mills/kWh or $163 million/yr**	
COSTS		
Economic		
Fuel	11.1 mills/kWh**	Small
Operation and maintenance	9.3 mills/kWh**	Moderate
Total	$92 million/yr**	Small
Decommissioning	$56-94 million†	Small-Moderate

*Subjective measure of costs and benefits is assigned by reviewers, where quantification is not possible: "Small" = impacts that in the reviewers' judgments, are of such minor nature, based on currently available information, that they do not warrant detailed investigations or considerations of mitigative actions; "Moderate" = impacts that in the reviewers' judgments are likely to be clearly evident (mitigation alternatives are usually considered for moderate impacts); "Large" = impacts that in the reviewers' judgments, represent either a severe penalty or a major benefit. Acceptance requires that large negative impacts should be more than offset by other overriding project considerations.

**1986 dollars.

†1984 dollars.

7 LIST OF CONTRIBUTORS

The following persons participated in the preparation of this Draft Environmental Statement:

U.S. Nuclear Regulatory Commission Staff

E. J. Weinkam III	Licensing Project Manager; M.S. (Mechanical Engineering) 1984; Mechanical/ Nuclear Engineering; 10 years experience.
S. Acharya	Senior Radiological Engineer; Ph.D. (Physics) 1971; Nuclear Engineering; 15 years experience.
L. Bell	Nuclear Engineer; M.S. (Physics) 1967; Nuclear Engineering; 12 years experience.
C. Billups	Aquatic Scientist; Ph.D. (Marine Science) 1974; Aquatic/Fishery Resources, Aquatic Ecology; 14 years experience.
E. Brannagan	Health Physicist; Ph.D. (Nuclear and Radio Chemistry) 1971; Health Physics; 12 years experience.
L. Bykoski	Regional Environmental Economist; Ph.D. (Economics) 1965; 19 years experience.
C. Ferrell	Site Analyst; B.S. (Physics) 1950; Radiological Physics; 32 years experience.
E. N. Fields	Cost-Benefit Economist, Electrical Engineer; B.S. (Electrical Engineering) 1969; 15 years experience.
C. R. Hickey, Jr.	Senior Fishery Biologist: M.S. (Marine Science) [illegible] Marine/Fisheries Science; 14 years experience; AFS Certified Fisheries Scientist.
G. LaRoche	Senior Land Use Analyst; Ph.D. (Botany, Ecology) 1969; Land Use and Terrestrial Ecology; 28 years experience.
J. C. Lehr	Senior Environmental Engineer; M.S. (Environmental Engineering) 1972; Water Quality; 12 years experience.

J. Levine	Senior Meteorologist; M.S. (Meteorology) 1967; Meteorology; 30 years experience.
R. Wescott	Hydraulic Engineer; M.S. (Engineering Science) 1974; Hydraulic Engineering; 10 years experience.
Argonne National Laboratory	
Anthony J. Policastro	Noise Analyst; Ph.D. (Civil Engineering) 1970; Applied Mathematics; 13 years experience.
Oak Ridge National Laboratory	
Carolyn T. Hunsaker	Environmental Scientist; Ph.D (Environmental Science and Engineering) 1980; Aquatic Resources; 5 years experience.
Roger L. Kroodsma	Terrestrial Ecologist; Ph.D. (Zoology) 1970; Land Use and Terrestrial Ecology; 14 years experience
Richard B. McLean	Aquatic Ecologist; Ph.D. (Marine Biology) 1974; Fishery Harvest Estimates; 10 years experience.

8 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS ENVIRONMENTAL STATEMENT ARE BEING SENT

Advisory Council on Historic Preservation
Federal Energy Regulatory Commission
Rural Electrification Administration
U.S. Department of Agriculture
U.S. Department of the Army, Corps of Engineers
U.S. Department of Commerce
U.S. Department of Energy
U.S. Department of Health and Human Services
U.S. Department of Housing and Urban Development
U.S. Department of Interior
U.S. Department of Transportation
U.S. Environmental Protection Agency
Louisiana Public Service Commission
President of West Feliciana Police Jury
State of Louisiana, Department of Environmental Quality

9 RESERVED FOR NRC STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

APPENDIX A

RESERVED FOR COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

APPENDIX B

NEPA POPULATION-DOSE ASSESSMENT

APPENDIX B
NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 miles) of the River Bend facility, employing the same dose calculation models used for individual doses (see Regulatory Guide (RG) 1.109, Revision 1), for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR 50, Appendix I. In addition, dose commitments to the population residing beyond the 80-km region, 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) are taken into consideration for the purpose of meeting the requirements of the National Environmental Policy Act of 1969 (NEPA). This appendix describes the methods used to make these NEPA population-dose estimates.

1. Iodines and Particulates Released to the Atmosphere

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind; thus the concentration of these nuclides remaining in the plume is continuously being reduced. Within 80 km of the facility, the deposition model in RG 1.111, Revision 1, is used in conjunction with the dose models in RG 1.109, Revision 1. Site-specific data concerning production and consumption of foods within 80 km of the reactor are used. For estimates of population doses beyond 80 km, it is assumed that excess food not consumed within the 80-km area would be consumed by the population beyond 80 km. It is further assumed that none, or very few, of the particulates released from the facility will be transported beyond the 80-km distance; thus, they will make no significant contribution to the population dose outside the 80-km region, except by export of food crops. This assumption was tested and found to be reasonable for the River Bend Station.

2. Noble Gases, Carbon-14, and Tritium Released to the Atmosphere

For locations within 80 km of the reactor facility, exposures to these effluents are calculated with a constant mean wind-direction model according to the guidance provided in RG 1.111, Revision 1, and the dose models described in RG 1.109, Revision 1. For estimating the dose commitment from these radionuclides to the U.S. population residing beyond the 80-km region, two dispersion regimes are considered. These are referred to as the first-pass-dispersion regime and the world-wide-dispersion regime. The model for the first-pass-dispersion regime estimates the dose commitment to the population from the radioactive plume as it leaves the facility and drifts across the continental U.S. toward the northeastern corner of the U.S. The model for the world-wide-dispersion regime estimates the dose commitment to the U.S. population after the released radionuclides mix uniformly in the world's atmosphere or oceans.

(a) First-Pass Dispersion

For estimating the dose commitment to the U.S. population residing beyond the 80-km region as a result of the first pass of radioactive pollutants, it is assumed that the pollutants disperse in the lateral and vertical directions along the plume path. The direction of movement of the plume is assumed to be from the facility toward the northeast corner of the U.S. The extent of vertical dispersion is assumed to be limited by the ground plane and the stable atmospheric layer aloft, the height of which determines the mixing depth. The shape of such a plume geometry can be visualized as a right cylindrical wedge whose height is equal to the mixing depth. Under the assumption of constant population density, the population dose associated with such a plume geometry is independent of the extent of lateral dispersion, and is only dependent upon the mixing depth and other nongeometrical related factors (NUREG-0597). The mixing depth is estimated to be 1000 m, and a uniform population density of 62 persons/km^2 is assumed along the plume path, with an average plume-transport velocity of 2 m/s.

The total-body population-dose commitment from the first pass of radioactive effluents is due principally to external exposure from gamma-emitting noble gases, and to internal exposure from inhalation of air containing tritium and from ingestion of food containing carbon-14 and tritium.

(b) World-Wide Dispersion

For estimating the dose commitment to the U.S. population after the first-pass, world-wide dispersion is assumed. Nondepositing radionuclides with half-lives greater than 1 year are considered. Noble gases and carbon-14 are assumed to mix uniformly in the world's atmosphere (3.8×10^{18} m^3), and radioactive decay is taken into consideration. The world-wide-dispersion model estimates the activity of each nuclide at the end of a 20-year release period (midpoint of reactor life) and estimates the annual population-dose commitment at that time, taking into consideration radioactive decay and physical removal mechanisms (for example, carbon-14 is gradually removed to the world's oceans). The total-body population-dose commitment from the noble gases is due mainly to external exposure from gamma-emitting nuclides, whereas from carbon-14 it is due mainly to internal exposure from ingestion of food containing carbon-14.

The population-dose commitment as a result of tritium releases is estimated in a manner similar to that for carbon-14, except that after the first pass, all the tritium is assumed to be immediately distributed in the world's circulating water volume (2.7×10^{16} m^3) including the top 75 m of the seas and oceans, as well as the rivers and atmospheric moisture. The concentration of tritium in the world's circulating water is estimated at the time after 20 years of releases have occurred, taking into consideration radioactive decay; the population-dose commitment estimates are based on the incremental concentration at that time. The total-body population-dose commitment from tritium is due mainly to internal exposure from the consumption of food.

3. Liquid Effluents

Population-dose commitments due to effluents in the receiving water within 80 km of the facility are calculated as described in RG 1.109, Revision 1. It is assumed that no depletion by sedimentation of the nuclides present in the receiving water occurs within 80 km. It also is assumed that aquatic biota concentrate radioactivity in the same manner as was assumed for the ALARA evaluation for the maximally exposed individual. However, food-consumption values appropriate for the average, rather than the maximum, individual are used. It is further assumed that all the sport and commercial fish and shellfish caught within the 80-km area are eaten by the U.S. population.

Beyond 80 km, it is assumed that all the liquid-effluent nuclides except tritium have deposited on the sediments so that they make no further contribution to population exposures. The tritium is assumed to mix uniformly in the world's circulating water volume and to result in an exposure to the U.S. population in the same manner as discussed for tritium in gaseous effluents.

4. References

U.S. Nuclear Regulatory Commission, NUREG-0597, K. F. Eckerman, et al., "User's Guide to GASPAR Code," June 1980.

---, RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

---, RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Revision 1, July 1977.

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

APPENDIX C

IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the light water reactor (LWR)-supporting fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 (see Section 5.10 of the main body of this report) and the NRC staff's estimates for radon-222 and technetium-99 releases. For the sake of consistency, the analysis of fuel-cycle impacts has been cast in terms of a model 1000-MWe LWR operating at an annual capacity factor of 80%. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff's analysis and conclusions would not be altered if the analysis were to be based on the net electrical power output of the River Bend Station.

1. Land Use

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 460,000 m^2 (113 acres). Approximately 53,000 m^2 (13 acres) per year are permanently committed land, and 405,000 m^2 (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel-cycle plant, such as a mill, enrichment plant, or succeeding plants. On abandonment or decommissioning, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 405,000 m^2 per year of temporarily committed land, 320,000 m^2 are undisturbed and 90,000 m^2 are disturbed. Considering common classes of land use in the United States,* fuel-cycle land-use requirements to support the model 1000-MWe LWR do not represent a significant impact.

2. Water Use

The principal water-use requirement for the fuel cycle supporting a model 1000-MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43×10^6 m^3 (11.4×10^9 gal), about 42×10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (for example, evaporation losses in process cooling) of about 0.6×10^6 m^3 (16×10^7 gal) per year and water discharged to the ground (for example, mine drainage) of about 0.5×10^6 m^3 per year.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4% of those from the model 1000-MWe LWR using once-through cooling. The consumptive water use of 0.6×10^6 m^3 per year is about 2% of that from the

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*A coal-fired plant of 1000 MWe capacity using strip-mined coal requires the disturbance of about 810,000 m^2 (200 acres) per year for fuel alone.

model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of the model 1000-MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the proposed project.

3. Fossil Fuel Consumption

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. Electrical energy associated with the fuel cycle represents about 5% of the annual electrical power production of the model 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from the model plant. The staff finds that the direct and indirect consumptions of electrical energy for fuel-cycle operations are small and acceptable relative to the net power production of the proposed project.

4. Chemical Effluents

The quantities of chemical, gaseous, and particulate effluents associated with fuel-cycle processes are given in Table S-3. The principal species are sulfur oxides, nitrogen oxides, and particulates. On the basis of data in a Council on Environmental Quality report (CEQ, 1976), the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with the same emissions from the stationary fuel-combustion and transportation sectors in the United States; that is, about 0.02% of the annual national releases for each of these species. The staff believes that 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 such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. The flow of dilution water required for specific constituents is specified in Table S-3. 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 the NPDES permit.

