Final

environmental statement

related to operation of

DRESDEN NUCLEAR POWER STATION UNITS 2 AND 3

COMMONWEALTH EDISON COMPANY

DOCKET NOS. 50-237 AND 50-249

NOVEMBER 1973

SUMMARY AND CONCLUSIONS

This Final Environmental Statement was prepared by the U.S. Atomic Energy Commission, Directorate of Licensing.

1. This action is administrative.

2. The proposed action is the issuance of a full-term operating license to Commonwealth Edison Company for the Dresden Nuclear Power Station, Unit 2 (Docket No. 50-237) and the continuation of the operating license for Unit 3 (Docket No. 50-249). The Dresden units are located at the point where the Kankakee and Des Plaines Rivers merge to form the Illinois River in the State of Illinois.

   Units 2 and 3 employ boiling water reactors to produce up to 2527 megawatts thermal (MWt) each. A steam turbine-generator will use this heat to provide 809 MW (net) of electrical capacity for each unit. The exhaust steam will be cooled by closed-cycle flow of water obtained from the Dresden cooling lake.

   The combined environmental effects of Unit 1 with Units 2 and 3 are evaluated in this statement. Unit 1 is a 700 MWt boiling water reactor with an electric generation capacity of 200 MWe. Condenser cooling is provided by once-through flow of water obtained from the Kankakee River.

3. Summary of environmental impacts.

   a. In addition to the land purchased and occupied by Dresden 1 (953 acres), approximately 1573 acres of land, formerly agricultural, have been converted to the Units 2 and 3 cooling lake and canals (see Section 4.1).

   b. Approximately four miles of new transmission line rights-of-way were built for Units 2 and 3 involving some 93 acres of land with 0.6 acres removed from its original use for tower bases. Although construction of the transmission lines preceded publication of the U.S. Department of Interior "Environmental Criteria for Electric Transmission Systems" 1971, the present condition of the lines is considered environmentally acceptable by the Staff (see Section 4.1).

   c. Some fish are impinged on the intake screen. On the basis of the limited data available, significant adverse impact on the fish population of the river as a whole is not expected during closed cycle operation. A program of monitoring the fish kill rate and of determining the local fish population will be required to verify the extent of this impact. If adverse effects are indicated, the applicant shall be required to take corrective action. (See Section 5.5.1.b)

d. Some aquatic organisms entrained in the Station's cooling water system will probably be killed due to thermal, chemical, and mechanical shock. This loss is not expected to represent a significant fraction of the rivers' biomass or to affect the productivity of adjacent waters (see Section 5.5.1.a).

e. Cold kill of fish is not expected due to shutdown of Units 2 and 3 during the winter because of the large heat sink in the cooling lake. Should Unit 1 suddenly shut down, the discharge temperature drop will be limited by the warm effluent from the cooling lake (see Section 5.5.2.a).

f. The addition of heat to the Illinois River from the Dresden cooling lake blowdown is not expected to adversely affect aquatic life except in the immediate vicinity of the outfall. An adequate zone of passage for fish and planktonic organisms in the Illinois River will be required (see Section 5.5.2.a).

g. Fogging and icing from the Dresden cooling lake are not expected to adversely affect the surrounding area except for an increased hazard on the County Line Road and the Dresden Road. During periods of dangerous icing or fog, corrective action is required to assure traffic safety (see Section 5.1.2).

h. The chemical discharges to the river, including chlorine, will be in very low concentrations and pose no threat to aquatic life (see Section 5.5.5).

i. Operation of Units 2 and 3 will result in the production of solid radioactive waste (see Section 5.4.3).

j. Use of water by Units 2 and 3 should not measurably reduce supply sources nor impair the quality of return flows for other uses (see Section 5.2).

k. The risk associated with accidental radiation exposure is very low (see Section 7).

1. No significant environmental impacts are anticipated from normal operational releases of radioactive materials within 50 miles. The estimated dose to the population within 50 miles from operation of Units 2 and 3 is 160 man-rem/yr, which is less than the normal fluctuation in the 1.1×10^6 man-rem/yr background dose this population would receive (see Section 5.4).

4. Principal alternatives considered:

   - Conversion of the Station to fossil fuel.

   - Abandonment of Units 2 and 3.

   - Imposition of alternative cooling systems.

   - Imposition of mechanical techniques of condenser cleaning.

5. The following Federal, State, and local agencies were asked to comment on the Draft Detailed Environmental Statement:

   Advisory Council on Historic Preservation
   Department of Agriculture
   Department of Army, Office of the Chief Engineer
   Department of Commerce
   Department of Health, Education, and Welfare
   Department of Housing and Urban Development
   Department of the Interior
   Department of Transportation
   Environmental Protection Agency
   Federal Power Commission
   Executive Office of the Governor of Illinois
   Illinois Pollution Control Board
   Illinois Department of Public Health
   Illinois Commission on Atomic Energy
   Upper Mississippi River Basin Commission
   Board of Supervisors, Grundy County, Illinois
   Northeastern Illinois Planning Commission

   Comments on the Draft Environmental Statement issued in June 1973, were received from the following Federal, State and local agencies:

   Illinois Environmental Protection Agency

Office of the Assistant Secretary of Commerce
Department of Health, Education, and Welfare
Deparment of Transportation
Advisory Council on Historic Preservation
Department of Agriculture
Federal Power Commission
Illinois Natural Resource Development Board
Environmental Protection Agency
Illinois Commission on Atomic Energy (University of Chicago)
Illinois Department of Transportation
Department of Interior
Illinois Department of Public Health

The texts of these comments are appended to this Final Environmental Statement.

6. This Final Environmental Statement was made available to the public, to the Council on Environmental Quality, and to other specified Agencies in November 1973.

7. On the basis of the analysis set forth in this statement, after weighing the environmental, economic, technical, and other benefits of the Dresden Nuclear Power Station, Units 2 and 3 against environmental costs and considering available alternatives, the Staff concludes that the action called for under the National Environmental Policy Act of 1969 (NEPA) and Appendix D to 10 CFR Part 50 is the issuance of a full-term operating license for Unit 2 and the continuation of the operating license for Unit 3 subject to the following limitation for the protection of the environment:

   A. License Condition:

   - The Applicant shall complete any remaining modifications to the radwaste systems and the condenser cooling system necessary for closed cycle operation of Units 2 and 3 as soon as practical before December 1974. (Section 5.4.1)

   B. Technical Specification Requirements:

   - The Applicant shall maintain the cooling lake free of "nuisance" growths of aquatic organisms (see Subsection 5.5.3.b).

   - The Applicant shall at the earliest opportunity, determine by additional investigation, the cause of the 2-foot depression noted in inspection reports of the south dike.

Any repairs necessary to insure dike integrity shall be performed. The Applicant shall also demonstrate that the 4-in. diameter holes along the south dike are not initial stages of the movement of soil from the dike foundation. The results of these investigations and any proposed actions shall be submitted to the Commission for review and approval. In addition, the Applicant shall carry out a comprehensive surveillance program acceptable to the Staff which will provide for routine inspection of the dikes during the life of plant. (Subsection 5.1.4.d)

- The Applicant shall submit to the AEC for review and approval the proposed discharge design and supporting basis that will be determined from the model studies now in progress. (Section 5.5.2)

- The Applicant shall establish a revised and comprehensive biological sampling program to provide ecological data from which to measure the impact of Units 2 and 3 operation on the biota of the Illinois River (Section 6.2).

- The Applicant shall conduct a radiological monitoring program considered by the Staff to be adequate to determine any radiological effects on the environment from operation of Units 2 and 3 (Section 6.2).

- The criteria for the use of herbicides shall be specified. (Section 5.5.4.a b)

- Removal of lake dredgings from the perimeter of the lake shall require prior Commission approval. (Section 5.5.3.c)

- The Applicant shall limit the extent of the thermal plume (5°F isotherm) and shall monitor the surface and vertical extent of the thermal plume for extreme and average river flows and lake blowdown temperatures (Section 6).

- The Applicant shall monitor the fecal coliform and fecal streptococcus content of the spray canals. (Subsection 5.5.3.e)

- Chlorine discharge shall be monitored and controlled (Subsection 5.5.5.a).

- The Applicant shall take reasonable measures to assure travel safety on affected roads during periods of fogging or icing from the lake or spray canals including closing roads to traffic under such conditions if necessary. (Section 5.1.2)

- The cooling lake shall be operated in the closed-cycle mode. (Section 5.2.2)

- The Applicant shall collect fish population and impingement kill data to determine if the fish killed by impingement at the Dresden traveling screens result in an adverse depletion of fish species and numbers in the Illinois and Kankakee Rivers. If such adverse effects are indicated, the Applicant shall be required to take corrective action, including reducing the intake velocity, if necessary. (Subsection 5.5.1.b)

- If any other harmful effects or evidence of irreversible damage are detected, the Applicant shall provide to the Commission the supporting analysis and proposed course of action to alleviate the problem.

FOREWORD

This final statement reviews the environmental considerations associated with the proposed issuance of a full-term operating license for Dresden Unit 2 and the continuation of the full-term operating license for Dresden Unit 3 in accordance with the U.S. Atomic Energy Commission's regulation, 10 CFR Part 50 Appendix D, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA). This document was prepared by the U.S. Atomic Energy Commission (Commission), Directorate of Licensing (Staff).

The National Environmental Policy Act of 1969 states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may:

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

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

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects . . .

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

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

Pursuant to Appendix D of 10 CFR Part 50, the AEC Directorate of Licensing prepares a detailed statement on the foregoing consideration with respect to each application for a construction permit or full-power operating license for a nuclear power reactor.

When application is made for a construction permit or a full power operating license, the Applicant submits an environmental report to the AEC. In conducting the required NEPA review, the Staff meets with the applicant to discuss items of information in the environmental report, to seek new information from the applicant that might be needed for an adequate assessment, and generally to ensure that the Staff has a thorough understanding of the proposed project. In addition, the Staff seeks information from other sources that will assist in the evaluation, and visits and inspects the project site and surrounding vicinity. Members of the Staff may meet with State and local officials who are charged with protecting State and local interests. On the basis of all the foregoing, and other such activities or inquiries as are deemed useful and appropriate, the Staff makes an independent assessment of the considerations specified in Section 102(2)(c) of the NEPA and Appendix D of 10 CFR Part 50. This evaluation leads to the publication of a draft environmental statement, prepared by the Directorate of Licensing, which is then circulated to Federal, State, and local governmental agencies for comment. Interested persons are also invited to comment on the draft statement.

After receipt and consideration of comments on the draft statement, the Staff prepares a final environmental statement, which includes a discussion of problems and objections raised by the comments and the disposition thereof; a final cost-benefit analysis which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, the action called for is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values. This procedure applies to Dresden Unit 2.

In addition, Dresden Unit 3, which was issued an operating license in the period January 11, 1970-September 9, 1971, is subject to Section B of Appendix D of 10 CFR Part 50. In a proceeding such as this, the final detailed statement includes a conclusion as to whether, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, the action called for as regards to previously issued operating licenses or their appropriate conditioning to protect environmental values.

Single copies of this statement may be obtained by writing the Deputy Director for Reactor Projects, Directorate of Licensing, Regulation, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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1. INTRODUCTION

1.1 HISTORY AND STATUS OF PROJECT

The Dresden Nuclear Power Station (the Station) was originally selected by the Applicant as the site for the Dresden 1 power plant. This unit was the world's first privately financed, full scale, commercial nuclear power plant. Since Unit 1 began commercial service in 1960, over 12 billion kilowatt hours (gross) of electrical energy have been generated by this 200 MWe unit.[1]

In order to supply the continuously increasing demand for power in its service area, the Applicant committed itself in 1965 to the construction of two additional nuclear units at the Dresden site--Dresden 2 and Dresden 3. The Commission's construction permit for Unit 2 (CPPR-18) was issued on January 10, 1966. The construction permit for Unit 3 (CPPR-22) was issued on October 14, 1966.

A Commission provisional operating license, issued for Unit 2 (DPR-19) on December 22, 1969 (34 FR 20368, 12/30/69), permitted operation of this unit until July 1971. The provisional license was extended on June 10, 1971, to permit operation of this unit to continue until December 22, 1972. A request for conversion of the provisional license to a full-term license was submitted by the Applicant in November 1972. The acceptance by the Commission of the request for license conversion allows continued operation of this unit until the final licensing action is taken. On October 27, 1972, the Applicant submitted "Environmental Report for Dresden 2," a letter which broadened the scope of the Unit 3 Environmental Report and its supplements to include Unit 2.

Following a filing by the Applicant of "Environmental Statement-Dresden Nuclear Power Station Unit 3" with the Commission on July 23, 1970 (35 FR 12568, 8/6/70), and the receipt of comments on said report by various departments of the Federal Government, the Commission issued on December 31, 1970 (36 FR 334, 1/9/71), the "Detailed statement on the environmental considerations by the Division of Reactor Licensing, U.S. Atomic Energy Commission, related to the proposed issuance of an operating license to the Commonwealth Edison Company for the Dresden Nuclear Power Station Unit 3." Unit 3 was issued a full-term license on (36 FR 839, 1/19/71) January 12, 1971 (DPR-25). In accordance with the revisions to 10 CFR 50, Appendix D, dated September 9 and 30, 1971, the Applicant submitted "Supplement I to the Dresden 3 Nuclear Power Station Environmental Report" on November 8, 1971 (37 FR 747, 1/18/72). Additional supplemental information was submitted on January 10, 1972; October 18, 1972; October 27, 1972; January 15, 1973; and March 12, 1973.

The above reports have been used in the preparation of this Statement. Copies of these reports and other pertinent documents were placed in the Commission's Public Document Room and in the local public document room of the Morris Public Library, 604 Liberty Street, Morris, Illinois. The availability of the reports was published in the "Federal Register." Independent calculations and sources of information were also used as a basis for the assessment of environmental impact. In addition, some of the information was gained from visits by the staff to the Dresden site and surrounding areas in November 1972.

The Applicant has committed itself to the modification and backfitting of an alternate gaseous and liquid radioactive waste treatment system for both Units 2 and 3. Recent interpretations of the Illinois Sanitary Water Board standard[2] made it necessary for the Applicant to adopt a closed-cycle cooling system in order to comply with the mixing zone limitation of the standards as it applies to river discharges within the State of Illinois.

Both Units 2 and 3 are operating at the present time. Back-fitting of the committed radwaste system modifications and cooling systems is in process. The scheduled completion date for the radwaste system modification is February 1974 at which time closed-cycle cooling will be used.[3]

As part of its safety evaluation leading to the issuance of construction permits and operating licenses, the Commission makes a detailed evaluation of the Applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal conditions and potential accident conditions, including the effects of natural phenomena on the facility. Inasmuch as these aspects are considered fully in other documents, only the salient features that bear directly on the anticipated environmental effects are repeated in this environmental statement. This statement evaluates the environmental impact of the operation of Units 2 and 3 and their additive and interactive effects with those of Unit 1.

1.2 STATUS OF REVIEWS AND APPROVALS

A listing of the known permits and licenses for the construction and operation of the Station is given in Table 1.1. Information regarding the current status is also shown.

TABLE 1.1 Permits and Licenses for Construction and Operation of the Dresden Nuclear Units No. 2 and 3

;ency	Permit Description	Current Status
ınd Township		
'ounty (No permits prior to 1969)	Zoning Permit (cooling lake)	Issued 4-6-70
	Building permit (cooling lake) Permit No. 70-8-20	Issued 3-31-70
nty	Zoning Permit (cooling lake)	Utility exemption
	Building permit (cooling lake)	None required
ke Township	Road Closing and Relocation Order (Will-Grundy County Line Road)	Issued 11-4-70
	Road Vacation Order (Downey Road)	Issued 5-4-71
	Road Vacation Order (for 525 of Collins)	Issued 5-4-71
	Opening and Laying Out of Road Order (General Electric By-pass Road)	Issued 6015-71
	Bridge #3 Construction Permit (Dresden Road reconstruction)	Issued 1-18-71 Extended 7-31-71
›n Township	Road Closing and Relocation Order (Will-Grundy County Line Road)	Issued 11-4-70
Illinois		
Water Board	Liquid Radwaste Treatment Permit	Issued 8-15-60
	Sewage Treatment Permit	Issued 7-12-67
	Supplemental Liquid Radwaste Treatment Permit	Issued 9-2-66

Table 1. 1 (Cont'd)

ency	Permit Description	Current Status
nt of Aeronautics	Meteorological Survey Tower Permit Chimney Permit	Issued 7-6-67 Issued 5-10-67
nt of Public Works/ on of Waterways	Dredging of flume (Permit #11195)	Issued 12-12-66 Revised 1-29-69
	Water sampling station (Permit #11412) and approval for hoses in river	Issued 8-28-67 Revised 1-16-68
	Leases of "buffer strips" on Illinois River	Issued 12-8-70 & 2-19-70
	Approval to construct and operate cooling lake	Granted 7-13-70
n Control Board	Thermal Standard Variance	Issued 11-23-71 Extended to 11-73
	Application to extend variance to Nov. 23, 1974	Applied 8-23-73
Environmental :ion Agency	Operating Permit Cooling Water and Industrial Waste Discharge. Discharge #2	Issued 4-2-73
Commission	Certificate of Convenience & Necessit·. Section 50 Order (Station only)-Cas. #43336	Issued 9-24-56
	Section 50 Order (cooling lake only)-Case #55536	Issued 4-15-70
	Section 55 Order (Transmission lines only)-Case #53717	Issued 12-13-67

Table 1.1 (Cont'd)

gency	Permit Description	Current Status
nt of Transportation	Fog Detection Site Permit (I-55 and Lorenzo Road)-No. 1-4398-E	Issued 1-6-71
<u>tates Government</u>		
ps of Engineers	Dredging Permit (intake & discharge flumes)	Issued 1-19-67 Revised 1-22-69
	Permit for hoses in river and water sampling	Issued 7-31-67 Revised 1-5-68
	Permit to build cooling lake	None required
	Right-of-Entry on Fee Owned Land	Granted 11-20-70
	Discharge Permit (Section 13, 1899 Rivers and Harbors Act)	Applied for 7-1-71
ergy Commission	By-product Material License #12-05650-01 (plus 17 Amendments)	Issued 8-25-69 to 6-18-71
	By-product Material License #12-05650-03	Issued 3-18-64
	Special Nuclear Material License, SNM-1096	Issued 11-25-68
	Amendment #1	Issued 9-19-69
	Amendment #2	Issued 10-7-69
	Amendment #3	Issued 10-17-69
	SNM-1207	Issued 8-25-70
	Amendment #1	Issued 11-30-70
	Provisonal Construction Permit (Unit 2), CPPR-18	Issued 1-10-66
	Extension #1	Issued 5-1-69
	Extension #2	Issued 11-24-69
	Provisional Construction Permit (Unit 3), CPPR-22	Issued 10-14-66

Table 1.1 (Cont'd)

cy	Permit Description	Current Status
	Extension #1	Issued 5-28-70
	Extension #2	Issued 11-30-70
	Operating License (Unit 2)-Provisional (18 month) DPR-19	Issued 12-22-69
	Extension #1-Provisional (18 month)	Issued 6-10-71
	Request for conversion to full-term license	Entered 11-15-72
	Operating License (Unit 3)-Full-Term	Issued 1-12-71
viation	Meteorological Survey Tower Permit	Issued 7-11-67
stration	Chimney Permit	Issued 6-1-67

References

1. Nucleonics Week, Vol. 13, No. 43, McGraw-Hill, Inc., New York, N.Y. (October 26, 1972).

2. "Rates and Regulations" SWB-8, Illinois Sanitary Water Board, Springfield, Illinois (1968). Newer interpretations by Illinois Pollution Control Board (IPCB) for the Dresden Unit 3 (IPCB No. 70-21 Board Opinions--March 3, 1971, and November 23, 1971).

3. Testimony of James Ellis at the Illinois Pollution Control Board hearing (PCB #72-350) in Joliet, Illinois (December 14, 1972).

2. THE SITE

2.1 PLANT LOCATION

The Station is located in Goose Lake Township, Grundy County, Illinois, approximately 50 miles southwest of downtown Chicago (Fig. 2.1). It is situated on the parcel of land lying on the south shoreline of the Illinois River and the west shoreline of the Kankakee River at the point where the Kankakee and Des Plaines Rivers join to form the Illinois River (Fig. 2.1). The approximate geographic coordinates are 41°20'N and 88°15'W. The site consists of a tract of land of approximately 2,500 acres, owned by the Applicant, containing the Station, cooling (spray) canals and a cooling lake to the south and east of the Station; and a tract of approximately 17 acres (in two narrow strips) of river frontage leased from the State of Illinois and located near the northeast corner of the site. Approximately one half of the lake is in Wilmington Township of Will County, Illinois (see Fig. 2.1a).

2.2 REGIONAL DEMOGRAPHY, LAND, AND WATER USE

The population in the immediate vicinity of the Station is low. The present and projected future population distributions in the 0-5 and 0-10 mile areas around the Station are shown in Figs. 2.2 and 2.3 respectively. The 1970 population figures within a five-mile radius are based on a 1971 actual house count weighted at three persons per house and are not intended to represent the 1970 U. S. Census data. The 1980 projections for the 0-5 mile radius are based on an assumed 5% annual growth in all areas except those in which the property is presently platted. The 1970 population figures for the 5- to 10-mile annulus and for the 10, 20, 30, 40, and 50-mile radii are based on the 1970 U. S. Census data. The 1980 projections for the populations from 5 to 50 miles are extrapolations based on the growth rate of the population from 1960 to 1970. The total population within the 50-mile radius was found to be 6,137,524 and is projected to reach 8,070,968 by 1980 with about 91% of the total beyond the 30-mile radius of the site.[1] The population of those counties serviced by CECO was projected to the year 2000 by the Applicant's consultant using the DEMOS model (Demographic Economic Modeling System).[19] The Staff has adjusted those Figures on the basis of the 1970 population within 50 miles of the Station resulting in a year 2000 projection of 12,900,000 within this radius. The Staff considers this to be a reasonable projection.

Several residences are found at the Dresden Dam about 0.8 mile northwest of the Station. A few homes are located on top of the Kankakee Bluffs to the northeast (on the north side of the Illinois River). Several farm residences are located in the areas approximately one mile to the south and to the southwest of the Station. A small cluster of about 20 cottages is located on the west shore of the Kankakee River

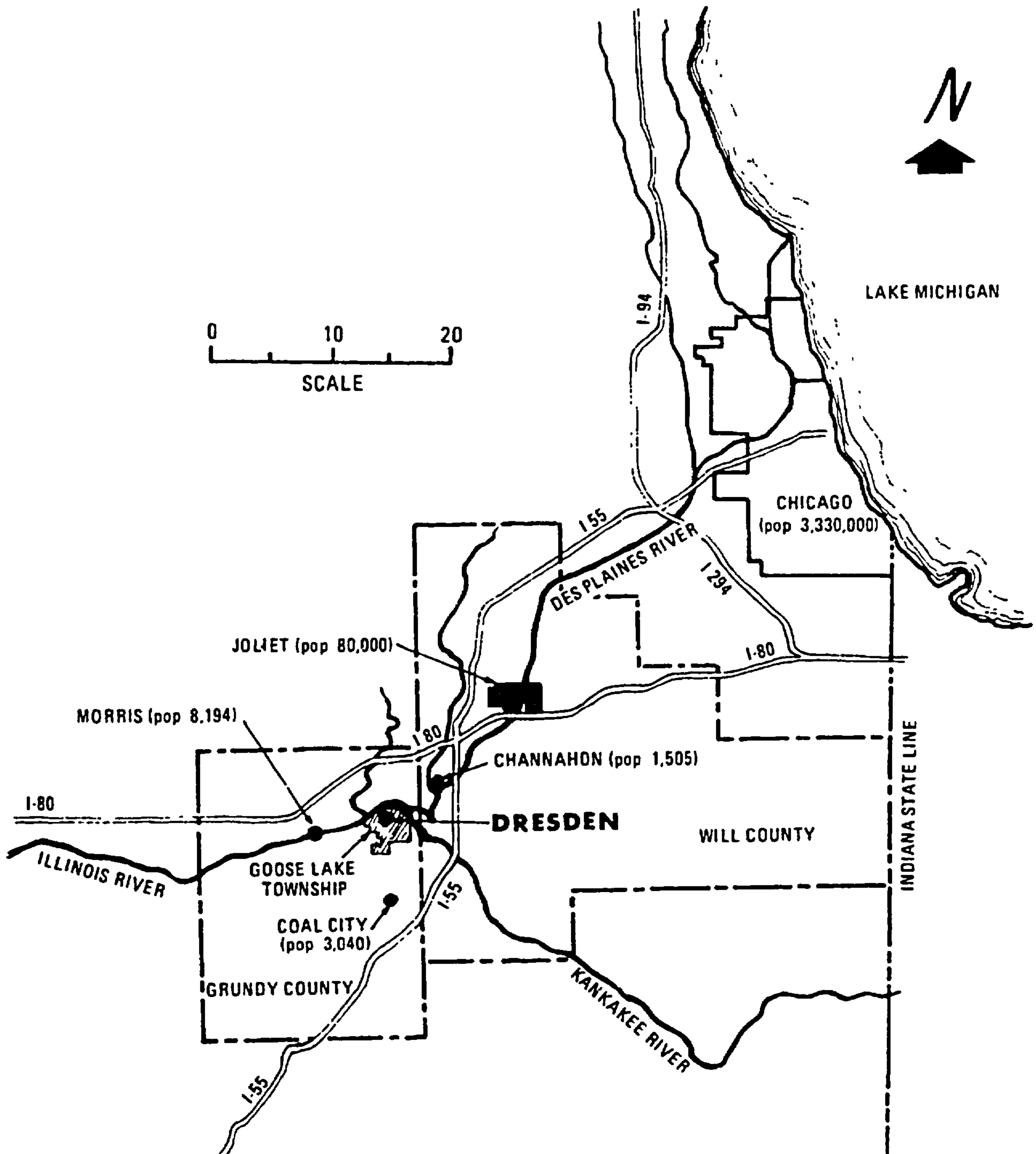


Fig. 2.1. Dresden Nuclear Power Station Location Map.

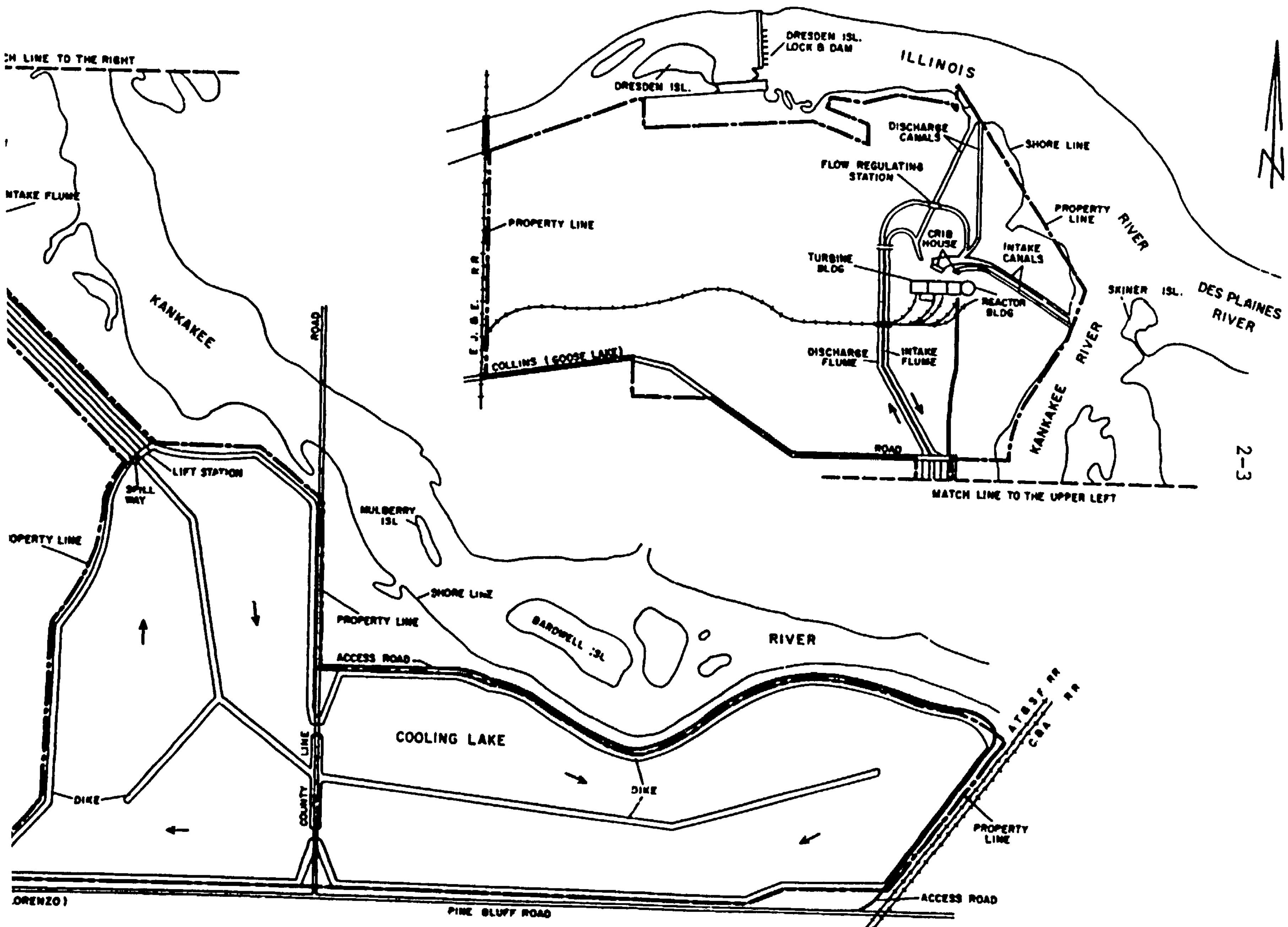


FIG. 2.1a DRESDEN STATION

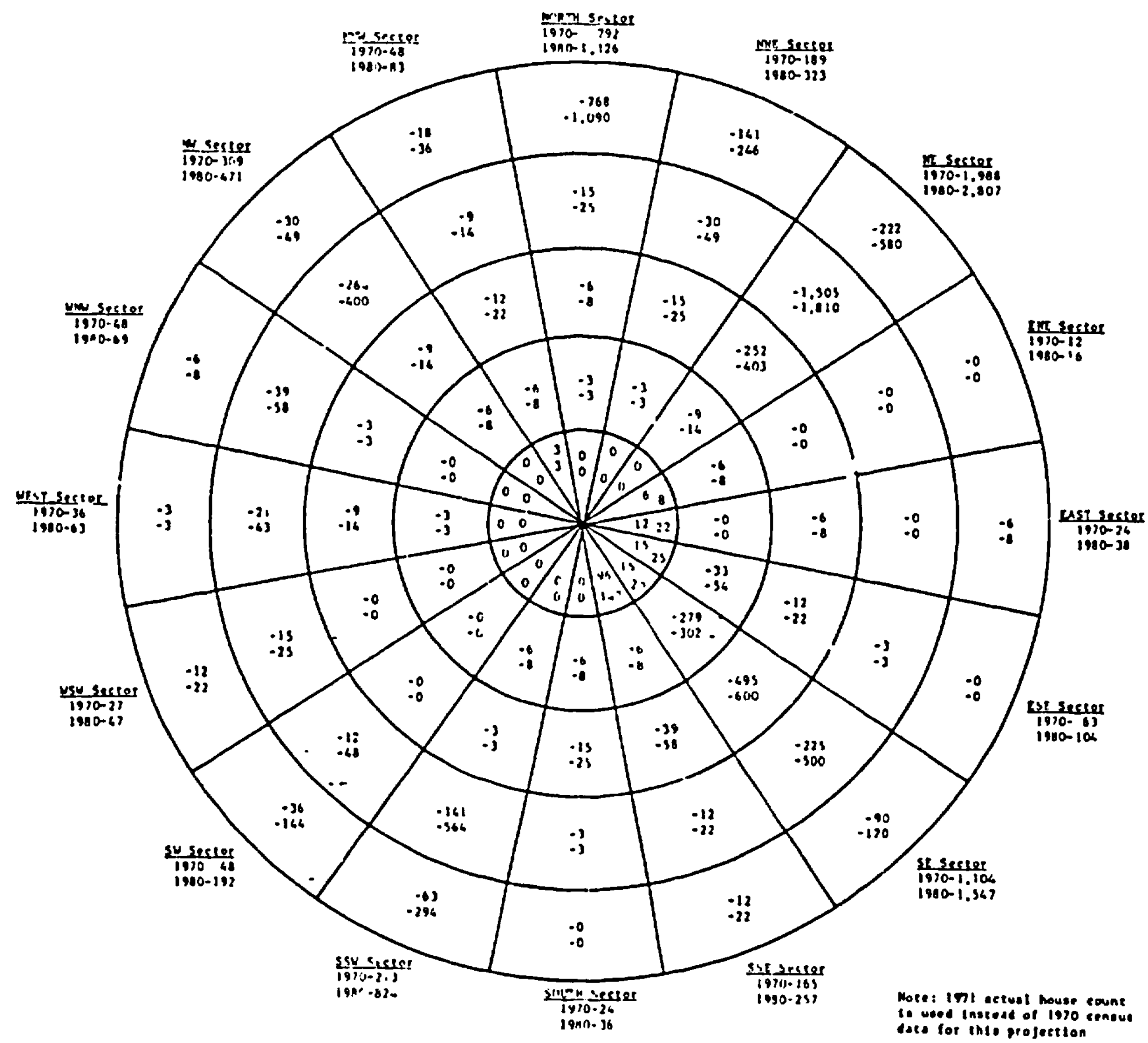


Fig. 2.2. Present and Future Population Distributions, 0–5 Miles from the Station. From Applicant's Environmental Report, Supplement I.

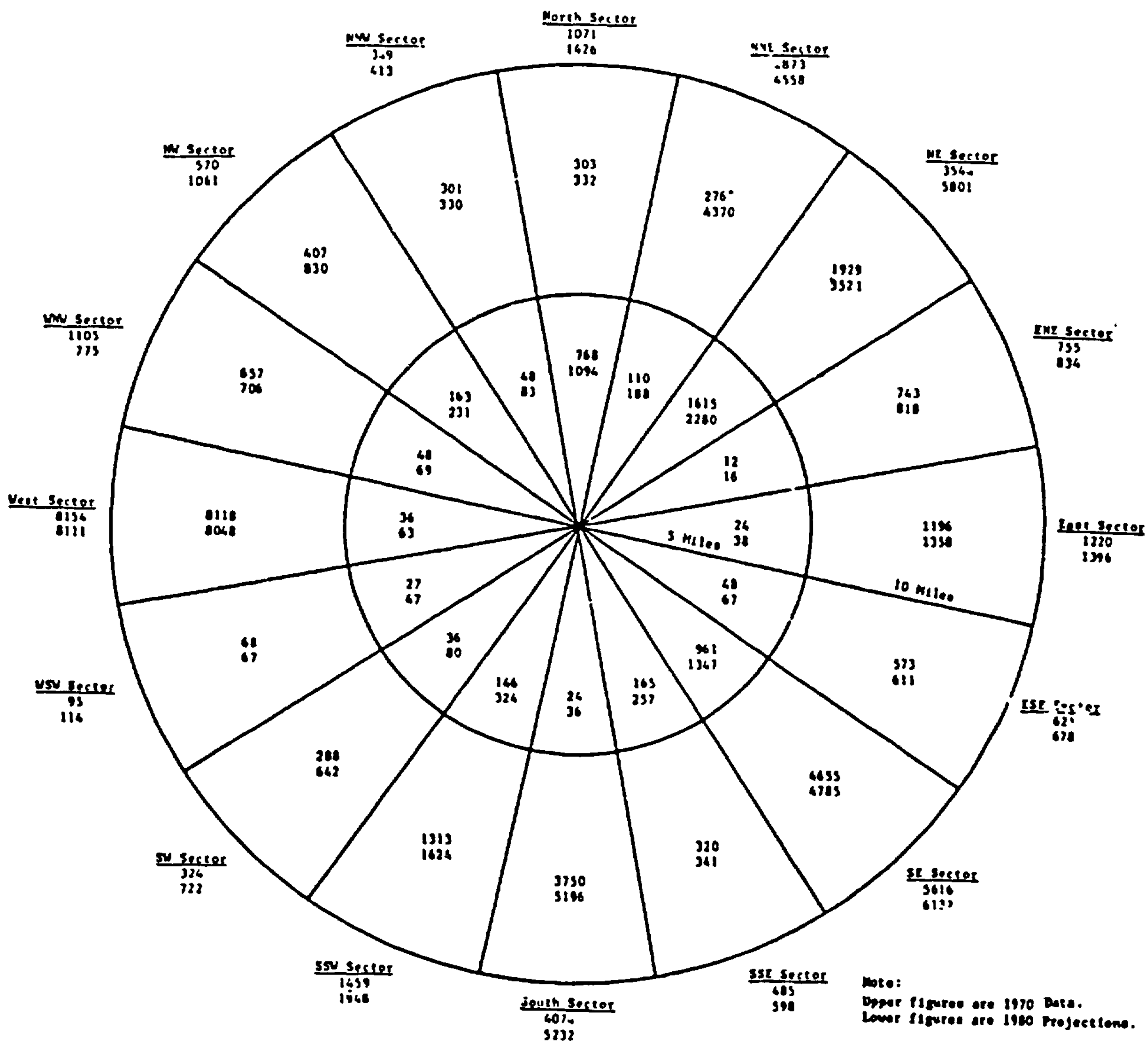


Fig. 2.3. Present and Future Population Distributions, 0–10 Miles from the Station. From Applicant's Environmental Report, Supplement I.

lake). Clusters of homes and cottages have been built and will probably continue to be built on the peninsula between the Kankakee and Des Plaines Rivers just north of the cooling lake.

The closest population center is Channahon (population 1505)[2] which is located approximately fou 's northeast of the Station. Other population centers near the Station include:

Name	Population[2]	Distance	Direction
Morris, Ill.	8,194	7.5 miles	WSW
Coal City, Ill.	3,040	8 miles	S
Braidwood, Ill.	2,323	9 miles	SSE
Wilmington, Ill.	4,335	10 miles	SE
Joliet, Ill.	80,000	15 miles	NE
Aurora, Ill.	76,500	27 miles	N
Kankakee, Ill.	31,200	30 miles	SE
Chicago, Ill.	3,330,000	50 miles	NE

Grundy County is principally an agricultural area. However, several industrial plants are located south and west of the Station site, north of the Station across the Illinois River and along the Des Plaines River northeast of the Station. One of the industrial plants which is adjacent to and south of the Station property is the Midwest Fuels Reprocessing Plant (G. E.). This is also a nuclear facility. It operates under a Commission license and was the subject of a separate environmental review (AEC Docket No. 50-268). The area south of the Station also contains abandoned strip mines, some of which are used for recreational purposes. A map of the local area is shown in Fig. 2.4.

The 1513-acre Goose Lake Prairie Nature Preserve is located approximately one mile southwest of the Station. Plans are being made to expand the acreage and to develop some of the land into a state park.[3]

The Applicant has recently petitioned the Illinois Commerce Commission for a Certificate of Public Convenience and Necessity and an order authorizing the construction of the 2500-MWe Collins Electric Generating St[illegible] in Goose Lake Township, Grundy County. This generating station, to contain five oil-fired boilers, is proposed for construction along the Illinois River and adjacent to the north edge of the Goose Lake Prairie Nature Preserve. The Collins Station would be located approximately 1.5 miles west of the Dresden Station (Fig. 2.4). The proposed station would also use a man-made reservoir to provide cooling water for the turbine condensers.

The Illinois and Des Plaines Rivers are presently used for navigation, sewage disposal for metropolitan Chicago and some of its suburbs, and for industrial water supply purposes. All potable water in the area is obtained from underground sources, however, because of the poor quality

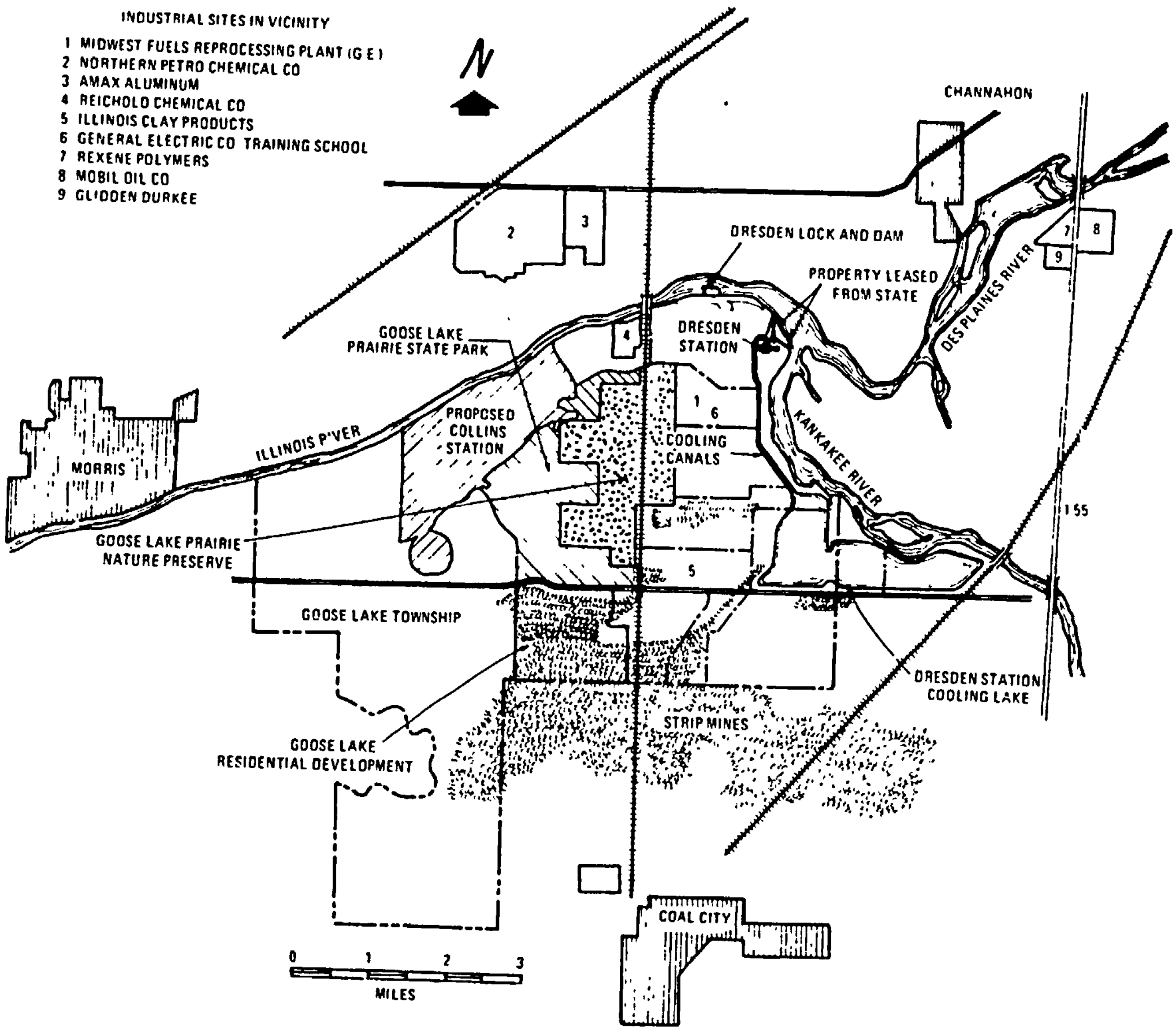


Fig. 2.4. Dresden Nuclear Power Station Area Map. From Applicant's Environmental Report, Supplement II.

Kankakee Rivers in the vicinity of the Station were reclassified in March 1972 as "Public and Food Processing Water Supplies."[4] This reclassification implies that the extensive upstream pollution will be abated by future water pollution control activities. Excerpts of this new State of Illinois regulation can be found in Appendix A. The U. S. Environmental Protection Agency recently approved the Illinois regulations in accordance with Section 303(A)(1) of the Federal Water Pollution Control Act Amendments of 1972, except for changes specifically noted. The approval letter is also included in Appendix A.

The bulk of the land along the Illinois River in Grundy County is classified for industrial use.[5] A list of the industries in the area is noted in Fig. 2.4.

Current air pollution data for the Grundy County area are presented in Table 2.1.

