NUREG-0854

Final Environmental Statement

related to the operation of Clinton Power Station, Unit No. 1

Docket No. 50-461

Illinois Power Company, et al.

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

May 1982

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ABSTRACT

This final environmental statement contains the second assessment of the environmental impact associated with operation of Clinton Power Station Unit 1 pursuant to the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51, as amended, of the NRC's regulations. This statement examines: the affected environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. Land-use and terrestrial- and aquatic-ecological impacts will be small. Air-quality impacts will also be small. However, steam fog from the station's cooling lake has the potential for reducing visibility over nearby roads and bridges. A fog-monitoring program for roads and bridges near the lake has been recommended. Impacts to historic and prehistoric sites will be negligible. Chemical discharges to Lake Clinton and Salt Creek are expected to have no appreciable impacts on water quality under normal conditions and will be required to meet conditions of the station's NPDES permit. The hydrothermal analyses indicate that under certain meteorological conditions (1-in-50-year drought), the plant would have to be operated at reduced power levels in order to meet the thermal standards established by the Illinois Pollution Control Board Order PCB 81-82. The effects of routine operations, energy transmission, and periodic maintenance of rights-of-way and transmission line facilities should not jeopardize any populations of endangered or threatened species. No significant impacts are anticipated from normal operational releases of radioactivity. The risk associated with accidental radiation exposure is very low. Contentions associated with environmental issues accepted during the operating-license hearing are related to assessment of effects of low-level radiation. The net socioeconomic effects of the project will be beneficial. The action called for is the issuance of an operating license for Unit 1 of Clinton.

SUMMARY AND CONCLUSIONS

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

1. This action is administrative.

2. The proposed action is the issuance of an operating license to the Illinois Power Company for the startup and operation of the Clinton Power Station Unit 1 located in DeWitt County, about 10 km (6 mi)* east of Clinton, Illinois, and 100 km (60 mi) northeast of Springfield, Illinois.

   The facility will employ a boiling-water reactor producing 2894 megawatts thermal (MWt). A steam turbine-generator will use this heat to provide a net electrical output of 933 megawatts (MWe). The maximum design thermal output of the unit is 3039 MWt. The source of cooling water is Lake Clinton, which was created when the applicant constructed a dam near the confluence of the Salt Creek and the North Fork of the Salt Creek, 90 km (56 mi) east of where Salt Creek joins the Sangamon River.

3. The information in this statement represents the second assessment of the environmental impact associated with Clinton Power Station Unit 1 pursuant to the guidelines of the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51 of the Commission's Regulations. After receiving an application in October 1973 to construct this station, the staff of the Atomic Energy Commission (now Nuclear Regulatory Commission) carried out a review of impacts that would occur during its construction and operation. That evaluation was issued as a Final Environmental Statement - Construction Phase in October 1974. After this environmental review, a safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and public hearings in Clinton, Champaign, and Decatur, Illinois, between June 17, 1975, and January 8, 1976, the Commission issued construction permit Nos. CPPR-137 and CPPR-138 in February 1976 for the construction of Clinton Units 1 and 2. In August 1980 the applicant applied for operating licenses for Units 1 and 2 and submitted the required safety and environmental reports in support of the application. However, the applicant requested by letter dated October 30, 1981 that the licensing review for

*Throughout the text of this document most values are presented in both metric and English units. For the most part, measurements and calculations were originally made in English units and subsequently converted to metric. The number of significant figures given in a metric conversion is not meant to imply greater or lesser accuracy than that implied in the original English value.

Clinton Unit 2 be postponed until such time as construction of Unit 2 is substantially completed. Therefore the action under consideration in this document is the licensing of only Unit 1. As of October 1981, the construction of Unit 1 was about 81% complete. The applicant estimates a fuel-loading date of January 1984 for the unit.

4. The staff has reviewed the activities associated with the proposed operation of the station and the potential impacts, both beneficial and adverse, which are summarized as follows:

   a. Electric energy production costs from the Clinton station are estimated to be 13 mill/kWh (in 1984 dollars) (Sec. 6.4.2.1).

   b. Of the 5700 ha (14,100 acres) of site land, physical alteration of about 4820 ha (11,900 acres) of land for the station has occured. About 4148 ha (10,250 acres) is being managed by the Illinois Department of Conservation and provides recreational activities (Secs. 4.2.1, 4.2.2, and 5.2).

   c. All the water used for operating the station will come from Lake Clinton, which receives its inflow from the drainage basins of Salt Creek and North Fork Salt Creek. The average water use due to forced evaporation from Lake Clinton during normal operation of Unit 1 is 9.37×10^6 m^3 (7600 acre-ft) per year. There are no water users on Salt Creek, the Sangamon River, or the Illinois River downstream of the Clinton site that could be adversely affected by the reduced flows (Sec. 5.3.1).

   d. Chemical discharges to Lake Clinton and Salt Creek are expected to have no appreciable impacts on water quality under normal conditions, and will be required to meet conditions of the station's NPDES permit (Sec. 5.3.2).

   e. The applicant shall continue monitoring groundwater on the site. If mitigation against migration of pollutants to the groundwater becomes necessary, it shall be instituted in a timely manner (Sec. 5.3.2.1).

   f. The results of thermal modeling indicate that under certain meteorological conditions (1-in-50-year drought), the plant would have to be operated at reduced power levels in order to meet the thermal standards established by the Illinois Pollution Control Board Order PCB 81-82 (Sec. 5.3.2.2).

   g. The effect of seepage from the settlement pond on groundwater quality is expected to be insignificant (Sec. 5.3.2).

   h. An effect of the alterations in the flooding characteristics of Salt Creek caused by the construction of the station and cooling lake may be an increase in recession time of Trenkle Slough during the 100-year flood event, which may reduce the effectiveness of some agricultural land drains during major floods in the Trenkle Slough Drainage

District. The applicant, however, has completed channel improvements upstream of the reservoir which appear to be lowering the flood levels in Trenkle Slough (as compared to those under preconstruction conditions) for minor floods. Hence, the net effect of the reservoir and channel improvements is indeterminate at this time. Since construction activities for the main dam had already begun at the time that Executive Order 11988, Floodplain Management, was signed in May 1977, it is the staff's conclusion that consideration of alternatives to the modification of Salt Creek as caused by the main dam is neither required nor practicable (Sec. 5.3.3).

i. Steam fog from the station's cooling lake has the potential for reducing visibility over nearby roads and bridges. Rime ice falling from trees and poles along the edge of roads can reduce traction on the road surface. Both fog and rime ice may create highway-traffic safety problems. The staff recommends a fog-monitoring program for roads and bridges near the lake. If such problems occur, the applicant will be required to take mitigating actions (Sec. 5.4.1).

j. The aquatic biota of Lake Clinton and downstream Salt Creek will not be adversely affected by the chemical and thermal discharges during operation of Unit 1 (Sec. 5.5.2).

k. The environmental effects resulting from routine station operation, energy transmission, and the periodic maintenance of rights-of-way and transmission line facilities should not jeopardize any populations of endangered or threatened species (Sec. 5.6).

l. The operation of the station is not expected to affect any cultural sites on or eligible for the National Register of Historic Places (Sec. 5.7).

m. Socioeconomic effects of the station's operation are expected to be minimal with the exception of substantial tax benefits to DeWitt County, Harp Township, Unit 15 School District, and Jr. College District 537 (Sec. 5.8).

n. No measurable radiological impact on man or biota other than man is expected to result from routine operations (Sec. 5.9.3).

o. Production cost savings and benefit/cost analyses given in this statement are broad enough and conservative enough to account for the small potential reduction in plant availability due to thermal limitations mentioned in item f above (Sec. 6).

5. A draft statement was made available to the public, to the Environmental Protection Agency, and to other specified agencies in December 1981.

6. 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, it is concluded by the staff that the action called for under NEPA and 10 CFR Part 51 is the issuance of an operating license for Clinton 1, subject to the following conditions for the protection of the environment:

   a. Before engaging in additional construction or operational activities that may result in a significant adverse environmental 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 staff, and implemented in the technical specifications and environmental protection plan that will be incorporated in the operating license for Clinton 1.

   c. If adverse environmental effects or evidence of irreversible environmental damage is detected during the operating life of the station, the applicant shall provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

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FOREWORD

This 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 regulation, 10 CFR Part 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 Illinois Power Company's Clinton Power Station Unit 1. 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 October 1974 in support of issuance of a construction permit for Clinton Units 1 and 2.

The information to be found in the various sections of this statement updates the FES-CP in four ways: (1) by evaluating changes to facility design and operation that will result in different environmental effects of operation (including those which would enhance as well as degrade the environment) than those projected during the preconstruction review; (2) by reporting the results of relevant new information that has become available subsequent to the issuance of the FES-CP; (3) by factoring into the statement new environmental policies and statutes that have a bearing on the licensing action; and (4) by identifying unresolved environmental issues or surveillance needs which are to be resolved by means of license conditions. No unresolved issues have been identified in this statement for the case of Clinton. Two surveillance needs have been identified, namely the monitoring of fog and ice and of the temperatures at the discharge point and at Salt Creek downstream of Lake Clinton.

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 are available for inspection at the Commission's Public Document Room, 1717 H Street NW, Washington, DC, and at the Warner Vespasian Library, Clinton, Illinois. Single copies may be obtained by writing to:

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. J.H. Williams is the NRC Licensing Project Manager for this project. He may be contacted at the above address or at 301/492-9777.

1. INTRODUCTION

The proposed action is the issuance of an operating license to the Illinois Power Company for startup and operation of the Clinton Power Station Unit 1 in DeWitt County near Clinton, Illinois. Eighty percent of the unit is owned by Illinois Power Company, 10.5% by Soyland Power Cooperative, Inc. (Soyland), and 9.5% by Western Illinois Power Cooperative, Inc. (WIPCO).

The generating system consists of a boiling-water reactor, steam turbine-generator, a heat-dissipation system, and associated auxiliary facilities and engineered safeguards. Waste heat will be dissipated to the atmosphere from a cooling lake, Lake Clinton, which was created when the applicant constructed a dam near the confluence of Salt Creek and the North Fork of the Salt Creek, about 90 km (56 mi) east of where Salt Creek joins the Sangamon River.

The rated thermal capability of the Unit 1 reactor is 2894 MWt (ER-OL,* Sec. 3.2.1); the design electrical rating is 933 MWe net, and the design thermal (stretch) capability is 3039 MWt (ER-OL, Sec. 3.2.1).

1.1 ADMINISTRATIVE HISTORY

On July 23, 1973, Illinois Power Company (the applicant) filed an application with the Atomic Energy Commission (AEC), now Nuclear Regulatory Commission (NRC), for a permit to construct Clinton Power Station Units 1 and 2. This application was docketed on October 30, 1973. The conclusions resulting from the staff's environmental review were issued as a Final Environmental Statement - Construction Phase in October 1974. Following reviews by the NRC regulatory staff and its Advisory Committee on Reactor Safeguards, public hearings were held before an Atomic Safety and Licensing Board in Clinton and Champaign, Illinois, between June 17 and July 3, 1975. On September 30, 1975, the ASLB issued Partial Initial Decision on environmental and site suitability considerations. A Limited Work Authorization was issued to Illinois Power Company in October 1975. Hearings on health and safety issues were held in Decatur, Illinois, on January 7 and 8, 1976. The ASLB rendered its second decision, dealing with the remaining radiological health and safety questions, on February 20, 1976. Construction Permit Nos. CPPR-137 and CPPR-138 were issued in February 1976 for Units 1 and 2, respectively. Upon appeal by intervenors from the partial initial decision of the ASLB, the Atomic Safety and Licensing

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* "Clinton Power Station Environmental Report, Operating License Stage," issued by Illinois Power Company in August 1980. 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 Environmental Statement - Construction Phase, published in October 1974, is referred to as the FES-CP.

Appeal Board (ASLAB) considered the matter and affirmed the ASLB decision on July 29, 1976.

On January 31, 1978, Illinois Power Company requested on amendment to CPPR-137 to add Soyland Power Cooperative, Inc. and Western Illinois Power Cooperative, Inc. as co-owners of Unit 1. Amendment 1 was issued in September 1978 and identified the applicant as

Illinois Power Company
Soyland Power Cooperative, Inc.
Western Illinois Power Cooperative, Inc.

On August 29, 1980, Illinois Power Company, acting for itself and as an agent for Soyland Power Coop., Inc., and Western Illinois Power Coop., Inc., submitted an application, including a Final Safety Analysis Report (FSAR) and Environmental Report (ER-OL), requesting issuance of operating licenses for Clinton Units 1 and 2. These documents were docketed on September 8, 1980. Operational safety and environmental reviews were then initiated. The action being considered here is the issuance of an operating license for only Unit 1. Unit 2 has been deferred by the applicant and construction stopped.

As of October 1981, construction of Clinton Unit 1 was about 81% complete. The applicant estimates that Unit 1 will be ready for fuel loading in January 1984.

1.2 PERMITS AND LICENSES

The applicant has provided a status listing in Section 12 of the ER-OL plus Supplement 1, as of June 1981, 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 is not aware of any potential non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the station. The issuance of a water quality certification pursuant to Section 401 of the Clean Water Act of 1977 by the Illinois Environmental Protection Agency, Division of Water Pollution Control, is a necessary prerequisite for the issuance of an operating license by the Nuclear Regulatory Commission. This certification was received by the applicant on August 25, 1975. The U.S. Environmental Protection Agency issued a National Pollutant Discharge Elimination System (NPDES) permit with modification pursuant to Section 402 of the Clean Water Act of 1977 to the applicant on October 21, 1977 (Appendix B).

2. PURPOSE OF AND NEED FOR ACTION

The Commission has amended 10 CFR Part 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 Section 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). Pursuant to the amended regulations, need for power issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications. See 10 CFR Sections 51.21, 51.23(e), and 51.53(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 construction permit (CP) stage of the regulatory review where a finding of insufficient need could factor into denial of issuance of a CP. At the operating license (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 which supports the conclusion that nuclear plants are lower in operating costs than conventional fossil plants. If conservation, or other factors, lowers 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, March 26, 1982). See also 46 FR 39440, August 3, 1981.

Accordingly, this final 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 has amended its regulations in 10 CFR Part 51, effective April 26, 1982, to provide that issues related to alternative energy sources 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 Section 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). In addition, these issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications. See 10 CFR Sections 51.21, 51.23(e), and 51.53(c).

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 which operation of the nuclear plant would have over available alternative sources (47 FR 12940, March 26, 1982). See also 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 Section 2.758. Accordingly, this final environmental statement does not consider alternative energy sources or alternative sites.

4. PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT

4.1 RESUME

The following sections provide a description of the Clinton facility and related environment with respect to changes that have occurred since the FES-CP review. The staff has performed a one-unit review instead of a two-unit review as was done in the FES-CP, for reasons discussed in Section 1. Some minor changes have been made in the design and layout of Clinton 1 (Sec. 4.2.1). More of the applicant's property has been devoted to farm land than was originally planned because of the abandonment of the Tall Grass Prairie restoration project originally proposed (Sec. 4.2.2). The Clinton Power Station will use water from Lake Clinton to meet all its water supply needs except at the visitor's center, where some groundwater will continue to be used (Sec. 4.2.3). The cooling system remains essentially unchanged from the description in the FES-CP, except the bottom width of the discharge flume has been reduced slightly (Sec. 4.2.4). The applicant has elected to meet the radioactive-waste-treatment requirements of the Annex to Appendix I, 10 CFR 50, dated September 4, 1975 (Sec. 4.2.5). Periodic cleaning of the condenser with acids may be necessary (Sec. 4.2.6.1). There has been an increase in the amount of chlorine biocide to be used (Sec. 4.2.6.1). The thermal analysis was redone for one-unit operation based on information provided by the applicant (Sec. 4.2.6.2). The design capacity of the sanitary waste system has been increased slightly. There will only be three emergency diesel generators for one-unit operation (Sec. 4.2.6.3). The routing of one transmission line has been changed (Sec. 4.2.7). The derived mean annual discharge at the dam site is slightly different from that cited in the FES-CP, Section 2.5.1. The volume of sediment deposited in 30 years will be a small percentage of the lake capacity (Sec. 4.3.1).

The observance of methane in groundwater wells led to a decision to utilize Lake Clinton for service water (Sec. 4.3.2). Air-quality data for the region surrounding the Clinton site which were not available at the CP stage are presented; (Sec. 4.3.3). A remnant prairie stand has been expanded in lieu of the originally proposed prairie restoration (Sec. 4.3.4.1). The developing biotic community of Lake Clinton is described (Sec. 4.3.4.2). There is a potential for the establishment of the Asiatic clam in the lake (Sec. 4.3.4.2). There is a potential for the establishment of human pathogenic encephalitic amoebae in the lake (Sec. 4.3.4.2). Current information on endangered and threatened species is provided (Sec. 4.3.5). Current information on community characteristics and on historic and prehistoric sites is provided (Secs. 4.3.6 and 4.3.7, respectively).

4.2 PROJECT DESCRIPTION

4.2.1 External Appearance and Station Layout

A general description of the external appearance, plant layout and land use is provided in Sections 2, 3, and 4 of the FES-CP. An architectural rendering of Clinton Power Station Units 1 and 2 is also presented in Figure 3.1.1 of the applicant's ER-OL.

Since publication of the FES-CP and the ER-OL architectural rendering, the major change that has occurred is the deferral of Clinton Unit 2 and the decision to proceed with the construction of only Unit 1. Until construction work is resumed on Unit 2, only Unit 1 structures will be visible. Thus, the Unit 2 reactor building, turbine building, auxiliary buildings and railroad spur will not appear. The 112 spray modules in the cooling canal are not now included.

Other changes which have occurred since the FES-CP include expansion of the sewage treatment plant to include two additional holding tanks, moving of the parking lot across the road to east of the power station and placing the visitors center to the west side of the lake at Route 54.

The configuration of the site boundary remains essentially the same as shown in Figure 4.1 of the FES-CP.

4.2.2 Land Use

The site consists of 5703 ha (14,092 acres), down from the earlier estimated size of 6160 ha (15,210 acres) indicated in the FES-CP (Sec. 2.1.2). Physical alteration of about 4820 ha (11,900 acres) of site property has occurred. Table 4.1 presents a land-use comparison of preconstruction use and present station use of total acreage.

With the completion of land acquisition and construction activities, some land use within the site differs from what was described in the FES-CP (Sec. 2.1.2). About 135 ha (333 acres) will be used for station structures and 2250 ha (5560 acres) will be occupied by the station's cooling lake, dam and spillway, discharge flume, and spoils. The cooling lake covers essentially the same area of 1983 ha (4900 acres) as given in the FES-CP (Sec. 3.4.2). The change of land use related to the site preparation, construction activities, and lake formation is described in greater detail in the ER-OL (Secs. 4.1.1 and 4.3.1).

The applicant has abandoned plans for initiating the Tall Grass Prairie restoration project in the peninsular portion of the site. A prairie remnant east of the North Fork has, however, been expanded by planting of appropriate grasses and forbs (ER-OL, Sec. 4.5.3). This decision resulted in an increase in the amount of prime farmland to remain in production. Of the 587 ha (1451 acres) presently leased as cropland, 504 ha (1246 acres) are designated as prime farmland. An additional 57 ha (140 acres) of prime farmland in the general area of the station complex may be restored to agricultural use following completion of project construction (ER-OL, Sec. 4.3.1).

Table 4.1. Clinton Power Station Land-Use Comparison†[1]

	Preconstruction Use (acres)†[2]	Station Use (acres)†[2]
Lake area†[1]	--	4895
Homesteads	5	--
Agricultural land	2845 (710 prime)	--
Timber/brushland	2000	--
Miscellaneous	50	--
Timber and grassland (greenbelt)†[2]	1450	5871
Agricultural land	7742 (2254 prime)	1451 (1246 prime)
Silphium prairie	--	60
Station facilities		
Station complex	--	980
Discharge flume	--	285
Dam & Spillway	--	380
Other facilities†[3]		
Marina	--	150
Visitors center	--	20
TOTAL	14,092	14,092†[4]

†[1] Modified from ER-OL, p. 4.3-8.

†[2] Land available for recreational activities. A total of 4150 ha (10,250 acres) of this land has been leased to the Illinois Department of Conservation to manage as a recreation/conservation area.

†[3] These facilities are open for public use by the applicant.

†[4] All of the site property was purchased primarily for the construction and operation of the Clinton Power Station. Secondary usage of some of the acreage is provided for agricultural and recreational purposes.

Note: To convert acres to hectares, multiply by 0.405.

Since August 1979, a total of 4217 ha (10,420 acres) of the site has been open to public use for recreational and wildlife study activities; 4148 ha (10,250 acres) are managed by the Illinois Department of Conservation (IDOC) and 69 ha (170 acres) by the applicant (ER-OL, Sec. 4.1.1). Implementation of the IDOC Wildlife Resources Management Plan--thus promotes multiple use of local resources, i.e., power generation, wildlife habitat, public recreation and agricultural use. Among other considerations of integrated land use, provisions of the IDOC management plan preclude soil tillage (tenant farming operations) in areas characterized by high erosion potential (e.g., steep slopes and/or highly erosive soils). Additionally, buffer zones such as grasslands or forest vegetation are to be maintained between cultivated croplands and adjacent drainageways and/or Lake Clinton (Ref. 29), thus restricting sediment transport by surface runoff.

As pointed out in Table 4.1, 4150 ha (10,250 acres) have been leased to the Illinois Department of Conservation to manage as a recreation/conservation area. Lake Clinton is the only recreation facility within 8 km (5 mi) of the station. With the exception of Weldon Springs State Park, located 8.8 km (5.5 mi) southwest of the site, which offers fishing, boating, and hiking on a 150-ha (370-acre) park, Lake Clinton constitutes the only other major recreational facility in the surrounding area. Lake Clinton offers year-round recreational facilities providing boating, fishing, hunting, camping, picnicking, and hiking. The Illinois Department of Conservation has estimated that in 1980 the site was visited by 520,212 persons and expects the visitation to increase to 750,000 persons in 1982 and 1,000,000 persons in 1983 and beyond.

The construction of the power station and Lake Clinton has resulted in vacating portions of certain roads, relocating portions of roads, and building some new road. The following changes occurred:

(a) New bridges and approaches were built across North Fork of Salt Creek (Route 54) and Salt Creek (Route 48), and Route 10 was elevated at the point where the lake crosses under the highway.

(b) A 1500-m (4900-ft) section of County Highway 14 was relocated. The relocation involved 2100 m (7000 ft) of highway and three new bridges.

(c) In Harp Township 13.8-km (8.6-mi) of road was vacated and three old bridges were removed. About 5.8 km (3.6 mi) of new roads and a new bridge over the North Fork of Salt Creek were built.

(d) In Creek Township 3.0 km (1.9 mi) of road was vacated, one old bridge removed and 3.2 km (2 mi) of new roads were built.

(e) In DeWitt Township 8 km (4.9 mi) was vacated and two old bridges removed. One new bridge and 9 km (5.9 mi) of new road were built.

(f) In Nixon Township 0.2 km (0.1 mi) of road was vacated and about 3.1 km (1.9 mi) of new roads were built.

4.2.3 Water Use

The Clinton Power Station will use water from Lake Clinton to meet its water supply needs. Proposed station use of groundwater was abandoned due to high methane concentrations found in test wells during construction. There are no users of the Salt Creek or its North Fork for domestic, industrial, or municipal purposes. Salt Creek water is not used for irrigation within 80 km (50 radial mi) downstream from the station. All water supplies for such purposes are obtained from groundwater sources. The nearest public water supply which could be influenced by Salt Creek or its North Fork would be Alton, Illinois, on the Mississippi River, approximately 390 km (242 river mi) downstream of the Clinton Power Station.

Lake Clinton is used by the public for sport fishing, powerboating, water skiing, and wildlife observation and study, and lakefront areas are being prepared for use as swimming beaches (staff observations, site visits of March and September 1981). The effect of station effluents on lake water quality is covered in Sections 5.3.2 and 5.5. Consumptive water use resulting from station operation is discussed in Section 5.3.1.

Groundwater use by the project will be limited to the Clinton Power Station Visitor Center and recreational areas during operation. Use of groundwater at these locations will be minimal and will have no significant effect on local or regional hydrology.

4.2.4 Cooling System

Except for the fact that only one unit will be operated, the station cooling system will remain unchanged from what was described in the FES-CP (Sec. 3.4), that is, a once-through system withdrawing water from, and discharging water to, an impoundment of Salt Creek, named Lake Clinton.

4.2.4.1 Intake Structure

There have been no changes in the cooling water intake structure from what was described in the FES-CP (Sec. 3.4.4).

4.2.4.2 Discharge Structure

Other than a reduction in the bottom width of the discharge flume from 43 m (140 ft) to 37 m (120 ft) (ER-OL, Sec. 3.4.3), the discharge structure will be generally as described in Section 3.4.5 of the FES-CP. The applicant does not plan to install a series of spray modules in the discharge flume for supplemental cooling during the period of one-unit operation as indicated in the ER-OL (Sec. 3.4.4).

4.2.5 Radioactive-Waste Treatment

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

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

The staff's detailed evaluation of the liquid and gaseous radwaste systems and the capability of these systems to meet the requirements of Appendix I is presented in Chapter 11 of the staff's Safety Evaluation Report which was issued in February, 1982. The quantities of radioactive material calculated by the staff to be released from the station during normal operations, including anticipated operational occurrences, are presented in Section 5.9 of this environmental statement, along with the calculated doses to individuals and to the population that will result from these effluent quantities. The staff's evaluation concludes that the final designs of radwaste systems and effluent control measures are capable of meeting the design objectives of Appendix I to 10 CFR 50, such that radioactive materials in effluents released to unrestricted areas can be kept as low as reasonably achievable.

Before the issuance of an operating license, the applicant will submit technical specifications that will establish release rates for radioactive material in liquid and gaseous effluents. These specifications will also provide for the routine monitoring and measurement of all principal release points to assure that the facility operator is in conformance with the requirements of Appendix I to 10 CFR Part 50.

4.2.6 Nonradioactive-Waste-Management Systems

As a result of the change in the station's source of makeup and potable water from deep wells to Lake Clinton (Sec. 4.2.3), the designs of the makeup water treatment system and associated waste management systems have been changed from what was described in the FES-CP (Secs. 3.6 and 3.7). Additionally, the analysis of thermal discharge has changed from that given in the FES-CP (Sec. 3.4) in light of plans for one-unit operation.

4.2.6.1 Chemicals

Makeup and Potable Water Treatment

Plant makeup and potable water will be taken from Lake Clinton and then treated by prechlorination, clarification and solids removal--using alum or sodium aluminate and a coagulant aid, lime softening, and sand filtration. Plant makeup water will undergo further treatment using carbon filtration and demineralization (ER-OL, Secs. 3.3.4.1 and 3.6.2).

Wastes generated during backwash cleaning of the sand and carbon filters, removal of sludge from the clarification basins, lime softener blowdown, and demineralizer regeneration and condenser cleaning will be routed to two wastewater treatment ponds, located southwest of the plant near the edge of Lake Clinton, with a total capacity of about 1.9×10^4 m^3 (5.0×10^6 gal). The supernatant effluent from the wastewater treatment ponds will be neutralized by addition of acid, caustic, or lime and then sand filtered before discharge to Lake Clinton via the discharge flume. If the quality of wastewater does not meet NPDES effluent limitations (Appendix B) provisions have been made for routing the sand filter effluent back to the wastewater treatment ponds. The sludge collected in the wastewater treatment ponds will be dredged when necessary and transported offsite to a licensed landfill (ER-OL, Sec. 3.6.4). Although the wastewater treatment ponds will not be lined, infiltration of seepage from the ponds into the aquifers in the vicinity of the station will be impeded by the low permeability (less than 10^{-5} cm/s) of the rock and soils in the site area (ER-OL, Sec. 2.4.3.4).

Cooling Water Treatment

Biocides. The concentration of chlorine to be used for Unit 1 condenser biofouling control has been increased about one-third since the FES-CP was issued (FES-CP, Sec. 3.6.2). Plans now call for about 4 mg/L--average (5.3 mg/L--maximum) of chlorine to be injected into the circulating water upstream of the condenser for periods of about 30 minutes three times daily. The free available chlorine (FAC) concentration during chlorination will be about 0.5 to 1.0 mg/L, which will be reduced to about 0.1 mg/L at the condenser outlet. Total residual chlorine (TRC) levels are dependent upon a variety of reactions--with inorganic compounds, ammonia, and organic compounds, as well as reactions prompted by sunlight--in which chlorine is consumed (Refs. 1-3). On the basis of expected water quality in Lake Clinton, the staff estimates that the TRC concentration during chlorination will be about 1.5 to 2.5 mg/L, which will be reduced to about 0.3 mg/L at the condenser outlet. Only one unit will be in operation, and thus untreated circulating water from the second unit will not be available to reduce the chlorine concentration through reaction and dilution upon mixing, as was anticipated in the FES-CP (Sec. 3.6.2). However, the staff estimates that the long transit time in the discharge flume (about 3.9 hours) will reduce residual chlorine through further reactions as an oxidizing agent (Refs. 4-6), resulting in a reduction of FAC to well below 0.1 mg/L and TRC to below 0.2 mg/L prior to discharge into Lake Clinton (ER-OL, Secs. 3.3.1 and 3.6.1).

As described in Section 4.3.4.2, if the Asiatic clam becomes established in Lake Clinton, the clams may block the power plant condenser tubes. This possibility was not considered in the FES-CP. In waters similar to those expected in Lake Clinton, an effective method to control juvenile Asiatic clams is to asphyxiate them by creation of anaerobic conditions. During condenser outages, water in the cribhouse is allowed to remain undisturbed for about 36 hours while adding oxygen scavengers (about 150 to 200 mg/L sodium meta-bisulfite, 5 to 8 mg/L hydrogen sulfide, and 0.3 ppm cobalt chloride). At the end of the treatment period, water is neutralized by reaeration prior to discharge. Reaeration restores the dissolved oxygen content and oxidizes sodium meta-bisulfite and hydrogen sulfide to sulfates (Ref 7).

Scale Control. The applicant estimates that it may be necessary to remove scale from the condenser after five to seven years of operation (and, possibly, at similar intervals thereafter) (ER-OL, Response to Question 291.9).

If scale develops, chemical scale control will be considered using sulfuric, formic, or phosphoric acid in a 5% to 15% solution during a condenser outage. Cleaning of the condenser is expected to produce about 1900 m^3 (5×10^5 gal) of waste, plus rinse water; the waste solution will be neutralized, precipitated in one of the two wastewater treatment ponds, and filtered, as described in the section on makeup and potable water treatment (ER-OL, Response to Question 291.9). Following treatment, the wastewater will be discharged into Lake Clinton, resulting in an initial increase of about 1 ppm in the salt concentration in the lake, which should be reduced to immeasurable quantities shortly after condenser cleaning is completed.

4.2.6.2 Thermal

The applicant has reevaluated its thermal plume predictions for Lake Clinton since issuance of both the FES-CP and the ER-OL. This reevaluation was undertaken because (1) the original predictions were for two unit operation, but the applicant has decided only Unit 1 will be in operation for an indefinite period of time, and (2) there have been advances in thermal field predictive techniques since the applicant's original analysis.

During the construction-permit stage, the applicant used a one-dimensional (longitudinal) thermal-plume model (called LAKET) to predict the thermal effect of station operation upon the Clinton cooling lake and the thermal impact of the water discharged into Salt Creek below the dam (FES-CP, Sec. 5.3). In its revised hydrothermal analysis, the applicant used the Laterally Averaged Reservoir Model (LARM) to simulate the two-dimensional (longitudinal and vertical) variations of both the velocities and temparatures in Lake Clinton (Ref. 8). The applicant computed the hydrodynamic and temperature regimes in Lake Clinton for a heat-rejection rate of 6.2 MMJ/hr (5.9×10^9 Btu/hr) with one-unit operation at 100% load factor (plant factor) and for the climatological and hydrological conditions of 1978 and 1955. The year 1978 was used to provide a verification case under no heat load (filling of the lake was completed in May 1978, and some actual lake-temperature data were available). The year 1955 was selected because it experienced the highest summer water temperatures in the 26 years (1953-1978) of record (Ref. 8, Sec. 4.2.3) and because it corresponds to the 1-in-50-year drought (ER-OL, Sec. 5.1.2).

The cooling water temperature rise for one-unit operation at maximum load was calculated to be 10.1C° (18.2F°) based on a total station heat rejection rate of 6.2 MMJ/hr (5.9×10^9 Btu/hr) and a flow rate of 41 m^3/s (1447 cfs). The temperature reduction in the discharge flume was estimated to be about 0.5C° (0.9F°) for the 1955 meteorological conditions and about 1.0C° (1.8F°) for the 1978 conditions.

The applicant presented the newly predicted lake temperature data for one-unit operation in the Thermal Demonstration Report (TDR) and submitted the report in 1980 to the Illinois Pollution Control Board (IPCB) to support the applicant's petition for alternative thermal standards for Unit 1.

In October 1981, the applicant, in response to the staff's question about the applicant's thermal demonstration, indicated that for one-unit operation at 100% load, the station heat-rejection rate would be 7.0 MMJ/hr (6.61 × 10^9 Btu/hr) (Ref. 9). Also, at lake elevation of 210 m (690 ft) MSL, it was reported that the circulating water flow rate would be 38.8 m^3/s (1370 cfs), and the service water flow rate would be 2.8 m^3/s (98 cfs) (about 95% of this will go to the discharge flume). Therefore, the combined circulating and service water flow rate would be 41.6 m^3/s (1468 cfs) instead of 41 m^3/s (1447 cfs) as previously reported, and the resulting water temperature rise, at 100% power, would be 11.2C° (20.1F°) instead of 10.1C° (18.2F°). The Applicant's lake temperature distribution data for the revised heat-rejection and cooling-water-flow rates were not available to the staff.

The staff conducted an independent hydrothermal analysis for Lake Clinton using the above flow and temperature data and the transient temperature prediction model called "MITEMP" developed by Massachusetts Institute of Technology (MIT) for natural reservoirs and cooling impoundments (Refs. 10,11). The MITEMP program is a flexible, multipurpose computer code that contains several submodels for predicting temperature structure and flow pattern in natural impoundments, deep stratified cooling ponds, and shallow, vertically mixed cooling ponds.

The staff simulated the hydrothermal performance of Lake Clinton for the conditions during the period of May through October in the extreme dry year of 1955. Meteorological data for Springfield, Illinois, were used (Ref. 12). Based on the applicant's lake drawdown analysis, the staff assumed that the lake level would be at the extreme low level of 209 m (685.5 ft) MSL (ER-OL, p. 3.4-1) with no flow over the spillway. The only downstream water released from the cooling lake to Salt Creek was considered to be discharged through the submerged lake outlet, which has a crest elevation of 204 m (668 ft) MSL. The simulation was first performed for the case with the station operating at 100% load factor, which represents the worst-case situation in terms of potential thermal impact.

The cooling water flow rate used by the staff is somewhat different from the value provided by the applicant. Since the lake elevation would drop to 209 m (685.5 ft) MSL under the 1955 conditions, the intake pumping rates would be expected to be less than 38.8 m^3/s (1370 cfs) for circulating water and 2.8 m^3/s (98 cfs) for service water, which as the applicant pointed out, are the pumping rates at lake elevation of 210 m (690 ft) MSL (Ref. 9). The staff calculated that at lake elevation of 209 m (685.5 ft), the circulating and service water flow rates would be 37 m^3/s (1310 cfs) and 2.7 m^3/s (95 cfs). The combined cooling water discharge rate into the lake would be 39.6 m^3/s (1400 cfs), since only 95% of the service water would go into the discharge flume. At 100% load factor, the station heat rejection rate of 7.0 MMJ/hr (6.61 × 10^9 Btu/hr) would result in a combined temperature rise of 11.8C° (21.2F°). Assuming that the temperature reduction in the discharge flume would be 0.5C° (0.9F°) for the conditions of the year 1955, the water-temperature rise for the discharge into Lake Clinton would therefore be 11.3C° (20.3F°) at 100% power.

A staff evaluation of the given pond characteristics indicated that Lake Clinton would tend to be stratified. Therefore, the deep stratified cooling pond submodel of the MITEMP program was used by the staff for its simulation. The simulated discharge temperatures in the lake as computed by the staff are shown in Figure 4.1 and in Table 4.2 for one-unit operation at 100% load

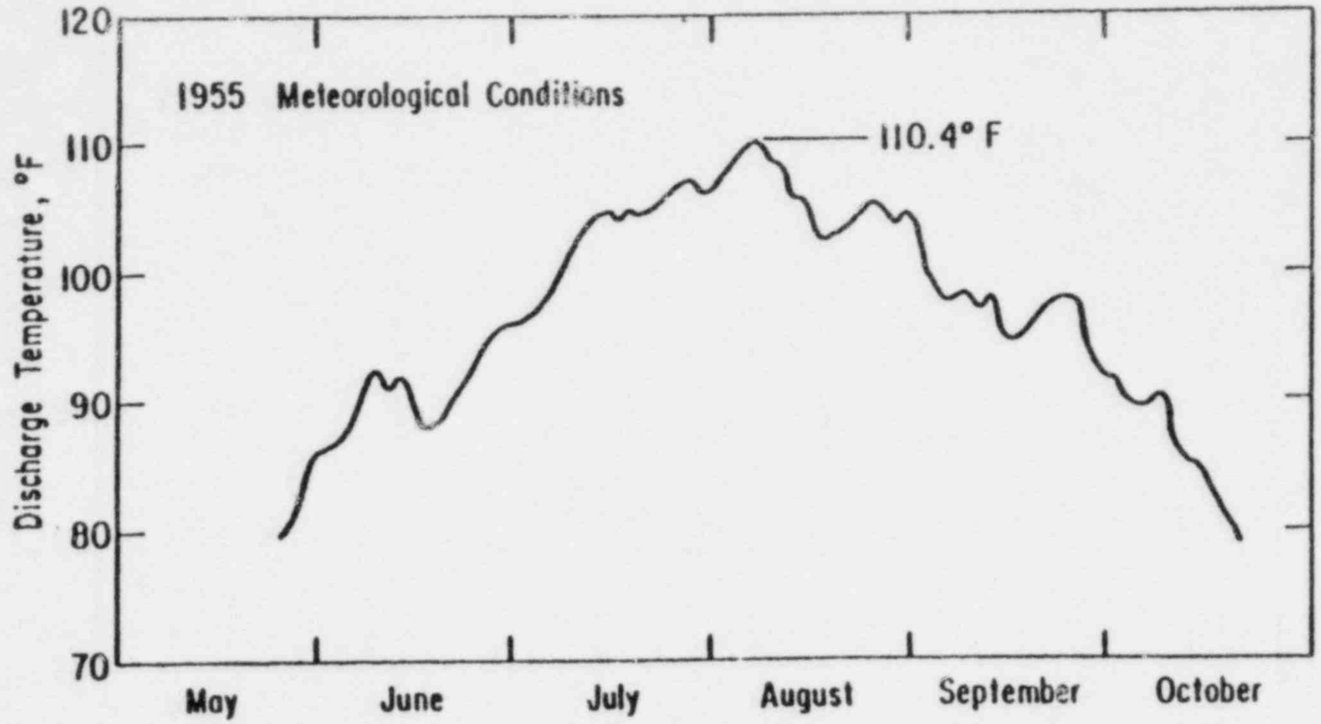

Figure 4.1. Staff's Predicted Discharge Temperature into Lake Clinton for One-Unit Operation at 100% Load Factor. [°C = (°F - 32) × 0.555]

Table 4.2. Results of the Staff's Predicted Temperatures for Year 1955 (Lake Surface Elevation = 685.5 ft MSL).

Cooling Water Discharge (cfs)	Water Temperature Rise (F°)	Flume Temperature Reduction (F°)	Maximum Discharge Temperature to Lake†[1,2] (°F)	Annual Frequency above 99°F†[1,3] (%)	Maximum Discharge Temperature to Salt Creek†[1,4] (°F)
100% Load Factor†[5]					
1400	21.2	0.9	110.4	16.4	90.1
1463†[6]	20.1†[6]	0.9	109.5	16.0	90.0
78% Load Factor†[7]					
1400	16.5	0.9	105.5	11.8	85.7
1463†[6]	15.7†[6]	0.9	104.7	10.0	85.6

†[1] See Section 5.3.2.2 for details of the IPCB thermal standards.

†[2] IPCB standard is 108.3°F.

†[3] IPCB standards limit frequency of occurrence of releases above 99.0°F.

†[4] IPCB standard is 90.0°F.

†[5] Heat-rejection rate = 6.61×10^9 Btu/hr.

†[6] Data provided by the applicant.

†[7] Heat-rejection rate = 5.16×10^9 Btu/hr.

Note: °C = (°F - 32) × 0.555; m^3/s = cfs × 0.028

factor. The maximum temperature of water released from Lake Clinton to Salt Creek is also presented in Table 4.2. In addition to using the cooling water flow rate and the water temperature rise as derived by the staff to perform thermal analysis, the staff also predicted the lake temperature by using the flow and temperature data provided by the applicant. These results are also shown in Table 4.2.

Based on the MITEMP program and the input data derived by the staff, the predicted maximum discharge temperature into the lake would be about 43.6°C (110.4°F) for 100% load factor. The results also indicated that the maximum discharge temperatures would generally occur around August 5 under the 1955 conditions. The maximum temperature of water released from Lake Clinton to Salt Creek was predicted to be 32.3°C (90.1°F).

In addition, the staff has performed similar modelings for other station operating conditions. The results for one-unit operation at 78% load factor are also presented in Table 4.2. This reduced operating level, as discussed in Section 5.3.2.2, would produce discharge temperatures into Lake Clinton within the limits established by the IPCB.

The staff has reviewed the temperature distributions in the lake, as provided by the applicant in its thermal demonstration reports (Ref. 8) for slightly different flow-rate and temperature parameters than indicated in Table 4.2. The observation of the temperature distributions indicated that a large fraction of Lake Clinton would have water temperatures at or below 32.2°C (90°F) (Sec. 5.5.2.3). The staff believes that this conclusion about lake temperature would remain valid under the station operating conditions indicated in Table 4.2.

4.2.6.3 Other

Sanitary Wastes

The sanitary waste treatment scheme given in Section 3.7.1 of the FES-CP remains valid. The only change is the design capacity, which has been increased from 142 m^3/day (37,500 gal/day) to 161 m^3/day (42,500 gal/day), primarily to meet the needs of an increased labor force during refueling. The normal operation work force is expected to be about 350 people for one-unit operation (ER-OL, Response to Question 310.1). The staff has determined that based on a water usage rate of 1.5×10^{-6} m^3/s (35 gal/day) per person (Ref. 13), the design capacity of the sanitary system is sufficient.

Gaseous and Particulate Emissions

The only change from the FES-CP (Sec. 3.7.2) is that there will be only three emergency diesel generators for one-unit operation, as opposed to the six originally planned for two-unit operation (FES-CP, Sec. 3.7.2). These generators will be on standby status and will be periodically tested (ER-OL, Sec. 3.7.3). The total annual discharge of sulfur dioxide is estimated to range between 170 and 270 kg (370 and 600 lb); total annual discharge of nitrogen oxides is expected to range between 100 and 170 kg (230 and 370 lb) (ER-OL, Sec. 3.7.3). Small amounts of particulates will also be released. The staff considers these estimates to be within the range of emissions normally to be expected from such sources. Another source of air pollution during station operation will be fugitive dust and combustion-product emissions from vehicle operation. The amounts of such pollutants have not been estimated, but are expected by the staff to be relatively small compared with other sources in the area.