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

5. Radioactive Effluents

Radioactive effluents estimated to be released to the environment from reprocessing and waste-management activities and certain other phases of the fuel-cycle process are set forth in Table S-3. Using these data, the staff has calculated for 1 year of operation of the model 1000-MWe LWR, the 100-year involuntary environmental dose commitment* to the U.S. population from the LWR-supporting fuel cycle. Dose commitments are provided in this section for exposure to four categories of radioactive releases: (1) airborne effluents that are quantified in Table S-3 (that is, all radionuclides except randon-222 and technetium-99); (2) liquid effluents that are quantified in Table S-3 (that is, all radionuclides except technetium-99); (3) the staff's estimate of radon-222 releases; and (4) the staff's estimate of technetium-99 releases. Dose commitments from the first two categories are also described in a proposed explanatory narrative for Table S-3, which was published in the Federal Register on March 4, 1981 (46 FR 15154-15175).

Airborne Effluents

Population dose estimates for exposure to airborne effluents are based on the annual releases listed in Table S-3, using an environmental dose commitment (EDC) time of 100 years.* The computational code used for these estimates is the RABGAD code originally developed for use in the "Generic Environmental Impact Statement on the Use of Mixed Oxide Fuel in Light-Water-Cooled Nuclear Power Plants," GESMO (NUREG-0002, Chapter IV, Section J, Appendix A). Two generic sites are postulated for the points of release of the airborne effluents: (1) a site in the midwestern United States for releases from a fuel reprocessing plant and other facilities, and (2) a site in the western United States for releases from milling and a geological repository.

The following environmental pathways were considered in estimating doses: (1) inhalation and submersion in the plume during its initial passage; (2) ingestion of food; (3) external exposure from radionuclides deposited on soil; and (4) atmospheric resuspension of radionuclides deposited on soil. Radionuclides released to the atmosphere from the midwestern site are assumed to be transported with a mean wind speed of 2 m/sec over a 2413-km (1500-mile) pathway from the midwestern United States to the northeast corner of the United States, and deposited on vegetation (deposition velocity of 1.0 cm/sec) with subsequent uptake by milk- and meat-producing animals. No removal mechanisms are assumed during the first 100 years, except normal weathering from crops to soil (weathering half-life of 13 days). Doses from exposure to carbon-14 were estimated using the GESMO model to estimate the dose to U.S. population from the initial passage of carbon-14 before it mixed in the world's carbon pool. The model developed by Killough (1977) was used to estimate doses from exposure to carbon-14 after it mixed in the world's carbon pool.

In a similar manner, radionuclides released from the western site were assumed to be transported over a 3218-km (2000-mile) pathway to the northeast corner of the United States. The agricultural characteristics that were used in computing doses from exposure to airborne effluents from the two generic sites are described in GESMO (NUREG-0002, page IV J(A)-19). To allow for an increase in population, the population densities used in this analysis were 50% greater than the values used in GESMO (NUREG-0002, page IV J(A)-19).

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*The 100-year environmental dose commitment is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years.

Liquid Effluents

Population dose estimates for exposure to liquid effluents are based on the annual releases listed in Table S-3 and the hydrological model described in GESMO (NUREG-0002, pages IV J(A)-20, -21, and -22). The following environmental pathways were considered in estimating doses: (1) ingestion of water and fish; (2) ingestion of food (vegetation, milk, and beef) that had been produced through irrigation; and (3) exposure from shoreline, swimming, and boating activities.

It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from gaseous releases from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 450 person-rems to the total body for each year of operation of the model 1000-MWe LWR (reference reactor year, or, RRY). Based on Table S-3 values, the additional involuntary total-body dose commitments to the U.S. population from radioactive liquid effluents (excluding technetium-99) as a result of all fuel-cycle operations other than reactor operation would be about 100 person-rems per year of operation. Thus, the estimated involuntary 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is about 500 person-rems (whole-body) per RRY.

Because there are higher dose commitments to certain organs (for example, lung, bone, and thyroid) than to the total body, the total risk of radiogenic cancer is not addressed by the total body dose commitment alone. Using risk estimators of 135, 6.9, 22, and 13.4 cancer deaths per million person-rems for total-body, bone, lung, and thyroid exposures, respectively, it is possible to estimate the total body risk equivalent dose for certain organs (NUREG-0002, Chapter IV, Section J, Appendix B). The sum of the total body risk equivalent dose from those organs was estimated to be about 100 person-rems. When added to the above value, the total 100-year environmental dose commitment would be about 650 person-rems (total body risk equivalent dose) per RRY (Section 5.9.3.1.1 describes the health effects models in more detail).

Radon-222

At this time the quantities of radon-222 and technetium-99 releases are not listed in Table S-3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal technetium-99 releases occur from gaseous diffusion enrichment facilities. The staff has determined that radon-222 releases per RRY from these operations are as given in Table C-1. The staff has calculated population-dose commitments for these sources of radon-222 using the RABGAD computer code described in Volume 3 of NUREG-0002, Appendix A, Chapter IV, Section J. The results of these calculations for mining and milling activities prior to tailings stabilization are listed in Table C-2.

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*The 100-year environmental dose commitment is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years.

The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining and milling, and active tailings, and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. The staff has assumed that after completion of active mining, underground mines will be sealed, returning releases of radon-222 to background levels. For purposes of providing an upper bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open-pit mines, releases from them would be 110 Ci per RRY. However, because the distribution of uranium-ore reserves available by conventional mining methods is 66% underground and 34% open pit (Department of Energy, 1978), the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these proportions. This means that long-term releases from unreclaimed open-pit mines will be 0.34 x 110 or 37 Ci per year per RRY.

Based on a value of 37 Ci per year per RRY for long-term releases from unreclaimed open-pit mines, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods would be about 3700 Ci and 37,000 Ci per RRY, respectively. The total dose commitments for a 100- to 1000-year period would be as shown in Table C-3.

These commitments represent a worst case situation in that no mitigating circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for open-pit uranium mines. If so, long-term releases from such mines should approach background levels.

For long-term radon releases from stabilized-tailings piles, the staff has assumed that these tailings would emit, per RRY, 1 Ci per year for 100 years, 10 Ci per year for the next 400 years, and 100 Ci per year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized-tailings piles per RRY would be 100 Ci in 100 years, 4090 Ci in 500 years, and 53,800 Ci in 1000 years (Gotchy, 1978). The total-body, bone, and bronchial epithelium dose commitments for these periods are as shown in Table C-4.

Using risk estimators of 135, 6.9, and 22 cancer deaths per million person-rems for total-body, bone, and lung exposures, respectively, the estimated risk of cancer mortality resulting from mining, milling, and active-tailings emissions of radon-222 (Table C-2) is about 0.11 cancer fatality per RRY. When the risks from radon-222 emissions from stabilized tailings and from reclaimed and unreclaimed open pit mines are added to the value of 0.11 cancer fatality, the overall risks of radon-induced cancer fatalities per RRY range as follows:

0.19 fatality for a 100-year period
2.0 fatalities for a 1000-year period

These doses and predicted health effects have been compared with those that can be expected from natural-background emissions of radon-222. Using data from the National Council on Radiation Protection (NCRP, 1975), the staff calculates the average radon-222 concentration in air in the contiguous United States to be about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 millirems. For a stabilized future U.S. population of 300 million, this represents a total lung-dose commitment of 135 million person-rems per year. Using the same risk estimator of 22 lung-cancer fatalities per million person-lung-rems used to predict cancer fatalities for the model 1000 MWe LWR, the staff estimates that lung-cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year, or 300,000 to 3,000,000 lung-cancer deaths over periods of 100 to 1000 years, respectively.

Current NRC regulations (10 CFR 40, Appendix A) require that an earth cover, not less than 3 m deep, be placed over tailings to reduce the radon-222 emanation from the disposed tailings to less than 2 pCi/m^2-sec, on a calculated basis above background. In October 1983, EPA published environmental standards for the disposal of uranium and thorium mill tailings at licensed commercial processing sites.* EPA's regulations (40 CFR 192) require that disposal be designed to limit radon-222 emanation to less than 20 pCi/m^2-sec, average over the surface of the disposed tailings. The NRC is reviewing its regulations for tailings disposal to ensure that they conform with the EPA regulations. Although a few of the dose estimates in this appendix would change if NRC adopts EPA's higher flux limit for disposal of tailings, the basic conclusion of the appendix should still be valid. That is: "the staff concludes that both the dose commitments and health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources."

Technetium-99

The staff has calculated the potential 100-year environmental dose commitment to the U.S. population from the release of technetium-99. These calculations are based on the gaseous and the hydrological pathway model systems described in Volume 3 of NUREG-0002 (Chapter IV, Section J, Appendix A) and are described in more detail in the staff's testimony at the operating license hearing for the Susquehanna Station (Branagan and Struckmeyer, 1981). The gastrointestinal tract and the kidney are the body organs that receive the highest doses from exposure to technetium-99. The total body dose is estimated at less than 1 person-rem RRY and the total body risk equivalent dose is estimated at less than 10 person-rems per RRY.

Summary of Impacts

The potential radiological impacts of the supporting fuel cycle are summarized in Table C-5 for an environmental dose commitment time of 100 years. For an environmental dose commitment time of 100 years, the total body dose to the U.S. population is about 790 person-rems per RRY, and the corresponding total body risk equivalent dose is about 2000 person-rems per RRY. In a similar manner, the total body dose to the U.S. population is about 3000 person-rems per RRY, and the corresponding total body risk equivalent dose is about 15,000 person-rems per RRY using a 1000-year environmental dose commitment time.

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*U.S. Environmental Protection Agency, "Environmental Standards for Uranium and Thorium Mill Tailings at Licensed Commercial Processing Sites (40 CFR 192)," Federal Register, Vol 48, No. 196, pp. 45926-45947, October 7, 1983.

Multiplying the total body risk equivalent dose of 2000 person-rems per RRY by the preceding risk estimator of 135 potential cancer deaths per million person-rems, the staff estimates that about 0.27 cancer death per RRY may occur in the U.S. population as a result of exposure to effluents from the fuel cycle. Multiplying the total body dose of 790 person-rems per RRY by the genetic risk estimator of 258 potential cases of all forms of genetic disorders per million person-rems, the staff estimates that about 0.20 potential genetic disorder per RRY may occur in all future generations of the population exposed during the 100-year environmental dose commitment time. In a similar manner, the staff estimates that about 2 potential cancer deaths per RRY and about 0.8 potential genetic disorder per RRY may occur using a 1000-year environmental dose commitment time.

Some perspective can be gained by comparing the preceding estimates with those from naturally occurring terrestrial and cosmic-ray sources. These average about 100 millirems. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million person-rems per year, or 3 billion person-rems and 30 billion person-rems for periods of 100 and 1000 years, respectively. These natural-background dose commitments could produce about 400,000 and 4,000,000 cancer deaths and about 770,000 and 7,700,000 genetic disorders, during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects of the LWR-supporting uranium fuel cycle are very small when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

6. Radioactive Wastes

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) associated with the uranium fuel cycle are specified in Table S-3. For low-level waste disposal at land-burial facilities, the Commission notes in Table S-3 that there will be no significant radioactive releases to the environment. The Commission notes that high-level and transuranic wastes are to be buried at a Federal repository and that no release to the environment is associated with such disposal. NUREG-0116, which provides background and context for the high-level and transuranic Table S-3 values established by the Commission, indicates that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is anticipated from such disposal.

7. Occupational Dose

The annual occupational dose attributable to all phases of the fuel cycle for the model 1000-MWe LWR is about 200 person-rems. The staff concludes that this occupational dose will have a small environmental impact.

8. Transportation

The transportation dose to workers and the public is specified in Table S-3. This dose is small in comparison with the natural-background dose.

9. Fuel Cycle

The staff's analysis of the uranium fuel cycle did not depend on the selected fuel cycle (no recycle or uranium-only recycle), because the data provided in Table S-3 include maximum recycle-option impact for each element of the fuel cycle. Thus the staff's conclusions as to acceptability of the environmental impacts of the fuel cycle are not affected by the specific fuel cycle selected.