2.3 HISTORIC AND ARCHEOLOGICAL SITES AND NATIONAL LANDMARKS

Across the Illinois River from the Dresden Station is the Illinois and Michigan Canal; this canal and its lockage facilities have historic value and are listed in the National Register of Historic Places.[6] In addition, part of the unused Illinois and Michigan Canal has been incorporated into the Channahon State Park. Other places of historic and scientific interest near the Dresden site are the Goose Lake Prairie State Park and Nature Preserve and the Kankakee River Nature Preserve. The former, which was established to preserve a remnant of the Illinois Grand Prairie as it existed prior to the arrival of European man, is in the process of development. It is anticipated that this facility will become a local attraction after it is completed in 1977-1978. The Illinois Nature Preserve Commission states that the Kankakee River Nature Preserve was dedicated specifically for the protection of *Iliamna remota*, and provides the only remaining location for the scientific study of this mallow.[7]

The Kankakee-Des Plaines area is an extremely rich archeological region and there are many archeological sites in the vicinity of the Station. The Illinois Archeological Survey lists 13 in the immediate environs and 432 within a 50-mile radius. The State of Illinois Historic Preservation Officer has been contacted and has reaffirmed this information.[8] One of the sites is on Station property and has been examined by a professional archeologist who determined that any disturbance caused by construction to date is minimal.[9]

2.4 METEOROLOGY

The climate of Illinois is typical continental with cold winters and warm, humid summers, with frequent short-period fluctuations in temperature, humidity, cloudiness, and wind speed and direction. The winds are controlled primarily by the storm systems and weather fronts which move

TABLE 2.1. Air Pollution Data - Grundy County, Illinois

Class	Particulates	Sulfur Oxides	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides	Aldehydes	Organic Acids
	Area Source Emissions (tons/year)-1970 Estimates						
Residential gas	10.1	0.3	10.6	4.2	26.5	5.3	0.5
Residential oil	21.2	109.9	10.6	6.4	25.4	4.2	0.0
Residential coal	51.5	342.3	25.7	7.7	15.4	0.0	0.0
Transportation	106.7	92.5	20626.9	3343.0	2987.4	103.1	234.7
Private dry cleaners	0.0	0.0	0.0	53.7	0.0	0.0	0.0
Commercial dry cleaners	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid waste	174.1	10.9	924.7	326.4	65.3	0.0	0.0
Grain	2162.7	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fertilizer	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Railroads	4.9	12.7	13.7	9.8	14.7	0.8	1.4
Total	2531.1	568.6	21612.3	3751.2	3134.7	113.4	236.6
	Point Source Emissions (tons/year)-1970 Estimates						
Fuel combustion:							
Coal	2806.9	2744.6	22.9	8.9	469.4		
Distillate oil	0.6	1.1	0.0	0.0	2.1		
Residual oil	2.3	31.3		0.2	7.9		
Natural gas	24.3	0.3	1.3	52.5	276.9		
Chemical process industries	22.5						
Metallurgical industries	436.6		2286.3				
Mineral products industries	26195.4				7.1		
Total	29488.7	2777.3	2310.5	61.6	763.4		

From "1970 Emission Inventory Data Summary," State of Illinois, Environmental Protection Agency, Springfield, Ill.

winds usually bring mild and wet weather. The southerly winds are warm and showery while westerly winds are dry with moderate temperatures, and winds from the northwest and north are usually cool and dry.

The annual mean temperature, based on a 27-year record, at the Morris, Illinois, Weather Station (Morris 5N) approximately eight miles northwest of the Station is 50.9°F; temperatures ranged from a high of 109°F to a low of -22°F. During the period 1950-1960 the area experienced a ten-year mean of eight July days with temperatures of 90°F or higher and a nine-year mean of 30 January days with temperatures 32°F or lower.[11] Total annual average precipitation at Morris 5N was 31.04 inches over the 49 years of record prior to 1961. Total average annual snowfall in the area approximately 15 miles northeast (Joliet) over the 14-year period prior to 1961 was 22.8 inches. The annual mean number of days with precipitation of 0.50 inch or more at Morris 5N was 22 days over the period 1950-1960.[11]

The most severe weather phenomena which occur in Grundy County are tornadoes. Tornadoes have been observed a total of 28 times from 1916 to 1961 in the 1° latitude-longitude square which contains the site.[12] In adjacent 1° squares, tornado occurrence ranged from a high of 36 to a low of 19 during the same interval. Grundy County was the origin of three tornadoes during the period 1916 to 1969 and it experienced three additional ones which originated in La Salle County (the next county west).[12] The tornado recurrence interval is 758 years.

The Applicant has had a 400-foot meteorological tower on the site for the past several years. Wind speed, wind direction and wind persistence are measured at the 35, 125, 300, and 400-foot levels. In addition, temperature measurements are made at the 35- and 400-ft levels and the dew-point temperature at the five-foot level is recorded continuously. A weighing-bucket rain gauge is used to measure precipitation. This tower is located about 600 feet south of the plant between the two spray canals as shown in Fig. 3.11. A new tower has been constructed west of the turbine building approximately 1/2 mile. This tower will replace the old tower when it becomes fully operational. An example of the winds at the site is shown in Figure 2.5, which is an annual wind rose for the 35-foot level.

Adequate meteorological data are available for the site. On-site meteorological data, therefore, were used in the radiation dose calculations to determine diffusion conditions at the site. These data are contained in a computer program[13] which was used by the Staff in performing the independent radiation dose calculations which appear in Section 5.4 of this report. The 300-foot wind data have been used by the Staff to estimate dispersion rates at the site.[14] Table 2.2 shows the relative frequency of winds from a given direction by Pasquill stability classes. The variability of the 300-foot wind direction was used to determine the stability

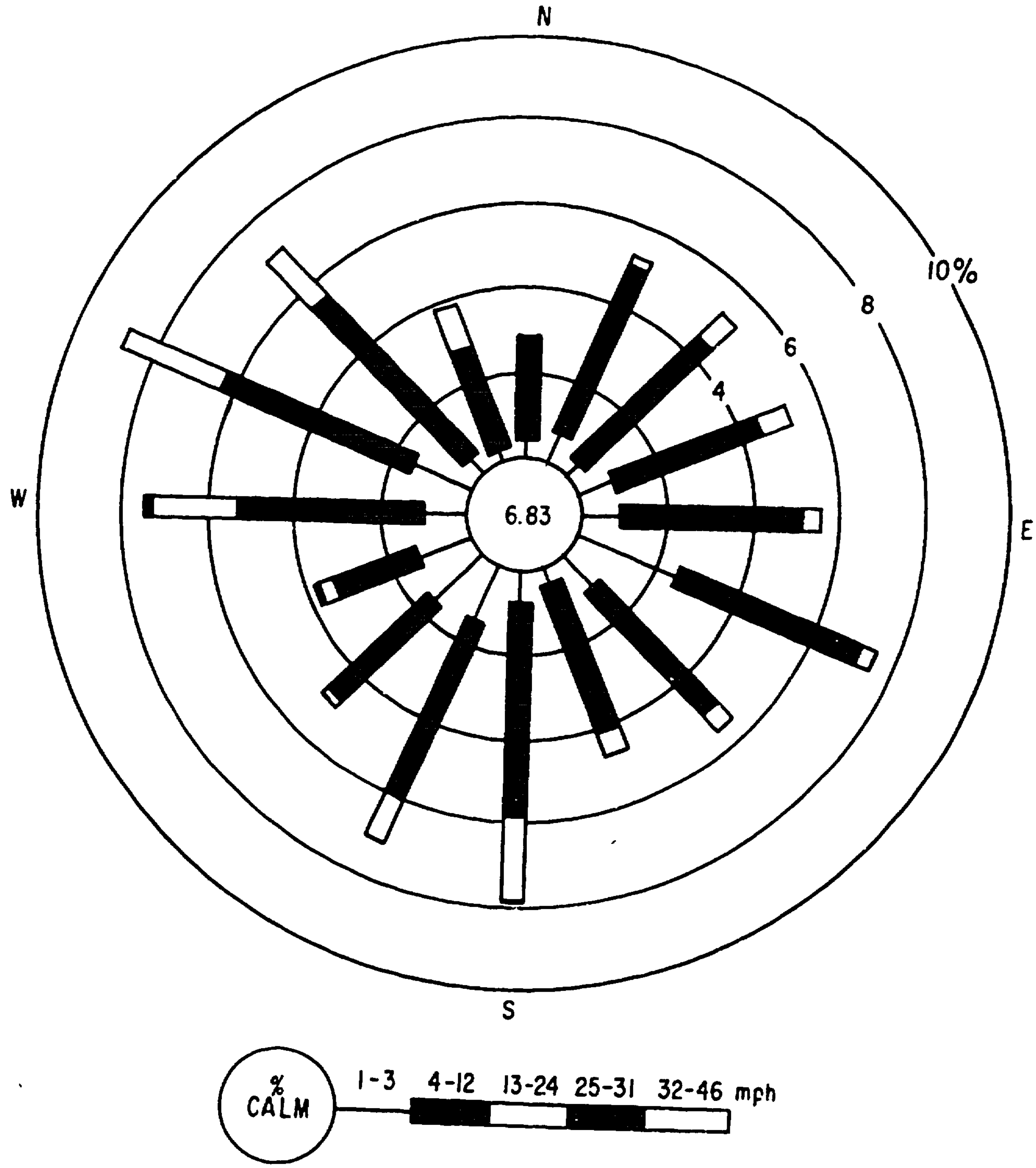


Fig. 2.5. Annual Wind Rose at 35-foot Level at Dresden site. From Braidwood Station Environmental Report. Commonwealth

TABLE 2.2. Joint Frequency Distribution of Pasquill Stability Class and Wind Direction, Dresden, 300-foot Level (percent of total observations)

NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	Calm
0.30	0.36	0.06	0.08	0.08	0.10	0.18	0.29	0.20	0.13	0.05	0.04	0.08	0.27	0.22	0.32	0.00
[illegible]	0.15	0.14	0.09	0.14	0.25	0.33	0.32	0.33	0.15	0.05	0.08	0.08	0.24	0.10	0.11	0.74
0.22	0.32	0.23	0.22	0.19	0.34	0.32	0.61	0.49	0.48	0.28	0.39	0.33	0.48	0.23	0.71	0.00
0.70	0.85	0.80	1.08	0.77	1.07	1.32	3.03	2.32	2.23	1.46	1.97	1.81	1.78	1.70	1.99	0.00
1.22	1.36	1.41	1.31	1.00	2.16	2.14	2.83	3.71	3.81	2.39	3.88	3.06	2.89	2.17	1.10	0.95
0.33	0.62	0.55	0.49	0.86	1.36	0.88	1.22	1.23	2.01	1.75	2.66	2.22	1.48	0.82	0.46	0.00
0.19	0.15	0.09	0.24	0.24	0.63	0.27	0.38	0.55	0.66	0.56	0.91	0.80	0.74	0.28	0.16	0.00
3.01	3.81	3.27	3.50	3.29	5.91	5.43	8.68	8.83	9.47	6.54	9.94	8.38	7.88	5.52	4.86	1.69

The following table gives the frequency of each stability class and the average wind speed at 300 feet for that class.

Class	Frequency	Wind Speed (mph)
A	2.74	9.5
B	3.35	7.2
C	5.84	9.4
D	24.89	15.9
E	37.39	16.0
F	18.95	16.2
G	6.85	13.6

The closest meteorological station that has collected fog data is the Joliet Municipal Airport (about 12 miles NNE). These data have been summarized by Murray and Trettel, Inc., the Applicant's consultant.[15] Meteorological observations representing 99,165 hours (about 11 years) indicate that a total of 12,284 hours (12.4%) of fog with visibilities of six miles or less occurred at the airport. Dense fog having "zero" visibility (up to 330 feet) occurred 0.26% of the time, or about 23 hours per year. These critical cases occurred most often in winter, least in summer (most often in January and least in June) and most often in the early morning hours (0500-0900 CST). The "zero" visibility fogs had a median persistence of up to three consecutive hours. However, they occurred once for 12 consecutive hours with a return period of 10-20 years.

2.5 GEOLOGY

The Chicago region lies near the center of the Central Lowland Province, a glaciated lowland that stretches from the Appalachian Plateau on the east to the Great Plains on the west.[16] The Station is situated in a subdivision called the Kankakee Plain, which is a level to gently undulatory plain that occupies the position of a basin between higher moraine country to the east and west. Low ridges, terraces, bars, and dunes locally rise above the general level. The elevation in the immediate vicinity of the site varies from 509 to 526 feet above sea level. The only deviation is the Kankakee Bluffs, elevation 591 to 624 feet, located just northeast of the Station on the north (opposite) bank of the Illinois River. The generalized geologic section for Northeast Illinois is shown in Fig. 2.6. The upper layer of bedrock varies across the region, being primarily of Silurian or Ordovician age (Fig. 2.7). The upper layer of the smaller portion, which includes the site, is of Pennsylvania age. This is shown in Fig. 2.8. The rocks of the Pennsylvania system belong to the "Coal Measures" or strata associated with beds of coal.[17,18] They consist mainly of fine-grained sandstone, clay, shale, and one or two seams of coal. The Dresden cooling lake is situated on top of an old abandoned coal mine

SERIES	GROUP OR FORMATION	HYDROLOGIC UNITS	LOG	THICKNESS (FT.)	DESCRIPTION	DRILLING AND CASING CONDITIONS	WATER-YIELDING PROPERTIES	CHEMICAL QUALITY OF WATER	WATER TEMPERATURE °F
lelstocene		Glacial drift aquifers		0-350+	Unconsolidated glacial deposits - pebbly clay (till), silt, and gravel. Alluvial silts and sands along streams.	Boulders, heaving sand locally; sand and gravel wells usually require screens and development; casing required in wells into bedrock.	Sand and gravel, permeable. Some wells yield more than 1000 gpm. Specific capacities from 2. to 66 gpm/ft, av. 12 gpm/ft. Coefficient of trans. from 3400 to 100,000 gpd/ft, av. 25,000 gpd/ft.	McHenry County, hardness from 100 to 450 ppm., av. 275. Other counties, see Silurian below and text.	46° min. 52° av. 54° max.
	Carbondale Tradewater			0-175	Shale; sandstones, fine-grained; limestones; coal; clay.				
nderhook				0-365	Shale, green and brown, dolomitic; dolomite, silty.	Shale requires casing.	Jointed beds yield small supplies locally. Limited areal extent; not used as aquifer.		
				0-25	Shale, calcareous; limestone beds, thin.				
agaran	Port Byron Racine Waukesha Joliet Kankakee Edgewood	Silurian (Shallow dolomite aquifer)		0-465	Dolomite, silty at base, locally cherty.	Upper part usually weathered and broken; extent of creviceing varies widely.	Not consistent; some wells yield more than 1000 gpm. Crevices and solution channels more abundant near surface. Specific capacities from 0.1 to 550 gpm/ft. Highest av. specific capacities (54.4 gpm/ft) in Du Page Co. wells, lowest (5 gpm/ft) in Lake Co. Coefficient of trans. averages 100,000 gpd/ft in Du Page Co., 9000 gpd/ft in Lake Co.	Variable. Hardness, <100 to >1000 ppm. [illegible] 500 ppm in 85% of analyses.	54°
ncinnatian	Maquoketa	Maquoketa (Shallow dolomite aquifer)		0-250	Shale, gray or brown; locally dolomite and/or limestone, argillaceous.	Shale requires casing.	Shales, generally not water yielding, act as barriers between shallow and deep aquifers. Crevices in dolomite yield small amounts of water.		
hawkian	Galena Decorah Platteville	Galena-Platteville		220-350+	Dolomite and/or limestone, cherty. Dolomite, shale partings, speckled. Dolomite and/or limestone, cherty, sandy at base.	Creviceing common only where formations underlie drift. Top of Galena usually selected for hole reduction and seating of casing.	Where formation lies below shales, development and yields of crevices are small; where not capped by shales, dolomites are fairly permeable.	Hardness < 100 ppm. H_2S often present.	54° to 55°
	Glenwood				Sandstone, fine- and coarse-grained, little dolomite, shale at top.				
azyan	St. Peter	Glenwood-St. Peter (Cambrian-Ordovician Aquifer)		100-650	Sandstone, fine- to medium-grained; locally cherty red shale at base.	Lower cherty shales cave and are usually cased. Friable sand may slough.	Small to moderate quantities of water. Trans. probably about 15% of that of Cam.-Ord. Aquif.	Water similar in quality or slightly harder than that in Ironton-Galesville Sandstone.	53° to 56° 56° to 58° (Lake Co.)
irie du Chien	Shakopee New Richmond Oneota	Prairie du Chien		0-340	Dolomite, sandy, cherty (oolitic); sandstone. Sandstone, interbedded with dolomite. Dolomite, white to pink, coarse-grained, cherty (oolitic), sandy at base.				
	Trempealeau	Trempealeau		0-225	Dolomite, white, fine-grained, geodic quartz, sandy at base	Crevices encountered locally in the dolomite, especially in Trempealeau. Casing not required.	Crevices in dolomite and sandstone generally yield small amounts of water. Trempealeau locally well creviced and partly responsible for exceptionally high yields of several deep wells.		
	Franconia	Franconia		45-175	Dolomite, sandstone, and shale, glauconitic, green to red, micaceous.				
St. Croixian	Ironton Galesville	Ironton-Galesville		105-270	Sandstone, fine to medium-grained, well sorted, upper part dolomitic.	Amount of cementation variable. Lower part more friable. Sometimes sloughs.	Most productive unit of Cam.-Ord. Aquif; trans. probably about 80% its total. Coefficients of trans. and storage of the Cam.-Ord. Aquif. [illegible] 17,400 gpd/ft and [illegible] 635.	Hardness 2[illegible] to 25[illegible] ppm in northwest part of area, increasing toward east and south. [illegible] ppm.	56° - 58° to 62° - 64°
	Eau Claire	Eau Claire (upper and middle beds)		235-450	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic.	Casing not usually necessary. Locally weak shales may require casing.	Shales, generally not water yielding, [illegible] is barrier between Ironton-Galesville and Mt. Simon.	Water soft [illegible]	[illegible]
	Mt. Simon	Sandstones Eau Claire (lower) & Mt. Simon (Mt. Simon)		2000±	Sandstone, coarse-grained, white, red in lower half; lenses of shale and siltstone, red, micaceous.	Casing not required.	Moderate amounts of water, permeability intermediate between that of Glenwood-St. Peter and Ironton-Galesville.	[illegible]	[illegible]
					Precambrian	crystalline rocks			

Stratigraphy and Water-yielding [illegible]

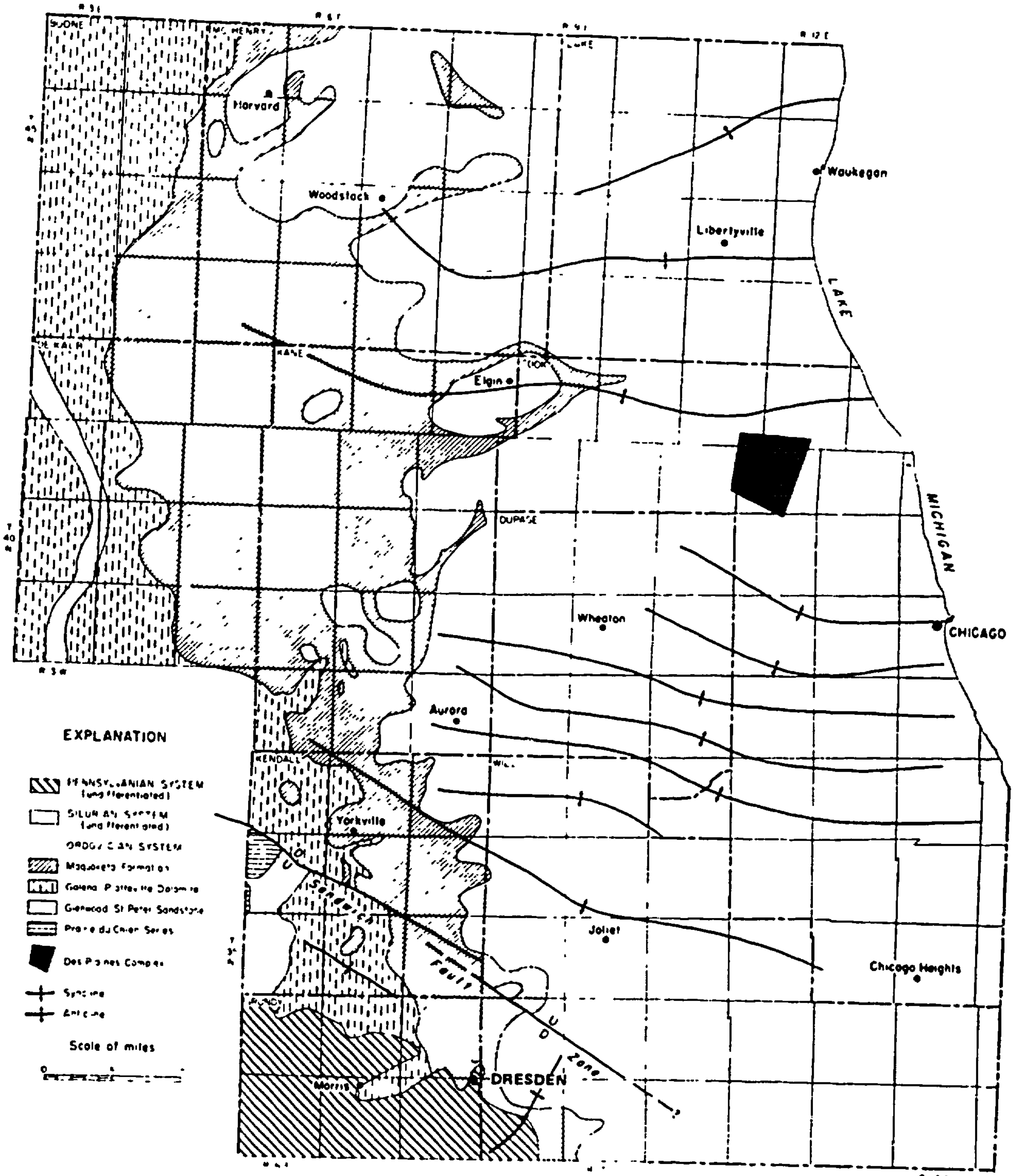


Fig. 2.7. Aerial Geology of the Bedrock Surface and Major Structures in the Chicago Region. From "Preliminary Report on Ground-Water Resources of the Chicago Region," Illinois Cooperative Ground-Water Report 1. Illinois State Water Survey, 1959.

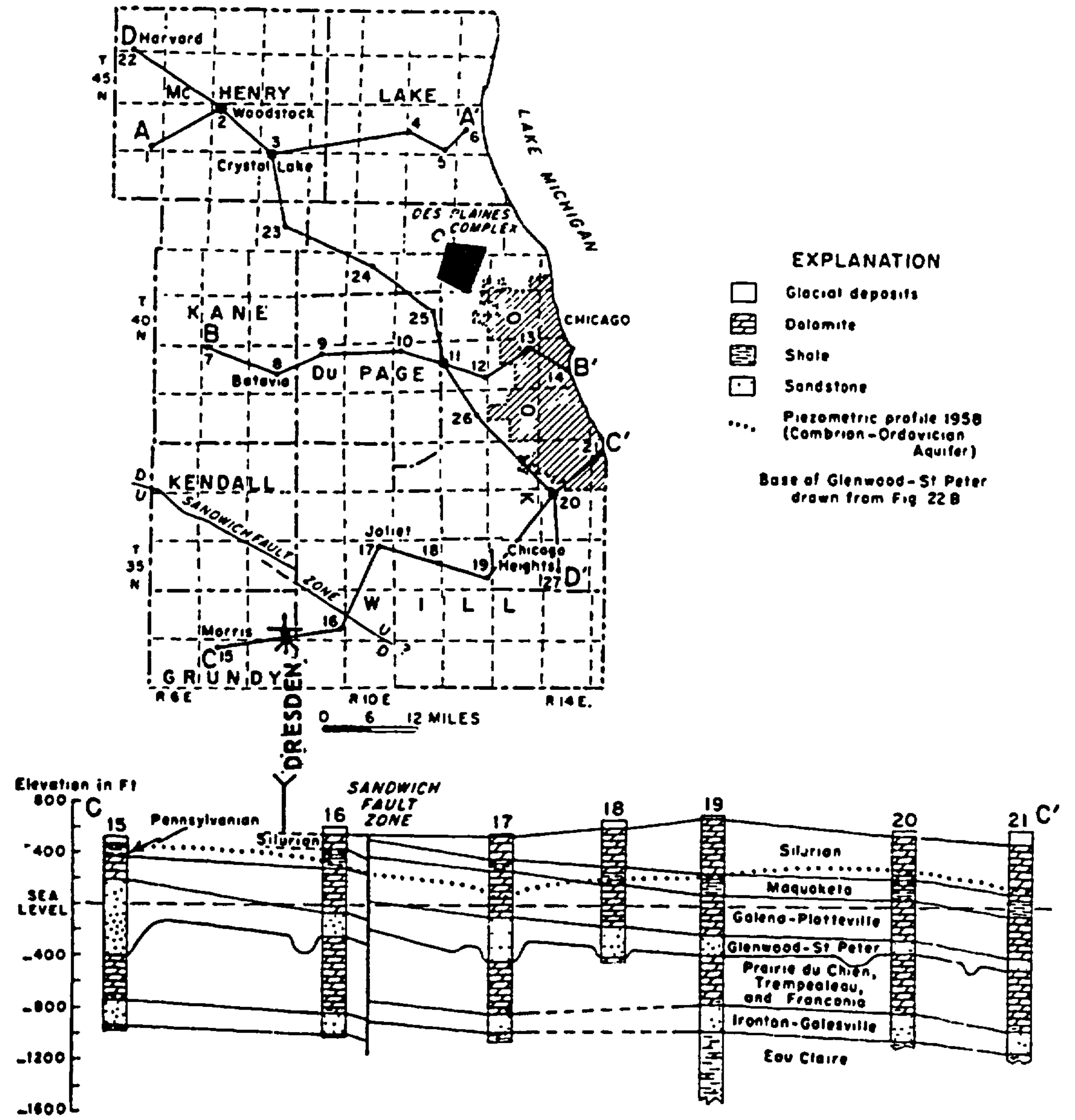


Fig. 2.8. Cross Sections of the Structure and Stratigraphy of the Bedrock and Piezometric Profiles of the Cambrian-Ordovician Aquifer across the Dresden Area. From "Preliminary Report on Ground-Water Resources of the Chicago Region," Illinois Cooperative Ground-Water Report 1. Illinois State Water Survey, 1959.

of plant operations and a more detailed analysis of their safety significance will be presented in the Safety Evaluation for Dresden Units 2 and 3.

The topsoil in the area of the site is typically one to two and one half feet thick, composed of black silt with some sand, clay, and organic material. Beneath the topsoil are found dense, cohesive glacial till soils consisting of sandy silts with clay and clayey silts with sand.[18] This glacial till extends to the top of the bedrock, which ranges from 12 to 31 feet below the surface.

2.6 HYDROLOGY

Ground water resources in the region are developed from four aquifer systems as shown in Fig. 2.6. They are:

- glacial drift aquifer
- shallow dolomite aquifer located mainly in Silurian age rock
- Cambrian-Ordovician aquifer
- Mt. Simon aquifer

The Cambrian-Ordovician aquifer is used almost exclusively as the ground water supply for the municipal and industrial use in the area. This aquifer consists, in descending order, of the Galena-Platteville dolomite, Glenwood-St. Peter sandstone, and Prairie du Chien Series of Ordovician age; and the Trempeauleau dolomite, Franconia Formation and Ironton-Galesville sandstone of Cambrian age. This aquifer is separated from the Mt. Simon aquifer by shale beds of the Eau Claire formation.

The two wells at the Dresden site are each 1500 feet deep[19] and tap the Cambrian-Ordovician aquifer.

The primary surface water resources in the area are the Illinois Waterway and its tributaries. The Illinois Waterway is a series of eight navigational pools (with headwaters above a lock and dam) extending 327.2 miles from its confluence with the Mississippi River at Grafton, Illinois, to the Chicago River outlet at Lake Michigan (Fig. 2.9). The Illinois River is the stretch of the Waterway from the confluence of the Kankakee and Des Plaines Rivers to the Mississippi River.

The Illinois River and its tributaries drains an area of 32,081 square miles,[20] and is unique in the sense that its headwaters during dry weather (low flow) are essentially the treated liquid wastes from about 5.5 million people and the various industries in the metropolitan Chicago area, mixed with the water diverted from Lake Michigan.[21]

The Station is located at approximately River Mile 27? ? [illegible]

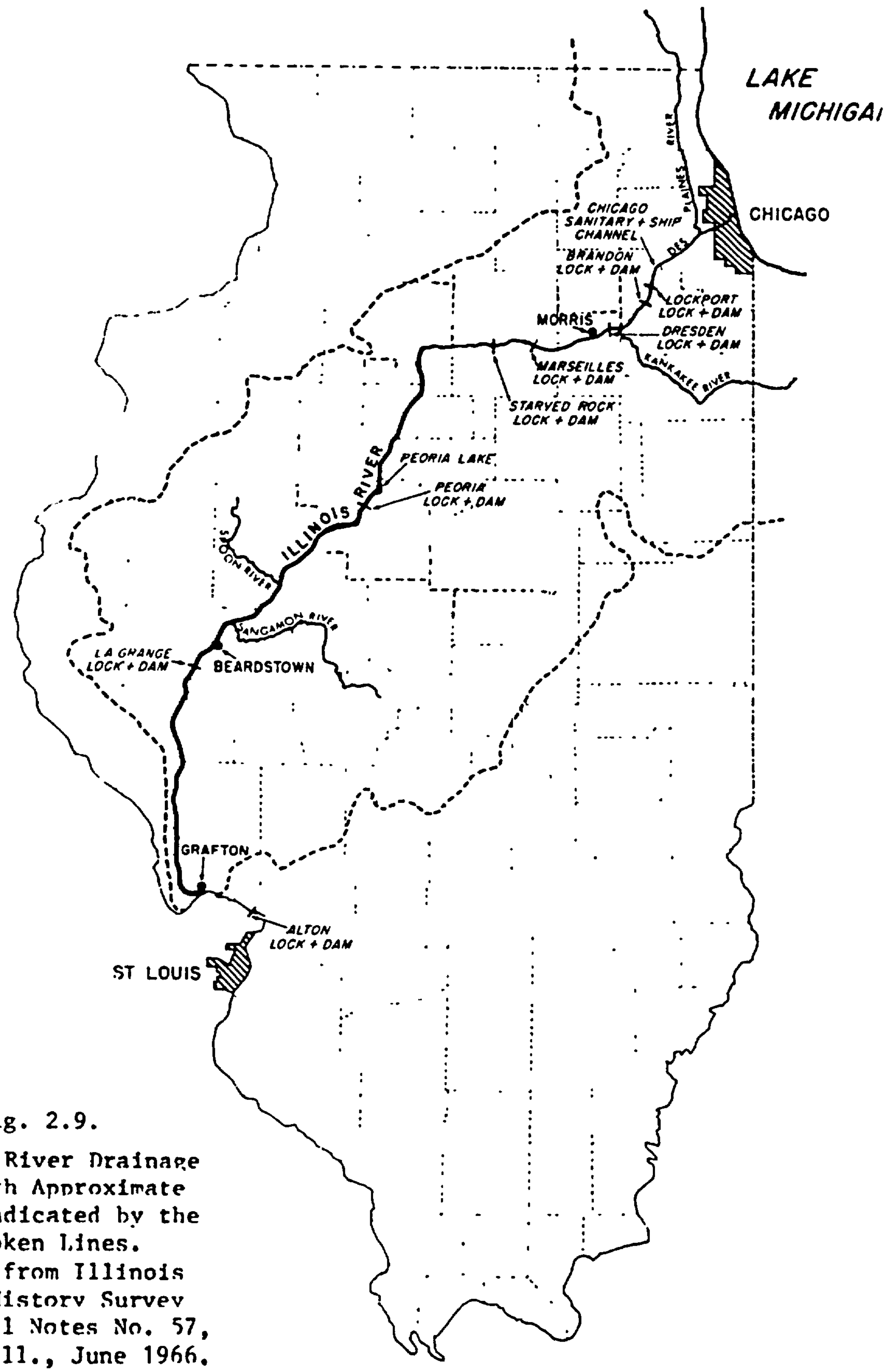


Fig. 2.9.

Illinois River Drainage Basin with Approximate Limits Indicated by the Heavy Broken Lines. Modified from Illinois Natural History Survey Biological Notes No. 57, Urbana, Ill., June 1966.

should be kept in mind, however, that the major inputs to this ecosyst originate upstream, and that outputs from this ecosystem are felt down

The Station's primary source of condenser cooling water is the Kankake River, and its characteristics will be discussed separately from those of the Illinois River.

2.7 ECOLOGY

2.7.1 Physical and Chemical Characteristics of the Illinois River

Turbidity. The Illinois River was described in 1787 as being "clear".[2] Agricultural activities since the early 1800's have increased the silt load of the river. Movement of tow boats and dredging to maintain the navigational channel have kept much of the river in a turbid condition (see Table 2.3). Turbidity has been a factor in the decline of aquatic vegetation, and it depresses phytoplankton photosynthesis.

Flow rate. Stream flows on the Illinois Waterway have been found to fluctuate significantly due not only to seasonal effects but to man's regulatory activities through Lake Michigan diversion and the lock-and-dam system. For example, on September 20, 1971, flows in the Dresden Pool dropped from about 17,000 cfs on the preceding day to 2400 cfs.[21] Average flow rate over the period 1921 to 1945 as measured at Marseilles (downstream of the Dresden Pool) was 12,050 cfs (5,400,000 gpm).[22] A seven-day 10-year low flow of 3300 cfs was determined from data collecte from 1940 to 1965 at Marseilles.[21] A maximum discharge of 93,900 cfs occurred at Marseilles in April of 1957.[23]

Temperature, Dissolved Oxygen, and Oxygen Demand. Temperature and dissolved oxygen values are given in Table 2.3. It is interesting to note that in July-September 1971 the average temperatures for the Dresden Island Pool were the highest of all pools: average 27.6°C (81.7°F), minimum 24.9°C (76.8°F), maximum 31.2°C (88.2°F).[21] Also of interest are the results of studies[21] during July-September 1971 on dissolved oxygen and oxygen demand (see Fig. 2.10). Because of lower flow velociti and deeper water than other pools, Dresden Island Pool was indicated as having one of the lowest capabilities for assimilating wastes. The studies[21] concluded that the principal oxygen demand on this pool is carbonaceous. An additional oxygen demand (nitrogenous) occurs in downstream pools (see Appendix B).

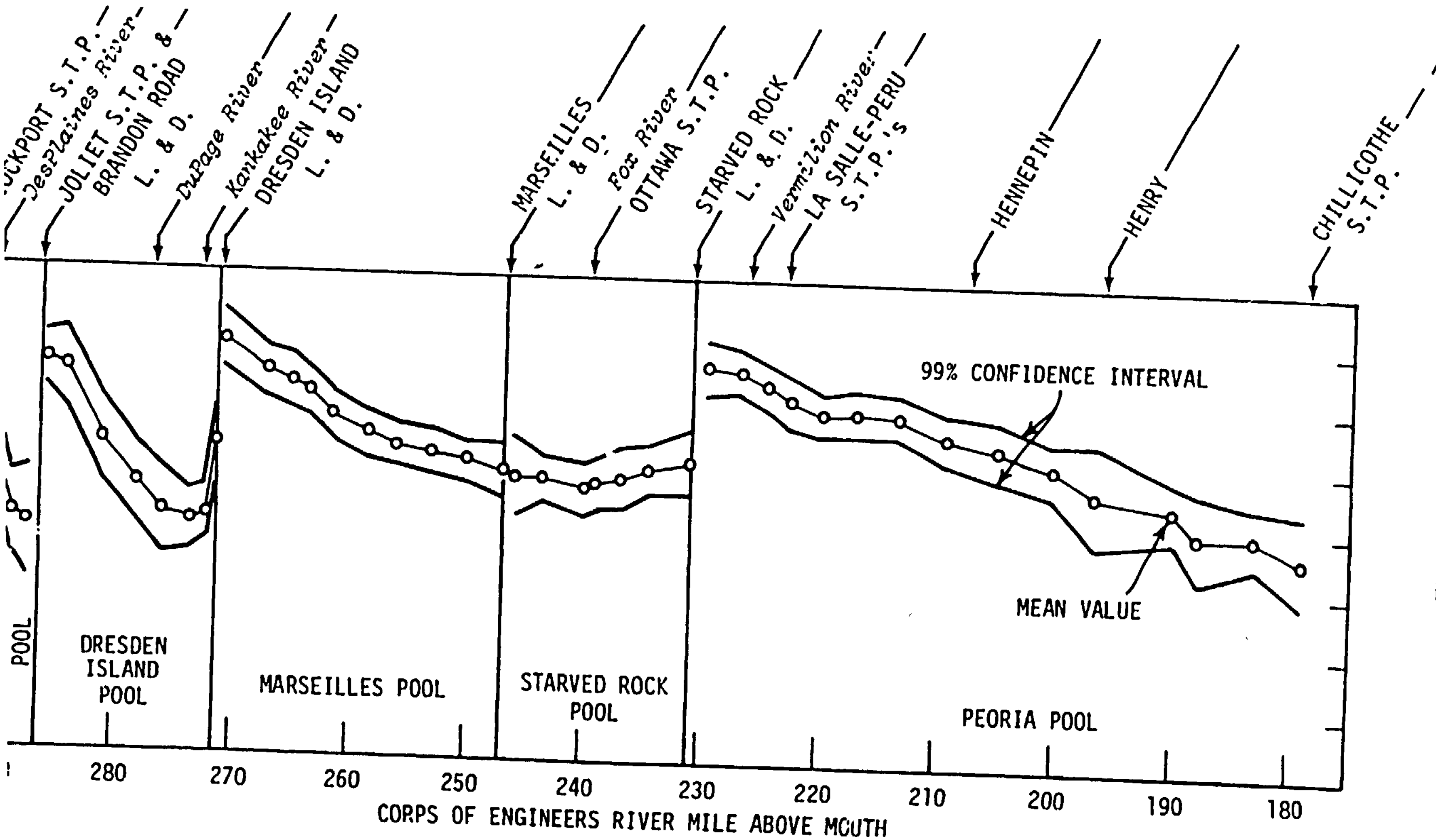
Other physical and chemical characteristics of the Illinois River near the Station site are given in Table 2.3.

2.7.2 Biota of the Illinois River

Benthos. Mills et al.[20] have described the general biological characteristics of the Illinois River in 1965 and noted the decline of diversity in benthic ...

TABLE 2.3. Characteristics of the Illinois River at Morris, Illinois

Parameter[a]	1971		1958-1971	
	Range	Average	Range	Average
Water temp., °F	44 - 77	60	34 - 85	60
Turbidity, JTU	16 - 190	78	16 - 330	67
Dissolved oxygen, mg/l	2.6 - 12.5[t]	8.1		
Biochemical oxygen demand, mg/l			3 - 12	6
Chemical oxygen demand, mg/l	16 - 48	35	6 - 48	21
Alkalinity, mg/l as $CaCO_3$			96 - 208	174
Hardness, mg/l as $CaCO_3$			144 - 388	283
Total dissolved solids, mg/l	415 - 520	464	250 - 670	448
Chloride, mg/l			23 - 162	58
Sulfate, mg/l			11 - 125	48
Nitrate, mg/l as NO_3	0 - 5	1	0 - 35	6
Ammonia, mg/l as N	2.3 - 8.2	5.3	0 - 11	3.9
Orthophosphate, mg/l as PO_4			0 - 1.5	0.4
Total P, mg/l as PO_4	1.2 - 5.0	3.5	0.1 - 37.0	3.8
pH	7.6 - 7.9	7.8	7.2 - 8.2	7.6
Methylene blue active substances, mg/l	1.2 - 1.7	1.3	0.1 - 2.3	0.7
Fluoride, mg/l	0.4 - 1.1	0.8	0.4 - 2.1	0.9
Iron, mg/l	0.1 - 0.5	0.3	0.0 - 0.5	0.1
Specific conductivity, micromhos	700 - 810	770	410 - 1050	700
Coliform/100 ml	700 - 17,600	8660	140 - 130,000	22,716
Fecal coli./100 ml	10 - 1300	665	10 - 2000	977



. Mean Dissolved Oxygen Profile, July 14–September 30, 1971. From "A Water Quality Investigation of the Upper Illinois Waterway," Preliminary Report, Water Quality Section, Illinois State Water Survey, July 1972.

of the channel to maintain navigability for barge traffic and the traffic itself probably prevent establishment of a more stable benthic community.

A study of the river bottom at the Dresden site in 1969-1970[25] indicated that benthic populations were mainly oligochaete worms, with a few clams, snails, and aquatic insect larvae (see Table C.1 and Fig. C.1 of Appendix C

Plankton. Surface samples collected in July-September 1971 by the Illinois State Water Survey[21] indicated that the dominant genera in the upper Illinois Waterway were diatoms, particularly *Cyclotella*, *Navicula*, and *Melosira*. Green algae, particularly *Scenedesmus*, flagellates, and blue-green algae were also present. The occurrence of these and other genera is shown in Table C.2 of Appendix C.

The Dresden Island Pool appeared to be the most diverse of the Illinois Waterway pools in terms of the algal populations noted in the study by the Illinois Water Survey.[21] Algal densities ranged from about 300 counts per milliliter to 13,700 counts per milliliter, and appeared to increase progressively downstream, on a pool-by-pool basis (see Fig. C.2 of Appendix C). Although algal densities greater than 500 counts/ml have been characterized as "nuisance blooms," no such blooms were observed in the Waterway in 1971,[21] probably because the predominant populations were diatoms.

In samplings made for the Applicant's preoperational studies[25] at several depths in the Dresden Pool, green algae were found to predominate in October 1968 and August 1969, while diatoms predominated in October 1969. These results were attributed to seasonal water temperature fluctuations. The same study[25] also indicated that *Cladophora* (a green alga) and *Oscillatoria* (a blue-green alga) were the predominant periphyton on rocks and logs along the shore during the summer and autumn. A subsequent study[26] by Industrial Bio-Test Laboratories found that diatoms composed about 85% of the phytoplankton in the Illinois River near the site (predominantly *Stephanodiscus* and *Cyclotella*). Phytoplankton abundances are indicated in Figs. C.3-C.7 of Appendix C. Diatoms were also predominant in the periphyton community in 1971. (For detailed species lists, see Reference 26).

Zooplankton collected from the river near Dresden in 1972 are listed in Table C.3 of Appendix C.

Fish. Prior to 1908, the Illinois River supported a large commercial and sport fishery, predominantly largemouth bass (*Micropterus salmoides*) and carp (*Cyprinus carpio*). Since then, increases in turbidity, sedimentation, drainage of bottomland lakes, and organic and inorganic chemical pollution have caused a loss of aquatic vegetation and benthos, resulting in a reduction of habitat and food for some fish species. In 1964 carp was the only species that occurred abundantly throughout characteristic.[20] Disappearance of fingernail clams and low dissolved oxygen are the factors suggested[20] to explain the small size of carp in the middle and upper Illinois River.

In 1971, collections at two sampling sites by Industrial Bio-Test Laboratories using shoreline seining in the Illinois River near the Station site, indicated that at least 16 species of fish were present in the Dresden Pool (see Table 2.4). The relatively few species of fish found at one of the sampling stations (D5) has been explained by its proximity to the "polluted" Des Plaines River and the lack of favorable fish habitat. Most of the fish collected at both sampling sites were und 100 mm in length.[26]

The once luxuriant growth of aquatic plants along the Illinois River and its lakes[20] has all but disappeared. Increased turbidity and rising water levels combined with unknown factors have contributed to the eradication of this vegetation, which is important as food for certain waterfowl and as habitat for fish.

Waterfowl. The Illinois River Valley serves as a resting and feeding are for migrating birds. Numbers of most species have declined in recent years, as indicated in Table 2.5.

The large decline in populations of the lesser scaup, ring-necked duck, and canvasback appear to coincide with the loss of molluscs, particularly fingernail clams, and aquatic vegetation on the river. Ruddy ducks, which feed on aquatic insect larvae as well as on small molluscs, did not decline to the same extent as the first three species in Table 2.5. The mallard population, which feeds primarily on seeds of marshy plants and crop grain, was apparently not affected by the loss of molluscs and aquatic plants. The decline of mallards was attributed to drought on the northern plains breeding grounds, and reflects the continental trend for this population.[20]

A decline in the numbers of other species was apparently not related to the quality of the Illinois River. After 1950, there was a rapid decline in the numbers of cormorants (*Phalacrocorax auritus*) visiting the valley; the cause of this decline is presently unknown.