4.2.7 Power-Transmission Systems

The completed transmission facilities associated with the station differ from those described in the FES-CP (Sec. 3.8). They are fully described in the ER-OL (Sec. 3.9.1). The major change is the substitution of "Route I" (south) for "Route B" to facilitate connection with the Oreana Substation (Fig. 4.2). Route I contains two parallel rows of single-circuit, wood H-frame structures with 345-kV lines on 8.7 km (5.4 mi) of the applicant's property; the route then continues on private rights-of-way, employing double-circuit, single-column steel structures. The columns carry two 345-kV lines to the intersect and tie-in with the existing Latham Rising Transmission Line 4571, with one 345-kV line continuing from Line 4571 to the Oreana substation. Changes in the corridors of transmission line routes F-G and H are minor. The combined length of the three transmission lines added to the Illinois Power Company

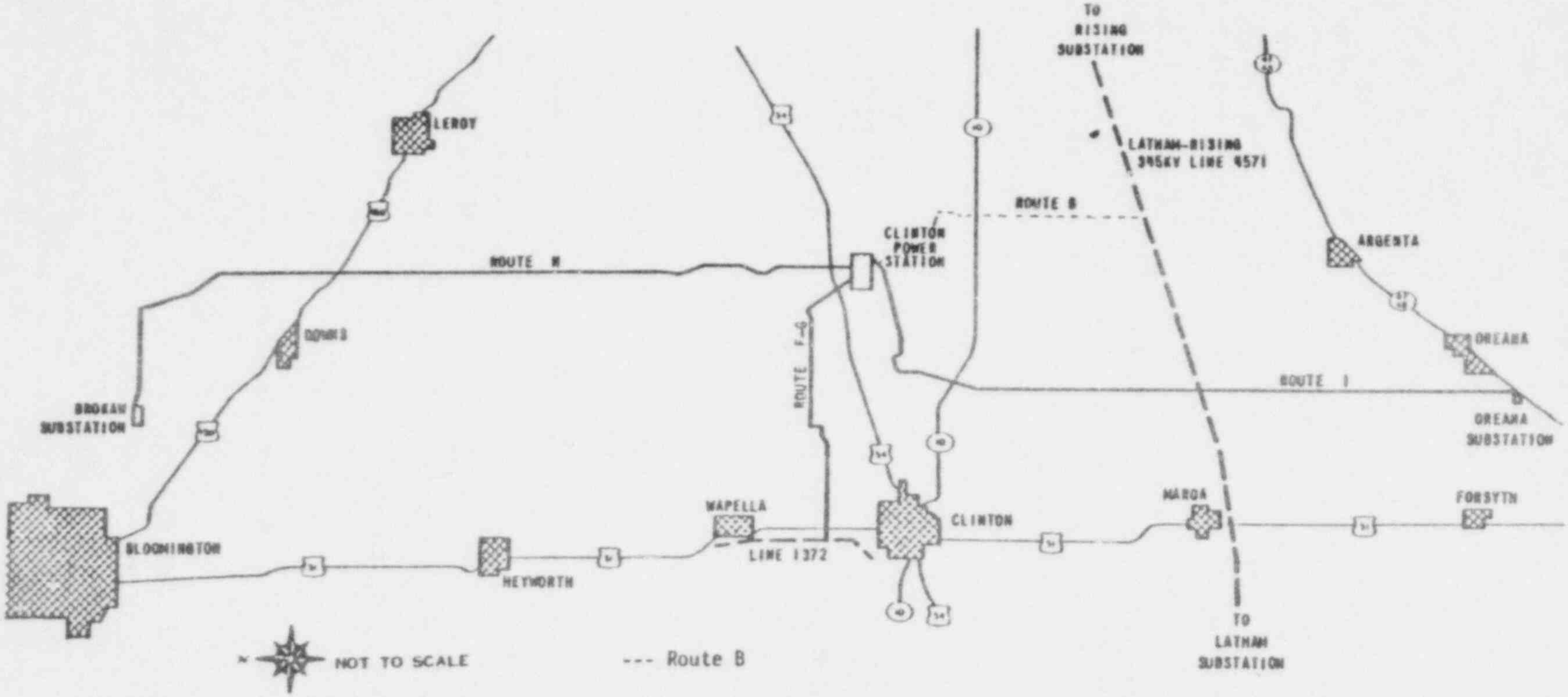

Figure 4.2. Transmission Line Routes. [Modified from the ER-OL, Fig. 3.9-1.]

system is about 92 km (57 mi); the associated corridors include about 367 ha (906 acres).

4.3 PROJECT-RELATED ENVIRONMENTAL DESCRIPTIONS

4.3.1 Hydrology

4.3.1.1 Surface Water

The surface water descriptions presented in Section 2.5 of the FES-CP are still valid with the additions and discussions below. In addition, Section 5.3.3 of this report contains a discussion of the hydrologic effects of alterations in the floodplain as required by Executive Order 11988-Floodplain Management.

Runoff for the Clinton Lake watershed was estimated using discharge data collected at the USGS gaging station near Rowell, 19 km (12 mi) downstream of the Clinton Lake dam. The drainage area monitored at Rowell is 866 km^2 (334 mi^2). The discharges of Salt Creek at the dam site were derived by multiplying the recorded discharges at Rowell by the drainage area ratio 296/334 = 0.886. A 33-year period of record, 1942-1975, was used in runoff calculations for Clinton Lake.

Derived discharge data for Salt Creek at the main dam site are shown in Table 4.3. The maximum flood of record at Rowell, which occurred on May 16, 1968, produced an estimated peak discharge of 612 m^3/s (21,600 cfs) at the main dam. Such a flood has an estimated recurrence interval of about 60 years. Floods greater than 283 m^3/s (10,000 cfs) at Rowell (estimated recurrence interval of 10 years) were recorded in 1943, 1956, 1961, 1964, and 1968.

Table 4.3. Derived Discharge Data for Salt Creek at Dam Site

Discharge	Magnitude
Mean annual	6 m^3/s (212 ft^3/s)
Highest mean monthly (April)	13 m^3/s (461 ft^3/s)
Lowest mean monthly (September)	0.9 m^3/s (32 ft^3/s)
Maximum peak	612 m^3/s (21,600 ft^3/s)
Minimum low	17 L/s (0.6 ft^3/s)

The minimum recorded flow at Rowell, observed on October 4, 1954, was 20 L/s (0.7 cfs), which has an estimated recurrence interval of 75 years. The drought which produced this record low flow occurred from 1952 to 1957. The corresponding minimum flow estimated at the main dam is 17 L/s (0.6 cfs). The estimated seven-day once-in-ten-years low flow for the Rowell gaging station is 76 L/s (2.7 cfs), which translates to approximately 68 L/s (2.4 cfs) at the main dam.

Because of the flood attenuation effect of the lake, the magnitude of flood flows downstream from the dam will be lower than under preconstruction conditions. Minimum flows downstream of the dam will be greater than the minimum flow of record because of a guaranteed minimum release from the cooling lake of 142 L/s (5 cfs).

Lake Clinton has a normal pool elevation of 690 ft above mean sea level which was reached on May 17, 1978, a surface area 19.8 km^2 (4895 acres), and a storage capacity of 9.15×10^7 m^3 (74,200 acre-ft) at normal pool elevation. The hydrologic analyses and hydraulic design for the main dam and the lake are based on a Probable Maximum Flood (PMF) condition with a Standard Project Flood (SPF) as an antecedent flood. The PMF water surface elevation in the lake at the dam site is estimated to be 708.8 ft.

A determination was made of the expected reduction in lake capacity due to sedimentation. A sedimentation rate of 240 $m^3/km^2/yr$ (0.5 acre-ft/mi^2/yr) was selected on the basis of data obtained from three sources: (1) turbidity measurements made during a six-year period, 1950 to 1956, at Rowell, (2) sedimentation surveys and studies conducted by the Illinois State Water Survey on 85 reservoirs in Illinois, and (3) turbidity measurements made on the site of Lake Clinton beginning in 1972. Using the selected sedimentation rate, the volume of sediment deposited in Lake Clinton at the end of 30 years would be about 5.5×10^6 m^3 (4450 acre-ft), or 6% of lake capacity at normal pool elevation. Such a loss in capacity should have no effect on normal station operations. Analyses made by the applicant regarding the effect of 50 years of sedimentation on lake flood levels showed no appreciable rise in water surface elevation in the upper reaches of the reservoir.

4.3.1.2 Groundwater

The principal source of potable groundwater in the region occurs in sand and gravel aquifers associated with glacial deposits. Glacial outwash deposits in the Mahomet bedrock valley are the primary source of municipal water in DeWitt County. Other aquifers in limited public and domestic use are sand and gravel lenses in the glacial till and alluvial deposits. The Pennsylvanian bedrock aquifer, underlying the glacial drift, is not generally used as a water source because of the greater accessibility of glacially deposited aquifers.

The Mahomet valley aquifer is as much as 46 m (150 ft) thick and overlain by approximately 61 m (200 ft) of relatively impervious clayey tills. Water from this aquifer will not be used by the station, as stated in construction phase reports, due to its high methane content (see Sec. 4.2.3).

Local groundwater levels range in elevation from stream level in the valleys to 3 to 12 m (10 to 40 ft) below the surface in the uplands between streams. Regional groundwater movement is westward toward the Illinois River at a gradient of 0.04% to 0.06% [0.4 to 0.6 m/km (2 to 3 ft/mi)] locally steeper gradients occur near stream valleys.

High groundwater levels occur in the upland areas that are poorly drained. The limited permeability of the subsoil, the poor natural drainage, and the subsequent high groundwater levels contribute to a considerable drainage problem in the agricultural uplands. Much of the agricultural land is drained artifically by tile and ditch, some of which discharge into Salt Creek.

4.3.2 Water Quality

4.3.2.1 Surface Water

The staff has performed an analysis of the new monitoring data provided in the ER-OL (Secs. 2.2.2.1 and 2.4.1.6) on water quality in Salt Creek, the North Fork of Salt Creek, and Lake Clinton--during and after lake filling. The applicant's preoperational monitoring program was begun in May 1974 and performed on a quarterly basis through September 1975 at four locations: the North Fork, about 13 km (8 mi) upstream of the confluence of Salt Creek and the North Fork; on the Salt Creek about 19 km (12 mi) upstream of the confluence; and two locations [6 km (4 mi) and 11 km (7 mi)] downstream of the confluence. Frequency of monitoring was increased at the above locations to monthly sampling in October 1975. When the main dam was closed in November 1977, the monitoring program was expanded to include five additional sampling locations: two on Salt Creek, 27 km (17 mi) and 26 km (16 mi) upstream of the original confluence; and three in Lake Clinton, one at the point where the discharge flume enters the lake, one near the intake structure, and one in the deepest portion of the lake near the original confluence (ER-OL, Sec. 6.1). The chemical and bacteriological constituents measured during the preoperational monitoring program are listed in Table 4.4.

Table 4.4. Chemical and Bacteriological Constituents Measured during Preoperational Environmental Monitoring†1

<u>General Water Quality Parameters</u>	<u>Nutrients</u>
Alkalinity, total	Ammonia
Chlorine, total	Biochemical oxygen demand (5-day)
Conductance, specific	Nitrate
Oxygen, dissolved	Organic carbon, total
Oxygen, saturation	Organic nitrogen, total
pH	Orthophosphate, soluble
Temperature	Phosphorous, total
Total dissolved solids	Silica, soluble
Total suspended solids	
Turbidity	<u>Trace Metals</u>
	Copper
<u>Sacteriological</u>	Lead
Bacteria, fecal coliform	Mercury
Bacteria, fecal streptococci	Zinc

†1 From ER-OL, Table 6.1-1.

Some changes in water quality were observed from the data reported in the FES-CP (Sec. 2.5.3), primarily due to point sources of domestic waste, nonpoint sources of agricultural runoff, and filling of Lake Clinton. The concentrations of aquatic nutrients and bacteria were often quite high. The range of total phosphorous concentrations often exceeded the standard of the Illinois Pollution Control Board (0.05 mg/L), and ranged from 0.02 to 0.6 mg/L in upstream Salt Creek; 0.04 to 0.33 mg/L in the upstream North Fork; 0.015 to 0.12 mg/L in Lake Clinton; and 0.06 to 0.6 mg/L in downstream Salt Creek. Fecal coliform colonies or counts (FC), which were not reported in the FES-CP, frequently exceeded the Illinois standard (400 FC/100 mL), and ranged from 130 to 150,000 FC/100 mL in upstream Salt Creek, 240 to 10,000 FC/100 mL in upstream North Fork, 0 to 1600 FC/100 mL in Lake Clinton, and 0-4700 FC/100 mL in downstream Salt Creek. Dissolved oxygen levels followed natural seasonal trends and generally met the minimum specified level of 5.0 mg/L. Concentrations of trace metals monitored were below their respective Illinois standards.

Because of the potential for the establishment of encephalitic human pathogenic amoebae in Lake Clinton (Sec. 4.3.4.2), and because the lake is used by the public for water contact recreation (Sec. 4.2.3), the staff recommends that monitoring for such amoebae be added to the existing monitoring program in accordance with recommendations of the Illinois Department of Public Health so that appropriate mitigation can be designed if the organisms are found.

4.3.2.2 Groundwater

Groundwater quality in the station vicinity has shown no appreciable change from that described at the construction-permit review stage, with the exception of groundwater in the buried Mahomet Bedrock Valley. In 1979, water containing a high methane concentration was obtained from a test well located about 1.5 km (1 mi) south of the station. As a result, all plant water needs will be supplied by surface water (ER-OL, Sec. 2.4.2 and Table 2.4-16).

4.3.3 Climatology and Air Quality

4.3.3.1 Climatology

The Clinton site in east-central Illinois is situated in a continental-type climate with marked annual temperature variation. Average minimum temperature in January is -8°C (18°F) while average maximum is 29°C (84°F) in July (Ref. 14). Extreme temperature values measured at Decatur, Illinois (Ref. 15), near the site, show a minimum of -26°C (-15°F) and a maximum of 45°C (113°F) through April 1975. Extremes observed onsite (Ref. 16) ranged from -28.8°C (-20°F) to 35.2°C (95°F). Mean annual precipitation in the area is about 940 mm (37 in), with normal monthly precipitation that varies from 53 to 123 mm (2.1 to 4.8 in). The larger amounts occur from April through June. Snowfall has been observed from November through April and for the winter season averaged 534 mm (21 in) for the period 1950-1974.

Thunderstorms and tornadoes are observed in the site vicinity and thunderstorm days averaged about 50 per year (Ref. 16). The thunderstorms generally result either from the passage of frontal systems over the area or from warm unstable air transported into the area from the Gulf of Mexico during the summer. Tornadoes, which can occur with the more vigorous thunderstorms, have been reported in Illinois 404 times during 1953-1971 (Ref. 17). Thus an average of 21 tornadoes per year can be expected statewide. Maximum wind speed observed in the region through 1976 at Springfield, Illinois (Ref. 18), was 120 km/hr (74 mph). Average monthly wind speed is approximately 18 km/hr (11 mph) in the region, with the prevailing winds from the south to the south-southwest directions most of the year. However, during January through March, northwest winds prevail. Onsite winds measured at the 10-m (33-ft) level during 1972-1977 are shown in Figure 4.3 and reflect the general wind flow typical for the region.

Diffusion characteristics in the site vicinity can be represented by average mixing height conditions as described by Holzworth (Ref. 19) for Peoria, Illinois (Table 4.5). The mixing height has diurnal and seasonal variation, with best conditions observed in the summer afternoon and less favorable conditions in the summer morning.

Table 4.5. Peoria, Illinois, Mixing Heights (meters)

Season	Winter	Spring	Summer	Autumn	Annual
Morning	392	431	305	321	362
Afternoon	594	1433	1532	1104	1168

4.3.3.2 Air Quality

This section provides a discussion of air quality not previously presented in the FES-CP.

Air quality data are not collected in the site vicinity, but are collected at five Illinois air pollution monitoring stations in the region: Bloomington, 40 km (25 mi) north of the site; Champaign, 53 km (33 mi) to the east; Decatur, 32 km (20 mi) to the south; Springfield, 76 km (47 mi) to the southwest; and Peoria, 82 km (51 mi) to the northwest (ER-OL, Fig. 2.3-14).

Annual summaries of air quality data collected at these five locations since the FES-CP was issued are available in References 20,21, for five atmospheric pollutants for which National Ambient Air Quality Standards (NAAQS) have been set--total suspended particulates (TSP), sulfur dioxide (SO_2), carbon monoxide (CO), oxidants/ozone (as ozone, O_3), and nitrogen dioxide (NO_2). These data indicate that air quality at the monitoring stations is in compliance with NAAQS for SO_2, CO, and NO_2. For ozone, the Illinois hourly standard (0.008 ppm) is frequently exceeded; however, the Federal NAAQS (0.12 ppm) is never exceeded. Peoria and Decatur are in violation of the annual NAAQS for TSP, and the 24-hour NAAQS for TSP is occasionally violated at all sites except Champaign.

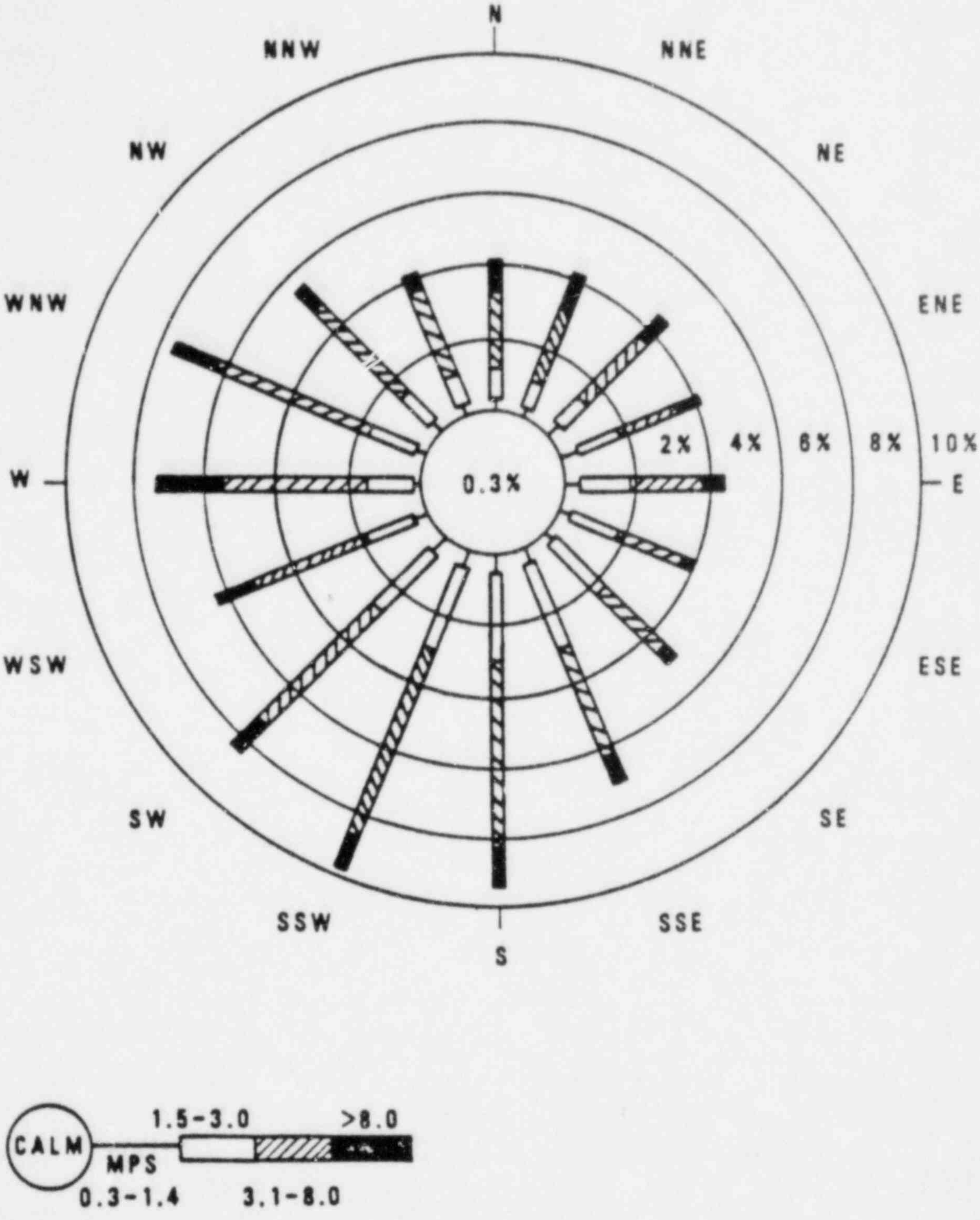

Figure 4.3. Wind Rose, 10-Meter Level, Clinton Station Site, Period of Record. [From ER-OL, Fig. 2.3-1.]

4.3.4 Ecology

4.3.4.1 Terrestrial

Station

Staff analysis of monitoring data acquired by the applicant since the issuance of the FES-CP (ER-OL, Sec. 2.2.1) indicates that the terrestrial biotic description of the site as presented in the FES-CP (Sec. 2.7.1) remains generally valid.

The applicant has implemented staff recommendations presented in the FES-CP (Sec. 4.3.1), especially with respect to the planting of native grasses on former cropped lands adjacent to the lake, and establishing tree plantings of diverse composition. A prairie remnant east of the North Fork has been expanded by planting appropriate grasses and forbs in an adjacent field (ER-OL, Sec. 4.5.3). The area, named Silphium Prairie, was developed in lieu of the Tall Grass Prairie restoration program originally proposed (FES-CP, Sec. 4.3.1). In general, wildlife breeding, nesting, and forage habitats have been developed or enhanced wherever feasible. In their management of the lands leased to the State of Illinois, the Department of Conservation includes specific measures relative to management of recreation activities and wildlife (ER-OL, Response to Question 290.4).

Transmission System

The general characterization of terrestrial habitat under the original Route B as described in the FES-CP (Sec. 3.8) remains valid for the terrestrial habitat under the replacement Route I (ER-OL, Sec. 3.6).

4.3.4.2 Aquatic

The description of Lake Clinton design provided in Section 3.4.2 of the FES-CP remains basically valid. Review by the staff of preoperational monitoring data (ER-OL, Sec. 2.2.2, and Sec. 4.4 of Ref. 8) indicates that the biotic community of the lake is developing as predicted in the FES-CP (Sec. 4.3.2). The following discussion is provided as a brief supplement to the information presented in the FES-CP. More detailed information, including information about the size, relative numbers, and location preference of 42 species of fish, is given in Reference 8.

Much of the lake basin was cleared prior to impoundment, and thus, the lake bottom consists principally of fine silt, the basic surface soil of central Illinois (Ref. 8). Brushy areas are generally confined to coves that were left undisturbed and the upper reaches of each arm of the reservoir. Weedy areas are scattered throughout the shallow sections of the lake, but beginning in 1980 and during 1981 major portions of these weedy areas receded naturally and no longer exist. Even with this reduction of weedy areas, the bushy areas in the lake provide preferred habitat for several fish species, and thermal refuges will be available for the maintenance of fish populations during periods of maximum thermal discharge from the station (Sec. 5.5.2.3).

The dominant species presently are gizzard shad, carp, largemouth bass, bluegill, and green sunfish. A stocking program to maintain the recreational fishery in the lake has been established under the management of IDOC, subject to the approval of the applicant. Based on studies at other cooling lakes, self-sustaining populations of several native game species should become established in Lake Clinton. Stocked experimental game species include the tiger musky (northern pike × muskellunge), walleye, and the striped bass × white bass hybrid. Since these hybrid species are infertile and natural reproduction is not expected to maintain the walleye population, the experimental game species may be restocked, depending on the outcome of their introduction into the cooling lake. The threadfin shad is also being stocked to provide additional forage fish. The shad will be restocked only when it does not successfully overwinter (Ref. 8).

There is a potential for establishment of the Asiatic clam (Corbicula fluminea) in Lake Clinton. This exotic species has extended its range well into the Midwest (Ref. 22), and has been known to block power-plant condenser tubes by entering the cribhouse as juveniles and maturing in the cribhouse. Chemical treatment may be required to prevent the small clams from reaching a size large enough to plug condenser tubes (Ref. 7).

The staff also believes that there is the potential for the establishment of encephalitic human pathogenic amoebae such as Naegleria fowleri in Lake Clinton after power production begins. Such organisms are known to have become established in other thermally altered power-plant lakes in Illinois (Ref. 30).

4.3.5 Endangered and Threatened Species

The U.S. Department of the Interior, Fish and Wildlife Service, has stated (Appendix H) that two endangered species may occur in the vicinity of the site--the bald eagle (Haliaeetus leucocephalus) and the Indiana bat (Myotis sodalis). Only the bald eagle has been observed at the site during the applicant's site-monitoring program. This species has been sighted at Lake Clinton several times since 1978, especially during the winter (Ref. 23).

The Fish and Wildlife Service stated that the Indiana bat may occur in the vicinity of Lake Clinton because the riparian timber area is good habitat for this species (Appendix H). No individuals of this species were observed at the site during the applicant's monitoring; however, the monitoring programs (ER-OL, Sec. 6.1.4.3.2.) were not specifically designed to detect bats.

The staff has determined that sites used as hibernacula by Indiana bats are not reported to occur in DeWitt and contiguous counties (Ref. 24); however, populations are widely dispersed during the summer (Ref. 25). The staff is not aware of any field investigation conducted to survey bat populations at or near the Clinton site; thus, information for determining if, or the extent to which, the Indiana bat may frequent the area is not available. However, given that Indiana bats are present in the area, the staff does not foresee any reasonable circumstances whereby operation of Clinton Unit 1 and related activities would jeopardize the local population of bats.

Eight bird species listed under the Illinois Endangered Species Act of 1977 (Ref. 26) as threatened or endangered have been seen at or near the site (ER-OL, Sec. 2.2.3). Six of these species are listed as endangered--the bald eagle, the marsh hawk (Circus cyaneus), the brown creeper (Certhia familiarus), the Cooper's hawk (Accipiter cooperii), the upland sandpiper (Bartramia longicauda), and the long-eared owl (Asio otus)--and two as threatened--the Bewick's wren (Thryomanes bewickii) and the veery (Catharus fuscescens). Presence of the river otter (listed by the state as threatened) was indicated by its track and slide near the site in February 1977 (ER-OL, Sec. 2.2.1.2.2). The applicant found no evidence of breeding populations of any of these species (ER-OL, Sec. 2.2.3.2). However, the staff does not consider the absence of breeding populations to be uniquely or equally indicative of the importance of onsite habitat resources to the various endangered and threatened species. Further, induced changes in the features of the site (e.g., tree plantings), as well as natural successional development, have and will continue to alter onsite habitat conditions. Such alterations may induce some of these species to reestablish local breeding populations.

The applicant has asserted that "no rare or endangered plant species were found" during vegetation surveys at the Clinton site, and that "no habitat type was found that was considered unique to central Illinois" (ER-OL, Sec. 2.2.1.1). However, the ginseng plant (Panax quinquefolius) is included in the applicant's inventory of plant species observed onsite (ER-OL, Table 2.2-67); this plant is designated as a threatened species in the "Illinois List of Endangered and Threatened Plants" that was formally adopted by the Department of Conservation on April 15, 1980. An appreciable number of plants, included in the applicant's inventory of observed species are incompletely identified, i.e., by the genus taxon only. In 17 of such instances, the state listing includes one or more species of these genera; thus, the ginseng may not be the only state-listed plant species occurring at the site.

There are no known federally listed endangered or threatened aquatic species in the vicinity of the site.

4.3.6 Historic and Prehistoric Sites

Section 2.3 for the FES-CP discusses historic and archeological sites. In this section it was stated that the National Register of Historic Places had no sites listed for DeWitt County. Since that time the C.H. Moore House located in Clinton has been listed in the National Register of Historic Places (Ref. 27). This section also mentioned plans to relocate Valley Mill, an old grist mill, to Clinton and the possible relocation of some iron bridges. The mill was unfortunately vandalized and burned before the relocation could take place. Ownership of the eight iron bridges was retained by the townships, with seven of the bridges being removed and either salvaged or disposed of. One bridge remains intact and continues in use in Harp Township. Section 2.3 refers to the 1973 survey made by the Illinois State Museum and discusses future work to be performed on some of the sites which were anticipated to be affected by construction activities. The survey selected 18 sites for more detailed description which were assigned a cultural affiliation.

Subsequently, subsurface testing was conducted on 10 of 11 sites which were expected to be inundated by the proposed Clinton reservoir. The testing revealed one site, designated as the Pabst site, to be significant (ER-OL, Appendix 2.6a). The site was nominated to the National Register of Historic Places and accepted on April 30, 1975. The Pabst site was later salvage excavated (ER-OL, Appendix 2.6b) under an August 1975 Memorandum of Agreement signed by the Advisory Council on Historic Preservation, the Illinois Historic Preservation Officer, and the Nuclear Regulatory Commission. The Pabst collections are curated by the Illinois State Museum.

Six of the 18 sites described in the 1973 report remain essentially undisturbed on the station property. The sites are not located within the area of environmental impact related to the normal operation of the station, to planned recreational activities, or to any identified future construction activities on the station site. Site ISM DWV95, formerly a cultivated field, is located in the immediate vicinity of a transmission line. Normal inspection of transmission lines will utilize aircraft with foot patrols being conducted only in extraordinary circumstances.

4.3.7 Community Characteristics

The general socioeconomic characteristics of the region, including demography and land use, are presented in Section 2 of the FES-CP. As indicated in the FES-CP, the plant is located in central Illinois in DeWitt County about midway between the cities of Lincoln, 43.6 km (27.1 mi) to the west; Champaign, 48.1 km (29.9 mi) to the east; Bloomington, 36.5 km (22.7 mi) to the north; and Decatur, 36.0 km (22.4 mi) to the south.

DeWitt County is basically agricultural with about 95% of the county being in farms. Industry is located mostly in the two largest cities of the county, which are Clinton (1980 population 8014), 9.7 km (6 mi) west of the site, and Farmer City (1980 population 2252) about 17.7 km (11 mi) northeast of the site. Some businesses such as small commercial centers and grain storage are located in smaller communities. DeWitt County grew by a total of 1133 persons from 1970 to 1980 from 16,975 to 18,108 persons, with Clinton accounting for 372 persons of the total increase.

Most of the 16-km (10-mi) area surrounding the site is rural and in addition to Clinton includes DeWitt, Weldon, and Wapella. The 1970 total population within 16 km (10 mi) of the site is estimated to be 13,143 persons and 12,976 persons in 1980, with the population in 2020 estimated to be 18,608 persons (ER-OL, Fig. 2.1-12).

The County Board of DeWitt County intends to control future growth. In a recently passed resolution the County Board instructed the DeWitt County Regional Planning Commission that its revision of the Comprehensive Plan and Zoning Ordinance should adhere to the priorities of maintaining and preserving all of the agricultural lands of the County, and to control the growth and development so as to avoid the admixture of urban and rural uses in the county, while preserving property values (Ref. 28).

References for Section 4

1. V.L. Snoeyink and D. Jenkens, "Water Chemistry," John Wiley & Sons, 1980.

2. S.D. Faust and J.V. Hunter (eds.), "Principles and Applications of Water Chemistry," John Wiley & Sons, 1967.

3. J.D. Johnson (ed.), "Disinfection," Ann Arbor Science, 1975.

4. V.L. Snoeyink and F.I. Markus, "Chlorine Residuals in Treated Effluents," Report prepared for Illinois Institute for Environmental Quality, Urbana, Illinois, 1973.

5. V.L. Snoeyink and F.I. Markus, "Chlorine Residuals in Treated Effluents," in Water and Sewage Works 122:35-38, 1974.

6. J.D. Johnson, "Measurement and Persistence of Chlorine Residuals in Natural Waters," in Water Chlorination: Environmental Impact and Health Effects, Vol. 1, R.L. Jolley (ed.), Ann Arbor Science, 1978.

7. J.A. Smithson, "Control and Treatment of Asiatic Clams in Power Plant Intakes," Presented at 43rd Annual Meeting of the American Power Conference, April 27-29, 1981.

8. "Thermal Demonstration Pursuant to Illinois Pollution Control Board Rules and Regulations, Chapter 3, Section 203 i (10)," prepared by Energy Impact Asociates, Pittsburgh, for Illinois Power Company, July 1980.

9. Letter from G.E. Wuller, Illinois Power Company, to J.R. Miller, U.S. Nuclear Regulatory Commission, October 9, 1981.

10. G.H. Jirka, M. Watanabe, K.H. Octavio, C.F. Cerco, and D.R.F. Harleman, "Mathematical Predictive Models for Cooling Lakes and Ponds, Part A: Model Development and Design Considerations," Technical Report No. 238, R.M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology, Cambridge, December 1978.

11. K.H. Octavio, M. Watanabe, E.E. Adams, K.R. Helfrich, and D.R.F. Harleman, "Mathematical Predictive Models for Cooling Ponds and Lakes, Part B: User's Manual and Application of MITEMP; Part C: Transient Analytical Model for Shallow Cooling Ponds," Technical Report No. 262, R. M. Parsons Laboratory for Water Resources and Hydrodynamics, Cambridge, April 1980.

12. "Local Climatological Data, Springfield, Illinois," U.S. Department of Commerce, 1955.

13. "Wastewater Engineering: Collection, Treatment, Disposal," Metcalf & Eddy, Inc., McGraw-Hill, New York, 1972.

14. "Climatography of the United States No. 20: Climate of Urbana, Illinois," National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, Asheville, NC, April 1975.

15. "Climate of Decatur Illinois," National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, NC, April 1975.

16. "Clinton Power Station, Final Safety Analysis Report," Section 2.3, August 1980.

17. V.A. Ruffner and F.E. Bair, "The Weather Almanac," Gale Research Co., Detroit, MI, 1974.

18. "Local Climatological Data, Springfield Illinois, 1976," National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, NC.

19. G.C. Holzworth, "Mixing Heights, Wind Speeds and Potential for Urban Air Pollution throughout the Contiguous United States," Environmental Protection Agency, Research Triangle Park, January 1972.

20. "Air Quality Data--1977 Annual Statistics," U.S. Environmental Protection Agency, EPA-450/2-28-004, Research Triangle Park, September 1978.

21. "Air Quality Data--1978 Annual Statistics," U.S. Environmental Protection Agency, EPA-450/5-79-037, Research Triangle Park, November 1979.

22. D.W. Aldridge and R.F. McMahon, "Growth, Fecundity, and Bioenergetics in a Natural Population of the Asiatic Freshwater Clam, Corbicula manilensis Phillipi, from North Central Texas," J. Moll. Stud. 44:49-70, 1978.

23. Letter from M.S. Pallo, Illinois Power, to J. Lehr, U.S. Nuclear Regulatory Commission, August 31, 1981.

24. D.W. Schafer and K.E. Robeck, "Threatened and Endangered Fish and Wildlife of the Midwest," ANL/EES-TM-101, Argonne National Laboratory, Argonne, IL, 1980.

25. S.R. Humphrey, A.R. Richter, and J.B. Cope, "Summer Habitat and Ecology of the Endangered Indiana Bat, Myotis sodalis," J. Mammology 58(3), 1977.

26. "Illinois List of Endangered and Threatened Species," Illinois Department of Conservation, April 1979.

27. "National Register of Historic Places," Federal Register, Vol. 45, No. 54, Part II, March 18, 1980, and subsequent listings.

28. County Board of DeWitt County, Illinois resolution passed April 14, 1981.

29. J. Cole, "Clinton Lake State Recreation Area, W-76-D. Wildlife Resources Management Plan," Illinois Department of Conservation, March 1981.

30. R.L. Tyndall, E. Willaert, and A.R. Stevens, "Pathogenic Amoebae in Power Plant Cooling Lakes," Electric Power Research Institute, EPRI EA-1897, June 1981.

5. ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 RÉSUMÉ

In the following sections the staff discusses and evaluates the environmental consequences and mitigating actions relative to aspects of station operation for which additional information is available or changes have occurred since the FES-CP review. The staff has evaluated one-unit operation instead of two-unit operation as was done in the FES-CP. Where there is no new information or changes that would affect impacts, no discussion is provided. In general no new significant impacts were identified.

The effect of a change in the routing of one transmission line and minor changes in land-use patterns on the applicant's property since the FES-CP was issued have been evaluated (Sec. 5.2). Surface-water-use impacts have been reevaluated for one-unit operation (Sec. 5.3.1). The staff has evaluated the changes in the amount and constituents of chemical effluents to the Lake Clinton and Salt Creek (Sec. 5.3.2.1). The staff has reevaluated the potential impacts of station thermal discharges on water quality (Sec. 5.3.2.2). The staff expects more severe steam-fog effects than predicted in the FES-CP (Sec. 5.4.1). The staff has reevaluated its findings of the FES-CP (Sec. 5.5.2) on the impacts on aquatic biota (Sec. 5.5.2). The staff has evaluated the impacts of the treatment of Asiatic clams (Sec. 5.5.2). The staff has evaluated the impacts to historic and prehistoric sites (Sec. 5.7). The staff has evaluated the socioeconomic impacts of the station's operation, including a discussion of the potential public health impacts of encephalitic amoebae, if they become established in the lake (Sec. 5.8). The staff presents estimates of offsite and occupational radiation exposures from the operation of Clinton Unit 1 and the associated fuel cycle (Secs. 5.9 and 5.10).

5.2 LAND USE

Changes that have occurred since publication of the FES-CP include a reduction of total station site area from 6160 ha (15,210 acres) to 5703 ha (14,092 acres). Fewer station structures were built as a result of the decision to delay construction of Unit 2.

The discussions in the FES-CP (Secs. 5.1, 5.5, and 5.6) concerning impacts on land use remain valid. Neither the operation of the station, alterations in routing of one of the station's transmission lines (Sec. 4.2.7), nor operation of the transmission system is expected to alter the evaluation of impacts on land use as stated in the FES-CP (Sec. 5.1.2). The staff considers that the currently proposed land use for the operation period of the station is a suitable alternative to uses projected in the FES-CP.

The development of the 27-ha (66-acre) Silphium Prairie (Sec. 4.2.2) in lieu of the 890-ha (2200-acre) Tall Grass Prairie restoration project originally proposed in the ER-CP (Sec. 4.3.1) has resulted in a greater portion of the project site being retained in agricultural use. Barring future land-use changes, about 590 ha (1450 acres) of the site, including 504 ha (1246 acres) of prime farmland, will be available for agricultural use throughout the operational life of the station. The applicant's upgrading of drainage conditions in areas adjacent to Salt Creek immediately upstream from Lake Clinton has contributed to maintaining local agricultural productivity by alleviating potential flooding of farmland (Sec. 4.3.1).

5.3 WATER

5.3.1 Use

5.3.1.1 Surface Water

The primary water-use impacts from station operation will be reduced downstream flow in Salt Creek and drawdown of the cooling lake. The applicant has estimated the average forced evaporation from Lake Clinton based on a 70% load factor on Unit 1 to be about 9.37×10^6 m^3 (7600 acre-ft) per year. Natural evaporation will be approximately double that, or about 17.9×10^6 m^3 (14,500 acre-ft) per year. The combined evaporative losses for one-unit operation would be about 13% of Lake Clinton's annual average inflow of 204×10^6 m^3 (165,000 acre-ft). According to the applicant's calculations, flows during the months of August through October will be the most significantly affected, with flows from Lake Clinton being less than one-half the natural flow in Salt Creek. During an average year, for one-unit operation, the September flow in Salt Creek downstream of Lake Clinton will be somewhat greater than the minimum reservoir release of 142 L/s (5 cfs) which was indicated by the applicant for two-unit operation, but significantly less than the preconstruction average September flow of 909 L/s (32 cfs).

There are no known surface water users on Salt Creek, the Sangamon River, or the Illinois River downstream of the station that could be adversely affected by the reduced flows from Lake Clinton. During years of normal precipitation there may be a minor impact on recreation in the lower reaches of Salt Creek. However, during extreme drought years the net impact of station operation may be positive because the 142 L/s (5 cfs) guaranteed minimum discharge from the lake will be greater then the expected natural flow.

A design drought with a 100-year recurrence interval was used in the applicant's analysis of minimum water level in the cooling lake. The minimum water level obtained for the once-in-100-year drought (with a duration up to 60 months) is elevation 682.3 ft MSL, almost 8 ft below the normal lake elevation of 690 ft. The lowest reservoir level for station operation is elevation 677 ft MSL. Were the reservoir to reach this elevation, the station would be shut down, using the submerged reservoir (the ultimate heat sink) to supply cooling water.

5.3.1.2 Groundwater

Groundwater will not be used during station operation except at the Visitor Center and in recreational areas. Use at this facility is minimal and will have no impacts on offsite users.

5.3.2 Quality

5.3.2.1 Chemical

Surface Water

During plant operation, concentrations of dissolved substances in Lake Clinton and Salt Creek will be greater than those observed prior to plant construction and during lake filling. The major part of this increase will be due to evaporation of water from plant heat dissipation (Sec. 5.3.3), as well as the addition of plant operation wastes to the lake (Sec. 4.2.6.1). However, these effects will be less than predicted in the FES-CP (Sec. 5.5.2.4) because only one unit will be operating. In addition, all plant wastewater will be treated to ensure that it will meet effluent limitations listed in the station's NPDES permit (Appendix B). A detailed description of the quality of the station effluent prior to discharge into Lake Clinton and the resulting effect on the water quality of the lake is given in Table 5-1.

The daily maximum limit for the total residual chlorine (TRC) concentrations during chlorination at the discharge from the flume as stipulated in the original NPDES permit is 0.2 mg/L. The effects of one-unit operation are discussed in Section 4.2.6.1. The free available chlorine residual is expected by the applicant to be reduced to about 0.1 mg/L at the condenser outlet because of reaction with reducing- and chlorine-demanding substances. The staff concurs with this estimate. The staff expects that the TRC concentration will be 0.3 mg/L at the condenser outlet and will be further reduced during the 3.9-hour transit period from the condenser outlet to the discharge into Lake Clinton. In addition, TRC will be monitored during chlorination to comply with the proposed conditions of the NPDES permit. Thus, the staff expects that the TRC limitation given in the NPDES permit will be met.

As described in Section 4.2.6.1, condenser cleaning is expected to occur every five to seven years. The effluent from condenser cleaning must meet NPDES and Illinois Water Quality Standards following treatment and prior to discharge into Lake Clinton. The staff notes that use of phosphoric acid for condenser cleaning may infrequently result in high concentrations of total phosphorous in the lake if discharged without prior treatment. If the maximum concentration of phosphoric acid is used during condenser cleaning, the volume of water in the discharge flume may not be sufficient to dilute the amount of total phosphorous to a level that would meet NPDES limitations (1.0 mg/L). Phosphorous is essential to the growth of aquatic organisms and can be the nutrient that limits the productivity of a body of water. In instances where phosphate is the growth-limiting nutrient, the discharge of wastewater containing phosphorous to a receiving water may stimulate the growth, in nuisance quantities, of photosynthetic aquatic organisms (Refs. 1-3). Thus, in order to reduce phosphorous to acceptable levels following condenser cleaning, chemical treatment, such as coagulation with alum and/or lime, may be necessary (Refs. 4,5).

The sanitary waste treatment system, described in Section 4.2.6.3, will reduce levels of BOD_5 and total suspended solids to meet limitations given in the NPDES permit. The staff considers the potential levels of bacterial contamination from the station's sanitary waste effluent to be minimal because of disinfection during the sanitary waste treatment process (ER-OL, Sec. 3.7). As described in Section 4.3.2.1, coliform bacteria counts in excess of the

Table 5.1. Estimated Composition of Waste Stream Leaving the Wastewater Treatment Ponds and Applicable Limitations

Parameter	Effluents from Waste-Water Treatment Ponds[a]	NPDES Effluent Limitations (ppm)	State Effluent Limitations (ppm)	State Water Quality Limit (ppm)
Flow (gal/day)	92,423	--		
Calcium (as Ca)	162 ppm			
Phosphorus (as P)		1.0	1.0[c]	0.05[c]
Magnesium (as Mg)	182 ppm	--		
Sodium (as Na)	457 ppm	--		
M.O. Alkalinity (as $CaCO_3$)	308 ppm	--		
P. Alkalinity (as $CaCO_3$)	~0 ppm	--		
Chloride (as Cl)	300 ppm	--		500
Sulfate (as SO_4)	1,564 ppm	--		500
Nitrate (as N)	27 ppm	--		10 (Drinking Water Only)
Silica (as SiO_2)	36 ppm	--		
TSS	20 to 50[b] ppm	15 Maximum	15	
BOD-5		5 Average	30	
TDS	2,800 ppm	--	3500; Δ750	1,000
pH	7-8	6-9	5-10	6.5-9.0 except for natural causes
Oil and Grease	15 ppm	15 Maximum	75 Maximum 30 Daily Average 15 Monthly Average	None Visible
Iron, Total (as Fe)		1.0	2.0	1.0
Copper, Total (as Cu)		1.0	1.0	0.02
Zinc, Total (as Zn)		1.0	1.0	1.0

[a]Figures reflect pretreatment flow rate at design capacity of 500 gpm, once a day backwashing of sand filters and carbon purifiers, and an average regeneration of one primary demineralizer train per day.

[b]Approximated values, since no data are available to permit calculation of these values. Settling pond effluent will be routed to a waste filter house for further reduction of TSS to ensure compliance with applicable limitations.

[c]Water quality limit in lakes and streams at point of entry into lakes; effluent limitations on large discharge to lakes and tributaries thereto.

From ER-OL, Table 3.6-5.

Illinois standard were frequently observed in Lake Clinton and Salt Creek, presumably from domestic and agricultural wastes.

Groundwater

As discussed in Section 4.2.6.1, the low permeability of the soil beneath the wastewater treatment ponds will inhibit the migration of pollutants to the groundwater. The staff expects that the impact on groundwater quality due to leaching from the pond will be minimal. However, there are at least 137 private, shallow wells within 8 km (5 mi) of the site for domestic use and livestock watering and 36 known active and inactive wells on the station property. To ensure that groundwater in the upper glacial tills does not become contaminated, the applicant shall continue monitoring groundwater on the site. Should mitigation become necessary, such as the installation of a liner beneath the sedimentation ponds, it shall be instituted in a timely manner.

5.3.2.2 Thermal

In 1980, the applicant submitted a proposal for an alternative thermal effluent limitation for one-unit operation for consideration by the Illinois Pollution Control Board (IPCB) based on the applicant's updated thermal demonstration and on available biological data (Ref. 6). The request was granted by IPCB in its Order PCB 81-82 (May 28, 1981). The limitation specifies that the daily average temperature of water discharged to Lake Clinton shall not exceed 37.2°C (99.0°F) during more than 12% of the hours in 12-month periods ending with any month and shall at no time exceed 42.4°C (108.3°F). Based on the results of the thermal analyses presented in Section 4.2.6.2, the staff believes that the operation of Unit 1 at 100% load factor (plant factor) would yield discharge temperatures exceeding the maximum limitation of 42.4°C (108.3°F) under 1955 conditions. The staff has subsequently determined, based on thermal modeling results, that under 1955 meteorological conditions (1-in-50-year drought), Unit 1 would have to be operated at reduced power (78%) for several days during the summer in order to meet the IPCB thermal standards.

It is specified in the water quality standards of Illinois (Ref. 7) that the maximum summer water temperatures released to Salt Creek should not exceed 32.2°C (90°F) for more than 1% of the time and by no more than 1.7C° (3F°). The staff's predicted temperature results (Sec. 4.2.6.2) show that under the worst-case scenario, the discharge temperatures to Salt Creek would exceed the 32.2°C (90°F) limit by less than 1.7C° (3F°) and only for 0.3% of the time.