10. References

Branagan, E., and R. Struckmeyer, testimony from "In the Matter of Pennsylvania Power & Light Company, Allegheny Electric Cooperatives, Inc. (Susquehanna Steam Electric Station, Units 1 and 2)," U.S. Nuclear Regulatory Commission, Docket Nos. 50-387 and 50-388, presented on October 14, 1981, in the transcript following page 1894.

Council on Environmental Quality, "The Seventh Annual Report of the Council on Environmental Quality," Figures 11-27 and 11-28, pp. 238-239, September 1976.

Gotchy, R., testimony from "In the Matter of Duke Power Company (Perkins Nuclear Station)," U.S. Nuclear Regulatory Commission, Docket No. 50-488, filed April 17, 1978.

Killough, G. G., "A Diffusion-Type Model of the Global Carbon Cycle for the Estimation of Dose to the World Population from Releases of Carbon-14 to the Atmosphere," ORNL-5269, Oak Ridge National Laboratory, May 1977.

National Council on Radiation Protection and Measurements (NCRP), "Natural Background Radiation in the United States," NCRP Report No. 45, November 1975.

U.S. Department of Energy, "Statistical Data of the Uranium Industry," GJO-100(8-78), January 1978.

U.S. Nuclear Regulatory Commission, NUREG-0002, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light-Water-Cooled Reactors," August 1976.

---, NUREG-0116 (Supplement 1 to WASH-1248), "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," October 1976.

Table C-1 Radon releases from mining and milling operations and mill tailings for each year of operation of the model 1000-MWe LWR*

Radon source	Quantity released
Mining**	4060 Ci
Milling and tailings*** (during active mining)	780 Ci
Inactive tailings*** (before stabilization)	350 Ci
Stabilized tailings*** (several hundred years)	1 to 10 Ci/year
Stabilized tailings*** (after several hundred years)	110 Ci/year

*After three days of hearings before the Atomic Safety and Licensing Appeal Board (ASLAB) using the Perkins record in a "lead case" approach, the ASLAB issued a decision on May 13, 1981 (ALAB-640) on the radon-222 release source term for the uranium fuel cycle. The decision, among other matters, produced new source term numbers based on the record developed at the hearings. These new numbers did not differ significantly from those in the Perkins record which are the values set forth in this table. Any health effects relative to radon-222 are still under consideration before the ASLAB. Because the source term numbers in ALAB-640 do not differ significantly from those in the Perkins record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources. Subsequent to ALAB-640, a second ASLAB decision (ALAB-654, issued September 11, 1981) permits intervenors a 60-day period to challenge the Perkins record on the potential health effects of radon-222 emissions.

**R. Wilde, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)," Docket No. 50-488, April 17, 1978.

***P. Magno, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)" Docket No. 50-488, April 17, 1978.

Table C-2 Estimated 100-year environmental dose commitment per year of operation of the model 1000-MWe LWR

		Environmental dose commitment (person-rems)			
Radon source	Radon-222 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)	Total body risk equivalent dose
Mining	4100	110	2800	2300	630
Milling and active tailings	1100	29	750	620	170
Total	5200	140	3600	2900	800

Table C-3 Estimated 100-year environmental dose commitments from unreclaimed open-pit mines for each year of operation of the model 1000-MWe LWR

		Environmental dose commitment (person-rems)			
Time span (years)	Radon-22 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)	Total body risk equivalent dose
100	3,700	96	2,500	2,000	550
500	19,000	480	13,000	11,000	3,000
1,000	37,000	960	25,000	20,000	5,500

Table C-4 Estimated 100-year environmental dose commitments from stabilized-tailings piles for each year of operation of the model 1000-MWe LWR

		Environmental dose commitment (person-rems)			
Time span (years)	Radon-22 releases (Ci)	Total body	Bone	Lung (bronchial epithelium)	Total body risk equivalent dose
100	100	2.6	68	56	15
500	4,090	110	2,800	2,300	630
1,000	53,800	1,400	37,000	30,000	8,200

Table C-5 Summary of 100-year environmental dose commitments per year of operation of the model 100-MWe light-water reactor

Source	Total body (person-rems)	Total body risk equivalent (person-rems)
All nuclides in Table S-3 except radon-222 and technetium-99	550	650
Radon-222		
Mining, milling, and active tailings, 5200 Ci	140	800
Unreclaimed open-pit mines, 3700 Ci	96	550
Stabilized tailings, 100 Ci	3	15
Technetium-99, 1.3 Ci*	<1	<10
TOTAL	790	2000

*Dose commitments are based on the "prompt" release of 1.3 Ci/RRY. Additional releases of technetium-99 are estimated to occur at a rate of 0.0039 Ci/yr/RRY after 2000 years of placing wastes in a high-level-waste repository.

APPENDIX D

EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

APPENDIX D

EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

1. Calculational Approach

As mentioned in the main body of this report, the quantities of radioactive material that may be released annually from the River Bend facility are estimated on the basis of the description of the design and operation of radwaste systems as contained in the applicant's FSAR and by using the calculative models and parameters described in NUREG-0016. These estimated effluent release values for normal operation, including anticipated operational occurrences, along with the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, are used in the calculation of radiation doses and dose commitments.

The models and considerations for environmental pathways that lead to estimates of radiation doses and dose commitments to individual members of the public near the plant and of cumulative doses and dose commitments to the entire population within an 80-km (50-mile) radius of the plant as a result of plant operations are discussed in detail in RG 1.109, Revision 1. Use of these models with additional assumptions for environmental pathways that lead to exposure to the general population outside the 80-km radius is described in Appendix B of this statement.

The calculations performed by the staff for the releases to the atmosphere and hydrosphere provide total integrated dose commitments to the entire population within 80 km of this facility based on the projected population distribution in the year 2000. The dose commitments represent the total dose that would be received over a 50-year period, following the intake of radioactivity for 1 year under the conditions existing 20 years after the station begins operation (that is, the mid-point of station operation). For younger persons, changes in organ mass and metabolic parameters with age after the initial intake of radioactivity are accounted for.

2. Dose Commitments from Radioactive Effluent Releases

The NRC staff's estimates of the expected gaseous and particulate releases (listed in Table D-1) along with the site meteorological considerations (summarized in Table D-2) were used to estimate radiation doses and dose commitments for airborne effluents. Individual receptor locations and pathway locations considered for the maximally exposed individual in these calculations are listed in Table D-3.

Two years of meteorological data were used in the calculation of concentrations of effluents. The calculation used the guidance of RG 1.111, and onsite meteorological data collected from March 1977 through March 1979, with wind measured at the 9.1-m elevation and vertical temperature difference between 9.1 m and 45.7 m, as a measure of atmospheric stability. The results include an effluent recirculation factor as described in the regulatory guide cited above for the continuous mixed mode, periodic and ground-level releases.

The NRC staff estimates of the expected liquid releases (listed in Table D-4), along with the site hydrological considerations (summarized in Table D-5), were used to estimate radiation doses and dose commitments from liquid releases.

(a) Radiation Dose Commitments to Individual Members of the Public

As explained in the text, calculations are made for a hypothetical individual member of the public (that is, the maximally exposed individual) who would be expected to receive the highest radiation dose from all pathways that contribute. This method tends to overestimate the doses because assumptions are made that would be difficult for a real individual to fulfill.

The estimated dose commitments to the individual who is subject to maximum exposure at selected offsite locations from airborne releases of radioiodine and particulates and waterborne releases are listed in Tables D-6, D-7, and D-8. The maximum annual total body and skin dose to a hypothetical individual and the maximum beta and gamma air dose at the site boundary are presented in Tables D-6, D-7, and D-8.

The maximally exposed individual is assumed to consume well above average quantities of the potentially affected foods and to spend more time at potentially affected locations than the average person as indicated in Tables E-4 and E-5 of Revision 1 of RG 1.109.

(b) Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne and waterborne radioactive releases from the River Bend facility are estimated for two populations in the year 2000: (1) all members of the general public within 80 km (50 miles) of the station (Table D-7) and (2) the entire U.S. population (Table D-9). Dose commitments beyond 80 km are based on the assumptions discussed in Appendix B. For perspective, annual background radiation doses are given in the tables for both populations.

3. References

U.S. Nuclear Regulatory Commission, NUREG-0016, F. P. Cardile and R. R. Bellamy (editors), "Calculation of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors," Revision 1, January 1979.

---, RG 1.109, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

---, RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Reactors," Revision 1, 1977.

Table D-1 Calculated releases of radioactive materials in gaseous effluents from River Bend Station (Ci/yr)

Nuclides	Reactor building stack* (Interm't)~	Auxiliary building stack (Cont)~	Radwaste Building (Cont)~	Turbine building vent (Cont)~	Air ejector exhaust (Cont)~	Mechanical vacuum pump*** (Interm't)~	Total
Ar-41	15	a	a	a	15	a	30
Kr-83m	a	a	a	a	a	a	a
Kr-85m	1	3	a	5	a	a	9
Kr-85	a	a	a	a	210	a	210
Kr-87	a	2	a	12	a	a	14
Kr-88	1	3	a	18	a	a	22
Kr-89	a	2	29	120	a	a	150
Xe-131m	a	a	a	a	3	a	3
Xe-133m	a	a	a	a	a	a	a
Xe-133	27	83	220	30	11	1300	1700
Xe-135m	15	45	530	80	a	a	670
Xe-135	33	94	280	66	a	500	970
Xe-137	45	140	83	200	a	a	470
Xe-138	2	6	2	200	a	a	210
			Total Noble Gases				4500
Cr-51	b	0.000009	b	0.00014	b	b	0.0002
Mn-54	b	0.00001	0.00004	0.00015	b	b	0.0002
Co-58	b	b	b	0.0002	b	b	0.0002
Fe-59	b	0.000003	0.000003	0.00005	b	b	0.000027
Co-60	0.00001	0.00004	0.00007	0.0002	b	b	0.00032
Zn-65	0.00001	0.00004	0.000003	0.00012	b	b	0.00017
Sr-89	b	b	b	0.00012	b	b	0.00012
Sr-90	b	0.00000007	b	0.000004	b	b	0.0000041
Nb-95	0.00001	0.00009	b	0.0000012	b	b	0.0001
Zr-95	0.000003	0.000007	0.000008	0.000008	b	b	0.000026
Mo-99	0.00006	0.0006	b	0.0004	b	b	0.0011
Ru-103	0.000002	0.00004	b	0.00001	b	b	0.000052
Sb-124	b	0.0000003	0.0000007	0.00002	b	b	0.000021
Cs-134	0.000007	0.00004	0.000024	0.00004	b	b	0.00011
Cs-136	0.000001	0.000004	b	0.00002	b	b	0.000025
Cs-137	0.00001	0.00005	0.00004	0.0002	b	b	0.0003
Ba-140	b	0.0002	b	0.002	b	b	0.0022
Ce-141	b	b	b	0.002	b	b	0.002
			Total Particulates				0.0072
I-131	0.0021	0.0041	0.0021	0.044	a	0.016	0.068
I-133	0.028	0.054	0.028	0.6	a	0.17	0.88
H-3	37	-	-	37	-	-	75
C-14	a	a	a	a	9.5	a	9.5

*Intermittent release, 20 4-hr releases per year from reactor building ventilation.

**Intermittent release from mechanical vacuum pump air removal system.

~Interm't = intermittent; cont = continuous.

a = less than 1.0 Ci/yr for noble gases and C-14, less than 10^{-4} Ci/yr for iodine.

b = less than 1% of total for this nuclide.

Table D-2 Summary of atmospheric dispersion factors (χ/Q) and relative deposition values for maximum site boundary and receptor locations near River Bend Station*

Location**	Source***	χ/Q (sec/m^3)	Relative deposition (m^{-2})
Nearest effluent-control boundary (1.3 km NW)	A	1.0×10^{-6}	2.0×10^{-8}
	B	4.1×10^{-7}	8.0×10^{-9}
	C	1.5×10^{-5}	3.5×10^{-8}
Nearest residence and garden (1.3 km NW)	A	1.0×10^{-6}	2.0×10^{-8}
	B	4.1×10^{-7}	8.0×10^{-9}
	C	1.5×10^{-5}	3.5×10^{-8}
Nearest milk cow (1.3 km NNW)	A	9.5×10^{-7}	2.0×10^{-8}
	B	3.2×10^{-7}	6.8×10^{-9}
	C	8.3×10^{-6}	2.3×10^{-8}
Nearest meat animal (1.3 km NW)	A	1.0×10^{-6}	2.0×10^{-8}
	B	4.1×10^{-7}	8.0×10^{-9}
	C	1.5×10^{-5}	3.5×10^{-8}

*The values presented in this table are calculated 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.