Populations of the great blue heron (*Ardea herodias*) and American egret (*Casmerodius albus*) have fluctuated throughout the years and trends have not been established. The decline of the population of the prothonotary warbler (*Protonotaria citrea*) is attributed to the loss of nesting sites when dead willows along the edges of lakes decayed.[20]

2.7.3 Physical and Chemical Characteristics of the Kankakee River

The Station's source of cooling water is the Kankakee River. Compared to the Illinois River, the Kankakee is a relatively small river. with

TABLE 2.4. Relative Abundance of Fish Collected in the Illinois River near Dresden Nuclear Power Station in 1971

Scientific Name	Common Name	Sampling Station	
		D-5[a]	D-7[b]
Dorosoma cepedianum	Gizzard shad	-	2.7[c]
Moxostoma erythrurum	Golden redhorse	-	0.2
Cyprinus carpio	Carp	-	1.3
Carassius auratus	Goldfish	1.6[c]	2.7
Campostoma anomalum	Stoneroller	-	0.2
Pimephales vigilax	Bullhead minnow	3.3	0.7
Pimephales notatus	Bluntnose minnow	-	12.6
Notropis blennius	River shiner	-	1.3
Notropis cornutus	Common shiner	-	2.0
Notropis lutrensis	Red shiner	-	4.1
Notropis stramineus	Sand shiner	4.9	-
Notropis atherinoides	Emerald shiner	90.2	69.2
Ictalurus punctatus	Channel catfish	-	1.1
Ambloplites rupestris	Rock bass	-	0.5
Lepomis cyanellus	Green sunfish	-	0.7
Lepomis humilis	Orangespotted sunfish	-	0.7

From B. G. Johnson and L. P. Beer, "Environmental Monitoring (thermal) of the Des Plaines, Kankakee, and Illinois Rivers near Dresden Nuclear Power Station," Industrial Bio-Test Laboratories, Inc., 1972.

[a]About 0.2 mile above plant discharge.

[b]About 0.2 mile below plant discharge.

[c]Units - Percentage of total number collected for three sampling periods.

TABLE 2.5. Waterfowl in the Illinois River Valley

Species	1954 Census	1964 Census
Lesser scaup (*Aythya affinis*)	∿1.5 million	<100,000
Ringneck (*Aythya collaris*)	>300,000	<60,000
Canvasback (*Aythya vallisineria*)	∿150,000	∿10,000
Ruddy duck (*Oxyura jamaicensis*)	>36,000	∿12,000
Mallard (*Anas platyrhynchos*)	>3.6 million	∿3 million

From H. B. Mills et al., "Man's Effect on the Fish and Wildlife of the Illinois River," Illinois Natural History Survey Biological Notes No. 57, Natural History Survey Division: Dept. of Registration and Education, State of Illinois.

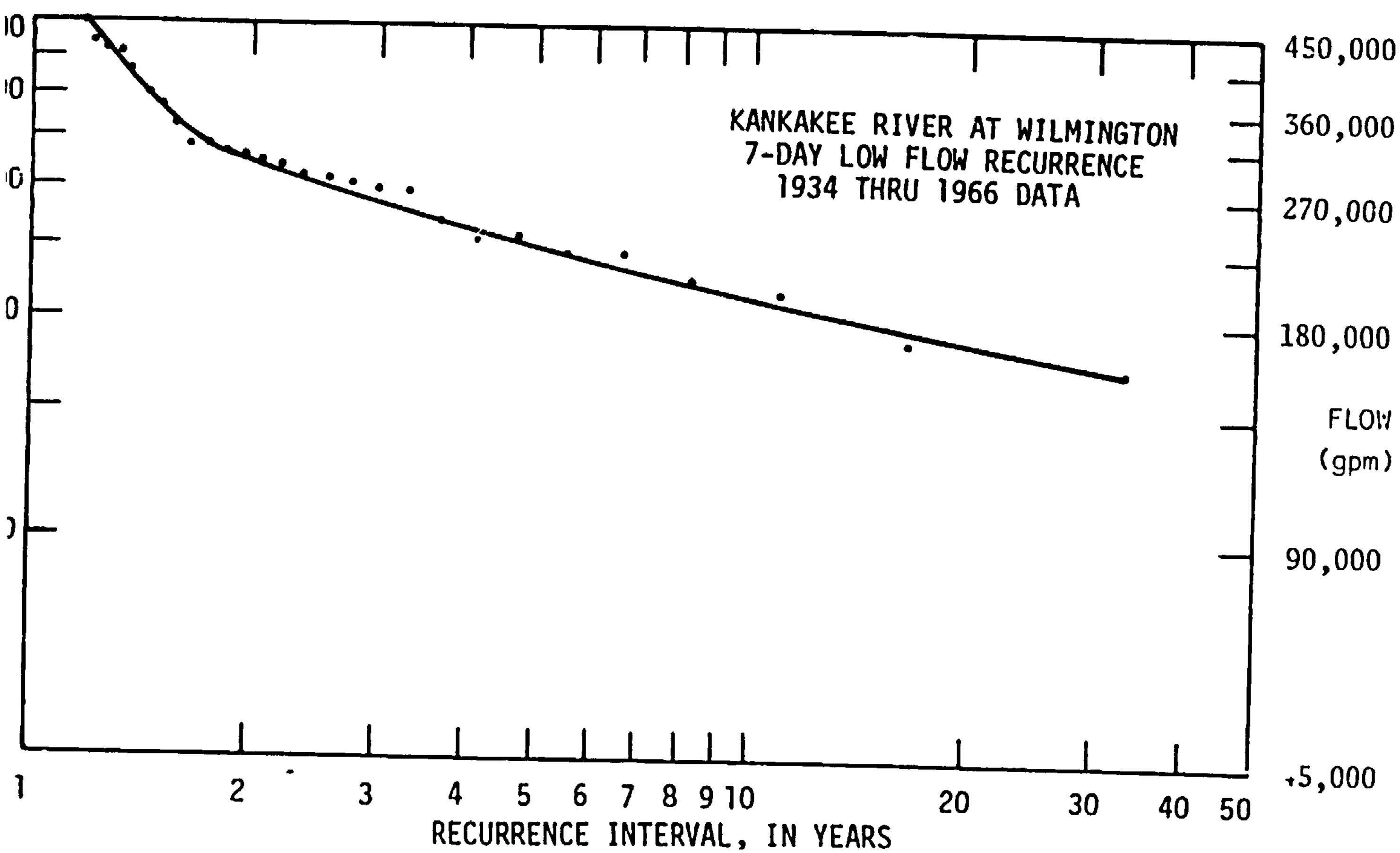


Fig. 2.11. Recurrence Interval foı Seven-Day Low Flow for the Kankakee River at Wilmington, Illinois. From "A Water Quality Investigation of the Upper Illinois Waterway," Preliminary Report, Water Quality Section, Illinois State Water Survey, July 1972.

The Kankakee is usually several degrees cooler than the Illinois (see Table 2.6), and is not disturbed by barge traffic or dredging, as is the Illinois. These are probably the major factors for the existence of a more diverse fish population in the Kankakee than in the Illinois. Water quality of the Kankakee is not spectacularly better than that of the Illinois, and in some aspects is even poorer (compare Table 2.6 with Table 2.3), based on data for the particular sampling station on the Kankakee (Route 66 bridge).

2.7.4 Biota of the Kankakee River

Shoreline seining by Industrial Bio-Test Laboratories[26] near the Dresden Power Station intake canal on the Kankakee River in 1971 indicated that at least 18 species of fish are present in this section of the river (see Table 2.7). The same study[26] indicated that the benthic population at this site was composed primarily of mayfly nymphs (*Hexagenia*), chironomids (*Procladius*), and tubificid worms.

Analysis of the stomach contents of fish from the Kankakee River[26] indicated that water boatmen (Corixidae) and midges (Chironomidae) were important food for young smallmouth bass. Chironomids were also important to young green sunfish.

Phytoplankton analysis[26] in the Kankakee River near the Dresden site showed that diatoms (predominantly *Stephanodiscus* and *Cyclotella*) made up to 89 percent of the phytoplankton, green algae made up 4 to 75 percent, and blue-green algae 0.1 to 19 percent, depending on the year and season the samplings were made. Sampling technique may have also been a factor in the wide variations observed. Detailed lists of phytoplankton species can be found in Reference 26. Abundances of phytoplankton are indicated in Figs. C.3–C.7, Appendix C.

Of the periphyton species found on natural substrates in 1971 at the Kankakee River sampling site,[26] diatoms appeared to predominate, primarily *Navicula* and *Nitzschia*. Lists of periphyton species may be found in Reference 26.

Data on zooplankton in the Kankakee River near Dresden are listed in Table C.3 of Appendix C.

2.7.5 Terrestrial

a. General

In the environs of the Station, it is difficult to define any land that has not been disturbed by man's activities. In hope of preserving some small portion of the "original" Illinois prairie, the Illinois Nature Preserves Commission set aside [illegible]

TABLE 2.6 Characteristics of the Kankakee River at the Rt. 66 Bridge, 1971

Parameter[a]	1971 Range	1971 Average	1958-1971 Range	1958-1971 Average
Temperature, °F	32-78	55	32-86	57
Turbidity, JTU	7-400	121	1-400	58
Dissolved oxygen, mg/l	5.4-13.4	10.7	5.4-14.6	10.1
Biochemical oxygen demand, mg/l			1-30	3
Chemical oxygen demand, mg/l	6-162	42	5-162	17
Alkalinity, mg/l as $CaCO_3$	130-130	130	116-220	178
Hardness, mg/l as $CaCO_3$			116-576	308
Total dissolved solids, mg/l	170-525	336	170-530	362
Chloride, mg/l	25-25	25	9-56	21
Sulfate, mg/l	100-100	100	20-152	78
Nitrate, mg/l as NO_3	1-6	2	0-24	6
Ammonia, mg/l as N	0.3-10.1	2.8	0-10.1	1.0
Orthophosphate, mg/l as PO_4			0.9-0.9	0.9
Total P, mg/l as PO_4	0.24	0.8	0.0-10.0	1.1
pH	7.1-8.8	8.1	7.1-8.8	7.9
Methylene blue active substances, mg/l	1.1-2.0	1.4	0.0-2.4	0.5
Fluoride, mg/l			0.0-0.4	0.2
Iron, mg/l			0.0-12.0	1.1
Coliform/100 ml	10-30,000	4120	10-260,000	13,601
Fecal coli/100	10-110	45	10-800,000	31,848

Compiled from Water Quality Network 1971. Summary of Data, Vol. 1, Environmental Protection Agency, State of Illinois.

TABLE 2.7. Relative Abundance of Fish Collected from the Kankakee River near the Dresden Nuclear Power Station Intake Canal in 1971

Scientific Name	Common Name	Relative Abundance
Lepisosteus osseus	Longnose gar	0.8[a]
Dorosoma cepedianum	Gizzard shad	3.4
Carpoides carpio	River carpsucker	0.8
Cyprinus carpio	Carp	0.3
Carassius auratus	Goldfish	0.3
Hybopsis micropogon	River chub	0.3
Pimephales vigilax	Bullhead minnow	6.9
Pimephales notatus	Bluntnose minnow	27.1
Notropis blennius	River shiner	0.8
Notropis atherinoides	Emerald shiner	9.2
Ictalurus punctatus	Channel catfish	0.3
Labidesthes sicculus	Brook silverside	4.2
Percina caprodes	Logperch	0.3
Ambloplites rupestris	Rock bass	1.2
Lepomis cyanellus	Green sunfish	36.7
Lepomis humilis	Orangespotted sunfish	0.8
Pomoxis nigromaculatus	Black crappie	0.8
Micropterus dolomieui	Smallmouth bass	5.8

From "Environmental [illegible]

the fact that the Preserve is composed of a variety of natural habitats with diverse vegetation (more than 350 species) and wildlife, and represents one of the largest public-owned tall grass prairie stands in the nation,[27] demands that the area be protected from further destructive effects of man. The ecological survey presented below describes the present state of the Preserve. This is necessary to establish a baseline for future evaluation of the effects of the Dresden Power Plant.

b. Goose Lake Prairie Nature Preserve

John Schwegman of the Illinois Nature Preserves Commission has described the Preserve[28] and much of the material presented here is taken from his work.

Geology and soils. The topography of the Preserve is flat to gently rolling, and is apparently related to bedrock topography. The glacial till which once covered the area was replaced with a gravelly alluvium by channels of the Illinois River, except at elevations above 520 feet. Occasional floods removed the till at these higher levels, leaving exposed boulders which have remained to the present. Most of the till and alluvium of the Preserve is underlain by limestone and fireclay (Pottsville formation), limestone and shale (Maquoketa formation) and dolomite (Galena-Platteville formation). The soils vary in texture from silt loams to clay loams, ranging in depth from 4.5 feet to less than 2 feet.

Vegetation. Several types of plant communities (through which most of the animal life apparently moves freely) are found in the Preserve:

Open water and marshes. Goose Lake was drained around 1920, but several acres of open water areas presently exist. Fish are generally not found in these waters, probably due to the shallowness of the water. In one of the sloughs, however, central mudminnows, golden shiner, and fathead minnows were collected.[29] The Goose Lake marshes are examples of the pot holes once common on the Illinois Prairie. They appear to be relatively undisturbed and are dominated by four species of wetland plants: river bulrush, cattail, great bulrush, and reed.

Wet prairie, widespread in the area, is dominated by cord grass and sedges, with blue-joint grass being common.

Tall grass prairie is dominated by big bluestem, with Indian grass and switch grass also present. Goldenrod, wild rose, and sunflower are common. Invasion by hawthorns has been taken as evidence of a past history of grazing. Although the area was probably plowed more than 30 years ago, prairie seems to have reclaimed the area.

Short grass prairie, consisting of one large stand and several smaller areas, is dominated by little bluestem and Indian grass. Common forbs are goldenrod, cinquefoil, and bush clover.

Dry prairie, although largely eliminated from the area due to cattle grazing, can be found, particularly on the south-facing slopes of the bedrock scarp in the southeastern section of the Preserve. The community contains shrubs such as hazelnut and New Jersey tea. Bush clover, aster, and bee balm are present. Kentucky bluegrass has overrun some of the areas where natural vegetation was destroyed by cattle.

Disturbance communities (areas that have been cultivated and allowed to return to prairie) are dominated by switch grass, with Indian grass also common.

A list of vascular plants in the Preserve, compiled by the Illinois State Nature Preserve Commission, can be found in Reference 28.

Wildlife. Goose Lake Prairie and its marshes are a haven for birdlife. Over a hundred species have been observed. Migratory ducks and geese rest and feed in the area. Red-winged blackbirds, sparrows, marsh wrens and mockingbirds, among others, nest in the Preserve. It has been suggested that prairie chickens be introduced.[28]

Deer, rabbit, muskrat, and small rodents are locally abundant. Pocket gopher and mole are found in the better-drained areas. Badger, woodchuck, and ground squirrel are present and may increase in numbers with time under the protection of the Preserve.[28]

Data are not yet available from a survey of insects being carried out by the State Natural History Survey Division, but studies on the Collins Power Plant site, adjacent to the Preserve, have indicated that dragonflies, beetles, butterfiles, and bees, among others, are present in and around the Preserve.[30]

Frogs, salamanders, and garter snakes have also been found in the Preserve and adjacent areas.

Lists of the fauna observed in the area may be found in References 28 and 30.

2.7.6 Dresden Cooling Lake

The 1275-acre Dresden cooling lake became operational in October 1971, and is connected to the Station by parallel intake and discharge canals (see Fig. 2.12). The lake consists of five pools. The physical details of the lake are described in Section 3.4.

A preliminary survey[31] of the biota in the lake after about one year of operation indicated that at least 13 species of fish were present (see Table C.4 of Appendix C). The presence of these fish would infer that a proportion of the fish eggs, larvae and fry that are entrained in the intake water from the Kankakee and Des Plaines Rivers survive condenser passage and establish themselves in the lake.

Results of phytoplankton sampling are given in Table C.5 of Appendix C. Diatoms comprised 95% of the phytoplankton community in August 1972, with *Cyclotella meneghiana* predominating (60%). Zooplankton sampling indicated that rotifers were the most numerous, with *Branchionus* sp.

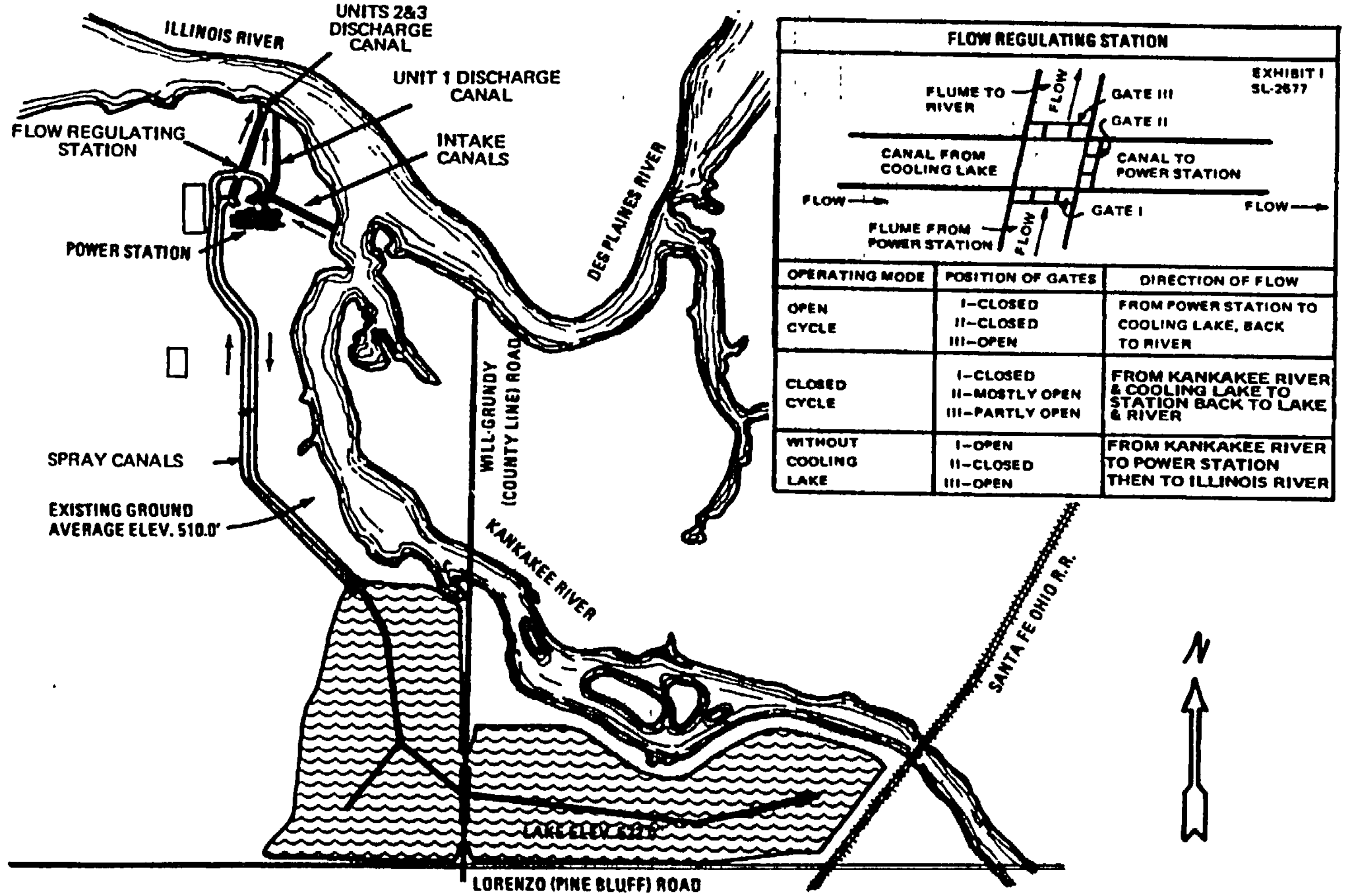


Fig. 2.12. Dresden Station Showing Cooling Water Intake, Spray Canals, Cooling Lake and Discharge Canal. From Applicant's Environmental Report, Supplement II, Fig. 2.2 (modified by Staff).

predominating.[31] The abundance of zooplankton was about 20% higher in the coolest pool of the lake than in the warmest.[31] Results of zooplankton sampling are given in Table C.6 of Appendix C.

Benthic sampling along pool transects with a Ponar dredge brought up dipteran larvae and oligochaetes (worms). Interpool differences in substrate types were noted.[31]

On occasion, waterfowl have been observed on the lake surface, but little aquatic vegetation is apparent. When the water level in the lake dropped following a break in the dike, silt deposits were noted on the lake bottom.

2.7.7 Summary

The Illinois River with its tributaries, bottomland lakes and marshes, was once vibrant with plants, fish, and waterfowl. Due largely to man's use of the river as a navigation channel and as a sewer for his domestic and industrial waste, life other than phytoplankton, a few benthic organisms and rough fish has all but disappeared. Reclassification of this river from an "industrial water supply sector" to a "public and food processing water supply" waterway should promote the reclamation of the river and its resources (see Section 2.2).

The land in the vicinity of the Station had been mainly used for agriculture and strip mining. A trend toward industrial use is presently occurring. A few wild areas remain, the largest of which is the Goose Lake Nature Preserve. Although this natural prairie has undoubtedly been influenced by man's activities, diverse wildlife and vegetation do exist.

The cooling lake constructed by the Applicant in 1971 and filled with water from the Kankakee River presently supports species of phytoplankton (predominantly diatoms), zooplankton (mainly rotifers), and about a dozen species of fish. Discharges from this body of water are inputs to the ecosystem in the Dresden Pool of the Illinois River.

2.8 NATURAL RADIATION BACKGROUND

The background radiology of the region is unremarkable, consonant with its position in the north-central Great Plains. Cosmic, terrestrial, and total backgrounds (45, 65, and 135 mrem/yr respectively) are very close to the averages of the United States as a whole (45, 60, and 130 mrem/yr respectively).[32] In addition, the area immediately surrounding the Station possesses a cosmic plus terrestrial component about 10 mrem/yr less than that of the state as a whole, so that it is slightly below the United States average.[33] Medical background is about 70 mrem/yr for the state and, again, slightly less in the immediate area so that the overall medical and natural background is slightly below United States average.[33,34]

Some 30 state and federal monitoring stations have been active within 300 km of the Station for the last two decades, as well as some quite intensive monitoring in the immediate vicinity of the Station for the past decade.[33,34] Thus, a considerable backlog of data is available.

Values reported for recent years by some of the major stations are summarized in Table 2.8. These regional stations have monitored not only the Illinois River but also surface, rain, ground and tap/well waters of the region, as well as milk, dietary, and atmospheric concentrations, and a large number of trophic and transfer chains in the local biota. This large reservoir of available information easily provides an adequate baseline against which to measure present and future plant impact.

TABLE 2.8 Radiological Monitoring Stations in the Midwest Area of the United States

	Distance from Station	Sample Type[a]	Sample Year	Analysis	Range[a]	Mean[a]
Burlington, Iowa (Mississippi River)	150 miles SW	SW	Jan.-Oct. 1971	Gross beta, diss	3-12	8
				Gross beta, susp	<1-21	7
				Gross alpha, diss	<0.2-2	1
				Gross alpha, susp	<0.2-6	1
Chicago, Illinois	50 miles NE	DA	Jan.-Oct. 1971	Sr-90	5-10	8
				Cs-137	0	0
		PM	July-Jan. 1969-1972	Sr-90	5-11	7
Indianapolis, Indiana	220 miles SE	PM	July-Jan. 1969-1972	Sr-90	6-10	8
		SA	July-Feb. 1969-1972	Gross beta	0-5	1
Iowa, City Iowa	170 miles W	PM	July-Jan. 1969-1972	Sr-90	4-10	8
		SA	July-Feb. 1969-1972	Gross beta	0-7	1
		P	" "	Gross beta	0-32,000	2,000
		TW	Jan.-Dec. 1971	Tritium	500-900	600
Lemont-Argonne, Illinois	30 miles NE	TW	July-Aug. 1968	Gross beta	23-47	20
			Jan.-Feb. 1969-1971	Gross alpha	5-38	8
Madison, Wisconsin	140 miles NNW	SA	July-Feb. 1969-1972	Gross beta	0-4	1
		P	" "	Gross beta	1-24	8
Milwaukee, Wisconsin	120 miles NNE	PM	July-Jan. 1969-1972	Sr-90	5-10	6
Moline, Illinois (Mississippi River)	110 miles W	SW	Oct.-Dec. 1970-1971	Tritium	0-500	100
		TW	1967 & 1970	Gross beta, diss	8-9	8
				Gross beta, susp	0-9	4
				Gross alpha, diss	0	0
				Gross alpha, susp	0	0
Morris, Illinois	5 miles WSW	TW	Oct.-Dec. 1970-1971	Tritium	0-600	125
St. Louis Missouri	215 miles SW	DA	July-Oct. 1969-1971	Sr-90	5-14	7
				Cs-137	0-14	0
		PM	Nov.-Jan. 1970-1972	Sr-90	0-8	6
South Haven, Michigan	170 miles NE	PM	July-Jan. 1969-1972	Sr-90	5-8	7

[a]DA = Diet analysis, pCi/kg
PM = Pasteurized milk, pCi/l
SA = Surface air, pCi/m^3
P = Precipitation, pCi/m^2/month
SW = Surface water, pCi/l
TW = Tap water, gross beta, gross alpha, and/or tritium, pCi/l

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3. THE STATION

3.1 EXTERNAL APPEARANCE

The external appearance of the Dresden Station is similar to other boiling water reactor power stations except for the presence of the hemispherically shaped building which houses the Dresden 1 reactor and the two spray canals which run from the west side of the Station to the cooling lake located approximately 5000 feet south and 1500 feet east of the Station. The principal buildings[1] of the Station are shown in Figs. 3.1 and 3.2.

The Reactor Building, Turbine Building, and Radwaste Building are each shared by Units 2 and 3. Other structures and facilities[1] that are shared by Units 2 and 3 and sometimes Unit 1 are:

- The administration building.
- The access control building.
- A 310-foot chimney (Units 2 and 3 only).
- The reactor building ventilation stack (Units 2 and 3 only).
- The liquid radioactive waste control facilities (Units 2 and 3 only).
- The cooling water intake building (crib house), including screen wash refuse pit (Units 2 and 3 only).
- The off-gas filter building (Units 2 and 3 only).
- A 400-foot meteorological tower.
- The diesel generator building (Units 2 and 3 only).
- The warehouse building.
- The liquid waste and condensate storage tanks.
- The electric switchyards and transmission facilities.
- A 100-foot chimney for two oil-fired steam heating boilers. (Units 2 and 3 only).

A 350-foot microwave tower owned by Illinois Bell Telephone Company is located on the site approximately 1000 feet southwest of the reactor building but is totally unrelated to the Station operation.[2]

The major visual features of the Station are the buildings, transmission lines, spray canals (with their fountain-like spray modules), and the cooling lake, which is visible only intermittently from the Lorenzo

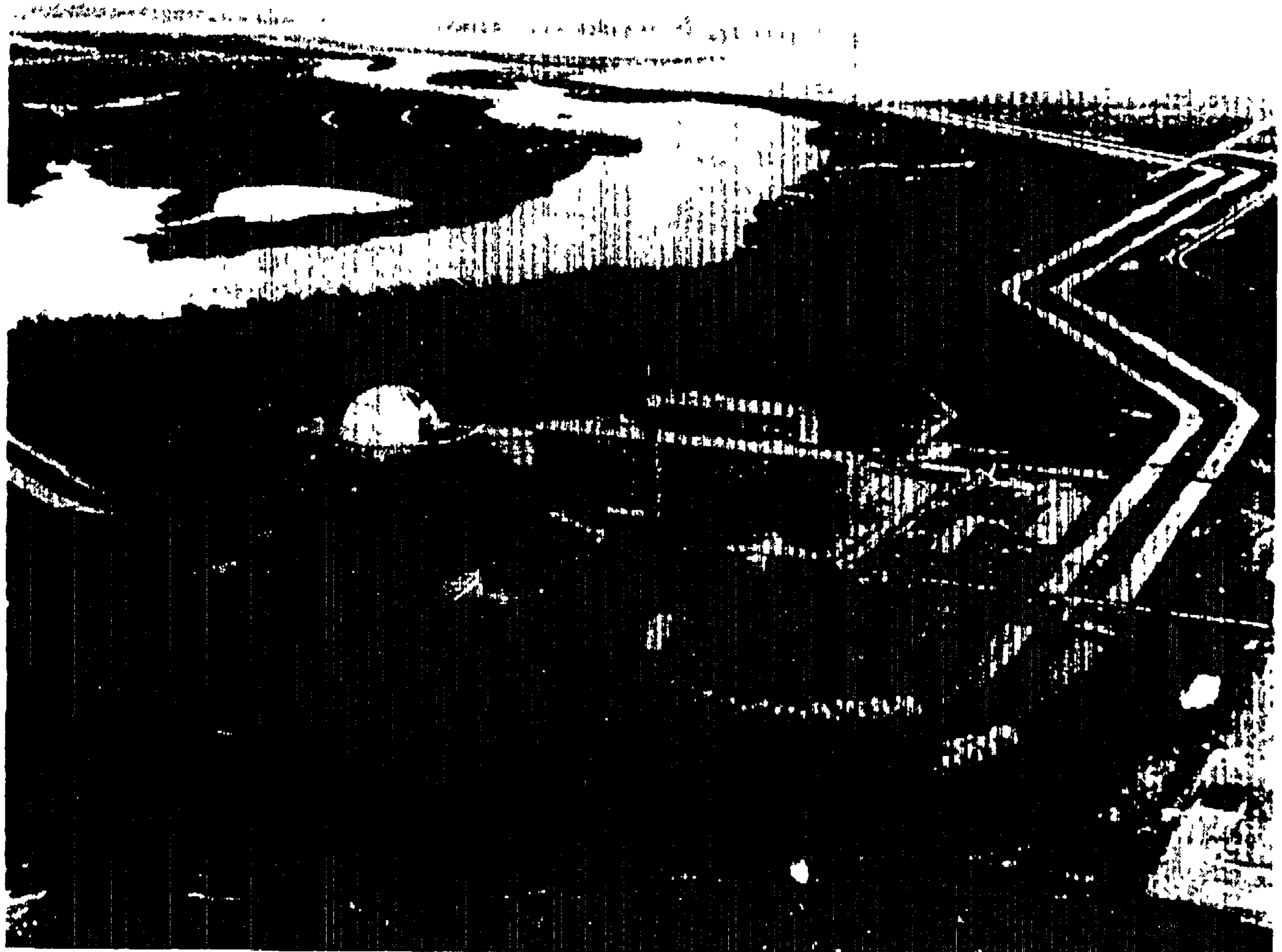


Fig. 3.1. Aerial View of the Dresden Nuclear Station looking SSE.

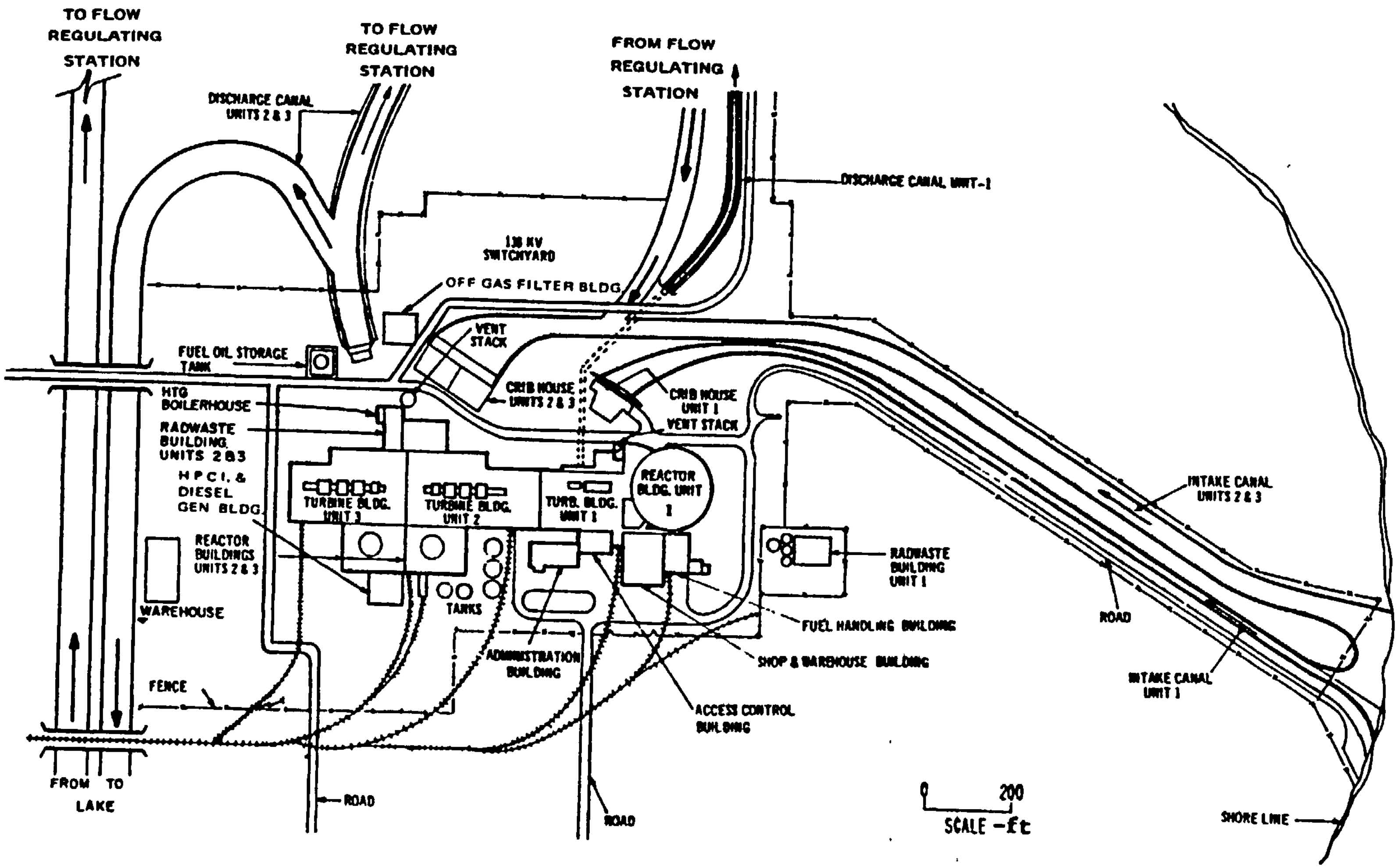


Fig. 3.2. Plot Plan of the Dresden Nuclear Station. From the Applicant's Safety Analysis Report (modified by Staff).

(Pine Bluff) Road south of the cooling lake and the County Line (Will-Grundy) Road, which crosses the lake from south to north.

The topography of the site and the environs south of the Illinois River is relatively flat with elevations varying from 509 to 526 feet.[3] The cooling lake (elev. 522'-0") has a surface area of approximately 1275 acres and cost $23,000,000.[4] The perimeter of the cooling lake, except for approximately 5000 feet at the southeast corner is retained by an earthen dike having a top elevation of 527'-0".[3] Figure 3.3 is a photograph of a section of the approximately 35,000-foot long dike[5] as it appears from the road at the intersection of Lorenzo Road and Dresden (Pequot) Road. This is a typical view from the surrounding area since the lake is completely hidden from direct view at most off-site locations. Figure 3.4 is a photograph of the cooling lake as it appears from its southeast corner, which is part of the approximate 5000-foot natural shoreline.[5]

3.2 REACTOR, STEAM ELECTRIC SYSTEM, AND FUEL INVENTORY[6]

The Dresden Units 2 and 3 each utilize a single-cycle, forced circulation boiling water reactor (BWR) supplied by General Electric Company. Each reactor produces saturated steam for direct use in a separate steam turbine-generator unit. The capacity of each reactor is 2527 megawatts thermal (MWt). The steam turbine-generator units convert a portion of the thermal energy of the steam into electrical energy. Each unit is designed for a gross electrical output of 850 million watts electrical (MWe). The net electrical output per unit is 809 MWe.

Each reactor contains 724 fuel assemblies, each with a 7 x 7 fuel rod array. The fuel rods, which use Zircaloy-2 as the cladding material, contain UO_2 fuel pellets. The total weight of UO_2 per fuel assembly is 492.5 pounds. Thus each reactor contains approximately 175 tons of UO_2 fuel. The Unit 1 reactor contains approximately 62 tons of UO_2 fuel. The total fuel inventory on site is variable and depends on the amount of unconsumed fuel in the reactors, the numbers of spare fuel rods or assemblies on hand, and the amount of spent fuel which is still on site and awaiting fuel reprocessing.

3.3 PLANT WATER USAGE

A diagram of the water usage at the Station is given in Fig. 3.5. The quantities shown are the long-term averages and may be exceeded by as much as 20% for relatively brief periods. The major water use is condenser cooling. The water is drawn from two intakes located side by side in the Kankakee River and discharged through two outlets located side by side in the Illinois River. The smaller of these parallel systems is used for once-through cooling of the Unit 1 condenser; the other serves Units 2 and 3. Under the present mode of operation, which is indicated by the solid lines in Fig. 3.5, the cooling water for Units 2 and 3, after passage through the condensers, is pumped through the spray canals and the cooling lake with about a 2-1/2-day passage time and is discharged

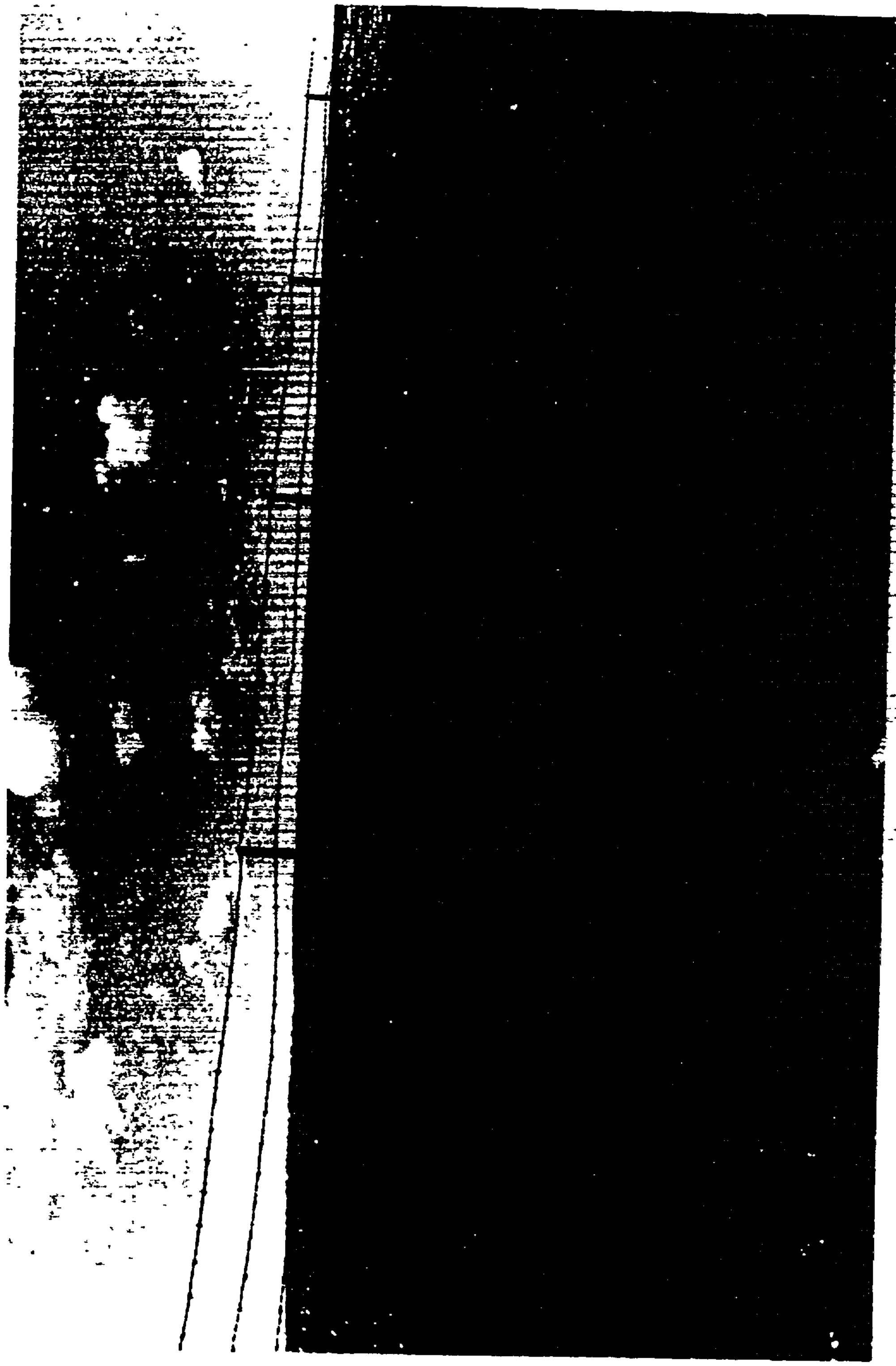


Fig. 3.3. View of the Dike from the Road.

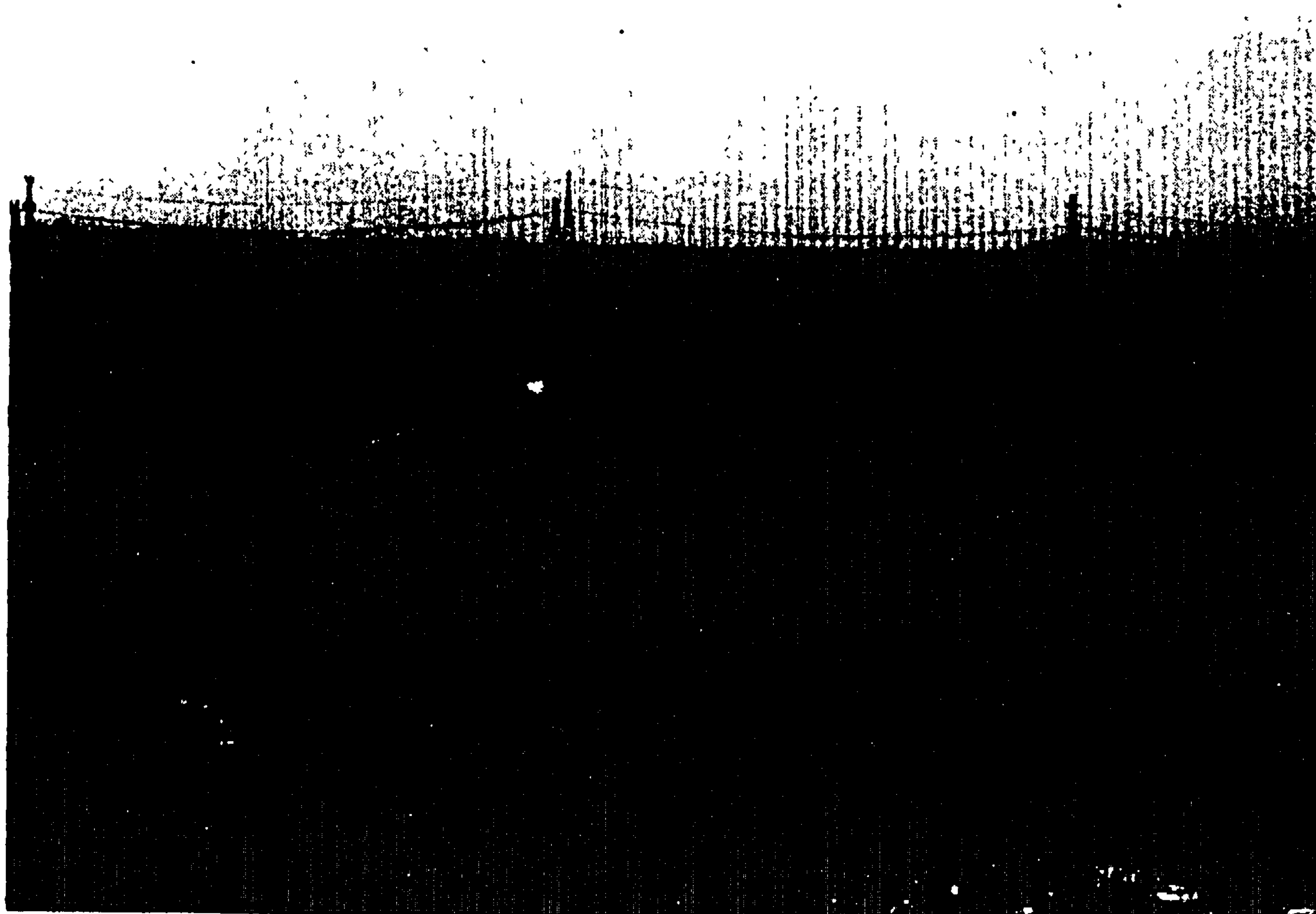


Fig. 3.4. View of the Dresden Cooling Lake from the Natural Shoreline.