5.3.3 Hydrologic Alterations and Floodplain Effects

5.3.3.1 Hydrologic Alterations

The principal hydrologic alterations related to the construction of Clinton Power Station include the creation of Lake Clinton and the concomitant rise in groundwater levels, the resulting change in the flood-handling capability of the floodplain, the sealing of private wells on site property, and the channelization of Trenkle Slough. Discussions of the construction-impact control program (ER-OL, Sec. 4.5) and the flood-handling capability of the floodplain were not included in the FES-CP and thus are presented in this section. Other hydrological impacts resulting from construction were evaluated in the FES-CP and are therefore not discussed herein.

Hydrological-related activities within the construction-impact control program included programs for erosion, rainfall runoff, channelization of Trenkle Slough, and groundwater. The applicant states that erosion control checklists were completed weekly during lake clearing and initial station construction work. Rainfall-runoff control consisted of retention ponds, which served as stilling basins, and a belt of vegetation which filtered water flowing from the site clearing area to the creek bed. Channelization of Trenkle Slough and a portion of Salt Creek upstream of the lake, discussed in Section 5.3.3.2, was required to provide adequate drainage of the Trenkle Slough Drainage District. The work was performed under the U.S. Army Corps of Engineers' 404 permit and an agreement between the applicant, the U.S. Fish and Wildlife Service, and the Illinois Department of Conservation. Groundwater control included well filling to prevent possible contamination, and monitoring of groundwater levels at the dam and around the lake.

Impoundment of the cooling lake caused a change in the local base level for groundwater flow and therefore a change in the hydraulic gradient at the site. No further significant changes of this type are expected due to plant operation because the water level in the lake is only affected by natural causes and the need to maintain a minimum flow rate in Salt Creek.

5.3.3.2 Floodplain Effects

Construction of the main dam for Lake Clinton, which significantly altered the floodplain aspects of the Clinton site, had already begun at the time Executive Order 11988, Floodplain Management, was signed in May 1977. It is therefore the staff's conclusion that considerations of alternatives to the modification of Salt Creek as caused by the main dam is neither required nor practicable.

The following paragraphs address the floodplain-related effects of the dam, which include a greatly increased 100-year floodplain on Salt Creek upstream of the dam and increased drainage time of agricultural lands adjacent to Trenkle Slough.

The 100-year (1% chance per year) flood-peak discharge on Salt Creek at the dam site before construction of the dam was estimated to be 747 m^3/s (26,400 cfs). The area above and immediately below the dam site along Salt Creek inundated by this flood is shown in Figure 5.1. The 100-year flood with the dam in place results in a spillway discharge of 329 m^3/s (11,610 cfs) and results in a water surface elevation in the lake of 697 ft MSL. The area inundated by the backwater effect of the 100-year flood at the dam along with the applicant's property boundary is shown in Figure 5.2. As shown, the 100-year flood boundary is within the applicant's property boundary. The 100-year flood flow downstream of the dam will be decreased below that of the flood occurring under natural conditions due to the flood-storage capacity within the lake.

Structures within the postconstruction 100-year floodplain include the intake and discharge structures, modified highway bridges, a marina, and seven boat ramps. The existence of these structures has an insignificant effect on the 100-year flood level within the lake and does not affect flood levels outside of the site property lines.

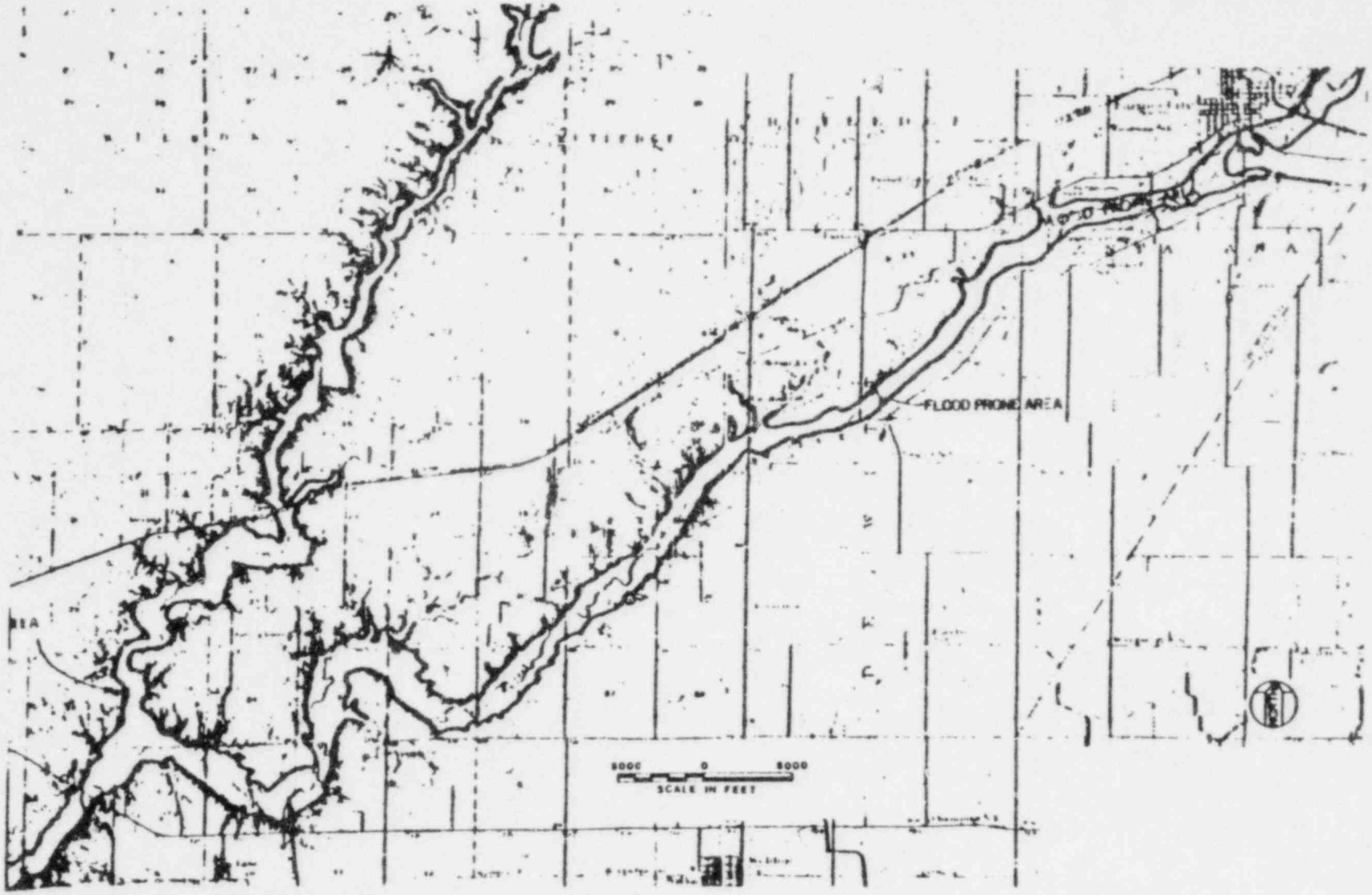

Figure 5.1. Preconstruction Flood-Prone Area. [From ER-OL, Supplement 1, Fig. 2.4-10A.]

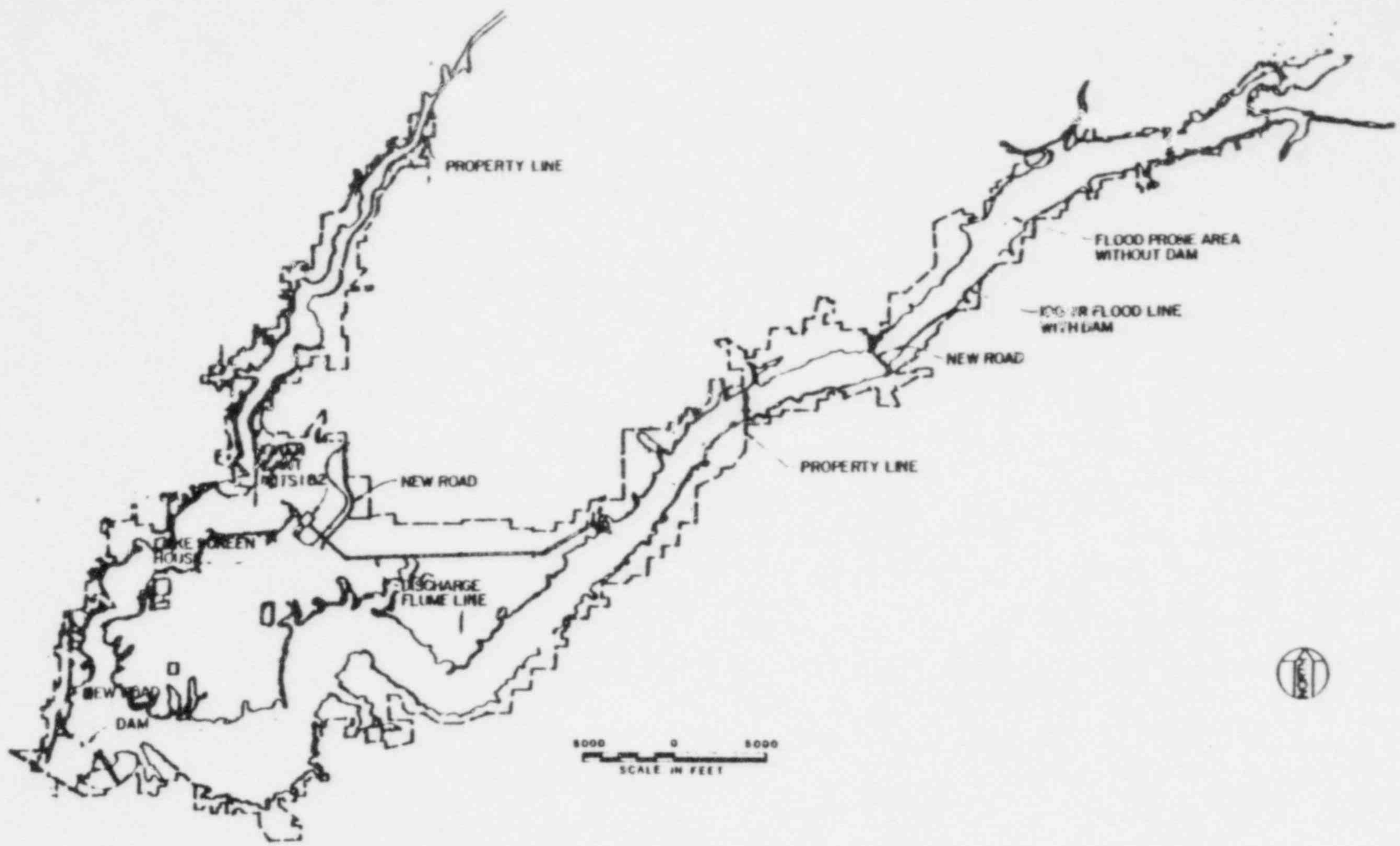

Figure 5.2. Flood-Prone Area with Dam in Place. [From ER-OL, Supplement 1, Fig. 2.4-10C.]

Portions of the intake and discharge structures are, by design, located below the 100-year flood levels. However, the plant has been designed to withstand the flooding effects of a Probable Maximum Flood (PMF) which reaches an elevation of 708.9 ft MSL. Safety-related equipment necessary to shut down the plant and maintain the plant in a shutdown condition are flood-protected up to elevation 730 ft MSL.

An effect of the alteration in the flooding characteristics of Salt Creek caused by the construction of the dam may be an increase in the recession time of Trenkle Slough during the 100-year flood event. An analysis by the applicant determined that the increase in recession time for the 100-year flood is about three days at the confluence of Trenkle Slough and Salt Creek and decreases to about seven hours 4.8 km (3 mi) upstream under natural conditions. The applicant has widened the Salt Creek channel from the mouth of Trenkle Slough to Iron Bridge, 0.8 km (0.5 mi) downstream to improve the drainage characteristics in the Trenkle Slough Drainage District and avoid adverse impacts on agricultural land drainage.

A recent study completed for the applicant has concluded that the channel improvements have significantly lowered flood levels in Salt Creek and in Trenkle Slough over the last two years. However, information supplied in regard to this study thus far by the applicant does not indicate any observed lowering of water levels during severe floods.

The staff concludes that the construction of the station will not have any significant adverse flood effects either upstream or downstream of the dam except for the possible reduction in the effectiveness of agricultural land drains in the Trenkle Slough Drainage District during major floods.

5.4 AIR QUALITY

5.4.1 Fog and Ice

The state-of-the-art in cooling-lake-plume modeling does not permit a very precise assessment of the fogging and icing impacts of the operation of the Clinton cooling lake (Refs. 8-10), but based on recent observations and research results (Refs. 8,11-17), the staff expects a more severe steam-fog effect and a somewhat greater hazard to local highway traffic near the lake than was predicted in the FES-CP (Sec. 5.3.5). Observations made at Dresden Nuclear Power Station near Morris, Illinois, and at other existing cooling lakes indicate that steam fog, under most weather conditions, is usually shallow, wispy, in turbulent motion, and does not penetrate inland more than 30 to 150 m (100 to 500 ft) before evaporating, thinning, or lifting to become stratus clouds. However, if the air is very cold [below -18°C (0°F) and the lake very warm [20 to 25°C (70 to 80°F)], the fog is very dense (Refs. 11-15). This type of fog can move inland as much as 1.6 to 3.2 km (1 to 2 mi) (Refs. 8,12,13,16); however, the restriction to visibility and icing effects in the fog zone decrease rapidly as the fog travels inland. Observations show that as they move inland, such fogs tend to evaporate, become thinner, or lift to become stratus clouds.

In subfreezing temperatures, thick deposits of light, friable rime ice form on elevated objects within the steam-fog zone. Thick deposits are generally limited to areas within 100 m (300 ft) of the lake. Because of the low weight and the crumbly nature of these ice accumulations, it causes little damage.

The staff expects that during very cold winter periods, lake-produced fog will at times reduce visibility on roads and bridges over and near the warmest part of the cooling lake. These include the bridges carrying County Route 14 (FES-CP; Fig. 4.2), a local road south of the lake (study area No. 2 in Fig. 4.5-1 of the ER-OL); Illinois Route 10 just south of the lake (FES-CP, Fig. 6.1); and perhaps Illinois Route 48 over the lake upstream of the discharge structure (FES-CP, Fig. 4.2). While steam fog does not cause icing on roads at ground level, rime ice falling from trees and poles along the edge of a road can reduce traction on the road surface.

Since the discharge canal is narrow and spray modules will not be utilized (see Sec. 4.2.4.2), the staff expects no offsite or highway impacts from this portion of the cooling system.

The staff recommends that the applicant initiate a fog-monitoring program for the highways and bridges in the area to determine the frequency and density of fogs that could produce highway-safety hazards and other problems. The staff suggests monitoring during one winter (November-March) after Unit 1 begins operation. This effort should be performed in cooperation with local highway safety officials.

The applicant has made a commitment to the Illinois Department of Transportation to minimize hazards to public use of bridges over and highways near the cooling reservoir [ER-OL, Response to Questions 451.2 and 451.3; and Illinois Power Co.'s Comment 32 on the DES (see Appendix A)]. If monitoring indicates that fog and/or ice will be a problem, the staff recommends that mitigative measures be taken, including installation of warning lights, signs, driver aids, and covered bridges.

5.4.2 Emissions and Dust

As indicated in Section 4.2.6, nonradioactive gaseous emissions released during routine station operation will be combustion products from testing of standby diesel generators and from operation of vehicles. Based on the amounts of pollutants expected to be released during testing of the generators (Sec. 4.2.6), the staff concludes that no violations of applicable air quality regulations will result. Combustion-product emissions from vehicles are also small, and thus are not expected by the staff to have any appreciable impact on air quality.

Fugitive dust can be minimized by paving (or wetting) roads and parking lots and by minimizing vehicle traffic on unpaved roads.

5.5 ECOLOGY

5.5.1 Terrestrial

5.5.1.1 Station

No adverse effects on the terrestrial environment are expected by the staff beyond those caused by construction, because no further destruction of habitat is expected, and terrestrial communities will adapt to the prevailing conditions.

As indicated in Section 5.4.1, during subfreezing temperatures, rime ice may form on vegetation in the steam-fog zone near the cooling lake; however, such ice is light and friable. For this reason, and those discussed in the FES-CP (Sec. 5.3.5.1), the staff concludes that this ice would rarely, if ever, cause appreciable damage to plants.

The staff agrees with the applicant (ER-OL, Sec. 6.1.6.7) that the terrestrial monitoring program, which was designed to monitor the wildlife and vegetation communities during the development phases of the site, has been adequately completed and should be terminated. No further substantial benefit can be realized by its continuation. Two monitoring programs related to the site have recently been initiated by outside agencies. The Illinois Natural History Survey conducts an in-season monthly aerial sightings of waterfowl on Lake Clinton (ER-OL, Sec. 6.3). The Illinois Department of Conservation will maintain records of population trends, derived from field surveys and hunter check station counts, of upland game species, deer, waterfowl, and furbearers (Ref. 18).

The use of Lake Clinton as a heat sink during station operation (Sec. 4.2.4.2) will essentially preclude ice formation on the lake during the winter. This condition will tend to delay fall migration of waterfowl and shorebirds, as well as encourage some species to overwinter in the area, thereby increasing competition for food resources. The Illinois Department of Conservation (IDOC) site management plan provides for augmenting the availability of plant foods for waterfowl by appropriate land-use practices. The heated condition of lake waters may also enhance the potential for development of waterfowl disease pathogens. The IODC is preparing contingency plans related to potential waterfowl disease problems at Lake Clinton. Accordingly, the staff has elected not to require monitoring for specific waterfowl diseases. However, in the event of a serious waterfowl disease outbreak or other significant adverse environmental impact related to wildlife, the applicant will be required to initiate actions as specified in Section 6.1 of this statement.

5.5.1.2 Transmission System

The staff expects effects on the terrestrial environment from the transmission of energy along the transmission lines and the maintenance of the transmission line rights-of-way (including periodic clearing of vegetation) to be minimal. The applicant has revised proposed use of herbicides for controlling woody vegetation within transmission line corridors since issuance of the FES-CP (ER-OL, Sec. 5.5.2). Current commitments by the applicant relative to use of herbicides are summarized as follows:

- Herbicides used for controlling woody vegetation shall be limited to those approved for such use by the U.S. Environmental Protection Agency.

- Applications of herbicides shall be limited to selective basal spraying.

- Use of herbicides shall be limited to one application per year.

- Herbicides shall not be applied during or after a heavy rain, and efforts should be made to avoid usage prior to expected rainfalls.

Herbicides of any kind shall not be applied in areas where contamination of water supplies is likely.

The staff regards the foregoing as fundamental guidelines for prudent herbicide usage, but also notes that herbicide applications in or immediate to intensive-use recreational sites and other areas of concentrated public use should be avoided.

Transmission facilities and other tall structures of the station will be hazards to species capable of flight, although the number of impingements will likely be relatively low. Clearances between energized and grounded components of the transmission facilities are such as to essentially preclude electrocution of birds. The applicant appears to have taken the necessary precautions by grounding all transmission towers, as well as fences, metal structures, and other fixed metal objects in transmission rights-of-way (ER-OL, Sec. 3.9.3, Appendix 39B). The staff has considered available information on transmission field effects (Refs. 19-22), including earlier staff analyses of the subject (Refs. 23,24) and concludes that operational hazards of high-voltage transmission lines (345 kV) are unlikely to have a measurable impact on terrestrial ecology.

5.5.2 Aquatic

In the following analysis, potential impacts on the aquatic ecosystem are evaluated on the basis of full-power one-unit operation instead of a two-unit operation as was done in the FES-CP (Sec. 5.5.2).

5.5.2.1 Impingement and Entrainment

In the FES-CP (Secs. 5.5.2.2 and 5.5.2.3), the staff concluded that minimal impact to the aquatic community of Clinton Lake would occur as a result of entrainment and impingement from two-unit operation. Since the volume of water withdrawn for one-unit operation will be proportionately less than for two-unit operation, it is the staff's conclusion that there will be no significant impact from impingement and entrainment losses during operation of Clinton 1. Additionally, impingement losses that will occur may be partially offset by stocking of forage and game fish if needed as part of the fishery management program on the lake. The shoreline location of the intake (ER-OL, Sec. 4.3.2) is also generally considered to be advantageous in minimizing impingement and entrainment in areas where there is relatively low fish abundance (Ref. 25). The number of fish that escape over the spillway may be appreciably greater than the number lost from the lake by impingment. For example, the Illinois Department of Conservation has estimated that more than 1000 striped bass × white bass hybrids escaped over the spillway in 1981. (The IDOC and the applicant plan to discuss the possibility of installing a spillway screen to alleviate such losses of fish from the lake.)

5.5.2.2 Chemical Discharges

As stated in Sections 4.2.6.1 and 4.3.4.2, sodium meta-bisulfite and hydrogen sulfite may be used on an intermittent basis to control the Asiatic clam population in the cribhouse (Ref. 26). Because the affected water will be treated to neutralize any remaining chemical residues to nontoxic sulfates prior to discharge, the staff believes that lake organisms in the discharge area will not be harmed by sodium meta-bisulfite and hydrogen sulfide residues.

As noted in Section 5.3.2, discharge of chemical effluents to Lake Clinton and to Salt Creek below the lake will be subject to conditions of the NPDES permit (Appendix B). The staff believes that adherence to the limits of the permit will protect lake and creek organisms. Elevated thermal conditions at the dam may cause downstream movement of some creek fish in warmer months and congregation of creek fish near the dam in cooler months. Lake discharge flow rates at the dam are required to be > 8 m^3/min (5 cfs). The IDOC recommends an increase in the minimum flow releases to 32 m^3/min (19 cfs) in order to minimize downstream fishery impacts, but this issue has not yet been clarified between the applicant and the IDOC. Required discharge flow rates will maintain more acceptable stream-flow conditions than existed prior to plant operation (i.e., 1 m^3/min, or 0.6 cfs, for 100-year, one-day low flow) (ER-CP, Sec. 3.3.6).

5.5.2.3 Thermal Discharges

In the FES-CP (Sec. 5.5.2.4.3) concern was expressed regarding impacts on Lake Clinton biota (especially fish) as a result of thermal discharges from two-unit operation. The applicant currently plans to operate one unit up to a load factor consistent with the thermal standards discussed in Section 4.2.6.2. In light of the changes in operating parameters, the staff has reviewed thermal tolerance levels required for survival, growth, spawning, and embryo survival of selected species that inhabit Lake Clinton. This information is summarized in Table 5.2 for species that generally dominate midwestern reservoirs (gizzard shad, bluegill, carp, and largemouth bass) and for species that are not well suited to reservoir conditions (black crappie, white crappie, and black bullhead).

During the warmest months (July through September) the water temperature in most of Lake Clinton will be at or below 32.2°C (90°F) (Sec. 4.2.6.2). Comparison with the data in Table 5.2 indicates that most of the lake will be well within the thermal tolerance for survival and at or below the thermal tolerance for growth for species adapted to reservoir conditions.

For extended adverse (hot) meteorological conditions, populations of such species as the crappie and black bullheads could be eliminated or greatly reduced during the summer months. However, ambient lake temperatures during severe meteorological conditions would limit available habitat within much of the lake for species that are thermally sensitive anyway (Fig. 6-10, Ref. 6). During other seasons beneficial impacts from thermal warming may occur; these include increased growth and earlier spawning. Although more thermally sensitive species may be adversely affected during hot weather, the ecological balance of the lake will not be affected. Thermally tolerant game species and the thermally tolerant golden shiner (Ref. 29) will fill the niche of the adult and juvenile crappies, respectively, and bottom feeders such as carp and channel catfish will functionally replace black bullheads (Ref. 6).

5.5.2.4 Reactor Shutdown

In the FES-CP (Sec. 5.5.2.5) the maximum lake cooling rate in the event of two-unit shutdown was estimated to be 0.3°C/hr (0.5°F/hr). The cooling-rate estimate for plant shutdown for a one-unit, full-power operation is expected to be less than that for two-unit operation.

Table 5.2. Summary of Criteria Temperatures (°C) for Fish Species Likely To Be in Lake Clinton when Operation Begins†[1]

Fish	STMT†[2] for Survival of Adults	MWAT†[3] for Growth
Bluegill	35.5	33
Largemouth bass	34.4	32.7
White crappie	31	28
Black crappie	31	27
Gizzard shad	35	-
Carp	34	32
Black bullhead	34	28
Channel catfish	35.8	32

†[1] Temperatures are U.S. EPA protocol as given in W.A. Brungs and B.R. Jones, "Temperature Criteria for Freshwater Fish: Protocol and Procedures," EPA-600/3-77-061, 1977.

†[2] STMT = Short-term maximum temperature.

†[3] MWAT = Maximum weekly average temperature.

The conclusions given in the FES-CP (Sec. 5.5.2.5) regarding minimal impact of reactor shutdown remain valid.

5.6 ENDANGERED AND THREATENED SPECIES

The staff expects that adverse impacts on endangered and threatened species resulting from operation of the Clinton Station and ancillary facilities will be minor. The vegetation within the transmission line rights-of-way will be controlled, but any further destruction of the potential habitat of endangered and threatened animals during station operation will likely be of minor consequence. Some state-listed plants may be adversely affected or destroyed during periodic maintenance of utility rights-of-way. Vehicular traffic directly and indirectly related to station operation may cause the maiming or death of a few animals on the endangered and threatened species lists. Transmission facilities and other tall structures of the station will be minor hazards to endangered and threatened species capable of flight, but the number of collisions will likely be relatively low. Clearances between energized and grounded components of transmission facilities essentially preclude electrocution of bald eagles. Other minor adverse effects are possible, and individual endangered or threatened plants and/or animals may be sacrificed; however, routine station operation and energy transmission, and the periodic maintenance of the Clinton Unit 1 facility are not expected to jeopardize populations of endangered and threatened plant and animal species.

5.7 HISTORIC AND PREHISTORIC SITES

The operation of the station is not expected to affect any cultural sites on or eligible for the National Register of Historic Places (see Sec. 4.3.6). While the staff believes that the possibility of any impact to ISM DWV95 is remote, in the event that a future major ground disturbance related to operation and maintenance of the transmission line is anticipated at this site, the applicant is required to seek consultation of the State Historic Preservation Office before taking action.

5.8 SOCIOECONOMICS

5.8.1 Community

Socioeconomic impacts of the Clinton Power Station's operation are discussed in Section 5.6 of the FES-CP. The socioeconomic effects are expected to be minimal with the exception of tax benefits to DeWitt County, Harp Township, Unit 15 School District and Junior College District 537 where the estimated tax accounts received range between 20% and 95% of all the revenues estimated to be received by the jurisdictions (see Table 5.?).

It is estimated that 300 workers will be required for the operation of Unit 1. One hundred and thirty-four operating workers are already at the site. The remaining workers are likely to reside in locations similar to those where existing plant employees live. Therefore, about 42% of the workers are expected to live in Decatur, 13% in Clinton, about 7% in Maroa, 6% in Champaign-Urbana, about 5% in Farmer City and Warrensburg, with the remaining living in other communities within a 40-km (25-mi) radius of the Clinton Power Station. Because of the relatively small number of workers required to operate the station, the impact on the infrastructure of the communities in which they reside and on traffic is expected to be minimal.

The estimated annual payroll for Unit 1 in 1984 is projected to be $11.5 million (in 1985 dollars). Local purchases of materials and supplies relating to the operation of the station is expected to total $100,000 annually (in 1980 dollars). Local purchases are expected to be made mainly in Decatur, with smaller purchases being made in Bloomington-Normal, Champaign-Urbana and Clinton.

5.8.2 Public Health

As discussed in Section 4.3, the potential exists for the establishment of pathogenic, thermophillic amoebae in Lake Clinton after power production begins. Such organisms gain entry into the human body via the nasal passages; infection is often associated with water-contact recreation where the organisms can be inhaled with contaminated water. Primary amoebic meningoencephalitis, caused by such pathogens, is a fulminating disease and is almost always lethal. Although it is stated that the risk rate for the U.S. population as a whole is estimated at less than 1 in 2.5 million persons (Ref. 70), it is the opinion of the staff that the risk rate for persons engaged in water-contact recreation in contaminated waters would be significantly higher. However, the staff is unaware of statistics addressing these circumstances.

Table 5.3. Estimated Clinton Power Station Unit 1 Real Estate Taxes†[1] (thousands of dollars)

Taxing District	1984 Payable in 1985	1985 Payable in 1986	1986 Payable in 1987	1987 Payable in 1988	1988 Payable in 1989	Estimated Percentage of Real Estate Taxes Represented by Clinton Unit 1
DeWitt County†[2]	1600	1600	1600	1700	1700	50% to 55%
Harp Township	300	400	400	400	500	90% to 95%
Unit 15 School District	4900	5200	5500	5800	6000	65% to 70%
Junior College District 537	500	500	500	500	500	20% to 25%
TOTALS	7300	7700	8000	8400	8700	

†[1] Modified from ER-OL, p. 8.1-6.

†[2] DeWitt County distributes their funds to the following categories: general corporate fund, highway, health, mental health, Illinois municipal retirement fund, insurance, matching federal aid (highways), audit, bridges, extension education, tax assessments, election, nursing home bonds, tax collection, civil defense, and tuberculosis.

Because of the uncertainties in predicting both the liklihood of occurrence of such thermophillic pathogens in Lake Clinton when power production occurs, and the infection rate for persons engaged in water-contact recreation in contaminated waters, the staff has recommended that the lake be monitored for the organisms (Sec. 4.3). If the organisms are found, the monitoring data may be used to plan mitigation strategies to protect the health and safety of the public.

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 maximum permissible levels of radiation in unrestricted areas and of radioactivity in effluents to unrestricted areas are recorded in 10 CFR Part 20, Standards for Protection Against Radiation (Ref. 30). These regulations specify limits on levels of radiation and limits on concentrations of radionuclides in the station'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, due to station operation, of more than 0.5 rem in one calendar year, or if an individual were continuously present in an area, 2 mrems in any one hour or 100 mrems in any seven 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 Part 20, there are recorded in 10 CFR Part 50.36a (Ref. 31) 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 is reasonably achievable (ALARA). Appendix I of 10 CFR Part 50 provides numerical guidance on dose-design objectives for LWRs to meet this ALARA requirement. Applicants for permits to construct and 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/yr to the total body or 10 mrems/yr to any organ from all pathways of exposure from liquid effluents; 10 mrads/yr gamma radiation or 20 mrads/yr beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems/yr to the total body or 15 mrems/yr to the skin from gaseous effluents; and 15 mrems/yr to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and the 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 Part 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 assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such small percentages, but still well within the limits specified in 10 CFR Part 20.

In addition to the impact created by station radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR Part 51 there are generic treatments of environmental effects of all aspects of the Uranium Fuel Cycle. These environmental data have been summarized in Table 5.12 (Table S-3 of 10 CFR Part 51) and are discussed later in this report in Section 5.10. In the same manner the environmental impact of transportation of fuel and waste to and from an LWR is summarized in Table 5.5 (Table S-4 of 10 CFR Part 51) of Section 5.9.3.

Recently an additional operational requirement for Uranium-Fuel-Cycle Facilities including nuclear power plants has been established by the EPA in 40 CFR Part 190 (Ref. 32). 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 Clinton Power Station, Unit 1, small quantities of radioactivity (fission and activation products) will be released to the environment. As required by NEPA, the staff has determined the dose estimated to members of the public outside of the plant boundaries due to the radiation from these radioisotope releases and relative to natural background radiation dose levels.

These station-generated environmental dose levels are estimated to be very small due to station design and the development of a program which will be implemented at the station to contain and control all radioactive emissions and effluents. As mentioned above, highly efficient radioactive-waste management systems are incorporated into the plant design and are specified in detail in the Technical Specifications for the station. The effectiveness of these systems will be measured by process and effluent radiological monitoring systems that permanently record the amounts of radioactive constitutents remaining in the various airborne and waterborne process and effluent streams. The amounts of radioactivity released through vents and discharge points to be further dispersed and diluted to points outside the plant boundaries are to be recorded and published semiannually in the Radioactive Effluent Release Reports of each facility.

The small amounts of airborne effluents that are released will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release and are generally much dispersed and diluted by the time they reach unrestricted areas that are open to the public. Similarly, the small amounts of waterborne effluents released will be diluted with plant waste water and then further diluted as they mix with the Clinton Lake beyond the station boundaries.

Radioisotopes in the station's effluents that enter unrestricted areas will produce doses through their radiations to members of the general public similar to the doses from background radiations (i.e., 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 station, such as direct radiation doses from the gaseous plume or liquid effluent stream outside of the station 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 present in drinking water outside the station, or incorporated into milk from cows at nearby farms.

These doses, calculated for the "maximally exposed" individual (i.e., 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 due to 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 the 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 (e.g., 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, to be required by the Radiological Technical Specifications of the operating license, will require that as use of the land surrounding the site boundary changes, revised calculations be made to ensure that this dose estimate for gaseous effluents always represents the highest dose 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.

For Clinton Power Station, in addition to the direct effluent monitoring, measurements will be made on a number of types of samples from the surrounding area to determine the possible presence of radioactive contaminants which, for example, might be deposited on vegetation, or be present in drinking water outside the plant, or incorporated into cow's milk from nearby farms.

5.9.3 Radiological Impacts from Routine Operations

5.9.3.1 Radiation Exposure Pathways: Dose Commitments

There are many environmental pathways through which persons may be exposed to radiation originating in a nuclear power reactor. All of the potentially meaningful exposure pathways are shown schematically in Figure 5.3. When an individual is exposed through one of these pathways, his dose is determined in part by the amount of time he is in the vicinity of the source, or the amount of time the radioactivity is retained in his body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. This dose commitment represents the total dose that would be received over a 50-yr period, following the intake of radioactivity for 1 year under the conditions existing 15 years after the station begins operation (i.e., the mid-point of station operation). However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure due to turnover of the nuclide by physiological processes and radioactive decay.

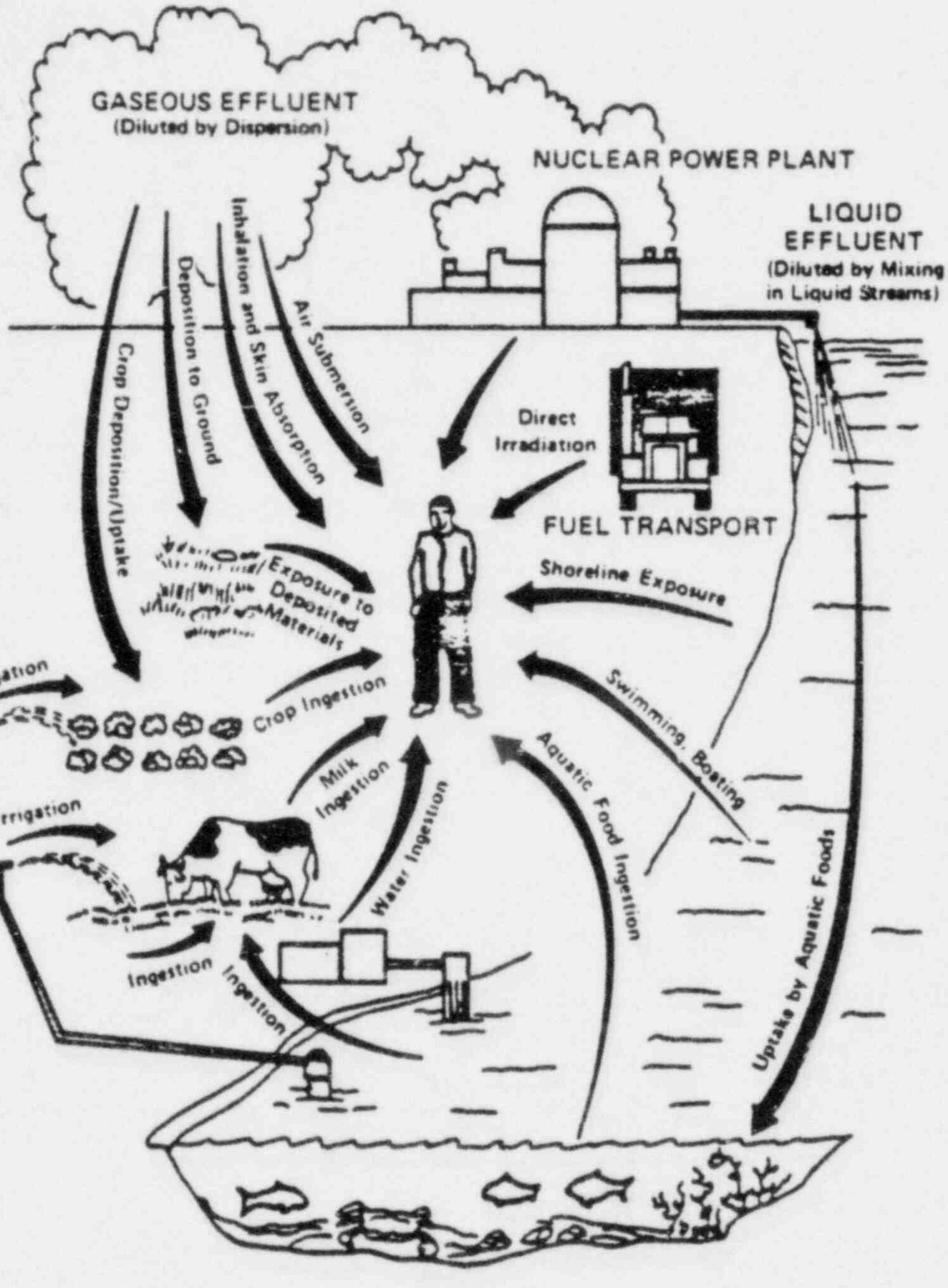

Figure 5.3. Potentially Meaningful Exposure Pathways to Individuals.

There are a number of possible exposure pathways to man that can be studied to determine whether the routine releases at the Clinton site are likely to have any significant impact on members of the general public living and working outside of the site boundaries, and whether the releases will in fact meet regulatory requirements. A detailed listing of these possibilities 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 significant 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, and direct radiation from within the plant itself.

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 has shown that all significant dose commitments (>0.1 mrem/yr) for radioactive effluents are accounted for within a radius of 80 km from the station. Beyond 80 km the doses to individuals are smaller than 0.1 mrem/yr, 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 significant pathways and has evaluated the radiation-dose commitments both to the station workers and the general public for these pathways resulting from routine operation of the station. A discussion of these evaluations follows.

5.9.3.1.1 Occupational Radiation Exposure for BWRs

Most of the dose to nuclear plant workers results from external exposure to radiation 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 Part 20 (Ref. 30), Standard Review Plan Chapter 12 (Ref. 33), and Regulatory Guide 8.8 (Ref. 34).

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 Safety Evaluation Reports. 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 154 BWR reactor years of operation is available for those plants operating between 1974 and 1980. (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 dose at BWRs has been about 740 person-rems, with some plants experiencing an average plant lifetime annual dose to date of 1650 person-rems (Refs. 35,36), and with one plant as high as 1853 person-rems. 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 (Ref. 35) has not varied significantly during this period. The worker dose limit, established by 10 CFR Part 20, is 3 rems/quarter (if the a.erage dose over the worker lifetime is being controlled to 5 rems/yr) or 1.25 rems/ quarter if it is not.

The wide range of annual collective doses experienced at U.S. BWRs results from a number of factors such as the amount of required maintenance, and the amount of reactor operations and in-plant 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. The need for high doses can occur, 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 Clinton Power Station are based on the assumption that the station will experience the annual average occupational dose for BWRs to date. Thus, the staff has projected that the occupational doses for Unit 1 will be 740 person-rems but could average as much as 2 to 3 times this value over the life of the station.

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 Part 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear power plant workers and compared it in Table 5.4 to risks that are published 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 number of health effects resulting from both offsite (see Sec. 5.9.3.2) and occupational radiation exposures due to normal operation of Clinton, the NRC staff used somatic (cancer) and genetic risk estimators based on widely accepted scientific information. Specifically, the staff's estimates are based on information compiled by the National Academy of Science's Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR) (Ref. 37). The estimates of the risks to workers and the general public are based on conservative assumptions (i.e., 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 (Ref. 37). Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the

Table 5.4. Incidence of Job-Related Mortalities

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

[a]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.

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

[c]The nuclear-plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The 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 nonradiation-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 is potential rather than actual.)

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 health effects have not been detected at doses in this dose-rate range. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers (Ref. 38).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (Ref. 37). The values 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), the National Council on Radiation Protection and Measurement (NCRP), the National Academy of Sciences BEIR III Report, and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Refs. 38-41). The risk of potential fatal cancers in the exposed work force population at Clinton Power Station and the risk of potential genetic disorders in all future generations of this workforce population, is estimated as follows. Multiplying the annual plant worker population dose (i.e., about 740 person-rems) by the risk estimators, the staff estimates that about 0.1 cancer death may occur in the total exposed population and about 0.2 genetic disorder may occur in all future generations of the same exposed population. The value of 0.1 cancer death means that the probability of one cancer death over the lifetime of the entire work force due to one year of operations at Clinton Power Station is about 1 chance in 10. The value of 0.2 genetic disorder means that the probability of 1 genetic disorder in all future generations due to one year of operations at Clinton Power Station is about 1 chance in 5.

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 Part 51.20 (Ref. 31). 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 Part 51.20, reproduced herein as Table 5.5. The cumulative dose to the exposed population as summarized in Table S-4 is very small when compared to the annual dose of about 61,000 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

Table 5.5. (Summary Table S-4) Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor[1]

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.

[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 (microfiche, $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.

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/yr 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/yr per unit, insignificant when compared with the natural background dose.

Low-level radioactivity storage containers outside the station are estimated to make a dose contribution at the site boundary of less than 0.1% of that due to the direct radiation described above.

Radioactive Effluent Releases: Air and Water

As pointed out in an earlier section, all effluents from the station will be subject to extensive decontamination, but small controlled quantities of radioactive effluents will be released to the atmosphere and to the hydrosphere during normal operations. Estimates of site-specific radioisotope release values have been developed on the basis of the descriptions of operational and radwaste systems in the applicant's ER-OL and FSAR and by using the calculational model and parameters developed by the NRC staff (Ref. 42). These have been supplemented by extensive use of the applicant's site and environmental data in the ER-OL and in subsequent answers to NRC staff questions, and should be studied to obtain an understanding of airborne and waterborne releases from the station.

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 noble gases--krypton, xenon, and 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 radioiodines, carbon-14, and tritium--are also gaseous but tend to be deposited on the ground and/or absorbed into the body during inhalation. 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 significance here.

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 barium and corrosion activition 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 Part 50.

The waterborne radioactive effluent constituents could include fission products such as nuclides of strontium and iodine; activation products, such as nuclides of sodium and manganese; and tritium as tritiated water. Calculations estimate the internal doses (if any) from fish consumption, from water ingestion (as drinking water), and from eating of 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 values 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 Regulatory Guide 1.109 (Ref. 43) and in Appendix D of this statement.

Examples of site-specific dose assessment calculations and discussions of parameters involved are given in Appendix C. Doses from all airborne effluents except the noble gases are calculated for the location (e.g., site boundary, garden, residence, milk cow, meat animal) where the highest radiation dose to a member of the public from all applicable pathways has been established. 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 C are based on radioactive-waste treatment system capability, the actual radiological impact associated with the operation of the station 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 Part 50 (Ref. 31).

The station's operation will be governed by operating license Technical Specifications which will be based on the dose-design objectives of Appendix I to 10 CFR Part 50 (Ref. 31). Since 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/yr) or the dose limits specified in 10 CFR Part 20 (500 mrems/yr - total body). As a result, the staff concluded that there will be no measurable radiological impact on any member of the public from routine operation of the station.

Operating standards of 40 CFR Part 190, the Environmental Protection Agency's Environmental Radiation Protection Standards for Nuclear Power Operations, (Ref. 32) 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 concluded that under normal operations the Clinton Power Station 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, occasionally 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 also be readily calculated and recorded. These risk estimates for Clinton Power Station are presented below.

The risk to the maximum 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 Part 50, Appendix I. This calculation results in a risk of potential premature death from cancer to that individual from exposure to radioactive effluents (gaseous or liquid) from one year of reactor operations of less than one chance in one million.* The risk of potential premature death from cancer to the average individual within 80 km (50 mi) of the reactor from exposure to radioactive effluents from the reactor 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 Clinton Power Station.

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation of Clinton Power Station (i.e., 30 person-rems) by the preceding risk estimators,

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

the staff estimates that about 0.004 cancer death may occur in the exposed population and about 0.008 genetic disorder may occur in all future generations of the exposed population. The significance of these risk estimates can be determined by comparing them to the natural incidence of cancer death and genetic abnormalities in the U.S. population. Multiplying the estimated U.S. population for the year 2000 (i.e., ~260 million persons) by the current incidence of actual cancer fatalities (i.e., ~20%) and the current incidence of actual genetic diseases (i.e., ~6%), about 52 million cancer deaths and about 16 million genetic abnormalities are expected (Refs. 37,44). The risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of Clinton Power Station are very small fractions (about 1 part in a billion or less) of the estimated normal incidence of cancer fatalities and genetic abnormalities in the year 2000 population.

On the basis of the preceding comparison (i.e., comparing the risk from exposure to radioactive effluents and transportation of fuel and waste from the annual operation of Clinton Power Station with the risk from the estimated incidence of cancer fatalities and genetic abnormalities in the year 2000 population), the staff concludes that the risk to the public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operation of Clinton Power Station will be very small.

5.9.3.3 Radiological Impacts on Biota Other Than Humans

Depending on the pathway and 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 human, 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 station. Furthermore, at all nuclear plants for which radiation exposure to biota other than humans has been analyzed (Ref. 45), 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 Part 20 (Ref. 30). Inasmuch as the 1972 BEIR Report (Ref. 37) concluded that evidence to date indicated 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 station.