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

***A - Containment-building stack, intermittent release, 20 releases per year, 4 hours each release, and mechanical vacuum pump air removal system, intermittent release.

B - Auxiliary-building exhaust stack, turbine-building-ventilation exhaust, and main-condenser air-ejector exhaust, continuous release.

C - Radwaste-building-ventilation exhaust, continuous release.

Table D-3 Nearest pathway locations used for maximally exposed individual dose commitments for River Bend Station

Location	Sector	Distance (km)
Nearest effluent-control boundary*	NW	1.3
Residence and garden**	NW	1.3
Milk cow	NNW	1.3
Meat animal	NW	1.3

*Beta and gamma air doses, total body doses, and skin doses from noble gases are determined at the effluent-control boundaries in the sector where the maximum potential value is likely to occur.

**Dose pathways including inhalation of atmospheric radioactivity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences. This particular location includes doses from vegetable consumption as well.

Table D-4 Calculated release of radioactive materials in liquid effluents from River Bend Station

Nuclide	Ci/yr	Nuclide	Ci/yr
Corrosion and Activation Products		Fission Products (cont'd)	
Na-24	0.0052	Ru-103	0.00002
P-32	0.000222	Rh-105	0.00023
Cr-51	0.0066	Te-129m	0.00004
Mn-54	0.00008	Te-131m	0.00008
Mn-56	0.0017	I-131	0.0039
Fe-55	0.0011	I-132	0.0016
Fe-59	0.00003	I-133	0.032
Co-58	0.00022	I-134	0.00005
Co-60	0.00045	Cs-134	0.00037
Cu-64	0.014	I-135	0.012
Zn-65	0.00022	Cs-136	0.00024
Zn-69m	0.00097	Cs-137	0.0010
W-187	0.00020	Ba-139	0.00005
Np-239	0.0072	Ba-140	0.00043
Fission Products			
Br-83	0.00018	Ce-141	0.00004
Sr-89	0.00011	La-142	0.00004
Sr-91	0.0014	Ce-143	0.00002
Y-91	0.00006	Pr-143	0.00004
Sr-92	0.00039		
		All Others*	0.0036
Y-92	0.0015		
Y-93	0.0015	Total (except H-3)	0.11
Mo-99	0.0019		
Tc-99m	0.0053	H-3	15

*Nuclides whose release rates are less than 10^{-5} Ci/yr are not listed individually but are included in "all others."

Table D-5 Summary of hydrologic transport and dispersion for liquid releases from River Bend Station

Location	Transit time (hours)	Dilution factor
Nearest sport-fishing location (discharge area)**	0	100
Nearest shoreline (bank of Mississippi River near discharge area)	0	100

*See Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

**Assumed for purposes of an upper-limit estimate; detailed information not available.

Table D-6 Annual dose commitments to a maximally exposed individual near River Bend Station

Location	Pathway	Doses (mrems/yr, except as noted)			
		Noble gases in gaseous effluents			
		Total body	Skin	Gamma air dose (mrads/yr)	Beta air dose (mrads/yr
Nearest* site boundary (1.3 km NW)	Direct radiation from plume	0.4	0.9	0.6	0.6
		Iodine and particulates in gaseous effluents**			
		Total body	Organ		
Nearest*** site boundary (1.3 km NW)	Ground deposition	a (C)	a (C) (thyroid)		
	Inhalation	a (C)	0.1 (C) (thyroid)		
Nearest residence and garden (1.3 km NW)	Ground deposition	a (C)	a (C) (thyroid)		
	Inhalation	a (C)	0.1 (C) (thyroid)		
	Vegetable consumption	a (C)	0.8 (8) (thyroid)		
Nearest milk cow (1.3 km NNW)	Ground deposition	a (I)	a (I) (thyroid)		
	Inhalation	a (I)	a (I) (thyroid)		
	Vegetable consumption	a (I)	a (I) (thyroid)		
	Cow milk consumption	a (I)	7.9 (I) (thyroid)		
Nearest meat animal (1.3 km NW)	Meat consumption	a (C)	a (C) (bone)		
		Liquid effluents**			
		Total body	Organ		
Nearest fish at plant-discharge area	Fish consumption	a (A)	0.3 (C) (bone)		
Nearest shore access near plant-discharge area	Shoreline recreation	a (T)	a (T) (skin)		

a = less than 0.1 mrem/year.

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for the age group and organ that results in the highest cumulative dose for the location: A=adult, T=teen, C=child, I=infant. Calculations were made for these age groups and for the following organs: gastrointestinal tract, bone, liver, kidney, thyroid, lung, and skin.

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

Table D-7 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of River Bend Station

	Annual dose per reactor unit	
	Individual	
	Appendix I design objectives*	Calculated doses**
Liquid effluents		
Dose to total body from all pathways	3 mrems	a
Dose to any organ from all pathways	10 mrems	0.3 mrem (bone)
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.6 mrad
Beta dose in air	20 mrads	0.6 mrad
Dose to total body of an individual	5 mrems	0.4 mrem
Dose to skin of an individual	15 mrems	0.9 mrem
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	7.9 mrems (thyroid)
	Population within 80 km, person-rems	
	Total body	Thyroid
Natural-background radiation†	85,000	
Liquid effluents	0.1	0.1
Noble-gas effluents	0.3	0.3
Radioiodine and particulates	0.7	2.9

a = less than 0.1 mrem/year.

*Design Objectives from Sections II.A, II.B, II.C, and II.D of Appendix I, 10 CFR Part 50 consider doses to maximally exposed individual and to population per reactor unit.

**Numerical values in this column were obtained by summing appropriate values in Table D-6. Locations resulting in maximum doses are represented here.

***Carbon-14 and tritium have been added to this category.

†"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average background dose for Louisiana of 84 mrems/yr, and year 2000 projected population of 1,000,000.

Table D-8 Calculated RM-50-2 dose commitment to a maximally exposed individual from operation of River Bend Station

	Annual dose per site	
	RM-50-2 design objectives**	Calculated doses
Liquid effluents		
Dose to total body or any organ from all pathways	5 mrems	0.3 mrem
Activity-release estimate, excluding tritium	5 Ci	0.1 Ci
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	0.6 mrad
Beta dose in air	20 mrads	0.6 mrad
Dose to total body of an individual	5 mrems	0.4 mrem
Dose to skin of an individual	15 mrems	0.9 mrem
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	7.9 mrems (thyroid)
I-131 activity release	2 Ci	0.068 Ci

*An optional method of demonstrating compliance with the cost-benefit Section (II.D) of Appendix I to 10 CFR Part 50.

**Annex to Appendix I to 10 CFR Part 50.

***Carbon-14 and tritium have been added to this category.

Table D-9 Annual total-body population dose commitments, year 2000

Category	U.S. population dose commitment, person-rems/yr
Natural background radiation*	26,000,000*
River Bend Station operation	
Plant workers	800
General public	
Liquid effluents**	0.1
Gaseous effluents	35.
Transportation of fuel and waste	3.

*Using the average U.S. background dose (100 mrems/yr) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 704, July 1977.

**80-km (50-mile) population dose

APPENDIX E

HISTORIC AND ARCHEOLOGICAL SITES

State of Louisiana
DEPARTMENT OF CULTURE, RECREATION AND TOURISM
OFFICE OF CULTURAL DEVELOPMENT
ROBERT B. DEBLIEUX
ASSISTANT SECRETARY

DAVID C. TREEN
GOVERNOR

MRS. LAWRENCE H. FOX
SECRETARY

DIVISION OF ARCHAEOLOGY
KATHLEEN BYRD, DIRECTOR

DIVISION OF THE ARTS
ALBERT B. HEAD, DIRECTOR

DIVISION OF HISTORIC PRESERVATION
ANN REILEY JONES, DIRECTOR

FOLKLIFE PROGRAM
NICHOLAS R. SPITZER,
PROGRAM MANAGER

December 5, 1983

Mr. R. L. Tedesco, Assistant Director
Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Report on Transmission Line Construction Activities within the Port Hudson National Historic Landmark

Dear Mr. Tedesco:

By letter dated November 23, 1983, Mr. J. E. Booker of Gulf States Utilities Company transmitted the above referenced report. My staff has reviewed the document, and we find it to be an accurate account of GSU's cultural resources compliance relative to the River Bend Station up to this point in time. Accordingly, we anticipate that operation and maintenance of the plant will not affect any sites or properties listed on the National Register of Historic Places.

The only possible exception to this are the remains of the Magnolia Plantation Sugar Mill (16WF36) which have been documented to be on the plant's property. It is our understanding that archaeological investigations are currently underway relative to determining the site's National Register eligibility. We will withhold further comment on the sugar mill remains pending completion of the investigations.

Should you have any questions regarding our comments, do not hesitate to contact my staff in the Division of Archaeology.

Sincerely,

Robert B. DeBlieux
State Historic Preservation Officer

RBD:PGR:tb

cc: J. E. Booker
Gulf State Utilities Company

P. O. BOX 44247 BATON ROUGE, LOUISIANA 70804 (504) 342-6680 AND LINC 421-6680

State of Louisiana
DEPARTMENT OF CULTURE, RECREATION AND TOURISM
OFFICE OF CULTURAL DEVELOPMENT
ROBERT B. DEBLIEUX
ASSISTANT SECRETARY

DAVID C. TREEN
GOVERNOR

MRS. LAWRENCE H. FOX
SECRETARY

DIVISION OF ARCHAEOLOGY
KATHLEEN BYRD, DIRECTOR

DIVISION OF THE ARTS
ALBERT B. HEAD, DIRECTOR

DIVISION OF HISTORIC PRESERVATION
ANN REILEY JONES, DIRECTOR

FOLKLIFE PROGRAM
NICHOLAS R. SPITZER,
PROGRAM MANAGER

March 13, 1984

Mr. J. E. Booker
Manager-Engineering
Nuclear Fuels & Licensing
River Bend Nuclear Group
Gulf States Utilities Company
P. O. Box 2951
Beaumont, TX 77704

Re: Historical and Archaeological Investigation of the Ruins of a Nineteenth Century Sugar Mill (16WF-36) in West Feliciana Parish, Louisiana

Dear Mr. Booker:

My staff has reviewed the above referenced report and have the following comments to make. Based on the results of this survey, we concur that 16WF36 is not eligible for nomination to the National Register of Historic Places (see enclosure).

In regard to the report, we would like to point out a minor point of disagreement. On page 19 is the statement that Magnolia Plantation "yielded 205 hogshead, a negligible amount compared with the 4,264 produced by the other 20 plantations of the parish." The 205 hogshead total is five percent of the total production of the parish or two hogsheads over the average production of 203 per plantation. This is more than a "negligible amount." Further, the 1857 through 1861 yields were more than "mediocre crops," (page 20). In fact, as can be seen in Table I, Magnolia produced the following percentages of the total parish production from 1857 to 1861 (compare Table I):

Year	Percent by Magnolia
1857	10%
1858	7%
1859	3%
1860	9%
1861	8%

Thus, we would disagree with the Archival Summary on pages 23-24. However, the sites ineligibility lies with the results of test excavations which indicated severe site disturbance and a lack of intact archaeological deposits. Therefore, we concur with the report's overall conclusion.

P. O. BOX 44247 BATON ROUGE, LOUISIANA 70804 (504) 342-6630 AND LINC 421-6680

Finally, we would like to extend our appreciation to Gulf States Utilities for their concern and interest in the cultural history of site 16WF36 and in carrying out the survey work. Mr. Cook's careful attention to the site by informing the Division and allowing us to initially visit the site is most commendable.