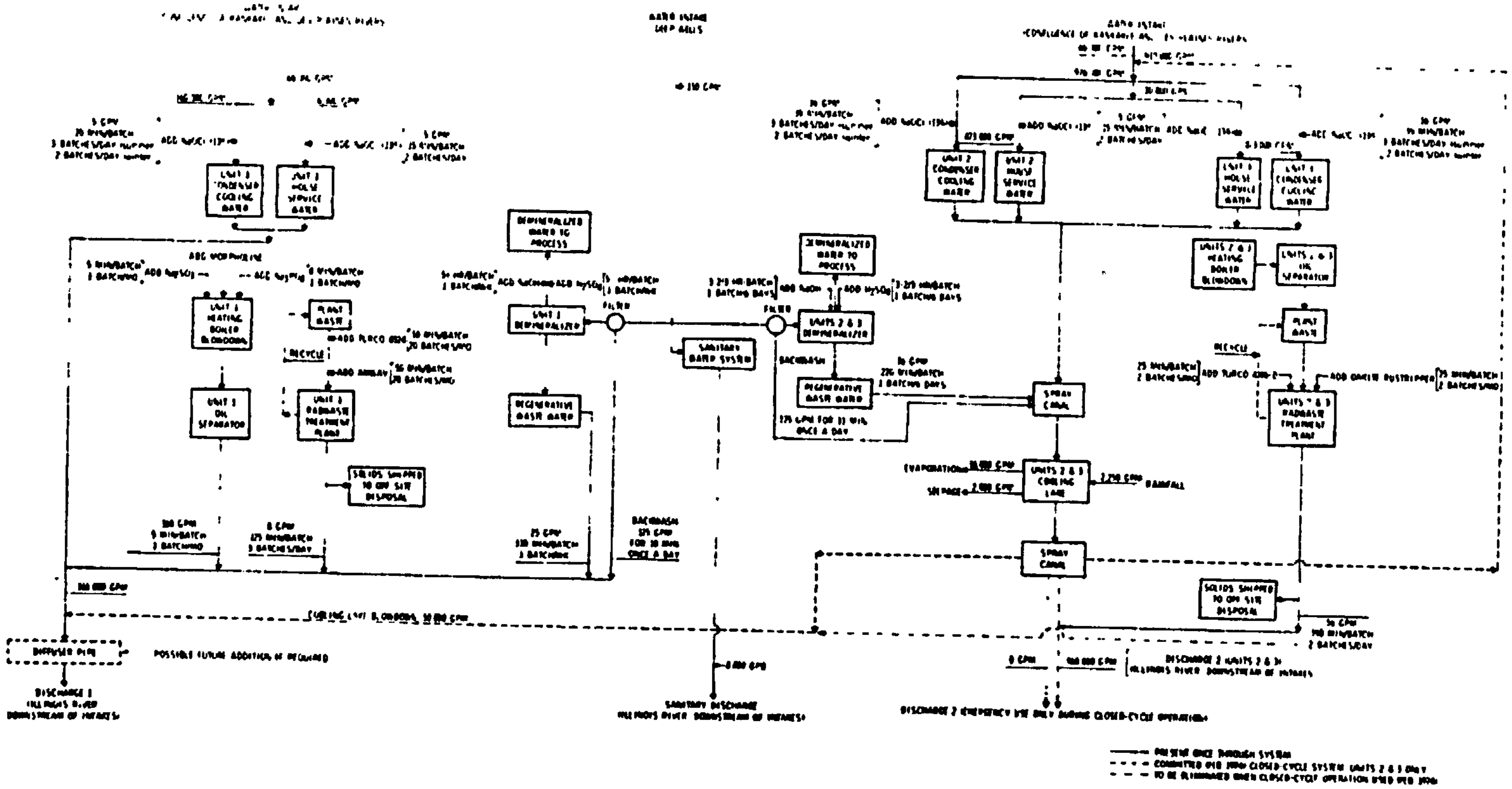


Fig. 3.5. Dresden Water Use Diagram

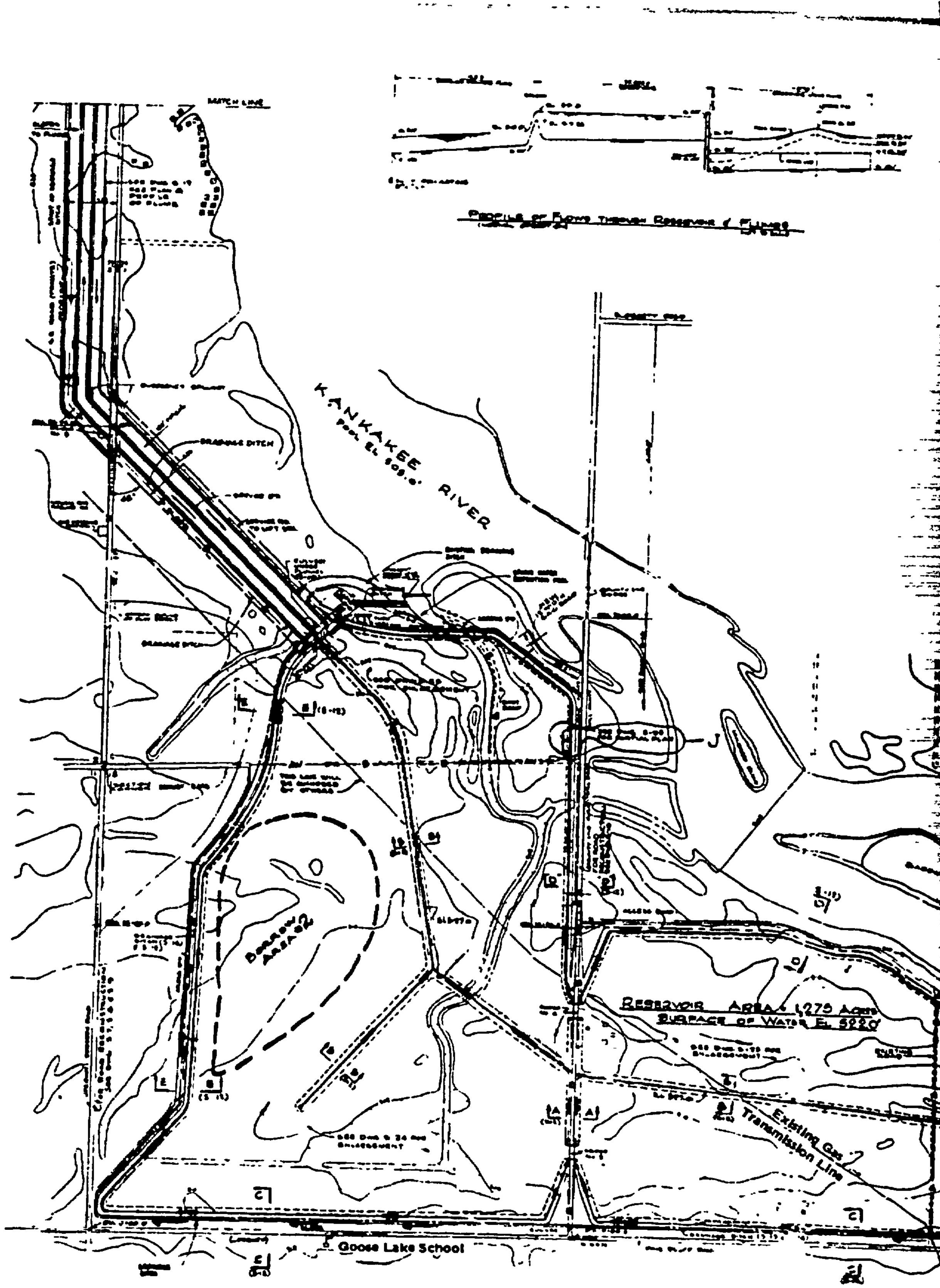


FIG. 3.8 DRESDEN COOLING LAKE DETA

to the Illinois River. In 1974, when the new radwaste system is completed, the Applicant will commence closed-cycle operation in which the cooling water will be drawn from the lake and only makeup water, ~66,000 gpm (long-term average), will be drawn from the Kankakee River; an average blowdown of about 50,000 gpm will be discharged into the Illinois River via the Unit 1 discharge canal.[7] This mode of operation is indicated by the dashed lines in Fig. 3.5. During closed-cycle operation the maximum rate of withdrawal of water from the Kankakee River for use in Units 2 and 3 will be about 70,000 gpm, which is 4.1% of the average flow, 36% of the seven-day low flow (10-year recurrence interval), and 76% of the lowest flow of record for the Kankakee River. This withdrawal will be in addition to the Dresden 1 withdrawal of approximately 166,000 gpm, which is 10.3% of the average flow, 86% of the seven-day (10-year recurrence interval) low flow, and 181% of the lowest flow of record for the Kankakee River when there will be a backflow of DesPlaines River water into the intake canals.

The Station is served by two wells, each 1500 feet deep, extending into the Cambrian-Ordovician aquifer. The wells, which are used for potable water supply and primary system makeup water, pump an average of 46,000 gallons per day (32 gpm), which is small compared to other withdrawals from the aquifer — about 1.5% of that drawn from the Morris wells (about 3×10^6 gallons per day).[3]

3.4 HEAT DISSIPATION SYSTEM

Each reactor produces 2527 MWt, 850 MW of which is converted into electric power. Thus, approximately two-thirds of the energy produced is waste heat and must be discharged directly to the environment. This waste heat is transferred to the approximately 946,000 gpm of water passing through the condensers. The 11.2×10^9 Btu/hr of waste heat from both units increases the temperature of the condenser cooling water by approximately 23°F.[3]

3.4.1 Cooling Water Intake

Water is withdrawn from the Kankakee River near its junction with the Des Plaines River. The two units share the river water intake canal (approximately 2000 feet long and 50 feet wide) and crib house (Fig. 3.6), which are independent of the river intake canal and crib house of Unit 1 (see Fig. 3.2). Bar racks, located at the entrance to the crib house for Units 2 and 3 and consisting of 1/2-inch by 2-inch bars spaced vertically on 2 1/2-inch centers, are used to prevent large objects such as logs from entering the cooling system. The vertical traveling screens (Fig. 3.7), composed of 3/8-inch mesh, are located immediately ahead of the pumps. These devices prevent most fish and other debris from entering with the cooling water.[3] The maximum design water-intake velocity at the bar racks is 0.6 foot per second and the velocity at the traveling screens is 1.85 feet per second. These velocities will occur under both closed- and open-cycle lake operation since the return flow from the lake is routed into the intake canal during closed-cycle operation. Six condenser-cooling pumps are provided, three for each unit. Each pump has a capacity of ~157,000 gpm.[8] The pumps force the

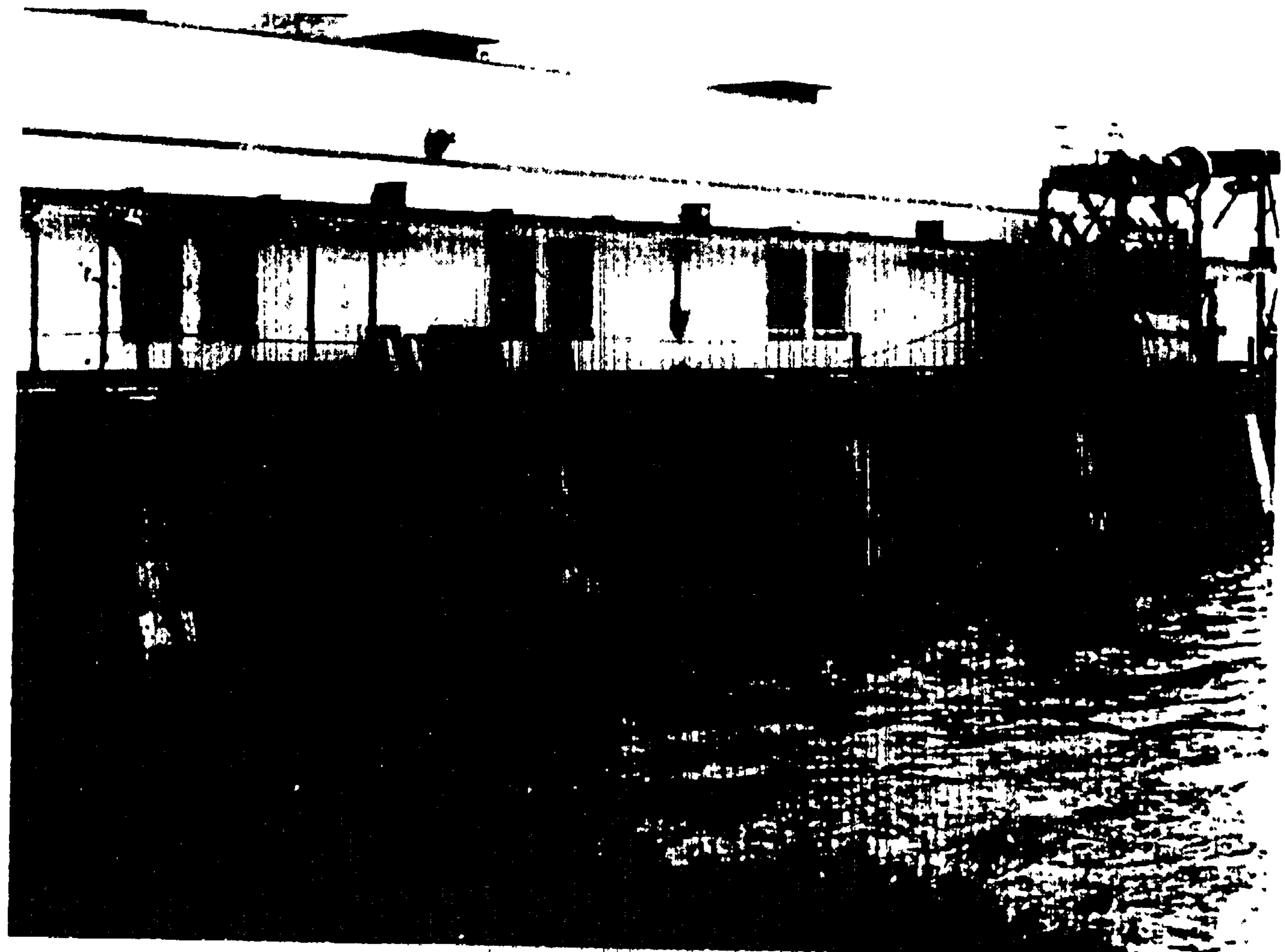


Fig. 3.6. Trash Rack and Crib House for Dresden Units 2 and 3.

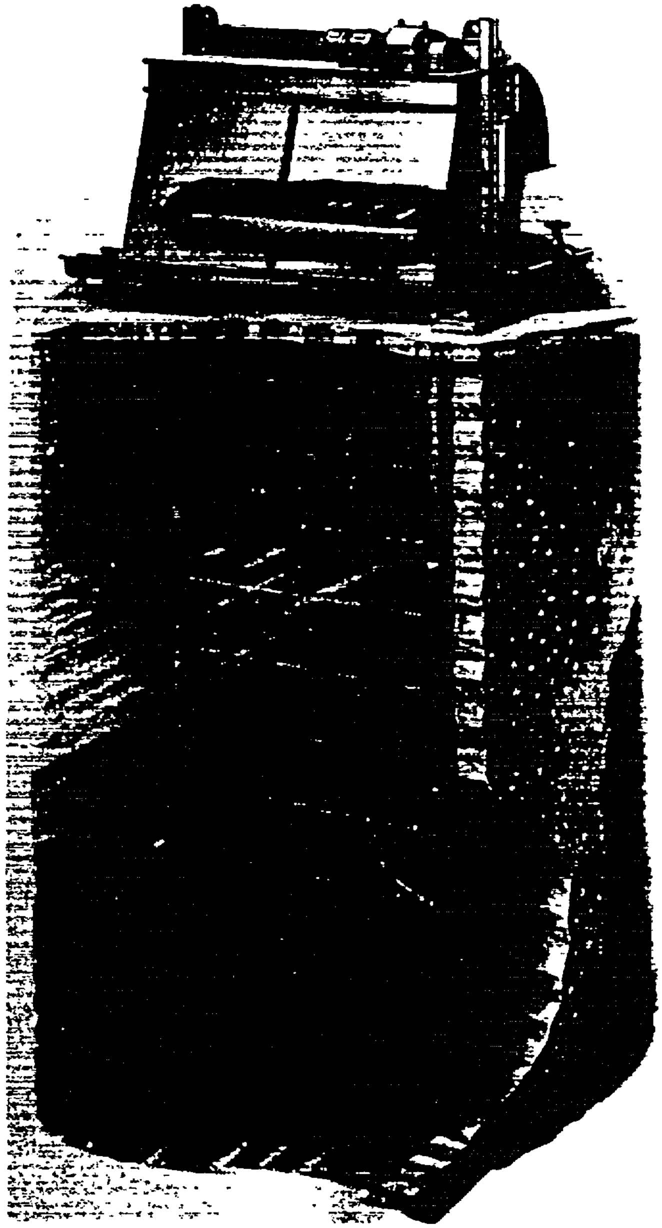


Fig. 3.7. A Traveling Screen of the Type Used for Dresden Units 2 and 3. From the Applicant.

water from the intake canal through the turbine condensers and into the east leg of the cooling canal. The Unit 1 bar rack and traveling screen are similar to those of Units 2 and 3. The flow velocity through both the Unit 1 bar rack and traveling screen is about 0.5 fps.

3.4.2 Original Cooling System

Units 2 and 3 were originally designed for once-through cooling, but on March 5, 1968, the Illinois Sanitary Water Board issued a set of standards (SWB-8)[9] which imposed a 93°F maximum temperature and a 5°F temperature rise limit within an area equivalent to a 600-foot radius circle (26 acres) in the Illinois River. The once-through cooling system could not meet these standards at all times. After studying alternate cooling systems, the Applicant elected to construct a cooling lake.

During design and construction of the lake from June 1971 to October 1971, the Station operated with once-through cooling assisted by the spray canals. The water from the condensers entered the spray canals, bypassed the lake, and emptied directly into the Illinois River. As in the case of the intake flumes, the discharge of Units 2 and 3 was separate from that of Unit 1. Unit 1 has always operated with once-through cooling, and there are no plans to alter this system.

3.4.3 Dresden Cooling Lake

a. General

Sargent and Lundy, Engineers, Inc., the Applicant's architect-engineer, designed the cooling lake. The construction was completed in October 1971. Their studies considered the utilization of the lake in a variety of combinations of open and closed cooling cycles. At that time it was intended that the operation would be open cycle with partial recirculation through the lake and a limited discharge flow to the river.[10,11]

Dikes constructed within the lake (Fig. 3.8) divide it into five pools which induce a clockwise flow maximizing the residence time of the water in the lake. The lake and spray canal systems occupy some 1573 acres of land, with the lake having a surface area of approximately 1275 acres. The average depth of the lake is 10 feet, although there are locations that exceed 20 feet, and it contains approximately four billion gallons of water with a recirculation time of about 2-1/2 days. Figure 3.9 shows sections through the dike at various locations as noted in Fig. 3.8.

The lake is connected to the Unit 2 and 3 condenser discharge flume by a canal which is approximately 8500 feet long and 57 feet wide.[3] A lift station with six 167,000 gpm pumps[8] located between the canal and the lake raises the 976,000 gpm of water approximately 22 feet and discharges it into the lake. The water circulates through the lake in a clockwise direction and returns to the lake discharge adjacent to the lift station where the discharge is controlled by a spillway. The lake discharge water then flows through a second canal which runs parallel to the aforementioned canal and is returned to a point near the Unit 2 and

3 intake. Gate structures in the return canal, intake canal, and river discharge canal are used to regulate the division of flow for recirculation and discharge to the Illinois River.

b. Site Investigation for Cooling Lake[12,13]

Pre-construction investigation consisted of approximately 140 borings made during the initial investigative stage of the project. These borings were made along the alignment of the dikes, the interior of the cooling lake and the canal and lift pump structure. The interior borings were made to define the extent of the borrow areas and the partition dike. Borrow area No. 1 is located in the southeast corner of the cooling lake and area No. 2 in the northwestern corner of the cooling lake (Fig. 3.8). A significant number of the borings were carried down to bedrock. The borings indicated that the bedrock varies over the site from limestone to siltstone and/or sandstone shale. The siltstone and sandstone are the caprock over the limestone formations beneath. The borings indicate that there is significant variation in the elevation of the bedrock formation over the site. This is probably accounted for by the variability of the resistance of the rocks and the erosion forces which have acted on them in their geologic past.

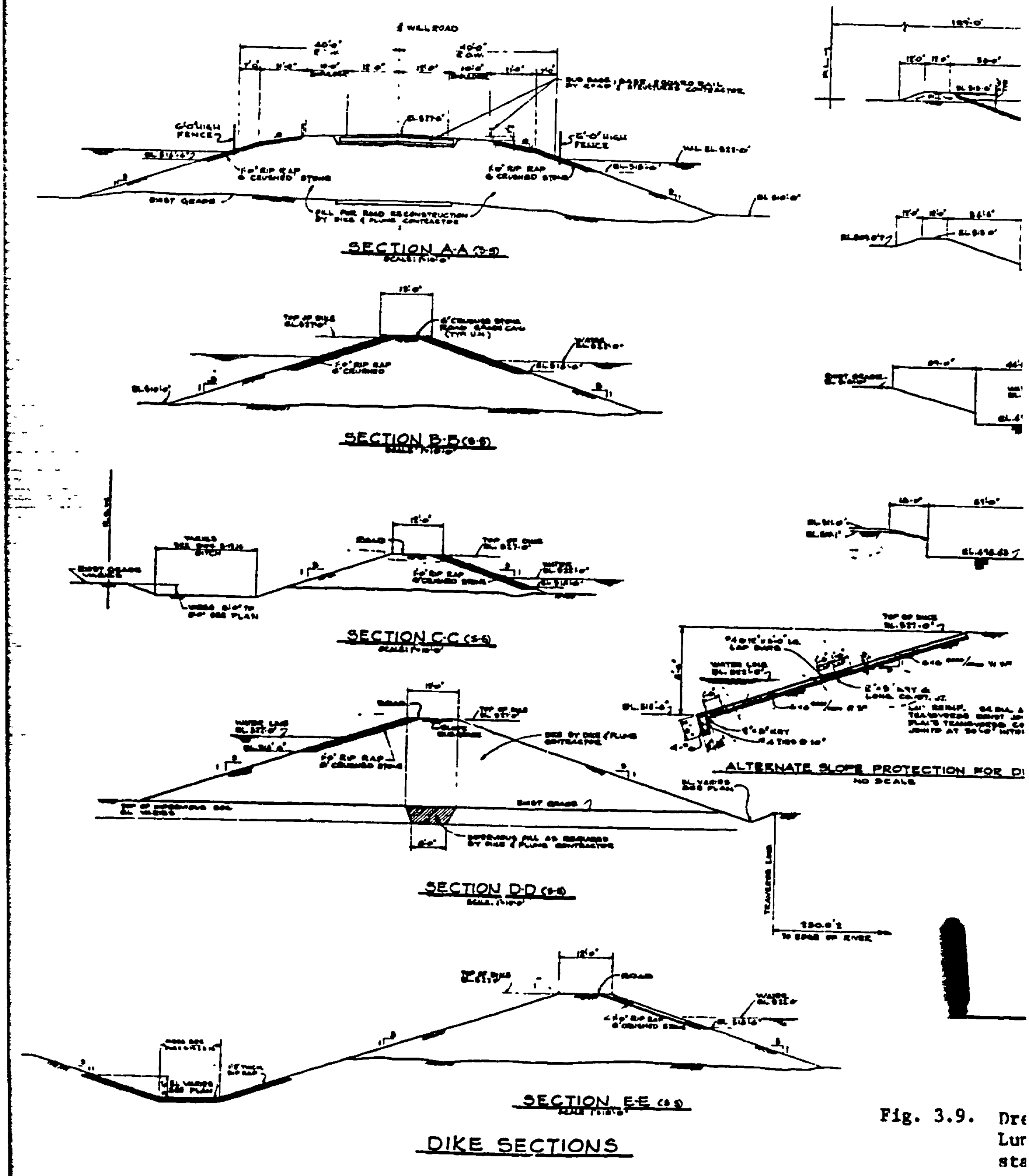
Samples of the foundation material were recovered and unconfined compression tests were run on representative samples of the soil to establish its shearing strength. Many of the borings indicate that there are lenticular deposits of granular soils along the perimeter dike of the cooling lake. The majority of these occur along the northern dikes which follow the bank of the Kankakee River.

c. Dike Construction[12,13]

Foundation preparation for the construction of the dikes required that all top soil, granular soils, and deleterious material be removed before construction of the dikes was started. The material used for construction was required to be silty clay soil which is indigenous to the area. It was determined that the soil removed from the borrow areas varied. Nine prototype soils were used to make the embankment. All of these nine soils were tested in the soils laboratory of R. W. Hunt Company, Engineers, who were responsible for the field control of the compacted dike. The construction specifications required that the soil be deposited in 8-inch loose layers and compacted with suitable compaction equipment so as to attain a minimum compacted density of 95% of modified Proctor density in accordance with ASTM D 1557. Continuous testing of each lift of the compacted embankment material was required during construction. Examination of the QA documentation indicated that this program was carried out.

d. Dike Design[12,13]

The embankment was designed for the licensee by Sargent & Lundy, Inc., Engineers. The design parameters which were used were based upon the unconfined compressive strength of the material used in the embankment construction and the unconfined compressive strength of typical foundation soils. The embankment was proportioned to have a top width of 12 feet



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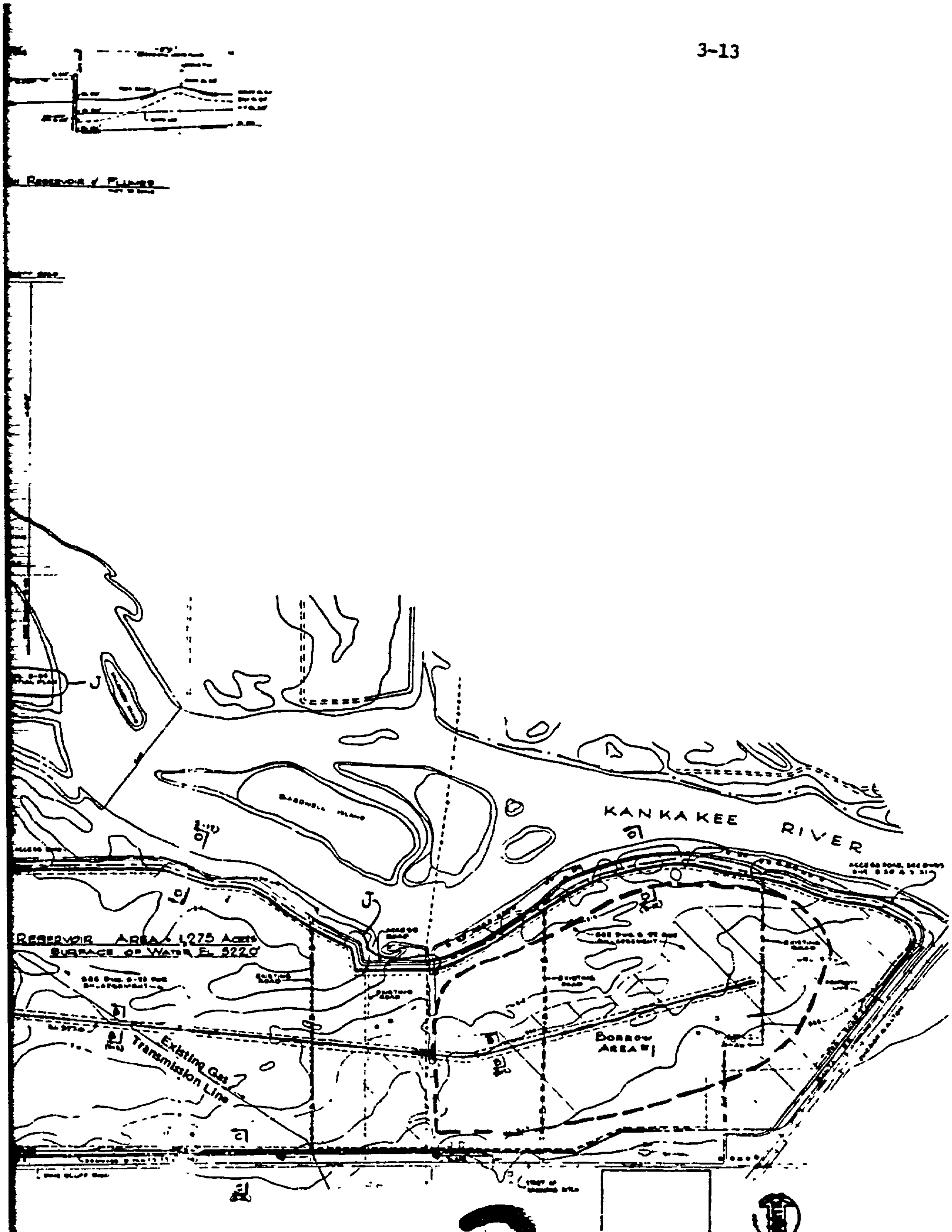

3.8 DRESDEN COOLING LAKE DETAILS.

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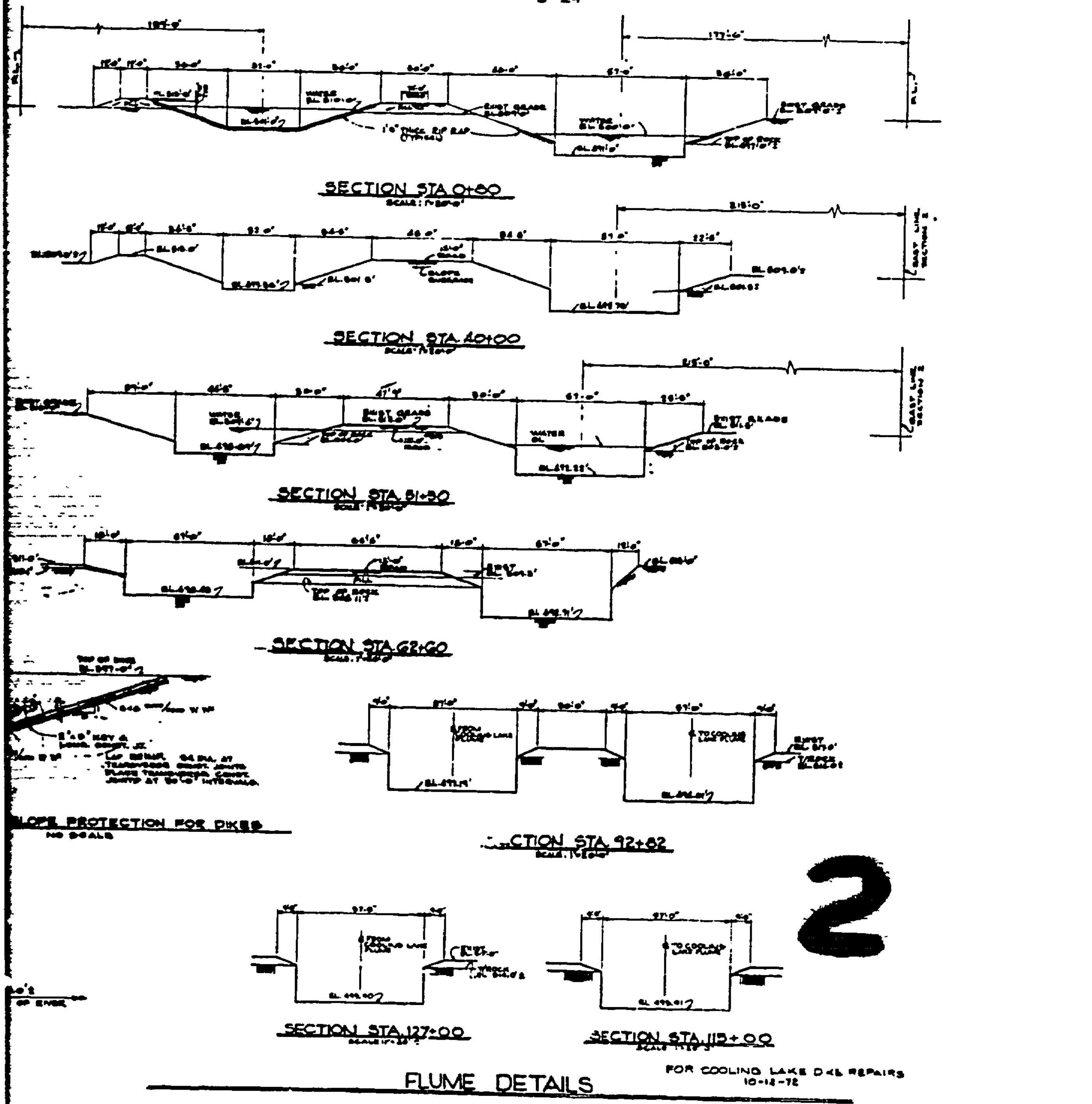

Fig. 3.9. Dresden Dike Section and Flume Details. From Sargent and Lundy, Engineers, Drawing No. S-12 (revised to as-built status).

and side slopes on the inside and outside faces of three (3) horizontal to one (1) vertical with the inside face of the embankment protected by a sound rock riprap 12 inches thick placed on a 6-inch layer of crushed stone which extends from elevation 518'6" to elevation 527'0", the top of the dike. The remaining dike surfaces are planted with grass as protection against erosion.

The initial design assumed that the dikes would encounter two foundation conditions; one being silty clay soil similar to the embankment material and the second being the embankment constructed on a rock foundation. The designs were prepared using the foundation information and the test data taken from the soil borings and the laboratory testing of the soil. The embankments were designed on the basis of a full cooling lake using acceptable analytical techniques.

e. Coal Mine[12,13]

A mid-Nineteenth Century coal mine was discovered beneath the Dresden cooling lake prior to filling. It is located southwest of the intersection of the center dike and the centerline of Grand Road (abandoned). To assess the possible affects of the mine on the lake, Dames and Moore, consultant to the Applicant, drilled 38 core borings to define the extent of the mine. The borings indicated that the mine was oriented in a northeast direction, was about 80 feet wide, and extended at least 600' to the southwest from the center dike. The distance that the mine extends toward the northeast is not known as 3 of the borings drilled along the center dike encountered the mine, and only one boring, which did not penetrate the mine, was drilled to the north.

f. Other Special Design Considerations[12,13]

Other potential hazards to the safety of the dike considered in the design of the cooling lake was the presence of a 36-inch diameter gas line buried 4 feet below original grade of the pond. The gas line passes under the dike in two places. The gas line was excavated and wrapped with a protection coating, and seepage collars were placed on the pipe where the pipe passed under the dike. Concrete weights, weighing approximately 9.7 tons, spaced 30 feet on center were fastened to the submerged section of the gas pipe. The submerged portion of the gas line was hydrostatically tested 8/21-22/70 at a test pressure of 1265 psig, a loss of only 75 psi was experienced in 24 hours, which was well within the criteria of the test. The line is valved a short distance before it enters and shortly after it leaves the lake area.

3.4.4 The Spray Modules

Subsequent to the newer interpretation of the Illinois Water Quality Standards (SWB-8), the Applicant elected to add spray units to the canals. Ninety-eight spray modules, each 120 feet long and weighing 25,500 pounds were purchased from the Ceramic Cooling Tower Company of Fort Worth, Texas. Each module withdraws water at the rate of 10,000 gpm and discharges it through 14- and 16-inch pipes to four spray nozzles, spaced at 40-foot intervals.[3] Figure 3.10 shows a spray module being installed in the canal, and Fig. 3.11 shows a group of modules in operation. The maintenance record to date on the spray modules has been very poor. There have been considerable difficulties with bearings, motors, nozzles, floats, mooring cables, piping, and power cables.[14]

Studies have been made by the Applicant[15] and by the manufacturer[16] to determine the effectiveness of the sprays. Those measurements by Ceramic Cooling Tower Company, the manufacturer, were taken before the lake was in operation. The heated water passing through the condensers flowed along the canal to the lake, passed directly into the return canal and then was discharged into the river. Approximately 92 units were operating at the time. The results of the measurement are shown in Table 3.1. It is seen that the sprays cool the water approximately 5.5°F. It should be noted that when the lake is being used in open cycle mode, the temperature of the water returning from the lake through the return canal will be cooler than it was in these tests due to cooling during passage through the lake, and therefore the sprays along the return section of the canal would be less effective than the tests indicate.

Data taken with the cooling lake in series with the canals (June 15, 1972, and July 13, 1972) indicate that the sprays on the canal going to the lake cool the water approximately 2-3°F.[15] Thus, there is no disagreement between the two sets of data. These data do not indicate that the water is further cooled in flowing from the lake to the river. However, during the closed-cycle mode, the lake discharge temperature is expected to be considerably higher, and, as a result, some cooling is to be expected while flowing from the lake to the intake structure (see Subsection 3.4.5.b).

3.4.5 Performance of the Cooling Lake

Since very little thermal data are as yet available from the Applicant for the open-cycle mode of operation with the cooling lake, it is of interest to assess the operation of the lake on theoretical grounds. Predictions of operation in the closed-cycle mode may also be inferred. The results of these calculations are discussed below. A more detailed discussion of the calculations can be found in Appendix D.

a. Open-Cycle Operation

The temperature measurements of June 15, 1972, to July 15, 1972, indicate that the temperature drop across the lake ($T_{in} - T_{out}$) is approximately 14°F. The theoretical values for these two months are 13.5°F and 14.6°F, respectively. Since the uncertainty in the calculations are on the order of ± 5°F, these values are in excellent agreement with the observed data.

b. Closed-Cycle Operation

As soon as the liquid radwaste system is completed (estimated date, Feb. 1, 1974), the Applicant intends to operate the cooling system in

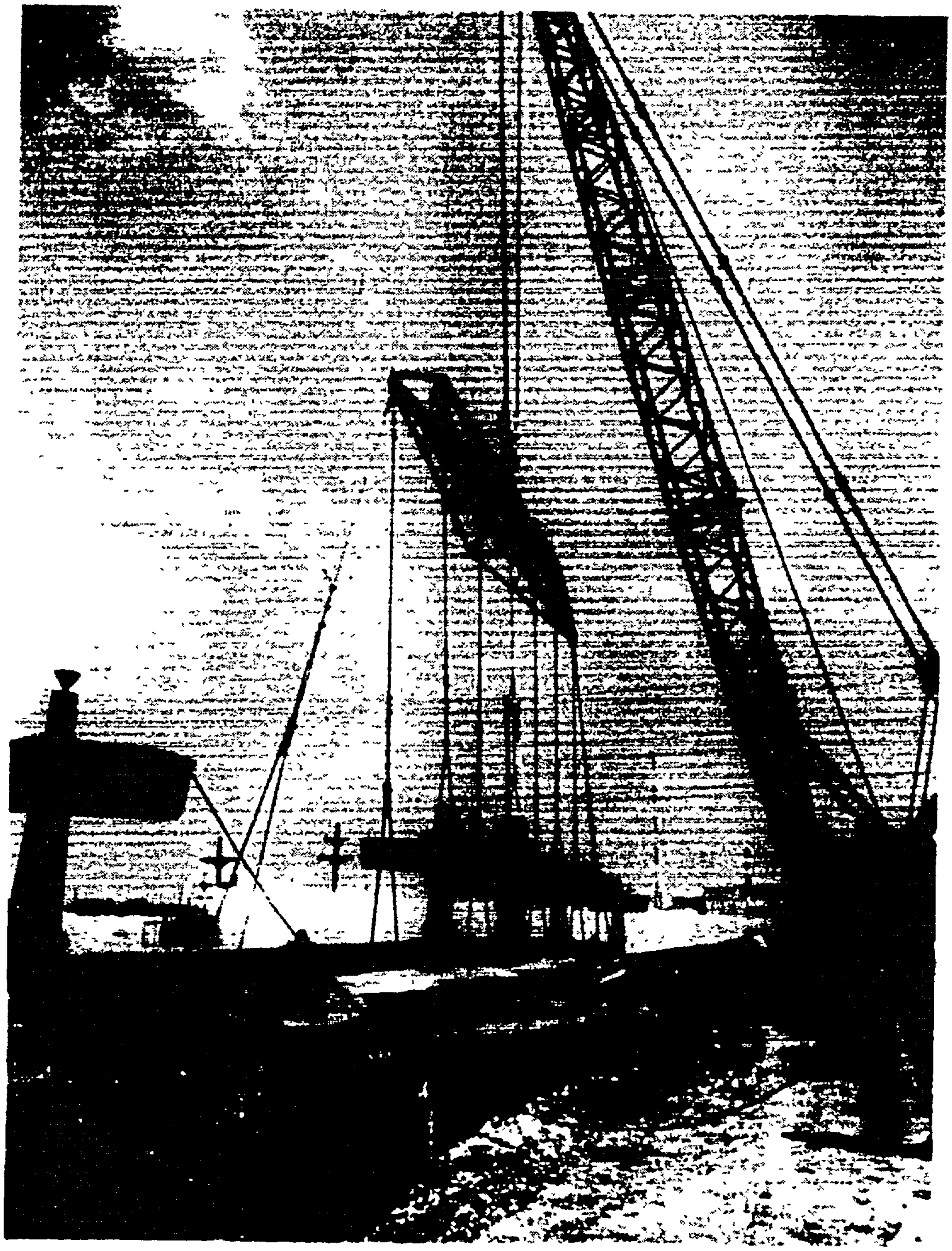

Fig. 3.10. Spray Module Being Installed in a Canal.

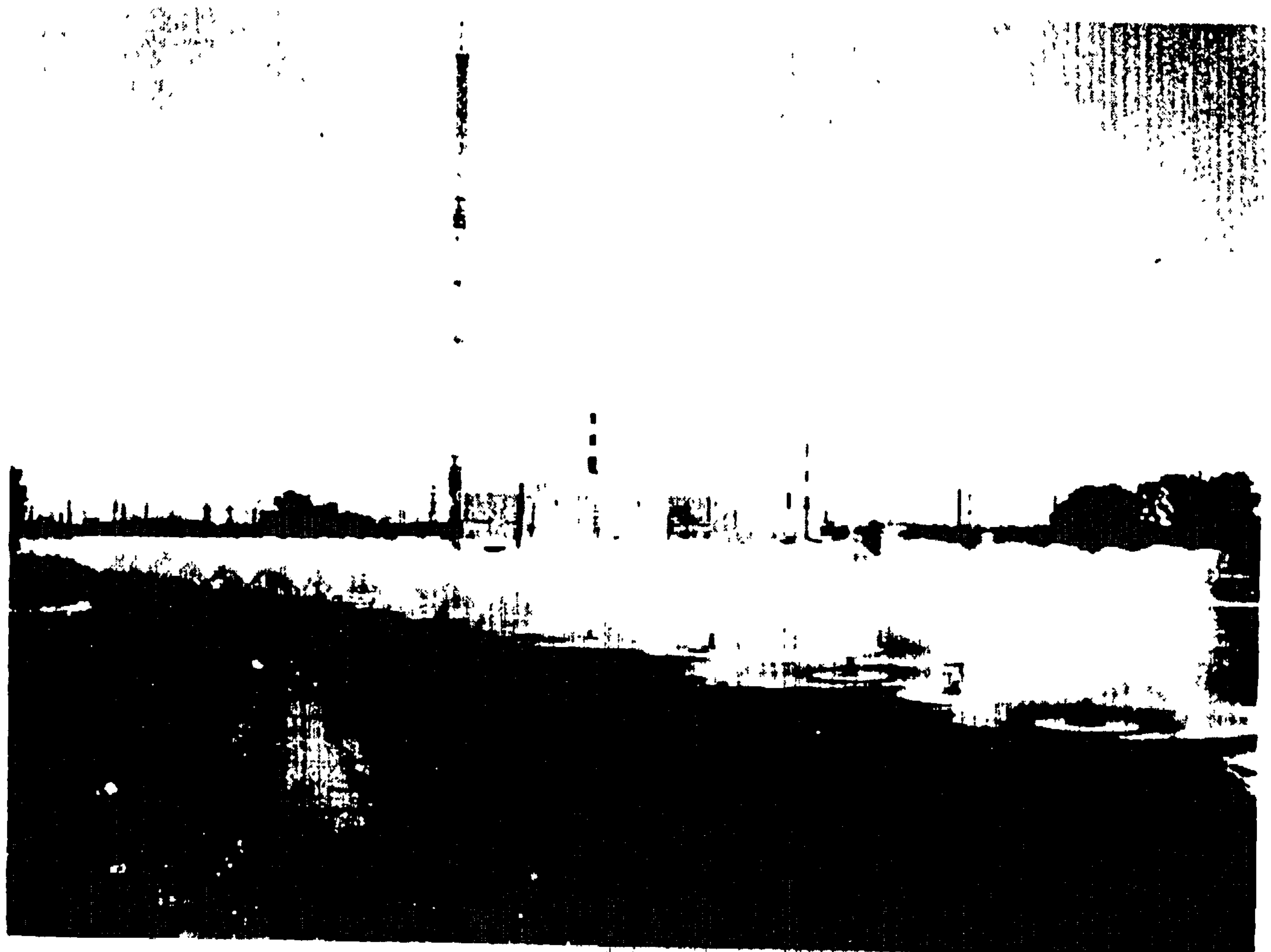

Fig. 3.11. Spray Cooling System in Operation at Dresden.