5.9.3.4 Radiological Monitoring

Radiological environmental monitoring programs are established to provide data on measurable levels of radiation and radioactive materials in the site environs.

Such monitoring programs are conducted to verify the effectiveness of in-plant 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 monitoring programs could identify the highly unlikely existence of unmonitored releases of radioactivity. 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.

These programs are discussed generically in NRC Regulatory Guide 4.1, Rev. 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Ref. 46), and the Radiological Assessment Branch Technical Position, Rev. 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program" (Ref. 47).

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 station, 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 Section 6.1.5 of the applicant's ER-OL and is summarized here in Table 5.6.

The applicant states that the preoperational program has been implemented, at least two years prior to initial criticality of Unit 1, to document background levels of direct radiation and concentrations of radionuclides that exist in the environment. The preoperational program will continue up to the initial criticality of Unit 1 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 acceptable.

5.9.3.4.2 Operational

The operational, offsite radiological-monitoring program is conducted to measure radiation levels and radioactivity in plant environs. It assists and provides backup support to the effluent-monitoring program as recommended in NRC Regulatory Guide 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" (Ref. 48).

The applicant states that the operational program will in essence be a continuation of the preoperational program described above with some periodic adjustment of sampling frequencies in expected critical exposure pathways. The actual pathways sampled will depend, in part, on the results of the land-use census. 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.

Table 5.6. Preoperational Radiological Environmental Monitoring Program Summary*

Critical Pathways/Groups	Sample Method	Parameters Measured	Sample Frequency
Air Sampling	TLD samples at 32 locations: two rings of TLD's, one in each sector at the site boundary and at distances of approximately 4 to 5 miles	Gross gamma analysis	92 days
	Air particulate samples at 8 locations	I-131 Gross-beta Gamma isotopic	7 days 7 days 92 days
Soils	Grab sample shoreline sediment at 2 locations	Gamma isotopic	182 days
Wellwater	Two locations	I-131 Gross-beta gamma isotopic Tritium	14 days 31 days 31 days 31 days
Drinking Water	One Location	I-131 Gross-beta gamma isotopic Tritium	14 days 31 days 31 days 31 days
Surface Water	Three locations	Gamma isotopic Tritium	31 days 31 days
Bottom Sediments	Grab samples at 2 locations	Gamma isotopic	182 days
Milk	None (no milk cows within 5 km).		
Fish	Electroshocker/Net, 1 location	Gamma isotopic	182 days
Vegetables	Grab (nearest garden)	I-131 Gross-beta Gamma isotopic	At time of harvest

*Adapted from the ER-OL (Table 6.1-8).

Note: 1 mile = 1.61 kilometers.

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 Impact 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 Clinton Power Station Unit 1 in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980 (Ref. 49). The following discussion reflects these considerations and conclusions.

The first section 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 their consequences if they should 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 impacts on society associated with actions to avoid such health effects are also identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are then described. This is followed by a summary review of safety features of the Clinton Power Station Unit 1 facilities and of the site that act to mitigate the consequences of accidents.

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

5.9.4.1.1 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. Such limits are specified in the Commission's regulations in 10 CFR Part 50, Appendix I.

There are several features which combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the 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 Clinton

Unit 1 station may be found in the applicant's Final Safety Analysis Report (Ref. 50), and in the staff's Safety Evaluation Report (Ref. 51). The most important mitigative features are described in Section 5.9.4.1.3.1 below.

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

5.9.4.1.1.1 Fission Product Characteristics

By far the largest inventory of radioactive material in a nuclear power plant is produced as a by-product 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.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment is dependent not only on mechanical forces that might physically transport them, but also upon 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 upon the assessment of the environmental 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 very low frequency but credible events (Sec. 5.9.4.1.2). It is for this reason that the safety analysis of each nuclear power plant analyzes a hypothetical design basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment system. If 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 system 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 may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release from the fuel. If 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, its potential for release 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 temperature, however, so that they have a strong tendency to condense (or "plate out") upon 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 systems 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 iodine, 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 transported to a lower temperature region and/or dissolve in water when present. The former mechanism can have the result of producing 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 or by precipitation (fallout), 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 (see Table 5.9). 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 is the reason that they are hazardous materials.

5.9.4.1.1.2 Exposure Pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive material, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways for the transport of radiation and radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Section 5.9.3, Figure 5.3. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 5.3. 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 through contact with ground water. These pathways may lead to external exposure to radiation, and to internal exposures if radioactivity is 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 consequences of accidental releases to the atmosphere would be very much dependent upon the weather conditions existing at the time.

5.9.4.1.1.3 Health Effects

The cause and effect relationships between radiation exposure and adverse health effects are quite complex (Ref. 52) but they have been more exhaustively studied than any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rem for a few persons and about 25 rem for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 10 to 20 times larger than the latter value, 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, e.g., 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 (i.e., the plateau period is 10 years). The health consequences model currently being used is based on the 1972 BEIR Report of the National Academy of Sciences (Ref. 37). The occurrence of cancer itself is not necessarily indicative of fatality.

Most authorities are in agreement 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 per million person-rem (although zero is not excluded by the data). The range comes from the latest NAS BEIR III Report (1980) (Ref. 38) 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 randomly occurring genetic changes per million person-rem would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million person-rem currently used by the NRC staff.

5.9.4.1.1.4 Health Effects Avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is a slow one, however, and where the material becomes relatively fixed in its location as an environmentally contaminant (e.g., in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential 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.

5.9.4.1.2 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 mid-1981, there were 71 commercial nuclear power reactor units licensed for operation in the United States at 50 sites with power generating capacities ranging from 50 to 1130 megawatts electric (MWe). (Clinton Power Station Unit 1 is designed for 950 MWe.) The combined experience with these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities (Ref. 53). Some of these 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 base is not large enough to permit a reliable quantitative statistical inference. It does, however, suggest that significant environmental impacts due to accidents are very unlikely to occur 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. In addition to the release of a few million curies of xenon-133, it has been estimated that approximately 15 curies of radioiodine was also released to the environment at TMI-2. This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. 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 millirem (Refs. 54,55). The total population exposure has been estimated to be in the range from about 1000 to 3000 person-rem. This exposure could produce between none and one additional fatal cancer over the lifetime of the exposed population. The same population receives each year from natural background radiation about 240,000 person-rem and approximately a half-million cancers are expected to develop in this group over its lifetime (Refs. 54,55), 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 impacted.

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 accidents, but the collective worker exposure levels (person-rem) due to accidents are a small fraction of the exposures experienced during normal routine operations that average about 500 person-rem per reactor year.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries (Ref. 53). Due to 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 the Enrico Fermi Atomic Power Plant Unit 1. This was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power in four years following the accident. It operated successfully and completed its mission in 1973. This 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 curies, to the environment. 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, the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-ft) stack. Milk produced in a 520-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. This kind of accident cannot occur in a water-cooled reactor like Clinton, however.

5.9.4.1.3 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the Nuclear Regulatory Commission has conducted a safety evaluation of the application to operate Clinton Unit 1. Although this evaluation contains more detailed information on plant design, the principal design features are presented in the following section.

5.9.4.1.3.1 Design Features

Clinton Unit 1 contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESF). The possibilities or probabilities of failure of these systems are incorporated into the assessments discussed in Section 5.9.4.1.4.2.

The containment system, one such ESF, is a passive mitigating system designed to minimize accidental radioactivity releases to the environment. The containment system is composed of two parts. The primary containment encloses the reactor vessel, the reactor coolant recirculation loops, and other reactor coolant system components. The secondary containment gas control boundary, which includes the fuel building and parts of the auxiliary building, encloses the primary containment, the spent fuel pool, and other auxiliary equipment.

An emergency core cooling system (ECCS) is designed to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage. A pressure suppression system is installed to prevent containment failure due to overpressure following an accident.

The Standby Gas Treatment System (SGTS) is designed to establish and maintain a negative pressure in the secondary containment following the signal for its isolation in the event of release of radioactivity to this building in an accident. Negative pressure, with respect to the outside atmosphere, would prevent out-leakage of radioactivity from this building to the environment except along the release path controlled by the SGTS. Radioactive iodine and particulate fission products would be substantially removed from the flow stream by safety-grade activated charcoal and high-efficiency particulate air filters.

The main steam isolation valve leakage control system is designed to control the release of fission products through the main steam isolation valves. This system directs the leakage through these valves to the area served by the SGTS. The spent fuel storage pool is located in the secondary containment where potential radioactive leakage from the stored fuel can be directed through the SGTS.

The mechanical systems mentioned above are supplied with emergency power from onsite diesel generators in the event that normal offsite station power is interrupted.

Much more extensive discussions of the safety features and characteristics of Clinton Unit 1 may be found in the applicant's Final Safety Analysis Report (Ref. 50). The staff evaluation of these features will be addressed in the Safety Evaluation Report (Ref. 51). In addition, the implementation of the lessons learned from the TMI-2 accident, in the form of improvements in design and procedures, and operator training, will significantly reduce the likelihood of a degraded core accident which could result in large releases of fission products to the containment. Specifically, the applicant will be required to meet those TMI-related requirements specified in NUREG-0737. As noted in Section 5.9.4.1.4.7, no credit has been taken for these actions and improvements in discussing the radiological risk of accidents.

5.9.4.1.3.2 Site Features

The NRC's reactor site criteria, 10 CFR Part 100, requires 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 Clinton site characteristics and how they meet these requirements.

First, the site has an exclusion area, as required by 10 CFR Part 100. The total site area is about 5739 ha (14,182 acres), of which about 36 ha (90 acres) are not station property. The exclusion area, located within the site boundary, is a circular area with a 975-m (3199-ft) radius centered on the normal gaseous effluent release point (i.e., the station standby gas treatment vent). There are no residents within the exclusion area. The applicant owns all surface and mineral rights in the exclusion area, and has the authority, required by Part 100, to determine all activities in this area. No public highways, railroads or waterways traverse the exclusion area except a right-of-way for the township road which traverses the exclusion area. This road provides access to privately owned property which lies outside the exclusion area. The applicant together with the local law enforcement agency will control access along this road in the event of an emergency. There are no other activities unrelated to plant operation within the exclusion area.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR Part 100. The LPZ for Clinton is a circular area with a 4-km (2.5-mi) radius, measured from the station standby gas treatment vent. 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 serious accident. The applicant has estimated, based on a house count, that 237 persons are projected to be living within 4.8 km (3 mi) of the site during mid plant operation (year 2000). The average transient population, consisting of individuals using the nearby recreational facilities associated with the cooling lake within the LPZ, is 729, while the peak usage (occurring about 20 days per year) is estimated at 8,000 persons (10,000 persons within 8 km (5 mi) of the station). In case of a radiological emergency, the applicant has made arrangements to carry out protective actions, including evacuation of personnel in the vicinity of the nuclear station. See also the following section on Emergency Preparedness.

Third, 10 CFR Part 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. Since 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 Part 100 to provide for protection against excessive exposure doses to people in large centers. The cities of Decatur, Illinois with an estimated 1980 population of 93,513 (90,397 in 1970) located 36 km (22.4 mi) SSW and Bloomington, Illinois, with an estimated 1980 population of 44,330 (39,992 in 1970) located 36.5 km (22.7 mi) NNW are the nearest population centers.

The population center distance is at least one and one-third times the LPZ outer radius. Current population density within 16 km (10 mi) of the site is estimated to be 42 people/mi^2 (1970 census) and projected to reach 60 people/mi^2 by the year 2020.

The safety evaluation of the Clinton site has also included a review of potential external hazards, i.e., activities offsite that might adversely affect the operation of the station and cause an accident. The review encompassed nearby industrial and military facilities that might create explosive, missile, toxic gas, or similar hazards. The risk to the Clinton facility from such hazards has been found to be negligibly small. The staff has not completed its review of hazardous conditions from nearby transportation routes.

The applicant has been requested to provide additional information in this area. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards will be reported in the staff's Safety Evaluation Report.

5.9.4.1.3.3 Emergency Preparedness

Emergency preparedness plans including protective action measures for the Clinton facility and environs are in an advanced, but not yet fully completed, stage. In accordance with the provisions of 10 CFR Section 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 (EPZ). A plume exposure pathway EPZ of about 16 km (10 mi) in radius and an ingestion exposure pathway EPZ of about 80 km (50 mi) 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.

NRC findings will be based upon a review of the Federal Emergency Management Agency (FEMA) findings and determinations as to whether State and local government emergency plans are adequate and capable of being implemented, and on the NRC assessment as to whether the applicant's onsite plans are adequate and capable of being implemented. NRC staff findings are reported in the staff's Safety Evaluation Report (Ref. 51). A supplement to this report will provide the staff's overall conclusions on the state of emergency preparedness for Clinton Power Station and related emergency planning zones. Although the presence of adequate and tested emergency plans cannot prevent the occurrence of an accident, it is the judgment of the staff that their implementation can and will substantially mitigate the consequences to the public if an accident should occur.

5.9.4.1.4 Accident Risk and Impact Assessment

5.9.4.1.4.1 Design Basis Accidents

As a means of assuring that certain features of the Clinton Unit 1 station meets acceptable design and performance criteria, both the applicant and the 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 the particular course taken by the accident and the conditions, including wind direction and weather, prevalent during the accident.

In the safety analysis and evaluation of the Clinton Unit 1 station, three categories of accidents have been considered by the applicant and the staff. These categories are based upon their probability of occurrence and include (a) incidents of moderate frequency, i.e., events that can reasonably be expected to occur during any year of operation, (b) infrequent accidents, i.e., events that might occur once during the lifetime of the plant, and (c) limiting faults, i.e., 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 5.9.3. Some of the initiating events postulated in the second and third categories for Clinton Unit 1 are shown in Table 5.7. These events are designated design basis accidents in that specific design and operating features as described above in Section 5.9.4.1.3.1 are provided to limit their potential radiological consequences. Approximate radiation doses that might be received by a person at the nearest site boundary [975 m (3199 ft) from the plant] are also shown in the table, along with a characterization of the time duration of the releases. The results shown in the table reflect the expectation that engineered safety and operating features designed to mitigate the consequences of the postulated accidents would function as intended. An important implication of this expectation is that the radioactive releases considered are limited to noble gases and radioiodines and that any other radioactive materials, e.g., in particulate form, are not expected to be released. The results are also quasi-probabilistic in nature in the sense that the meteorological dispersion conditions are taken to be neither the best nor the worst for the site, but rather at an average value determined by actual site measurements. In order to contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 5.7 are sometimes referred to as "realistic" doses.

The staff has also carried out calculations to estimate the potential upper bounds for individual exposures from the same initiating accidents in Table 5.7 for the purpose of implementing the provisions of 10 CFR Part 100, "Reactor Site Criteria." For these calculations, much more pessimistic (conservative or worst case) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include much larger amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESF's in a degraded mode,* and very poor meteorological dispersion conditions. The results of these calculations show that, for these events, the limiting whole-body exposures are not expected to exceed 10^{-4} rem to any individual at the site boundary. They also show that radioiodine releases have the potential for offsite exposures ranging up to about 300 rem 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 characteristic of a person jogging, for a period of two hours. The health risk to an individual receiving such a thyroid exposure is the potential appearance of benign or malignant thyroid nodules in about 1 out of 10 cases, and the development of a fatal cancer in about 4 out of 1000 cases.

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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 Part 100.11(a).

Table 5.7. Approximate Doses During a Two-Hour Exposure at the Exclusion Area Boundary* from Selected Design Basis Accidents

Infrequent Accidents (Category 2)	Duration of Release**	Whole Body Dose (rem)
Off-gas system failure	<2 hours	.005
Release of waste gas storage tank contents	<2 hours	.04
Small-break LOCA	hrs-days	<0.00005
Fuel handling accident	<2 hours	.01
Limiting Faults (Category 3)		
Main steam line break	< 2 hr	0.009
Control rod drop	hrs-days	0.017
Large-break LOCA	hrs-days	0.32

*975 m (3199 ft).

**< means "less than".

None of the calculations of the impacts of design basis accidents described in this section take into consideration possible reductions in individual or population exposures as a result of taking any protective actions.

5.9.4.1.4.2 Probabilistic Assessment of Severe Accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design basis accidents identified in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe, both for the plant itself and for the environment. These 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 system 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) which was published in 1975 (Ref. 56).* However, the sets of acci-

*Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 5.9.4.1.4.7.

dent sequences that were found in the RSS to be the dominant contributors to the risk in the prototype BWR (Peach Bottom Unit 2) have recently been updated (Ref. 57) ("rebaselined"). The rebaselining has been done largely to incorporate peer group comments (Ref. 58), and better data and analytical techniques resulting from research and development after the publication of the RSS. Entailed in the rebaselining effort was the evaluation of the individual dominant accident sequences-as they are understood to evolve. The earlier technique of grouping a number of accident sequences into the encompassing Release Categories as was done in the RSS has been largely eliminated.

Clinton Unit 1 is a General Electric designed BWR having similar design and operating characteristics to the RSS prototype BWR. Therefore, the present assessment for Clinton has used as its starting point the rebaselined accident sequences and sequence groups referred to above, and more fully described in Appendix E. Characteristics of the sequences (and sequence groups) used (all of which involve partial to complete melting of the reactor core) are shown in Table 5.8. 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. Moreover, there are design requirements in 10 CFR Part 50, Appendix A, relating to the effects of natural phenomena, and safeguards requirements in 10 CFR Part 73, assuring that these potential initiators are in large measure taken into account in the design and operation of the station. The data base for assessing the probabilities of events more severe than the design bases for natural phenomena or sabotage is small. Hence, inclusion of accident sequences initiated by natural phenomena and sabotage events is beyond the state-of-the-art of probabilistic risk assessment. In addition, the staff judges that the additional risk from severe accidents initiated by natural events or sabotage is within the uncertainty of risk presented for the sequences considered here.

Calculated probability per reactor year associated with each accident sequence (or sequence group) used is shown in the second column in Table 5.8. 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 (Ref. 58) (see also Sec. 5.9.4.1.4.7 below). The probability of accident sequences from the Peach Bottom plant were used to give a perspective of the societal risk at Clinton Unit 1 because, although the probabilities of particular accident sequences may be substantially different or even improved for Clinton, the overall effect of all sequences taken together is likely to be within the uncertainties (see Sec. 5.9.4.1.4.7 for discussion of uncertainties in risk estimates).

The magnitudes (curies) of radioactivity releases for each accident sequence or sequence group are obtained by multiplying the release fractions shown in Table 5.8 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 5.9 for the Clinton 1 station at the core thermal power level of 3039 megawatts, the power level used in the Safety Evaluation.

Table 5.8. Summary of Atmospheric Releases in Hypothetical Accident Sequences in a BWR (Rebaselined)

Accident Sequence or Sequence Group[b]	Probability per reactor-year	Fraction of Core Inventory release[a]						
		Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[c]	La[d]
$TC\gamma'$	2.0×10^{-6}	1.0	0.45	0.67	0.64	0.073	0.052	0.0083
$TW\gamma'$	3.0×10^{-6}	1.0	0.098	0.27	0.41	0.025	0.028	0.005
$TQUV\gamma'$ $AE\gamma'$ $S_1E\gamma'$ $S_2E\gamma'$	3.0×10^{-7}	1.0	0.095	0.3	0.36	0.034	0.027	0.005
$TC\gamma$	8.0×10^{-6}	1.0	0.07	0.14	0.12	0.015	0.01	0.002
$TW\gamma$	1.0×10^{-5}	1.0	0.003	0.11	0.083	0.011	0.007	0.001
$TQUV\gamma$ $AE\gamma$ $S_1E\gamma$ $S_2E\gamma$	1.0×10^{-6}	1.0	0.02	0.055	0.11	0.006	0.007	0.0013

(a) Background on the isotope groups and release mechanisms is presented in Appendix VII of WASH 1400.

(b) See Appendix E for description of the accident sequences and sequence groups.

(c) Includes Ru, Rh, Co, Mo, Tc.

(d) Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

NOTE: Please refer to Section 5.9.4.1.4.7 for a discussion of uncertainties in risk estimates.

Table 5.9. Activity of Radionuclides in Clinton Reactor Core at 3039 MWt

Group/Radionuclide	Radioactive Inventory in Millions of Curies	Half-Life (days)
A. NOBLE GASES		
Krypton-85	0.53	3,950
Krypton-85m	23	0.183
Krypton-87	45	0.0528
Krypton-88	65	0.117
Xenon-133	160	5.28
Xenon-135	32	0.384
B. IODINES		
Iodine-131	81	8.05
Iodine-132	110	0.0958
Iodine-133	160	0.875
Iodine-134	180	0.0366
Iodine-135	140	0.280
C. ALKALI METALS		
Rubidium-86	0.025	18.7
Cesium-134	7.1	750
Cesium-136	2.9	13.0
Cesium-137	4.5	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	5.6	0.391
Tellurium-127m	1.0	109
Tellurium-129	29	0.048
Tellurium-129m	5.0	34.0
Tellurium-131m	12	1.25
Tellurium-132	110	3.25
Antimony-127	5.8	3.88
Antimony-129	31	0.179
E. ALKALINE EARTHS		
Strontium-89	89	52.1
Strontium-90	3.5	11,030
Strontium-91	100	0.403
Barium-140	150	12.8
F. COBALT AND NOBLE METALS		
Cobalt-58	0.74	71.0
Cobalt-60	0.28	1,920
Molybdenum-99	150	2.8
Technetium-99m	130	0.25
Ruthenium-103	100	39.5
Ruthenium-105	68	0.185
Ruthenium-106	24	366
Rhodium-105	47	1.50

Table 5.9. (Continued)

Group/Radionuclide	Radioactive Inventory in Millions of Curies	Half-Life (days)
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	3.7	2.67
Yttrium-91	110	59.0
Zirconium-95	140	65.2
Zirconium-97	140	0.71
Niobium-95	140	35.0
Lanthanum-140	150	1.67
Cerium-141	140	32.3
Cerium-143	120	1.38
Cerium-144	81	284
Praseodymium-143	120	13.7
Neodymium-147	57	11.1
Neptunium-239	1600	2.35
Plutonium-238	0.054	32,500
Plutonium-239	0.020	8.9×10^6
Plutonium-240	0.020	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	0.022	6,630

NOTE: The above grouping of radionuclides corresponds to that in Table 5.8.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS (Ref. 59) and adapted to apply to a specific site. The essential elements are shown in schematic form in Figure 5.4. Environmental parameters specific to the Clinton 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- and 560-km (50- and 350-mi) radius from the site.

(3) The habitable land fraction within the 560-km (350-mi) radius, and

(4) Land-use statistics, on a state-wide basis, including farm land values, farm product values including dairy production, and growing season information, for the State of Illinois and each surrounding state within the 560-km (350-mi) region.

To obtain a probability distribution of consequences, the calculations are performed assuming the occurrence of each accident release sequence at each of 91 different "start" times throughout a one-year period. Each calculation utilizes the site-specific hourly meteorological data and 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. The evacuation model used (see Appendix F) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the Clinton site are estimates made by the staff and are partly based upon preliminary evacuation time estimates prepared by the applicant. There normally would be special facilities near a plant, such as schools or hospitals, where special equipment or personnel may be required to effect evacuation. Several such facilities have been identified near the Clinton site, such as the John Warner Hospital (including several nursing homes nearby), the Lake Clinton Recreation Center, and the Clinton School District. Further, there may be people who either do not receive notification to evacuate or who choose not to evacuate. Therefore, actual evacuation effectiveness could be greater or less than that characterized but would not be expected to be very much less.

The other protective actions include: (a) 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, (b) 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 (c) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels reduce to such values by radioactive decay and weathering so that land and property can be economically decontaminated as in (b) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment.

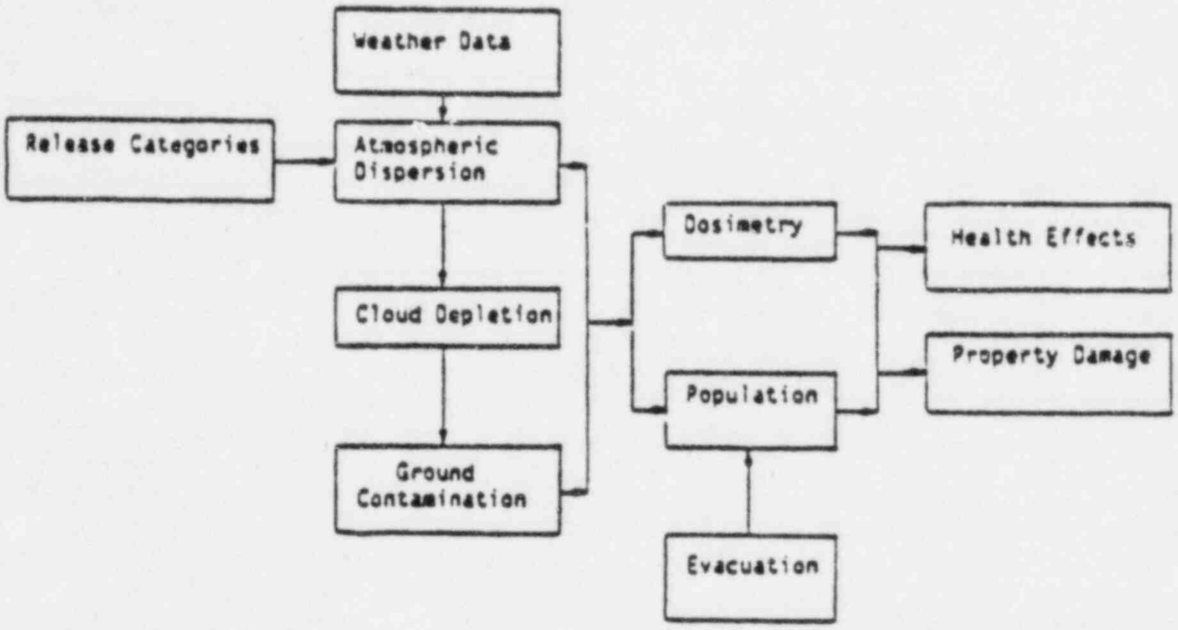

Figure 5.4. Schematic Outline of Atmospheric Pathway Consequence Model.

Early evacuation within and early relocation of people from outside (see Appendix F) the plume exposure pathway EPZ and other protective actions as mentioned above are considered as essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for the Clinton reactor includes 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 accident probabilities (see Fig. 5.4).

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.

5.9.4.1.4.3 Dose and Health Impacts of Atmospheric Releases

The results of the calculations of dose and health impacts performed for the Clinton facility and site are presented in the form of probability distributions in Figures 5.5 through 5.8 and are included in the Impact Summary Table 5.10. All of the six accident sequences and sequence groups shown in Table 5.8 contribute to the results, the consequences from each being weighted by its associated probability.

Figure 5.5 shows the probability distribution for the number of persons who might receive whole-body doses equal to or greater than 200 rem and 25 rem, and thyroid doses equal to or greater than 300 rem from early exposure,* all on a per-reactor-year basis. The 200-rem whole-body 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 (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and 300-rem thyroid figures correspond to the Commission's guideline values for reactor siting in 10 CFR Part 100.

The figure shows in the left-hand portion that there is less than two chances in 100,000 (i.e., 2×10^{-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 each of the three curves approaches a horizontal line shows that if one person were to receive such doses the chances are about the same that several tens to hundreds would be so exposed. The chances of larger numbers of persons being exposed at these levels are seen to be considerably smaller. For example, the chances are less than 1 in 100,000,000 (10^{-8}) that several thousand or more people might receive whole body doses of 200 rem or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 48.4-km (30-mi) radius of the plant. Virtually all would occur within a 161.3-km (100-mi) radius.

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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.

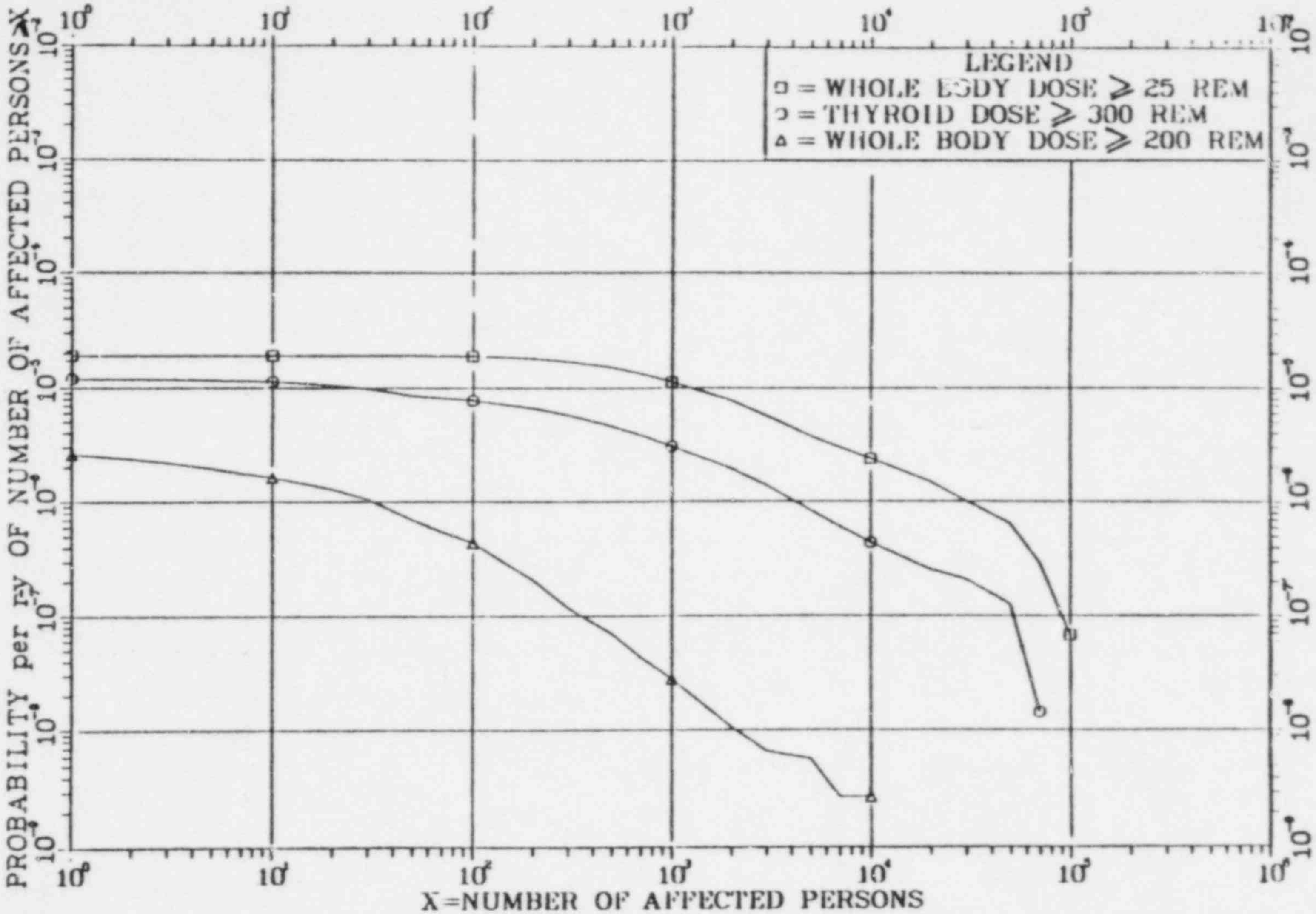

Figure 5.5. Probability Distributions of Individual Dose Impacts.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

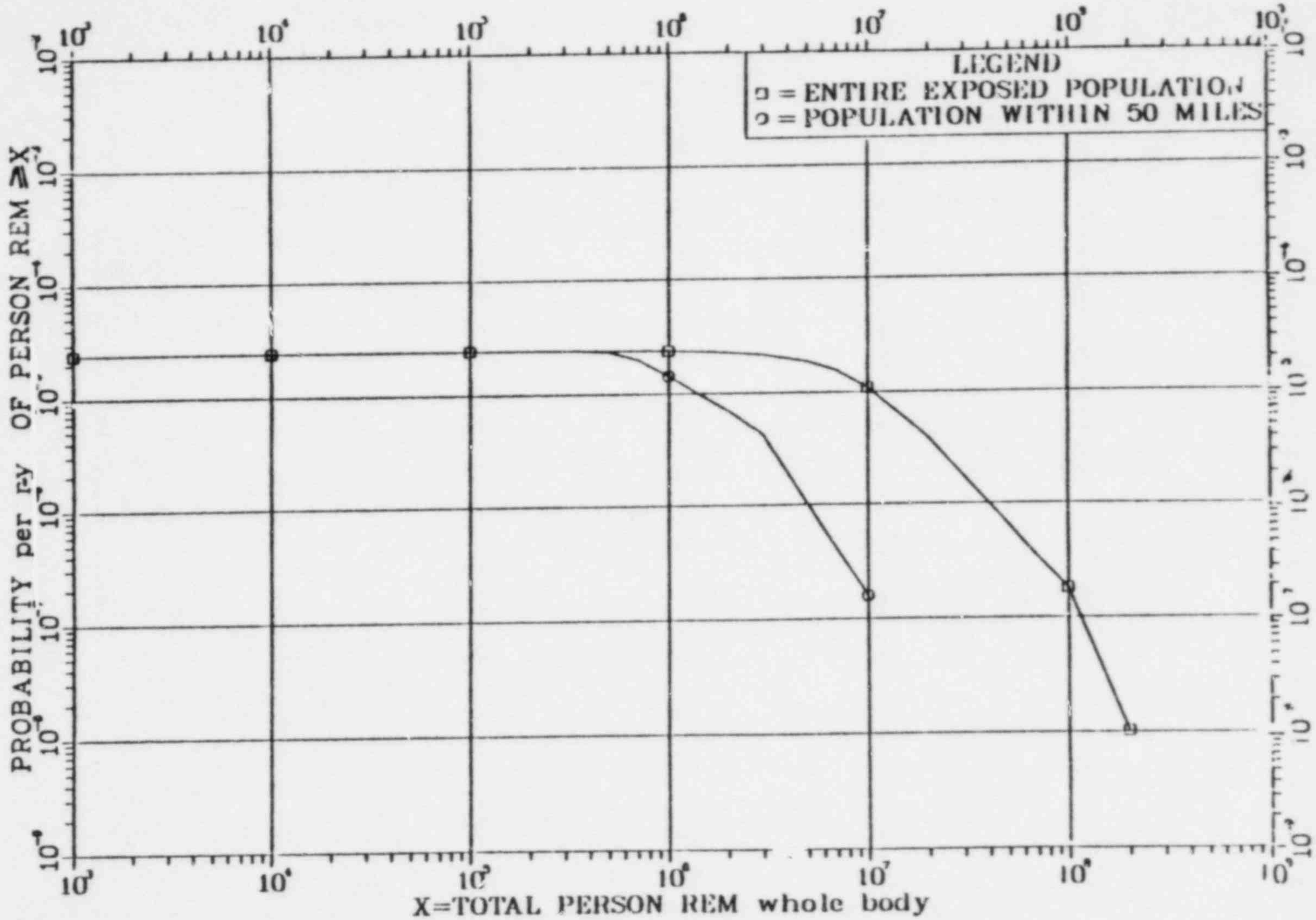

Figure 5.6. Probability Distributions of Population Exposures.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

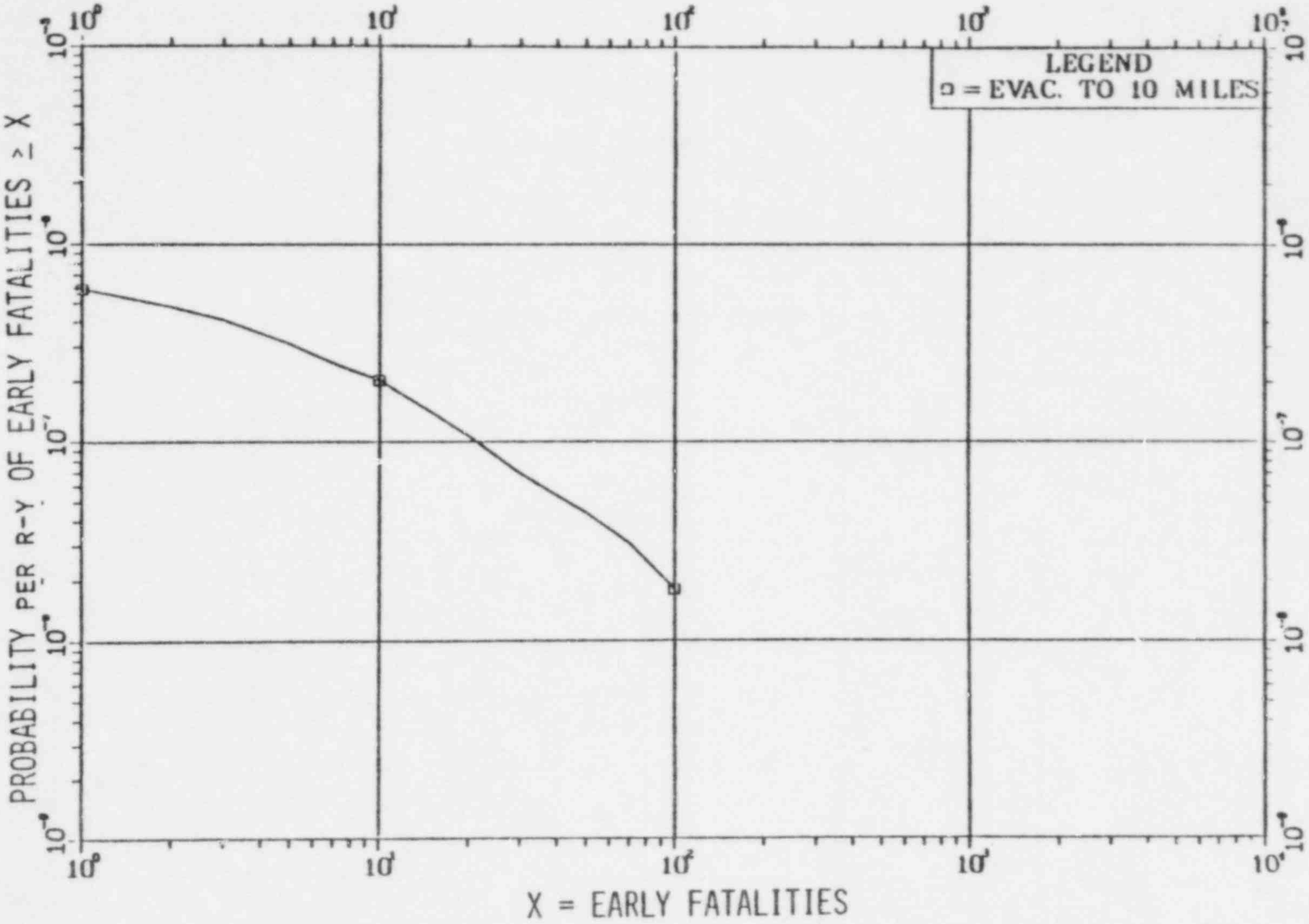

Figure 5.7. Probability Distribution of Early Fatalities.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

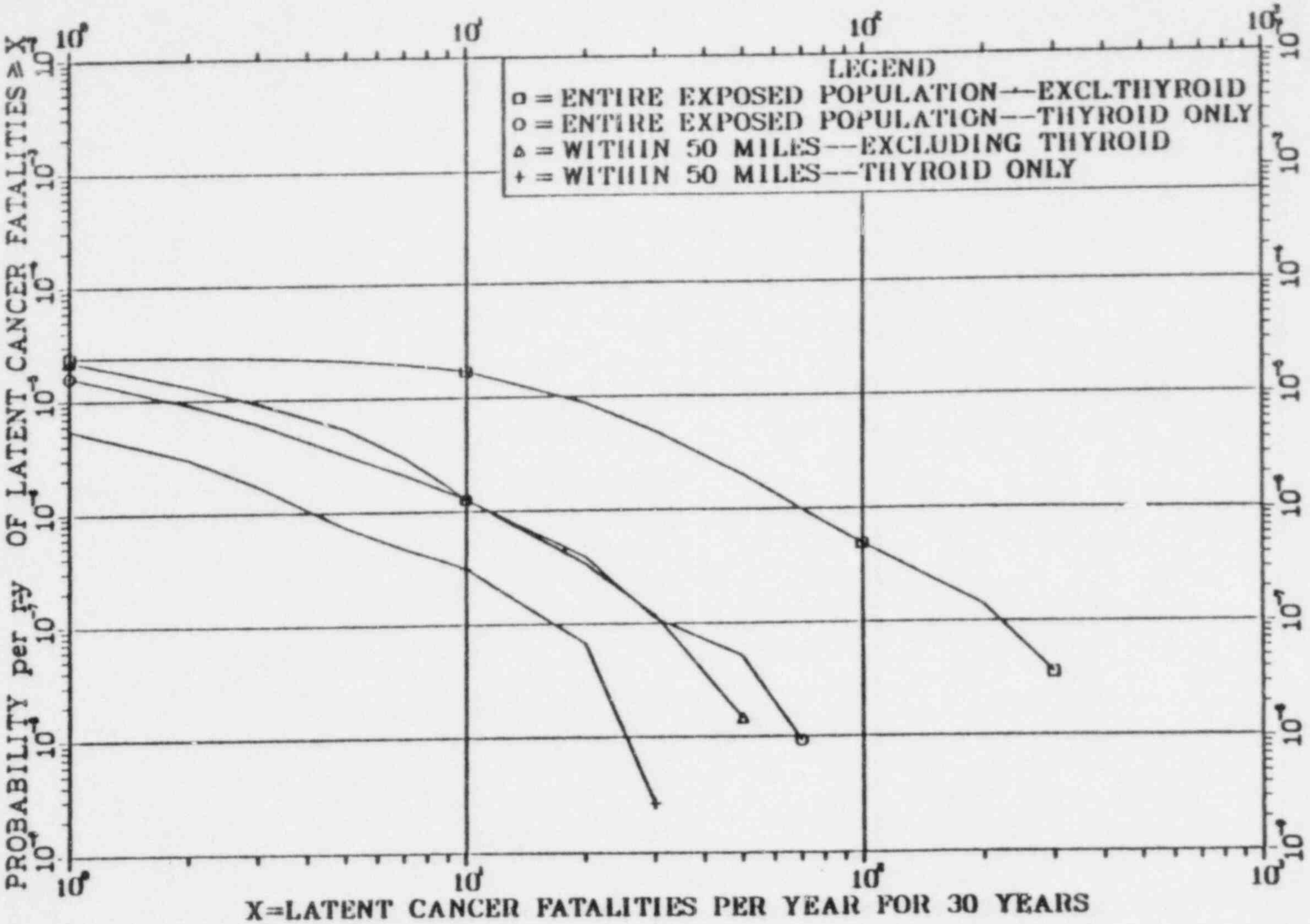

Figure 5.8. Probability Distribution of Cancer Fatalities.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

Table 5.10. Summary of Environmental Impacts and Probabilities

Probability of Impact per Reactor-Year	Persons Exposed over 200 rem	Persons Exposed over 25 rem	Early Fatalities	Population Exposure Millions of person-rem 50 mi/Total	Latent* Cancers 50 mi/ Total	Cost of Offsite Mitigating Actions Millions of Dollars
10^{-4}	0	0	0	0/0	0/0	0
10^{-5}	0	1,200	0	1.3/11	125/510	180
5×10^{-6}	0	3,200	0	2.5/17	186/972	340
10^{-6}	31	30,000	0	5/40	453/2,430	920
10^{-7}	340	90,000	21	12/115	1,380/7,560	2,800
10^{-8}	2,100	-------	140	---/200	2,220/11,100	9,100
Related Figure	5.5	5.5	5.7	5.7	5.8	5.9

*Includes cancers of all organs. Thirty times the values shown in the Figure 5.8 are shown in this column reflecting the 30-year period over which cancers might occur. Genetic effects might be approximately twice the number of latent cancers.

NOTE: Please refer to Section 5.9.4.1.4.7 for a discussion of uncertainties in risk estimates.

Figure 5.6 shows the probability distribution for the total population exposure in person-rem, i.e., the probability per year that the total population exposure will equal or exceed the values given. Most of the population exposure up to 1 million person-rem would occur within 80 km (50 mi), but the more severe accident sequences or sequence groups such as the first three in Table 5.8 would result in exposure to persons beyond the 80-km (50-mi) range as shown.

For perspective, population doses shown in Figure 5.6 may be compared with the annual average dose to the population within 80 km of the Clinton site due to natural background radiation of 94,500 person-rem, and to the anticipated annual population dose to the general public from normal station operation of about 1 person-rem (excluding plant workers)--see Section 5.9.3.

Figure 5.7 shows the probability distributions for early fatalities, representing radiation injuries that would produce fatalities within about one year after exposure. All of the early fatalities would be expected to occur within a 24.2-km (15-mi) radius and the majority within a 3.2-km (2-mi) radius. The results of the calculations shown in this figure and in Table 5.10 reflect the effect of evacuation within the 16.1-km (10-mi) plume exposure pathway EPZ only.

For the very low probability accidents having the potential for causing radiation exposures above the threshold for early fatality at distances beyond 16.1 km (10 mi), it would be realistic to expect that authorities would evacuate persons at all distances at which such exposures might occur. Early fatality consequences would therefore reasonably be expected to be very much less than the numbers shown. [Figure F.1 of Appendix F illustrates the potential benefits of evacuation within 24.2 km (15 mi).]

Figure 5.8 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 (50 mi) are shown separately. Further, the fatal, latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

5.9.4.1.4.4 Economic and Societal Impacts

As noted in Section 5.4.1.1, various measures for avoidance of adverse health effects including those due to residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for the Clinton facility and environs have also been made. Unlike the radiation exposure and adverse 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 5.9 and are included in the Impact Summary Table 5.10. 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 due 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 5.9 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, less than one chance in ten million per reactor-year.