Sincerely,

Robert B. DeBlieux
State Historic Preservation Officer

RBD:SDS:tb

Enclosure: As stated

Statement of the opinion of the State Historic Preservation Officer concerning the eligibility of a property for inclusion in the National Register

I understand that the __Nuclear Regulatory Commission__ (agency) is requesting the opinion of the State Historic Preservation Officer concerning the eligibility of __the Magnolia Plantation Sugar Mill (16WF36)__ (property(ies)) for inclusion in the National Register and that my opinion may be submitted to the Secretary of the Interior with a formal request for a determination of eligibility on this property. This statement confirms my consultation as part of the determination of eligibility procedures.

___ (1) In my opinion, the property is eligible for inclusion in the National Register.

_X_ (2) In my opinion, the property is not eligible for inclusion in the National Register.

___ (3) I have no opinion and prefer to defer to the opinion of the Secretary of the Interior.

Justification and comments:

Signed: ______________________
State Historic Preservation Officer

Date: 3/13/84

APPENDIX F

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

(NPDES)

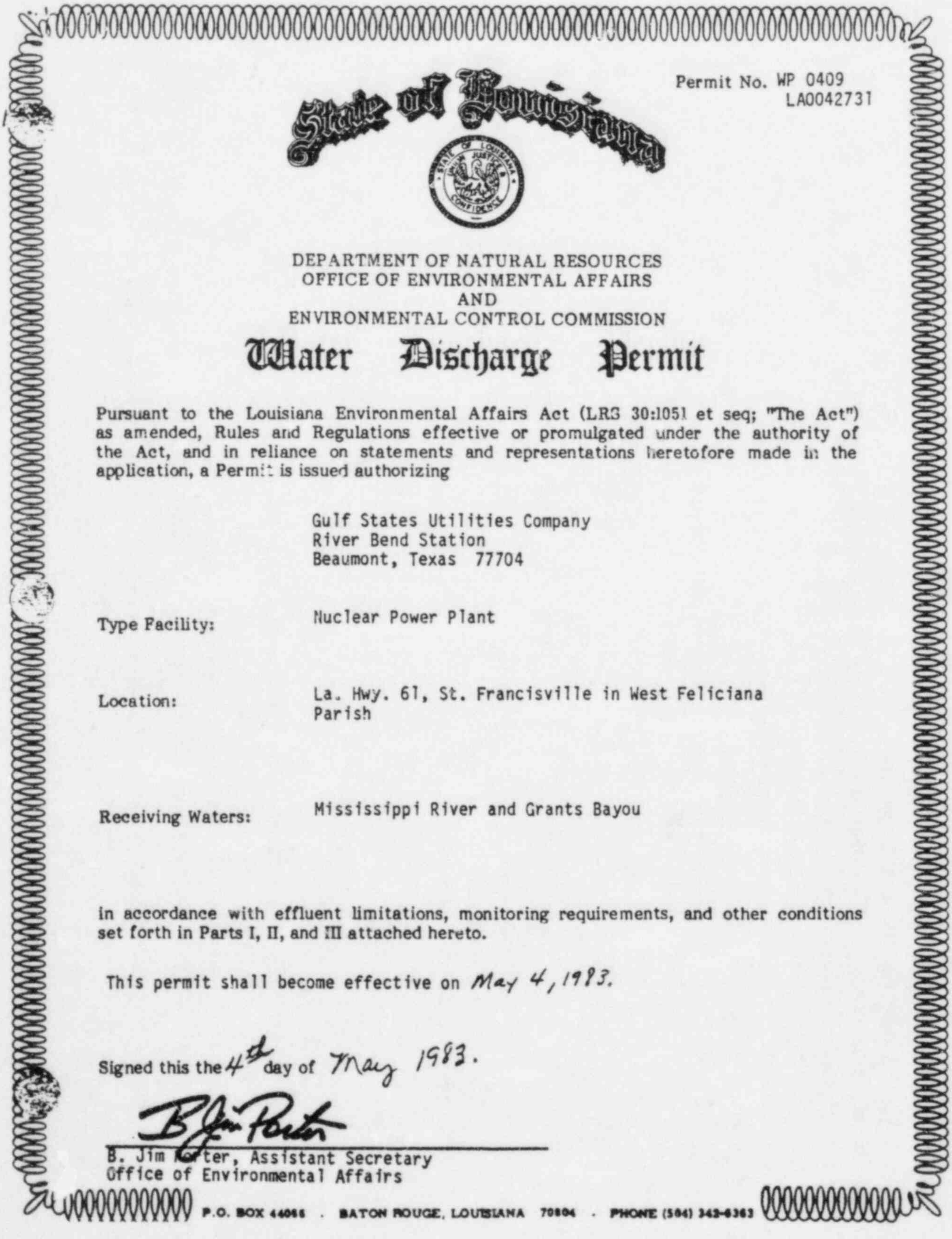
PERMIT NO. WP 0409

LA0042731

FOR

RIVER BEND STATION

GULF STATES UTILITIES COMPANY



Permit No. WP 0409
LA0042731

State of Louisiana

DEPARTMENT OF NATURAL RESOURCES
OFFICE OF ENVIRONMENTAL AFFAIRS
AND
ENVIRONMENTAL CONTROL COMMISSION

Water Discharge Permit

Pursuant to the Louisiana Environmental Affairs Act (LRS 30:1051 et seq; "The Act") as amended, Rules and Regulations effective or promulgated under the authority of the Act, and in reliance on statements and representations heretofore made in the application, a Permit is issued authorizing

Gulf States Utilities Company
River Bend Station
Beaumont, Texas 77704

Type Facility: Nuclear Power Plant

Location: La. Hwy. 61, St. Francisville in West Feliciana Parish

Receiving Waters: Mississippi River and Grants Bayou

in accordance with effluent limitations, monitoring requirements, and other conditions set forth in Parts I, II, and III attached hereto.

This permit shall become effective on May 4, 1983.

Signed this the 4th day of May 1983.

B Jim Porter

B. Jim Porter, Assistant Secretary
Office of Environmental Affairs

P.O. BOX 44066 . BATON ROUGE, LOUISIANA 70804 . PHONE (504) 342-6363

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

001, cooling tower blowdown to Mississippi River.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	7.8	9.2	Continuous	Record
Temperature[1]	---	---	91°F	96°F[2]	Continuous	Record
Free Available Chlorine[3]	1.1	3.2	0.2 mg/l	0.5 mg/l	1/week	Grab
Oil & Grease	---	---	10 mg/l	15 mg/l	1/week	Grab

1. See Part III, Paragraph 6.
2. Instantaneous maximum.
3. See Part III, Paragraph 10, samples shall be representative of periods of chlorination.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from cooling tower blowdown prior to commingling with other wastes.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

002, standby cooling tower blowdown to Mississippi River.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	Report	Continous	Record
Temperature[1]	---	---	---	95°F[2]	Continuous	Record
Free Available Chlorine[3]	---	---	0.2	0.5 mg/l	1/week	Grab

1. See Part III, Paragraph 8.
2. Instantaneous maximum.
3. See Part III, Paragraph 10, samples shall be representative of periods of chlorination.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from standby cooling tower blowdown prior to commingling with other wastes.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning December 31, 1985 and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

003, treated chemical waste to Mississippi River.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	0.01	0.05	Continous	Record
Total Suspended Solids	---	---	30 mg/l	100 mg/l	1/week	Grab
Oil & Grease	---	---	15 mg/l	20 mg/l	1/week	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from treated chemical waste prior to commingling with other wastes.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

004, low level radioactive waste to Mississippi River.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations*				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	(0.06)	(0.15)	Continous	Record
Temperature	---	---	110°F	130°F[1]	Continuous	Record
Total Suspended Solids	---	---	30 mg/l	100 mg/l	1/week	Grab
Oil & Grease	---	---	15 mg/l	20 mg/l	1/week	Grab

1. Instantaneous maximum.

* See Part III, 14.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from low level radioactive waste prior to commingling with other wastes.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A the permittee is authorized to discharge from outfall(s) serial number(s):

005, excess well water to Grants Bayou.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	(0.432)	Continous	Record
Total Suspended Solids	---	---	Report	20 mg/l	1/week	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

before discharge to lined portion of West Creek.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

006, non-radioactive floor drain waste to Grants Bayou.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	Report	Daily	Estimate
Total Suspended Solids	---	---	30 mg/l	100 mg/l	1/week	Grab
Oil & Grease	---	---	---	15 mg/l	1/week	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from non-radioactive floor drain waste prior to commingling with other sources.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A the permittee is authorized to discharge from outfall(s) serial number(s):

007, treated sanitary wastewater to Grants Bayou.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	0.047	0.059	Daily	Estimate
BOD_5	---	---	30 mg/l	45 mg/l	1/week	Grab
Total Suspended Solids	---	---	30 mg/l	45 mg/l	1/week	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

before mixing with any other sources in the storm sewer outfall to East Creek near Grants Bayou.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date **and lasting through** N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

008, non-contaminated stormwater runoff to East Creek.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	1.9	Daily	Estimate

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

at various pipeline discharge points to East Creek.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A the permittee is authorized to discharge from outfall(s) serial number(s):

009, non-contaminated stormwater runoff to West Creek.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)		Measurement Frequency	Sample Type
	Daily Avg	Daily Max	Daily Avg	Daily Max		
Flow-MGD	---	---	Report	1.4	Daily	Estimate

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

at various pipeline discharge points to West Creek.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A the permittee is authorized to discharge from outfall(s) serial number(s):

010, construction dewatering discharge to Grants Bayou.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)		Measurement Frequency	Sample Type
	Daily Avg	Daily Max	Daily Avg	Daily Max		
Flow-MGD	---	---	Report	Report	Daily	Estimate
Total Suspended Solids	---	---	---	50 mg/l	1/week	Grab

The pH shall not be less than 5.5 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

at stilling basin discharge to Grants Bayou.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through N/A

the permittee is authorized to discharge from outfall(s) serial number(s):

011, concrete wastewater to West Creek.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	Report	Daily	Estimate
Total Suspended Solids	---	---	20 mg/l	30 mg/l	1/week	Grab

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from concrete wastewater basin prior to discharging to West Creek.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through December 31, 1985

the permittee is authorized to discharge from outfall(s) serial number(s):

012, preoperational hydrostatic testing and flushing of piping and vessels.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD	---	---	Report	Report	Daily*	Estimate
Total Suspended Solids	---	---	30 mg/l	100 mg/l	1/day*	Grab
Oil & Grease	---	---	15 mg/l	20 mg/l	1/day*	Grab
Total Iron**	---	---	Report	Report	1/month	Grab
Total Copper**	---	---	Report	Report	1/month	Grab

* When discharging.

** At some future date, the Water Pollution Control Division may impose additional monitoring or establish effluent limitations.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/week by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from hydrostatic testing and flushing and prior to commingling with other wastes.

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning the effective date and lasting through December 31, 1985

the permittee is authorized to discharge from outfall(s) serial number(s):

013, demineralizer regeneration wastes for flushing program to Grants Bayou.

Such discharges shall be limited and monitored by the permittee as specified below:

Effluent Characteristic	Discharge Limitations				Monitoring Requirements	
	(lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-MGD**	---	---	Report	Report	Daily	Estimate
Total Suspended Solids	---	---	30 mg/l	100 mg/l	1/day*	Grab
Oil & Grease	---	---	15 mg/l	20 mg/l	1/day*	Grab

* During discharge.

** As described in the permittee's application, the release of this effluent shall coincide with the other discharges to the East Ditch to minimize the effects of total dissolved solids. The permittee shall monitor the combined wastewater flow in the East Ditch once per month (during the release of demineralizer regeneration wastes) by grab sample for chlorides, sulfates, and total dissolved solids.

The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored 1/day* by grab sample.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s):

the discharge point from demineralizer regeneration waste and prior to commingling with other wastes.

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   Compliance to be achieved on the effective date of the final permit. (The anticipated start-up date of the facility is January 1, 1985, and the start-up date of outfalls 012 & 013 is April 4, 1983.)

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

C. MONITORING AND REPORTING

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Reporting

Monitoring results obtained during the previous 3 months shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No.3320-1 or approved substitute), postmarked no later than the 28th day of the month following the completed reporting period. The first report is due on * . Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Technical Secretary for Water and the Regional Administrator for the United States Environmental Protection Agency at the following Addresses:

Mr. Myron Knudson (6W)
Director, Enforcement Division
U.S. Environmental Protection
Agency, Region VI
First International Building
1201 Elm Street
Dallas, Texas 75270

Mr. J. Dale Givens, Administrator
Water Pollution Control Division
Office of Environmental Affairs
Department of Natural Resources
Post Office Box 44066, Capitol Station
Baton Rouge, Louisiana 70804-4066

* As per established NPDES reporting schedule.