TABLE 3.1. Thermal Performance Evaluation of the Powered Spray Module System (PSM)

Date	Test Period	Measured Values: Bulk Water Temp. into Channel, °F	Measured Values: Bulk Water Temp. @ PSM Discharge, °F	Measured Values: Ambient Wet-Bulb Temp., °F	Measured Values: Avg. Wind Speed, mph	Temperature Drop through Spray Canals, °F
7/30/71	2:00-3:00 PM	88.5	82.7	55.5	5.0	5.8
7/31/71	4:00-5:00 AM	80.5	75.4	49.0	2.5	5.1
7/31/71	9:00-10:00 PM	81.0	76.0	60.0	6	5.0
8/1/71	1:00-2:00 AM	81.5	75.9	56.3	4.5	5.6
8/4/71	9:00-10:00 AM	85.2	79.8	62.0	5.0	5.4
8/5/71	6:00-7:00 AM	86.2	80.2	58.0	4.0	6.0

From: "PSM System -- Thermal Performance Evaluation," Reference PSM-105, Ceramic Cooling Tower Company, Fort Worth, Texas (Oct. 26, 1971), Attachment to Reference 16.

a closed-cycle mode. All of the water cooled by the lake, with the exception of 50,000 gpm, will be returned to the condenser intake and recirculated. The 50,000 gpm (blowdown) will be discharged into the Illinois River through the Unit 1 discharge canal. This blowdown is necessary to prevent the buildup of dissolved solids in the cooling lake and to provide a dilution stream for the liquid radioactive waste discharge.

In this mode of operation, approximately 66,000 gpm makeup will be withdrawn from the Kankakee River to replenish the 50,000 gpm blowdown and the approximately 16,000 gpm of water evaporated from the lake.

The water in the lake under closed-cycle operating conditions will tend to become much warmer than under open-cycle operation. During closed-cycle operation, water that returns to the condensers after passing through the lake will be warmer than the intake water from the river because the full heat load is not transferred to the environment in one pass through the lake. Thus, the $T_{out} - T_{river}$ is not zero. On succeeding passes through the condenser, the warmed water is heated to even higher temperatures. This warming process will continue until the water reaches a temperature that will allow the full heat load to be dissipated by the lake and spray canal. Table 3.2 contains the Staff's estimate of the cooling lake performance. The values cited are taken from the Staff's analysis, which is contained in Appendix D. The assumptions used in making the calculations are also noted in Appendix D. It is expected that the temperatures in the warmest portion of the cooling lake (near the lift station) will be approximately 15°F warmer than T_{out} under full load steady state operation.

3.4.6 River Discharge

The combined cooling water discharged into the Illinois River from Units 1, 2 and 3 is calculated by the Staff to add about 2.5×10^9 Btu/hr of heat. The mixed temperature of the lake blowdown and the Unit 1 discharge will be approximately 21°F higher than the Illinois River temperature (see Table 3.2).

In order to predict the effects of the heated effluent upon the biota of the river, the Staff has attempted to estimate the size, shape and location of the thermal plume[17] (Figs. 3.12-3.15). The calculations are based upon the analytical plume model developed by Louis H. Motz and Barry A. Benedict.[18,19] None of the analytical models, including the Motz-Benedict model, have as yet been adequately tested with thermal discharges, due primarily to a lack of reliable field data.

Two important parameters in this model are the entrainment coefficient, e, and the ambient velocity, V_a, of the river.

The entrainment coefficient must be determined empirically. The area enclosed by a given isotherm is inversely proportional to the entrainment coefficient. For the particular physical characteristics of the discharge plume and the Illinois River at the Dresden Station, the uncertainty in e is large ($0.04 < e < 0.4$). The effect due to this

TABLE 3.2. Staff's Estimated Performance of the Closed-Cycle Cooling System

Month	T_{out}	$(T_{out})_e$	T_{mixed}	$(T_{mixed})_e$	$T_{mixed}-(T_R)$ Min	$(T_{mixed})_e-(T_R)$ Max
J	59.2	66.7	54.2	65.3	20.2	19.3
F	62.0	71.0	54.8	67.8	20.8	19.8
M	68.0	76.5	57.6	72.1	21.6	20.1
A	75.5	83.5	67.1	84.7	21.1	18.9
M	84.8	92.3	73.8	92.1	21.8	19.1
J	93.0	100.0	82.6	100.8	21.6	18.8
JL	96.5	103.3	92.1	106.3	20.1	18.3
A	93.5	101.0	92.3	104.2	19.3	18.2
S	86.0	92.5	81.2	100.9	20.2	16.9
O	76.0	83.8	72.0	92.0	20.0	17.0
N	65.0	72.2	59.4	80.8	20.4	16.8
D	60.2	68.2	54.5	70.4	20.4	18.4

where

T_{out} = Temperature of Unit 2 and 3 blowdown

$(t_{out})_e$ = The extreme value of T_{out}

T_{mixed} = The mixed temperature of the blowdown from Unit 2 and 3 and the discharge of Unit 1 assuming $T_{R\ min}$

$(T_{mixed})_e$ = The extreme value of T_{mixed} assuming $T_{R\ max}$

$(T_R)_{min,\ max}$ = The minimum and maximum temperature of the Illinois River (see Fig. D.3).

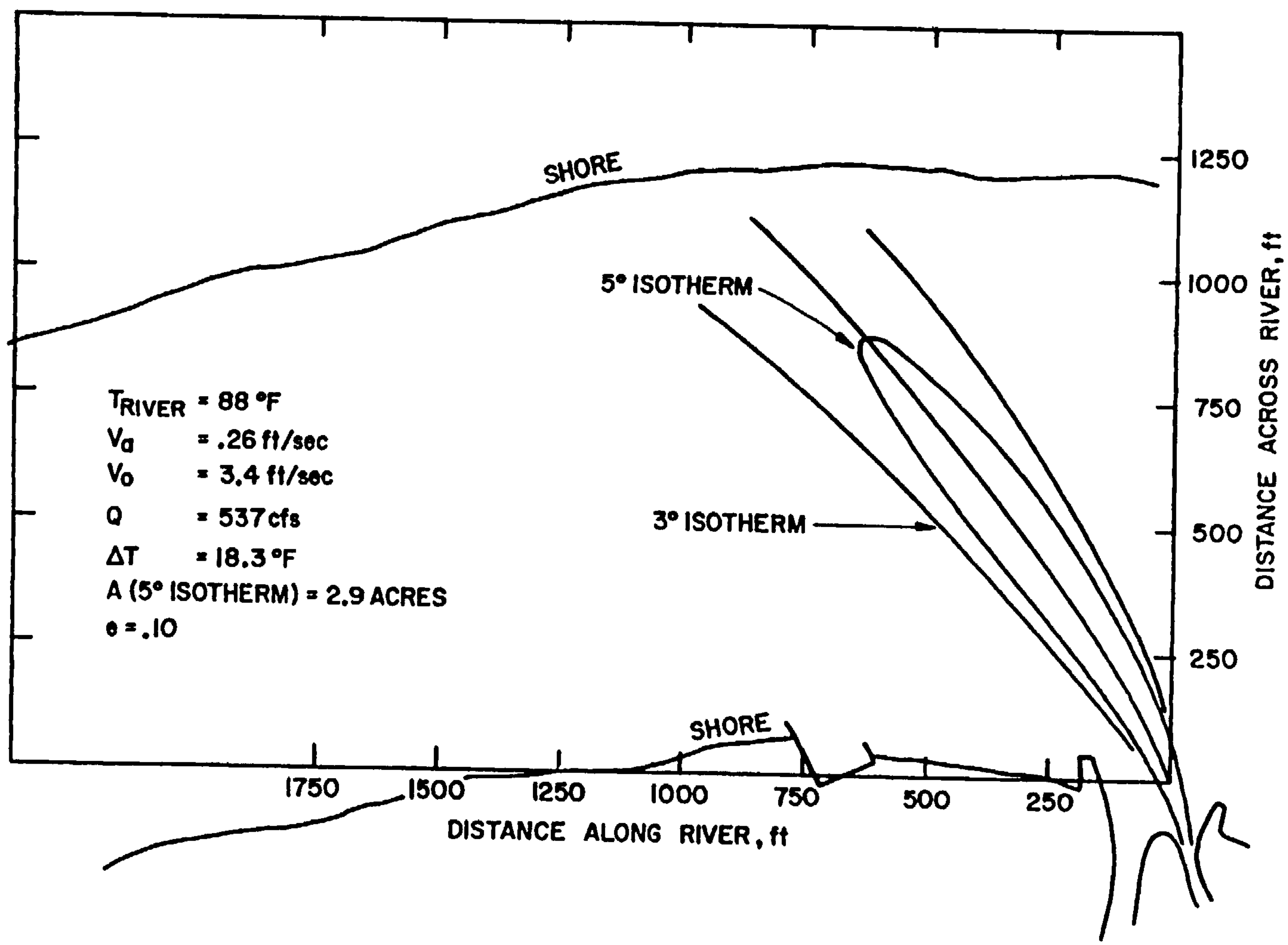

Fig. 3.12. Summer Isotherms from Dresden Station during Low River Flow Conditions (e = 0.10)

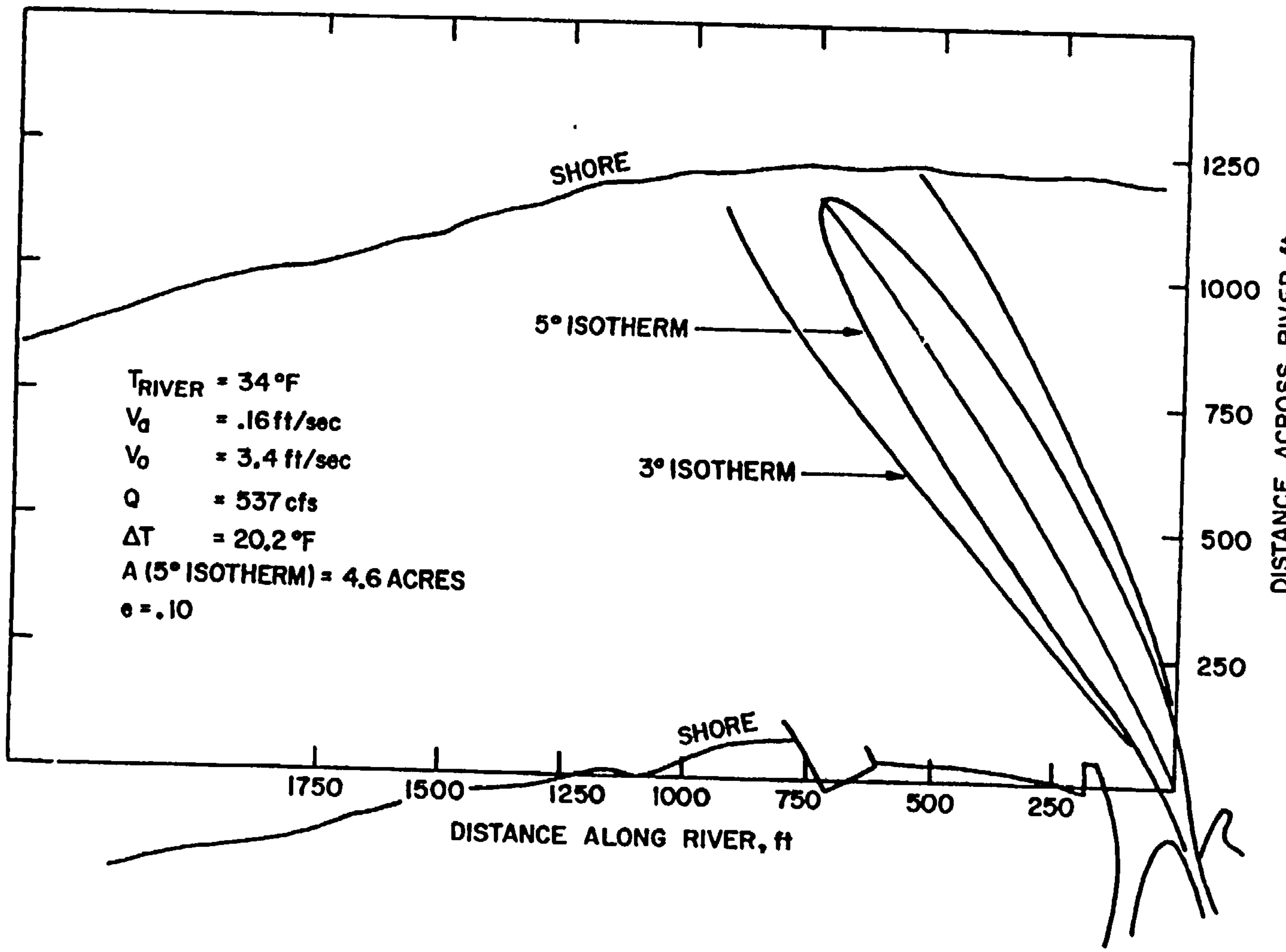

Fig. 3.13. Winter Isotherms from Dresden Station during Low River Flow Conditions (e = 0.10)

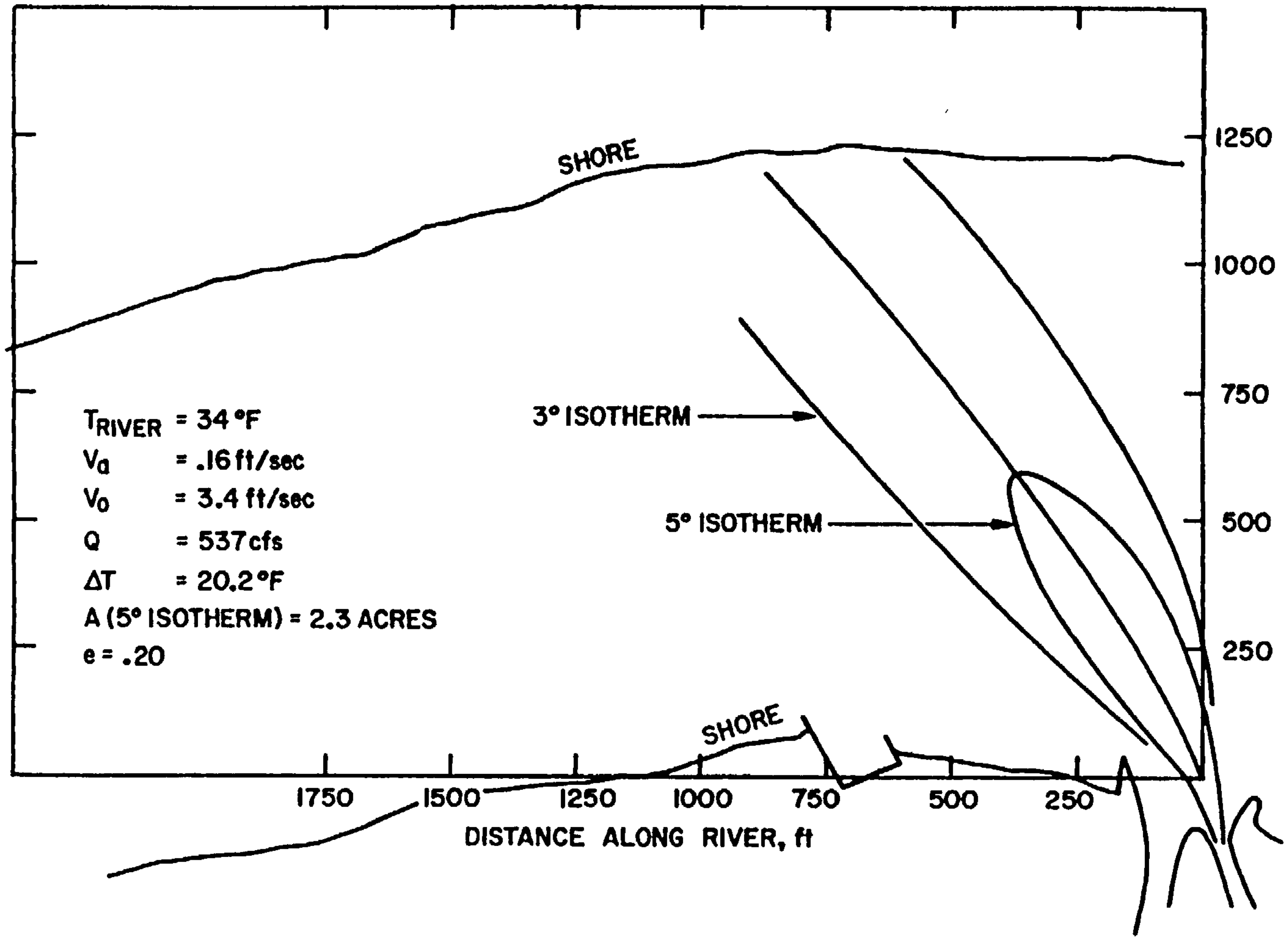

Fig. 3.14. Winter Isotherms from Dresden Station during Low River Flow Conditions (e = 0.20)

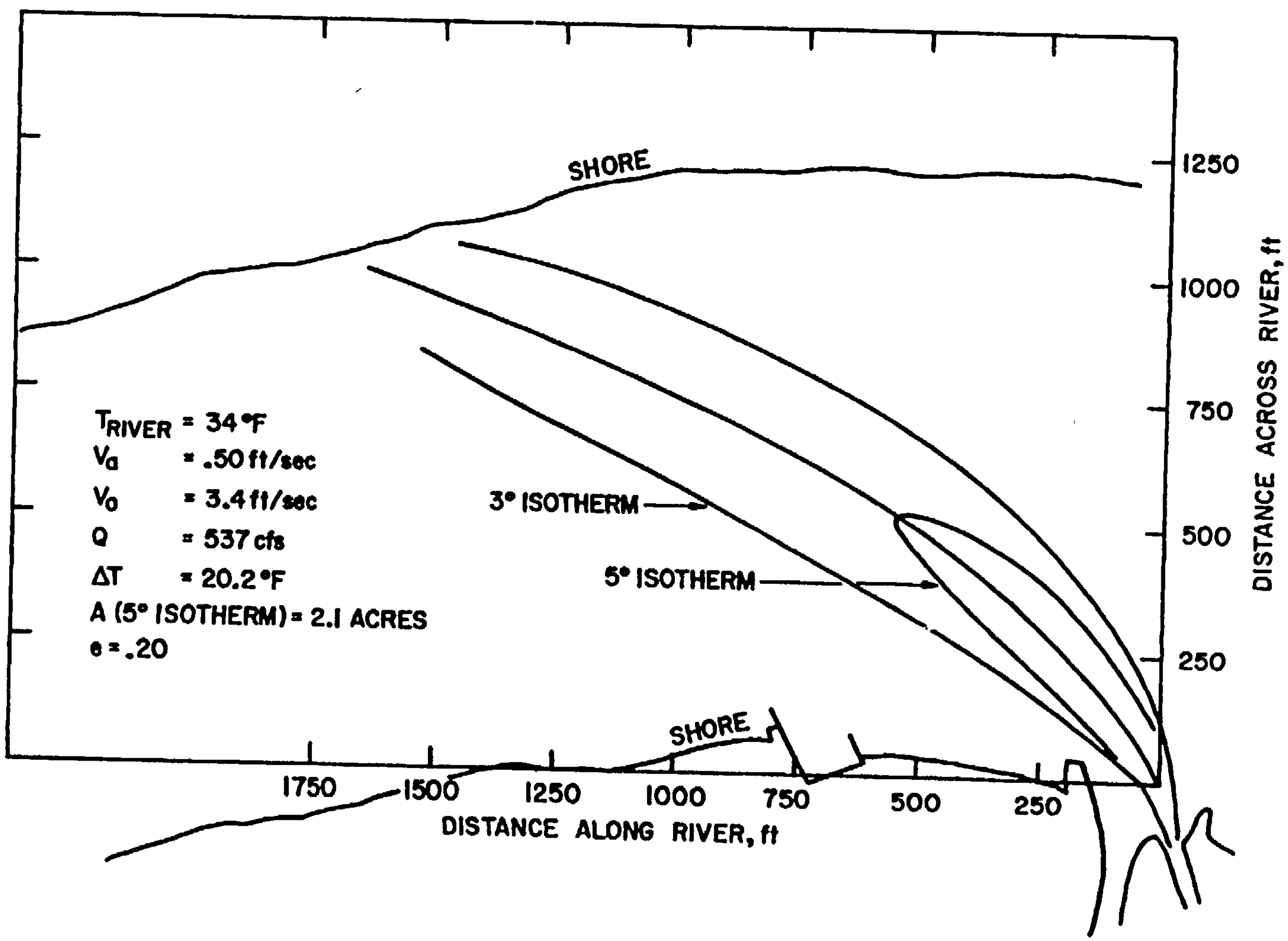

Fig. 3.15. Winter Isotherms from Dresden Station during Non-Low River Flow Conditions (e = 0.2)

uncertainty can be seen by comparing Fig. 3.13 (e = .10) and Fig. 3.14 (e = .20). The position of the centerline of the plume across the river is strongly affected by the ambient river velocity, V_a. This effect can be seen by comparing Fig. 3.14 (V_a = .16 ft/sec) and Fig. 3.15 (V_a = .50 ft/sec).

In all cases analyzed, the area within the $\Delta T = 5°F$ isotherm is less than 26 acres as required by the State of Illinois Standards. This is true even if e < .10. However, an adequate zone of free passage as defined in section 5.5.2 between the 5°F isotherm and the opposite shore of the river may not exist and the Applicant shall measure the extent of this plume (see Section 5.5.2).

The Staff does not know of any models that take into account the sinking plume phenomenon. This phenomenon occurs when the density of the warm effluent is greater than the ambient river water (water has a maximum density at about 39°F). Figures 3.13 through 3.15 represent the surface plumes in winter if this sinking phenomenon is ignored. It is estimated that the area within the 5° or 3° isotherm would approximately double as it sinks to the bottom of the river.

The conclusions drawn from this analysis are not quantified because of the uncertainty of the results. The conclusions are as follows:

1. Using conservative values of the parameters that enter the model (although not the most conservative possible), the area within the 5°F isotherm will be less than 26 acres.

2. The size of the zone of free passage is very sensitive to the values of e and V_a. Therefore, it is not possible to state with any degree of certainty whether or not an adequate zone will exist with the present discharge canal design.

The Applicant had originally stated that a diffuser pipe would be installed to increase the mixing of the effluent with the river water. Studies of such a system have been undertaken by William W. Sayre, Acting Director of the Iowa Institute of Hydraulic Research, University of Iowa.[20] However, the Applicant is studying the possibility of satisfying the regulations without installing the diffuser pipe.[21]

3.5 RADWASTE SYSTEMS

During the operation of Units 2 and 3, radioactive material is produced by fission and by neutron activation reactions in metals and other materials in the reactor system. Small amounts of gaseous and liquid radioactive wastes enter the effluent streams, which are monitored and processed within the Station to minimize the radioactive nuclides ultimately released to the atmosphere and into the Illinois River. The radioactivity released during operation of the Station is in accordance with the Commission's regulations as set forth in 10 CFR Part 20, Appendix B, and 10 CFR Part 50.

The waste handling and treatment systems for Units 2 and 3 are described in the following paragraphs. Separate waste handling and treatment systems serve Unit 1. They are designed to collect and process the gaseous, liquid, and solid waste which may contain radioactive materials.

The waste handling and treatment systems for Units 2 and 3 installed at the Station are discussed in the Applicant's Final Safety Analysis Report, November 17, 1967, and in the Environmental Report, July 24, 1970, and Supplements, November 8, 1971, and January 10, 1972. For Unit 1, these systems are discussed in the Applicant's Preliminary Hazard Summary Report dated September 3, 1957, and subsequent supplements. However, the releases of radioactivity from Unit 1 were determined on the basis of the operating experience of the Dresden Station and averaged for the years 1969, 1970, and 1971. In these references, the Applicant has prepared an analysis of its treatment systems and has estimated the annual effluents. The following analysis is based on the Staff's model, adjusted to apply to these units, and uses somewhat different operating conditions. The Staff's calculated effluents are, therefore, different from the Applicant's. The conditions used in determining the releases of radioactivity from Units 2 and 3 were based on the waste treatment systems as installed (present and augmented) and from the experience with other operating nuclear reactors (see Tables 3.3 and 3.4).

3.5.1 Liquid Wastes

The liquid radwaste systems are designed to collect, process, monitor, and dispose of radioactive liquid waste. The liquid waste from Units 2 and 3 are collected and treated in a common system as high purity, low purity, and chemical, classified on the basis of chemical composition and not radioactivity (see Fig. 3.16). The laundry waste system for Unit 1 serves Units 2 and 3.

In addition, separate cleanup systems for Units 2 and 3 maintain the required purity as well as reducing the radioactivity level of the primary coolant. The reactor cleanup system continually processes a portion of the water from the reactor through non-regenerable mixed bed demineralizers. The condensate cleanup system processes the full reactor condensate flow through regenerable mixed bed demineralizers.

High purity (low conductivity) liquid wastes from Units 2 and 3 are collected in the waste collector tank from the equipment drains located in the drywell; the reactor, radwaste and turbine buildings; and the chemical evaporator condenser. These wastes are processed through a precoat filter and a 400-gpm mixed bed demineralizer and sent to the waste sample tanks. After sampling and analysis the processed effluent will be normally pumped to the condensate storage tank for reuse. If it does not meet specifications for reuse, it will be recycled for additional treatment. In our evaluation we assumed that after processing, 90% of this water will be returned to the reactor coolant systems and 10% released through the circulating water discharge canal to the Illinois River.

TABLE 3.3 Principal Staff Conditions and Parameters Used in Calculating Releases of Radioactive Material in Liquid and Gaseous Effluents from the Dresden Nuclear Power Station, Units 2 and 3

Power	2527 MWt
Plant factor	0.8
Fraction of fuel releasing radioactivity	100,000 μCi/sec noble gases after 30 min delay for 3400 MWt reactor
Coolant mass - liquid	1.7×10^6 lb
- steam	60,000 lb
Steam flow rate	9,800,000 lb/hr
Coolant leaks - to drywell	1,700 lb/hr
- to reactor bldg.	480 lb/hr
- to turbine bldg.	1,700 lb/hr
- gland seal	9,800 lb/hr
Main condenser air inleakage rate	20 scfm
Iodine partition factor	
Reactor (steam/liquid)	0.012
Reactor building	0.001
Turbine building (air/steam)	1
Gland seal	0.01
Condenser air ejector	0.005
Iodine decontamination factors	
Charcoal adsorbers	10
Gas holdup times	
Air ejector - delay line	4 hr
- charcoal bed - krypton	18 hr
- xenon	310 hr
Turbine glad seal	2 min

TABLE 3.4. Principal Staff Assumptions and Parameters Used in Calculating Releases of Radioactivity in Liquid Effluents from Dresden Units 2 and 3

System	Processed Volume, gpd	Activity, % of Coolant	Holdup Tanks, gal	Process[a] gpd	Delay Time Days	I	Cs, Rb	Other Cations	Other Anions	Processed Effluent Released, %
High purity waste	50,000[b]	32	130,000	580,000	0.5	100	10	100	100	10
Low purity waste	20,000[b]	30	240,000	580,000	1	100	1	100	100	100
						(1)	(1)	(1)	(1)	
Chemical waste	9,400	1	17,000	35,000	4	100,000	100,000	1,000,000	1,000,000	100

[a]Other decontamination factors: Mo and Tc (100) and Y (10) due to holdup in reactor coolant system; tritium (1).
[b]Totals for Units 2 and 3; single system serves both reactors.
( )Present system provides filtration only.

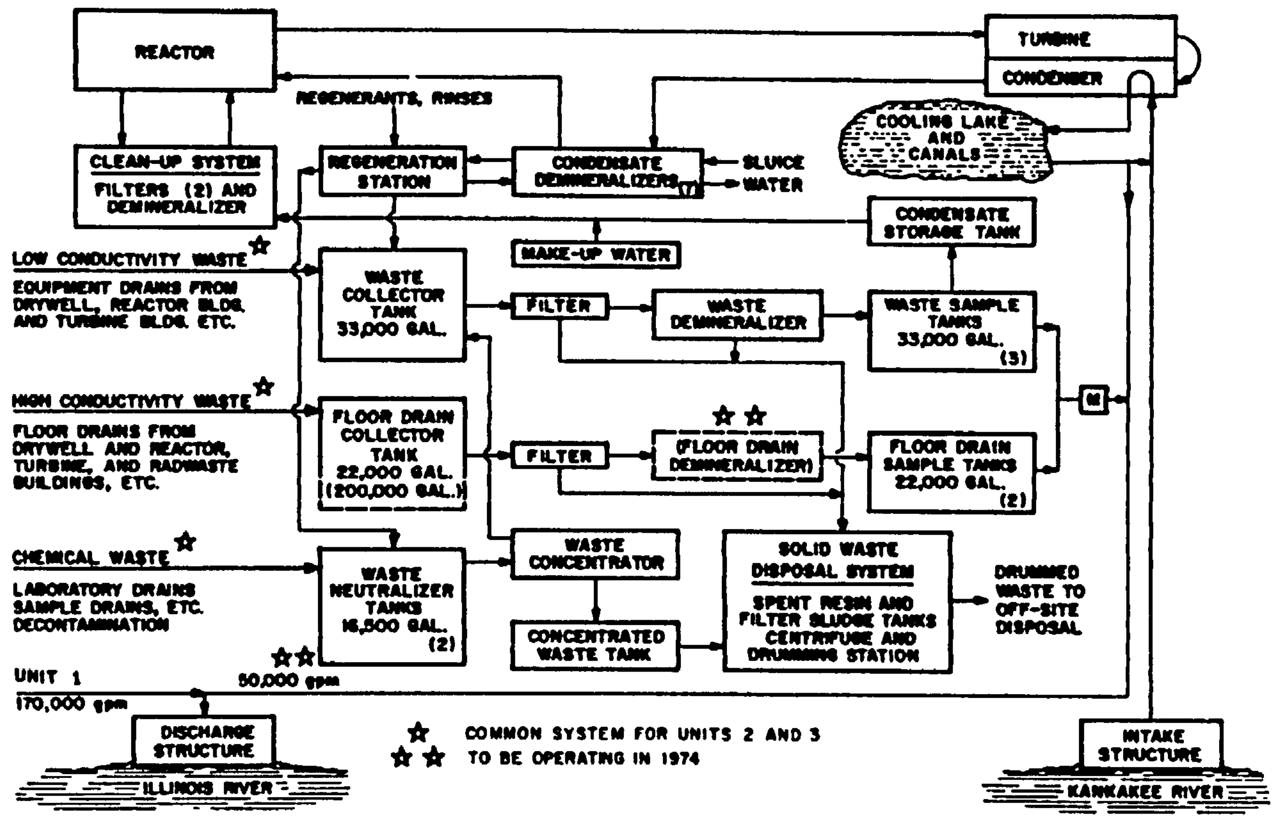

Fig. 3.16. Radioactive Liquid and Solid Waste Systems.

Low purity (high conductivity) liquid wastes are collected in the floor drain collector tank from the drywell floor drain and from the reactor, turbine and radwaste building floor drains. In the present system these wastes are processed through a precoat filter to the floor drain sample tank. After sampling and analysis the waste batch is released through the circulating water discharge canal to the Illinois River.

The Applicant is committed in its environmental report to augment the low purity waste system by early 1974. Two demineralizers (mixed deep-bed type) will be added following the filter for further decontamination. While the Applicant plans to recycle most of the effluent from this augmented system, we assumed that it would be released after sampling and analysis through the Unit 1 circulating water canal to the Illinois River.

The spent filter cake and demineralizer resin from the high and low purity systems will be transferred to the solid waste system.

Chemical wastes which are collected in the waste neutralizer tank include laboratory drains, demineralizer regenerants, decontamination effluents from the shop and flushes from the shutdown cooling system. These wastes are neutralized and then evaporated in a 24-gpm evaporator. In this evaluation the Staff assumed that the condensate is transferred to the high purity waste collector tank for reuse in the reactor. The evaporator concentrate is transferred to the waste concentrate tank and from there to the solid waste system.

Based on our evaluation of the augmented liquid waste systems for Units 2 and 3 (see Table 3.5), the calculated releases of radioactivity in the Illinois River will be less than 5 Ci/yr/unit. Until this change is accomplished, our evaluation indicates that 66 Ci/yr/unit of radioactivity excluding tritium will be released in the liquid waste. Based on the operating experience of other BWR's, we estimated that the tritium release will be approximately 20 Ci/yr/unit. With the present systems the Applicant estimated that the radioactivity released to the Illinois River will be less than 15 Ci/yr/unit, excluding tritium and less than 30 Ci/yr/unit of tritium.

The total radioactivity releases in the gaseous and liquid effluent from Unit 1 shown in Table 3.6 are based on Unit 1 operating data for 1969, 1970 and 1971. However, for the radionuclide distribution for the liquid we assumed the same distribution as the augmented Dresden Units 2 and 3. Total releases of radioactive materials in liquid wastes from Units 1, 2 and 3 before and after the augmented system is installed are shown in Table 3.7. With the augmented system their estimate is about 0.14 Ci/yr/unit excluding tritium. Their tritium estimate is about 15 Ci/yr/unit. Data on actual releases from Units 1, 2 and 3 for the years 1969-1972 are shown in Table 3.10.

3.5.2 Gaseous Wastes

During power operation of Units 2 and 3, radioactive materials released to the atmosphere in gaseous effluents include: fission-product noble

TABLE 3.5. Calculated Annual Release of Radioactive Material in Liquid Effluents from Dresden Units 2 and 3 (curies/year/unit)

Nuclide	Present System	Augmented* System	Nuclide	Present System	Augmented* System
Rb-86	0.00055	0.0013	I-130	0.014	0.00018
Sr-89	3.3	0.11	I-131	6.9	0.19
Sr-90	0.20	0.0068	I-132	0.68	0.014
Sr-91	0.36	0.0049	I-133	7.11	0.098
Y-90	0.096	0.044	I-135	0.19	0.0027
Y-91m	0.23	0.0033	Cs-134	0.29	0.79
Y-91	0.33	0.65	Cs-136	0.10	0.22
Y-93	0.060	0.060	Cs-137	0.26	0.71
Zr-95	0.036	0.0012	Ba-137m	0.25	0.68
Zr-97	0.010	0.00014	Ba-140	5.1	0.15
Nb-95	0.032	0.0011	La-140	3.5	0.13
Nb-97m	0.0098	0.00013	Ce-141	0.096	0.0023
Nb-97	0.010	0.00014	Ce-143	0.055	0.00082
Mo-99	0.091	0.14	Ce-144	0.022	0.00074
Tc-99	0.087	0.13	Pr-143	0.040	0.0013
Ru-103	0.023	0.00076	Pr-144	0.022	0.00074
Ru-106	0.0071	0.00024	Nd-147	0.012	0.00033
Rh-103m	0.023	0.00076	Pm-147	0.0030	0.00010
Rh-105	0.017	0.0023	Cr-51	1.7	0.054
Rh-106	0.0071	0.00024	Mn-54	0.14	0.0046
Sn-125	0.00019	0.000005	Fe-55	6.9	0.23
Sb-125	0.00011	0.000003	Fe-59	0.26	0.0085
Sb-127	0.0015	0.000030	Co-58	17.	0.55
Te-125m	0.00096	0.000033	Co-60	1.7	0.057
Te-127m	0.0063	0.00021	Zn-65	0.0033	0.00011
Te-127	0.0094	0.00026	W-187	5.9	0.031
Te-129m	0.061	0.0020	P-32	0.17	0.0018
Te-129	0.039	0.0013			
Te-131m	0.048	0.00071	Total (excluding H-3)	66 Ci/yr/unit	5 Ci/yr/unit
Te-131	0.0087	0.013			
Te-132	0.66	0.013	H-3	20 Ci/yr/unit	20 Ci/yr/unit

*Operating by February 1974

By Staff

TABLE 3.6. Annual Release of Radioactive Material in Liquid and Gaseous Effluents from Dresden Nuclear Power Station Unit 1 Operation

Liquids

Nuclide	Ci/yr	Nuclide	Ci/yr
Rb-86	0.00002	I-130	0.0003
Sr-89	0.18	I-131	0.30
Sr-90	0.011	I-132	0.022
Sr-91	0.0078	I-133	0.16
Y-90	0.070	I-135	0.0043
Y-91m	0.0053	Cs-134	1.3
Y-91	1.0	Cs-136	0.35
Y-93	0.096	Cs-137	1.1
Zr-95	0.0019	Ba-137m	1.1
Zr-97	0.0002	Ba-140	0.24
Nb-95	0.0018	La-140	0.21
Nb-97m	0.0002	Ce-141	0.0037
Nb-97	0.0002	Ce-143	0.0013
Mo-99	0.22	Ce-144	0.0012
Tc-99m	0.21	Pr-143	0.0021
Ru-103	0.0012	Pr-144	0.0012
Ru-106	0.0004	Nd-147	0.0005
Rh-103m	0.0012	Pm-147	0.0002
Rh-105	0.0037	Cr-51	0.086
Rh-106	0.0004	Mn-54	0.0074
Sb-127	0.0001	Fe-55	0.37
Te-127m	0.0003	Fe-59	0.014
Te-127	0.0004	Co-58	0.88
Te-129m	0.0032	Co-60	0.091
Te-129	0.0021	Zn-65	0.0002
Te-131m	0.0012	W-187	0.050
Te-131	0.021	P-32	0.0029
Te-132	0.021		
		Total	8 Ci/yr
		H-3	6.6 Ci/yr

Gases

Nuclide	Ci/yr	Nuclide	Ci/yr
Kr-85m	45,000	Xe-135	140,000
Kr-85	250	Xe-138	310,000
Kr-87	120,000		
Kr-88	110,000	Total (Noble Gases)	1,000,000 Ci/yr
Xe-133	71,000		
Xe-135m	190,000	I-131	1.6 Ci/yr

By Staff

TABLE 3.7. Calculated Radioactivity Releases in Effluents from Dresden Units 1, 2 and 3 (curies/year)

Unit No.	Design Power, MWt	Liquids: Fission and Activation Products	Liquids: Tritium	Gases: Noble Gases	Gases: Iodine-131
		Present Station Basis			
1[a]	700	8	6.6	1,000,000	1.6
2	2527	66	20	2,000,000	6[b]
3	2527	66	20	2,000,000	6[b]
Total		140	47	5,000,000	14
		Augmented Station Basis[c]			
1[a]	700	8	6.6	1,000,000	1.6
2	2527	5	20	48,000	0.34
3	2527	5	20	48,000	0.34
Total		18	47	1,100,000	2.3

[a] Based on operation of Unit 1 for calendar years 1969, 1970 and 1971. By mid-1975, a modified off-gas system is scheduled to be installed for Unit 1. This will reduce the Unit 1 off-gas release levels to approximately that of either Units 2 or 3. See references 14 and 52 of Section 5.

[b] Release of iodine-131 limited by Technical Specifications to 6 Ci/yr/unit when both units are operating.

[c] By early 1974 demineralizers will be provided in Units 2 and 3 for floor drain waste treatment, and recombiners and charcoal delay beds for the turbine condenser air ejector off-gas.

By Staff

gases (krypton and xenon) and halogens (mostly iodine): activated argon, oxygen, nitrogen; tritium contained in water vapor; and particulate material including both fission products and activated corrosion products.

The major source of gaseous waste activity during normal station operation is the offgas from the turbine condenser air ejectors. Other sources of gaseous waste include turbine gland seal steam exhaust, offgases from the mechanical vacuum pump, ventilation air released from the radwaste systems, and purge gases from the drywell and suppression chamber. The gaseous waste treatment system together with the various ventilation paths are shown schematically in Fig. 3.17.

The gases from the turbine condenser air ejectors are presently discharged through a 30-minute delay line and HEPA filter to the plant chimney. An augmented system is now being installed to process these gases through catalytic recombiners to remove the radiolytic hydrogen and oxygen, followed by a condenser, a four-hour delay line, a high efficiency particle (HEPA) filter, and a 36-ton charcoal delay system. The Staff's calculations indicate that the charcoal delay system operating at ambient temperature has capacity to delay the release of krypton for 18 hours and the xenon for 310 hours. The gases from the charcoal delay system will then be discharged through HEPA filters to the plant chimney, discharging 310 feet above grade. The recombiner condensate is sent to the liquid waste system.

The mechanical vacuum pump during startup will exhaust radioactive gas from the turbine condenser through a 1.75-minute delay line and the 310-foot plant chimney to the atmosphere. The Staff assumed the pump would be operated approximately 10 hr/yr.

The reactor building ventilation exhaust system is normally discharged without treatment through the reactor building vent, 160 feet above the ground. The drywell and the suppression chamber is normally a sealed volume. In our evaluation, we assumed that it will be necessary to purge the system four times per year through HEPA filters to the reactor building vent.

The turbine building ventilation system will be exhausted without treatment to the 310-foot plant chimney. The turbine gland seals are provided with primary steam and are exhausted through a 2-minute holdup pipe to the plant chimney.

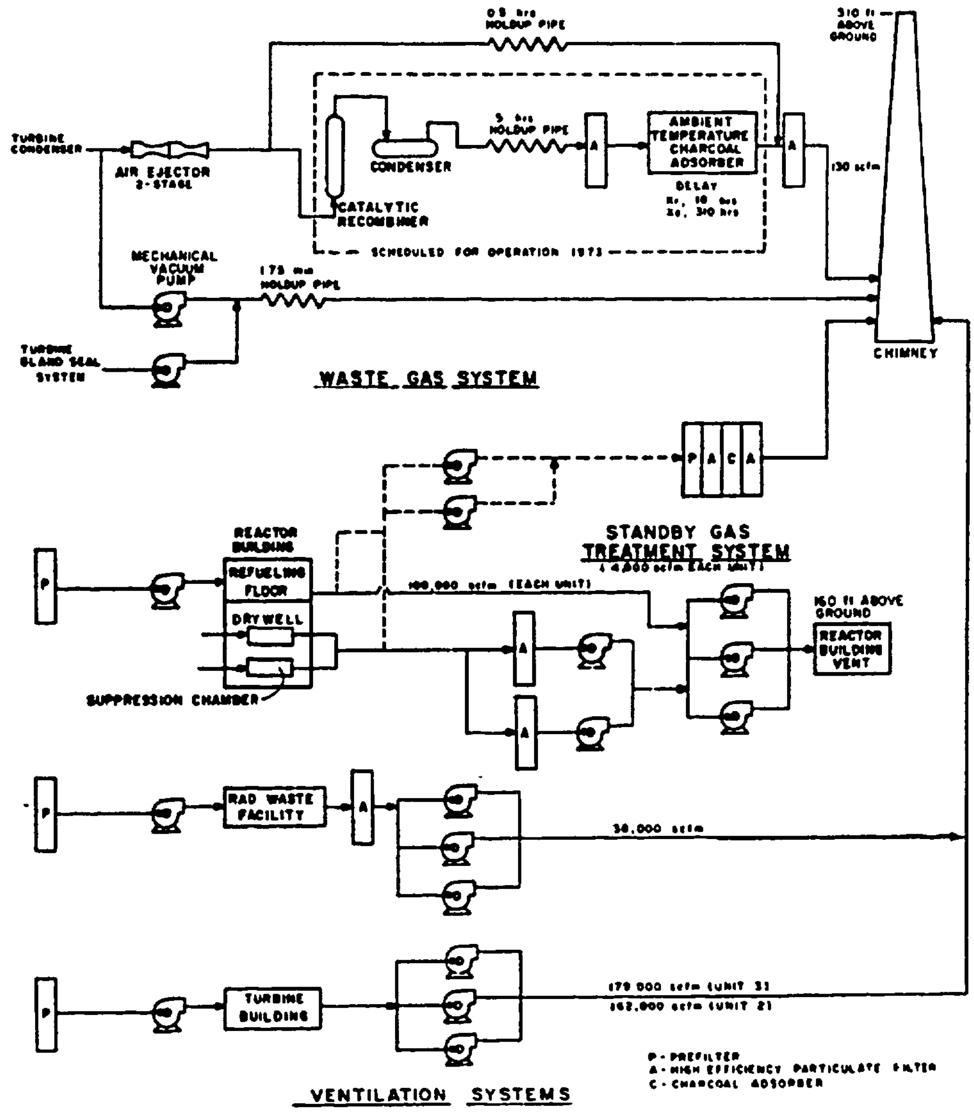

Fig. 3.17. Radioactive Gas Waste System for Dresden Units 2 and 3 (one unit shown).