Additional economic impacts that can be monetized include costs of decontamination of the facility itself and the costs of replacement power. Probability distributions for these impacts have not been calculated, but they are included in the discussion of risk considerations in Section 5.9.4.1.4.6 below.

5.9.4.1.4.5 Releases to Groundwater

A pathway for public radiation exposure and environmental contamination that would be unique for severe nuclear reactor accidents was identified in Section 5.9.4.1.1.2 above. Consideration has been given to the potential environmental impacts of this pathway for the Clinton Power Station. The principal contributors to the risk are the core-melt accidents. 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 to 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 escape of radioactive ECCS 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) (Ref. 60). The LPGS compares the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming and shoreline usage) for four 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 they represented no real sites in particular. The study concluded that the individual and population doses for the liquid pathway through groundwater contamination range from small fractions to very small fractions of those that can arise from the atmospheric pathways.

The discussion in this section is a summary of an analysis performed to determine whether or not the liquid pathway consequences of a postulated accident at the Clinton site initiated by a release to groundwater beneath a reactor would be unique when compared to the generic Small River land-based site considered in

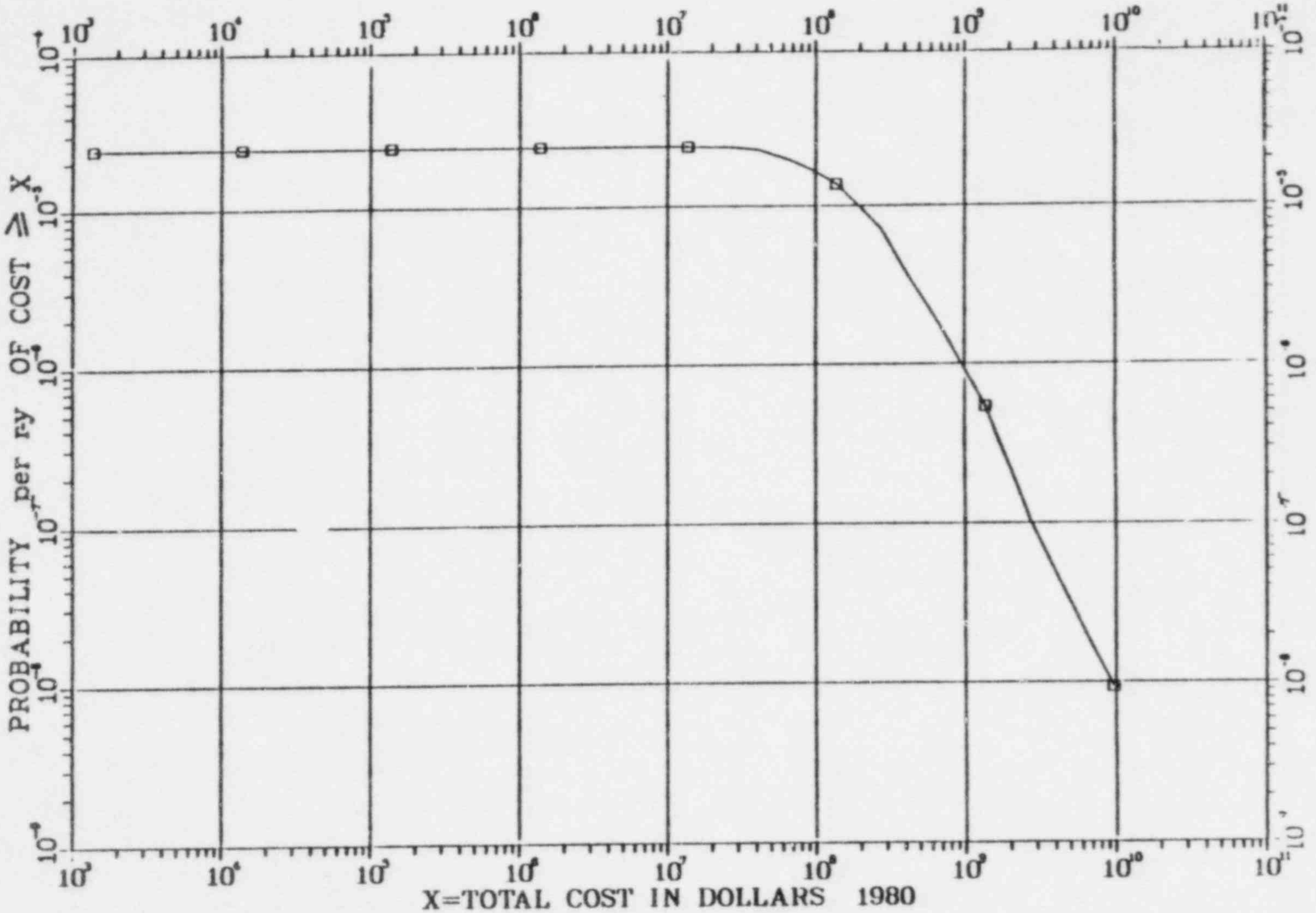

Figure 5.9. Probability Distribution of Mitigation Measures Cost.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

the LPGS. The comparison is made on the basis of population doses from drinking contaminated water and eating contaminated fish. The parameters which were evaluated include the amounts and rate of release of radioactive materials to the ground, groundwater travel time, sorption on geological media, surface water transport, drinking water usage, and aquatic food consumption.

All of the reactors considered in the LPGS were Westinghouse pressurized water reactors (PWR) with ice condenser containments. There are likely to be significantly different mechanisms and probabilities of releases of radioactivity for the Clinton boiling water reactor (BWR). The staff is not aware of any studies which indicate the probabilities or magnitudes of liquid releases for boiling water reactors. It is unlikely, however, that the liquid release for a BWR would be any larger than that conservatively estimated for similarly sized PWRs in the LPGS. The source term used for Clinton in this comparison therefore is assumed to be equal to that 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 significant 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 water-related activities might 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 Clinton site is located on Lake Clinton, which is formed by the damming of the Salt Creek and North Fork drainages. Groundwater at the site exists in Pleistocene glacial tills and underlying bedrock units, and in discontinuous sand lenses.

Contaminants released in a postulated core melt accident would be initially deposited to the soil beneath the site and transported in the direction of Lake Clinton by groundwater flow. There are no groundwater users along this pathway. A conservative analysis of possible flow paths through sand lenses was used to calculate a minimum groundwater travel time of 172 days from the reactor to the lake. For groundwater travel times of this magnitude, the most important contributors to population dose would be Cs-137 and Sr-90. These radionuclides would be adsorbed to an extent by the geologic media through which they were flowing. This would have the effect of delaying their arrival to the lake. Published values (Ref. 61) of geohydrologic and geochemical properties for materials similar to those underlying the site were used to calculate conservative or realistic values of the retardation coefficient, R_d, which is the ratio of the groundwater velocity to the velocity of the sorbed substance. The conservative and realistic values of R_d for strontium were estimated to be 17 and 68, respectively. For cesium, the conservative and realistic values of R_d were estimated to be 211 and 960, respectively. These estimated values of R_d were used to estimate the fraction of available core inventory which could be released through the groundwater pathway. In the "conservative" case, 82% of the Sr-90 and 10% of the Cs-137 would be released to Lake Clinton. In the "realistic" case, 47% of the Sr-90 and 0.003% of the Cs-137 would be released to Lake Clinton. These figures compare to the 87% Sr-90 release and the 31% Cs-137 release for the LPGS site.

Radioactivity entering Lake Clinton would mix in the lake and be transported downstream, affecting Salt Creek, the Sangamon River, the Illinois River, and the Mississippi River. The nearest drinking water users would be on the Mississippi River. Approximately 2.1 million drinking water users would be exposed as compared to about 0.61 million in the Liquid Pathway Generic Study small-river case. Values of populations, flow rates, and radionuclide releases were used to calculate a relative drinking water population dose for the Clinton site compared to the LPGS small-river site. The drinking water population dose for the Clinton site is 64% of that calculated in the LPGS for the "conservative" retardation coefficients and 31% for the "realistic" retardation coefficients.

Quantities of all recreational and sports fish catch were estimated to be 7×10^6 kg/yr (1.5×10^7 lb/yr) from affected waters between the Clinton site and the Mississippi River delta. This compares to the approximately 1.2×10^6 kg/yr (2.6×10^6 lb/yr) catch used in the LPGS. Most of the exposure in the Clinton case would come from the estimated 35,000 to 90,000 kg/yr (77,175 to 198,450 lb/yr) catch in Lake Clinton, immediately adjacent to the site. Dilution in the lake is small because the annual average flow rate through the lake is only about 5.6 m^3/s (200 ft^3/s). The greatest portion of the fish catch in the Clinton case, though, would be in the Mississippi River, where average flow rates are on the order of 14,160 m^3/s (500,000 ft^3/s).

Two cases of population dose caused by the ingestion of contaminated fish were evaluated. The "conservative" case used the lower values of retardation coefficients and the upper estimate for fish catch in Lake Clinton at 90,000 kg/yr (198,450 lb/yr). The population dose for this case was determined to be a factor of about 23 times higher than the LPGS fish ingestion case. About 95% of the exposure was due to Lake Clinton and Salt Creek. If these bodies of water were excluded from consideration, the fish ingestion contribution to population would have been only a factor of 1.1 times the LPGS case.

The second case of population dose caused by fish ingestion was evaluated using "realistic" values of the retardation coefficients and the best estimate of fish catch in Clinton Lake of 35,000 kg/yr (77,175 lb/yr). The population dose contribution from ingestion of fish was determined to be a factor of 1.3 times the LPGS case. This factor would be reduced to about 18% of the LPGS case if Lake Clinton and the Salt Creek fisheries were not included.

When population doses from the Clinton site drinking water and fish ingestion pathways are combined, they range from about a factor of 250% to 40% of the LPGS population doses. If the Clinton Lake and Salt Creek fisheries are not included, the relative population doses compared to the LPGS site are about 70% to 31%. The staff believes that these estimates are conservative because the presence of a viable groundwater pathway through a sand lens from the site to the lake is not a certainty, and conservative estimates of transport along this hypothetical pathway have been used.

The Clinton liquid pathway contribution to population dose, therefore, has been demonstrated to be of the same order of magnitude as that predicted for the LPGS small-river site. Thus, the Clinton site is not unique in its liquid pathway contribution to risk.

Finally, there are measures which could be taken to minimize the impact of the liquid pathway. The staff estimated that the minimum groundwater travel time from the Clinton site to Lake Clinton would be about 172 days, and that the holdup of much of the radioactivity would be even greater. This would allow ample time for engineering measures such as slurry walls and well-point dewatering to isolate the radioactive contamination near the source.

5.9.4.1.4.6 Risk Considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Since the ranges of both factors are quite broad, it is useful to combine them to obtain average measures of environmental risk. Such averages 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 people's attitudes about risk, 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.

In Table 5.11 are shown average values of risk associated with population dose, acute fatalities, latent fatalities, and costs for early 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. Since the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

Table 5.11. Average Values of Environmental Risks due to Accidents per Reactor-Year

Population exposure	
person-rem within 50 miles	44
person-rem total	320
Early Fatalities	0.000009
Latent cancer fatalities	
all organs excluding thyroid	0.017
thyroid only	0.0021
Cost of protective actions and decontamination	$6,700

NOTE: Please see Section 5.9.4.1.4.7 for discussions of uncertainties in risk estimates.

The population exposure risk due to accidents may be compared with that for normal operations. These are shown in Section 5.9.3 for Clinton Unit 1. The radiological dose to the population from normal operation may result in about 1 person-rem per year, which may result in about 0.0001 latent cancer in the exposed population.

There are no acute fatality nor 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 acute fatality risk of about 0.000009 per year, however, we note that to a good approximation the population at risk is that within about 24.2 km (15 mi) of the station, about 45,000 persons in the year 2000. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 10 for motor vehicle accidents, 4 from falls, 1 from drowning, 1 from burns, and 0.5 from firearms (Ref. 62). The early fatality risk of 0.000009 per reactor-year is thus an extremely small fraction of the total risk embodied in the above combined accident modes.

Figure 5.10 shows the calculated risk expressed as whole-body dose to an individual from early exposure as a function of the distance from the station within the plume exposure pathway EPZ. The values are on a per-reactor-year basis and all accident sequences and sequence groups in Table 5.8 contributed to the dose, weighted by their associated probabilities.

Evacuation and other protective actions reduce the risks to an individual of acute and latent cancer fatalities. Figure 5.11 shows curves of constant risk per reactor-year of acute fatality to an individual within the 16-km (10-mi) radius plume exposure pathway EPZ as functions of distance due to potential accidents in the reactor. Figure 5.12 shows curves of constant risk per reactor-year to an individual living within the plume exposure pathway EPZ of death from latent cancer. Subsection 5.9.4.1.3.2, "Site Features", discusses the relationship of the exclusion area and low population zone to the features of Figure 5.11. A discussion of the emergency planning zone with respect to other features of Figure 5.11 is found in subsection 5.9.4.1.4.6. Directional variation of these curves reflect the variation in the average fraction of the year the wind would be blowing into different directions from the station. For comparison the following risks of fatality per year to an individual living in the U.S. may be noted (Ref. 62); 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}.

The relative consequences and risks due to contamination fo Lake Michigan as a result of atmospheric fallout from severe accidents in the Clinton Unit 1 reactor would be similar in kind to those determined for contamination of Lake Erie and the other Great Lakes via the severe accident atmospheric fallout route for a Perry (PNPP) (Ref. 71) reactor which was in turn based on calculations performed for the Fermi Unit 2 plant (Ref. 72). Clinton Unit 1 is, however, more than 210 km (130 mi) from Lake Michigan, whereas Perry is on the Lake Erie shore. Thus, atmospheric concentrations of airborne radionuclides over Lake Michigan due to a severe accident at Clinton would be substantially less than similar concentrations over Lake Erie due to a severe accident at PNPP.

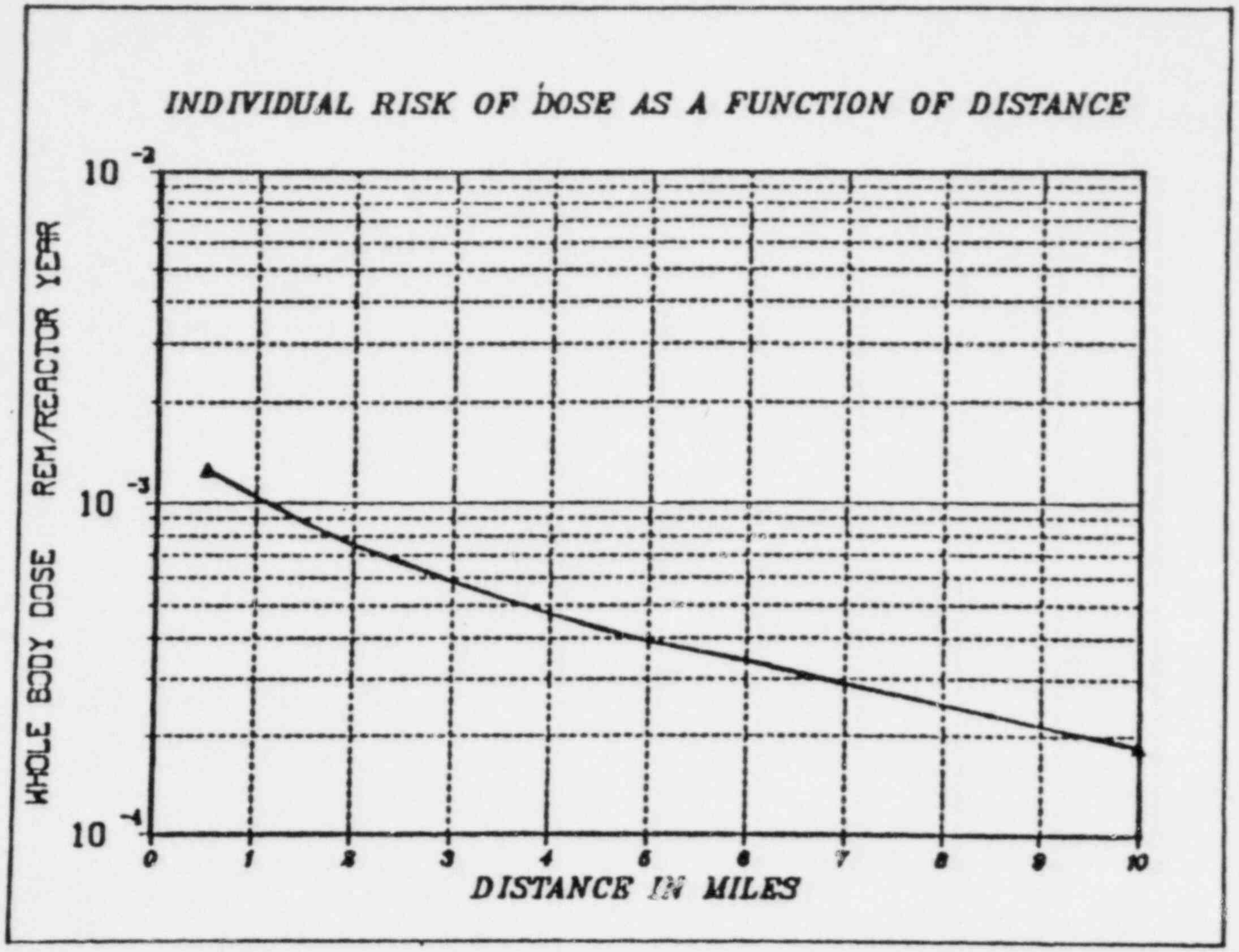

Figure 5.10. Individual Risk of Dose as a Function of Distance.

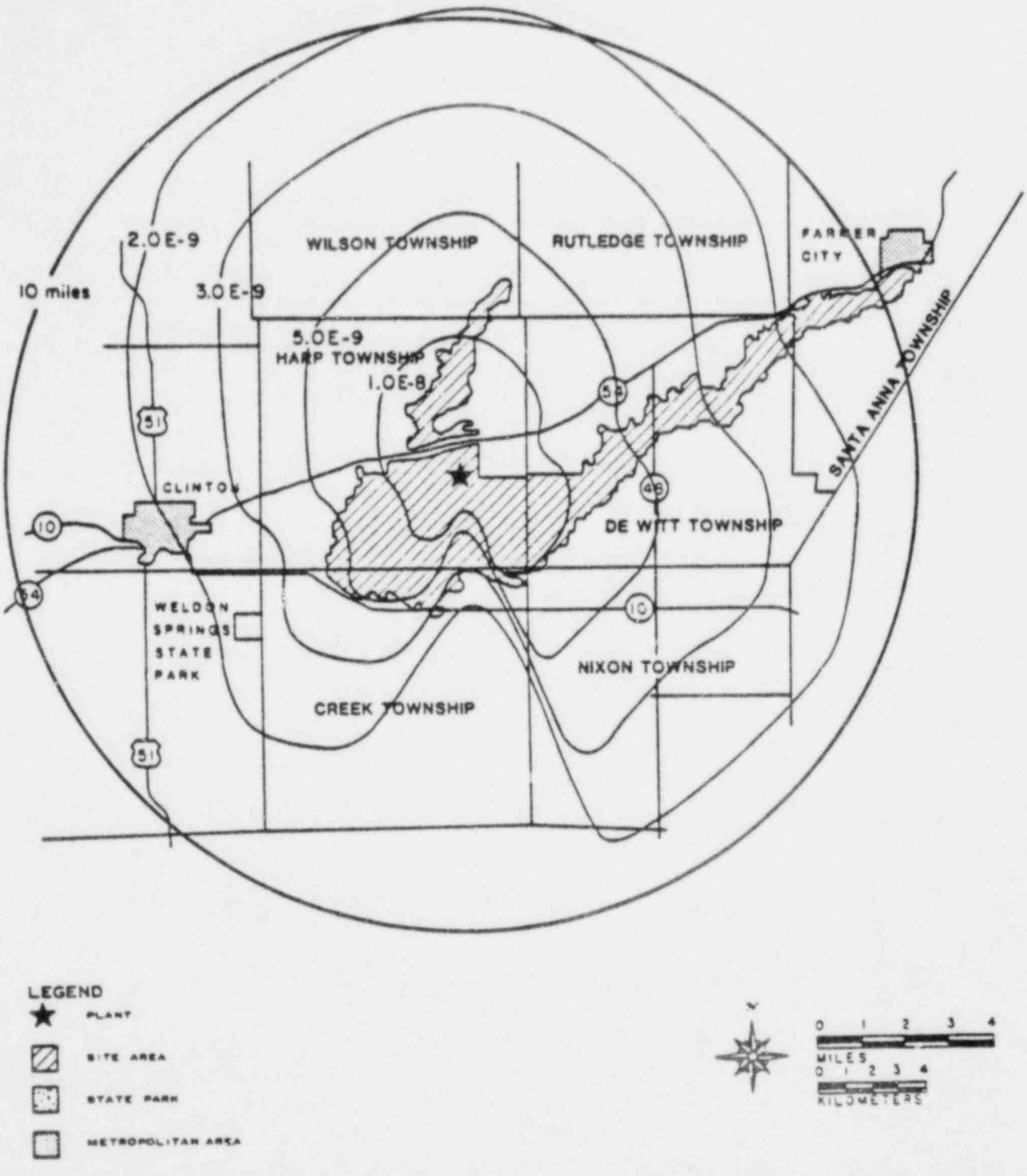

Figure 5.11. Isopleths of Risk of Early Fatality per Reactor Year to an Individual.

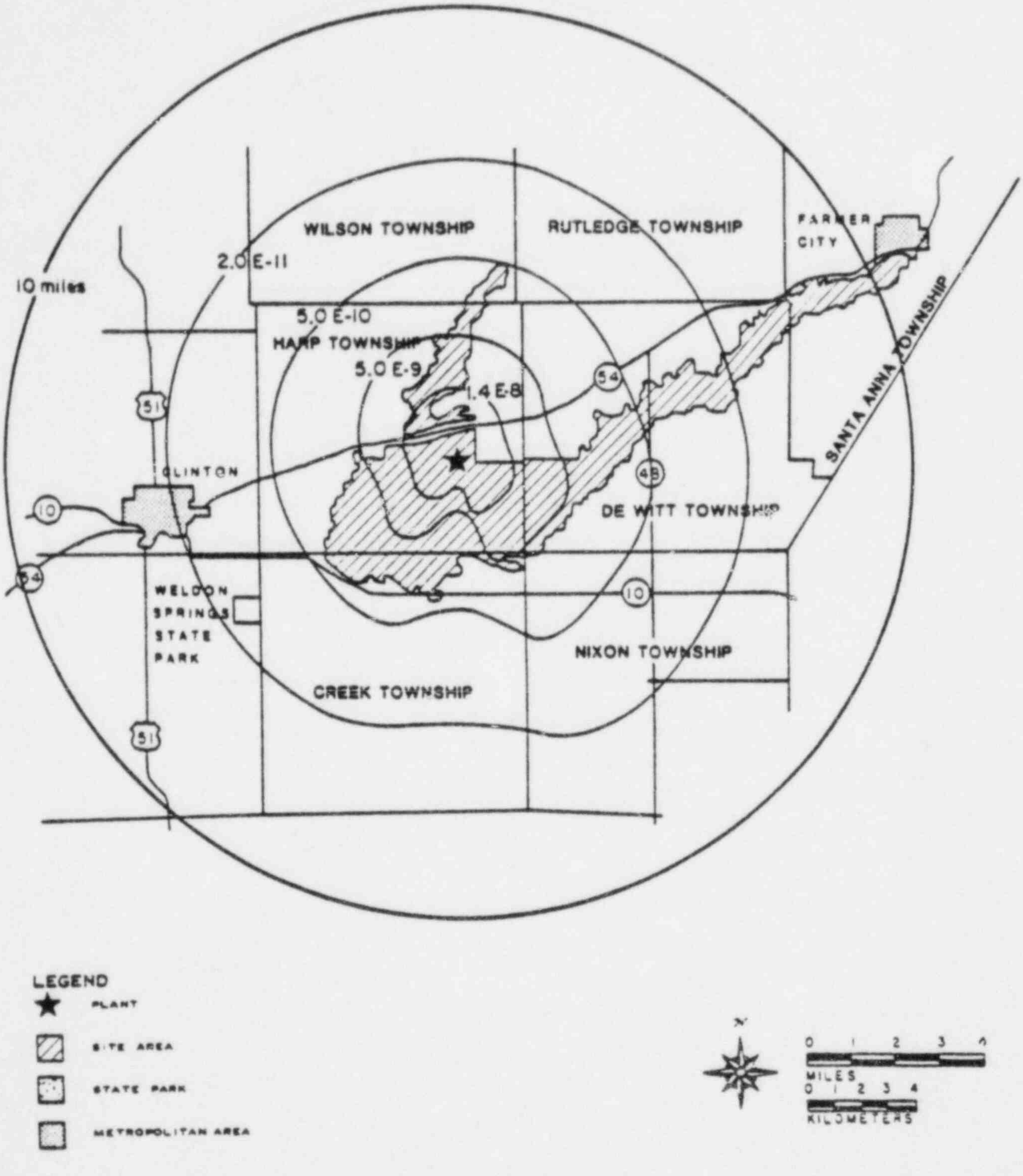

Figure 5.12. Isopleths of Risk of Latent Cancer Fatality per Reactor Year to an Individual.

The consequences and risks to society and an individual of delayed cancer fatalities from unrestricted (without any decontamination or interdiction of exposure pathways) use of Lake Michigan and the other Great Lakes contaminated by fallout from atmospheric releases from the Clinton Unit 1 reactor would be of similar orders of magnitude as those resulting from the exposure pathways from air and ground contamination following these releases, shown in Tables 5.10 and 5.11 and Figure 5.12. These latter consequences and risks were calculated only after exposure pathways interdiction or decontamination was assumed. If similar interdiction of or decontamination in exposure pathways arising from Lake Michigan and the other Great Lakes were assumed, then the consequences and risks from fallout on the Great Lakes would be small compared to those from air and ground contamination, and would not alter conclusions with respect to accident risks compared to risks of normal operation, or with respect to Clinton accident risks compared to other accident risks to which the general population is exposed.

The economic risk associated with protective actions and decontamination could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels, coal or oil, for example, would emit substantial quantities of sulfur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (Ref. 63). This effect has not, however, been sufficiently quantified to draw a useful comparison at this time.

There are other economic impacts and risk that can be monetized that are not included in the cost calculations discussed in Section 5.9.4.1.4.4. These are accident impacts on the facility itself that result in added costs to the public, i.e., 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 Three Mile Island accident. If an accident occurs during the first full year of Clinton Unit 1 operation (1984), the economic penalty associated with the initial year of the unit's operation is estimated at between \$950 million and \$1600 million (Ref. 64) for decontamintion and restoration, including replacement of the damaged nuclear fuel. For purposes of this analysis, staff will choose the conservative (high) estimate of \$1600 million and assume the total cost occurs during the first year of the accident, whereas in reality the costs would be spread over several years thereafter. Although insurance would cover \$300 million of the \$1600 million, the insurance is not credited against the \$1600 million because the \$300 million times the risk probability should theoretically balance the insurance premium. In addition, staff estimates additional fuel costs of \$85 million for replacement power during each year the station is being restored. This estimate assumes that the energy that would have been forthcoming from Clinton Unit 1 (assuming 60% capacity factor) will be replaced primarily by coal-fired generation in the Illinois-Missouri area. Assuming inoperation of the nuclear unit for eight years, the total additional replacement power costs would be approximately \$680 million.

If the probability of sustaining a total loss of the original facility is taken as the sum of the occurrences of a core melt accident (the sum of the probabilities for the categories in Table 5.8) then the probability of a disabling accident happening during each year of the unit's service life is 2.43×10^{-5}. Multiplying the previously estimated costs of \$2280 million for an accident to Clinton during the initial year of its operation by the above 2.43×10^{-5} probability results in an economic risk of approximately $55,000 applicable to Clinton during its first year of operation. This is also approximately the economic risk during the second and each subsequent year of its operation. Although nuclear units depreciate in value and may operate at reduced capacity factors such that the economic consequences due to an accident become less as the units become older, this is considered to be offset by higher costs of decontamination and restoration of the units in the later years due to inflation.

5.9.4.1.4.7 Uncertainties

The foregoing probabilistic and risk assessment discussion has been based upon the methodology presented in the Reactor Safety Study (RSS) which was published in 1975.

In July 1977, the NRC organized an Independent Risk Assessment Review Group to (1) clarify the achievements and limitations of the Reactor Safety Study Group, (2) assess the peer comments thereon and the responses to the comments, (3) study the current state of such risk assessment methodology, and (4) recommend to the Commission how and whether such methodology can be used in the regulatory and licensing process. The results of this study were issued September 1978 (Ref. 58). This report, called the Lewis Report, contains several findings and recommendations concerning the RSS. Some of the more significant findings are summarized below.

(1) A number of sources of both conservatism and nonconservatism in the probability and consequence calculations in RSS were found, which were very difficult to balance. The Review Group was unable to determine whether the overall probability of a core melt given in the RSS was high or low, but they did conclude that the error bands were understated.

(2) The methodology, which was an important advance over earlier methodologies that had been applied to reactor risk, was sound.

(3) It is very difficult to follow the detailed thread of calculations through the RSS. In particular, the Executive Summary is a poor description of the contents of the report, should not be used as such, and has lent itself to misuse in the discussion of reactor risk.

On January 19, 1979, the Commission issued a statement of policy concerning the RSS and the Review Group Report. The Commission accepted the findings of the Review Group.

The accident at Three Mile Island 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 (Ref. 65). It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents like that one, by a significant number of investigative groups both within NRC and outside of it. 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, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident," NUREG-0660, Vol. I, May 1980, collects 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 will result in a gradually increasing improvement in safety as individual actions are completed. The Clinton station is receiving and will receive the benefit of these actions on the schedule indicated in NUREG-0660. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements.

5.9.4.1.5 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the Clinton facility. These 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 severely damaged reactor core or core melt.

The environmental impacts that have been considered include potential 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 (a) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment; (b) that, in order to obtain a license to operate the Clinton facility, it must comply with the applicable Commission regulations and requirements; and (c) a probabilistic assessment of the risk based upon the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents shows that it is roughly comparable to the risk for normal operational releases although accidents have a potential for early fatalities and economic costs that cannot arise from normal operations. The risks of early fatality from potential accidents at the site are small in comparison with the risks of acute fatality from other human activities in a comparably sized population.

We have concluded that there are no special or unique features about the Clinton site and environs that would warrant special mitigation features for the Clinton Unit 1 station.

5.10 THE URANIUM FUEL CYCLE

The Uranium-Fuel-Cycle Rule 10 CFR Part 51.20 (44 FR 45362) 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" (Ref. 66), and NUREG-0216 (Ref. 67) 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" (Ref. 68). 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. This explanatory narrative was published in the Federal Register on March 4, 1981 (46 FR 15154-15175). Appendix G 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 herein as Table 5.12. 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 G to this statement contains a description of the environmental impact assessment of the uranium fuel cycle as related to the operation of the Clinton Power Station. 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 the station 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 part of the facility site that is not permanently committed 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" (Ref. 69).

Since 1960, 68 nuclear reactors, including five licensed reactors that had been used for the generation of electricity, 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 decommissioning smaller facilities is generally relevant to the decommissioning of any type of nuclear facility.

Radiation doses to the public, as a result of decommissioning activities at the end of a commercial power reactor's useful life, should be small and 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.

Table 5.12 (Table S.3). Table of 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.
Permanentiy 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.
HC1	.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	
C1	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 5.12 (Table S.3). 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)	22.6	From reprocessing and waste management.

[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.

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

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

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

The NRC is currently conducting a generic rulemaking which 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.

An estimate of the economic cost of decommissioning Clinton 1 is provided in Table 6.1.

5.12 EMERGENCY PLANNING

Emergency preparedness plans, including protective action measures for the Clinton facility and environs, are in an advanced, but not yet fully completed stage. 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 system will be infrequent and insignificant.

References for Section 5

1. "D.W. Schlinder, "Carbon, Nitrogen and Phosphorous and the Eutrophication of Freshwater Lakes," Journal of Phycology 7(4):321-329, 1971.

2. H. Stefan, T. Skaglund, and R. Megard, "Wind Control of Algae Growth in Eutrophic Lakes," Journal of the Environmental Engineering Division, American Society of Civil Engineers, Vol. 102 (EE6), pp. 1201-1213, 1976.

3. "R.A. Vollenweider and F.J. Dillon, "The Application of the Phosphorous Loading Concept to Eutrophication Research," NCR Assoc. Comm. on Sci. Criteria for Environmental Quality, Canada Center for Inland Waters, Burlington, Ontario, Canada, 1974.

4. "R.L. Culp, G.M. Wesner, and G.L. Culp, "Handbook of Advanced Wastewater Treatment," Van Nostrand Reinhold, 1978.

5. "W.J. Weber, "Physicochemical Processes for Water Quality Control," Wiley Interscience, 1972.

6. "Thermal Demonstration Pursuant to Illinois Pollution Control Board Rules and Regulations, Chapter 3, Section 203 i (10)," prepared by Energy Impact Associates, Pittsburgh, for Illinois Power Company, July 1980.

7. State of Illinois Pollution Control Board Rules and Regulations, Chapter 3: Water Pollution, 1980.

8. E.L. Currier et al., "Cooling Pond Steam Fog," J. Air Pollut. Control Assoc. 24:860-864, 1974.

9. B.B. Hicks, "The Prediction of Fog Over Cooling Ponds," J. Air Pollut. Control Assoc. 27:140-142, 1977.

10. B.B. Hicks, "The Generation of Steam Fog Over Cooling Ponds," In: "Environmental Effects of Atmospheric Heat/Moisture Releases," K.E. Torrance and R.G. Watts (eds.), pp. 14-15, Am. Soc. Mech. Eng., New York, NY, May 1978.

11. J.R. Murray and D.W. Trettel, "Report on Meteorological Aspects of Operating the Cooling Lake and Sprays at Dresden Nuclear Plants," Report 1001-5 to Commonwealth Edison Co., Chicago, IL, August 1, 1973.

12. J.L. Vogel and F.A. Huff, "Steam Fog Occurrences over Cooling Lakes," In: "Preprints of the Sixth Conference on Planned and Inadvertent Weather Modification," Boston, MA, 10-13 October 1977, pp. 69-72, Am. Meteorol. Soc., 1977.

13. F.A. Huff, and J.L. Vogel, "Meteorological Effects from Large Cooling Lakes," In: "Proceedings of the Second Waste Heat Management and Utilization Conference," Miami Beach, FL, December 4-6, 1978.

14. R.G. Everett and G.A. Zerbe, "Winter Field Program at the Dresden Cooling Ponds," Radiol. and Environ. Res. Div. Annual Report, ANL 76-88, Pt. IV, Atmospheric Physics, Jan-Dec 1976, pp. 108-113, 1977.

15. J.D. Shannon and R.G. Everett, "Effects of the Severe Winter Upon a Cooling Pond Fog Study," Bull. Am. Meteorol. Soc. 59:60-61, 1978.

16. J.E. Carson, "Atmospheric Impacts of Evaporative Cooling Systems," Argonne National Laboratory Report ANL/ES-53, 1976.

17. J.E. Carson, "Meteorological Effects of Evaporative Cooling Systems," In: "Atmospheric Planetary Boundary Layer Physics. Developments in Atmospheric Science, 11," A. Longhetto (ed.), pp. 287-326, Elsevier Scientific Publishing Company, 1980.

18. John Cole, "Clinton Lake State Recreation Area, W-76-D. Wildlife Resources Management Plan," Illinois Department of Conservation, March 1981.

19. A.D. Phillips and W.T. Kaune, "Effects of Electric Fields on Small Laboratory Animals," Batelle Pacific Northwest Laboratories, presented at Environmental Control Symposium, Washington DC, November 27-30, 1978.

20. "Evaluation of Health and Environmental Efforts of Extra High Voltage (EHV) Transmission," ITT Research Institute, Chicago, prepared for the U.S. Environmental Protection Agency, February 1979.

21. "Potential Environmental Effects of 765-kV Transmission Lines," views presented before the New York State Public Service Commission, Cases 265-29 and 265-59, 1976-1978, U.S. Department of Energy, Division of Environmental Control Technology, November 1979.

22. "Final Environmental Impact Statement - 500 kV International Transmission Line NSP-TR-1," Northern States Power Co., U.S. Department of Energy, DOE/EIS-0032, 1979.

23. "Draft Environmental Statement Related to Operation of Callaway Plant Unit 1," U.S. Nuclear Regulatory Commission, Docket No. 50-483, NUREG-0813, September 1981.

24. "Draft Environmental Statement Related to Operation of Grand Gulf Nuclear Station, Units 1 and 2," U.S. Nuclear Regulatory Commission, Docket Nos. 50-416, 50-417, NUREG-0777, May 1981.

25. "Development Document for Best Technology Available for the Location, Design, Construction, and Capacity of Cooling Water Intake. Structures for Minimizing Adverse Environmental Impact." U.S. Environmental Protection Agency, EPA 440/1-76/015-a, April 1976.

26. J.A. Smithson, "Control and Treatment of Asiatic Clams in Power Plant Intakes," Presented at 43rd Annual Meeting of the American Power Conference, April 27-29, 1981.

27. [Deleted]

28. [Deleted]

29. W.C. Alpaugh, "High Lethal Temperatures of Golden Shiners (Notemigonus crysoleucas), Copeia 1972(1):185, 1972.

30. "Standards for Protection Against Radiation," Title 10 Code of Federal Regulations Part 20, January 1981.

31. "Domestic Licensing of Production and Utilization Facilities," Title 10 Code of Federal Regulations Part 50, January 1981.

32. "Environmental Radiation Protection Standards for Nuclear Power Operations." Title 40 Code of Federal Regulations Part 190, January 1981.

33. "Radiation Protection," In: "Standard Review Plan," Chapter 12, NUREG-0800, U.S. Nuclear Regulatory Commission, July 1981.

34. "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.8, Revision 3, U.S. Nuclear Regulatory Commission, June 1978.

35. B. G. Brooks, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors, 1979," NUREG-0713, Vol. 1, U.S. Nuclear Regulatory Commission, March 1981.

36. Memo from C. S. Hinson to W. E. Kreger, U.S. Nuclear Regulatory Commission, "Preliminary LWR Exposure Data for 1980," May 28, 1981.

37. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (BEIR I), Advisory Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences/National Research Council, November 1972.

38. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (BEIR III), Committee on the Biological Effects of Ionizing Radiations, National Academy of Sciences/National Research Council, July 1980.

39. "Recommendations of the International Commission on Radiological Protection," International Commission on Radiological Protection, ICRP Publication 26, January 1977.

40. "Review of the Current State of Radiation Protection Philosophy," National Council on Radiation Protection and Measurements, NCRP Report No. 43, January 1975.

41. "Sources and Effects of Ionizing Radiation," United Nations Scientific Committee on the Effects of Atomic Radiation, 1977.

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

43. "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," Regulatory Guide 1.109, Revision 1, U.S. Nuclear Regulatory Commission, October 1977.

44. "Cancer Facts and Figures 1979," American Cancer Society, 1978.

45. B. G. Blaylock and J. P. Witherspoon, "Radiation Doses and Effects Estimated for Aquatic Biota Exposed to Radioactive Releases from LWR Fuel-Cycle Facilities," Nuclear Safety 17:351, 1976.

46. "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," Regulatory Guide 4.1, Revision 1, U.S. Nuclear Regulatory Commission, April 1975.

47. "An Acceptable Radiological Environmental Monitoring Program," Radiological Assessment Branch Technical Position, Revision 1, U.S. Nuclear Regulatory Commission, November 1979.

48. "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," Regulatory Guide 1.21, Revision 1, U.S. Nuclear Regulatory Commission, June 1974.

49. Statement of Interim Policy, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969," 45 FR 40101-40104, June 13, 1980.

50. "Final Safety Analysis Report (FSAR), Clinton Power Station Units 1 and 2, Docket Numbers 50-461 and 50-462," Illinois Power Company, August 29, 1980, as amended.

51. "Safety Evaluation Report (SER) related to the operation of Clinton Power Station, Unit 1, Docket No. 50-461," U.S. Nuclear Regulatory Commission, NUREG-0853, February 1982.

52. "Energy in Transition 1985 - 2010, "Final Report of the Committee on Nuclear and Alternative Energy Systems (CONAES), National Research Council, 1979, Chapter 9, pp. 517-534; also C.E. Land, Science 209, 1197, September 12, 1980.

53. H.W. Bertini et al., "Descriptions of Selected Accidents that Have Occurred at Nuclear Reactor Facilities," Nuclear Safety Information Center, Oak Ridge National Laboratory, ORNL/NSIC-176, April 1980; also, "Evaluation of Steam Generator Tube Rupture Accidents," L.B. Marsh, U.S. Nuclear Regulatory Commission, NUREG-0651, March 1980.

54. "Three Mile Island - A Report to the Commissioners and the Public," Vol. I, Mitchell Rogovin, Director, Nuclear Regulatory Commission Special Inquiry Group, Summary Section 9, January 1980.

55. "Report of the President's Commission on the Accident at Three Mile Island," Commission Findings B, Health Effects, October 1979.

56. "Reactor Safety Study," U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014), October 1975.

57. "Task Force Report on Interim Operation of Indian Point," U.S. Nuclear Regulatory Commission, NUREG-0715, August 1980.

58. H.W. Lewis et al., "Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission," U.S. Nuclear Regulatory Commission, NUREG/CR-0400, September 1978.

59. "Overview of the Reactor Safety Study Consequences Model," U.S. Nuclear Regulatory Commission, NUREG-0340, October 1977.

60. "Liquid Pathway Generic Study," U.S. Nuclear Regulatory Commission, NUREG-0440, February 1978.

61. D. Isherwood, "Preliminary Report on Retardation Factors and Radionuclides Migration," Lawrence Livermore Laboratories, UCID-A3.44, August 5, 1977.

62. CONAES Report, (Ref. 52) p. 577.

63. CONAES Report, (Ref. 52) pp. 559-560.

64. Report to the Congress by the Comptroller General of the United States, EMD-81-106, August 26, 1981.

65. CONAES Report, (Ref. 52) p. 553.

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

67. "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," U.S. Nuclear Regulatory Commission, NUREG-0216 (Supplement 2 to WASH-1248), March 1977.

68. "Environmental Survey of the Uranium Fuel Cycle," U.S. Atomic Energy Commission, WASH-1248, April 1974.

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

70. Letter from W.L. Kempiners, Illinois Department of Public Health, to J.H. Williams, U.S. Nuclear Regulatory Commission, February 17, 1982.

71. "Draft Environmental Statement Related to the Operation of Perry Nuclear Power Plant, Units 1 and 2," U.S. Nuclear Regulatory Commission, NUREG-0884, March 1982.

72. "Final Environmental Statement Related to the Operation of Enrico Fermi Atomic Power Plant, Unit No. 2," U.S. Nuclear Regulatory Commission, NUREG-0769, Addendum, No. 1, March 1982.

6. EVALUATION OF THE PROPOSED ACTION

6.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The staff has reassessed the physical, social, and economic impacts that can be attributed to operation of Clinton 1. Such impacts, beneficial or adverse, are summarized in Table 6.1 of this environmental statement. Inasmuch as the station is currently under construction, many of the expected adverse impacts of the construction phase are evident. The applicant is committed to an ongoing program of restoration and redress of the station site, which will be completed after the termination of the construction period.

The staff foresees no impacts of a magnitude requiring mitigation. However:

a. Before engaging in additional construction or operational activities that may result in a significant adverse environmental 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 as discussed in Section 5 of this statement and as modified and approved by the staff and implemented in the environmental protection plan that will be incorporated in the operating license for Clinton 1

c. If adverse environmental effects or evidence of irreversible environmental damage are detected during the operating life of the station, the applicant shall 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 continuing escalation of costs has increased the dollar values of the materials used for constructing and fueling the station.

6.3 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

There have been no signficant changes in the staff's preconstruction evaluation of the relationship between environmental effects of short-term uses (construction and operation of the station) and long-term productivity (FES-CP, Sec. 10.2). The conclusion that the dedication of resources for a nuclear generating station at the Clinton site is consistent with the balancing of short- and long-term objectives for use of the environment is still valid.

Table 6.1. Benefit-Cost Summary for Clinton 1

Benefit or Cost (Reference)	Magnitude or Reference†[2]	Staff Assessment of Benefit or Cost†[2]
BENEFITS		
Direct		
Electrical energy (Sec. 6.4.1)	5 billion kWh/yr	Large
Additional IP capacity (Sec. 6.4.1)	933 MWe	Large
Reduced generating costs (Sec. 6.4.1)	Over $90 million/yr	Large
Indirect		
Local property taxes (Sec. 5.8)	$7.3 million/yr†[3]	Large
Employment (Sec. 5.8)	300 employees	Moderate
Payroll (Sec. 5.8)	11.5 million/yr†[4]	Moderate
Local purchases by utility (Sec. 5.8)	$100,000/yr†[5]	Small
COSTS		
Economic		
Fuel (Sec. 6.4.2)	12.5 mill/kWh (1985)	Small
Operation and maintenance (Sec. 6.4.2)	1.6 mill/kWh (1985)	Small
Decommissioning	$58 million (1984)	Small
Environmental and Socioeconomic		
Resources committed:		
Land (Sec. 4.2.2)	2649 ha	Large
Water (Sec. 5.3.1)	9.15×10^7 m^3	Large
Uranium - U_3O_8 (NUREG-0480)	About 5000 t	Small
Other materials and supplies	(FES-CP, Sec.10.3)	Small
Aquatic Resources:		
Consumption		
Surface Water	17.9×10^6 m^3/yr	Large
Groundwater	None	None
Contamination		
Surface Water	(Sec. 5.3.2)	Small
Groundwater	(Sec. 5.3.2)	Small
Ecological		
Impingement and Entrainment	(Sec. 5.5.2)	Small
Thermal effects	(Sec. 5.5.2)	Small
Chemical discharges	(Sec. 5.5.2)	Small
Terrestrial Resources		
Fog and ice	(Sec. 5.5.1)	Small

Table 6.1. (Continued)

Benefit or Cost (Reference)	Magnitude or Reference†[1]	Staff Assessment of Benefit or Cost†[2]
	COSTS (Continued)	
	Environmental and Socioeconomic (Continued)	
Adverse socioeconomic effects due to:		
Loss of historic or prehistoric resources	(Sec. 5.7)	Small
Visual intrusion	(Sec. 4.2.1)	Small
Increased traffic	(Sec. 5.8)	Small
Increased demands on public facilities and services	(Sec. 5.8)	Small
Increased demands on private facilities and services	(Sec. 5.8)	Small
Adverse nonradiological health effects due to:		
Air-quality changes	(Sec. 5.4)	Small
Water-quality changes	(Sec. 5.3.2)	Small
Adverse radiological health effects due to:		
Reactor operation on:		
General population	(Sec. 5.9.3)	Small
Workers onsite	(Sec. 5.9.3)	Small
Balance of fuel cycle	(Sec. 5.10)	Small
Accident risks	(Sec. 5.9.4)	Small

†[1] - Where a particular unit of measure for a benefit/cost category has not been specified in the EIS, or where an estimate of the magnitude of the benefit/cost under consideration has not been made, the reader is directed to the appropriate EIS section or other source for further information.