3. Definitions

a. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

b. The "daily maximum" discharge means the total discharge by weight during any calendar day.

4. Test Procedures

Test procedures for the analysis of pollutants shall conform to the latest edition of Standard Methods for the Examination of Water and Wastewater or other permitting Agency approved/EPA approved methods.

5. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The exact place, date, and time of sampling;

b. The dates the analyses were performed;

c. The person(s) who performed the analyses;

d. The analytical techniques or methods used; and

e. The results of all required analyses.

6. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1) or approved substitute. Such increased frequency shall also be indicated.

7. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the permitting Agency or by the Regional Administrator for the U.S. Environmental Protection Agency.

A. MANAGEMENT REQUIREMENTS

1. Change in Discharge

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production changes, or process modifications which will result in new, different, or altered discharges of pollutants will require the submission of a new discharge application and subsequent Commission authorization before initiating any action which will effect a change or, if such changes will not violate the effluent limitations specified in this permit, by notice to the permit issuing authority of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Noncompliance Notification

If, for any reason, the permittee does not comply with or will be unable to comply with any daily maximum effluent limitation specified in this permit, the permittee shall provide the permitting agency and the U.S. Environmental Protection Agency (at the addresses shown in C 2. above) with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. Facilities Operation

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to the "waters of the state" resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the permitting agency and the U.S. Environmental Protection Agency in writing of each such diversion or bypass.

6. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering the "waters of the state".

7. Power Failures

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of the primary source of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. Right of Entry

The permittee shall allow the head of the permitting agency, the U.S. Environmental Protection Agency Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

a. To enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants; and

c. As otherwise provided for by LRS 30:1061, C, 8.

2. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the permitting agency and the U.S. Environmental Protection Agency at the addresses shown in Part I, C, 2.

3. Availability of Reports

Except for data determined to be confidential under 30:1077 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the permitting agency and the Regional Administrator. Knowingly making any false statement on any such report will be considered as a permit violation and may subject the permittee to appropriate enforcement action under the Act.

4. Permit Modification

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. Toxic Pollutants

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under provisions of the Act, for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. Civil and Criminal Liability

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under regulations established under Part VII, "Hazardous Waste Control Law" of the Act.

8. State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation.

9. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of State, Federal or local laws or regulations.

10. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

PART III

OTHER REQUIREMENTS

1. The Office of Environmental Affairs reserves the right to impose more stringent discharge limitations or additional restrictions, if necessary, to maintain the water quality integrity and the designated usage(s) of the receiving water bodies.

2. This permit may be modified, or alternatively, revoked and reissued, to comply with any applicable effluent standard or limitation issued or approved under regulations established pursuant to or by the Act, if the effluent standard or limitation so issued or approved:

    a. Contains different conditions or is otherwise more stringent than any effluent limitation in the permit; or

    b. Controls any pollutant not limited in the permit.

    The permit as modified or reissued under this paragraph may also contain any other requirements of existing regulations or the Act then applicable.

3. Reporting of upsets, bypasses, or spills shall be made within 24 hours to the Louisiana Department of Natural Resources, Water Pollution Control Division followed by a written report in five days.

4. Authorization to discharge pursuant to the conditions of this permit does not relieve the permittee of any liability for damages to state waters or private property. For discharges to private land, the permittee should obtain approval from the land owner or appropriate easements and rights of way.

5. The permittee shall, as soon as they have knowledge of any discharge from the facility of any substances of sufficient quantity which could interfere with downstream potable and/or industrial water usages, immediately execute the alert procedure of the Lower Mississippi River WATERWORKS WARNING NETWORK PLAN by the Department of Health and Human Resources, Office of Health Services and Environmental Quality.

    Any significant abnormality detected through self-monitoring of an outfall shall cause immediate notification of the Water Pollution Control Division of the Office of Environmental Affairs. The permittee may then be directed to initiate the warning system on a precautionary basis.

OTHER REQUIREMENTS (Continued)

6. The "daily average" concentration means the arithmetic average (weighted by flow value) of all the daily determinations of concentrations made during a calendar month. Daily determinations of concentration made using a composite sample shall be the concentration of the composite sample. When grab samples are used, the daily determination of concentration shall be the arithmetic average (weighted by flow value) of all the samples collected during that calendar day.

7. The "daily maximum" concentration means the daily determination of concentration for any calendar day.

8. Daily average temperature shall be computed and recorded on a daily basis as the average in a 24-hour period of temperatures at intervals not greater than two hours.

9. Grab Sample - an individual sample collected in less than 15 minutes.

10. The term "free available chlorine" shall mean the value obtained using the amperometric titration method for free available chlorine described in the latest edition of "Standard Methods for the Examination of Water and Wastewater".

    The term "total residual chlorine" (or total residual oxidants for intake water with bromides) means the value obtained using the amperometric method for total residual chlorine described in the latest edition of "Standard Methods for the Examination of Water and Wastewater".

    Neither free available chlorine nor total residual chlorine may be discharged from any power generating unit for more than two hours in any one day and not more than one unit in any plant may discharge free available or total residual chlorine at any one time unless the permittee can demonstrate to the permitting Agency that the units in a particular location cannot operate at or below the limitations specified in this permit.

11. Water Treatment clarifier sludge wastes may be returned to the stream without treatment if not previously combined with any other untreated waste source, including demineralizer and softener wastes.

12. There shall be no discharge of cooling water maintenance chemical which contain the 129 priority pollutants defined in Appendix B of CFR, Part 423.

13. There shall be no discharge of polychlorinated bi-phenyl transformer fluids to navigable waters.

OTHER REQUIREMENTS (Continued)

14. All limitations and monitoring requirements for liquid radioactive waste discharges shall be in accordance with the Nuclear Regulatory Commission regulations as set forth in 10 CFR Part 20 and 10 CFR Part 50.

15. The conditions of this permit shall no way supercede the mandatory requirements for operation of nuclear power plants imposed by the Nuclear Regulatory Commission.

APPENDIX G

ESTIMATE OF FISHERIES HARVEST DOWNSTREAM OF THE RIVER BEND STATION

Final Draft
(April 1984)

Prepared by

Richard Mclean, Ph.D.
Oak Ridge National Laboratory

for the

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Engineering

APPENDIX G

ESTIMATE OF FISHERIES HARVEST DOWNSTREAM OF THE RIVER BEND STATION

Introduction

The recreational and commercial fisheries harvest downstream of the River Bend Station was estimated. River Bend is located on the Mississippi River at river kilometer 421 (RM 262). It was assumed that any accidental release of radioactivity reaching the river would impact only the main stem river because flow could be prevented from entering Bonnet Carre Spillway, Intercoastal Waterway, and the Mississippi River Gulf Outlet Canal.

Commercial Harvest

The reach of river below the plant is located within two statistical segments for which the U.S. Fish and Wildlife Service keeps records. The first segment begins at the Arkansas-Louisiana border and extends south to the Ascension Parish line, just south of Baton Rouge, Louisiana. The second segment begins at the St. Charles Parish and extends south to the Gulf of Mexico. There is a 60-km (37-mile) segment between St. Charles Parish and Ascension Parish that is excluded from coverage, although some catch for this region is recorded at Donaldsonville near the Ascension Parish line.

Fisheries statistics in the segment that extends above and slightly below the plant represent five times more area than would be affected by the plant. Thus, only 20% of the harvest in this segment was used as that potentially affected. All of the catch in the lower segment was assumed to be potentially affected.

Catch by species in the two segments for 1979 and 1980 is presented in Table G-1. Shad are used primarily for bait; thus, they were not included in the analysis. Data for 1979 were used as a maximum probable catch. Thus, the numbers used in the analysis were derived as follows:

For statistical segment 1

Commercial catch (kg) by species x 0.2 = potentially affected catch below River Bend Station

For statistical segment 2

Commercial catch (kg) by species x 1.0 = potentially affected catch below River Bend Station

Segment 1 + Segment 2 = total commercial catch potentially affected

Recreational Harvest

Two methods were used to estimate the recreational harvest: (1) assuming the recreational harvest is a percentage of the commercial harvest and (2) assigning levels of productivity to segments of the river and calculating expected recreational harvest.

- Method I

Assumptions employed were: (1) Carp, catfish, bowfin, freshwater drum, crawfish, freshwater shrimp, turtle, and frogs make up the recreational fishery. (2) The recreational fishery catch for each of these fish or group of animals is 50% of the commercial catch except for catfish and carp.

Leidy and Jenkins (1977) showed that the average commercial harvest of carp and catfish in 40 reservoirs in the Arkansas, Red River, Upper Mississippi, Tennessee Valley, Ohio Basin, and Missouri Basin drainage areas was 21.7 kg/ha (19.4 lb/acre). The recreational harvest for these two fish was 26.6 kg/ha (23.7 lb/acre). Thus the recreational harvest was 123% of the commercial harvest. The Mississippi River below the River Bend Station is not as productive as a reservoir, which is one reason why it is not fished heavily for recreation. There is also poor access in some areas. However, the recreational fishing does include species not caught commercially such as black bass, sunfish, white bass, and others. For a conservative estimate, the recreational harvest for carp and catfish was assumed to be 123% of the commercial harvest and the harvest of all other organisms was 50% of the commercial catch. These estimates are presented in Table G-2.

Method II

The main stem Mississippi River downstream of the station was divided into three segments. The segments were subjectively delineated based on a number of factors including the availability of data, the reported quantity (subjectively estimated) of the harvest, and the known level of river use and access by the recreational fishery. These river segments were assigned one of two subjective levels of harvest. Subjective information on the recreational harvest was obtained from U.S. Department of the Interior's Cooperative Fishery Unit at Louisiana State University and the National Marine Fisheries Service Area Office in New Orleans, Louisiana. Approximate surface areas of these segments were computed using a compensating polar planimeter on U.S. Geologic Survey topographic quadrangles. Harvest per hectare values for the recreational harvest for small rivers and streams were obtained from the liquid pathway generic study (LPGS) (NRC, 1978). In areas of known high fishing pressure and success, the harvest figures published in the LPGS were multiplied by 1.5. In areas of known low recreational harvest due to either low standing crop or lack of access, a value approximately 50% of that published in the LPGS was used.

Segment 1 consisted of the river downstream of the River Bend Site to Baton Rouge. Segment 2 consisted of the river downstream of Baton Rouge to the St. Charles Parish line, just north of New Orleans. Segment 3 consisted of the remainder of the river downstream of the St. Charles Parish line.

Table G-3 lists each segment, the approximate surface area, the subjective level of recreational harvest in relation to the LPGS estimate, and the estimated harvest in kg. Harvest estimates by this method are provided only for finfish. The LPGS does not provide estimates of yearly harvest per hectare of crustaceans and frogs and turtles from freshwater.

Summary

The total estimated commercial harvest below the River Bend site for all organisms is 4.93×10^5 kg (see Table G-2). This estimate is based on two statistical segments for which the U.S. Fish and Wildlife service has records. Only 20% of the catch in one of the segments was used because any discharge from the plant would affect only about 20% of that segment. Using assumptions in the LPGS, an annual commercial finfish catch of 1.0×10^5 kg was estimated. This would include all fish, edible and non-edible.

Two estimates of the recreational finfish harvest were made. One estimate (4.92×10^3 kg/yr) is based on a percentage of the commercial catch (see Table G-2) and the other (1.0×10^5 kg/yr) is based on the expected yield of finfish per hectare (see Table G-3). Use of the larger of the two estimates is recommended to obtain a conservative estimate that accounts for unknown harvests of crayfish, turtles, frogs, and freshwater shrimp.

The estimate of recreational harvest of finfish (4.89×10^5 kg/yr) as a percentage of the commercial catch is about five times larger than the estimate (1.0×10^5 kg/yr) that uses the assumptions in the LPGS.

The total commercial and recreational harvest of finfish, turtles, crayfish, and frogs, from the River Bend Station to the Gulf of Mexico, is 9.85×10^5 kg/yr.