Based on the augmented gaseous waste treatment system to be installed by the last quarter of 1973, the Staff's calculations indicate that the radioactivity released from Dresden 2 and 3 to the atmosphere will be approximately 48,000 Ci/yr/unit of noble gases and 0.34 Ci/yr/unit of iodine-131 as shown in Table 3.8. The Applicant's estimate of the annual release of activity from the augmented system is about 58,000 Ci/yr/unit of noble gases, which is in reasonable agreement with the Staff's estimate.

With the present gas treatment system for Units 2 and 3, our calculated values indicate that approximately 2,000,000 Ci/yr/unit of noble gases and 9.3 Ci/yr/unit of Iodine-131 will be released, as shown in Table 3.9. However, since the Iodine-131 release rate is limited by the Technical Specifications to 6 Ci/yr/unit, our evaluation is based on this figure. The Applicant's estimate of 3,100,000 Ci/yr/unit for noble gases is in reasonable agreement with the Staff's estimate.

Combined releases of radioactive materials in the gaseous wastes from Units 1, 2 and 3 are shown in Table 3.7. The radioactivity in the gaseous effluents from Unit 1 is shown in Table 3.6.

Data on actual releases from Units 1, 2 and 3 for the years 1969-1972 are shown in Table 3.10. The releases for Units 2 and 3 are less than the calculated values because of low plant operating factors for 1971 and 1972 and because the leakages rates assumed in the calculations (Table 3.3) are more conservative than actual conditions to date.

3.5.3 Solid Waste

The solid wastes from Units 2 and 3 will include the evaporator bottoms, spent resins, and filter sludge from the liquid waste processing system along with filters, miscellaneous paper, and rags. Sludges from the precoat filters and spent resins from the demineralizers will be collected and centrifuged with the excess water returned to either the floor drain collector, waste collector, cleanup filter sludge storage or filter sludge storage tank. The dewatered sludges and resins along with the evaporator concentrates will be solidified by mixing with cement in 55-gallon drums. Contaminated clothing, rags, and paper will be compressed into bales and packaged. Approved containers will be provided for gas filters and other bulky items. To maintain control of contaminated particles where operating the packaging equipment, ventilation is provided. After a suitable period of storage to allow for decay, these packages will be shipped to a licensed burial facility. All solid waste will be packaged and shipped in accordance with AEC and DOT regulations. For Units 2 and 3, the Applicant estimated that approximately 2000 drums of solid waste containing approximately 4800 curies of activity will be shipped annually.

TABLE 3.8. Calculated Annual Release of Radioactive Nuclides in Gaseous Effluents from Dresden Units 2 and 3 with Charcoal Delay System - early 1974 (curies/year/unit)

Nuclide	Reactor Bldg.[a]	Turbine Bldg.	Gland Seal	Air Ejector	Mech. Pump	Total[b]
Kr-83m	-	11	63	18	-	92
Kr-85m	-	18	100	3300	-	3400
Kr-85	-	-	-	540	-	540
Kr-87	-	54	310	2	-	370
Kr-88	-	59	340	1500	-	1900
Kr-89	-	210	820	-	-	1000
Xe-131m	-	-	-	220	-	220
Xe-133m	-	1	7	120	-	130
Xe-133	-	32	190	33,000	2300	35,000
Xe-135m	-	94	500	-	-	590
Xe-135	-	92	530	-	350	830
Xe-137	-	350	1500	-	-	1800
Xe-138	-	300	1600	-	-	1900
Noble Gas Total		1200	6000	39,000	2700	49,000
I-131	0.01	0.31	0.02	0.01	-	0.35
I-133	0.03	1.8	0.10	0.05	-	2.0

- Quantity less than 1 Ci/yr of noble gases and 10^{-4} Ci/yr of iodine.

[a]Released from reactor building vent at 160 feet above grade.

[b]Excluding reactor building; released from plant chimney at 310 feet above grade.

TABLE 3.9. Calculated Annual Release of Radioactive Nuclides in Gaseous Effluents from Dresden Units 2 and 3 with No Charcoal Delay System - early 1974 (curies/year/unit)

Nuclide	Reactor Bldg.[a]	Turbine Bldg.	Gland Seal	Air Ejector	Mech. Pump	Total[b]
Kr-83m	-	11	63	53,000	-	53,000
Kr-85m	-	18	100	96,000	-	96,000
Kr-85	-	-	-	540	-	540
Kr-87	-	54	310	240,000	-	240,000
Kr-88	-	59	340	300,000	-	300,000
Kr-89	-	210	820	1700	-	2700
Xe-131m	-	-	-	470	-	480
Xe-133m	-	1	7	6600	-	6600
Xe-133	-	32	190	180,000	2300	180,000
Xe-135m	-	94	500	140,000	-	140,000
Xe-135	-	92	530	510,000	350	510,000
Xe-137	-	350	1500	8600	-	10,000
Xe-138	-	300	1600	500,000	-	500,000
Noble Gas Total		1200	6000	2,000,000	2700	2,000,000
I-131[c]	0.01	0.31	0.02	8.9		9.3
I-133	0.03	1.8	0.10	51		53

\- Quantity less than 1 Ci/yr of noble gases and 10^{-4} Ci/yr of iodine.

[a]Released from reactor building vent at 160 feet above grade.

[b]Excluding reactor building; released from plant chimney at 310 feet above grade.

[c]Release of iodine-131 limited by Technical Specification to 6 Ci/yr/unit when both units are operating.

TABLE 3.10. Radioactivity Releases Based on Operating Experience

Year	Unit	Radioactivity Released (ci/yr)			
		Liquid		Gaseous	
		Radio-nuclides[a]	Tritium	Noble Gases	I-131
1969[c]	1	9.5	6.0	800,000	0.26
1970[c]	1	8.2	5.0	900,000	3.3
	2	-	31.0	-	1.6
1971[c]	1	6.2	8.7	750,000	<0.67
	2, 3	23.0	39.0	580,000	8.7
1972[d]	1	6.7	43.0[b]	880,000	2.5
	2, 3	22.0	26.0	430,000	2.8

[a]Excluding tritium.

[b]Large quantity due to release of excess water accumulated during extended shutdown.

[c]Releases of Radioactivity in Effluents from Nuclear Power Reactors, 1971; Division of Reactor Operations, U. S. Atomic Energy Commission, October 1972.

[d]Dresden Nuclear Power Station Semi-Annual Operating Reports, January 1-June 30, 1972, and July 1-December 31, 1972.

3.5.4 Transportation of Radioactive Materials

a. New Fuel

New fuel will be shipped by truck in AEC-DOT approved containers. About 10 truckloads of 16 containers each are required per year.

b. Irradiated Fuel

Fuel assemblies removed from the reactor will be unchanged in appearance and will contain some of the original U-235 (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel assembly will contain large amounts of fission products and some plutonium. Radioactive decay of these fission products produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. However, the fuel elements are placed underwater in a storage pool for at least 100 days for cooling and radioactive decay prior to being loaded into a cask for transport.

The Applicant states that the irradiated fuel elements will be shipped in approved casks (NFS CASK NFS-4 and GE Cask IF 300 are planned for use) designed for transport by either truck (NFS) or rail (GE). The casks will weigh perhaps 30 tons for truck or 100 tons for rail. Transport of the irradiated fuel will require an estimated 80 truckload shipments per year with two fuel assemblies per cask and one cask per truckload, or nine rail carload shipments per year with 18 fuel assemblies per cask and one cask per carload. An equal number of shipments will be required to return the empty casks. The most distant reprocessor considered by the Applicant is Allied Gulf Nuclear Services, Barnwell, South Carolina, a distance of about 870 miles.

c. Solid Radioactive Wastes

The Applicant ships solid radioactive wastes by truck to the Sheffield, Illinois, burial location, a shipping distance of about 80 miles. Approximately 2000 drums of 55-gallon size totalling some 5700 curies of activity involving 46 truckloads are shipped per year.

3.6 CHEMICAL AND BIOCIDE EFFLUENTS

Nonradioactive chemicals are used at the Station to purify well water, to regenerate condensate demineralizers, to prevent the fouling of heat exchangers, to inhibit corrosion, and for general cleaning. All of these uses generate waste effluents which are discussed below. The additions of chemicals to the process water are shown in detail in Fig. 3.5 and the concentrations of these chemicals in the plant effluents are given in Table 3.11.

TABLE 3.11. Chemical Effluents[a]

Chemical	Use of Chemical	Fate of Chemical	Short-term Concentration in Effluent, mg/l (closed-cycle mode)
Na_2SO_3	Treatment of boiler water	Sulfite converted to sulfate, released to discharge.	0.8
Na_3PO_4	Treatment of boiler water	Released to discharge	0.6
Morpholine	Treatment of boiler water	Decomposed into hydrogen, a nitrogen compound, various carbon compounds. Most of these products are expected to be released into the atmosphere.	Negligible
NaOH	Regeneration of makeup demineralizer	Released to discharge	0.3 (Unit 1) 0.1 (Units 2 and 3)
H_2SO_4	Regeneration of makeup demineralizer	Released to discharge	0.1 (Unit 1) 0.3 (Units 2 and 3)
Turco 4324[b]	Decontamination	Released to discharge	0.01
Amway[c]	Decontamination	Released to discharge	0.06
Turco 4306-D[b]	Decontamination	Released to discharge	0.003
Oakite Rustripper[d]	Decontamination	Released to discharge	0.04
NaOCl solution, 13% by weight	Biocide	Sodium hypochlorite is converted to sodium and chloride ions, a small amount forms chloramines. Released to discharge.	Unit 1: Na^+: 2.9, Cl^-: 4.5 Units 2 and 3: Na^+: 2.1, Cl^-: 3.3

[a] See Fig. 3.5.

[b] Composition of Turco 4324:

NH_4HCO_3	45-55%
$Na_{12}P_{10}O_{31}$	40-60%
Inorganic corrosion inhibitor	1%
Non-ionic biodegradable wetting agent	3-5%

Composition of Turco 4306-D:

$NaHSO_4$	40-50%
Sulfamic acid	40-50%
Petroleum distillate	<0.5%

[c] Composition of Amway unknown (proprietary secret).

[d] Composition of Oakite Rustripper:

NaOH	70-80%
Na_2CO_3	5%
Carboxylic type sequestrants	20-30%
Amino-carboxylic type sequestrants	<5%

From: Dresden Nuclear Power Station Environmental Report, Supplement IV, Commonwealth Edison Company, Chicago, Illinois (January 15, 1973).

3.6.1 Regeneration Wastes

The regeneration of the resins which purify well water for Station use results in an increase in the plant discharge of about 1 ppm of H^+, Ca^{++}, and $SO_4^=$ ions and an increase of about 1/2 ppm of Na^+, Cl^-, OH^-, and HCO_3^- for about 3-2/3 hours once every six days resulting from the operation of Units 2 and 3.[7] The operation of Unit 1 adds a concentration of about 1.1 ppm of H^+, Ca^{++} and $SO_4^=$ ions and about 0.3 ppm of Na^+, Cl^-, OH^- and HCO_3^- for about 5-1/2 hours each week. The concentrations are calculated on the assumption that the water demand for the units will approximate 600,000 to 900,000 gallons per month and are the long-term averages.[3] For short periods, when the plant water usage may reach ten times this estimate, concentrations of H^+, Ca^{++}, and $SO_4^=$ may be as much as 6 ppm and concentrations of Na^+, Cl^-, OH^-, HCO_3^-, and $SO_4^=$ may be as much as 3 ppm for ten hours in three days.[7]

In addition to the above, small releases of chemical reagents used in the regeneration of the condensate demineralizers may be expected. The daily volume discharged is expected to average about 3000 gallons[3]; however, these wastes pass through the liquid radwaste treatment system and releases are controlled by the radioactivity level of the solutions. Discharges are made at a flow rate of about 100 gpm[3] and the liquid is neutralized before release.

3.6.2 Biocides

Formation of bacterial slimes on heat-transfer surfaces of cooling systems is a problem common to all generating stations. The main condenser is the major item of equipment involved, although the problem exists, in relatively minor form, for other heat exchangers at the plant. The defouling method used at the Station is the intermittent addition of a 13% sodium hypochlorite solution to the cooling water.[3] For 17-1/2 minutes, two or three times a day by current practice, the solution is fed into the cooling water of one half of one of the condensers to maintain a residual free chlorine concentration of from 0.2 to 0.7 ppm in the condenser half — only one condenser half is treated at a time.[3] The hypochlorite is fed at 16 gpm for a total of 3-1/2 hours, so that during a 24-hour period 3360 gallons of the hypochlorite solution (equivalent to 4200 pounds of available chlorine) are used in Units 2 and 3. The regimen for Unit 1 is similar except that the hypochlorite is fed at 5 gpm in 20 minute batches for a total of two hours (both halves of the condenser) consuming 600 gallons of solution (equivalent to 750 pounds of available chlorine) every 24 hours.[3]

The increase in total dissolved solids carried by the water resulting from the addition of chemicals in Units 2 and 3 is about 4 ppm for periods of four hours per day whereas operation of Unit 1 results in an increase of about 8 ppm for a period of about 1-1/2 hours per day.

3.7 SANITARY WASTES AND OTHER EFFLUENTS

3.7.1 Sanitary Wastes

The Station sewage treatment facilities provide primary and secondary treatment with chlorination. The design capacity is 50 gallons per man day for 300 men. The maximum number of persons on site during a 24-hour period, which would be during a refueling outage, will be about 180.[22] The treatment works is supervised by a duly qualified sewage works operator certified under the regulations of the Illinois Sanitary Water Board.[22]

The treatment plant consists of a 12-foot Spirahoff tank, an 18-foot diameter trickling filter equipped with a water wheel rotary distribution, an unmechanized final settling tank equipped with a wet pit type sludge return pump, chlorine contact chamber, chlorinator and control equipment in a small enclosure.[22] Sewage is discharged to the treatment plant by means of four pneumatic sewage ejectors of 60-gpm capacity each, located in a lift station about 1200 feet from the treatment plant site, and the effluent from the treatment plant is discharged into the Illinois River via a pipe located downstream of the intakes. The free chlorine concentration at the settling tank is maintained at about 1 ppm and is undetectable when the effluent is discharged to the river some 300 yards from the settling tank.

3.7.2 Other Effluents

Four diesel-powered emergency generators are included in the Station; three are used in Units 2 and 3 and one is assigned to Unit 1. Each is rated at approximately 2500 kWe (continuous duty) and is run approximately one hour once a month for routine surveillance and occasionally as required for emergency use. Two startup boilers for Units 2 and 3 are also oil-fired and used intermittently. These boilers are also used for space heating, as is an additional boiler in the building housing Unit 1. The water pumps used for fire-fighting are also diesel powered. The quantities of gases emitted from all oil-fired equipment at the Station are listed in Table 3.12.

Miscellaneous non-radioactive solid wastes, such as industrial trash, material removed from the trash rack and fish or other material deposited in the collection basket of the traveling screens, are removed by a commercial waste disposal company and disposed of off-site.[23]

3.8 TRANSMISSION FACILITIES[4]

Units 2 & 3 are served by five 345-kV transmission lines. Construction of these lines, which total 92.9 circuit miles, was completed in November 1969 (Fig. 3.18).

Two of the lines, each 1.1 miles long, link the Station with an existing transmission line between the Pontiac substation (south) and the Electric Junction substation (north), east of Aurora, Illinois. These lines are located on a right-of-way that borders the west edge of the Station and are on the Dresden Station property.

TABLE 3.12. Gaseous Emissions from Oil-fired Equipment

Substance	Quantity Emitted (tons/yr): Units 2 and 3: Process and Space-heating Boilers	Units 2 and 3: Emergency Diesel Generators	Units 2 and 3: Diesel Fire Pumps	Unit 1: Space-heating Boilers	Unit 1: Emergency Diesel Generator	Unit 1: Diesel Fire Pumps	Total
Particulates	6.9	0.05	–[a]	5.2	–	–	12.6
Sulfur dioxide (SO_2)	42.4	0.16	0.01	31.7	–	–	74.27
Nitrogen oxides (NO_x)	36.0	0.27	0.01	13.5	–	–	49.78
Carbon monoxide (CO)	0.06	0.25	–	0.05	–	–	0.36

[a]Less than 0.01 ton/yr.

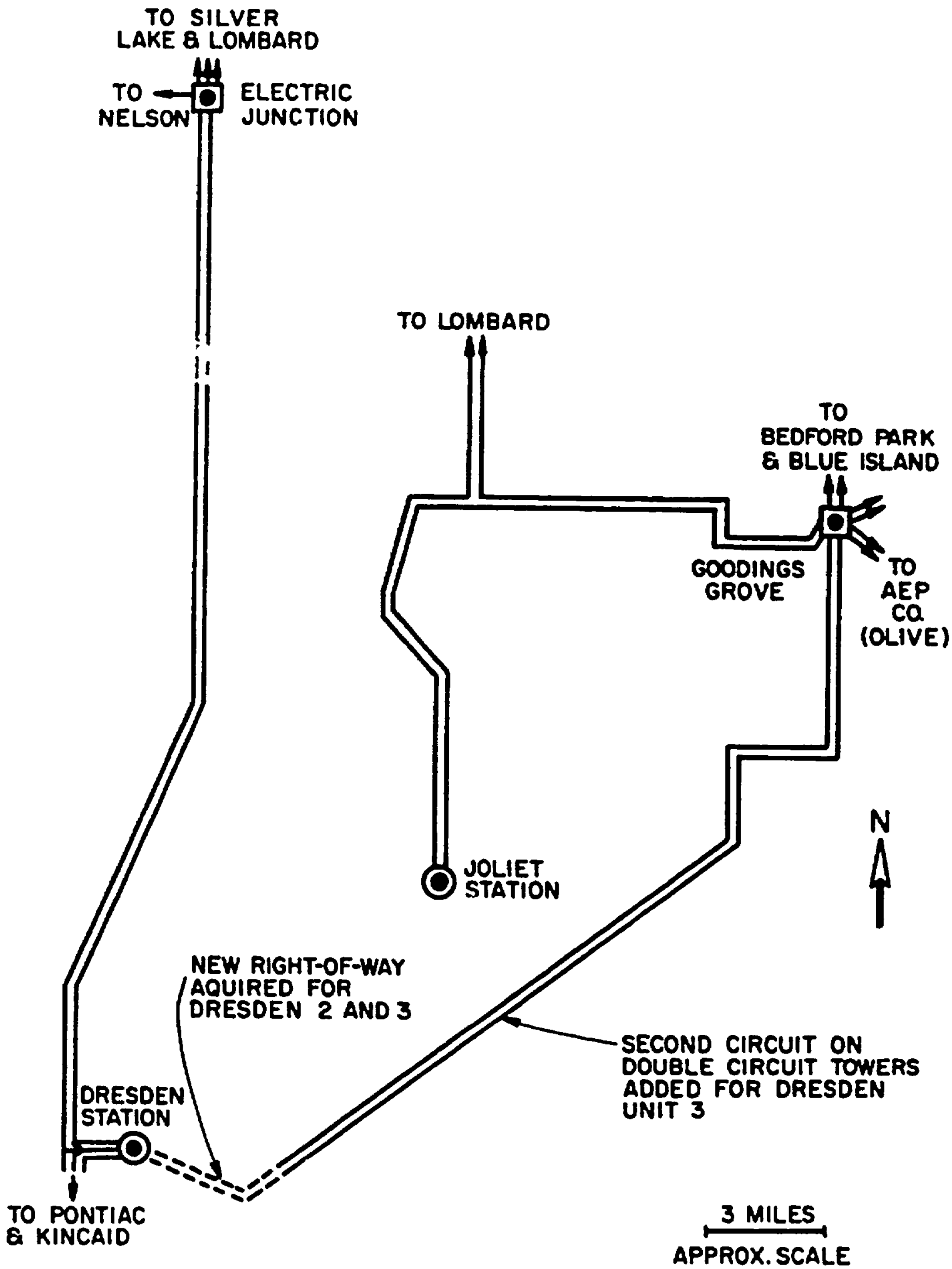

Fig. 3.18. The 345-kV Transmission System near the Dresden Station. From Applicant's Environmental Report, Supplement I.

The first 1.1 circuit miles of the third line follow the route of the two lines noted above. From the junction with the Pontiac-Electric Junction transmission line, however, an additional 30-circuit-mile line was added to existing transmission towers and extended to the Electric Junction substation (north). The addition of this line required no new right-of-way and was totally installed either on the Station property or in a vacant position on existing towers.

The remaining two lines are each 29.8 circuit miles long and extend from the Station to the Goodings Grove substation, east of Lockport. The first four miles of these lines were installed on new right-of-way acquired for this purpose. The first 1.3 miles cross Dresden Station property and an adjacent industrial area; the next 2.2 miles pass through a mixture of residential, industrial and farming areas; the next 0.5 mile crosses a State of Illinois conservation area. The remaining 25.8 miles (51.6 circuit miles) of these lines were installed on new structures on an existing right-of-way which passes mainly through farm land.

The tree trimming in the State of Illinois conservation area was done with the approval of the Illinois Department of Conservation. Long span, double circuit towers were used to reduce the number of structures and were installed adjacent to existing towers to minimize visual impact and restrictions to farming.

3.9 CONSTRUCTION PLANS

Because both Units 2 and 3 are completely built and operating, no large-scale construction activity is anticipated at the Dresden site. Aside from the addition of the radwaste treatment building, most of the anticipated work involves only the assembly and installation of equipment and all construction and installation work will occur on the Station property and within or immediately adjacent to the present plant buildings. The required cooling lake and cooling canal modifications are completed. Operation of the cooling system in the closed-cycle mode must await completion of the radwaste modification, which is anticipated to occur in February 1974.

References

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3. DNPS/ER, Supplement II. CECO (Jan. 10, 1972).

4. DNPS/ER, Supplement I. CECO (Nov. 8, 1971).

5. DNPS/ER, Supplement III. CECO question 24, (Oct. 17, 1972).

6. Dresden Nuclear Power Station Units 2 and 3, Safety Analysis Report. CECO (Revised Mar. 26, 1968).

7. DNPS/ER, Supplement IV. CECO (Jan. 15, 1973).

8. DNPS/ER, Supplement V. CECO (March 12, 1973).

9. "Rates and Regulations," SWB-8, Illinois Sanitary Water Board, Springfield, Ill. (1968). Newer interpretation by Illinois Pollution Control Board for the Dresden Nuclear Power Station (IPCB No. 70-21 Board Opinion).

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11. Testimony of Max Zar before the Illinois Pollution Control Board in PCB #72-350, Dec. 14, 1972, Illinois Pollution Control Board, Chicago.

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13. L. L. Beratan, "Evaluation of Cooling Lake Dikes — Dresden Station — Docket Nos. 50-237 and 50-249." USAEC, Directorate of Regulatory Operations (April 26, 1973).

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15. Dresden Synoptic Study. CECO (Aug. 16, 1972).

16. Letter, P. A. Frobwerk, Vice President, Marketing, Ceramic Cooling Tower Co., to Orville Travby, Commonwealth Edison Co. (Oct. 27, 1971).

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21. Testimony of Commonwealth Edison Co. before the Illinois Pollution Control Board in Joliet, Ill., PCB #72-350 (Dec. 14, 1972).

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23. DNPS/ER, Supplement III, question 52. CECO (Oct. 17, 1972).

4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION AND PLANT AND TRA' SMISSION FACILITIES CONSTRUCTION

4.1 IMPACTS ON LAND USE

The impact on land use occasioned by the addition of Units 2 and 3 and the additional 4 miles of transmission right-of-way necessary for these units has been negligible. As noted in Section 2, industrial zoning of the area was listed as the approved land use in the Grundy County Comprehensive Plan of 1967. The addition of Units 2 and 3 to the original 953-acre site (excluding the lake and canals) of an established and operating nuclear plant has not changed the character of the intended land use of the area.

Since the construction of the Units 2 and 3, as well as the construction of the transmission lines, cooling lake, and cooling canals is already complete, no further impacts of expansion of the Station are anticipated. It should be noted that construction of the transmission lines preceded publication of the U. S. Department of the Interior "Environmental Criteria for Electric Transmission Systems" (1971) and that only 4 miles of new right-of-way resulted from the addition of Units 2 and 3. The Staff concludes that any attempt to modify these lines to meet exactly these criteria would be environmentally and economically unjustified since such modifications would themselves result in adverse impacts during their construction. It is the conclusion of the Staff, therefore, that no further action relative to relocation of the transmission lines be attempted.

Th· impact of the construction of the cooling lake and canals has affected, to a small degree, the land use patterns of the area. Prior to the lake construction the principal use of the land was agricultural. Thus, approximately 1573 acres of land, most of which was crop land, was diverted for an industrial use. This diversion changed the proposed character of the Grundy County portion of the lake land from recreational open space use (as planned in the Grundy County Comprehensive Plan, 1967) to industrial use. Both the zoning change and the construction plans were reviewed by the Grundy County authorities, however, and the issuance of the building permit and zoning permit as noted in Section 1 have been interpreted by the Staff as prima facie evidence that the land use change was acceptable to the county's governing authority.

The impact of construction of the Will County portion of the cooling lake did not appear to violate any proposed land use (no comprehensive plan for Will County was found by the Staff) and required no approval of the Will County authorities as noted in Table 1.1. The soils of the lake bed consist of approximately 10% Proctor 148 (corn yield = 125 bu/acre), 50% Lorenzo 318 (corn yield = 75 bu/acre) and a 40% mixture of five different soil types having an average yield of about 101 bu/acre.[1] Thus the productive yield of the approximately 637 acres of farmland displaced by th· lake would average about 90 bu/acre or 57,300 bushels total. In the pr··e range of $1.00 to $1.50 per bushel, the economic loss due to this diversion is about $57,000 to $86,000. The diversion of this land from agricultural production is not considered by the Staff to be a significant loss in terms of either crop reduction or potential economic loss.

4.2 IMPACTS ON WATER USE

Presumably appreciable amounts of water were pumped into the Illinois River during the dewatering of building sites. Since the top of the Cambrian-Ordovician aquifer is 500 to 800 feet below the surface and there is an impermeable layer of limestone and shale immediately above it, no noticeable effects on the water table were produced. However, this operation and the excavation of the cooling lake apparently affected the shallow aquifer used for individually owned wells, since some of these wells were redrilled by the Applicant's contractor.

The sanitary sewage disposal system for the construction phase consisted of that described in Section 3.7.1 supplemented by portable chemical toilets which were used by most of the construction workers. Disposal of the waste from these toilets was made off site in compliance with state regulations.

The normally required preoperational flushing and cleaning of plant components involved the dumping of chemical cleaners, such as trisodium phosphate, into the Illinois River. This could have affected the quality of the river water in the vicinity of the Station, but normal downstream mixing should have diluted the concentrations to acceptable levels. In any event, no reports of adverse effects were found by the Staff.

Construction activities also caused some changes in the pattern of surface runoff at the site. Since the land area affected was small compared to that used for other activities, it is the conclusion of the Staff that this change, whether beneficial or adverse, is indiscernible.

4.3 ECOLOGICAL EFFECTS

In view of the fact that all large-scale construction activities associated with Units 2 and 3 are completed, no future construction impacts are anticipated to occur. The area of impact most affected by the construction required for Units 2 and 3 was the area used for the lake and canals. Since this area had been primarily used for agricultural activity, it is considered doubtful by the Staff that any unique or special ecosystem existed in the area which was destroyed or displaced by these construction activities. No evidence has been found by the Staff to indicate that any of the required construction activities have had either severe or long-term detrimental effects upon the area. Small animals, such as birds and rabbits, appear to inhabit the undisturbed areas on the site.

4.4 SOCIAL AND ECONOMIC EFFECTS

Although the construction of Units 2 and 3 occurred fairly recently, the designation and initial use of the site for nuclear power generation occurred over ten years ago. The addition of Units 2 and 3 does not appear to the Staff to have had a significant effect on the community.

Land-use pattern changes in the area since the completion of Interstate 80 and Interstate 55, which intersect a few miles northeast of the Station site, have been very pronounced in recent years. Whereas the area was formerly used almost exclusively for agriculture, a definite trend towards industrialization of the area has been noted by the Staff. Thus, the Station appears destined to become a nuclear park on the southern edge of an industrialized zone. Except for the continued recreational use (boating, fishing, and possible water contact sports if the quality of the rivers improves) along the Kankakee, Illinois, and Des Plaines Rivers, the entire character of this area is anticipated to change greatly within the 30 to 40 year life of the Dresden Units 2 and 3. It is the conclusion of the Staff, however, that this change will not occur as a result of the construction of the Station in general or Units 2 and 3 in particular.

References

1. "Soil Survey Map of Wilmington Township, Will County, Illinois," University of Illinois, Soil Conservation Department, Joliet, Illinois (undated).

5. ENVIRONMENTAL EFFECTS OF OPERATION OF UNITS 2 AND 3 AND THE ASSOCIATED TRANSMISSION FACILITIES

5.1 IMPACT ON LAND USE

5.1.1 General

Continued operation of the Dresden Station does not appear to violate the overall land-use plan for the area. The impact on the immediate vicinity will be small although increased traffic on the area roads will occur due to the transportation of employees, visitors, supplies, waste products, etc.

A population of 8003 persons within the 0-5 mile radius of the site has been projected by the Applicant for 1980 (see Section 2.2.). Since the population in this area is relatively small, the establishment of several moderate sized industrial plants or a few large industrial plants in the industrial zoned area north of the Station is conceivable and would, when it occurred, appreciably affect the normal 5% annual population growth of the area as a whole. Precise labor force population projections are not possible at this time due to the inability to accurately project either the timing, extent or type of industrialization likely to occur.

The Staff has concluded by its investigation that: 1. the proposed project has not and will not result in the transfer, sale, demolition or substantial alteration of potential national register property; 2. the proposed project will not affect any non-federally owned districts, sites, buildings, structures, or objects of historical, archeological, architectur. or cultural significance, provided the Applicant takes proper precautions to protect the two archeological sites in the vicinity of the Station.

5.1.2 Steam Fog and Ice

A major impact in the area adjacent to the cooling lake and the spray modules is the creation of steam fog and ice. This results from the conversion of the Units 2 and 3 condenser cooling systems from a once-through system to a lake and spray canal system and the resultant presence of large quantities of heated water in the open lake and canals.

Steam fog is created whenever the air is sufficiently colder than the underlying water. The air layer next to the water surface is then heated and has moisture added. Further mixing of this air with the unmodified air just above can lead to supersaturation and condensation forming steam fog.

However, further vertical mixing tends to evaporate the steam fog. It should be remembered that steam fog is fairly common in northern Illinois due to the frequent passage of cold air masses over open water. Because of higher water temperatures, steam fog often forms over the heated water in cooling ponds when conditions would not normally favor its formation over unheated bodies of water.

Natural fog is fairly common in this area, as noted in Section 2.4.6, and is generated by the cooling of surface air by radiation and/or advection and by the addition of moisture from warm rain falling into a shallow surface layer of cold air (prefrontal fog). Thus natural and steam fogs are formed by quite different processes.

The frequency, intensity, and inland penetration of lake and canal induced fogs are items of concern at the Station. Observations made at existing cooling ponds indicate that steam fog is usually thin and wispy, and does not penetrate inland more than 100 to 500 feet. It would appear that because the water vapor is released over large areas, ponds are not a major source of surface fog, despite the release of the water at ground level. As the water droplets move across the nearby land areas, some droplets will be removed by vegetation and other surfaces, causing a local increase in humidity and dew. During periods of subfreezing temperatures, some of the droplets will freeze and create a layer of ice on nearby vegetation and structures. Observations at existing ponds indicate that this rarely, if ever, causes problems with plants, power lines, etc.[1,2]

The visible plumes created by the spray modules contain drift water droplets in addition to drops of condensed vapor. These drift droplets tend to be larger than those produced by condensation and add considerably to the wetting and icing potential of the visible atmospheric plumes.

In contrast with cooling towers and ponds, there has been little operating experience (except at Dresden) with large spray cooling systems, especially in winter, the season of greatest interest. From the limited experience to date, it is reasonable to expect that a spray cooling system will create more severe icing conditions during winter than mechanical-draft cooling towers or cooling ponds; drift is the primary cause of this denser ice.

The Applicant is now sponsoring an investigation of the fogging and icing potential of the Dresden cooling system. This program is based primarily on observations of fogging and icing around the cooling facility. These observations are made every two hours during the daylight period, starting around dawn each day. Data recorded include presence of fog over nearby roads, icing of roads and other icing conditions, inland extent of surface fog, etc. This program began on November 26, 1971, and is continuing. The Applicant is now sponsoring an analysis of these data and an interim progress report was issued on December 7, 1972.[3] The Staff has examined this report and the data logs for the winter of 1971-1972, and members of the Staff have visited the area on several occasions, including days of extreme fog potential (i.e., very low air temperature).

On a very cold winter day, January 5, 1972 (air temperature -2.5°F, relative humidity about 80%), heavy steam fog was observed over the Dresden cooling pond and spray canal. Light rime ice up to 1/4 inch thick was observed on fences and vegetation up to 100 feet from the cooling lake. The horizontal visibility on the County Line Road bridge over the pond was always more than 100 feet and no ice was observed on the roadbed. Ice crystals were observed floating in the atmosphere over another road about 100 feet downwind of the pond. Over the spray canal, a dense plume rose to a height of 100 to 150 feet and extended inland about 1000 feet before evaporating. About 1-1/2 to 2-1/2 inches of hard, dense rime ice v deposited on vegetation and fences next to the canal. This dense ice, whose thickness decreased with distance from the canal, was found to extend inland 100 to 150 feet. Light rime ice formed further downwind, up to 1/2 inch thick 500 to 700 feet downwind, and 1/4 inch thick at 1000 feet downwind. It was observed that this rime ice formed only on vertical surfaces such as fences, posts, and vegetation. No ice was observed on a road 600 feet downwind of the spray units.

On January 14 and 15, 1972, the visibility on the bridges over the cooling lake averaged less than 100 feet as the fog moved in patches from the pond. The air temperature during this period remained near or below 0°F, with west to northwest winds 10 to 15 knots. At 8:00 AM on January 15, the air temperature was -16°F. Although dense portions of this fog would momentarily reduce visibility to 5 to 10 feet, a few seconds later the fog would thin and occasionally the visibility would improve to 200 feet. The bridge was quite slippery, owing mostly to two inches of snow which fell January 13. The combination of poor visibility and slippery roads caused two automobile accidents involving personal injuries. Visibility on Lorenzo Road, about 300 feet south of the pond, never went below 200 feet. This reduced visibility occurred only occasionally as puffs of fog moved from the pond to the road.

The maximum observed inland penetration of ground-level fog from the cooling lake was only about 200 feet.[3] The steam fogs either evaporated completely or moved aloft and formed small fractostratus-type clouds.

Thin steam fog was reported over Lorenzo Road four times during the winter of 1971-1972; on January 14, 15, and 30, and February 6, 1972. The visibility during these periods varied from 0.2 to 0.4 mile as puffs of fog drifted across the road.

County Line Road crosses two bridges over the lake near the warmest pond. Cold northwest winds have more than a mile of fetch over the warmest section of the pond before reaching these two bridges. On about 10 days during the winter of 1971-1972, steam fog reduced visibilities on the road to 100 feet or less. Typically, these conditions occurred on subzero days with west to northwest winds.[3]

During the winter of 1971-1972, the drift and fog from some of the spray modules on occasion caused icing on Dresden Road leading to the plant. However, the Applicant successfully reduced this problem by turning off the modules within 200 feet of this roadbed whenever such conditions occurred. The Applicant has recently relocated the spray modules to a section of the canal which is about 500 to 1000 feet east (predominantly leeward) of Dresden Road. This move should greatly reduce if not eliminate the icing problems previously encountered during winter operation of the spray modules.

Steam fog from the lake is often present over the water itself in summer, especially on calm, cool mornings from about dawn to 8:00 AM. This fog, however, appears to persist only over the water.

Experience with the Dresden cooling system to date, plus experience at cooling ponds elsewhere,[1,2,4] indicates that, except for the County Line Road, there will be no serious fogging or icing effects due to the operation of the Units 2 and 3 cooling system as proposed. Serious consideration must be given, however, to the fog problems created on County Line Road.

The Applicant has recently installed a system of warning lights to reduce the danger to automobile traffic on County Line Road. An electronic sensor (trade name Visiometer) is used to measure and record the horizontal visibility next to the road bed between the bridges over the cooling lake. The visibility detector automatically turns on two "Road Closed" signs (one north and one south of the bridges) whenever the visibility is less than 100 feet. No attempt is made, however, to actually stop traffic. For visibilities between 100 and 500 feet, two additional signs indicate "Fog Ahead - Reduce Speed to 20 mph." In addition, fog fences have been installed by the Applicant in an attempt to reduce the amount and density of steam fog over the roadway, and high-intensity strobe lights have been placed along the center line of the road. The use of both the fog fences and the strobe lights should continue until or unless a better method is found to finally resolve this problem.

5.1.3 Transmission Lines

The possible adverse impacts due to the operation of the transmission lines that were considered are the effects on railroad operations near the lines and the production of ozone. Ozone production is discussed in Section 5.5.4.

The effects of the transmission line operation on the signal systems, communication systems, and rolling stock of railroads adjacent to or under the transmission lines are considered. The Applicant is aware of the potential problems to the signal and communications systems and is working closely with the railroad companies to assure proper design of all parallel and intersecting rights-of-way. In view of the fact that both the railroads and the Applicant are aware of the potential problems, it is expected that any adverse interactions which could occur will be corrected.

The postulated impacts resulting from the interactions between the transmission lines and the railroad rolling stock is that of inducing voltages on inadequately grounded railroad cars. This impact might cause a safety hazard to the personnel working on the trains and/or increase the incidents of axle journal bearing failure. The Staff has determined that at least one incident of induced voltage and resultant electrical shock to a trainman (not lethal but sufficient to knock the trainman off a standing car) did occur. The Applicant is aware of the incident and intends to investigate the matter, but has been unable to locate a railroad car of the same design as that on which the incident occurred. The Staff has concluded from previous investigations that the impact potential is present but that the number of incidents reported are insufficient to assess the magnitude of the problem. The data base of journal bearing failure is even smaller than that of induced voltages and appears to rest on a preliminary but unverified correlation of increased journal bearing failure due to lightning. The Staff concludes that this potential impact is too poorly understood and documented at the present time to assess the magnitude of the problem.

5.1.4 Cooling Lake[5,6]

a. Independent Design Evaluation

An independent evaluation of the dike stability was conducted by the Analytical and Computer Division of Sargent & Lundy, Engineers. They evaluated the static design of the dike for a profile having weak soils and the dike resting directly on rock. The factors of safety obtained ranged from 6 to 13.

The design criteria require a minimum factor of safety against failure of 1.5. Though this dike was not analyzed for the effect of a seismic event, the factors of safety for the static analysis are sufficiently conservative that it is felt an acceleration factor of 0.1 to 0.15 g would not imperil the integrity of the cooling lake. The Coast and Geodetic Survey of the Department of Commerce, as part of the safety review for Dresden Unit 2, reported in a letter to Mr. H. L. Price, Director of Regulation, USAEC, on September 17, 1965, that ground accelerations of more than 0.1 g will not be encountered at the Dresden site during the lifetime of the facility.

b. Dike Failure and Repair

On October 13, 1972, a 50-foot section of the cooling lake dike failed resulting in the loss of the impounded water and some slight damage to public property. The failure occurred along County Line Road adjacent to two boat slips which had been dredged into the bank of the Kankakee River. An old drainage channel which had filled with granular material was not detected in the original site foundation investigation program. Seepage from the cooling lake through the foundation formed a hydraulic connection through this granular soil in the weathered rock trough with the river. As the fines in the soil matrix were washed out, flow increased, the material in the trough became "quick", and lost its ability to support the dike. The unsupported section of dike sheared away from the remainder of the embankment and dropped. The dropping of this section of dike below the lake water level caused it to be overtopped and washed out, resulting in the loss of the impounded water. Repair to the dike consisted of removing all material down to bedrock in the failed section and for a distance beyond, and replacing it with suitable impermeable soil. All soil was test-control-compacted to a minimum density of 95 percent of the modified Proctor density in accordance with ASTM D 1557. Particular attention was directed to keying the new section of dike into the existing embankment.

c. Additional Investigation and Improvement Program

To be assured that a potential failure condition did not exist elsewhere in the dike system, 337 additional borings were made through the dike to bedrock. All soil boring samples were examined by a qualified soils engineer and profiles plotted in all suspect areas. It was concluded by the Applicant's engineers that nowhere in the dike system was there a potential for the type of failure experienced to repeat itself. To provide an additional measure of certainty, sheet pile cutoff walls were installed and the sheeting driven into the bedrock wherever there was any question of the foundation material being able to perform its intended function. These walls provide additional stability and resistance to seepage, since the only place seepage can now take place is through the interlocks of the sheet piling.

d. Surveillance Program

A comprehensive formal surveillance program which will provide for routine inspection of the dikes during the life of the plant is in the process of being developed by the Applicant. The program shall include: detailed inspections, at relatively close time intervals, of the embankment slopes, the toe, and the ground surface beyond the toe; and the monitoring of local wells near the north and south dikes and inspection of the river bank above and below water level to determine if there is excess seepage from the lake. The purpose of this program is to identify any anomalies which might develop and to effect a rapid and meaningful repair. The surveillance program shall be included as part of the environmental technical specifications with a monthly surveillance interval.

The Applicant shall, also, at the earliest opportunity, determine by additional investigation, the cause of the 2-foot depression noted in inspection reports of the south dike. Any repairs necessary to insure dike integrity shall be performed. The results of the investigation and proposed action shall be submitted to the Commission for review and approval. The Applicant shall also demonstrate that the 4-in. diameter holes along the south dike are not initial stages of the movement of soil from the dike foundation.

5.2 IMPACTS ON WATER USE

5.2.1 Ground Water

The Station withdraws water only from the Cambrian-Ordovician aquifer at a rate which is small (about 1.5%) compared to other withdrawals in the area.[7] Thus, the Staff concludes that continued use of ground water by the Station will have negligible impact on the water level in the Cambrian-Ordovician aquifer.

Since the upper alluvial aquifer is hydraulically disconnected from the Cambrian-Ordovician aquifer, the Station usage of well water should have no effect on shallow wells or deep-rooted vegetation. The presence of the cooling lake produces a minor interaction with the shallow aquifer which the Staff does not expect to be deleterious.

The presence of buildings and roads on the site, and dikes around the cooling lake will affect the surface runoff. However, the area involved is small compared to the total runoff area. Therefore, the Staff expects that the impact will be negligible.

5.2.2 Surface Water

The rivers in the vicinity of the plant are used only for commercial navigation, sewage disposal, and recreational boating, with the exception of the Kankakee which is also used for sport fishing and swimming. Operation of the Station will have little discernible impact on these activities.

Inasmuch as the Station is scheduled to begin closed-cycle operation early in 1974, the impacts of surface water use will be discussed on this basis. Water will be withdrawn from the Kankakee River at an estimated average rate of 66,000 gpm; this makeup water will be combined with the return flow of 910,000 gpm from the cooling lake to provide the 976,000 gpm flow required by Units 2 and 3. The cooling water for Unit 1 (average withdrawal 166,000 gpm) is taken from the Kankakee River, passed through the condenser, and discharged directly to the Illinois River. Since the blowdown from the cooling lake is presently planned to be released into the Unit 1 discharge canal, the cooling water from Unit 1 serves as a diluent for the more concentrated blowdown, as is discussed below.