†[2] - Subjective measure of costs and benefits are 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 impats); "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.

†[3] - Estimated value for 1985.

†[4] - Estimated value for 1985 and stated in 1985 dollars.

†[5] - Estimated value for 1985 and stated in 1980 dollars.

6.4 BENEFIT-COST SUMMARY

The benefits and costs of operating Clinton 1 are summarized in Table 6.1, which provides the staff's assessments of degrees of benefit or cost, as well as magnitudes of impact where they are quantifiable. References that contain further information are indicated.

6.4.1 Benefits

The primary benefit to be derived from operation of the 933-MWe Clinton 1 is the annual production of about 5 billion kWh of baseload electrical energy over the lifetime of the plant. Based upon a review of production costs of units already in service, as provided by the applicant, the staff considers that there will be average annual a savings from 1985 onward of more than $90 million in production costs per year.

Secondary benefits arising from operation of Clinton 1 include wages paid to 300 operating personnel (projected to be 11.5 million per year in 1985) and taxes paid to local political subdivisions (Sec. 5.8). The applicant projects local tax payments of $7.3 million in 1985 (Sec. 5.8). The applicant estimates that local purchases by the station will be about $100,000 in 1985 (Sec. 5.8).

6.4.2 Costs

6.4.2.1 Economic

The economic costs associated with station operation include fuel costs and operation and maintenance costs, which for 1984, the first full year Clinton 1 is expected to operate commercially, are 11.5 mill/kWh and 1.5 mill/kWh in 1984 dollars, respectively.

6.4.2.2 Environmental and Socioeconomic

Changes in station design, operating procedures, and environmental data that were taken into consideration in this operating-license review have not led to significant increases in the environmental or socioeconomic costs over the corresponding costs that were estimated during the construction-permit review. Most of the costs are significantly less than those estimated in the FES-CP because the latter were for two operating units, while those summarized here are for one unit. The costs considered include those attributable to the uranium fuel cycle and to plant accidents. All costs are small or negligible.

6.4.3 Conclusions

As a result of the analysis and review of potential environmental, technical, economic, and social impacts, the staff has prepared an updated forecast of the effects of operation of Clinton 1. No new information has been obtained that alters the overall balancing of the benefits versus the environmental costs of plant operation. Consequently, the staff has determined that the station will most likely operate with only minimal environmental impact. The staff finds that the primary benefits of minimizing system production costs and increasing baseload generating capacity by 933 MWe greatly outweigh the environmental, social, and economic costs.

7. LIST OF CONTRIBUTORS

The following personnel of the Office of Nuclear Peactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC, participated in the preparation of this final environmental statement:

Contributor	Title	Section/Topic
J.H. Williams	Project Manager, Standardization and Special Projects Branch	Licensing Project Manager
John C. Lehr	Senior Environmental Engineer, Environmental Engineering Branch	Environmental Review Coordinator
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Jacques S. Boegli	Senior Nuclear Engineer, Effluent Treatment Systems Branch	Radioactive Waste Treatment
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*Cooperative student program.

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The following personnel of Pacific Northwest Laboratory, Richland, WA, participated in the preparation of this final environmental statement:

Contributor	Title	Section/Topic
Richard M. Ecker	Research Engineer	Hydrology
Ron Shalla	Research Engineer	Groundwater
Richard L. Skaggs	Group Leader	Hydrology

The following personnel of the Division of Environmental Impact Studies of Argonne National Laboratory, Argonne, IL, participated in the preparation of this final environmental statement:

Contributor	Title	Section/Topic
James H. Opelka	Mathematician	Project Leader
Lee S. Busch	Chemical Engineer	Need for Power, Benefit-Cost Analysis, Alternatives
James E. Carson	Meteorologist	Air Quality, Cooling Lake Effects
Rosemarie L. Devine	Scientific Associate	Terrestrial Ecology
John D. DePue	Technical Editor	Editor (ANL input)
Vanessa A. Harris	Environmental Scientist	Nonradioactive Waste Systems, Water Quality
Darwin D. Ness	Ecologist	Terrestrial Ecology
Howard N. Ross	Biologist (urp)*	Aquatic ecology, editor (ANL input)
William B. Sutton	Physicist (urp)*	Cooling System, thermal effects
Steve Y.H. Tsai	Civil Engineer	Cooling System, Thermal Effects
William S. Vinikour	Environmental Scientist	Aquatic Ecology

*Undergraduate research program.

8. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE DRAFT ENVIRONMENTAL STATEMENT WERE SENT

Advisory Council on Historic Preservation
Council on Environmental Quality
Department of Agriculture, Soil Conservation Service
Agricultural Research Service
Department of Agriculture, Natural Resources & Economic Division
Department of Agriculture, Rural Electrification Administration
Department of the Army, Corps of Engineers
Department of Commerce
Department of Commerce, National Marine Fisheries Service
National Oceanographic Data Center
Department of Energy
Department of Health and Human Services
Food & Drug Administration
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
Federal Energy Regulatory Commission
Office of the Attorney General, State of Illinois
DeWitt County Board
Illinois Department of Public Health
Illinois Institute of Natural Resources
Illinois State Clearinghouse
Brookhaven National Laboratory
Atomic Industrial Forum

9. RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR Part 51, the "Draft Environmental Statement Related to the Operation of Clinton Power Station, Unit No. 1" was transmitted, with a request for comments, to the agencies and organizations listed in Section 7.

In addition, the NRC requested comments on the draft environmental statement from interested persons by a notice published in the Federal Register on January 8, 1982 (47 FR 1063).

In response to this request, comments were received from:

U.S. Department of Agriculture, Economics and Statistics Service (DAESS)

Federal Energy Regulatory Commission (FERC)

U.S. Department of the Interior (DOI)

Department of Transportation, United States Coast Guard (USCG)

Peter S. Penner (PSP)

Dewitt County Regional Planning Commission (DCRPC)

Illinois Department of Public Health (IDPH)

Illinois Department of Nuclear Safety (IDNS)

U.S. Department of Agriculture, Soil Conservation Service (DASCS)

Illinois Environmental Protection Agency (IEPA)

Illinois Department of Conservation (IDOC)

Illinois Power Company (IPC)

U.S. Environmental Protection Agency (EPA)

The comment letters are reproduced in Appendix A.

The comments from DAESS, FERC, DOI, and EPA did not require a staff response either because these agencies or individuals had no comments or because their comments indicated agreement with the draft environmental statement. The remaining comments did require a staff response. The staff's consideration of these comments and its disposition of the issues involved are reflected in part by revised text in the pertinent sections of this final environmental statement and in part by the following discussion. The comments are referenced by use of the abbreviations indicated above, by the individual comment numbers noted in the margins of the comment letters shown in Appendix A, and by the page numbers in Appendix A on which copies of the comments appear.

Response to Comment of Department of Transportation, United States Coast Guard

(USCG 2/9/82 A-5)

Information relative to the likely impacts that plant associated roadway traffic may have on the nearby highway system was presented by the staff in the FES-CP. No adverse effects or necessary mitigative actions to reduce such effects were identified by the staff in its analyses in the FES-CP (see Secs. 4.1.5 and 5.6). It was noted at that time that the applicant was negotiating with the appropriate state and local highway administration officials concerning roadway modifications to accommodate construction and operation-related traffic. In the ER-OL, the applicant indicates that the necessary permits for roadway modifications necessitated by the Clinton Power Station have been obtained from the DeWitt County Superintendent of Highways, the Clintonia, Creek, DeWitt, Nixon, and Harp Townships highway commissioners and the Illinois Department of Transportation, Highways Division (Sec. 12). Also in the ER-OL, it was indicated that heavy equipment did not present traffic problems on nearby roadways during Unit 1 construction (Sec. 4.5.3.4). No adverse impacts from use of heavy equipment, truck traffic, or employee traffic to and from the Clinton site have been identified by the applicant, the NRC staff or the agencies and individuals contacted by the staff during the operating license review.

In the DES-OL, Table 5.5, the traffic density for transportation of fuel and waste to and from a light water cooled nuclear power reactor such as Clinton Unit 1 is estimated at less than one truck per day. This traffic density and loading is judged by the staff to be less than that already experienced during the construction phase of the Clinton project. Based on this estimate and assessment, the information supplied in the ER-OL and the FES-CP, and the staff review at the OL stage, the staff has not identified a need to update, in the FES-OL, the information presented in the construction permit stage environmental review.

Responses to Comments of Peter S. Penner

(PSP 2/17/82 A-6,7)

#1. The savings indicated in Section 6.4.1 of the DES are for the use of coal as a replacement fuel (see also the Summary and Conclusions, item 4a). This is the most conservative estimate of savings, since the cost of producing energy with coal units is cheaper than with oil or gas units. The staff does not perform its own analysis of economic dispatch logic but relies upon the applicant to provide production-cost data. For the applicant's system, which is predominantly coal-based, the assumption that replacement power would come from coal is reasonable. The staff considers the figures used by the applicant for coal and nuclear energy generation to be reasonable.

#2. Since Illinois Power Company is predominantly a coal-based utility, the change in production-cost savings is not particularly sensitive to adjustments in the rate of growth. Unless the rate of growth became much larger than projected, nuclear-generated power would be replacing coal-generated power, either from the applicant's own system or purchased, rather than oil- and gas-produced power.

#3. The staff agrees that the lower the capacity factor is, the less the savings will be. Conversely, the higher the capacity factor is, the greater the savings will be. An indication of the sensitivity of savings to capacity factor is available in NUREG-0480.

#4. The Commission has amended 10 CFR Part 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 Section 2.758 or the Commission otherwise so requires (47 FR 12940, March 26, 1982). Pursuant to the amended regulations, need for power issues need not be addressed by operating license applicants in environmental reports to the NRC, nor by the staff in environmental impact statements prepared in connection with operating license applications. See 10 CFR Sections 51.21, 51.23(e), and 51.53(c).

<u>Responses to Comments of Dewitt County Regional Planning Commission</u>

(DCRPC 2/17/82 A-8,9)

#1. The comment has been noted. The staff has no further comment.

#2. As noted in Sections 5.3.2 and 5.9.3.4.2, monitoring of groundwater and surface water will continue during station operation.

#3. The text on p. 4-22 has been changed to reflect the more recent 1980 census data.

#4. The text on p. 4-22 has been revised to clarify the basis of the year 2020 population projection.

#5. The staff does not agree with the Planning Commission's claim that the fog and ice problem created by operation of the Clinton Power Station will be much more severe than that discussed in Section 5.4.1. The staff's conclusion is supported by recent studies at operating power plants in Illinois (Refs. 8 through 17 of Sec. 5). As indicated in Section 5.4.1 and in the Illinois Power Company comment 32 to the DES, the applicant has made a commitment to the Illinois Department of Transportation to monitor the frequency and severity of fog and ice over nearby highways and to take mitigative measures to reduce hazards to highway traffic if necessary. The staff considers this commitment adequate, but further recommends that local (county) highway safety officials be part of this program.

#6 See response to DCRPC comment 5.

#7. The information presented in Chapter 4 with respect to the recreational aspects of Lake Clinton was provided as an update of information to the background description. As it was pointed out, the licensee has leased 4150 ha (10,250 acres) to the Illinois Department of Conservation to manage as a recreation/conservation area. The impacts associated with recreational use of the lake were treated at the construction licensing stage of the project.

Response to Comment of Illinois Department of Public Health

(IDPH 2/17/82 A-10,11)

The staff agrees with the Illinois Department of Public Health that a statement relevant to Naegleria infection be included, particularly in view of recent findings that encephalitic Naegleria fowleri have become established in other artificially heated power-plant cooling lakes in Illinois (R.L. Tyndall, E. Willaert, and A.R. Stevens, "Pathogenic Amoebae in Power Plant Cooling Lakes," EPRI EA-1897, June 1981). Appropriate material has been added to the text in Sections 4.3.2.1, 4.3.4.2, and 5.8.2. Furthermore, it is the judgment of the staff that since Lake Clinton is now open to water-contact recreation, such as water skiing, and is being prepared for swimming (Sec. 4.2.3), monitoring for thermophillic amoebic pathogens such as Naegleria should be instituted in accordance with recommendations of the Illinois Department of Public Health so that appropriate mitigation can be designed if such organisms are found (Sec. 4.3.2.1).

Responses to Comments of Illinois Department of Nuclear Safety

(IDNS 2/18/82 A-12,13)

#1. Since the applicant does not hold ASME Stamps (NA, NPT) he would be required to contract out any work requiring ASME Stamps. We are not aware of commitments or contractural agreements for future work beyond construction which would require code stamps. Such agreements would probably depend upon the specific work and the availability of contractors. The applicant does have an ASME Owners Certification Authorization for Unit 1 (N1425).

#2. As discussed in Section 5.3.2.2, the results of thermal analysis estimate that under 50-year drought conditions, Unit 1 would have to be operated at about 78% load factor for several days during the summer in order to meet the thermal standards established by IPCB in its Order PCB 81-82 (May 28, 1981). The Illinois EPA will monitor Illinois Power Company's adherence to the standards. It should be noted that compliance with the board order is dependent on discharge water temperature, not meteorological conditions. Thus, no meteorological monitoring instrumentation will be required for compliance with the ICPB order.

#3. A formal dose assessment for station workers was performed by the applicant in Section 12.4 of Clinton's FSAR. This dose assessment was based on current NRC criteria including 10 CFR Part 20, Regulatory Guide 8.19, "Occupational Radiation Dose Ass ment in Light-Water Reactor Power

Plants Design Stage Man-Rem Estimates," experience from currently operating BWRs, and the specific design of the Clinton Station. As part of the dose assessment the applicant identified changes in the plant design and administrative procedures that should lower radiation dose to workers during routine and anticipated operational occurrences. Specific information on dose to workers during SRV operations are discussed in Section 12.4.1.3.2 and Table 12.4-6 of the FSAR. Approaches used by the applicant to maintain worker doses ALARA include a suppression pool cleanup system and administrative procedures for exiting containment following SRV operation. These and other design improvements to maintain occupational exposures ALARA are outlined in Section 12 of the FSAR. The staff did not consider any potential future changes to 10 CFR Part 20.

#4. In computing whole body doses for inclusion in Table 5.7, the source term in Regulatory Guide 1.3 and the primary coolant inventory were used for the large and small break LOCAs, respectively. The radionuclide release rate was estimated from plant design, rather than using the conservative assumptions in the Regulatory Guides and NUREG-0800, and median atmospheric dispersion conditions were also assumed. While post-TMI requirements affect the safety review, they were not considered here, since the assumptions used in the analyses are not changed as a result of the requirements.

<u>Response to Comment of U.S. Department of Agriculture, Soil Conservation Service</u>

(DASCS 2/18/82 A-14)

The text in Section 4.2.2 has been revised.

<u>Response to Comment of Illinois Environmental Protection Agency</u>

(IEPA 2/19/82 A-15)

See response to the IDPH comment.

<u>Responses to Comments of Illinois Department of Conservation</u>

(IDOC 2/19/82 A-16 to A-20)

#1. See response to the IDPH comment.

#2. The text has been changed in Section 4.3.4.2 to correct the misleading implication that stocking will be done on an annual basis.

#3. The occurrence of the river otter was noted in the DES on p. 4-21, third full paragraph. Since the presence of the otter was detected on only a single occasion during field surveys, the staff believes that the observed otter tracks and slide were made by a transient individual. This opinion is supported by published information in that no permanent population of river otter is known to occur in the Lake Clinton area (Natural Land Institute, "Endangered and Threatened Vertebrate Animals and Vascular Plants of Illinois," Illinois Department of Conservation, 1981).

#4. According to the applicant's ER-OL, stream flow records from 1942 to 1977 at the Rowell gage indicated a mean September flow of 910 L/s (32 cfs) under natural conditions. With the one unit operating at a 70% load factor, calculated natural and forced evaporative losses will be less than the average inflow under normal conditions, and reservoir releases will probably exceed 140 L/s (5 cfs) during most Septembers. The 140-L/s average for September represents two-unit operation where natural and evaporative losses are almost equal to inflow during September and the 140-L/s release is required by the State of Illinois as a condition of the permit for construction of the dam. Section 5.3.1.1 has been revised to state that the average September release is expected to be somewhat greater than the 140 L/s which was estimated by the applicant.

#5. The staff has reviewed the information related to Salt Creek flows below Lake Clinton dam and has made additions to the text of Section 5.5.2.2 as a result of this information.

#6. The staff agrees that hunting pressure will tend to disperse waterfowl <u>during</u> the hunting season. However, the staff also notes that provisions of the IDOC Wildlife Resources Management Plan preclude hunting activities in appreciable areas of the site; other areas are designated as waterfowl refuges, thus alleviating hunting pressure as well as other disturbances. However unusual or uncommon, the staff considers it possible that adverse conditions such as heavy snowfall could result in a scarcity of food resources for migrating and resident waterfowl, as well as depletion of food resources for other resident birds with relatively similar food habits. Other factors could reinforce such adverse conditions; e.g., heavy snowfall could result in concentrating sources of available food, thereby causing overcrowding at feeding sites and increasing the potential for outbreaks of epidemic disease. The foregoing and/or other reinforcing considerations could prompt a decision to disperse waterfowl from the Lake Clinton area. Given such an event, it seems unlikely that management authorities would rely on "recreational users with boats" to disperse the waterfowl, especially during and following prolonged inclement weather.

#7. The text in Section 5.5.1.1 has been altered for clarification.

#8. The text in Section 5.5.1.2 has been revised to reflect this IDOC opinion.

#9. A statement concerning the loss of fish over the spillway of Lake Clinton has been added to Section 5.5.2.1.

#10. The text in Section 5.5.2.1 has been appropriately revised.

#11. The staff notes IDOC's suggestion; however, the sentence in question (last sentence on p. 5-12 of the DES) has been deleted based on a comment made by the applicant.

<u>Responses to Comments of Illinois Power Company</u>

(IPC 2/19/82 A-21 to A-31)

#1. The sentence in the Abstract describing thermal impacts has been revised.

#2. All references to "Ill-Mo Power Pool" have been deleted from this final environmental statement.

#3. Item 4c in the Summary and Conclusions has been revised.

#4a. Item 4f in the Summary and Conclusions has been revised.

#4b. The summary has been revised to include the new information contained in the Illinois Power Company comments. (See response to IPC comment 31.)

#5. This section of the environmental impact statement merely lists the current significant surveillance needs that have been identified during the entire environmental review process for Clinton Power Station. There is no intent in this section to imply that the NRC will require, as a part of its operating license, that station discharge temperatures be monitored and reported, because it is recognized that such surveillance has been made a part of the state NPDES permit.

#6. See response to PSP comment 4.

#7. The amount of oil-fired capacity used is small compared to the applicant's coal-fired baseload capacity. The assumption that all replacement power would be coal generated makes the cost-savings estimates conservative.

#8. See response to IPC comment 2.

#9. The text on p. 4-2 has been changed to reflect the substance of the comment.

#10. The suggested additional wording has been made in Section 4.2.3.

#11. Section 4.2.3 has been revised to include water used by the Lake Clinton recreational areas.

#12. Section 4.2.6.1 has been revised.

#13. Section 4.2.6.1 has been revised.

#14. Section 4.2.6.1 has been revised.

#15. The text of Section 4.2.6.2 has been revised.

#16. Section 4.2.6.3 has been revised.

#17. The last sentence in Section 4.2.7 has been revised.

#18. Table 4.4 has been revised.

#19. The temperature values given in Section 4.3.3.1 have been revised.

The data period used by the applicant includes periods with no systematic approach to tornado identification. As a result of the use of a systematic approach to tornado reporting since the early 1950s, use of the period chosen by the staff, 1953-1971, would provide a more reasonable certainty of including most tornadoes without redundancy or omissions in the report than does the longer period of record used by the applicant. Thus, an average of 21 tornadoes per year in Illinois determined by the staff reflects the likelihood of tornadoes being observed on the average in any year in the state and is believed to characterize conditions statewide.

#20. The text of Section 4.3.3.2 has been changed to reflect this correction.

#21. The staff has made appropriate text changes in Section 4.3.4.2.

#22. The staff agrees that the use of the word "annual" in describing the fish-stocking program is misleading, and has made an appropriate text change in Section 4.3.4.2.

#23. Appropriate text changes have been made in Section 4.3.4.2.

#24. The text of Section 4.3.7 has been changed to reflect these corrections.

#25. The text of Section 4.3.6 has been changed to reflect the suggested wording.

#26. See response to IPC comment 11.

#27. Section 5.3.2.1 has been revised.

#28. Table 5.1 has been revised.

#29. The staff's assessment of potential groundwater contamination from leaching of pollutants in the wastewater treatment pond is given in Section 5.3.2.1. Because moderate to severe impacts on groundwater quality were considered unlikely from the wastewater treatment ponds, and because existing observation wells for monitoring lake water intrusion would show any contamination from the wastewater treatment ponds, no additional observation wells are required. Continuation of existing monitoring was considered adequate mitigation. Thus, the discussion of groundwater quality and mitigation has been properly placed in the FES. However, should monitoring indicate the need for further mitigation measures, additional observation wells and the installation of a liner beneath the wastewater treatment ponds may be required.

#30. The text of Section 5.3.2.2 has been revised.

#31. The DES specifically addresses adverse effects during the 100-year flood, whereas the summary of the consultant's report (as provided in the comment) primarily addresses lower floods. The text has been revised, however, to reflect the positive effects of the channel improvements as stated in the comment.

#32. See response to DCRPC comment 5.

#33. See response to IDOC comment 6.

#34. The applicant's responsibilities in the event of a local waterfowl disease episode are implicit within the scope of provisions identified in

Section 6.1 (item c) of this document. The stated requirements are consistent with obligations of the NRC, a regulatory agency charged with protecting the environment, which includes preserving the well-being of the waterfowl resource. While IDOC participation relative to this matter is welcomed, the staff does not consider that such participation relieves the applicant of responsibilities delegated by the NRC. Further, the staff does not foresee events whereby concerns of the NRC would entail "...additional or potentially conflicting requirements..."

#35. See response to IDOC comment 8.

#36. The staff notes that fish stocking in order to offset some impingement losses is only a potential, rather than an established, part of the sport fishery management plan. Appropriate text changes have been made in Section 5.2.2.1.

#37. The staff acknowledges that the Illinois EPA has jurisdiction over the NPDES permit for the station. The sentence stating that the applicant will be required to observe impingement and entrainment monitoring provisions in the NPDES permit was put in the document more to indicate that there would be assessment to ensure that impingement and entrainment impacts would be minimal, rather than as a staff requirement. To avoid future misunderstanding, the sentence in question (last sentence in Section 5.5.2.1, p. 5-12 of the DES) has been deleted from the text of the FES.

#38. Although the staff believes that the last sentence on p. 5-12 of the DES is correct, the sentence has been deleted from the FES based on the applicant's suggestion so as to eliminate potential confusion in case the stocked experimental game species are not restocked.

#39. The staff has considered the suggestion to replace the word "stocked" with the word "native" in the last sentence of Section 5.5.2.3, based on the present uncertainty as to whether the stocking of experimental game species will be part of the future fishery management plan of the lake. However, the staff has decided to substitute the term "thermally tolerant" because this does not preclude the use of either native or stocked species to replace less thermally tolerant native species.

#40. The staff has made an appropriate addition to the text in Section 5.5.2.3.

#41. This comment is a suggested change to paragraph 2, p. 5-29. The paragraph cited is part of a general introduction to the "Radiological Monitoring" portion of the section on Radiological Impacts from Routine Operations and is not intended to be site specific. Therefore, the paragraph has not been revised to make it apply specifically to the applicant.

However, although this paragraph was intended to reference documents that discuss radiological monitoring generally, the staff does feel that a reader might infer that the licensee is committed to establishing a program that exactly follows these documents. Accordingly, the FES-OL has been revised to clarify the language.

#42. The text of the FES-OL has been revised to note that staff review of the applicant's preoperational environmental monitoring plan finds that plan to be acceptable.

#43. The text of the FES-OL has been revised to include these points, except that the number of air sampling locations has been changed to 40 at the request of the commenter.

#44. The suggested change to Section 5.9.4.1.3.1 has been made.

#45. The formation of acids in the atmosphere from sulfur dioxide and nitrogen dioxide acidifies rain and snow (see p. 559, "Energy in Transition, 1985-2010," National Academy of Sciences, Washington, D.C., 1979). The ecological effects of acid precipitation are greatest in waters that contain the least dissolved matter. Declining fish populations have been observed in lake areas where waters have shown increased acidity associated with acidified precipitation.

#46. The staff agrees that conditions which force operation at reduced power will occur infrequently, and for brief periods of time. Therefore, appropriate changes have been made to the text in Section 6.4.1.

APPENDIX A. COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

CONTENTS

United States Department of Agriculture
Economics and Statistics Service
Washington, D.C. 20250

January 11, 1982

Mr. James R. Miller, Chief
Standardization and Special
Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miller:

Thank you for forwarding the draft environmental statement relating to the startup and operation of the Clinton Power Station, Unit 1 (NUREG-0854), which is to be operated by the Illinois Power Company, located in DeWitt County, Illinois.

We have reviewed Docket No. 50-461 and have no comments.

Sincerely,

VELMAR W. DAVIS
Associate Director
Natural Resource
Economics Division

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON 20426

IN REPLY REFER TO:

Docket No. 50-461

January 13, 1982

Mr. James R. Miller
Chief, Standardization & Special
Projects Branch
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Miller:

I am replying to your request of December 28, 1981, to the Federal Energy Regulatory Commission for comments on the Draft Environmental Impact Statement for Operation of the Clinton Power Station, Unit No. 1. This Draft Supplement has been reviewed by appropriate FERC staff components upon whose evaluation this response is based.

This staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power, natural gas, and oil pipeline industries for which the Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. The Commission staff commented previously on this project on August 28, 1974. It does not appear that there would be any additional signifciant impacts in these areas of concern nor serious conflicts with this agency's responsibilities not previously addressed, should this action be undertaken.

Thank you for the opportunity to review this statement.

Sincerely,

Jack M. Heinemann
Advisor on Environmental Quality

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

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FEB 9 1982

James R. Miller, Chief
Standardization and Special
Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miller:

We have reviewed the draft environmental impact statement related to the operation of the Clinton Power Station, Unit 1, DeWitt County, Illinois (NUREG-0854), and find we have no comments.

The opportunity to review this document is appreciated.

Sincerely,

Bruce Blanchard, Director
Environmental Project Review

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DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS: G-WS
U.S. COAST GUARD
WASHINGTON, D.C. 20593
PHONE: 202-426-2262

FEB 9 1982

Mr. James R. Miller
Standardization and Special
Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miller:

This is in response to the correspondence received regarding the Draft Environmental Statement related to the proposed operation of the Clinton Power Station, Unit 1, located in DeWitt County, Illinois.

The concerned operating administrations and staff of the Department of Transportation have received the material submitted. The Federal Highway Administration had the following comment to make.

"The DEIS identified several adverse effects that the power station's operation may have on the highway system. The major effects are transporting radioactive fuel and waste over the highway system and the effects of fog and ice on highways in the area caused by the cooling lake. The impacts of transporting fuel and waste over the highway is only discussed relative to the population. There should be some discussion about the effects on the highway system.

The fog and ice caused by the cooling lake has the greatest potential for creating a hazard to the highways in the area. The power company's commitment to IDOT to set up a program to monitor the fog and ice on nearby highways is considered satisfactory."

Sincerely,

W. E. Caldwell

W. E. CALDWELL
Rear Admiral, U. S. Coast Guard
Chief, Office of Marine
Environment and Systems

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S/0

712 W. Clark Street
Urbana, IL 61801
February 17, 1982

50-461 OL
Docketing and Service Branch
Nuclear Regulatory Commission
Washington, DC 20555

Dear Sirs:

Solely as a concerned private citizen, I have reviewed the Clinton Power Station DEIS-OL Stage, and I am concerned about a number of the assertions made in the "purpose and need" section 2. The economic analysis conducted by the staff concerning the Clinton Station appears to contain a number of highly questionable assumptions which must be further supported by documentation and analysis if they are to be believed. Specifically, with regard to page 2-2:

#1 (a) What economic-dispatch model was used and what was the complete set of input data and assumptions? These data must be shown to be internally consistent as well as accurate and appropriate.

#2 (b) As an example of questionable consistency, the report states that the fuel savings computed "would not be significantly altered if the demand for electricity grows at a lower rate than assumed." This runs counter to economic wisdom and must be analytically demonstrated via a production cost model.

#3 (c) Similarly, since IP is a new reactor operator and may not achieve the optimistic capacity factors assumed in the analysis, sensitivity studies should be conducted with respect to this key variable.

#4 In addition, section 2.4 seems greviously deficient in that it fails to address the issue that the single Clinton unit will represent almost 25% of IP's system generating capacity. In Illinois Commerce Commission docket 79-0071, CBE witness Edward Kahn, submitted an analysis which found that the addition of a single large unit the size of Clinton adversely affected system reliability. At the very least, the DEIS should consider and discuss this possibility.

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Docketing & Service Branch
Nuclear Regulatory Commission
Page Two
February 17, 1982

Thank you for the opportunity to comment on this DEIS.

Sincerely,

Peter S. Penner
712 W. Clark Street
Urbana, IL 61801

cc Phil Willman
Alan Samuelson
Charles Bacon

DEWITT COUNTY REGIONAL PLANNING COMMISSION

923 South Sherman Street
R. R. 4 - Box 172
Clinton, Illinois 61727

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US NUCLEAR REGULATORY COMMISSION
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17 February 82

Director, Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

In Re: Draft Environmental Statement
Illinois Power Company, et al.,
Clinton Power Station, Unit
No. 1, DeWitt County, Illinois
Docket No. 50-461

To The Director and Commission:

The Regional Planning Commission of DeWitt County, Illinois, has reviewed the referenced Statement. Our comments are as follows:

#1 — 1. As stated on page 4-23, a priority and the intent of DeWitt County is the preservation of the agricultural base of the County. The Commission commends Illinois Power Company, et al., for their desire and action in keeping agricultural land in production. The Commission further recommends that this be continued and encouraged on those lands suitable.

#2 — 2. The Commission recommends the continued monitoring of surface and groundwater resources to ensure the protection of both.

#3 — 3a. The Commission feels that paragraph 4.3.7 (Community Characteristics) page 4-22, should be revised to reflect the 1980 census data as supplied to the County, by the Bureau of the Census. The Countys 1980 census population was 18,109; the City of Clinton's 8,014; the City of Farmer City's 2,252; the Village of Weldon 531. The Countys population increase by 1,134 persons since 1970.

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U.S. Nuclear Regulator Commission
Page 2 of 2
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#4 3b. The last sentence on page 4-22 (para. 4.3.7) leaves unclear whether the year 2020 population projection is for the entire County or for that area within 16 km (10 mi) of the site.

#5 4. The Commission recommends that paragraph 5.4.1 (Fog and Ice), pages 5-9 and 5-10, be studied in much greater detail. In the Commission's opinion, the fog and ice problem will be much more severe than is reported. Traffic hazards will be especially severe near the discharge flume, during those days when conditions are condusive. #6 The Commission recommends that instead of monitoring the situation for a specific period of months, then if a problem exists, act at a later date, the mechanisms and structure be in place so that <u>when</u> the conditions become hazardous, remedies be undertaken immediately to correct the hazards.

#7 5. The Commission recommends that additional study be made on the economic impacts of the completion of Unit No. 1 and the increasing influx of persons seeking recreational pursuits. The Commission feels that these impacts will be much more than "minimal."

The Commission wishes to thank you for the opportunity to make comments relative to the referenced. The Commission sincerely hopes that these comments will be taken into consideration and that adequate responses to these concerns will be forthcoming.

Sincerely yours,

Rita R. Riddle 2/17/82

Rita R. Riddle, Chair

DEWITT COUNTY
REGIONAL PLANNING COMMISSION

cc: Files EIS-IP3
R-19-75

ILLINOIS DEPARTMENT OF PUBLIC HEALTH
William L. Kempiners, Director
535 West Jefferson Street • Springfield, Illinois 62761 • Telephone: 217-782-4977

Reply to:

February 17, 1982

Mr. J. H. Williams, Licensing Project Manager
Standardization and Special Projects Branch
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Williams:

This is in reference to the Draft Environmental Statement (related to the operation of Clinton Power Station, Unit No. 1, Docket No. 50-461).

The Illinois Department of Public Health wishes that a statement be included in the final environmental statement relative to a potential risk of Naegleria infection among persons swimming or skiing in waters of the cooling lake for this power plant.

Naegleria infections are very rare in the United States (the Centers for Disease Control of the U. S. Public Health Service reports approximately 35 cases since 1965) and do not pose a major health risk in Illinois. Growth of the pathogenic form of this organism is enhanced when water temperature is increased, and direct water contact, e.g. swimming, skiing, etc., may result in a very small risk of contracting a severe form of meningoencephalitis caused by this amoeba. This risk rate has been estimated at less than 1 in 2.5 million persons by a staff member of the Centers for Disease Control of the U. S. Public Health Service.

Managers of recreational areas where increased water temperatures exist should be knowledgeable of the above information; however, the Illinois Department of Public Health does not consider the danger of Naegleria infection of sufficient magnitude to justify the prohibition of recreational use of such waters.

It should be noted that the above minimum potential risk of obtaining Naegleria infection is not limited to cooling lakes associated with

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Mr. J. H. Williams, Licensing Project Manager
Standardization and Special Projects Branch
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

nuclear plants but exists for other cooling lakes associated with more conventional power plants (e.g. coal).

I will appreciate your consideration to include the above in your final environmental statement.

Sincerely,

William L. Kempiners
Director of Public Health

cc: Illinois State Clearing House
614 Stratton Building
Springfield

Dick Lutz
Impact Analysis Section
Illinois Department of Conservation
Springfield, Illinois 62706

Ken Rogers
Planning Section, Division of Water Pollution Control
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

Illinois Department of Nuclear Safety

1035 Outer Park Drive Springfield, Illinois 62704 (217) 546-8100
Philip F. Gustafson
Director
Jane A. Bolin
Deputy Director

February 18, 1982

Director, Division of Licensing
Office of Nuclear Reactor Regulations
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Draft Environmental Statement Related to the Operation of Clinton Power Station, Unit #1 (NUREG-0854), Operating License Stage. (Docket No. 50-461)

Dear Sir:

After review of the subject document, the following comments and questions are directed to your attention:

A. Permits and Licenses - Section 1.2

#1 This section addresses environmentally related permits, approvals and licenses required from federal and state agencies in connection with the project. For all other nuclear plants in the State of Illinois, ASME registration, stamp requirements, and inspection certification with the state jurisdictional authority have been addressed in the draft environmental statements. The "constructor" presently maintains the required registration and inspection certification for this applicant. The procurement from the appropriate state jurisdiction of the necessary ASME Stamps, (NA, NPT) required to conduct maintenance on items officially turned over from the constructor to the applicant prior to operation of the plant and during the plant lifetime also needs to be addressed. What commitments or contractural agreements have been made by the applicant in this area?

B. Environmental Consequences and Mitigating Actions - Section 5

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#2 1. Section 5.3.2 "Quality" discusses the effect of the project on the area's water quality, and indicates that under certain meteorological conditions, Unit 1 may have to be operated at reduced power levels to prevent severe thermal pollution to the Salt Creek. What operating restrictions, technical specification requirements, etc. will be placed on the plant, as well as the meteorological monitoring instrumentation, to restrict these thermal releases?

#3 — 2. Section 5.9, "Radiological Impacts" discusses the radiological impacts of routine and postulated accident conditions, and the applicants proposals for its ALARA programs. The staff indicates that its occupational dose estimates are based on annual average occupational doses for other BWR's to date. The staff also indicates that actual values could be two to three times higher, which are still within the limits of the current 10CFR Part 20. What considerations or assessments have been made for these evaluations in light of the proposed revisions to 10CFR 20? Since the containment design has several different design features compared to other operating BWRs, (e.g. suppression pool indirectly open to refueling floor area) what ALARA approaches will be taken by the applicant during events like relief valve releases and other small break incidents within containment?

#4 — 3. Section 5.94, "Environmental Impact of Postulated Accidents", specifically addresses plant accidents and their impacts. In light of the guidance from NRC Regulatory Guides and NRC NUREGs on Post TMI-2 requirements, which source terms and related assumptions have been used for this plant design in considering Design Basis Accidents and small break loss of coolant accidents?

Thank you for the opportunity to review the Clinton Draft Environmental Statement - Operating License Stage. Your consideration of the above comments is appreciated.

Sincerely,

Philip F. Gustafson, Director
Department of Nuclear Safety

PFG:RWD:jt

cc: Gary N. Wright
Roger Dettenmeier

United States Department of Agriculture

Soil Conservation Service

Springer Federal Building
301 North Randolph Street
Champaign, IL 61820

February 18, 1982

James R. Miller, Chief
Standardization and Special Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miller:

The draft environmental statement for the Clinton power station, unit 1 (NOREG-0854), has been reviewed by our field office. We suggest that a statement be included in section 4.2.2 that addresses the management of agricultural land to control excessive erosion.

We have no other comments at this time.

Sincerely,

August J. Dornbusch, Acting

AUGUST J. DORNBUSCH, JR.
Acting State Conservationist

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DOCUMENT MANAGEMENT BR
NRC

cc:
Roger Rowe, AISWCD, Marseilles, IL
John Rowley, IDOA, Springfield, IL
Ron Darden, IDOA, Springfield, IL
Don Manecke, Orion, IL
Holtsclaw, A4
Phipps-Goetsch, A4
N. Berg, Chief, SCS, Washington, D.C.
E. Pope, Director, MTSC, Lincoln, NE

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ILLINOIS EPA

Environmental Protection Agency

2200 Churchill Road, Springfield, Illinois 62706

217/782-3397

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February 19, 1982

Mr. J. H. Williams, Licensing Project Manager
Standardization & Special Projects Branch
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Williams:

The purpose of this letter is to comment on the Draft Environmental Impact Statement related to the operation of Illinois Power Company's Clinton Power Station Unit No. 1 (Docket No. 50-461).

The Illinois Department of Conservation and the Illinois Department of Public Health have indicated to us that the possible presence of pathogenic amoebae (Nyglaeria fowleri) in Clinton Lake could present a health risk. In view of this potential problem, we request that you consider including a risk evaluation, appropriate mitigation measures and the need for monitoring in your final environmental impact statement.

Sincerely,

Richard J. Carlson
Director
Illinois Environmental Protection Agency

cc: Illinois Department of Conservation
Illinois Department of Public Health
Illinois State Clearinghouse

RJC:KRR/kj

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Illinois Department of Conservation
life and land together

605 WM. G. STRATTON BUILDING • 400 SOUTH SPRING STREET • SPRINGFIELD 62706
CHICAGO OFFICE – ROOM 100, 160 NO. LASALLE 60601
David Kenney, Director • James C. Helfrich, Assistant Director

February 19, 1982

Mr. J. H. Williams
Licensing Project Manager
Standardization and Special Projects Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Williams:

The Department has completed its review of the December 1981 Draft Environmental Statement related to the operation of Clinton Power Station, Unit No. 1, Docket No. 50-461.

As stated in Section 4.2.2 and 4.2.3, the Department and Illinois Power Company have reached agreement whereby 10,420 acres of the site has been opened to public use for year-round recreational activities including boating, fishing, hunting, camping, picnicking, wildlife viewing, hiking and other water sports. The Department is appreciative of Illinois Power Company's cooperation in providing these recreational facilities and opportunities to the citizens of Illinois.

As managers of these recreational facilities, we wish to bring to your attention the following information/problems/issues which we have encountered, or have become aware of, since the issuance of the Final EIS-Construction Phase in 1974. While we believe it is important these items are included in the final EIS-Operational Phase because of their relevance to the area's natural resources and the public's use and enjoyment of these resources, we do not believe they should deter from the anticipated issuance of an operating license to the Illinois Power Company for the start-up and operation of the Clinton Power Station, Unit 1. We are also confident that continued discussions between Illinois Power and the Department will lead to mutually satisfactory resolution of the problems/issues discussed here. These items are as follows:

. According to the Forward (p. XV) of the draft EIS, the purpose of the document is to report relevant new information that has become available subsequent to the issuance of the Final Environmental Statement-Construction Phase and to identify unresolved environmental issues or surveillance needs which are to be resolved. The Forward further states that no unresolved issues have been identified in this DEIS for the case of Clinton Power Station. The only surveillance needs identified were the monitoring of fog and ice and the temperature at the discharge point and at Salt Creek downstream of Lake Clinton.

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#1

The probable occurrence of pathogenic amoebae (Nyglaeria fowleri) in the thermal discharge from the Clinton Power Station is a potentially serious issue which we believe should be addressed in the final EIS and an issue which may require monitoring after plant operation begins in early 1983.

Two studies (Tyndall et al. 1981 - EPRI[1]; Tyndall et al. 1981 - NRC[2]) which tested for the presence of pathogenic amoebae between cooling waters of northern and southern electric power plants and control lakes in those areas both reported a statistically significant association between the presence of the thermophillic pathogenic amoebae and artificially heated water in northern states. We are particularly concerned because of four cooling lakes examined in Illinois during the course of those studies, three tested positive for the presence of pathogenic amoebae.

The recreational plan for Clinton lake was developed in conjunction with the Department and includes plans for a public swimming beach and bathhouse in the area of thermal influence, and allows water skiing throughout the thermal discharge zone. Summer temperatures in the discharge zone and at the beach are predicted to be within the range of 30-40°C, the range at which other northern cooling lakes (including three from Illinois) were found positive for the pathogen. Clinton Lake was opened to swimming and water skiing activities in 1979, so a historical pattern of use and economic development of the area has already been established.

Since the pathogenic amoebae is usually contracted by inhaling water through the nasal passages, participation in these activities may present potential health risks to individuals using Clinton Lake for these and other water-contact recreational purposes after plant start-up and thermal input begins in early 1983.

To guide us in our resolution of these concerns, we are soliciting expert opinions from knowledgeable persons and agencies both in and outside of Illinois regarding potential public health risks, if any, to individuals using Clinton and other Illinois cooling lakes for various types of public recreation. We have held discussions

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[1] Tyndall, R. L., E. Willaert, and A. R. Stevens, 1981
Pathogenic amoebae in power plant cooling lakes. Final Report to Electric Power Research Institute. EA-1847. Research Project 1514-1.

[2] Tyndall, R. L., E. Willaert, and A. R. Stevens, 1981
Presence of pathogenic amoebae in power plant cooling waters. Final Report for the period October 15, 1977, to September 30, 1979. Oak Ridge National Laboratory Pub. No. 1623 prepared for U.S. Nuclear Regulatory Commission.

#1 with the Illinois Environmental Protection Agency and the Illinois Department of Public Health. Based on these discussions to date, it is our understanding that direct water contact, e.g., swimming, skiing, etc. may result in a very small risk of contracting a severe form of meningoencephalitis caused by the amoebae Naegleria. Growth of the pathogenic form of this organism is enhanced by warm temperatures, such as may occur after the plant becomes operational, and direct water contact under such conditions may result in a risk of acquiring this infection at a rate which a staff member of the Centers for Disease Control of the Public Health Service has estimated at less than 1 in 2.5 million persons. We will continue to monitor new information as it becomes available and we are available for further consultations concerning this issue.

#2 . In Section 4.3.4.2, p. 4-20 an annual stocking program is implied with regard to walleye, hybrid striped bass and tiger musky. These supplemental stockings will not necessarily be annual, but will be governed by management needs and fish availability.

#3 . It should be noted in Section 4.3.5, p. 4-21 that a river otter track and slide was discovered in February of 1977. The river otter is an Illinois threatened mammal.

#4 . In Section 5.3.1.1, p. 5-2 it is stated, "During an average year the September flow in Salt Creek downstream of Lake Clinton will consist only of the minimum reservoir release of 142 L/s (5 cfs)." True, the low flow of record was an estimated .6 cfs at the dam (.7 at the Rowell gage x .886)[1] and the 7-10 flow is an estimated 2.4 cfs at the dam site. These flows, by definition, do not even approach an annual frequency and do not represent September flows. The average monthly flow for September, 1970-77, was 98 cfs at Rowell, an estimated 86.8 cfs at the dam site. The minimum release stated in the DEIS in effect is 5.8% of the naturally occurring flow. The 5 cfs release approximates the lowest one day flow occurring in the eight Septembers, 1970-77 - a flow of 5.1 cfs on September 7, 1976 - a flow occurring once out of 240 September days.