References

Leidy, G. R. and R. M. Jenkins, "The development of fishery compartments and population rate coefficients for use in reservoir ecosystem modeling," U.S. Department of the Interior, Fish and Wildlife Service, National Reservoir Research Program, Contract Report Y-77-1, Fayetteville, Arkansas, 1977.

U.S. Nuclear Regulatory Commission, NUREG-0440, "Liquid Pathway Generic Study," 1978.

Table G-1 Commercial harvest of aquatic biota from two segments of the Mississippi River within the State of Louisiana for 1979 and 1980

	Arkansas State line to St. Charles Parish			
	1979		1980	
Species	lbs	Value ($)	lbs	Value ($)
Bowfin	1,700	173	1,800	226
Buffalo	796,200	136,740	797,800	145,000
Carp	41,700	3,003	27,600	2,201
Catfish	400,500	156,357	430,200	192,313
Garfish	47,400	10,217	34,000	8,723
Paddlefish	18,500	2,023	19,900	2,399
Shad	287,000	29,081	56,000	6,605
Freshwater drum	241,100	39,983	299,600	50,654
Crayfish	50,500	16,968	16,600	9,273
Turtle	9,100	5,578	7,100	5,112
Frog	7,300	7,156	7,800	8,691
Freshwater shrimp	3,000	2,250	-	-
TOTAL	1,904,000	409,529	1,698,400	431,197
	St. Charles Parish to Gulf of Mexico			
Catfish	733,000	334,138	637,700	30,252
Freshwater drum	9,400	1,978	5,200	1,140
Buffalo	3,000	568	1,100	238
Turtles	900	852	900	550
Carp	30,900	5,984	600	98
TOTAL	777,200	343,520	645,500	32,278

Table G-2 Estimate of commercial and recreational catch of aquatic organisms for human consumption from a portion of the Mississippi River from the River Bend Station to the Gulf of Mexico

Species	Commercial* catch, kg (lb)	% of commercial catch equal to recreational catch	Recreational catch, kg (lb)
Paddlefish	1.68×10^3 (3.70×10^3)	0	0
Buffalo	7.36×10^4 (1.62×10^5)	0	0
Catfish	3.69×10^5 (8.14×10^5)	123	4.54×10^5 (1.00×10^6)
Carp	1.78×10^4 (3.92×10^4)	123	2.19×10^4 (4.83×10^4)
Bowfin	1.54×10^2 (3.40×10^2)	50	7.70×10^1 (1.70×10^2)
Freshwater drum	2.48×10^4 (5.46×10^4)	50	1.24×10^4 (2.73×10^4)
Crayfish	4.58×10^3 (1.01×10^4)	50	2.29×10^3 (5.05×10^3)
Turtle	1.23×10^3 (2.72×10^3)	50	6.17×10^2 (1.36×10^2)
Frog	6.62×10^3 (1.46×10^3)	50	3.31×10^2 (7.30×10^2)
Freshwater shrimp	2.72×10^2 (6.00×10^2)	50	1.36×10^2 (3.00×10^2)
TOTAL	4.93×10^5 (1.09×10^6)		4.92×10^5 (1.08×10^6)

*Based on 1979 commercial catch data.

Table G-3 Estimate of total Mississippi River recreational finfish harvest using surface areas of segments and estimates of catch

Segment	Description	Area, hectare	Relative catch	Harvest/year,* kg/yr
I	River Bend site to Baton Rouge	5,000	1.5	3.8×10^4
II	Baton Rouge to New Orleans	14,000	0.5	3.5×10^4
III	New Orleans to Head of Passes	11,875	0.5	3.0×10^4
TOTAL		29,875		1.0×10^5

*Based on LPGS 5 kg/ha/yr.

APPENDIX H

CONSEQUENCE MODELING CONSIDERATIONS

APPENDIX H

CONSEQUENCE MODELING CONSIDERATIONS

H.1 Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of a substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation," which denotes a post-accident response to reduce exposure from long-term ground contamination after plume passage. The Reactor Safety Study (RSS) (NUREG-75/014, formerly WASH-1400) consequence model contains provisions for incorporating radiological consequence reduction benefits of public evacuation. The benefits of a properly planned and expeditiously executed public evacuation would be manifested in a reduction of early health effects associated with early exposure; namely, in the number of cases of early fatality (see Section H.2) and acute radiation sickness that would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 as well as in NUREG-0340 and NUREG/CR-2300. The evacuation model that has been used herein is a modified version of the RSS model (Sandia, 1978) and is, to a certain extent, site emergency planning oriented by inclusion of site-specific delay time before evacuation and effective evacuation speed as model parameters. The modified version is briefly outlined below.

The model uses a circular area with a specified radius (the 16-km (10-mile) plume exposure pathway emergency planning zone (EPZ)), with the reactor at the center. It is assumed that people living within portions of this area would evacuate if an accident should occur involving imminent or actual release of significant quantities of radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building). For the purpose of calculation of radiological exposure, the model assumes that all people who live in a fan-shaped area (fanning out from the reactor) within the circular zone with the downwind direction as its median--that is, those people who would potentially be under the radioactive cloud that would develop following the release--would leave their residences after lapse of a specified amount of time* and then evacuate. The delay time is calculated from the beginning of the warning time and is recognized as the sum of the time required by the reactor operators to notify the responsible authorities; the time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and the time required for the people to mobilize and get under way.

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*Assumed to be a constant value, 1.6 hours, that would be the same for all evacuees.

The model assumes that each evacuee would move radially outward* away from the reactor with an average effective speed** (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time) over a fixed distance from the evacuee's starting point. This distance is selected to be 24 km (15 miles) (which is 8 km or 5 miles more than the 16-km (10-mile) plume exposure pathway EPZ radius). After reaching the end of the travel distance, the evacuee is assumed to receive no further radiation exposure. In a real evacuation, paths of evacuees would be dictated by the site road network. However, each segment of the actual trajectory of an evacuee would project a component in the downwind direction that, in the consequence model, is assumed to be radial. Therefore, each evacuee's actual motion would have a component of motion along the radial downwind direction. The evacuation model assumption that evacuees originating from areas that would come under the radioactive cloud would move radially out over a certain distance amounts to only an artifice for dose calculation: as if the evacuees' radiological exposures are due to their component motion along the radial downwind direction (over a component path length that is assumed to be 24 km).

The model incorporates a finite length of radioactive cloud in the downwind direction that would be determined by the product of the duration over which the atmospheric release would take place and the average wind speed during the release. It is assumed that the front and back of the cloud would move with an equal speed, which would be the same as the prevailing wind speed. Therefore, the length of the cloud would remain constant at its initial value. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time were less than the warning time, then all evacuees would have a head start; that is, the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time were more than the warning time, then, depending on the initial locations of the evacuees, it is possible that (1) an evacuee would still have a head start, or (2) the cloud would be already overhead when an evacuee starts to leave, or (3) an evacuee would be initially trailing behind the cloud. However, this initial picture of cloud/people disposition would change as the evacuees travel, depending on the relative speed and positions between the cloud and people. The cloud and an evacuee might overtake one another one or more times before an evacuee would reach his/her destination. In the model, the radial position of an evacuating person, either stationary or in transit, is compared to the front and back of the cloud as a function of time to determine a realistic period of exposure to airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while the people are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this, at least in part, the revised model assumes that persons are (1) exposed to the total ground contamination concentration that is calculated to exist after complete passage of the cloud, after they are

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*In the RSS consequence model, the radioactive cloud is assumed to travel radially outward only, spreading out as it moves away (2.9 m/sec).

**Assumed to be a constant value, 2.9 m/sec (6.5 mph), that would be the same for all evacuees.

completely passed by the cloud; (2) exposed to one-half the calculated concentration when anywhere under the cloud; and (3) not exposed when they are in front of the cloud. Different values of the shielding protection factors for exposures from airborne radioactivity and ground contamination have been used.

Results shown in Section 5.9.4.5 of the main body of this report for accidents involving significant release of radioactivity to the atmosphere were based on the assumption that all people within the 16-km (10-mile) plume exposure pathway EPZ would evacuate according to the evacuation scenario described above.

Because sheltering can be a mitigative feature, it is not expected that detailed inclusion of any facility (see Section 5.9.4.5(2)) near a specific plant site from which not all persons would be quickly evacuated would significantly alter the conclusions. The applicant has provided estimates of the time required to clear the 16-km (10-mile) zone. From these estimates, the staff has estimated the delay time before evacuation of 1.6 hours and the effective evacuation speed of 2.9 m per second (6.5 mph). The staff believes that the delay time of 1.6 hours appropriately reflects the Commission's emergency planning requirements.

As a part of the base-case emergency response, a modification of the RSS consequence model was used, which incorporates the assumption that outside of the evacuation zone if the calculated ground dose to the total marrow over a 7-day period were to exceed 200 rems, this high dose rate would be detected by actual field measurements following plume passage, and people from these highly contaminated areas would be relocated immediately. For this situation, the model limits the period of ground dose calculation to 12 hours; otherwise, the period of ground exposure is limited to 7 days for calculation of early dose.

Figure H.1 shows the early fatalities for alternative assumptions of (1) a pessimistic case for which no early evacuation is assumed and all persons are assumed to be exposed for the first 24 hours following plume passage and are then relocated, and (2) another pessimistic case, the same as (1) except that relocation from only highly contaminated areas occurs 12 hours after plume passage.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as the original RSS model. For this purpose the model assumes that for atmospheric releases of durations 3 hours or less, all people living within a 90° angular sector within the plume exposure pathway EPZ and centered on the downwind direction will be evacuated and temporarily relocated. However, if the duration of release were to exceed 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would be evacuated and temporarily relocated. For either of these situations, the cost of evacuation and relocation is assumed to be $225 (1980 dollars) per person, which includes cost of food and temporary sheltering for a period of 1 week.

H.2 Early Health Effects Model

The medical advisors to the RSS (WASH-1400, Appendix IV, Section 9.2.2, and Appendix F) proposed three alternative dose-mortality relationships that can be used to estimate the number of early fatalities that might result in an exposed population. These alternatives characterize different degrees of post-exposure medical treatment from "minimal," to "supportive," to "heroic"; they are more fully described in NUREG-0340. There is uncertainty associated with both the mortality relationships (NUREG/CR-3185) and the availability and efficacy of different classes of medical treatment (Elliot, 1982). Estimates of the early fatality risks using the dose-mortality relationship that is based upon the supportive treatment alternative are presented in the text of Section 5.9.4.5(7). This implies the availability of medical care facilities and services for those exposed in excess of 175 rems, the approximate level that the medical advisors to the RSS indicated would be indicative of the potential need for more than minimum services to reduce early fatality risks. At the extreme low probability end of the spectrum (i.e., at the 1 chance in 100 million per reactor-year level), the number of persons involved might exceed the capacity of facilities for such services, in which case the number of early fatalities might have been underestimated. To gain perspective on this element of uncertainty, the staff has also performed calculations using the most pessimistic dose-mortality relationship based upon WASH-1400 medical experts' estimated dose-mortality relationship for minimal medical treatment and using identical assumptions regarding offsite emergency response as made in Section 5.9.4.5. These results are also presented in Section 5.9.4.5 and in Figure H.1. The staff has also considered the uncertainties associated with the WASH-1400 dose-mortality relationship for minimal medical treatment and has concluded that early fatality risk estimates as bounded by the uncertainties discussed in Section 5.9.4.5(7) are reasonable. This is because it is inconceivable that a major reactor accident at River Bend would not be followed by a mobilization of medical services, services that can be expected to reduce mortality risks to less than those indicated by the WASH-1400 description of minimal medical treatment.

H.3 References

Elliot, D. A., Andrulis Research Corp., Task 5 letter report to Ms. A. Chu, NRC, on Technical Assistance Contract No. NRC-03-82-128, December 13, 1982.

Sandia Laboratories, "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND-78-0092, June 1978.

U.S. Nuclear Regulatory Commission, NUREG-75/014, "Reactor Safety Study--An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants," formerly WASH-1400, October 1975.

---, NUREG-0340, "Overview of the Reactor Safety Study Consequences Model," October 1977.