The closed-cycle operation of Units 2 and 3 results in an increased concentration of chemicals in the cooling lake. Part of the increase occurs because chemicals are added during operation of the Station, but the major increase results from evaporation and the resulting concentrating effect. As an illustration, consider the total dissolved solids (TDS) present in the cooling lake. The lake is assumed to be filled initially with Kankakee River water with a TDS of 362 ppm (see Table 2.6, 1958-1971 average); thus, there are $1.2. \times 10^7$ pounds of TDS present in the four-billion-gallon lake. During one minute of operation Units 2 and 3 will add 976,000 gallons of water with an average increase in TDS of 0.525 ppm,[8] or 4.27 pounds of TDS from operation. On the other hand, during that minute evaporation will remove 16,000 gallons of water which, when replaced by Kankakee River water, adds 48.2 pounds of TDS, or 11.3 times that added by operation of Units 2 and 3. Both these numbers are very small when compared to the amount already present, but repeated recycling increases the effect. Under equilibrium conditions, it may be shown that the final concentration, C, is given by the initial concentration, C_o, multiplied by the factor $1 + (E - R)/(B + S)$, where B, E, R, and S are the rates of blowdown, evaporation, rainfall, and seepage, respectively. These considerations indicate that the initial TDS, 362 ppm, will increase to 458 ppm in the cooling lake after a sufficient period of operation. The TDS in the blowdown will then tend to 458 ppm. In the Unit 1 discharge canal this will be mixed with water with a TDS of 362 ppm. The effective TDS discharged to the Illinois River is then

$$458 \text{ ppm} \times \frac{50{,}000 \text{ gpm}}{216{,}000 \text{ gpm}} + 362 \text{ ppm} \times \frac{166{,}000 \text{ gpm}}{216{,}000 \text{ gpm}} = 384 \text{ ppm}.$$

According to Table 2.2, the 14-year average TDS in the Illinois River is 448 ppm; hence, the Station discharge will be lower in TDS than the recipient river. Similar calculations may be made for the individual dissolved ions of interest (Na^+ and Cl^- are the major entities present since NaOCl is used to clean the condensers) and the conclusions are similar. In all but one case, the content of the Illinois River is greater than that of the discharge. The exception is $SO_4^=$ where an apparent increase of 51 ppm will occur. This is not a direct result of Station operation but is due almost entirely to the lake concentration effect raising the already high sulfate concentration in the Kankakee River. It should be noted that in all cases, the final concentration in the Illinois River will be very close to the original since all effects of the Station discharge are diluted by the ratio of the flow rates, i.e.

$$\frac{5{,}400{,}000 \text{ gpm}}{216{,}000 \text{ gpm}} = 25;$$

thus, the net increase in the $SO_4^=$ concentration in the Illinois River will be 2 ppm under average flow conditions.

The above considerations apply in a modified form under the present circumstances when the plant is operating open-cycle. The lake concentration effect does not build up (once through), so the increase in TDS due to evaporation is only 5.9 ppm or a total increase of 6.4 ppm. On the other hand, the dilution factor resulting from the relative rates of flow is smaller. The first effect outweighs the second so that this impact on the Illinois River is less.

From the discussion above no adverse effects are to be expected from the addition of chemicals to the Illinois River by the Station. One note of caution is desirable, however; this concerns the concentration of "free" chlorine present at the discharge to the Illinois River. Under closed-cycle operation, the contribution from Units 2 and 3 will be nil because the 2-1/2-day hold up in the cooling lake will result in the consumption of any free chlorine leaving the condenser.[53] There will be contributions, however, from Unit 1 and from the sewage treatment plant. The Applicant states that the residual concentration of free chlorine from the condenser cleaning operation is 0.2-0.7 ppm and from sewage treatment, 1 ppm (see Sections 3.6.2 and 3.7.1). It would appear to be advisable to maintain these concentrations at "lowest practicable" levels. It is true that the residual chlorine should be quickly consumed in natural waters by various oxidizable materials presenting a high clorine demand, but ammonia naturally present in the water (~3 ppm according to Table 2.8) reacts chemically with available chlorine to form chloramines, which are more persistent than chlorine and are also toxic to biota. However, it is not expected that chloramines will still be present in the blowdown after passage through the lake.[52]

Under the present conditions of open-cycle operation there is a "free" chlorine contribution from Units 2 and 3 also, and the discussion above is reinforced. For these reasons, it is desirable to maintain the concentration of residual chlorine in the discharges at the lowest possible level. For further discussion of this impact, see Section 5.5.

A further impact which should be noted is that the rate of withdrawal of cooling water, even under closed-cycle conditions, is comparable to low flows of the Kankakee River. The estimated average rate of withdrawal for the Station is 232,000 gpm. During the summer peak load period when it is likely that the Station will be operating at full power due to the higher than average power demand, the seven-day, 10-year recurrence low flow of the Kankakee River is approximately 200,000 gpm and there will be a backflow of Des Plaines River water into the Station's intake canals. Conditions are worse, of course, during open-cycle operation.

The Staff concludes that all postulated chemical releases will be considerably below the levels set by the Illinois Water Pollution Regulations. The Applicant is converting Units 2 and 3 to closed-cycle operation and the Staff agrees that this is the appropriate method of operation as discussed in Section 5.5.1.a.

5.3 RADIOLOGICAL IMPACT ON BIOTA OTHER THAN MAN

During normal operation of the Station, small quantities of radioactive materials will be released to the environment. The maximum rates of release that will probably occur have been given in Section 3.5. These releases were used as the basis for the dose computations below, using the ARIP program package.[9]

Dose rates have been included in Table 5.1 for the biota in the vicinity of the Station. These biota include phytoplankton, zooplankton, benthic organisms, terrestrial and aquatic plants, and local and migratory birds and mammals. Other terrestrial organisms will receive doses intermediate between those of littoral plants and birds. Doses at the effluent outfall or in the Illinois River are applicable only to aquatic forms. The river littoral was chosen to represent the maximum doses to be expected either on the land or at the aquatic-terrestrial interface. Doses for all other terrestrial areas will be lower than those given for the littoral.

In each case, doses are given for the species that are critical for this particular area because of maximum bioaccumulation effects, key position in the local trophic chains, or similar reason. Inspection of the table shows that these doses are, in fact, quite low for all of the biota of the area. At these dose levels no deleterious effects are anticipated for any of the biota in the area.[10,11]

Even at the outfall, the velocities of the liquid effluent discharge and of the river itself, preclude more than a momentary residence by mobile species. Thus, their annual dose commitments would be much less than those inferred from Table 5.1. Radiosensitivity is less for sessile organisms than for mobile ones by several orders of magnitude.[9,11] Thus, deleterious effects are not anticipated even for benthos in the immediate effluent. In any case, steady-state radioactive concentrations will drop one or two orders of magnitude within a few thousand feet along the river bed,[12] so that only a very limited area of benthos will be exposed.

A diagrammatic representation of some of the pathways utilized in this evaluation is included in Fig. 5.1. In addition, equilibration between geosphere, hydrosphere and atmosphere was considered, as well as the various levels of trophic interchange to and from birds, mammals, etc. in the biosphere. The lithosphere was taken to be inert, in this context.

TABLE 5.1. Doses to Biota in the Vicinity of the Station

	Dose Rates, mrem/yr						
	Effluent Units		River[1] Units		Littoral Units		
Organism Type	1	2 & 3	1	2 & 3	1	2 & 3	Reference Organism
Aquatic plants	210	900	9.7	12	9.7	12	*Cyclotella*, spp.
Aquatic invertebrates	53	224	2.4	3.1	2.4	3.1	*Sphaerium*, spp.
Aquatic vertebrates	30	123	1.4	1.7	1.4	1.7	*Dorosoma cepedianum*
Terrestrial plants	-	-	-	-	23.0	0.038	*Salix*, spp.
Terrestrial invertebrates	-	-	-	-	23.0	0.035	*Lumbricus*, spp.
Birds	-	-	-	-	13.0	1.5	*Oxyura jamaicensis*
Mammals	-	-	-	-	28.0	6.5	*Ondatra zibethicus*

[1]Computed downstream after complete mixing has occurred.

5.4 RADIOLOGICAL IMPACT ON MAN

The methodology above[9] was then extended to man. Tables 5.2 and 5.3 give direct doses to the human population via atmospheric dispersion (see Section 2.4) of Units 2 and 3, and Unit 1 releases, respectively, at the Station boundary, and for the population within the 16 sectors extending to 50 miles. The populations used are based on those supplied by the Applicant and discussed in Section 2.2. The Staff considers the population estimates reasonable except that minor adjustments have been made by the Staff to account for apparent summation errors. The doses are subdivided into the critical organ doses attendant on releases of halogens and particulates (e.g., I-131), and of noble gases (e.g., Kr-85). The critical organ doses are given because they represent the limiting cases of human hazard (e.g., carcinogenesis). The corresponding genetically significant doses (gonads), for example, are one or two orders of magnitude lower. Cumulative population doses and average individual doses vs. distance from Unit 1, and Units 2 and 3 are given in Table 5.4.

Airborne doses in all sectors are dominated by the noble gas component. The maximum airborne doses from Units 2 and 3 are found in the east sector between one and two miles. This sector is uninhabited, so that the maximum dose (0.29 mrem/yr) does not represent an actual dose commitment. The maximum dose committment (0.28 mrem/yr) occurs in the NE sector, one to two miles.

The annual population integrated dose commitment for Units 2 and 3 over the 50-mile radius will be 160 man-rem. The maximum airborne dose commitment for Unit 1 is in the same NE sector and equals 22 mrem/yr (Table 5.3). Thus the airborne dose from the Station (22 + 0.28 mrem/yr) is about 4% of the limits of 10 CFR 20, while the dose due to Units 2 and 3 alone is about 0.06% of these limits. The nearest dairy herds are pastured two to three miles north of the site. Annual dose to a child's thyroid via the air-cow-milk pathway will be about 1.5 mrem/yr from Units 2 and 3 and about 5.6 mrem/yr from Unit 1. The child's thyroid dose from Units 2 and 3 is very small and the combined thyroid dose from the Station is about 1.4% of the limits of 10 CFR 20. Atmospheric dispersion computations of Station releases were done using the methods described in Reference 9. These techniques take into account the chemical and decay characteristics of the effluent nuclides, the heat content and momentum of the discharged gases, and the actual location and nature of the various release points. These characteristics are then combined with the meteorological conditions of the site environs to determine the concentrations of the various isotopes over the area, and at various critical receptor points within the area. The population

TABLE 5.2. Population Doses due to Airborne Releases from Dresden Units 2 and 3[1]

Direction	[2]	Boundary	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
			Distance, miles									
N	a	9.3	9.4	16.0	15.0	13.0	11.0	7.2	3.5	1.9	1.3	0.94
	b	13.0	13.0	25.0	24.0	21.0	18.0	1	5.8	3.2	2.2	1.6
	c	0.0	0.0	0.76	1.9	5.2	190	35.	1000	5100	2000	4800
	d	2.1	2.1	3.9	3.8	3.2	2.7	1.8	0.90	0.50	0.34	0.25
	e	0.0	0.0	0.003	0.008	0.025	1.1	0.30	17.0	1[illegible]	91.0	300.
NNE	a	9.6	9.6	17.0	15.0	13.0	11.0	7.3	3.6	2.0	1.3	0.96
	b	13.0	13.0	26.0	25.0	21.0	18.0	12.0	5.9	3.3	2.2	1.6
	c	0.0	0.0	0.77	6.2	10.0	44.0	510	1200	3200	1200	1900
	d	2.1	2.1	4.0	3.8	3.3	2.8	1.9	0.92	0.51	0.34	0.25
	e	0.0	0.0	0.003	0.025	0.049	0.25	4.2	20.0	97.0	560.	1100.
NE	a	10.0	10.0	18.0	17.0	14.0	12.0	7.9	3.8	2.1	1.4	1.0
	b	14.0	14.0	28.0	26.0	23.0	19.0	13.0	6.4	3.5	2.4	1.7
	c	0.0	0.0	3.9	110.	410.	110.	450.	7800	2000	20000	39000
	d	2.2	2.2	4.3	4.1	3.5	3.0	2.0	0.98	0.55	0.37	0.27
	e	0.0	0.0	0.014	0.40	1.8	0.58	3.5	120.	57.0	860.	2300
ENE	a	7.3	7.3	12.0	12.0	9.7	8.2	5.4	2.7	1.5	0.98	0.71
	b	10.0	10.0	19.0	18.0	16.0	13.0	8.9	4.4	2.5	1.6	1.2
	c	0.0	0.80	1.5	0.0	0.0	0.0	73.0	680.	830.	14000	10000
	d	1.6	1.6	3.0	2.8	2.4	2.1	1.4	0.68	0.38	0.25	0.19
	e	0.0	0.008	0.008	0.0	0.0	0.0	0.82	15.0	34.0	940.	840.
E	a	10.0	10.0	18.0	17.0	15.0	12.0	8.2	4.0	2.2	1.5	1.1
	b	15.0	15.0	29.0	28.0	24.0	20.0	13.0	6.7	3.7	2.5	1.8
	c	0.0	3.3	0.0	2.2	0.0	1.6	180.	290.	570.	2200	1800
	d	2.3	2.3	4.5	4.3	3.7	3.1	2.1	1.0	0.57	0.38	0.28
	e	0.0	0.022	0.0	0.008	0.0	0.008	1.4	4.4	15.0	87.0	98.0
ESE	a	9.1	9.3	16.0	15.0	12.0	11.0	7.0	3.4	1.9	1.2	0.91
	b	13.0	13.0	24.0	23.0	20.0	17.0	11.0	5.6	3.1	2.1	1.5
	c	0.0	3.2	13.0	5.2	0.60	0.0	65.0	100.	200.	180.	210.
	d	2.0	2.0	3.8	3.6	3.1	2.6	1.8	0.87	0.49	0.33	0.24
	e	0.0	0.025	0.054	0.022	0.003	0.0	0.57	1.8	6.5	8.6	14.0
SE	a	8.4	8.5	15.0	14.0	12.0	9.9	6.5	3.2	1.8	1.2	0.86
	b	12.0	12.0	23.0	22.0	19.0	16.0	11.0	5.3	2.9	2.0	1.5
	c	0.0	3.2	13.0	5.2	0.60	0.0	65.0	100.	200.	180.	210.
	d	1.9	1.9	3.6	3.4	2.9	2.5	1.7	0.82	0.46	0.31	0.22
	e	0.0	0.025	0.30	0.60	0.50	0.12	4.6	3.8	65.0	13.0	3.8
SSE	a	6.1	6.2	11.0	9.9	8.4	7.0	4.6	2.3	1.2	0.83	0.61
	b	8.5	8.5	16.0	16.0	13.0	11.0	7.6	3.8	2.1	1.4	1.0
	c	0.0	13.0	1.3	9.1	2.9	2.5	26.0	180.	64.0	83.0	64.0
	d	1.3	1.3	2.5	2.4	2.1	1.8	1.2	0.58	0.32	0.22	0.16
	e	0.0	0.15	0.008	0.058	0.022	0.022	0.34	4.7	3.1	5.9	6.2

TABLE 5.2. (Contd.)

Direction		Boundary	Distance, miles									
			0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	a	5.2	5.2	9.4	8.7	7.3	6.2	4.1	2.0	1.1	0.73	0.53
	b	7.5	7.5	14.0	14.0	12.0	10.0	6.7	3.3	1.8	1.2	0.91
	c	0.0	0.0	1.2	3.4	0.35	0.0	350.	140.	38.0	29.0	180.
	d	1.2	1.2	2.2	2.1	1.8	1.6	1.0	0.51	0.28	0.19	0.14
	e	0.0	0.0	0.008	0.025	0.003	0.0	5.2	4.1	2.1	2.4	20.0
SSW	a	3.2	3.3	5.9	5.5	4.6	3.9	2.6	1.3	0.69	0.46	0.33
	b	4.7	4.7	9.0	8.6	7.4	6.3	4.2	2.1	1.2	0.77	0.57
	c	0.0	0.0	0.72	0.26	42.0	18.0	45.0	12.0	59.0	16.0	110.
	d	0.73	0.73	1.4	1.3	1.1	0.97	0.65	0.32	0.18	0.12	0.088
	e	0.0	0.0	0.008	0.003	0.56	0.29	1.1	0.58	5.2	2.0	19.0
SW	a	3.7	3.8	7.4	6.9	5.8	4.9	3.2	1.6	0.87	0.58	0.42
	b	5.9	5.9	11.0	11.0	9.3	7.9	5.3	2.6	1.4	0.97	0.72
	c	0.0	0.0	0.0	0.0	4.5	11.0	28.0	52.0	24.0	38.0	23.0
	d	0.92	0.92	1.8	1.7	1.4	1.2	0.82	0.40	0.22	0.15	0.11
	e	0.0	0.0	0.0	0.0	0.048	0.14	0.53	2.0	1.7	3.9	3.2
WSW	a	3.3	3.4	6.4	5.9	5.0	4.2	2.8	1.4	0.75	0.50	0.36
	b	5.1	5.1	9.8	9.4	8.0	6.8	4.5	2.2	1.3	0.84	0.62
	c	0.0	0.0	0.0	0.0	2.0	1.5	3.0	45.0	11.0	75.0	22.0
	d	0.79	0.79	1.5	1.4	1.2	1.1	0.70	0.35	0.19	0.13	0.090
	e	0.0	0.0	0.0	0.0	0.025	0.022	0.067	2.0	0.88	8.9	3.5
W	a	3.8	3.7	6.8	6.3	5.3	4.5	3.0	1.4	0.80	0.53	0.39
	b	5.5	5.5	10.0	10.0	8.6	7.3	4.9	2.4	1.3	0.89	0.66
	c	0.0	0.0	0.31	1.4	3.7	0.22	390.	18.0	120.	140.	160.
	d	0.85	0.85	1.6	1.5	1.3	1.1	0.75	0.37	0.21	0.14	0.10
	e	0.0	0.0	0.003	0.014	0.043	0.003	8.0	0.80	9.1	15.0	25.0
WNW	a	3.7	3.8	6.6	6.0	5.0	4.2	2.8	1.4	0.75	0.50	0.36
	b	5.1	5.1	9.8	9.4	8.0	6.8	4.6	2.3	1.3	0.84	0.62
	c	0.0	0.0	0.0	0.28	4.7	0.55	32.0	16.0	42.0	38.0	67.0
	d	0.79	0.79	1.5	1.5	1.2	1.1	0.71	0.35	0.19	0.13	0.096
	e	0.0	0.0	0.0	0.007	0.058	0.008	0.71	0.73	3.4	4.5	11.0
NW	a	6.3	6.3	11.0	10.0	8.8	7.5	4.9	2.4	1.3	0.88	0.65
	b	9.1	9.1	17.0	17.0	14.0	12.0	8.1	4.0	2.2	1.5	1.1
	c	0.0	0.0	1.4	2.3	57.0	5.9	48.0	58.0	28.0	60.0	53.0
	d	1.4	1.4	2.7	2.6	2.2	1.9	1.3	0.62	0.34	0.23	0.17
	e	0.0	0.0	0.008	0.014	0.40	0.049	0.59	1.5	12.0	4.1	4.8
NNW	a	6.2	6.3	10.0	9.4	7.9	6.7	4.4	2.1	1.2	0.78	0.57
	b	8.1	8.3	15.0	15.0	13.0	11.0	7.2	3.6	2.0	1.3	0.98
	c	0.0	0.24	1.2	3.3	1.8	3.9	24.0	100.0	260.0	100.0	820.
	d	1.3	1.3	2.4	2.3	2.0	1.7	1.1	0.51	0.31	0.21	0.15
	e	0.0	0.003	0.008	0.022	0.014	0.036	0.33	2.9	13.0	7.9	84.0

Total = 160 man-rem/yr.

(1) Doses are to critical organs, other doses are expected to be <critical organ dose.

(2) a. Dose from halogens + particulates, mrem/yr x 10^4.
 b. Dose from noble gases, mrem/yr x 10^2.
 c. Man rem/yr x 10^3.
 d. Dispersion factor (K_c) x 10^7. K_c = 1/D from eq. 5.73 of "Meteorology and Atomic Energy", TID-24190, U. S. Atomic Energy Commission, Washington, D. C. (1968).
 e. Sector population, in thousands.

TABLE 5.3. Population Doses due to Airborne Releases from Dresden Unit 1[1]

Direction	[2]	Boundary	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
		Distance, miles										
N	a	38.0	41.0	68.0	56.0	44.0	36.0	22.0	9.9	5.3	3.5	2.5
	b	11.0	12.0	20.0	16.0	13.0	11.0	6.5	3.0	1.6	1.0	0.77
	c	0.0	0.0	0.060	0.13	0.33	12.0	1.9	51.0	250.	96.0	230.
	d	2.9	3.2	5.1	4.3	3.4	2.7	1.7	0.76	0.41	0.27	0.20
	e	0.0	0.0	0.003	0.008	0.025	1.1	0.30	17.0	160.	91.	300.
NNE	a	38.0	42.0	69.0	57.0	45.0	37.0	22.0	10.0	5.4	3.5	2.6
	b	11.0	12.0	20.0	17.0	13.0	11.0	6.6	3.0	1.6	1.1	0.78
	c	0.0	0.0	0.061	0.42	0.65	2.7	28.0	59.0	160.	590.	900.
	d	2.9	3.2	5.2	4.3	3.4	2.8	1.7	0.77	0.42	0.28	0.20
	e	0.0	0.0	0.003	0.025	0.049	0.25	4.2	20.0	97.0	560.	1100.
NE	a	41.0	45.0	74.0	61.0	49.0	39.0	24.0	11.0	5.8	3.8	2.7
	b	12.0	13.0	22.0	18.0	14.0	12.0	7.0	3.2	1.7	1.1	0.84
	c	0.0	0.0	0.30	7.2	26.0	6.7	25.0	400.	98.0	980.	1900.
	d	3.1	3.4	5.6	4.6	3.7	3.0	1.8	0.83	0.45	0.30	0.22
	e	0.0	0.0	0.014	0.40	1.8	0.58	3.50	120.0	57.0	860.0	2300.
ENE	a	28.0	31.0	51.0	42.0	34.0	27.0	17.0	7.5	4.0	2.6	1.9
	b	8.4	9.2	15.0	12.0	9.9	8.0	4.9	2.2	1.2	0.79	0.58
	c	0.0	0.074	0.12	0.0	0.0	0.0	4.0	34.0	40.0	670.	440.
	d	2.2	2.4	3.9	3.2	2.6	2.1	1.3	0.57	0.31	0.21	0.15
	e	0.0	0.008	0.008	0.0	0.0	0.0	0.82	15.0	34.0	840.	840.
E	a	43.0	47.0	77.0	64.0	51.0	41.0	25.0	11.0	6.0	4.0	2.9
	b	13.0	14.0	23.0	19.0	15.0	12.0	7.4	[illegible]	1.8	1.2	0.88
	c	0.0	0.31	0.0	0.15	0.0	0.097	10.0	15.0	28.0	100.	86.0
	d	3.3	3.6	5.9	4.9	3.9	3.1	1.9	0.87	0.47	0.31	0.23
	e	0.0	0.022	0.0	0.008	0.0	0.008	1.4	4.4	15.0	87.0	98.0
ESE	a	36.0	40.0	65.0	54.0	43.0	35.0	21.0	9.5	5.1	3.3	2.4
	b	11.0	12.0	19.0	16.0	13.0	10.0	6.2	2.8	1.5	1.0	0.74
	c	0.0	0.29	1.0	0.35	0.038	0.0	3.6	5.0	9.9	8.7	10.0
	d	2.8	3.0	5.0	4.1	3.3	2.7	1.6	0.73	0.40	0.26	0.19
	e	0.0	0.025	0.054	0.022	0.003	0.0	0.57	1.8	6.5	8.6	14.0
SE	a	34.0	38.0	61.0	51.0	40.0	33.0	20.0	9.0	4.8	3.2	2.3
	b	10.0	11.0	18.0	15.0	12.0	9.6	5.9	2.7	1.4	0.95	0.70
	c	0.0	0.28	5.5	9.0	6.0	1.2	27.0	10.0	93.0	12.0	2.7
	d	2.6	2.9	4.7	3.9	3.1	2.5	1.5	0.69	0.37	0.25	0.18
	e	0.0	0.025	0.30	0.60	0.30	0.12	4.6	3.8	65.0	13.0	3.8
SSE	a	24.0	27.0	44.0	36.0	29.0	23.0	14.0	6.4	3.4	2.2	1.6
	b	7.1	7.8	13.0	11.0	8.4	6.8	4.2	1.9	1.0	0.67	0.49
	c	0.0	1.2	0.10	0.62	0.19	0.15	1.4	8.9	3.1	4.0	3.1
	d	1.8	2.0	3.3	2.7	2.2	1.8	1.1	0.49	0.26	0.17	0.13
	e	0.0	0.15	0.008	0.058	0.022	0.022	0.34	4.7	3.1	5.9	6.2

TABLE 5.3 (Contd.)

Direction		Boundary	Distance, miles 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	a	21.0	23.0	38.0	32.0	25.0	20.0	12.0	5.6	3.0	2.0	1.4
	b	6.3	6.9	11.0	9.3	7.4	6.0	3.7	1.7	0.90	0.59	0.44
	c	0.0	0.0	0.090	0.23	0.022	0.0	19.0	6.9	1.8	1.4	8.8
	d	1.6	1.8	2.9	2.4	1.9	1.6	0.95	0.43	0.23	0.15	0.11
	e	0.0	0.0	0.008	0.025	0.003	0.0	5.2	4.1	2.1	2.4	20.0
SSW	a	13.0	15.0	24.0	20.0	16.0	13.0	7.8	3.5	1.9	1.2	0.89
	b	3.9	4.3	7.0	5.8	4.7	3.8	2.3	1.0	0.56	0.37	0.27
	c	0.0	0.0	0.056	0.018	2.6	1.1	2.5	0.60	2.9	0.75	5.1
	d	1.0	1.1	1.8	1.5	1.2	0.97	0.59	0.27	0.15	0.096	0.070
	e	0.0	0.0	0.008	0.003	0.56	0.29	1.1	0.58	5.2	2.0	19.0
SW	a	17.0	19.0	30.0	25.0	20.0	16.0	9.8	4.4	2.4	1.6	1.1
	b	4.9	5.4	8.9	7.4	5.9	4.7	2.9	1.3	0.71	0.47	0.34
	c	0.0	0.0	0.0	0.0	0.28	0.68	1.5	2.6	1.2	1.8	1.1
	d	1.3	1.4	2.3	1.9	1.5	1.2	0.75	0.34	0.18	0.12	0.089
	e	0.0	0.0	0.0	0.0	0.048	0.14	0.53	2.0	1.7	3.9	3.2
WSW	a	14.0	16.0	26.0	22.0	17.0	14.0	8.4	3.8	2.0	1.3	0.97
	b	4.3	4.7	7.7	6.4	5.0	4.1	2.5	1.1	0.61	0.40	0.30
	c	0.0	0.0	0.0	0.0	0.13	0.090	0.17	2.3	0.54	3.6	1.0
	d	1.1	1.2	2.0	1.6	1.3	1.1	0.64	0.29	0.16	0.10	0.079
	e	0.0	0.0	0.0	0.0	0.025	0.022	0.067	2.0	0.88	8.9	3.5
W	a	15.0	17.0	28.0	23.0	18.0	15.0	9.0	4.1	2.2	1.4	1.0
	b	4.6	5.0	8.2	6.8	5.4	4.4	2.7	1.2	0.65	0.43	0.32
	c	0.0	0.0	0.025	0.095	0.23	0.013	21.0	0.93	5.9	6.7	7.9
	d	1.2	1.3	2.1	1.8	1.4	1.1	0.69	0.31	0.17	0.11	0.82
	e	0.0	0.0	0.003	0.014	0.043	0.003	8.0	0.80	9.1	15.0	25.0
NW	a	15.0	16.0	26.0	22.0	17.0	14.0	8.4	3.8	2.0	1.3	0.97
	b	4.3	4.7	7.7	6.4	5.1	4.1	2.5	1.1	0.61	0.41	0.30
	c	0.0	0.0	0.0	0.019	0.29	0.033	1.8	0.83	2.1	1.8	3.2
	d	1.1	1.2	2.0	1.6	1.3	1.1	0.65	0.29	0.16	0.10	0.077
	e	0.0	0.0	0.0	0.003	0.058	0.008	0.71	0.73	3.4	4.5	11.0
WNW	a	26.0	28.0	46.0	38.0	30.0	25.0	15.0	6.8	3.6	2.4	1.7
	b	7.6	8.3	14.0	11.0	9.0	7.3	4.4	2.0	1.1	0.72	0.53
	c	0.0	0.0	0.11	0.16	3.6	0.36	2.6	2.9	13.0	2.9	2.5
	d	2.0	2.2	3.5	2.9	2.3	1.9	1.1	0.52	0.28	0.19	0.14
	e	0.0	0.0	0.008	0.014	0.40	0.049	0.59	1.5	12.0	4.1	4.8
NNW	a	23.0	25.0	41.0	34.0	27.0	22.0	13.0	6.0	3.2	2.1	1.5
	b	6.7	7.4	12.0	10.0	8.0	6.5	3.9	1.8	0.97	0.64	0.47
	c	0.0	0.022	0.097	0.22	0.11	0.23	1.3	5.2	13.0	5.1	39.0
	d	1.7	1.9	3.1	2.6	2.1	1.7	1.0	0.46	0.25	0.17	0.12
	e	0.0	0.003	0.008	0.022	0.014	0.036	0.33	2.9	13.0	7.9	84.0

Total = 7700 man-rem/yr.

(1) Doses are to critical organs, other doses are expected to be <critical organ dose.

(2) a. Dose from halogens + particulates, mrem/yr x 10^4.

b. Dose from noble gases, mrem/yr.

c. Man rem/yr.

d. Dispersion factor (K_c) x 10^7. K_c = 1/D from eq. 5.73 of "Meteorology and Atomic Energy", TID-24190, U. S. Atomic Energy Commission, Washington, D. C. (1968).

e. Sector population, in thousands.

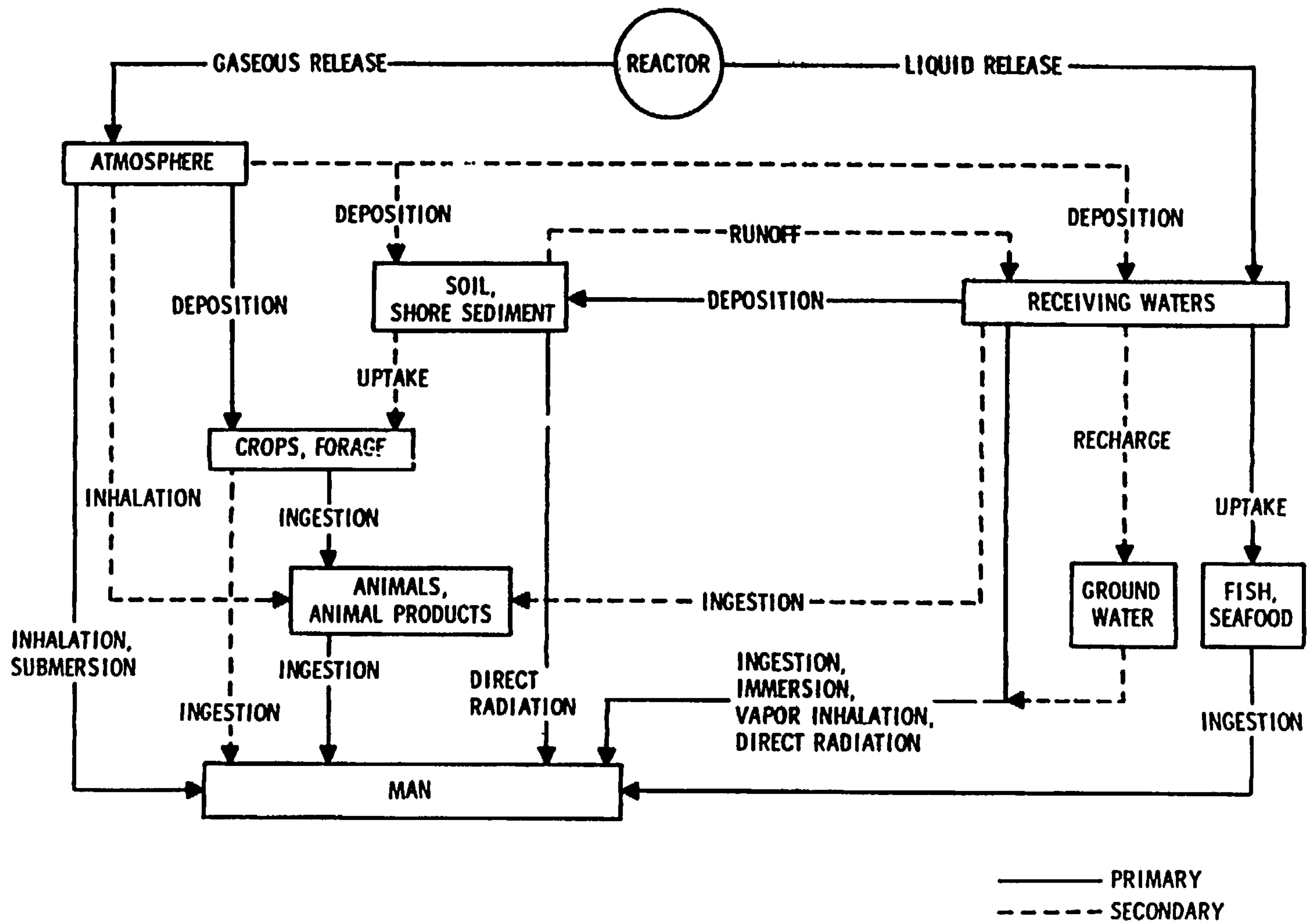

Fig. 5.1. Radiological Pathways to Man

TABLE 5.4. Cumulative Population, Cumulative Annual Dose, and Average Dose due to Airborne Releases from the Station

Radial Distance from Plant, miles	Cumulative Population	Cumulative Population Dose man-rem/yr		Average Individual Dose, mrem/yr	
		1	2 & 3	1	2 & 3
0-1	230	2.1	0.023	9.2	0.10
1-2	657	9.6	0.12	15.0	0.18
2-3	1862	28	0.39	15.0	0.21
3-4	5426	69	1.0	13.0	0.19
4-5	8048	93	1.4	12.0	0.18
5-10	40330	240	4.2	6.0	0.10
10-20	245700	850	16.0	3.4	0.066
20-30	727700	1600	31.0	2.1	0.042
30-40	3239000	4000	82.0	1.3	0.025
40-50	8070000	7700	160.0	0.96	0.020

distribution for the area is then used to determine the man-rem received. Instead of the X/Q concept, the Staff has employed the unitless concentration ratio K_c, to express the dispersion characteristics from a multi-source Station such as Dresden.

Direct and indirect doses to man from the Station via waterborne radionuclides are given in Table 5.5. These include doses to permanent residents of the area (e.g., via public water supplies at distances up to 50 miles from the Station), to temporary residents, hunters, anglers, boaters, swimmers, etc., and to consumers of foods produced in the area. The maximum cumulative annual dose received by any member of the permanent population via normal liquid releases from Units 2 and 3 would be less than 0.2 mrem. Corresponding population dose would be less than 0.5 man-rem/yr.

The dose due to the combined releases of Units 1, 2, and 3 was computed assuming dilution flow from all three units. The resultant maximum cumulative annual dose received by any member of the permanent population from the Station would be less than 0.25 mrem with the corresponding population dose being less than 1 man-rem/yr.

Liquid dispersion computations of Station releases were done using the methods described in Reference 9. These techniques take into account: the chemical and decay characteristics of the effluent nuclides; the radiobiological, ecological, bioaccumulation, and trophic parameters of the critical organisms in the area, including man; the hydrology, geology and benthic characteristics of the area; the dietary, agricultural and recreational parameters; and meteorological parameters where these affect dose levels in the geosphere or hydrosphere.

Direct dose rates from the Station will be less than 1 mrem/yr at the closest approach to the Station. This dose drops off very rapidly with distance, however, so that the total annual population dose from this source will be less than 0.1 man-rem. This source is essentially independent of Station releases.

5.4.1 Evaluation of Radiological Impact

Some perspective may be gained by comparing the doses attributable to this Station with those from the natural background and from medical diagnostic radiation. The natural-radiation background includes contributions from cosmic rays, cosmic-ray-produced tritium and carbon-14 in air and water, uranium- and thorium-bearing soils, and radioactive potassium within the human body. These sources contribute about 135 millirem

TABLE 5.5. Population Doses due to Liquid Releases from Unit 1, and Units 2 and 3

			Dose,[b] mrem/yr for Indicated Units									
			Total Body		GI Tract		Thyroid		Bone		Critical Organ	
Pathway	Population Type	Population[a] at Risk, Man-years/yr	1	2 & 3	1	2 & 3	1	2 & 3	1	2 & 3	1	2 & 3
Tap water	River intakes	0	1.7(-2)	2.2(-2)	1.3(-2)	1.8(-2)	6.9(-2)	8.8(-2)	2.6(-2)	4.3(-2)	9.5(-2)	1.2(-1)
Dietary	Commercial	8.1(+6)	7.7(-6)	9.9(-6)	5.9(-6)	8.1(-6)	3.1(-5)	4.0(-5)	1.2(-5)	1.9(-5)	4.3(-5)	5.4(-5)
Dietary	Sport	2.0(+3)	2.7(-3)	3.3(-3)	7.3(-4)	9.2(-4)	4.7(-4)	6.0(-4)	3.6(-3)	7.6(-3)	3.6(-3)	7.6(-3)
Direct	Recreational	8.0(+3)	2.1(-4)	3.0(-4)	2.1(-4)	3.0(-4)	2.1(-4)	3.0(-4)	2.1(-4)	3.0(-4)	2.1(-4)	3.0(-4)
Immersion	Recreational	8.0(+3)	1.4(-4)	1.8(-4)	1.4(-4)	1.8(-4)	1.4(-4)	1.8(-4)	1.4(-4)	1.8(-4)	1.4(-4)	1.8(-4)
Inhalation	Recreational	8.0(+3)	6.3(-7)	3.8(-6)	6.3(-7)	3.8(-6)	6.3(-7)	3.8(-6)	6.3(-7)	3.8(-	6.3(-7)	3.8(-6)
Total risk, man-rem/yr			0.071	0.078	0.052	0.072	0.25	0.33	0.11	0.17	0.36	0.46

[a] Example: 8.1(+6) = 8.1×10^6

[b] Doses from Unit 1 assume no dilution flow from Units 2 and 3. Doses from Units 2 and 3 assume no dilution flow from Unit 1.

per year per individual in Illinois. However, it is quite variable from place to place, depending mainly on altitude above sea level and the nature of the local soil. In the U. S., it ranges from about 60 to about 250 millirem per year. For the 8.1 million population projected within a 50 mile radius of the Dresden Station (1980), this amounts to a total population dose of about 1,100,000 man-rem/yr. The results of a Public Health Service survey reported in 1972[13] indicated that the genetically significant dose to the population averaged about 72 millirem per year per individual from diagnostic radiation. This would contribute about 500,000 man-rem/yr to the population considered here. Thus, total population dose attributed to the routine operation of Unit 1, and Units 2 and 3 (7900 man-rem/yr) is very small (about 0.5%) compared with the doses from natural background and medical diagnostic radiation, and the dose due to Units 2 and 3 alone (160 man-rem/yr) is extremely small. Although the combined gaseous effluent doses from the Station are small, the doses due to Unit 1 are about 50 times greater than from Units 2 and 3. In order to reduce these emissions Commonwealth Edison Company intends to install a modified off-gas system to reduce the Unit 1 off-gas releases to approximately the off-gas release levels of either Unit 2 or 3.[52] Present plans call to complete installation of this system during an extended outage planned for Unit 1 in the first half of 1975.[14] These low levels of population exposure can only be achieved by completion of the modified off-gas system and the modified liquid waste system. The applicant shall complete these modifications as soon as practical.

5.4.2 Transportation of Radioactive Material

a. New Fuel

Since the nuclear radiation and heat emitted by unirradiated fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 10 truck shipments per year, with two drivers for each vehicle, the total dose would be about 0.02 man-rem per year. The radiation level associated with each truckload of new fuel will be less than 0.1 mrem/hr at 6 feet from the truck. A member of the general public who spends three minutes at an average distance of three feet from the truck might receive a dose of 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

b. Irradiated Fuel

Based on actual radiation levels experienced with shipments of irradiated fuel elements, the Staff estimates the radiation level at three feet from the truck or rail car will be about 25 mrem/hr. Two truck drivers driving the 870-mile trip to Barnwell, S.C. will probably spend no more than about one hour outside the truck at an average distance of three feet from the cargo compartment and about 20 hours in the cab. Under these conditions, each truck driver could receive about 30 mrem from each shipment. For the 80 shipments by truck during the year with two drivers on each vehicle, the total dose would be about 4.8 man-rem/yr.

The train brakemen are likely to remain only a few minutes in the vicinity of the rail car for an average exposure of about 0.5 millirem per shipment. Assuming 10 different brakemen involved along the route, the cumulative dose for nine shipments during the year is estimated to be about 0.45 man-rem.

A member of the general public who spends three minutes at an average distance of three feet from the truck or rail car might receive a dose of as much as 1.3 millirem. If 10 persons were so exposed per shipment, the total annual dose for the nine shipments by rail would be about 0.12 man-rem, and for the 80 shipments by truck, about 1.04 man-rem. Approximately 261,000 persons who reside along the 870-mile route over which the irradiated fuel is transported might receive an annual dose of about 1.4 man-rem. The regulatory radiation level limit of 10 mrem/hr at a distance of six feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and one half mile on both sides of the shipping route. It was assumed that the shipment would travel 200 miles per day and the population density would average 300 persons per linear mile along the route.

The rate of release of heat to the air from each cask will vary from about 10 kilowatts for truck casks to about 70 kilowatts for rail casks or from about 35,000 to 250,000 Btu/hr. This might be compared to the rate at which waste heat is released from a 100 horsepower truck engine operating at full power, which is about 50 kilowatts or 180,000 Btu/hr. Because the amount of heat is small and is being released over the entire transportation route, no appreciable effect on the environment will result.

5.4.3 Solid Radioactive Waste

Under normal conditions, the individual truck driver might receive as much as 15 millirem per shipment. Assuming 46 shipments per year, if the same driver were to drive all truckloads in a year, he could receive an estimated dose of about 690 millirem during the year. The cumulative dose to all drivers for the year, assuming two drivers per vehicle, would be about 1.4 man-rem.

A member of the general public who spends three minutes at an average distance of three feet from the truck might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the cumulative dose for 46 shipments by truck would be about 0.6 man-rem. Approximately 24,000 persons who reside along the 80-mile route over which the solid radioactive waste is transported might receive a cumulative annual dose of about .06 man-rem. These doses were calculated for persons in an area between 100 feet and one half mile on either side of the shipping route, assuming 300 persons per linear mile, 10 mrem/hr at six feet from the vehicle, and the shipment traveling 200 miles per day.

5.5 NONRADIOLOGICAL EFFECTS ON ECOLOGICAL SYSTEMS

The nonradiological environmental impacts of the Station are grouped, for ease of discussion, under the following headings:

- Intake effects
- Thermal discharge effects
- Cooling lake and spray canal effects
- Transmission line effects
- Chemical discharge effects

5.5.1 Intake Effects

a. Entrainment

Entrained in the cooling water supply from the Kankakee River are drift organisms, phytoplankton, zooplankton, fish eggs, larvae, and fry, all of which are unable to swim away from the intake and are small enough to be drawn into the condensers through the traveling screens. These organisms will therefore be exposed to heat, mechanical stress, and chlorine. Under normal power plant operation such treatment has been shown to destroy or depress 15 to 50% of phytoplankton productivity.[15,16] Stimulation of phytoplankton photosynthesis under certain warm water conditions appeared to be nullified by the presence of chlorine in the water.[15,16] Zooplankton survival during condenser passage has been studied at several power plants. Zooplankton did not survive the once-through cooling system at a ΔT of 8.9°C (16°F) on the Green River in Kentucky (river temperature was about 82°F), but population volume recovered downstream, probably because of seeding by organisms bypassing the plant, followed by accelerated reproduction in the warm mixed river.[17]

A decrease in hatchability of zooplankton eggs and a 17-19% mortality of copepods and cladocerans due to condenser passage have been documented.[17] Survival of fish larvae and juveniles during condenser passage appears to be related to acclimation temperature, ΔT of the water, and length of time of exposure.[18] No fry of nine species of fish entrained in the condenser cooling water of a nuclear power plant on the Connecticut River survived passage to the lower end of the plant's mile-long discharge canal when temperatures were above 30°C (86°F).[19] The temperature of the intake water at Dresden can be as high as 86°F (30°C), as indicated in Table 2.6. For open cycle operation, the temperature of the water at the condenser exit may be as high as 106°F (about 42°C) during full-power operation. The resulting loss of organisms will have a negligible effect on the Kankakee River, since they occur at the mouth of the river. The effects on the Illinois River, however, cannot be neglected, and the loss of fish larvae and juveniles could contribute to a diminished fish population (species and numbers) in the Dresden Pool, and perhaps further downstream.