#5 Since filling of the lake was completed in May, 1978, flow releases have frequently and for extended periods been 16.8 cfs or less - 50% of water year 1980, 30% of water year 1979, and 34% of water year 1978 after May, or 39% of the time. Prior to dam construction, a flow of 16.8 cfs or less was experienced only 23.5% of the time. It is reasonable to assume that this 66% increase in duration of lower flows has already impacted Salt

---

1 Illinois Power's multiplier to convert Rowell gage readings to dam site readings.

*5 Creek below the dam. However, flows of 5 cfs have not yet been experienced since lake filling, although 8-11 cfs releases have been common (24.3% of the time) with up to 21 days duration. During September, 1978-80, 51% of the flow releases were in the 8.9 - 10.6 range, with up to 14 days duration, and releases were less than 8.0 cfs only 3% of the days.

At this time we lack the instream flow studies needed to recommend scheduled flow releases; however, we believe they should approximate 19 cfs to minimize fishery impacts downstream. The Department intends to work with Illinois Power to clarify and resolve the reservoir release questions.

*6 . The Department takes exception to the concept of the need for "...forced dispersal of waterfowl from the area by repeated disturbance using aircraft, boats, and other scare tactics...." as a result of inadequate food sources (p. 5-11, Sec. 5.5.1.1). We are of the opinion that no such action is warranted inasmuch as traditional migration patterns will dictate that in periods of food supply shortages, waterfowl will continue on their southerly migration.

*7 . We recommend clarification of line 12, paragraph 2, p. 5-11, Section 5.5.1.1. Does "development of disease pathogens" refer to wildlife diseases or human diseases?

*8 . In Section 5.5.1.2, p. 5-11 a discussion of periodic clearing of vegetation along transmission lines and rights-of-way is presented. It should be noted that in this Department's opinion hand trimming, cutting and use of herbicides are all viable methods of accomplishing this task. We recognize the effectiveness of certain herbicides for brush control and where applicable utilize them to create early successional habitats conducive to upland birds and mammals and see no reason to prohibit their use (FES-CP4.5.2., Item 5b).

*9 . Section 5.5.2, p. 5-11 discusses potential impacts on the aquatic ecosystem. We note there is no discussion concerning the loss of predatory fish (particularly walleye, hybrid-striped bass, and tiger musky) over the spillway during the periods of high water. These species do not reproduce naturally in the lake and must be restocked each year at considerable expense. During 1981 the Department estimated that more than a thousand hybrid-striped bass in the 5 to 6 pounds range escaped over the Clinton Lake Spillway. The loss of these supplementally stocked predatory species can be prevented by spillway screening. Spillway screens would insure that these large predators stay in the lake where they are a major asset and prevent them from entering the stream where they may have an adverse impact on other stream fishes. We are aware spillway screens may pose other management problems; therefore, full discussions between Illinois Power and our Department are anticipated before a strategy for problem resolution is derived.

#10 . We recommend deletion of "sport" in line 3, p. 5-12. The sentence would then read, "as part of the fishery management ...".

#11 . In Section 5.5.2.3, 2nd paragraph, p. 5-12 the term "stocked game species" is used. We would recommend that this be changed to "stocked experimental species".

The Department appreciates the opportunity to comment and we look forward to receiving copies of the final EIS.

Sincerely,

David Kenney

DK:RWL:ss

cc: Illinois State Clearinghouse
Illinois Power Co. - Gene Robinson
Illinois Environmental Protection Agency
Illinois Department of Public Health

ILLINOIS POWER COMPANY
500 SOUTH 27TH STREET, DECATUR, ILLINOIS 62525

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February 19, 1982

Mr. James R. Miller, Chief
Standardization & Special Projects Branch
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Miller:

Reference: Letter 12/28/81, J. R. Miller, NRC to L. J. Koch, IP, Subject: Issuance of Draft Environment Statement for the Clinton Power Station, Unit 1-NUREG-0854.

This is in reply to the referenced letter. Illinois Power Company has completed its evaluation of NUREG-0854, "Draft Environmental Statement Related to the Operation of Clinton Power Station, Unit No. 1." Attached are our comments for your consideration relative to your issuance of the Clinton Final Environmental Statement.

Please do not hesitate to contact us if you have any questions concerning our comments.

Sincerely,

G. E. Wuller
G. E. Wuller
Supervisor - Licensing
Nuclear Station Engineering

GEW:mr

cc: Mr. J. H. Williams, NRC Clinton Project Manager
[redacted] NRC Environmental Engineering Branch
Mr. H. H. Livermore, NRC Resident Inspector

ATTACHMENT February 19, 1982

Illinois Power Company Comments On
Draft Environmental Statement
Related to the Operation of
Clinton Power Station Unit No. 1 (NUREG-0854)

This attachment includes all the comments made by Illinois Power Company on the U. S. Nuclear Regulatory Commission's Draft Environmental Statement, related to the operation of Clinton Power Station, Unit No. 1 (Docket No. 50-461-NUREG-0854, December 1981). The comments are prefixed by the page number, section number and paragraph, as applicable, of the Draft Environmental Statement to which they refer.

1. Page iii, Lines 17 - 20

This sentence states, "under certain meteorological conditions, the plant will have to be operated at reduced power levels..."

To present an accurate and fair abstract, "certain meteorological conditions" should be further qualified. The applicant provided information (CPS-ER-OLS) that indicated these conditions can be considered the one in 50-year drought.

The applicant also provided information that the thermal standards are based on thermal modeling results based on conservative assumptions. Therefore, we propose the subject sentence to read: "Under certain meteorological conditions (1 in 50-year drought), the plant may have to be operated at reduced power levels based on the results of thermal modeling."

2. Page vi, Item 4a

The reference should be changed from Illinois-Missouri Power Pool to Ill-Mo Pool.

3. Page vi, 4c

"All the water for operating the plant will come from Salt Creek." This statement is incorrect and should be modified to read, "All the water for operating the plant will come from Lake Clinton."

4. (A.) Page vi, 4f

We propose the sentence read, "Under certain meteorological conditions (1 in 50 year drought), the plant may have to be operated at reduced power levels based on the results of thermal modeling."

(B.) Page vi, Item 4h

See IP comment #31 (page 6) regarding conclusions from drainage study.

5. Page xv, 3rd paragraph, Line 11

"...two surveillance needs..., temperatures at the discharge point and at Salt Creek downstream of Lake Clinton."

It is our current understanding that the NRC does not institute OL conditions that are to be monitored or tracked by another federal or state agency. In this instance, discharge temperatures to the lake and Salt Creek are carefully considered when the Illinois Environmental Protection Agency issues an NPDES permit for this facility. Therefore, NRC should delete these surveillance needs in order to avoid potential conflicts with other agencies' requirements and to avoid regulating an area which is the principal concern of another agency.

6. Page 2-1, 2nd paragraph

It is stated that the 1980 initial in-service date for Clinton Unit 1 was based on an expected annual average rate of peak load growth for 1975-1985 of 10%. After reviewing past peak load forecasts, we were unable to confirm that a growth rate as high as 10% was ever forecast.

7. Page 2-2, 1st paragraph

In the NRC's production cost analysis it was assumed that all replacement energy would be produced by coal-fired units in the event that Clinton Unit 1 was not in operation. Our production cost analysis shows that some of the replacement energy would be produced by oil-fired units.

8. Page 2-4, Section 2.4, 4th paragraph

The reference to Illinois-Missouri Power Pool should be changed to Ill-Mo Pool.

9. Page 4-2, 2nd and 3rd paragraphs

A. In paragraph 2: "Unit 2 reactor building" should read "Unit 2 containment building."

B. In paragraph 3 it is stated that "The heater bay has been located along the northwestern side of the turbine building (ER-OL, p. 3.1-1) rather than the northeastern side."

The heater bay was never located or intended to be on the northeast side of the turbine building. There was a typographical error in the CPS-ER (Construction Permit Stage).

10. Page 4-4, Section 4.2.3 Water Use, 2nd paragraph, first sentence, add:

"...waterfowl hunting and other water-based recreational activities."

11. Page 4-5, first three lines

To provide a more accurate statement, use the following: "Groundwater use by the project will be limited to the Clinton Power Station Visitors Center and recreational areas during operation. Use of groundwater at these locations will be minimal and should have no effect on local or regional hydrology."

12. Page 4-6, Section 4.2.6.1 Chemicals

Makeup and Potable Water Treatment

Plant makeup and potable water will be taken from Lake Clinton and then treated by prechlorination, clarification and solids removal -- using alum or sodium aluminate and a coagulant aid, lime softening, and sand filtration. Plant makeup water will undergo further treatment using carbon filtration and demineralization (ER-OL, Secs. 3.3.4.1 and 3.6.2).

13. Page 4-6, Section 4.2.6.1, 2nd paragraph

This paragraph should be rewritten to more accurately describe this treatment facility. Our suggested rewrite follows:

"Wastes generated during backwash cleaning of the sand and carbon filters, removal of sludge from the clarification basins, lime softener blowdown, and demineralizer regeneration and condenser cleaning will be routed to two wastewater treatment ponds, located southwest of the plant near the edge of Lake Clinton, with a total capacity of about 1.9×10^4 m^3 (5.0×10^6 gal). The supernatant effluent from the wastewater treatment ponds will be neutralized by addition of acid, caustic, or lime and then sand filtered before discharge to Lake Clinton. If the quality of wastewater does not meet NPDES effluent limitations (Appendix B) provisions have been made for routing the sand filter effluent back to the wastewater treatment ponds. The sludge collected in the wastewater treatment ponds will be dredged as necessary and transported offsite to a licensed landfill (ER-OL, Sec. 3.6.4). Although the wastewater treatment ponds will not be lined, infiltration of seepage from the ponds into the aquifers in the vicinity of the station will be impeded by the low permeability (less than 10^{-5} cm/s) of the rock and soils in the site area (ER-OL, Sec. 2.4.3.4)."

14. Page 4-7, Scale Control, 2nd paragraph, line 5

"...the sedimentation ponds..." are more accurately described as "a single wastewater treatment pond."

15. Page 4-8, Section 4.2.6.2, 2nd paragraph

In the last sentence 1955 is stated as having the "hottest summer" in 23 years of record. The 1955 meteorological conditions correspond to the 1 in 50-year drought.

16. Page 4-12, 4.2.6.3, Sanitary Wastes

Several design capacities have been changed. Thus, this paragraph should be rewritten as follows:

"The sanitary waste treatment scheme given in Section 3.7.1 of the FES-CP remains valid. The only change is the design capacity, which has been increased from 142 m^3/day (37,500 gal/day) to 161 m^3/day (42,500 gal/day), primarily to meet the needs of an increased labor force. The normal operation work force is expected to be about 350 people for one-unit operation (ER-OL, Response to Question 310.1). The staff has determined that based on a water usage rate of 1.5 x 10^{6} m^3/s (35 gal/day) per person (Ref. 13), the design capacity of the sanitary system is sufficient."

17. Page 4-12, Section 4.2.7 Power-Transmission Systems

Change the last sentence to read: "The three power transmission lines which have been added have a total length of about 92 km (57 mi), and the associated corridors occupy approximately 367 ha (906 acres)."

18. Page 4-16, Table 4.4

Nitrate is monitored and should be added to the list of nutrients.

19. Page 4-17, Section 4.3.3.1

A. Average minimum temperature in January is given as 6°C(35°F) and average maximum as 32°C(50°F) in July.

These should be changed to: "Average minimum temperature in January is -6°C(21°F) and average maximum as 32°C(90°F).

B. It is stated that: Tornadoes, have been reported in Illinois "404 times during 1953-1971. Thus an average of 21 tornadoes per year can be expected statewide."

It is customary to use longer period of data when reporting such weather phenomenon. An average of 10 tornado occurrences per year were reported based on the period of record 1916-1969. The reference for this data is: J. W. Wilson and S. A. Chagnon, Jr. "Illinois Tornadoes," Circular 103, Illinois State Water Survey, Urbana, Illinois, 1971.

20. Page 4-19, Section 4.3.3.2, paragraph 3, lines 7 and 8

This sentence implies that the federal NAAQS (.12 ppm) for ozone is frequently exceeded when it is the state standard (.08 ppm) that has several exceedances. The sentence should read: "For ozone, the hourly Illinois standard is frequently exceeded, however, the federal standard is never exceeded."

21. Page 4-20, 4.3.4.2 Aquatic Section, 2nd paragraph, line 5

Reference to weedy areas should be modified as follows:

"Weedy areas are scattered throughout the shallow sections of the lake but beginning in 1980 and during 1981 major portions of these weedy areas have naturally receded and no longer exist. Even with reduced weedy areas, the brushy areas provide preferred habitat for several fish species and thermal refuges will be available for the maintenance of fish populations during maximum thermal discharge periods (Sec. 5.5.2.3)."

22. Page 4-20, 4.3.4.2 Aquatic Section, 3rd paragraph, 2nd sentence

This sentence should be rewritten as follows: "A stocking program to maintain the recreational fishery in the lake has been established under the management of IDOC subject to the approval of the applicant."

The word "annual" has been deleted as it does not accurately describe the stocking program. Fish will be stocked in response to management plans for each species and in response to the availability of fish.

23. Page 4-20, 4.3.4.2, Aquatic Section, 3rd paragraph, 4th line

Insert "experimental" after "Stocked" and elsewhere to read:

"Stocked experimental game species include the tiger musky (northern pike x muskellunge), walleye and the striped bass x white bass hybrid. Since these hybrid species are infertile and natural reproduction is not expected to maintain the walleye population, the experimental game species may be restocked depending on the outcome of their introduction to a cooling lake."

It should also be noted that Illinois Power expects, based on other cooling lake situations, to have a self-sustaining population of native species in addition to the "experimental" species. Both of these groups of fishes will provide for a diverse sport fishery in Lake Clinton.

24. Page 4-22, Section 4.3.7

Change:

A. "Clinton (1980 population 7953)" to "1980 population 8014"

B. "Farmer City (1980 population 2225)" to "1980 populacion 2252"

C. "Dewitt County grew by a total of 970 persons from 1970 to 1980 from 16,975 to 17,945 persons" to Dewitt County grew by a total of 1,133 persons from 1970 to 1980 from 16,975 to 18,108 persons"

D. "Weldon (1980 population 543)" to "1980 population 531"

25. Page 4-22, 3rd paragraph, 1st line

This sentence needs further clarification since all "sites" are still on the station property. We suggest the following: "Six of the 18 sites described in the 1973 report remain essentially undisturbed on the station property."

26. Page 5-2, 5.3.1.2 Groundwater

To provide a correct statement, please modify the first sentence as follows: "Groundwater will not be used during station operation except at the Visitors Center and in recreational areas."

27. Page 5-3, 3rd paragraph, 6th line

Add "if discharged without prior treatment" after "in the lake."

If treatment is conducted or if another condenser cleaning agent is used, then the sentence in lines 6, 7, and 8 is not applicable and should be deleted. Regardless, the NPDES limit of 0.1 mg/l is incorrect; it should be 1.0 mg/l.

28. Page 5-4, Table 5.1, Table Title

Change "settling pond" to wastewater treatment ponds or place a footnote at bottom of table to read "wastewater treatment ponds."

29. Page 5-5 Groundwater

The applicant is presently conducting groundwater monitoring for lake water intrusion at 10 locations; 3 on the site and 7 off-site. Water wells at the various recreational areas are also monitored during the season (about April through November). No monitoring of groundwater at the wastewater treatment pond is being conducted.

If well monitoring for lake water intrusion is to be continued during the operational phase, the applicant requests this requirement be placed in the environmental protection plan (EPP) rather than in the FES. Future developments may dictate modifications to this monitoring program. It seems more appropriate to place these types of monitoring requirements in the EPP with other environmental requirements.

30. Page 5-5, 5.3.2.2 Thermal, 1st paragraph, last sentence

This statement should be changed to indicate these are modeled conditions and the station may have to be derated in this "worst summer for the period of record." The sentence should read as follows: "The staff has subsequently determined, based on modeled conditions, that under 1955 meteorological conditions (worst summer for the period of record), Unit 1 may have to be operated at reduced power (78%) for several days during the summer..."

31. Page 5-9, 1st full paragraph

This paragraph needs to be updated. A study completed by M & E/ Alstot, March & Guillou, Inc. for Illinois Power Company, dated July, 1981, addresses the upper Salt Creek drainage concern. The conclusions of that study are:

"Principal results of the five year gaging program, three years in the pre-construction phase and two years in the post-construction phase, are summarized as follows:

1. Information provided in Sections "B" and "C" contained in this report specifically shows that the channel

improvements and the maintenance of reservoir levels have, for rates of stream flow which occurred in the five year period, had the following results:

a. On Salt Creek in the vicinity of the Iron Bridge gaging station, the elevation of flood flows has been reduced from a small amount to as much as 1.2 feet. In no case is there evidence that the Clinton Reservoir has increased flood levels.

b. On Trenkle Slough, the channel improvements completed at no expense to the Trenkle Slough Drainage District, have resulted in a general lowering of water surface elevations, and at high flows the amount of lowering of the water surface exceeds two feet.

c. On Salt Creek, in the vicinity of Farmer City, the elevation of the flood flows has been reduced between 2.5 and 4.0 feet, with the larger number pertaining to the higher flood flows. In no case is there evidence that the Clinton Reservoir has increased flood levels.

2. The work performed under the agreement dated December 2, 1976 between Illinois Power Company and Trenkle Slough Special Drainage District has accomplished its stated objectives in improving the efficiency of the District's drainage system and offsetting any possible adverse effects of the Clinton Reservoir thereon."

The information from this study will be included in a forthcoming Supplement No. 3 to the Clinton Environmental Report-Operating License Stage (CPS-ER-OLS) to provide some additional updating information.

32. Page 5-10, 2nd and 3rd paragraphs

Illinois Power has already committed to resolve fog problems with IDOT. Therefore, the NRC should not make requirements that are potentially conflicting with what the state may require, especially with respect to specific recommendations on mitigative measures.

33. Page 5-11, 1st full paragraph regarding waterfowl dispersion

Since the lake will be open to fishing and waterfowl hunting during winter months once CPS becomes operational, we can foresee no reason to use additional "scare tactics" to move waterfowl. The recreational users with boats will disperse the waterfowl.

34. Page 5-11, 2nd half of 1st full paragraph, regarding disease pathogens

A state agency (IDOC) has accepted responsibility to manage the recreational facilities at Clinton. This would include waterfowl disease outbreaks if they should happen to occur. The IDOC has prepared a waterfowl disease contingency plan for the lake and the applicant strongly believes the NRC should not make additional or potentially conflicting requirements in this area. Therefore, the requirement should be deleted as a state agency is already active in this area.

35. Page 5-11, 5.5.1.2, Transmission System

The FES (CP stage) prohibits brush spraying of transmission lines on recreational lands at Clinton (page 4-13). Section 5.5.1.2 does not change this unnecessary requirement despite our proposed modification in the ER-OLS and our letter specifically requesting modification to the construction permit. Complete references are:

1) Page 5.5-1 and 5.5-2, Section 5.5.2 Vegetation Control CPS-ER-OLS,

2) Letter from L. J. Koch (IPC) to Dr. H. R. Dencon (NRC) dated August 31, 1981, U-0286, L20-81(08-31)-L.

It is therefore requested that these changes be incorporated into this section of the FES so brush spraying under transmission lines on recreational lands is allowed.

36. Page 5-12, top paragraph continued from page 5-11, Line 2

Sentence should be reworded as follows: "Additionally, impingement losses that will occur may be partially offset by stocking of forage and game fish if needed as part of the sport fishery management program for the lake."

37. Page 5-12, 1st paragraph regarding NPDES permit

The Illinois Environmental Protection Agency has jurisdiction over the NPDES permit for the station; therefore, this statement should be deleted.

38. Page 5-12, last sentence

This sentence should be deleted. The experimental game species have been stocked to evaluate their potential to provide an additional sport fishery in a cooling lake and to study their temperature tolerances under actual field conditions. A reevaluation of the fishery management plan after thermal addition will address the desirability of a continued stocking program for these species.

39. Page 5-13, 1st paragraph, last sentence

"Stocked game species" has been used by the staff to mean the experimentally stocked species throughout this statement. In this instance, "stocked" must be changed to "native" as the experimentally stocked game species may not be stocked in the future, depending on the future fishery management plan objectives and the success of the experimental species in a cooling lake environment.

40. Page 5-13, 1st paragraph, 4th sentence

This sentence should read: "Although more thermally sensitive species may be adversely affected during hot weather, the ecological balance of the lake will not be affected."

41. Page 5-29, 2nd paragraph

The radiological monitoring programs have been designed and implemented for CPS Unit 1 with the cognizance of the NRC Regulatory Guide 4.1, Rev. 1, "Program for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Ref. 46), and considering the guidance contained in the Radiological Assessment Branch Technical Position, Rev. 1, November 1979, "An acceptable Radiological Environmental Monitoring Program" (Ref. 47).

42. Page 5-29, 5th paragraph

Change first sentence to read: "The applicant states that their Radiological Environmental Monitoring Program has been patterned after the Branch Technical Position of the U.S. NRC, "An Acceptable Radiological Environmental Monitoring Program," dated March, 1978."

43. Page 5-30, Table 5.6

Several minor revisions to the table are in order as listed below. This changed information will be included in the forthcoming Supplement No. 3 to the Clinton Environmental Report - Operating License Stage.

1) For air sampling method - add: "at 41 locations."

2) For wellwater sample method - change three locations to two.

3) Add: Drinking water - one location - same parameters and sample frequency as wellwater.

4) For fish - change sample method to: "Electroshocker/Net, one location."

44. Page 5-37, 1st paragraph, 4th sentence

This sentence should read: "The secondary containment gas control boundary which includes fuel building and parts of the auxiliary building, encloses the primary containment, the spent fuel pool, and other auxiliary equipment."

45. Page 5-60, 3rd paragraph, reference to acid rain

There exists no scientifically proven evidence which supports the theory that sulfur dioxide emissions cause acid rain. There is no firm evidence that rain has become more acidic over the past 30 years either. Therefore, the staff should not conclude that sulfur dioxide emissions "lead to environmental and ecological damage through the phenomenon of acid rain."

46. Page 6-4, 6.4.1, 2nd paragraph

Any potential limitation on power output based on thermal discharge criteria must be qualified as possibly occurring in the 1955 modeled case, which was the worst in 50-year drought example.

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO ATTENTION OF

RECEIVED FEB 26 1982

22 FEB 1982

Mr. J. H. Williams
Licensing Project Manager
Standardization and Special
Projects Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: DE-NRC-F06012-IL
(82-005-701)

Dear Mr. Williams:

We have completed our review of the Draft Environmental Impact Statement (EIS) related to the Operation of Clinton Power Station, Unit No. 1 in DeWitt County, Illinois. This facility will use a boiling-water reactor to provide an electrical output of 933 megawatts of electricity. Cooling water will be obtained from a lake which was created by the applicant (Illinois Power Company) when they constructed a dam near Salt Creek and the North Fork of Salt Creek.

Based upon our review of this draft EIS, we have no environmental objections related to the operation of this power plant. The applicant has indicated their intent to comply with existing environmental regulations related to water, air and radioactive releases. Our Agency previously commented on the draft and final environmental impact statement for the construction license application of this power plant. At the time of our review of construction license application, we had significant environmental concerns related to the amount of heated effluent discharged to Lake Clinton and Salt Creek, and the potential for adverse water quality impacts upon Salt Creek below the dam. These concerns were mitigated by the applicant and our environmental objections were resolved.

A Radiological Emergency Response Plan has not been prepared for the Clinton Power Station. The Radiological Emergency Response Plan for the Clinton Station has not been included in the State plan since the plant is still under construction. When this plan is available and a test is scheduled, we will provide comments on the safety and environmental aspects of this plan.

We have rated the draft EIS as LO-1. This indicates that we have no objections to the operation of the power plant and believe the EIS addresses the environmental issues adequately. Notice of the availability of our comments on the project will be published in the Federal Register in accordance with our responsibility to keep the public informed of our views on other agencys' projects. If you have any questions related to our comments, please contact Mr. William Franz, at FTS 886-6687.

Sincerely yours,

William D. Franz

for Barbara Taylor Backley, Chief
Environmental Review Branch
Planning and Management Division

C002 B
s/0

APPENDIX B. NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT FOR CLINTON POWER STATION

received 10/28/77
dmf

Permit Book
A-17

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
230 SOUTH DEARBORN ST
CHICAGO, ILLINOIS 60604

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Larry L. Idleman
Director of Environmental Affairs
Illinois Power Company
500 South 27th Street
Decatur, Illinois 62525

OCT 21 1977

Re: Request for Modification of
NPDES Permit No. IL 0036919
Clinton Power Station

Dear Mr. Idleman:

The U.S. Environmental Protection Agency has examined the request in your letter of August 23, 1977, for the modification of the above referenced NPDES permit. Our final determination is to modify the permit as follows:

1. Outfall 002 has been deleted.

2. The limitations for outfall 003 have been revised.

Because the revisions made in the permit are minor in nature, no formal public notice of the modification will be issued.

Enclosed is a copy of the modified permit. This permit is effective 30 days from the date of signature and it supersedes NPDES Permit No. IL 0036919 dated September 30, 1975, and revision of 8/11/77.

Very truly yours,

Dale S Bryson

Dale S. Bryson, Acting Director
Enforcement Division

Enclosure
Modified Permit

cc: Mr. T. McSwiggin, Illinois Environmental Protection Agency, w/Permit

Permit No. IL0036919

Application No. IL0036919

AUTHORIZATION TO DISCHARGE UNDER THE

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. 1251 et seq; the "Act"),

ILLINOIS POWER COMPANY

is authorized by the United States Environmental Protection Agency, Region V,

to discharge from a facility located at the Clinton Power Station
Clinton, Illinois

to receiving waters named Salt Creek (Lake Clinton)

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit and the authorization to discharge shall expire at midnight, July 31, 1980 . Permittee shall not discharge after the above date of expiration. In order to receive authorization to discharge beyond the date of expiration, the permittee shall submit such information, forms, and fees as are required by the Agency authorized to issue NPDES permits no later than 180 days prior to the above date of expiration.

This permit, modified in accordance with 40 CFR 125, shall become effective 30 days from this date of signature and supersedes NPDES Permit number IL0036919 dated September 30, 1975

Signed this OCT 21 1977

Dale S. Bryson

Acting Director, Enforcement Division

PART I

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date of this permit and lasting until the expiration date the permittee is authorized to discharge from outfall(s) serial number(s) 001-Sanitary Waste Discharge

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day) Daily Avg	DISCHARGE LIMITATIONS kg/day (lbs/day) Daily Max	Other Units (Specify) Daily Avg	Other Units (Specify) Daily Max	MONITORING REQUIREMENTS Measurement Frequency	MONITORING REQUIREMENTS Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Weekly	Daily Average Flow Estimate
BOD^5	-	-	10 mg/l*	45 mg/l	Weekly	Grab
Suspended Solids	-	-	12 mg/l*	45 mg/l	Weekly	Grab
Fecal Coliform	-	-		400 counts/ 100 ml	Weekly	Grab

*Or 85% removal, whichever is less.

The pH shall not be less than 6.0 nor greater than 9.0 and shall be monitored by weekly grab samples.

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 a point representative of the discharge from the treatment plant (BOD_5-samples should be taken prior to chlorination.)

PART I

[illegible]

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date of this permit and lasting until the expiration dat the permittee is authorized to discharge from outfall(s) serial number(s) 003-Construction Runoff, Water Treatment and Demineralizer Waste

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS				MONITORING REQUIREMENTS	
	kg/day (lbs/day)		Other Units (Specify)			
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Weekly	Daily Averag Flow Estima
Suspended Solids	-	-	-	15 mg/l	Weekly	Grab
Oil and Grease	-	-	-	15 mg/l	Monthly	Grab

The pH shall not be less than 6.0 nor greater than 9.0 and shall be monitored

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 a point representative of the discharge but prior to mixing with other waste streams.

PART I

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date of the modification and lasting until the expiration date, the permittee is authorized to discharge from outfall(s) serial number(s) 003-Preoperational Metal Cleaning Wastes

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day) Daily Avg	Daily Max	Other Units (Specify) Daily Avg	Daily Max	MONITORING REQUIREMENTS Measurement Frequency *	Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Daily Total	Pump estimate
Suspended solids	-	-	-	15 mg/l	"	Composite of two or more grabs
Total iron	-	-	-	1.0 mg/l	"	
Total copper	-	-	-	1.0 mg/l	"	" "
Total Zinc	-	-	-	1.0 mg/l	"	" "
Total Phosphorus (as P)	-	-	-	1.0 mg/l	"	" "
Ammonia (as N) unionized	-	-	-	0.02 mg/l	"	" "
Oil & Grease	-	-	-	15 mg/l	"	" "
BOD_5	-	-	-	4 mg/l	"	" "

The pH shall not be less than 6.0 nor greater than 9.0 and shall be monitored by daily grab samples

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 a point representative of the discharge but prior to mixing with other waste streams.

*During batch Discharge

C. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

   A. The Illinois Power Company shall submit an acceptable Lake Management Plan for approval by the Illinois Environmental Protection Agency and the Illinois Department of Conservation by December 31, 1975. This plan shall include, but not be limited to:

      1) Detailed Plans for Control of Nuisance Algae and Aquatic Macrophytes;
      2) Detailed Plans for Fisheries Management at Lake Clinton.

   B. The Illinois Power Company shall submit quarterly progress reports on participatory research and monitoring programs. (First report is due by April 28, 1976.)

   C. The Illinois Power Company shall submit annual summary reports of research and monitoring as required by Part IV A(3),(4),(5),(6) and Part B(iii), (v), (vi) of this permit. The first annual summary report shall be submitted by January 28, 1977.

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 requirements.

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 - The permittee shall record monitoring results on Discharge Monitoring Report forms, using one such form for each discharge each month. The completed monthly forms shall be retained by permittee for a period of three months beginning with each calendar quarter, and the forms from those three months shall be mailed to USEPA no later than the 28th day of the following month, i.e. (a) January, February, March (submit April 28); (b) April, May, June (submit July 28); (c) July, August, September (submit October 28); October, November, December (submit January 28).

The permittee shall retain a copy of all reports submitted. All reports shall be submitted to:

U. S. Environmental Protection Agency
Attention: Chief, Compliance Unit
230 South Dearborn Street
Chicago, Illinois 60604

The permittee shall submit these monitoring reports each month to the appropriate District Office of the Illinois Environmental Protection Agency by the 15th day of the following month unless otherwise directed by the Illinois Environmental Protection Agency.

3. 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 Regional Administrator and the State with the following information, in writing, within five (5) days of becoming aware of such condition: (a) a description of the discharge; (b) cause of noncompliance; (c) the period of noncompliance, including exact dates and times; (d) if not corrected, the anticipated time the noncompliance is expected to continue, and (e) steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

4. Definitions

a. "Daily Average" Discharge

1. Weight Basis - 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 the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

2. Concentration Basis - The "daily average" concentration means the arithmetic average (weighted by flow value) of all the daily determinations of concentration made during a calendar month. Daily determination 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 the calendar day.

b. "Daily Maximum" Discharge

1. Weight Basis - The "daily maximum" discharge means the maximum total discharge by weight permitted during any calendar day.

2. Concentration Basis - The "daily maximum" concentration means the maximum value in terms of concentration permitted in the discharge during any calendar day.

5. Test Procedures - Test procedures for the analysis of pollutants shall conform to regulations published pursuant to Section 304(g) of the Act, under which such procedures may be required.

6. 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.

7. 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). Such increased frequency shall also be indicated.

8. 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 Regional Administrator or the State Water Pollution Control Agency.

PART II - 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 increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application 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. 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.

3. Adverse Impact - The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters 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.

4. 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 Regional Administrator and the State in writing of each such diversion or bypass.

5. Removed Substances - Solids, sludges, filter backwash, or other pollutants removed from or resulting from treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering navigable waters.

6. 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 no date for implementation appears in Part I, (b) halt, reduce or otherwise control production and/or all discharges upon the reduction, loss, or failure of one or more of the primary sources of power to the wastewater control facilities.

B. RESPONSIBILITIES

1. Right of Entry - The permittee shall allow the head of the State Water Pollution Control Agency, the 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.

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 Regional Administrator and the State Water Pollution Control Agency.

3. Availability of Reports - Except for data determined to be confidential under Section 308 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 State Water Pollution Control Agency and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of 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 Section 307(a) 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-4) and "Power Failures" (Part II, A-6), 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 Section 311 of the Act.

8. State Law - 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 under authority preserved by Section 510 of the Act.

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 Federal, State 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

A. Rainfall Runoff

1. Rainfall runoff from construction activity at the generating facility site and from material storage areas shall be controlled to meet all effluent restrictions specified in Part I A (2) of this permit.

2 Any untreated overflow from facilities designed, constructed and operated to treat the volume of material storage runoff and construction runoff which is associated with a 10 year, 24 hour rainfall event shall not be subject to the limitations for Suspended Solids and pH specified in Part I A (2) of this permit.

B. Erosion Control

The permittee shall utilize EPA Publication No. 430/9-73-007 "Process, Procedures, and Methods to Control Pollution Resulting from Construction Activity," October 1973, in developing and implementing procedures and methods for controlling erosion and sediment deposition.

As a minimum, the following practices shall be instituted:

1. Minimization of the duration of excavation and grading activities.

AS MODIFIED

2. Control of the speed and volume of stormwater runoff, as necessary, by:

   a. Proper sizing of drainage ditches;
   b. Use of energy dissipative devices such as check dams and pooling areas

3. Construction of sediment traps and settling areas as necessary to prevent sediment from leaving the site.

4. Soil stabilization by minimizing slopes, revegetating spoil banks and cleared surfaces by seeding or sodding and through the proper and timely surfacing of parking lots, roads and laydown areas with crushed rock or gravel.

5. Taking all necessary precautions to minimize erosion through proper timing and installation of necessary erosion control devices, by avoiding land clearing in fall (insofar as feasible) and prior to installation of sediment traps, runoff drainage or any necessary impoundments for sediment control.

C. Control of Other Construction - Related Activity

1. The company will dike and berm such areas as necessary to prevent accidental spills and leakage of fuel and oil.

2. Proper receptacles will be provided for collection of oil soaked rags and papers to prevent contact with area runoff.

3. In order to prevent oil discharges, drainage from equipment maintenance buildings and equipment maintenance areas will be routed through appropriate treatment systems to provide the following effluent quality and monitoring during periods of discharge:

Parameter	Limits: Monthly Average	Limits: Daily Maximum	Frequency	Sample Type
Flow		-	Monthly	Daily Maxim Flow Estima
Oil and Grease	15 mg/l	20 mg/l	Monthly	Grab

PART IV

A. <u>Alternative Thermal Effluent Limitations Pursuant to Section 316(a) of the Act</u>

Based upon a demonstration by the Company that effluent limitations proposed for the control of the thermal component of the discharge are more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made, the Regional Administrator has exercised his authority under Section 316(a) of the Act and imposed alternative thermal effluent limits subject to the following conditions:

1. The Company has committed to the installation of a spray canal system described, in a letter from the permittee on April 14, 1975, as follows:

   "IPC proposes to install 112 spray modules with Unit #1 and 120 spray modules with Unit #2. As can be seen on Figures 1 & 2 [attached on pages 17 & 18] the discharge temperature will only occasionally peak at 96°F for short durations during the one in ten year hot summer and in an average year, the maximum temperature reached will be approximately 92°F with the temperature for the most part being below 90°F."

   Said system shall be operated in the following manner:

   a. In the late spring when the condenser discharge temperature reaches 92°F or on June 1, whichever comes first, the supplemental cooling system will begin operation with approximately one-fifteenth (1/15) of the capacity being switched on;

   b. Each day thereafter another one-fifteenth (1/15) of the system will begin operation, until by June 15, at the latest, all modules will be operating;

   c. In the late summer, when the condenser discharge temperature reaches 92°F on the declining side of the time/temperature curve, or on September 19, whichever occurs last, the supplemental cooling system will begin to be sequenced off with approximately one-fifteenth (1/15) of the modules being shut down for the first six (6) days;

   d. Each day thereafter another two-fifteenths (2/15) or less of the modules will be shut off until by September 30, at the earliest, the complete system will be off.

2. The effluent temperature to the lake will not exceed 96°F at any time.

3. The permittee shall participate in a thermal research program at existing cooling lake sites to determine the effects of thermal discharges (including their interaction with other physical, chemical, and biological parameters) on cooling lakes.

Further the permittee shall evaluate the results obtained from such ongoing research along with other research results and data (as obtained from the literature and other sources) in a continuing process likely to result in a better understanding of the effects of the proposed thermal discharge into Clinton Lake.

And further, the permittee shall monitor the aquatic ecosystem before, during, and after lake filling (prior to and after initiation of thermal discharge). Such monitoring plan shall be submitted to the U.S. Environmental Protection Agency (U.S. EPA) and the State of Illinois for evaluation no later than December 31, 1975. The U.S. EPA agrees to consult with the NRC, IEPA, and Illinois Department of Natural Resources prior to approval or disapproval of such plan.

4. If, as a result of that research, data collection, monitoring, or evaluation of the literature described above, it is determined that conditions in Clinton Lake will be significantly different than has been described in the 316(a) demonstration, or if it is determined that the cooling water use, recreational aspects of the lake, or that protection and propagation of indigenous aquatic life cannot be assured, the Company agrees to take whatever measures are needed to correct the problem, including backfitting of the proposed or existing plant with additional cooling facilities.

5. The permittee shall research and submit to the U.S. EPA and the State of Illinois no later than December 31, 1975 a detailed plan for the control of nuisance algae and aquatic macrophytes which may develop in Clinton Lake.

6. The permittee shall submit to the U.S. EPA a detailed Fishery Management Plan developed in consultation with the Illinois Department of Conservation, no later than December 31, 1975.

Furthermore, the permittee shall submit to the U.S. EPA and the Illinois Environmental Protection Agency in annual summary reports the results of its participatory research in cooling lake management and impacts commencing with December 31, 1976 and shall submit its plans to implement the findings of such research if the research shows such need.

B. Conditions of State Certification AS MODIFIED

The Illinois Environmental Protection Agency has certified on August 11, 1975 that the discharge shall comply with the applicable provisions of Sections 301, 302, 306 and 307 of the Federal Water Pollution Control Act, as amended. This certification is contingent upon the following provisions:

(i) That Illinois Power Co. agrees to operate, as a minimum, a supplemental cooling system employing 232 spray modules, and otherwise consistent with that described in the Illinois Pollution Control Board Opinion PCB 75-31, in the following manner (When only Unit #1 of the two unit facility is operational, only 112 spray modules will be required. At the time when Unit #2 becomes operational, an additional 120 spray modules must be installed and operated.):

a. in the late spring when the condenser discharge temperature reaches 92°F or on June 1, whichever comes first, the supplemental cooling system will begin operation with approximately one-fifteenth (1/15) of the capacity being switched on;

b. each day thereafter another one-fifteenth (1/15) of the system will begin operation, until by June 15, at the latest, all modules will be operating;

c. in the late summer, when the condenser discharge temperature reaches 92°F on the declining side of the time/temperature curve, or on September 19, whichever occurs last, the supplemental cooling system will begin to be sequenced off with approximately one-fifteenth (1/15) of the modules being shut down for the first six (6) days;

d. each day thereafter another two-fifteenths (2/15) or less of the modules will be shut off until by September 30, at the earliest, the complete system will be off.

(ii) That the effluent temperature to the lake will not exceed 96°F at any time;

(iii) That Illinois Power Company prior to the filling of the impoundment submits an acceptable lake management plan for approval by the Illinois Environmental Protection Agency and the Illinois Department of Conservation, which plan will preserve the lake's recreational and fisheries value;

AS MODIFIED

B. Conditions of State Certification (continued)

(iv) That Illinois Power Company keeps the lake open to readily available public access throughout the life of the lake;

(v) That Illinois Power Company develops and submits an acceptable program prior to operation showing startup and shutdown procedures which will minimize the adverse effect of such activities on aquatic life;

(vi) That if it is determined after operation of the first unit or by ongoing research, that conditions in Clinton Lake will be significantly different than has been described in the 316(a) demonstration, or if it is determined that the cooling water use, recreational aspects of the lake, or that protection and propagation of indigenous aquatic life cannot be assured, Illinois Power Company shall take whatever measures are needed to correct the problem, including backfitting of the proposed or existing plant with additional cooling facilities;

(vii) That Petitioner Illinois Power Company submit quarterly progress reports to:

Illinois Environmental Protection Agency
Manager, Variance Section
Division of Water Pollution Control
2200 Churchill Road
Springfield, Illinois 62706

PART V

Proposed Conditions for Future Discharges into Lake Clinton

The following are proposed conditions for a permit to be issued to the Company upon the expiration of this permit on July 30, 1980. These proposed conditions reflect the present assessment of U.S. EPA and the Illinois EPA and are for informational purposes only. The limitations apply to discharges or waste sources not in existence during the construction phase of the Clinton Power Station.

A. Outfall Description

Outfall Serial No. 004 consists of the following sources:

1. Circulating Water Flow
2. Demineralizer Wastes
3. Plant Sanitary Wastes
4. Radiation Waste Treatment
5. Heating Boiler Blowdown
6. Auxiliary Cooling Equipment

Outfall Serial No. 005 consists of Crib House Screen Backwash.

Outfall Serial No. 006 consists of the following sources:

1. Oily Sump Drains
2. Nonradioactive Plant Drains
3. Storm Drainage

Only discharges from waste sources described in Part V above or covered by the existing permit will be permitted. Waste sources that are not covered by this permit include, but are not limited to, metal cleaning wastes and polychlorinated biphenyls, (such as commonly found in heat transfer oils).

PART V AS MODIFIED

B. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning on August 1, 1980 and lasting until July 31, 1985 the permittee is authorized to discharge from outfall(s) serial number(s) 004

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day)		Other Units (Specify)		MONITORING REQUIREMENTS	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-		Continuous	Continuous
Free Chlorine Residual (1)	-	-	0.2 mg/l	0.5 mg/l	Continuous During Chlorination	
Total Chlorine Residual (2)*	-	-	-	0.2 mg/l*	Continuous During Chlorination	
Discharge Temperature (2)	-	-	-	96°F	Continuous	Continuous
Condenser Temperature (1)	-	-	-	-	Continuous	Continuous
Intake Temperature	-	-	-	-	Continuous	Continuous
Plant Load Factor	-	-	-	-	Monthly Average	
Number of Spray Modules in Operation		-	-	-	Monthly Minimum, Average, and Maximum	

*The release of total chlorine residual into Lake Clinton will be limited to two hours per day for the facility.

The pH shall not be less than 6.0 nor greater than 9.0 and shall be monitored on a continuous basis at the discharge to the discharge canal.

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): (1) Measured at the Condenser
(2) Measured at the discharge to Lake Clinton

PART V

B. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

2. During the period beginning on August 1, 1980 and lasting until July 31, 1985 the permittee is authorized to discharge from outfall(s) serial number(s) 004-Boiler Blowdown, Demineralizer wastes, Radiation Waste Treatment System

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day)		DISCHARGE LIMITATIONS Other Units (Specify)		MONITORING REQUIREMENTS	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-		Weekly	Daily Average Flow Estimate
Suspended Solids	-	-	-	15 mg/l	Weekly	8-hr. Composi
Total Copper	-	-	-	1.0 mg/l	Weekly	8-hr. Composi
Total Iron	-	-	-	1.0 mg/l	Weekly	8-hr. Composi

The pH shall be monitored by weekly grab samples.

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 a point representative of the treatment system discharge prior to dilution with condenser cooling water.

PART V

B. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

3. During the period beginning on August 1, 1980 and lasting until July 31, 1985 the permittee is authorized to discharge from outfall(s) serial number(s) 004 Sanitary Wastes

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day)		Other Units (Specify)		MONITORING REQUIREMENTS	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Weekly	Daily Average Flow Estimate
Suspended Solids	-	-	30 mg/l	45 mg/l	Weekly	Grab
BOD5	-	-	30 mg/l	45 mg/l	Weekly	Grab
Chlorine Residual	-	-	-	1.0 mg/l	Weekly	Grab
Total Phosphorus	-	-	-	1.0 mg/l	Weekly	Grab

The pH shall be monitored by weekly grab samples.

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 a point representative of the discharge from the treatment system (BOD_5 samples shall be taken prior to chlorination) prior to [illegible] condenser cooling water.

PART V

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

4. During the period beginning on August 1, 1980 and lasting until July 31, 1985 the permittee is authorized to discharge from outfall(s) serial number(s) 005 Intake Screen Backwash

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day)		Other Units (Specify)		MONITORING REQUIREMENTS	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Monthly	Daily Average Flow Estimate

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): N/A

PART V

B. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

5. During the period beginning on August 1, 1980 and lasting until July 31, 1985 the permittee is authorized to discharge from outfall(s) serial number(s) 005

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS kg/day (lbs/day)		Other Units (Specify)		MONITORING REQUIREMENTS *	
	Daily Avg	Daily Max	Daily Avg	Daily Max	Measurement Frequency	Sample Type
Flow-M^3/Day (MGD)	-	-	-	-	Weekly	Total Flow Estimate
Suspended Solids (1)	-	-	15 mg/l	50	Weekly	Grab
Oil and Grease (1)	-	-	-	15 mg/l	Weekly	Grab
Oil and Grease (2)	-	-	15 mg/l	20 mg/l	Weekly	Grab

*During Periods of Discharge

The pH shall not be less than 6.0 nor greater than 9.0 and shall be monitored by weekly grab samples.