---, NUREG/CR-2300, "PRA Procedures Guide, Final Report," January 1983.

---, NUREG/CR-3185, "Critical Review of the Reactor Safety Study Radiological Health Effects Model," Sandia Laboratories, March 1983 (also issued as SAND-82-7081).

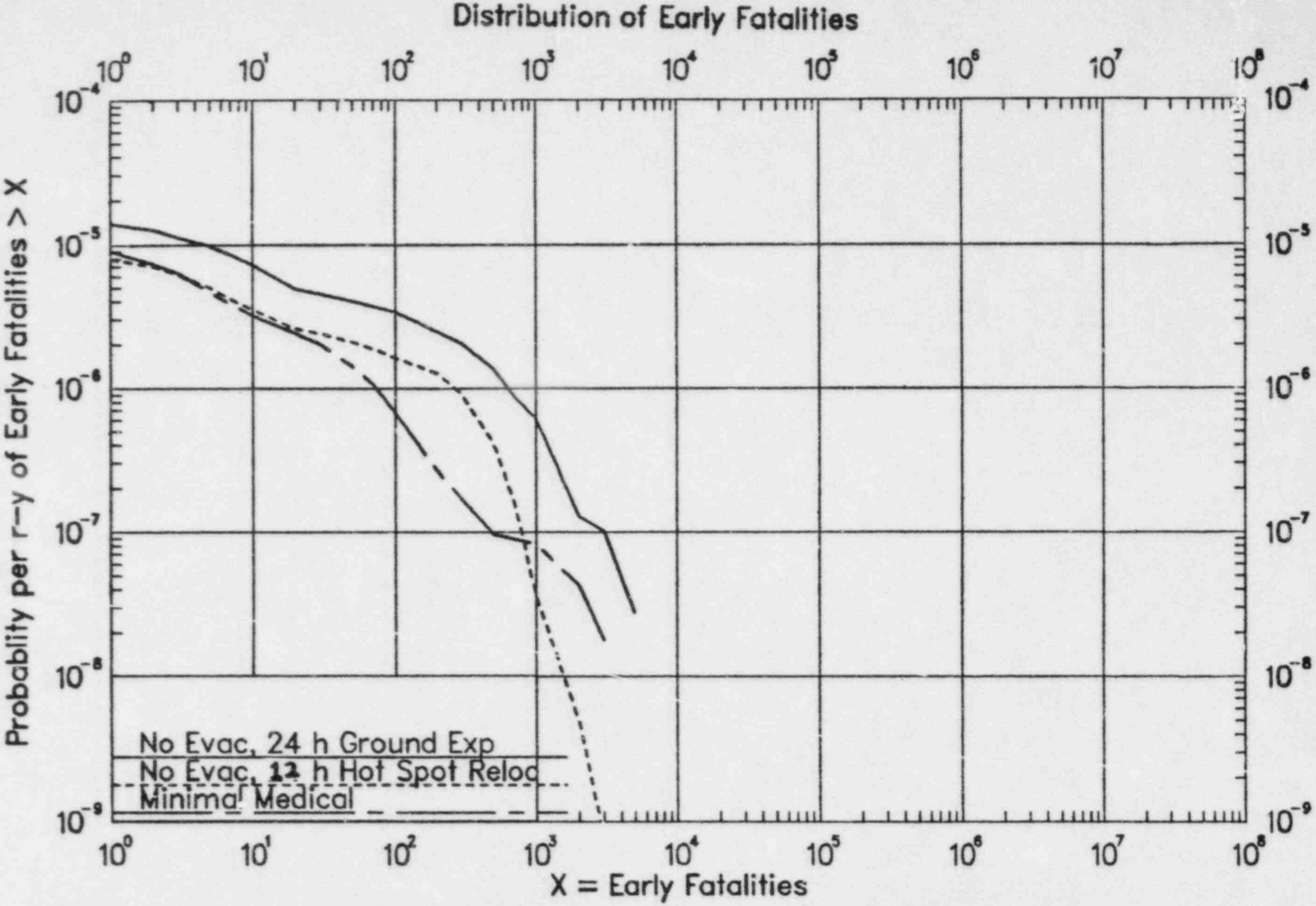

Figure H.1 Sensitivity of early fatalities to evacuation characteristics (see Section 5.9.2.1.4(7) for a discussion of uncertainties in risk estimates; see also footnote in section entitled "Dose and Health Impacts of Atmospheric Releases" for help in interpreting this figure).

APPENDIX I

ACCIDENT SEQUENCE MODELING

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In Section 7 of the River Bend Station Environmental Report, Operating Licensing Stage (ER-OL), the applicant provided an analysis of identification of severe accident sequences and the corresponding containment failure modes, quantification of probabilities, and specifications of atmospheric release of radionuclides associated with each accident sequence and containment failure mode combination. The applicant's analysis was based on an assessment of similarities and differences of the River Bend boiling water reactor (BWR) power plant and the Grand Gulf BWR power plant, because the two plants are of similar design, and for Grand Gulf a probabilistic safety study sponsored by the NRC was available (NUREG/CR-1659). In addition to the specification of release categories in terms of timing and quantities of radionuclides (commonly known as source terms) derived from the Grand Gulf Reactor Safety Study Methodology Applications Program (RSSMAP) (NUREG/CR-1659), the applicant also provided approved specifications of source terms based on methodologies available from the ongoing NRC-sponsored research programs at the Battelle Columbus Laboratory.

However, the staff chose not to use the applicant's source term specifications based on the results of the ongoing research programs because peer reviews of these new methodologies are not yet complete. Further, because there are insufficient details in the applicant's comparative analysis, the staff chose to use the Grand Gulf study itself as the surrogate for analysis of impacts of severe reactor accidents for the River Bend Station.

The release categories identified in Table 5.7 are comprised of one or more Grand Gulf-RRSMAP (NUREG/CR-1659) accident sequence-and-containment-failure-mode combinations based on similarities of timings and quantities of radionuclides in the atmospheric release. The timings were derived from the Grand Gulf-RRSMAP analysis of the accident progressions that used the MARCH code. The quantities of radionuclides were estimated in the Grand Gulf-RRSMAP study based on analysis by the CORRAL code. The probability assigned to each release category in Table 5.10 is the sum of the probabilities of the individual accident sequence and containment failure mode combinations that were included in the release category and were obtained from the Grand Gulf-RRSMAP. Because of the extremely low value of the probability of containment failure by steam explosion, this mode of containment failure was excluded from the release categories. The probability of the anticipated transient without scram (ATWS) sequence was set at 1×10^{-5} per reactor-year, with the assumption that ATWS modifications according to the NRC ATWS rule would be in place before issuance of the operating license. The total probability of all the release categories was assumed to be approximately 1×10^{-4} per reactor year. The individual accident sequences (and their containment failure modes) within each release category in Table 5.10 are described below.

BWR-2a Sequence

The BWR-2a sequence is composed of T_1PQI-δ and T_{23}PQI-δ accident sequences. Both of these sequences have the same release categories and were grouped as BWR-2a. These accident sequences are described as follows:

- Sequence T_1PQI-δ

This sequence is initiated by a loss of offsite power followed by a safety/relief valve failing to reseat, a failure to restore the power conversion system, and a failure of the residual heat removal system to start removing decay heat from the suppression pool within 28 hours. Containment failure is predicted to occur from overpressure due to gas generation.

- Sequence T_{23}PQI-δ

This sequence is initiated by any transient other than loss of offsite power followed by a safety/relief valve failing to reseat, a failure of the power conversion system, and a failure of the residual heat removal system to remove decay heat from the suppression pool within 28 hours. Containment failure is predicted to occur from overpressure due to gas generation.

Core melt for these sequences begins sometime after the containment failure at 28 hours.

BWR-2b Sequence

The BWR-2b sequence includes the accident sequences SI·δ, T_1QW-δ, and T_{23}QW-δ, all three of which have the same release categories. These accident sequences are described as follows:

- Sequence SI-δ

This sequence is initiated by small LOCAs followed by a failure of the residual heat removal system to remove decay heat from the suppression pool. Containment failure is predicted to occur from overpressure due to gas generation.

- Sequence T_1QW-δ

This sequence is initiated by a loss of offsite power followed by the unavailability of the power conversion system and the residual heat removal system to remove decay heat from the containment within 30 hours. Containment failure is predicted to be from overpressure due to gas generation.

- Sequence T_{23}QW-δ

This sequence is initiated by any transient which required an emergency reactor shutdown, other than a loss of offsite power, followed by the unavailability of the power conversion system and residual heat removal system to remove decay heat from the containment within 30 hours. Containment failure is predicted to be from overpressure due to gas generation.

BWR-2c Sequence

The BWR-2c sequence is the same as accident sequence $T_{23}C$-δ, which is defined as follows:

- Sequence $T_{23}C$-δ

This sequence is initiated by any transient which requires an emergency reactor shutdown, other than a loss of offsite power, followed by a failure to achieve reactor subcriticality. Containment failure is predicted to occur due to gas generation.

BWR-3M Sequence

The BWR-3M sequence is composed of T_1PQE-δ, $T_{23}PQE$-δ, and T_1QUV-δ accident sequences, which have the same release categories. These accident sequences are described as follows:

- Sequence T_1PQE-δ

This sequence is initiated by a loss of offsite power followed by a safety/relief valve failing to reseat, unavailability of the power conversion system, and a failure of emergency core cooling. Containment failure is predicted to occur from an overpressure due to rapid hydrogen burning.

- Sequence $T_{23}PQE$-δ

This sequence is initiated by any transient that requires an emergency reactor shutdown, other than a loss of offsite power, followed by a safety/relief valve failing to reseat, failure of the power conversion system, and failure of emergency core cooling. Containment failure is predicted to occur from overpressure due to rapid hydrogen burning.

- Sequence T_1QUV-δ

This sequence is initiated by a loss of offsite power followed by the unavailability of the power conversion system and failure of the high pressure systems and low pressure injection systems to provide emergency core cooling. Containment failure is predicted to occur from an overpressure due to rapid hydrogen burning.

In all of the above sequences, it was assumed that failure to inject water into the core quickly leads to a core melt.

BWR-4M Sequence

The BWR-4M sequence is composed of T_1PQE-δ, $T_{23}PQE$-δ, and T_1QUV-δ accident sequences. These sequences are the same as those described under the BWR-3M sequence above except that containment failure is from overpressure due to gas generation and not from rapid hydrogen burning.

Reference

U.S. Nuclear Regulatory Commission, NUREG/CR-1659, "Reactor Safety Study Methodology Applications Program: Grand Gulf No. 1 BWR Power Plant," Vol 4, October 1981.

NRC FORM 335
(2-84)
NRCM 1102,
3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any)
NUREG-1073

2. TITLE AND SUBTITLE
Draft Environmental Statement related to the operation of River Bend Station

3. LEAVE BLANK

4. DATE REPORT COMPLETED
MONTH July YEAR 1984

5. AUTHOR(S)

6. DATE REPORT ISSUED
MONTH July YEAR 1984

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code)
Same as 9 above

11a. TYPE OF REPORT
Draft Environmental Statement

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES
Docket No. 50-458
Gulf States Utilities Company
Cajun Electric Power Cooperative

13. ABSTRACT (200 words or less)

This Draft Environmental Statement contains the second assessment of the environmental impact associated with the operation of River Bend Station, pursuant to the National Environmental Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations, Part 51, as amended, of the Nuclear Regulatory Commission regulations. This statement examines the environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Comments on this statement should be filed no later than 45 days after the date on which the Environmental Protection Agency notice of availability of this statement is published in the Federal Register.

14. DOCUMENT ANALYSIS – a. KEYWORDS/DESCRIPTORS
Draft Environmental Statement
River Bend Station

b. IDENTIFIERS/OPEN-ENDED TERMS
DES

15. AVAILABILITY STATEMENT
Unlimited

16. SECURITY CLASSIFICATION
(This page)
Unclassified
(This report)
Unclassified

17. NUMBER OF PAGES

18. PRICE

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

120555078877 1 1AN
US NRC
ADM-DIV OF TIDC
POLICY & PUB MGT BR-PDR NUREG
W-501
WASHINGTON DC 20555