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): (1) At a point representative of Outfall Discharge.
(2) At a point representative of the discharge from the oily waste

C. Intake Monitoring

Within 30 days of the receipt of the permit and the determination of the Regional Administrator, the permittee shall submit to the Regional Administrator and the Illinois Environmental Protection Agency for approval the design for an intake monitoring program to document the effects of the present intake on the various species and life stages of fish. Such a monitoring program shall include, but not be limited to, a tabulation of all fish trapped by the present intake structure. This tabulation shall be performed every fourth day unless the permittee justifies some alternative schedule to the Regional Administrator and the Illinois Environmental Protection Agency within sixty (60) days after start up of Unit #1 and end within twelve (12) months of the commencement of tabulation and shall include the number, weight, length, and species of each fish entrapped. Such monitoring data shall be submitted quarterly with other reports.

The permittee shall submit a final report to the Regional Administrator and to the Illinois Environmental Protection Agency by no later than providing proposals for measures to be taken by the permittee to meet the requirements of Section 316(b) of the Act for the best cooling water intake technology available. Development of the report shall be guided by the "Development Document for Best Technology Available for Minimizing Adverse Environmental Impact for Cooling Water Intake Structures", as proposed by the U.S. EPA.

This report shall be evaluated with regard to Section 316(b) of the Act. As a result of this evaluation, the Regional Administrator may modify the permit in accordance with Part II B4 to establish an implementation schedule to insure compliance with Section 316(b).

APPENDIX C. EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

APPENDIX C. EXAMPLES OF SITE-SPECIFIC DOSE ASSESSMENT CALCULATIONS

C.1 CALCULATIONAL APPROACH

As mentioned in the text, the quantities of radioactive material that may be released annually from the Clinton Power Station are estimated on the basis of the description of the radwaste systems in the applicant's ER-OL and FSAR and by using the calculational model and parameters developed by the NRC staff (Refs. 1 and 4). These estimated effluent release values along with the applicant's site and environmental data in the ER-OL 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 station and of cumulative doses and dose commitments to the entire population within an 80-km (50-mi) radius of the station as a result of station operations are discussed in detail in Regulatory Guide 1.109 (Ref. 2). Use of these models with additional assumptions for environmental pathways that lead to exposure to the general population outside the 80-km radius are described in Appendix D 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 the station 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 one year under the conditions existing 15 years after the station begins operation (i.e., 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.

C.2 DOSE COMMITMENTS FROM RADIOACTIVE EFFLUENT RELEASES

The NRC staff's estimates of the expected gaseous and particulate releases (listed in Table C.1) along with the site meteorological considerations (summarized in Table C.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 C.3.

Two years of meteorological data were used in the calculation of concentrations of effluents. The data were collected onsite from April 1972 to April 1974. The long-term atmospheric dispersion estimates were made using the procedure described in Regulatory Guide 1.111, Revision 1 (Ref. 3).

The NRC staff estimates of the expected liquid releases (listed in Table C.8), along with the site hydrological considerations (summarized in Table C.9), were used to estimate radiation doses and dose commitments from liquid releases.

C.2.1 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 (i.e., 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 since 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 C.4, C.5, and C.6. 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 C.4, C.5, and C.6.

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 Regulatory Guide 1.109 (Ref. 2).

C.2.2 Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne and waterborne radioactive releases from the Clinton Power Station are estimated for two populations in the year 2020: (1) all members of the general public within 80 km (50 mi) of the station (Table C.5) and (2) the entire U.S. population (Table C.7). Dose commitments beyond 80 km are based on the assumptions discussed in Appendix D. For perspective, annual background radiation doses are given in the tables for both populations.

References for Appendix C

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

2. "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," Regulatory Guide 1.109, Revision 1, U.S. Nuclear Regulatory Commission, October 1977.

3. "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Reactors," Regulatory Guide 1.111, Revision 1, U.S. Nuclear Regulatory Commission, July 1977.

4. "Calculation of Release of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," U.S. Nuclear Regulatory Commission, NUREG-0017, April 1976.

Table C.1. Calculated Releases of Radioactive Materials in Gaseous Effluents from Clinton Power Station (Ci/yr per reactor)

Nuclide	Building Ventilation				Gland Seal	Air Ejector	Mech. Vac. Pump (Periodic)	Total
	Containment	Turbine	Auxiliary	Radwaste				
Kr-83m	a	a	a	a	a	a	a	a
Kr-85m	3	68	3	a	a	a	a	74
Kr-85	a	a	a	a	a	240	a	240
Kr-87	3	130	3	a	a	a	a	140
Kr-88	3	230	3	a	a	a	a	240
Kr-89	a	a	a	a	a	a	a	a
Xe-131m	a	a	a	a	a	a	a	a
Xe-133m	a	a	a	a	a	a	a	a
Xe-133	66	250	66	10	a	a	2300	2700
Xe-135m	46	650	46	a	a	a	a	740
Xe-135	34	630	34	45	a	a	350	1100
Xe-137	a	a	a	a	a	a	a	a
Xe-138	7	1400	7	a	a	a	a	1400
Total Noble Gases								6600
I-131	1.7(-2)[b]	1.9(-1)	1.7(-1)	5.0(-2)	a	a	3.0(-2)	.46
I-133	6.8(-2)	7.6(-1)	6.8(-1)	1.8(-1)	a	a	a	1.7
Cr-51	3.0(-6)	1.3(-2)	3.0(-4)	9.0(-5)	c	c	c	1.3(-2)
Mn-54	3.0(-5)	6.0(-4)	3.0(-3)	3.0(-4)	c	c	c	3.9(-3)
Fe-59	4.0(-6)	5.0(-4)	4.0(-4)	1.5(-4)	c	c	c	1.1(-3)
Co-58	6.0(-6)	6.0(-4)	6.0(-4)	4.5(-5)	c	c	c	1.3(-3)
Co-60	1.0(-4)	2.0(-3)	1.0(-2)	9.0(-4)	c	c	c	1.3(-2)
Zn-65	2.0(-5)	2.0(-4)	2.0(-3)	1.5(-5)	c	c	c	2.2(-3)
Sr-89	9.0(-7)	6.0(-3)	9.0(-5)	4.5(-6)	c	c	c	6.1(-3)
Sr-90	5.0(-8)	2.0(-5)	5.0(-6)	3.0(-6)	c	c	c	2.8(-5)
Zr-95	4.0(-6)	1.0(-4)	4.0(-4)	5.0(-7)	c	c	c	5.0(-4)
Sb-124	2.0(-6)	3.0(-4)	2.0(-4)	5.0(-7)	c	c	c	5.0(-4)

Table C.1. (Continued)

Nuclide	Building Ventilation: Containment	Turbine	Auxiliary	Radwaste	Gland Seal	Air Ejector	Mech. Vac. Pump (Periodic)	Total
Cs-134	4.0(-5)	3.0(-4)	4.0(-3)	4.5(-5)	c	c	3.0(-6)	4.4(-3)
Cs-136	3.0(-6)	5.0(-5)	3.0(-4)	4.5(-6)	c	c	2.0(-6)	3.6(-4)
Cs-137	5.5(-5)	6.0(-4)	5.5(-3)	9.0(-5)	c	c	1.0(-5)	6.3(-3)
Ba-140	4.0(-6)	1.1(-2)	4.0(-4)	1.0(-6)	c	c	1.1(-5)	1.1(-2)
Ce-141	1.0(-6)	6.0(-4)	1.0(-4)	2.6(-5)	c	c	c	7.3(-4)
H-3	-	-	-	-	-	-	-	57.
C-14	1.5	a	a	a	a	8.0	a	9.5
Ar-41	25.	c	c	c	c	c	c	25.

[a]Less than 1.0 Ci/yr for noble gas, 10^{-4} Ci/yr for iodine.

[b]Exponential notation; $1.7(-2) = 1.7 \times 10^{-2}$.

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

Table C.2. Summary of Atmospheric Dispersion Factors (χ/Q) and Relative Deposition Values for Maximum Site Boundary and Receptor Locations near the Clinton Power Statio:

Location	Continuous		Purge	
	χ/Q (sec/m^3)	Relative Deposition (m^{-2})	χ/Q (sec/m^3)	Relative Deposition (m^{-2})
Site boundary (E 1.2 km)	8.2×10^{-7}	6.6×10^{-9}	4.2×10^{-6}	3.3×10^{-8}
Nearest** residence and garden (NW 1.1 km)	1.1×10^{-6}	6.4×10^{-9}	5.9×10^{-6}	3.3×10^{-8}
Nearest milk cow & milk goat (ESE 8.0 km)	5.8×10^{-8}	2.3×10^{-10}	3.1×10^{-7}	1.3×10^{-9}
Nearest meat animal (N 1.6 km)	8.0×10^{-7}	5.5×10^{-9}	3.2×10^{-6}	2.2×10^{-8}

*The values presented in this table are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Rev. 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

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

Table C.3. Nearest Pathway Locations Used for Maximum Individual Dose Commitments for the Clinton Power Station

Location	Sector	Distance (km)
Site boundary*	E	1.2
Residence** and garden	NW	1.1
Milk cow & milk goat	ESE	8.0
Meat animal	N	1.6

*Beta and gamma air doses, total body doses, and skin doses from noble gases are determined at site 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 C.4. Annual Dose Commitments to a Maximally Exposed Individual near the Clinton Power Station

Location	Pathway	Doses (mrem/yr per unit)			
		Noble Gases in Gaseous Effluents			
		Total Body	Skin	Gamma Air Dose (mrad/yr per unit)	Beta Air Dose (mrad/yr per unit)
Nearest site boundary[a] (E 1.2 km)	Direct radiation from olume	0.42	0.90	0.65	0.70
		Iodine and Particulates in Gaseous Effluents[b]			
		Total Body		Organ	
Nearest[c] site boundary (E 1.2 km)	Ground deposit	0.08 (T)		0.08 (C) (thyroid)	
	Inhalation	0.003 (T)		0.40 (C) (thyroid)	
Nearest garden and residence (NW 1.1 km)	Ground deposit	0.08 (C)		0.08 (C) (thyroid)	
	Inhalation	0.003 (C)		0.55 (C) (thyroid)	
	Vegetable consumption	0.27 (C)		3.2 (C) (thyroid)	
Nearest milk cow & goat[d] (ESE 8.0 km)	Ground deposit	0.003 (C)		0.003 (I) (thyroid)	
	Inhalation	0.0002 (C)		0.024 (I) (thyroid)	
	Vegetable consumption	0.013 (C)		-	
	Goat milk consumption	0.009 (C)		2.63 (I) (thyroid)	
Nearest meat animal (N 1.6 km)	Meat consumption	0.03 (C)		0.27 (C) (bone)	
		Liquid Effluents (Adults)[b]			
		Total Body		Organ	
Discharge point	Water ingestion	0.009		0.028 (thyroid)	
	Fish consumption	0.017		0.008 (thyroid)	

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

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

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

[d]Doses presented here are for goat milk consumption as they exceed those for cow milk consumption at this location.

Table C.5. Calculated Appendix I Dose Commitments to a Maximally Exposed Individual and to the Population from Operation of Clinton Power Station

	Annual Dose per Reactor Unit	
	Individual	
	Appendix I Design Objectives[a]	Calculated Doses[b]
Liquid effluents		
Dose to total body from all pathways	3 mrem	0.026 mrem
Dose to any organ from all pathways	10 mrem	0.036 mrem (thyroid-adult)
Noble-gas effluents (at site boundary 1.2 km E)		
Gamma dose in air	10 mrad	0.65 mrad
Beta dose in air	20 mrad	0.70 mrad
Dose to total body of an individual	5 mrem	0.42 mrem
Dose to skin of an individual	15 mrem	0.90 mrem
Radioiodines and particulates[c]		
Dose to any organ from all pathways	15 mrem	3.8 mrem (thyroid-child)
	Population Within 80 km	
	Total Body (person-rem)	Thyroid (person-rem)
Natural-background radiation[d]	94,500.	-
Liquid effluents	< 0.04	< 0.02
Noble-gas effluents	0.31	0.31
Radioiodine and particulates	0.58	8.8

[a]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.

[b]Numerical values in this column were obtained by summing appropriate values in Table C.4. Locations resulting in maximum doses are represented here.

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

[d]"Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average back-ground dose for Illinois of 85 mrem/yr, and year 2020 projected population of 1,112,000.

Table C.6. Calculated RM-50-2 Dose Commitments to a Maximally Exposed Individual from Operation of the Clinton Power Station[a]

	Annual Dose per Site	
	RM-50-2 Design Objectives[b]	Calculated Doses
Liquid effluents:		
Dose to total body or any organ from all pathways	5 mrem	0.036 mrem
Activity-release estimate, excluding tritium (Ci)	10	0.2
Gaseous effluents:		
Noble-gas effluents (at site boundary 1.2 km E)		
Gamma dose in air	10 mrad	0.65 mrad
Beta dose in air	20 mrad	0.7 mrad
Dose to total body of an individual	5 mrem	0.42 mrem
Dose to skin of an individual	15 mrem	0.9 mrem
Radioiodine and particulates[c]		
Dose to any organ from all pathways	15 mrem	3.8 mrem (thyroid)
I-131 activity release (Ci)	2	0.46

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

[b]Annex to Appendix I to 10 CFR Part 50.

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

Table C.7. Annual Total-Body Population Dose Commitments, Year 2000

Category	U.S. Population Dose Commitment, person-rem/yr
Natural background radiation[a]	26,000,000[a]
Clinton Power Station operation	
Plant workers	740
General public:	
Liquid effluents[b]	< 0.04
Gaseous effluents	27.
Transportation of fuel and waste	3

[a]Using the average U.S. background dose (100 mrem/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. 541, February 1975.

[b]80-km (50-mi) population dose.

Table C.8. Calculated Release of Radioactive Materials in Liquid Effluents from Clinton Power Station

Nuclide	Ci/yr/reactor	Nuclide	Ci/yr/reactor
Corrosion and Activation Products		Fission Products (cont'd)	
Na-24	1.3(-3)[a,b]	Ru-103	3.0(-5)
P-32	1.4(-4)	Rh-103m	3.0(-5)
Cr-51	6.1(-3)	Tc-104	2.0(-5)
Mn-54	1.7(-4)	Ru-105	1.1(-4)
Mn-56	1.3(-3)	Rh-105m	1.1(-4)
Fe-55	2.8(-3)	Rh-105	4.0(-5)
Fe-59	5.0(-5)	Ru-106	3.0(-5)
Co-58	4.4(-4)	Te-129m	6.0(-5)
Co-60	1.2(-3)	Te-129	4.0(-5)
Cu-64	4.0(-3)	Te-131m	2.0(-5)
Zn-65	5.1(-4)	I-131	1.6(-1)
Zn-69m	2.8(-4)	I-132	7.0(-4)
Zn-69	2.9(-4)	I-133	5.8(-3)
Zr-95	1.0(-5)	I-134	3.0(-4)
Nb-95	2.0(-5)	Cs-134	2.4(-4)
W-187	5.0(-5)	I-135	2.0(-3)
Np-239	1.6(-3)	Cs-136	5.0(-5)
		Cs-137	5.1(-4)
Fission Products		Ba-137m	2.5(-4)
Br-83	7.0(-5)	Cs-138	1.3(-4)
Sr-89	1.8(-4)	Ba-139	1.0(-4)
Sr-90	2.0(-5)	Ba-140	2.5(-4)
Y-90	2.0(-5)	La-140	1.9(-4)
Sr-91	4.4(-4)	La-141	4.0(-5)
Y-91m	2.8(-4)	Ce-141	4.0(-5)
Y-91	1.2(-4)	La-142	7.0(-5)
Sr-92	2.9(-4)	Pr-143	3.0(-5)
Y-92	6.3(-4)	Ce-144	6.0(-5)
Y-93	4.6(-4)	All Others	6.0(-5)
Zr-95	1.0(-5)		
Nb-95	2.0(-5)	Total (except	
Nb-98	2.0(-5)	tritium)	2.0(-1)
Mo-99	4.8(-4)	Tritium	19
Tc-99m	1.8(-3)		

[a]Exponential notation; $1.3(-3) = 1.3 \times 10^{-3}$.

[b]Nuclides whose release rates are less than 10^{-5} Ci/yr/reactor are not listed individually but are included in the category "all others".

Table C.9. Summary of Hydrologic Transport and Dispersion for Liquid Releases from the Clinton Power Station[a]

Location	Transit Time (hours)	Dilution Factor
ALARA Calculations		
Sport fishing (discharge)	5.0	1.0
Drinking water (discharge)	5.0	1.0
Population Dose Calculations		
Sport fishing	5.0	1.0

[a]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.

APPENDIX D. NEPA POPULATION-DOSE ASSESSMENT

APPENDIX D. NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 mi) of the Clinton Power Station employing the same models used for individual doses [see Regulatory Guide 1.109, Rev. 1 (Ref. 1)] for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR Part 50, Appendix I (Ref. 2). 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.

D.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 (50 mi) of the facility, the deposition model in Regulatory Guide 1.111, Rev. 1 (Ref. 3) is used in conjunction with the dose models in Regulatory Guide 1.109, Rev. 1 (Ref. 1). Site-specific data concerning production and consumption of foods within 80 km of the plant are used. For estimates of population doses beyond 80 km it is assumed that excess food not consumed within the 80-km distance 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 contribution to the population dose outside 80-km region, except by export of food crops. This assumption was tested and found to be reasonable for the Clinton Power Station.

D.2 NOBLE GASES, CARBON-14, AND TRITIUM RELEASED TO THE ATMOSPHERE

For locations within 80 km (50 mi) of the reactor facility, exposures to these effluents are calculated with a constant mean wind-direction model according to the guidance provided in Regulatory Guide 1.111, Rev. 1 (Ref. 3), and the dose models described in Regulatory Guide 1.109, Rev. 1 (Ref. 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 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 United States toward the northeastern corner of the United States. 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.

D.2.1 First-Pass Dispersion

For estimating the dose commitment to the U.S. population residing beyond the 80-km (50-mi) region due to 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 northeastern corner of the United States. 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 (Ref. 4). The mixing depth is estimated to be 1000 m (3300 ft), and a uniform population density of 62 people/km^2 (24 people/mi^2) is assumed along the plume path, with an average plume-transport velocity of 2 m/s (4.5 mph).

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.

D.2.2 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 one 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 15-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 (e.g., C-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 due to 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 (250 ft) 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 15 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.

D.3 LIQUID EFFLUENTS

Population-dose commitments due to effluents in the receiving water within 80 km (50 mi) of the facility are calculated as described in Regulatory

Guide 1.109 (Ref. 1). It is assumed that no depletion by sedimentation of the nuclides present in the receiving water occurs within 80 km. It is also 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 80 km 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.

References for Appendix D

1. "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," Reg. Guide 1.109, Rev. 1, U.S. Nuclear Regulatory Commission, October 1977.

2. "Domestic Licensing of Production and Utilization Facilities," Title 10 Code of Federal Regulations, Part 50, January 1981.

3. "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Regulatory Guide 1.111, Rev. 1, U.S. Nuclear Regulatory Commission, July 1977.

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

APPENDIX E. REBASELINING OF THE RSS RESULTS FOR BOILING-WATER REACTORS

APPENDIX E. REBASELINING OF THE RSS RESULTS FOR BOILING-WATER REACTORS

The results of the Reactor Safety Study (RSS) have been updated. The update was done largely to incorporate results of research and development conducted after the October 1975 publication of the RSS and to provide a baseline against which the risk associated with various LWRs could be consistently compared.

Primarily, the rebaselined RSS results (Ref. 1) reflect use of advanced modeling of the processes involved in meltdown accidents, i.e., the MARCH computer code modeling for transient and LOCA-initiated sequences and the CORRAL code used for calculating magnitudes of release accompanying various accident sequences. These codes* have led to a capability to predict the transient and small LOCA-initiated sequences that is considerably advanced beyond what existed at the time the Reactor Safety Study was completed. The advanced accident process models (MARCH and CORRAL) produced some changes in the staff estimates of the release magnitudes from various accident sequences in WASH-1400. These changes primarily involved release magnitudes for the iodine, cesium, and tellurium families of isotopes. In general, a decrease in the iodines was predicted for many of the dominant accident sequences, while some increases in the release magnitudes for the cesium and tellurium isotopes were predicted.

Entailed in this rebaselining effort was the evaluation of individual dominant accident sequences as we understand them to evolve rather than the technique of grouping large numbers of accident sequences into encompassing, but synthetic, release categories as was done in WASH-1400. The rebaselining of the RSS also eliminated the "smoothing technique" that was criticized in the report by the Risk Assessment Review Group (sometimes known as the Lewis Report, NUREG/CR-0400).

In both of the RSS designs (PWR and BWR), the likelihood of an accident sequence leading to the occurrence of a steam explosion (α) in the reactor vessel was decreased. This was done to reflect both experimental and calculational indications that such explosions are unlikely to occur in those sequences involving small-size LOCAs and transients because of the high pressures and temperatures expected to exist within the reactor coolant system during these scenarios. Furthermore, if such an explosion were to occur, there are indications that it would be unlikely to produce as much energy and the massive missile-caused breach of containment as was postulated in WASH-1400.

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*It should be noted that the MARCH code was used on a number of scenarios in connection with the TMI-2 recovery efforts and for post-TMI-2 investigations to explore possible alternative scenarios that TMI-2 could have experienced.

For rebaselining of the RSS BWR design, the sequence TCγ' (described later) was explicitly included into the rebaselining results. The accident processes associated with the TC sequence had been erroneously calculated in WASH-1400.

In general, the rebaselined results led to slightly increased health impacts being predicted for the RSS BWR design. This is believed to be largely attributable to the inclusion of TCγ'.

In summary, the rebaselining of the RSS results led to small overall differences from the predictions in WASH-1400. It should be recognized that these small differences due to the rebaselining efforts are likely to be far outweighed by the uncertainties associated with such analyses.

The accident sequences identified in the rebaselining effort which are expected to dominate risk of the RSS-BWR design are briefly described below. These sequences are assumed to represent the approximate accident risks from the Clinton BWR design.

Each of the accident sequences is designated by a string of identification characters in the same manner as in the RSS. Each character represents a failure in one or more of the important plant systems or features (see Table E.1 for definitions of the characters). For example, in sequences having a γ' at the end of the string, it means a particular failure mode (overpressure) of the containment structure (and a rupture location) where a release of radioactivity takes place directly to the atmosphere from the primary containment. In the sequence having a γ at the end of the string, the containment failure mode is again by overpressure, but this time the rupture location is such that the release takes place into the reactor building (secondary containment) before discharging to the environment. In this latter (γ) case, the overall magnitude of radioactivity release is somewhat diminished by the deposition and plateout processes that take place within the reactor building.

<u>TCγ' and TCγ</u>

These sequences involve a transient event requiring shutdown of the reactor while at full power, followed by a failure to make the reactor subcritical (i.e., terminate power generation by the core). The containment is assumed to be isolated by these events; then, one or the other of the following chain of events is assumed to happen:

(a) High-pressure coolant-injection system would succeed for some time in providing makeup water to the core in sufficient quantity to cope with the rate of coolant loss through relief and safety valves to the suppression pool of the containment. During this time, the core power level varies, but causes substantial energy to be directed into the suppression pool; this energy is in excess of what the containment and containment heat-removal systems are designed to cope with. Ultimately, in about 1-1/3 hours, the containment is estimated to fail by overpressure and it is assumed that this rather severe structural failure of the containment would disable the high-pressure coolant-makeup system. It is assumed that over a period of roughly 1-1/2 hours after breach of containment, the core would melt. This has been estimated to be one of the more dominant sequences in terms of accident risks to the public.

Table E.1. Key to BWR Accident Sequence Symbols

A	-	Rupture of reactor coolant boundary with an equivalent diameter of greater than six inches.
C	-	Failure of the reactor protection system.
E	-	Failure of emergency core cooling injection.
Q	-	Failure of normal feedwater system to provide core makeup water.
S_1	-	Small pipe break with an equivalent diameter of about 2"-6".
S_2	-	Small pipe break with an equivalent diameter of about 1/2"-2".
T	-	Transient event.
U	-	Failure of HPCI or RCIC to provide core makeup water.
V	-	Failure of low pressure ECCS to provide core makeup water.
W	-	Failure to remove residual core heat.
α	-	Containment failure due to stream explosion in vessel.
γ	-	Containment failure due to overpressure - release through reactor building.
γ'	-	Containment failure due to overpressure - release direct to atmosphere.

(b) A variant to the above sequence is one where the high-pressure coolant-injection system fails somewhat earlier and prior to containment overpressure failure. In this case, the earlier melt could result in a reduced magnitude of release because some of the fission products discharged to the suppression pool, via the safety and relief valves, could be more effectively retained if the pool remained subcooled. The overall accident consequences would be somewhat reduced in this earlier melt sequence, but ultimately the processes accompanying melt (e.g., noncondensibles, steam, and steam pressure pulses during reactor vessel melt-through) could cause overpressure failure (γ or γ') of the containment.

TWγ' and TWγ

The TW sequence involves a transient where the reactor has been shut down and it and the containment have been isolated from their normal heat sink. In this sequence, the failure to transfer decay heat from the core and containment to an ultimate sink could ultimately cause overpressure failure of containment. Overpressure failure of containment would take many, many hours, allowing for repair or other emergency actions to be accomplished, but it is assumed that should this sequence occur, the rather severe structural failure of containment would disable the systems (e.g., HPI, RCIC) providing coolant makeup to the reactor core. (In the RSS design, the service water system which conveys heat from the containment via RHR system to the ultimate sink was found to be the dominant failure contribution in the TW sequence.) After breach of containment, the core is assumed to melt.

[TQUVγ', AEγ', S_1Eγ', S_2Eγ'] and [TQUVγ, AEγ, S_2Eγ, S_2Eγ]

Each of the accident sequences shown grouped into the two bracketed categories above are estimated to have quite similar consequence outcomes, and these would be somewhat smaller than the TCγ', γ and TWγ' sequences described above. In essence, these sequences, which are characterized as in the RSS, involve failure to deliver makeup coolant to the core after a LOCA or a shutdown transient event requiring such coolant makeup. The core is assumed to melt down and the melt processes ultimately cause overpressure failure of containment (either γ' or γ). The overall risk from these sequences is expected to be dominated by the higher frequency initiating events (i.e., the small LOCA (S_2) and shutdown transients (T)).

References for Appendix E

1. "Reactor Safety Study Methodology Applications Program," U.S. Nuclear Regulatory Commission, NUREG/CR-1659, Vol. 1, April 1981.

APPENDIX F. CONSEQUENCE MODELING CONSIDERATIONS

APPENDIX F. CONSEQUENCE MODELING CONSIDERATIONS

F.1 EVACUATION MODEL

"Evacuation", used in the context of offsite emergency response in the event of 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. The Reactor Safety Study (RSS) (Ref. 1) consequence model contains provision for incorporating radiological consequence reduction benefits of public evacuation. The benefits of a properly planned and expeditiously carried out public evacuation would be well manifested in a reduction of early health effects associated with early exposure; namely, in the number of cases of early fatality (see Sec. F.2) and acute radiation sickness which would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 (Ref. 1) as well as in NUREG-0340 (Ref. 2). However, the evacuation model which has been used herein is a modified version (Ref. 3) of the RSS model and is, to a certain extent, site emergency planning oriented. The modified version is briefly outlined below:

The model utilizes a circular area with a specified radius (such as a 16-km (10-mi) 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 - i.e., 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 delay time* and then evacuate. The delay time is reckoned 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, time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate, and time required for the people to mobilize and get underway.

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*Assumed to be of a constant value which would be the same for all evacuees.

The model assumes that each evacuee would move radially out in the downwind direction* 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 mi), which is 8 km (5 mi) more than the 16-km (10-mi) plume exposure pathway EPZ radius). After reaching the end of the travel distance the evacuee is assumed to receive no further radiation exposure.

The model incorporates a finite length of the radioactive cloud in the downwind direction which would be determined by the product of the duration over which the atmospheric release would take place and the average windspeed during the release. It is assumed that the front and the back of the cloud formed would move with an equal speed which would be the same as the prevailing windspeed; therefore, its length 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, i.e., 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 initial locations of the evacuees there are possibilities that (a) an evacuee will still have a head start, or (b) the cloud would be already overhead when an evacuee starts to leave, or (c) 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 zero, or one or more number of times before the evacuee would reach his or her destination. In the model, the radial position of an evacuating person, either stationary or in transit, is compared to the front and the 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 they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person who is 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 (a) exposed to the total ground contamination concentration which is calculated to exist after complete passage of the cloud, after they are completely passed by the cloud; (b) exposed to one-half the calculated concentration when anywhere under the cloud; and (c) not exposed when they are in front of the cloud. The model provides for use of different values of the shielding protection factors for exposure from airborne radioactivity and contaminated ground.

Results shown in Section 5.9.4.1.4.2 for accidents involving significant release of radioactivity to the atmosphere were based upon the assumption that all people within the 16-km (10-mi) plume exposure pathway EPZ would evacuate as per the evacuation scenario described above. It is not expected that detailed inclusion of any special facility near a specific plant site, where not all persons would be quickly evacuated, would significantly alter the conclusions. Sheltering in such cases can provide significant mitigation of consequences in

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*In the RSS consequence model, the radioactive cloud is assumed to travel radially outward only.

**Assumed to be of a constant value which would be the same for all evacuees.

most instances. For the delay time before evacuation, a generic value of one hour, considered to be achievable by appropriate planning, was used. The staff estimated the effective speed of evacuation to be 0.78 m/s (1.75 mph) based upon the applicant's estimate or the time necessary to clear the 16-km (10-mi) zone. As an additional emergency measure for the Clinton site, it was also assumed that all people beyond the evacuation distance who would be exposed to the contaminated ground would be relocated after passage of the plume. For the people outside the evacuation zone and within 40 km (25 mi), a reasonable relocation time span of eight hours has been assumed, during which each person is assumed to receive additional exposure to the ground contamination. Beyond the 40-km (25-mi) distance the usual assumption of the RSS consequence model regarding the period of ground exposure was used--which is that if the calculated ground dose to the total marrow over a seven-day period would exceed 200 rem, then this high dose rate would be detected by actual field measurements following the plume passage, and people from those regions would then be relocated immediately. For this situation the model limits the period of ground dose calculation to 24 hours; otherwise, the period of ground exposure is limited to seven days for calculation of early dose.

It is also realistic to expect that authorities would evacuate persons at distances from the site where exposures above the threshold for causing early fatalities could occur regardless of the plume exposure pathway EPZ distance. Figure F-1 illustrates the reduction in early fatalities that can occur by extending evacuation to a larger distance, such as 24 km (15 mi), from the Clinton site. Also illustrated in Figure F-1 is a pessimistic case for which no early evacuation is assumed and all persons are assumed to be exposed for the first 24 hours following an accident and are then relocated.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as in the orginal RSS model. For this purpose, the model assumes that for atmospheric releases of durations three hours or less, all people living within a circular area of 8-km (5-mi) radius centered at the reactor plus all people within a 45° angular sector within the plume exposure pathway EPZ and centered on the downwind direction would evacuate and temporarily relocate. However, if the duration of release would exceed three hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would evacuate and temporarily relocate.

For either of these situations, the cost of evacuation and relocation is assumed to be $125 (1980 dollars) per person, which includes cost of food and temporary sheltering for a period of one week.

F.2 EARLY HEALTH EFFECTS MODEL

The medical advisors to the Reactor Safety Study (Ref. 1) 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," and are more fully described in NUREG-0340 (Ref. 2).

The calculational estimates of the early fatality risks presented in the texts of Section 5.9.4.1.4.3 and Section F.1 of this appendix used the dose-mortality relationship that is based upon the supportive treatment alternative. This

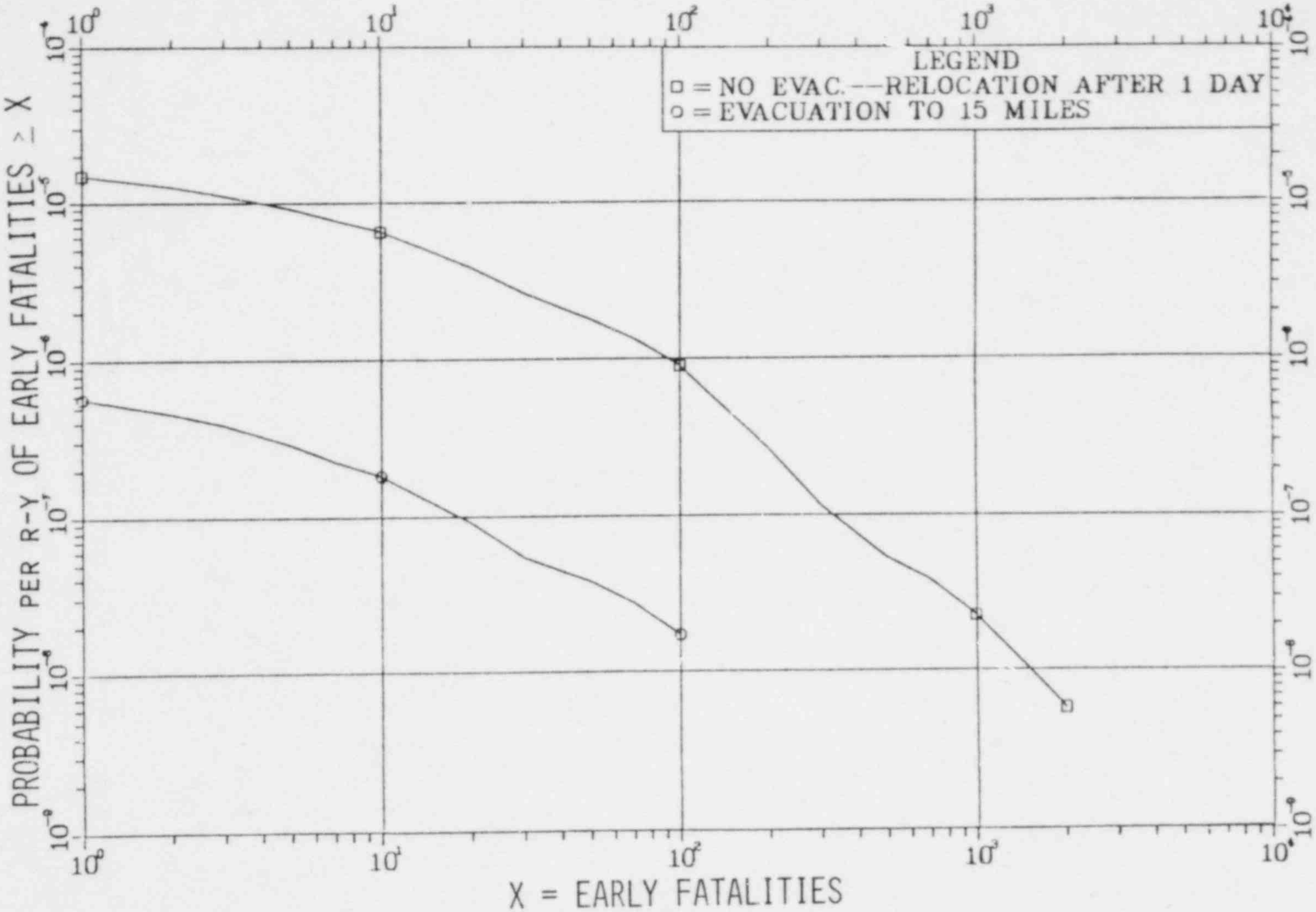

Figure F.1. Sensitivity of Probability Distribution of Early Fatality to Evacuation Distance.
NOTE: Please see Section 5.9.4.1.4.7 for discussion of uncertainties in risk estimates.

implies the availability of medical care facilities and services for those exposed in excess of about 200 rem. At the extreme low probability end of the spectrum, i.e., at the one chance in one-hundred-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 somewhat underestimated. To gain perspective on this element of uncertainty, the staff has also performed calculations using the most pessimistic dose-mortality relationship based upon minimal medical treatment and using identical assumptions regarding early evacuation and early relocation as made in Section 5.9.4.1.4.3. This shows 5 early fatalities at the one chance in one-million per reactor-year level, an increase from 140 to 300 early fatalities at the one chance in one-hundred-million per reactor-year level (see Table 5.9), and an overall five-fold increase in annual risk of early fatalities (see Table 5.10). The major fraction of the increased risk of early fatality in the absence of supportive medical treatment would occur within 5 km (3 mi) and virtually all would be contained within 6[illegible] km (40 mi) from the Clinton site.

References for Appendix F

1. "Reactor Safety Study," U.S. Nuclear Regulatory Commission, WASH-1400, NUREG-75/014, October 1975.

2. "Overview of the Reactor Safety Study Consequences Model," U.S. Nuclear Regulatory Commission, NUREG-0340, October 1977.

3. "A Model of Public Evacuation for Atmospheric Radiological Releases," Sandia Laboratories, SAND 78-0092, June 1978.

APPENDIX G. IMPACTS OF THE URANIUM FUEL CYCLE

APPENDIX G. IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 (Sec. 5.10) and the staff's analysis of the radiological impact from radon releases. For the sake of consistency, the analysis of fuel-cycle impacts has been cast in terms of a model 1000-MWe light-water-cooled reactor (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 Clinton Power Station.

G.1 LAND USE

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 46 ha (113 acres). About 5.3 ha (13 acres) are permanently committed, and 41 ha (100 acres) are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel-cycle plant; e.g. 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 41 ha per year of temporarily committed land, 32 ha (79 acres) are undisturbed and 9 ha (22 acres) 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.

G.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 (11.1×10^9 gal) are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (e.g., evaporation losses in process cooling) of about 0.6×10^6 m^3 (160×10^6 gal) per year and water discharged to ground (e.g., mine drainage) of about 0.5×10^6 m^3 (130×10^6 gal) 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/yr is about 2% of that from the model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming

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*A coal-fired power plant of 1000-MWe capacity using strip-mined coal requires the disturbance of about 81 ha (200 acres) per year for fuel alone.

that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of that 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.

G.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 generated primarily 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.

G.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. Judging from data in a Council on Environmental Quality report (Ref. 1), the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with these 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.

G.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 listed in Table S-3. Using these data, the staff has calculated for one year of operation of the model 1000-MWe LWR, the 100-year involuntary environmental dose commitment* to the U.S. population.

It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be about 400 person-rems 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) due to 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.

At this time, the radiological impacts associated with radon-222 and technetium-99 releases are not addressed 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 G.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 (Ref. 2). The results of these calculations for mining and milling activities prior to tailings stabilization are given in Table G.2.

When added to the 500 person-rems total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is about 640 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.**

The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining, 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

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* The environmental dose commitment (EDC) is the integrated population dose for 100 years; i.e., it represents the sum of the annual population doses for a total of 100 years.

**Based on an annual average natural-background individual dose commitment of 100 millirems and a stabilized U.S. population of 300 million.

Table G.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/yr

*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. 58-488, April 17, 1978.

Table G.2. Estimated 100-Year Environmental Dose Commitment for Each Year of Operation of the Model 1000-MWe LWR

Radon Source	Radon-222 Release (Ci)	Dosage (person-rems)		
		Total Body	Bone	Lung (bronchial epithelium)
Mining	4100	110	2800	2300
Milling and active tailings	1100	29	750	620
Total		140	3500	2900

34% open-pit (Ref. 3), 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 37 Ci/yr (0.332 × 110) per RRY.

Based on these assumptions, 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 G.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 the tailings would emit, per RRY, 1 Ci/yr for 100 years, 10 Ci/yr for the next 400 years, and 100 Ci/yr 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 (Ref. 4). The total-body, bone, and bronchial-epithelium dose commitments for these periods are as shown in Table G.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 is about 0.11 cancer fatality per RRY. When risk from radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities per RRY is estimated over a 1000-year release period. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon-induced cancer fatalities per RRY range as follows:

> 0.11-0.19 fatality for a 100-year period,
> 0.19-0.57 fatality for a 500-year period, and
> 1.2 -2.0 fatalities for a 1000-year period.

To illustrate: A single model 1000-MWe LWR operating at an 80% capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1000 years as a result of releases of radon-222.

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) (Ref. 5), the average radon-222 concentration in air in the contiguous United States is 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, estimated lung-cancer fatalities alone from background

Table G.3. Population-Dose Commitments from Unreclaimed Open-Pit Mines for Each Year of Operation of the Model 1000-MWe LWR

Time Period (yr)	Radon-222 Release (Ci)	Population-Dose Commitments (person-rems)		
		Total Body	Bone	Lung (bronchial epithelium)
100	3,700	96	2,500	2,000
500	19,000	480	13,000	11,000
1,000	37,000	960	25,000	20,000

Table G.4. Population-Dose Commitments from Stabilized-Tailings Piles for Each Year of Operation of the Model 1000-MWe LWR

Time Period (yr)	Radon-222 Release (Ci)	Population-Dose Commitments (person-rems)		
		Total Body	Bone	Lung (bronchial epithelium)
100	100	2.6	68	56
500	4,090	110	2,800	2,300
1,000	53,800	1,400	37,000	30,000

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 and 1000 years, respectively.

The staff is currently in the process of formulating a specific model for analyzing potential impact and health effects from release of technetium-99 during the fuel cycle. However, for the interim period until the model is completed, the staff has calculated that the potential 100-year environmental dose commitment to the U.S. population from the release of Tc-99 should not exceed 100 person-rems per RRY. 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 (Ref. 2). When added to the 640 person-rem total-body dose commitment for the balance of the fuel cycle, including radon-222, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is about 740 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.*

The staff also considered the potential health effects associated with this release of technetium-99. Using the modeling systems described in NUREG-0002, the major risks from Tc-99 are from exposure of the GI tract and kidney, although there is a small risk from total-body exposure. Using organ-specific risk estimators, these individual organ risks can be converted to total-body risk equivalent doses. Then, by using the total-body risk estimator of 135 cancer deaths per million person-rems, the estimated risk of cancer mortality due to technetium-99 releases from the nuclear fuel cycle is about 0.01 cancer fatality per RRY over the subsequent 100 to 1000 years.

In addition to the radon- and technetium-related potential health effects from the fuel cycle, other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures. It is estimated that an additional 0.08 to 0.12 cancer death may occur per RRY (assuming that no cure for or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

The latter exposures also can be compared 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 during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared with dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

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*Based on an annual average natural-background individual dose commitment of 100 millirems an a stabilized U.S. population of 300 million.

G.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. It is indicated in NUREG-0116 (Ref. 6), in which are provided background and context for the high-level and transuranic Table S-3 values established by the Commission, that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is expected from such disposal.

G.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 not have a significant environmental impact.

G.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.

G.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.

References for Appendix G

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

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

3. "Statistical Data of the Uranium Industry," GJO-100(8-78), U.S. Department of Energy, January 1, 1978.

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

5. "Natural Background Radiation in the United States," Publication No. 45, National Council on Radiation Protection and Measurements. November 1975.

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

APPENDIX H. LETTER FROM THE U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE, CONCERNING ENDANGERED AND THREATENED SPECIES IN THE VICINITY OF THE CLINTON POWER STATION

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
2701 Rockcreek Parkway, Suite 106
North Kansas City, Missouri 64116

KANSAS CITY AREA OFFICE
816/374-6166

ECOLOGICAL SERVICES
816/374-5951

June 8, 1981

RECEIVED
JUN 11 1981
U.S. NUCLEAR REGULATORY COMMISSION

Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington D.C. 20555

Dear Mr. Youngblood:

This is in response to your letter of May 4, 1981, regarding the Byron and Clinton nuclear power plant sites in Ogle and DeWitt Counties, Illinois.

In accordance with Section 7(c) of the Endangered Species Act, as amended, we have reviewed the project information and our Endangered Species distribution information and we have determined that the following listed species may occur in both project areas.

Listed Species	
Bald eagle	(Haliaeetus leucocephalus)
Indiana bat	(Myotis sodalis)

The bald eagle is a winter resident. Wintering eagles are commonly encountered along streams, rivers and reservoirs where open water and a plentiful food supply exists. A single bald eagle was sited 15 miles SW of the Byron site this past winter. Additional eagle sightings have been made in the Clinton Lake area.

The Indiana bat is a summer resident throughout Illinois. They utilize riparian timber areas for establishing small nursery colonies. The areas indicated on your maps contain good bat habitat.

It is the Nuclear Regulatory Commission's responsibility to review the project and evaluate the possible effects on federally listed species. The determination to be made on each project is whether the proposed action "may affect or will not affect" listed threatened or endangered species. If it is determined the project "will not affect" an endangered species, no further action is necessary, and the procedure is terminated. If, however, your determination is the project "may affect," you should request formal consultation. The Area Manager, U.S. Fish and Wildlife Service, Kansas City, Missouri, has the prerogative to request your agency to formally consult on any project if deemed necessary. If there are any questions regarding the biological assessment or how it applies to the consultation process, please contact Mr. Larry Visscher, Endangered Species Coordinator, U.S. Fish and Wildlife Service, 2701 Rockcreek Parkway, Suite 106, North Kansas City, Missouri (816/374-6166).

Sincerely yours,

C002
S1/0

Tom A. Saunders
Area Manager

A 8106120253

NRC FORM 335 (7 77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

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Docket No. 50-461

14. (Leave blank)

16. ABSTRACT (200 words or less)
This Final Environmental Statement contains the second assessment of the environmental impact associated with operation of the Clinton Power Station, Unit 1, pursuant to the National Environmental Policy Act of 1969 (NEPA) and 10 CFR Part 51, as amended, of the NRC's regulations. This statement examines: the purpose and need for the Clinton project; the affected environment, environmental consequences and mitigating actions, and environmental and economic benefits and costs. The action called for is the issuance of an operating license for Unit 1 of the Clinton Power Station.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
UNLIMITED

19. SECURITY CLASS (This report)
UNCLASSIFIED

20. SECURITY CLASS (This page)
UNCLASSIFIED

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