The Station's source of condenser cooling water is the Kankakee River (a relatively clean river, compared to the Illinois and Des Plaines Rivers), which supports a variety of sport and rough fish (see Section 2.7). The requirement for cooling water when Units 2 and 3 are operating on open cycle is approximately 976,000 gpm, in addition to the 166,000 gpm for Unit 1.[8] This total exceeds the seven-day, two-year recurrence low flow of the Kankakee at Wilmington, Illinois (see Section 2.7), and is about 67% of the average flow rate at Wilmington, which indicates that during periods of low flow all of the Kankakee and some of the Des Plaines River water will pass through the Station's cooling system before it is discharged to the Illinois River. This major diversion of Kankakee River water could result in a significant loss of the biota of the Kankakee River at its mouth. However, this condition will be substantially reduced when closed-cycle operation begins.

Under closed-cycle operation, about 4% (assuming average river flow) of the Kankakee River will be diverted through the Units 2 and 3 condensers. Assuming that all entrained biota will be killed under closed-cycle operation, this will amount to about a 4% loss of small organisms from the Kankakee flow into the Illinois. Some of the drift organisms and zooplankton killed will be used as fish food. Phytoplankton destruction will not affect the Illinois River ecosystem since this river as a whole supports a large phytoplankton population. During the extremely low river flows (10-year recurrence interval), up to 35% of the Kankakee River will flow through Dresden 2 and 3. Under these conditions, phytoplankton populations in the Dresden

Pool could be measurably reduced, but will recover when flow returns to normal. Such reduction in phytoplankton numbers may at times be beneficial to the Dresden Pool, particularly during the low-flow periods when the phytoplankton numbers may be large enough to cause rapid depletion of dissolved oxygen by algal respiration and decomposition.

Entrainment of biota by Unit 1 (a once-through system) will result in about a 20% loss of phytoplankton productivity and populations of zooplankton and drift organisms. In the cooling water this results in about a 2% loss from the Kankakee River, assuming average flow. This loss should be recovered downstream. Fish larvae at sensitive stages of development will likely be killed, but as mentioned in Section 2.7, the presence of about a dozen species of fish in the cooling lake indicates that a proportion of fish, either as eggs, larvae, or juveniles, can survive entrainment in a once-through system.

The Staff concludes that entrainment effects of closed-cycle operation of Dresden 2 and 3, even when compounded with the effects of Unit 1, will cause no irreversible damage to the Illinois River. When flow of the Kankakee River is extremely low, populations of juvenile fish, zooplankton and phytoplankton in the Dresden Pool may decrease due to Station operation, but this should cause no long-term adverse effects on the river as a whole.

b. Impingement

Fish from the Kankakee River (during either closed- or open-cycle operation) may be drawn to the cooling water intake and be injured or killed by impingement on the bar racks or traveling screens. Data from the operation of Indian Point Nuclear Generating Plant Unit 1 indicate that the number of fish killed on traveling screens was considerably reduced when the intake velocity was decreased from 1.2 to 0.8 feet per second (see Fig. 5.2).[20] The maximum water intake velocity at the bar racks at the Dresden Units 2 and 3 is 0.6 foot per second and the velocity at the traveling screens is 1.85 feet per second.[8] (Velocities at the bar racks and traveling screens of Unit 1 are about 0.5 foot per second). Most healthy adult fish will be able to swim away from the bar racks and re-enter the river, but juveniles may be drawn through the bars and killed on the screens of Units 2 and 3. Most fish populations can stand a certain harvest rate, and loss of fish through the predation of the traveling screens can be considered part of this harvest. A limited study by the Applicant (see Table 5.6) indicates that about 400 to 1000 fish per 24 hours may be killed by impingement on the intake screens at Dresden,

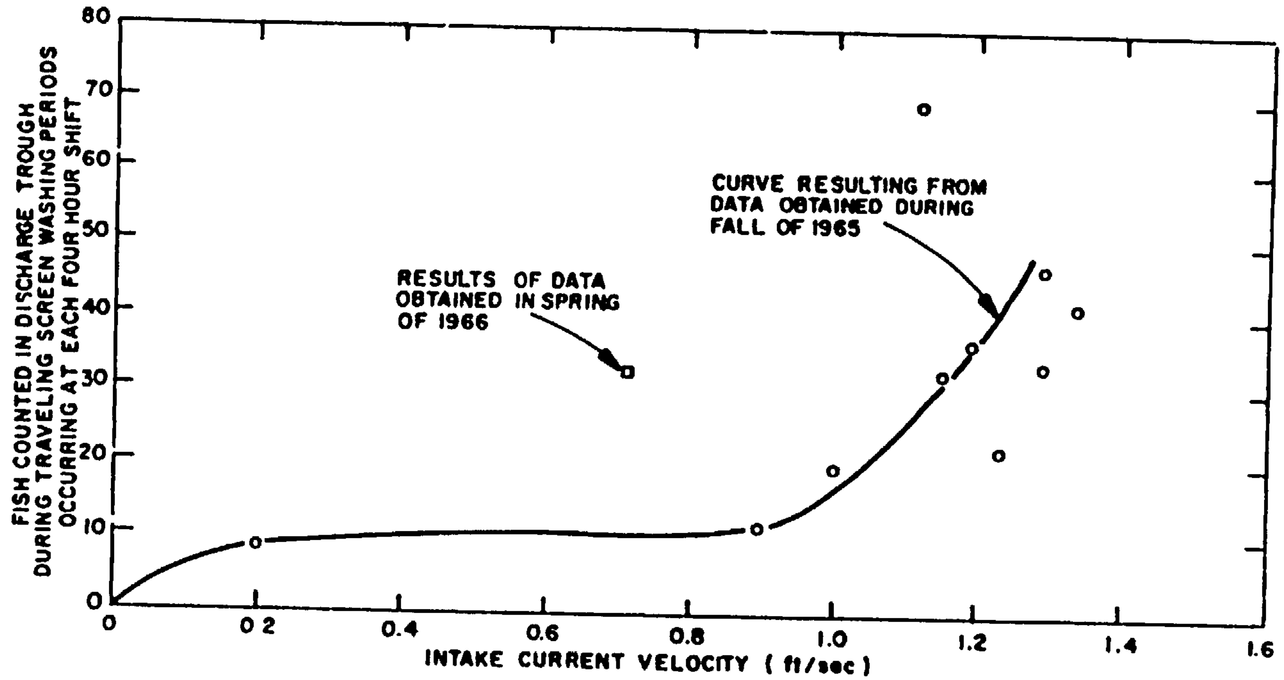

Fig. 5.2. Fish Count per Screen Washing Period vs. Average Current Velocity. From "Final Environmental Statement, Indian Point Nuclear Generating Plant, Unit 2."

TABLE 5.6. Dresden Plant Intake Screen Fish Mortality for Selected Species

Date	Water Temp, °F	Number of Pumps Operating[a]	Time, hours	Caught on Intake Screen[b]															
				Shad		Blue Gill		Pike		Sunfish		Smallmouth Bass		Sucker		Carp		Catfish	
				No.	Len.	No.	Len.	No.	Len.	No.	Len.	No.	Len.	No.	Len.	No.	Len.	No.	Len.
9/1/72	77	6	24	516	2.5	1	2.0	1	6.0	4	2.5	1	3.0	7	10.1	12	8.5	166	3.4
9/8/72	70	6	24	322	3.1	0	-	0	-	0	-	5	6.0	6	13.3	10	9.5	70	[illegible].9
9/15/72	69	5	12	487	2.3	2	2.5	0	-	0	-	0	-	0	-	2	15.0	27	5.4
9/22/72	67	5	14	576	2.7	1	3.0	2	6.0	0	-	0	-	6	11.8	0	-	15	6.8
9/29/72	57	5	18	554	2.2	1	2.0	0	-	0	-	0	-	3	12.6	4	7.7	22	3.6
						Number Caught Per 24 Hour Basis													
9/1/72				516		1		1		4		1		7		12		166	
9/8/72				322		0		0		0		5		6		10		70	
9/15/72				974		2		0		0		0		0		4		54	
9/22/72				987		2		3		0		0		10		0		26	
9/29/72				736		1		0		0		0		4		5		29	

[a]Pumping rate is 157,000 gpm Per Pump.
[b]Lengths are average values, in inches.
Source: Braidwood Station Environmental Report, Commonwealth Edison Co. (In preparation).

based on data collected during September 1972. The fish kill number that can be tolerated by the fish population at the Dresden site has not been determined, and it is therefore impossible at the present time to assign an acceptable number for such kills on any scientific basis. Present evidence is insufficient to require the Applicant to reduce intake velocities at the traveling screens to less than 1 ft/sec from the design value of 1.85 ft/sec. The Applicant, therefore, shall be required to collect fish monitoring data (see Section 6), and to show that fish killed by impingement at the Dresden traveling screens does not result in an adverse depletion of fish species and numbers in the Illinois and Kankakee Rivers. If such adverse effects are indicated, the Applicant shall be required to take corrective action, including reducing the intake velocity, if necessary.

5.5.2 Thermal Discharge Effects

a. Effects on Biota

Under conditions of average flows and maximum anticipated temperature rise in the lake, the rise in river temperature over ambient after complete mixing of the Station's effluent with the river, is calculated to be about 0.8°F under closed cycle operation. This temperature increase is not expected to be adverse, either directly to individual organisms or to the total river ecosystem. Under conditions of 7-day low flow (10 year recurrence) of the Illinois River, the temperature rise of the Dresden pool may be as high as 2.8°F. During the summer months this is not expected to have any adverse effect on the river. In winter, when preemergence of insects can occur from the increased water temperatures brought about by the Station discharge, the temperature increase of about 0.8°F postulated for average river flows should cause no adverse effects. Any insect preemergence at the temperature increase of 2.8°F above ambient postulated for low river flows, could result in insect kills due to the low air temperature. This in turn may deplete one of the sources of food for some of the fishes in the Dresden pool. The Staff concludes that this is not a serious problem since it would be a very local effect and other food sources would be available.

Before mixing, temperatures up to 22°F above ambient are expected. Fish appear to seek a preferred temperature, the value of which depends generally on their acclimation temperature.[21] Adult fish tend to avoid lethal temperatures. For example, gizzard shad, carp, buffalo fish, longnose gar, shortnose gar, channel catfish, and flathead catfish in the Wabash River were found to frequent the hottest zones (average 32°C or 90°F) of the heated effluent from a power station.[22] However, at temperatures of 35°C (95°F) and above, the fish left the area and no mortality due to excess heat was noted. Fish mortality from thermal discharges did occur when the fish were trapped in discharge canals.[17] It thus appears that as long as adult fish are free to move, they will avoid lethal temperatures. Young fish, however, may not exhibit this thermal responsiveness*, and a non-avoidance phenomenon has been observed for young white perch and striped bass.[23] Although neither of these species has been found in the Illinois River, the phenomenon may be applicable to some of the species that are in this river. With the present open-cycle mode of operation, the thermal plume appears to spread across the width of the river in a surface layer approximately two meters thick.[24] Certain species of zooplankton carried through the plume by the river flow may be subjected to stress and possible injury. It is not likely that phytoplankton will be harmed by passage through the plume at the temperatures of open-cycle operation. Under the closed-cycle mode of operation, effluent temperatures are estimated by the Staff to be up to 22°F above ambient (see Table 3.2, Section 3.4). Such temperatures may stress planktonic organisms carried through the plume, but the area of such effects will be limited to the immediate outfall. Freshwater algae are often able to endure temperatures adverse for growth by forming resting stages[25] and when temperatures return to normal, the algae recover. The temperatures found to be lethal to algae were 37-38°C (98.6-100.4°F) for large diatoms, and 44.5°C (112.1°F) for green algae.[25] Benthic organisms are apparently more sensitive to high temperatures than are algae. An extensive loss in numbers, diversity, and biomass of the benthos occurred in the Delaware River with temperatures above 90°F.[26] Data on the lethal temperatures for zooplankton species present in the Illinois River are lacking. Lethal temperatures for *Cyclcps* species have been reported as 36-38.5°C (96.8-101.3°F), and 30-44°C (86-111.2°F) for *Daphnia* species.[27] It is quite likely that the effluent temperatures at the Station under closed-cycle operation will be lethal to sensitive species and to certain life stages of some of the zooplankton in the river carried through the Station's plume particularly at the immediate outfall, but the populations are expected to recover downstream.

Figure 5.3 indicates Units 1, 2, and 3 combined effluent temperatures predicted under the closed-cycle operation of Units 2 and 3, and the lethal temperatures (upper temperature tolerance limits, thermal death point, or LD_1 were used, depending on the data available) for some of the fish species in the Illinois and Kankakee Rivers. For about 8 months of the year, the temperatures even in the immediate outfall will not be

*Defined as the ability of a fish to avoid areas in a thermal gradient which produce stressful conditions.[23]

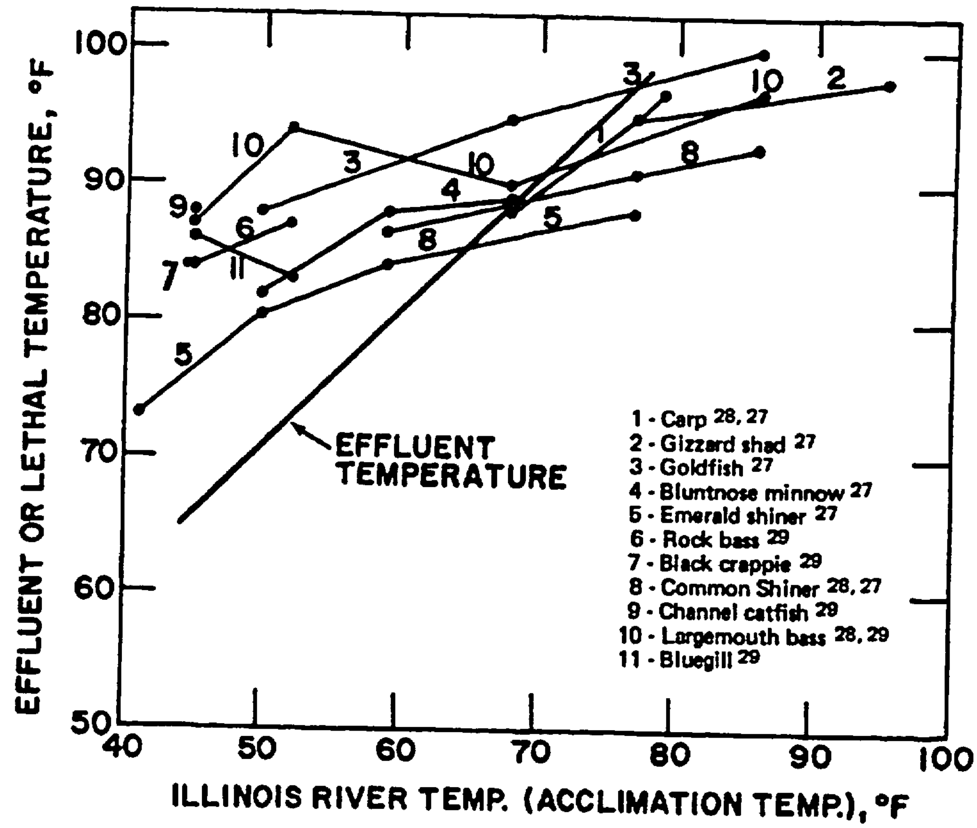

Fig. 5.3. Predicted Maximum Temperatures of the Combined Effluent from Units 1, 2 and 3 and Lethal Temperatures for Some Fishes in the Illinois and Kankakee Rivers near Dresden.

Note: The effluent temperatures are based on a constant 21°F. increase of the combined effluent from Units 1, 2 and 3 over the ambient river temperature which was assumed to be the same for the Kankakee and Illinois Rivers.

lethal to these fish, nor to other fish species expected to be present in these rivers. During June through September, however, when ambient water temperatures may be 80°F or more, effluent temperatures can exceed the upper temperature tolerance limits for these fish. Adults will likely avoid this area, and mortality due to temperature is not expected. Juveniles which do not avoid the immediate outfall will suffer stress and possible death, but these are very localized impacts and are not expected to adversely affect the total populations in the river. Possible effects of the thermal discharge during the warm months can be summarized as follows:

At the outfall:

1. Absence of benthic organisms.
2. Absence of adult fish due to avoidance behavior.
3. Absence of diatoms.
4. Mortality of some zooplankton, fish larvae, and juveniles.
5. Changes in dissolved oxygen in the water (see discussion on dissolved oxygen, below).

Within the mixing zone:

1. Scarcity of benthic organisms, with the possible exception of tubificid worms.
2. Increased phytoplankton productivity.
3. Increased predation upon fish larvae and juveniles.

For the period from about December through March, temperatures of the outfall and in the mixing zone will be sufficiently above ambient to be attractive to adult fish, which generally tend to seek their preferred temperatures. The warmer water in this area will tend to increase growth of periphyton on rocks, which will also attract fish. Residence of fish in the warm plume in winter may have the following effects:

1. Premature spawning, resulting in death of fry due to lack of proper food.

2. Exposure to concentrations of chemical discharges higher than ambient ($SO_4^=$ and Chlorine).

3. Increased metabolic rate, resulting in loss of condition (e.g. weight/length ratio). This effect has been described for certain fish species in the Connecticut River, due to residence in the discharge canal of a power plant on the river.[17]

4. Increased susceptibility to pesticides. Toxicity of pesticides to fish is generally thought to be greater at higher temperatures as a result of higher metabolic rates.[30] Although this temperature effect will be operative also in the summer, the presence of the thermal plume in winter effectively maintains elevated temperatures during a period in which fish would not normally be subjected to this stress. Pesticide analyses of the water and fish in the Illinois River near Dresden were not obtained by the Staff at the time of this writing, but the presence of organochlorine pesticide residues in all samples of mussels (average concentration 0.0331 ppm) collected from the Illinois River in 1966[31] and agricultural practices in Illinois, indicate that fish in the Illinois River would undoubtedly be exposed to water containing pesticide residues.

5. Possible incidence of gas bubble "disease" resulting in fish mortality. The formation of gas bubbles in the blood of fish can occur when water becomes supersaturated with air. This supersaturation sometimes occurs when water that is close to saturation is heated. The condition can also be brought about when a large algal bloom results in high oxygen production, or when water cascades over a dam. If the degree of supersaturation is great enough, the fish may show external symptoms of gas bubble disease such as "pop-eye", caused by bubbles in the tissue in or behind the eye. Incidence of gas bubble disease in about a dozen species of warm water fish in the heated effluent of a steam generating station has been reported.[53]

These cold weather effects may be observed under either the open- or closed-cycle systems, but the area within which such effects may occur will be very much smaller under the closed- than under the open-cycle mode of lake operation.

An additional factor that should be considered is plant shutdown during the winter. Fish resident in the thermal plume in winter, and acclimated to plume temperatures, would be subjected to cold shock resulting in death (cold-kill) if outflow of heated water should suddenly cease. Shutdown of Units 2 and/or 3 will not cause such an adverse effect, since the 2-1/2-day travel time in the cooling lake will allow a gradual decrease in water temperature. However, rapid shutdown of Unit 1, without a reduction of condenser flow, may result in cold-kill of fish resident in the plume, unless the temperature drop at the combined effluent occurs at a rate of about 2°F per hour or less.

The Staff concludes that adverse effects due to the discharge of heated water from the Station to the Illinois River may be observed at the immediate outfall which, under closed-cycle operation, will attain temperatures of approximately 20°F or more above ambient. Less severe effects may be observed up to the perimeter of the 5°F isotherm, which is estimated to cover an area less than 20 acres during low river flow conditions. (The assumptions upon which this estimate was based are discussed in Section 3.4.6). The Staff concludes that these localized impacts will have no adverse effects on the Illinois River as a whole, if the configuration, as well as the area, of the mixing zone is taken into consideration. As long as a major cross section of the river is at ambient temperature, down stream movement of planktonic organisms as well as up and down stream movement of fish will not be adversely effected by the Station's discharge.

The State of Illinois allows a mixing zone not to exceed the area of a 600-foot radius circle (equivalent to about 26 acres) of such configuration that a "reasonable zone of passage for aquatic life" is assured.[32] The U. S. Environmental Protection Agency has recently defined this zone of passage to include the National Technical Advisory Committee (Department of the Interior) recommendation that the total mixing zone, at any transect of the stream, should contain no more than 25% of the cross-sectional area and/or volume of flow of a stream (see Appendix A, page A-13). The Staff concurs in the EPA definition and will impose this condition on the Applicant. It is the opinion of the Staff that when the state standard is so vague as to lack a definition of the mixing zone, the Staff can impose a definition. When a mixing zone definition is eventually imposed by the state/USEPA, the AEC will recognize it as binding. The State of Illinois further requires that the maximum temperature rise above natural temperatures shall not exceed 5°F outside the mixing zone, nor, in the case of the Illinois River, shall maximum temperatures exceed 90°F (April to November) except for one percent of the hours in a 12-month period when the temperature may be up to but not exceed 93°F (April to November) and 63°F (December to March).[32]

According to the Illinois Natural History Survey Division at Havana, Illinois, fish in the Illinois River do not generally use the mid-river channel because of the lack of benthos, poor dissolved oxygen conditions, and disturbance brought about by dredging and barge traffic. Fish that move to and from the Kankakee, Des Plaines, and Illinois Rivers use the waters near the shores, where the shallower depths and less disturbance provide better habitat. The configuration of the mixing zone, therefore, is extremely important, since any barrier to movement of fish to and from the Kankakee River may result in depletion of populations in the upper stretches of the Illinois and possibly further downstream. Migration of certain species of warm water fish has been found to be important not only to reproduction, but also to the metabolic patterns of the fish, and hence to a river's ecological balance.[33] During July and August, temperatures of the Illinois River may be as high as 88°F or more (see Reference 13 of Section 3). Under these conditions the plume could result in water temperatures of 91°F or more across the river. These temperatures are close to the upper temperature tolerance limits* of some of the fish in the Kankakee and Illinois Rivers and may effectively block the movement of adult fish through this section of the river. Also, improvement in water quality expected in the future suggests that other fish species such as redhorse, sauger, and white sucker may become established in these rivers, and these species appear to be less tolerant of high temperatures than the present populations. Movement of carp, longnose gar, and gizzard shad will probably be unaffected unless temperatures reach 95°F or more.

The Staff concludes that as long as the 5°F plume is restricted to 25% of the cross-sectional area or volume of flow of the river, it is unlikely that the plume will span the width of the river unless it spreads out as a very thin surface layer, in which case the fish can cross this section of the river by swimming underneath the plume.

Based on the plume modeling done by the Staff in Section 3.4.6, the 25% zone of passage limit is likely to be exceeded if the discharge is through the unmodified Unit 1 discharge canal. The Applicant's studies with the University of Iowa to determine the best discharge configuration must take into account not only the size of the mixing zone but also the resulting zone of passage. The results of these studies shall be submitted to the AEC for review and approval of the final discharge design.

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*Temperature tolerance limits of fish depend, among other factors, on acclimation temperature, which in this case would be the ambient river temperature (see Fig. 5.3). In general, the higher the acclimation temperature, the higher the upper temperature tolerance limit (up to the ultimate lethal temperature), although the increases tolerated are not the same for all species of fish. For example, when the acclimation temperature is raised from 50°F to 86°F, the thermal death point of the fathead minnow goes up 9°F; raising the acclimation temperature from 41°F to 77°F results in the thermal death point of the speckled trout being elevated only 2.9°F.[28]

During 1% of the hours in a 12-month period (about four days) during which temperatures up to 93°F will be allowed by the State of Illinois, passage of some fish species may be effectively blocked if isotherms of 91°F or more cross the width of the river at the surface and to appreciable depths. This condition may occur at times in the months of July and August. Due to a paucity of data on fish movements it is presently unknown whether such temporary blockage will occur at critical periods of fish movement. The Applicant shall limit the extent of the thermal plume (5°F isotherm) to less than 25% of the cross-sectional area of the river and shall monitor the surface and vertical extent of the thermal plume for extreme and average river flows and lake blowdown temperatures (see Section 6).

b. Effects on Dissolved Oxygen

Under the present open-cycle mode of operation at Dresden, dissolved oxygen concentrations in the water are not appreciably affected by passage through the Station, insofar as accumulated data indicate.[24] Similarly, measurable reductions of dissolved oxygen in the water due to Unit 1 operation are not expected. For closed-cycle operation of Units 2 and 3, in which a smaller volume of water will be discharged at a higher temperature than under open-cycle, no data are available. Several effects of plant operation upon the dissolved oxygen concentration in the water are possible:

1. No change. Any decrease in dissolved oxygen concentration in the cooling water brought about by being heated during condenser passage and the B.O.D. of the lake will be offset by the aerating action of the spray modules, lift station, and weir.

2. An increase. The aerating effects mentioned above are sufficient to increase the dissolved oxygen in the effluent.

3. A decrease. Recirculation of the water through the plant at elevated temperatures, consumption of oxygen by algal respiration and decomposition (particularly if blooms occur), and other oxygen demanding reactions may decrease dissolved oxygen concentrations to levels which cannot be compensated for by the aerating discussed above.

The Dresden Pool generally has the lowest dissolved oxygen values of all the pools in the Illinois Waterway (see Section 2.7, Fig. 2). Further depression of dissolved oxygen would hamper the self-purification abilities of this section of the river and place additional stress on aerobic organisms in it. The concentration of dissolved oxygen in water is a function of temperature (all other conditions being equal), i.e., warmer water will hold less dissolved oxygen than cooler water. The maximum expected temperature of the hottest part of the lake is estimated to be about 120°F (see Section 3.4.5). The solubility of oxygen in water at 120°F is approximately 6 mg/l which is the minimum continuous concentration of the Illinois State Regulation (see Appendix A). Thus, it is not expected that elevated temperatures alone would reduce the oxygen level below 6 mg/l. However, oxvgen consumption in the lake could reduce this level.

The Applicant shall maintain the lake free of nuisance growths (see Section 5.5.3b) and shall monitor the dissolved oxygen in the intake and discharge canals to determine that the D.O. is not reduced below 6 mg/l due to plant operation (see Section 6). These activities will be controlled by the Environmental Technical Specifications.

5.5.3 Cooling Lake and Spray Canal Effects

Operation of the 1275-acre cooling lake and spray canals at the Station may result in the following effects:

a. Increase in Relative Humidity and Moisture

The presence of the Dresden cooling lake will increase local fogging and icing (see Section 5.1.1), but will not likely affect the general climate of the area, nor cause an increase in relative humidity of the air at the Goose Lake Nature Preserve. (The creation of the Salton Sea and Lake Mead, 300 and 175 square miles, respectively, in southwestern United States, has resulted in scarcely any change in the climate, even in the immediate vicinity of the lakes. The moisture content of the air 2000 feet from the Salton sea shore line is relatively unaffected.[34]) However, rime ice has been observed up to 1000 feet from the Dresden spray canals, indicating that moisture can be significantly increased in this area due to the spray module operation. An increase in relative humidity and the presence of free moisture in the land areas immediately adjacent to the sprays may be conducive to the occurrence of plant fungal diseases such as blight.[35] Factors which contribute to the occurrence of a blight disease include the presence of spores, non-resistant crops, poor plant vigor, and moisture. The limiting factor is often the presence of free concentration of total chlorine discharged to the river. Although the addition of chlorine to the intake water is intermittent, the closed-cycle mode of operation may result in a continuous discharge of chlorine to the river although this is unlikely.[52] Intermittent discharges (a maximum of two hours per day) of total chlorine shall not exceed 0.1 mg/l in the discharge, to protect most organisms in the Illinois River. For a continuous discharge, total chlorine shall not exceed 0.01 mg/l. The monitoring program (Section 6) will include measurements of total chlorine.

The effluent from Unit 1 also contains residual chlorine. Since this discharge does not pass through the cooling lake and spray canals, chloramines may be present in the discharge to the Illinois River. (The Applicant's study mentioned above found no free or combined chlorine in the Unit 1 discharge to the river.) A portion of any residual chlorine from Unit 1 will react with chlorine-demanding substances in the lake upon combination of the lake discharge under the closed-cycle mode of operation. This will reduce the amount of any residual chlorine in Unit 1 discharge to the river. The combined (Units 1, 2, and 3) discharge must conform to the recommendations outlined above.

Residual chlorine in the sewage discharge to the river must likewise conform to these recommendations. It may be necessary to hold up this discharge after treatment until residual chlorine is low enough to meet the limits specified above.

b. Other Chemicals

Miscellaneous chemicals added to the Station's water and their concentrations in the discharge to the Illinois River are given in Table 3.11. As far as is known none of these chemical discharges are toxic to aquatic life at the concentrations expected. The maximum short-term concentrations of 6 ppm $CaSO_4$, and 3 ppm of NaCl, $NaHCO_3$, or Na_2SO_4, are much below the 96-hr TLm of 2,980 ppm, 12,946 ppm, 8,600 ppm, and 13,500 ppm, respectively, reported for fish.[50] The lake and river water quality and biological monitoring programs (see Section 6) should detect any buildup of chemical concentrations in the water and adverse effects upon aquatic life. If such effects occur, the Applicant shall take immediate action to prevent further discharge of the offensive chemicals.

c. Gaseous Effluents

Nonradioactive gaseous effluents from the Station are listed in Table 3.12. The nitrogen oxide emissions could add approximately 2.2% to the point source emissions in the area (see Table 2.1). These emissions, however, add to the pesticide burden of the fish in the Illinois River. The most common inorganic algicide, copper sulfate, tends to accumulate in bottom sediments[36] and must not be used, if the sediments are to eventually be dredged and deposited elsewhere. Methods for the physical removal of aquatic weeds and the use of microstrainers for algae are described in Reference 36. The use of the latter at a water treatment installation on Lake Michigan results in 46 to 97% algal removal.[37]

If dredging is not to be carried out, copper sulfate in concentrations of 0.05 to 0.08 mg $CuSO_4 \cdot 5H_2O$ per liter may be used. Although these concentrations are not high enough to prevent the growth of the green algae *Chlorella pyrenoidosa*, such levels can kill certain species of blue-green algae,[54] which are the nuisance organisms that may bloom under the warm lake conditions. Since copper can be toxic to certain species of fish and invertebrates at these relatively low concentrations,[55] extreme caution must be used if this algicide is employed.

c. Accumulation of Silt

As the water flows through the lake, silt will tend to settle out and accumulate on the lake bottom. This will improve one aspect of the quality of the water discharged to the Illinois River. Conservative calculations show that the volume of deposited material over the lifetime of the plant will be a small fraction of the total volume of the lake. However, excessive silt buildup may occur at specific points such as at the lift pump discharge as a result of eddy currents, etc. Dredging to remove or redistribute this silting might be required. The Applicant does not have a program for dredging at this time. Therefore, the Applicant shall not remove any lake dredgings outside the contained area of the lake without obtaining prior Commission approval.

d. Additional Stress on Entrained Organisms

As mentioned in Section 5.5.1, biota from the Kankakee River surviving entrainment in the condenser cooling water will be subjected to further chemical and thermal stress during residence in the lake before discharge to the river. Under the open-cycle mode of operation, a majority of phytoplankton and invertebrates and a minority of fish larvae will probably survive this trip through the lake. Under the closed-cycle mode of operation, entrained organisms will be repeatedly subjected to condenser passage and higher lake temperatures, and it is likely that under these conditions few organisms other than some phytoplankton and bacteria will survive. The total number of organisms subjected to stress will be greater under the open-cycle than under the closed-cycle mode of operation (see Section 5.5.1).

e. Dispersal of Microorganisms

The water of the Kankakee River contains a number of fecal coliforms which are of interest from a human health standpoint since they serve as evidence of human fecal contamination. This number was relatively low in 1971 (see Table 2.6) and will probably remain low as long as Illinois State standards for the Kankakee River are complied with by sewage dischargers on this river. If fecal coliforms in the Station's intake water should increase several thousand-fold due to upstream discharges, dispersal of viable fecal organisms in aerosols due to the spray system at the Station may be a potential health hazard, depending on climatic conditions and the presence of pathogenic organisms in the water. (Viable fecal coliforms were found as far as 0.8 mile downwind from the trickling filter of a sewage treatment plant.[38]) The Applicant's monitoring program must, therefore, include fecal coliform and fecal streptococcus determinations in the spray canals.

5.5.4 Transmission Line Effects

Aside from the aesthetic impact and withdrawal of land along the right-of-way corridor from other (e.g., agricultural) uses, the operation of transmission lines from the Station can have at least two adverse environmental effects, the production of ozone and contamination by herbicides.

a. Production of Ozone

Ozone (O_3) can form in the air around the cylindrical conductors of high-voltage transmission lines under certain conditions, due to ionization of the air molecules. This ionization is accompanied by a glow (corona). Formation of ozone in the atmosphere also occurs naturally. In the mountains of West Virginia and Maryland, where there are no high-voltage lines, ozone levels up to 0.16 ppm have been measured.[39] The degree of ionization, hence of ozone formation, around transmission lines is dependent upon several variables, including voltage, humidity, conductor diameter, surface roughness, and spacing between conductors.[39] The Federal EPA has set an air quality standard for photochemical oxidants of 0.08 ppm as the maximum one-hour concentration not to be exceeded more than once per year (cited in Reference 39). The limit of detection of 1972 analytical instruments is about 2 ppb by volume, and presently available information indicates that the increases in ozone concentrations above ambient due to coronas from 765-kv lines are within the uncertainties of the measuring instruments.[39] Ozone produced from the 345-kv lines (Dresden 2 and 3 have five of these) would presumably be within the instrument uncertainties. No adverse effects are postulated by the Staff from the ozone produced by these transmission lines.

herbicide to 24 parts fuel oil flowed onto the stump to eliminate sprouting. The herbicide consists of either one third 2,4-D (2,4-dichlorophenyoxyacetic acid) and two thirds 2,4,5-T amine (2,4,5-trichlorophenoxyacetic acid) or straight 2,4,5-T amine. At approximately five year intervals, all young trees of tall-growing species located under conductors are basal sprayed. The same herbicides are used, and the spray is directed so that only the lower two feet of the tree is treated.

Herbicide use has several advantages over physical removal of obstructing vegetation, e.g., in areas where use of heavy equipment would damage or erode the soil and plant cover such as on steep slopes, or in areas inaccessible to vehicles. Also, herbicide use is generally less expensive than manual cutting and trimming.

The herbicides 2,4-D and 2,4,5-T are registered by the Federal EPA for use on forest and range land and on utility rights-of-way.[41]

On the other hand, there are possible environmental hazards associated with the use of these phenoxy herbicides. For example, the compounds 2,4,5-T and 2,4-D have been implicated as possible teratogens (agents capable of causing birth defects or abnormalities).[42,43] Also, the 2,4,5-T presently available from commercial sources may contain up to 0.5 ppm dioxin (2,3,7,8-tetrachloro-p-dibenzodioxin). This dioxin has been reported to be teratogenic at about 0.01 ppb (0.00001 ppm).[43]

2,4,5-T is eliminated from the soil in three to six months, but there are indications that the dioxin contaminant may accumulate in soil from one year to the next, and that a small amount of this may be absorbed by plants.[41] Although no residues of this dioxin were found in three-foot core samples from experimental plots (sensitivity of analysis was 1 ppb) of Lakeland sand receiving massive doses of 2,4,5-T,[44] heavier textured soils may tend to hold the chemical in the upper layers. In light-textured soils, leaching of the chemical into lower layers would pose the danger of contaminating ground water and aquifers.

Inadvertent damage to wildlife, crops, and other non-target species may result from drift during spray operations, or from careless application; exudation of 2,4,5-T from the roots of ash and maple has been demonstrated,[45] and suggests that transmission of this chemical can occur from plant to plant through the roots.

In view of the above, the Staff concludes that the Applicant's use of phenoxy herbicides shall include the following considerations some of which are reflected in current guidelines.[46]

1. Use of 2,4-D and 2,4,5-T herbicides shall be limited to the stump and basal applications as described by the Applicant in Reference 32 and above.

2. The use of these herbicides shall be replaced by hand trimming and cutting in conservation, recreational, and residential areas.

3. Herbicides shall not be applied immediately before, after, or during a heavy rain or irrigation of cropland along the right-of-way.

4. Herbicides shall not be applied within 100 feet of any body of water, nor in areas where contamination of water supplies is likely.

5. Treatment with herbicides shall not be more often than once a year.

6. Herbicides shall not be applied when winds are greater than 5 mph.

7. No formulation shall be used whose dioxin contamination level exceeds 0.1 ppm.

8. As soon as the Administrator of the Federal EPA issues standards for pesticide and herbicide applicators, all applications must be done by an individual meeting these standards or under his *immediate* supervision.

The Applicant shall therefore include in its Environmental Technical Specifications the criteria for the use and control of all herbicides.

5.5.5 Chemical Discharge Effects

a. Chlorine

The condenser cooling water for each unit at the Station is treated with a hypochlorite solution (see Section 3.6.3). Part of the free chlorine of this solution acts as a biocide which prevents slime accumulation in the condenser tubes. In the process, hypochlorous acid and the hypochlorite ion are converted to the chloride ion, which is relatively harmless to aquatic life. Part of the free chlorine is also converted to the chloride ion by reactions with other compounds in the water. If ammonia or compounds containing ammonia are present in the water, part of the free chlorine is converted to chloramine compounds, termed "combined chlorine." Free chlorine and chloramine compounds are toxic to aquatic life.[15,16,47-49] Chloramines have the added disadvantage of being more persistent in water than free chlorine. Any active (whether free or combined) chlorine remaining in the water after a given period of time (e.g., after passage through the Station) is termed "residual chlorine." The sum of the free and combined forms is termed "total chlorine."

At Dresden, no residual free chlorine is expected to be present in the effluent to the river from Units 2 and 3 because of reactions with compounds in the water during passage through the lake. The presence of ammonia in the water at concentrations up to 10 ppm (see Table 2.6), however, may result in concentrations of chloramines that are toxic to fish and other biota. The concentrations of these compounds that produce detrimental effects on aquatic life appear to depend primarily on the species and life stage of the organisms, on the temperature and pH of the water, and on the nature of the chemical compounds in the water.

The Applicant's current practice (see Section 3.6.2) is to maintain an average free chlorine residual of 0.5 ppm in a condenser half. To maintain such a concentration of free chlorine, the amount of hypochlorite added will depend on the concentrations of compounds in the water capable of reacting with the chlorine (e.g., chlorine-demanding substances and ammonia). It is conceivable that along with the average concentration of 0.5 ppm residual free chlorine, a combined chlorine concentration of 8 ppm or greater may occur. The concentration of total residual chlorine in a condenser half will be reduced by dilution and reaction with the water from the unchlorinated half. Further dissipation and degradation of chloramines will occur in the spray canals and passage through the lake. The concentration of total chlorine at the point of discharge to the river is difficult to estimate, since the chlorine demand and ammonia concentrations of the intake water fluctuate widely and the rate of volatilization of di- and trichloramines depends on factors such as temperature and pH, which also fluctuate. (A study made by the Applicant on July 26, 1972, indicated that no residual chlorine or chloramine was found in the effluent from Units 2 and 3. The sampling site was in the plant discharge before travel through the spray canals and lake. Measurements were made every two to five minutes after start of a chlorination period using both the amperometric titration and orthotolidine methods.) The mode of lake operation (open- or closed-cycle) will also affect the moisture, which is essential for the germination of fungal spores. Depending on climatic conditions, a blight disease could remain at a particular location (during a "dry" year) or spread over several miles (during a "wet" year). Although it is seldom that complete destruction of a crop will occur as a result of a blight disease, decreases in yield of up to 50% (usually less than 20%) can result.

At Dresden, the land area within 1000 feet immediately west of the spray canals is controlled by the Applicant and General Electric. The land east of the spray canals, between Dresden Road and the Kankakee River, is privately owned. About 20 acres of this land (according to the owner) is occasionally planted to corn, oats, wheat, or beans. This is a particularly sensitive area since it is in the direction of the prevailing winds and within about 2000 feet of the spray canals. If crops are grown, blight-resistant varieties of corn, or soybeans, would probably be suitable. Wheat and oats would be less suitable in this limited area.

Operation of the sprays will result in deposition of salt on vegetation and land within about 500 feet of the sprays due to drift. Under closed-cycle operation, concentration of salts in the lake water by a factor of about 1.3 will occur due to evaporation. Assuming an average total dissolved solids content in Kankakee River water of 360 mg/l (see Table 2.6), the drift will contain about 460 mg/l. The manufacturer has not specified the droplet size distribution of the spray modules, and the amount and distance of salt deposition can therefore not be calculated at present. On the basis of observations of icing on roads and vegetation, it is estimated that drift will not usually extend much beyond 500 feet downwind from the sprays. The Staff does not expect damage to property or vegetation due to salt in the spray drift.

b. Excessive Growth of Algae

The temperatures in the cooling lake, particularly under the closed-cycle mode of operation, may tend to favor the growth of green and blue-green algae.[36] If allowed to accumulate, unpleasant odors may be produced as the algae decompose. If oxygen concentrations in the lake water are extremely low, algal decomposition and respiration may lead to fish suffocation. If discharged to the Illinois River, dead algae and fish carcasses may further depress the dissolved oxygen in the Dresden Pool, which, as was pointed out in Section 2.7, has the least capability for assimilating wastes. Operation of the cooling lake must therefore include procedures for removal of excess algal and aquatic weed growth if such occurs. It is important that residues of any algicides used in such management must not be discharged to the river. Organic algicides, in particular, will represent only about 0.5% of the area source emissions (which exclude point sources). All other gaseous emissions are less than these values. The Staff concludes that the effects of these gaseous effluents will be negligible.

5.6 EFFECTS ON THE COMMUNITY

Except for the steam fog effect noted in Section 5.1.2, the Staff has not identified any significant adverse impact which would affect the community as a result of the continued operation of Units 2 and 3.

The increased tax base represented by the increased assessed valuation due to the addition of Units 2 and 3 will have a beneficial effect on the area's school, township, and county finances. Likewise, the many jobs created by the operation of these units will have a beneficial effect on the area's job market and income.

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6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL PROGRAMS

6.1.1 Nonradiological St...

Preoperational studies for Units 2 and 3 were carried out during the period July 1969 to June 1970. The "baseline" characteristics of the aquatic environs which will serve for future evaluations of the Station's environmental effects thus include conditions brought about by Unit 1, which has been in commercial operation since 1960 and for which no preoperational programs were carried out.

The 1969-1970 preoperational environmental study was made for the Applicant by Industrial Bio-Test Laboratories, Inc. The specific objective of the study was to determine the physical, chemical, bacteriological, and biological conditions of the Des Plaines, Kankakee, and Illinois Rivers in the vicinity of the Station during the period July 1969 to June, 1970. Fish and terrestrial studies were not included.

a. Sampling Locations

Ten sites were sampled for the physical, chemical, bacteriological, and biological parameters in August and October 1969 and in May 1970, from the Des Plaines and Kankakee Rivers above the Station site and from the Illinois River downstream to the Aux Sable River four miles below the site. An additional twelve temperature determinations were made during each sampling trip. In March 1970 seven samples for biological analyses were taken in the pool upstream of the Dresden Lock and Dam.[1] Sampling sites are indicated in Appendix E.

b. Field and Analytical Procedures

Sampling locations were determined from field observations made during previous studies conducted in 1968.[2] Various physical, chemical, bacteriological, and biological parameters were measured at each location.

Physical measurements included current velocity, water temperature, turbidity, relative humidity, air temperature, and wind speed.

Chemical measurements were conducted both in the field and laboratory. Most chemical analyses employed in this study were those given in "Standard Methods for the Examination of Water and Wastewater,"[3] Exceptions to this included metal analyses which were conducted by atomic absorption spectrophotometry. Alkalinity, pH, and dissolved oxygen (azide modification of iodometric method) were determined in the field, while other chemical analyses were conducted in the laboratory. Analytical procedures for forms of nitrogen were direct nesslerization for ammonia, phenoldisulfonic acid method for nitrates, and the diazotization method for nitrites. Soluble orthophosphate and total phosphate were determined by the stannous chloride method.

Bacteriological samples were returned to the laboratory for analysis. Coliform organisms were determined as most probable numbers (MPN)/100 ml by the multiple tube fermentation technique. The elevated temperature test (44.5°C) was used to determine fecal coliform concentrations.

Biological measurements of plankton, periphyton and benthos were made. Water samples for plankton enumeration were concentrated by means of a plankton centrifuge. In order to identify blue-green algal forms which might be lighter than water and thus lost in the centrifugation process, an unconcentrated sample was scanned and the blue-green algal population recorded. Concentrated plankton samples were examined microscopically with the aid of a Sedgwick-Rafter counting chamber and Whipple micrometer disc. The organisms present were identified, usually to genus by standard references, and counted. Bottom organisms were collected by means of a Ponar dredge, separated from the sediments by retaining them on a No. 30 sieve, and identified by standard references.

Attempts to determine periphyton growth by the use of artificial substrate samplers were abandoned as a result of problems with siltation and loss of samplers due to changing water levels and pilferage. Consequently, periphyton samples were obtained by scraping rocks and logs in representative environments for a qualitative rather than a quantitative measurement of growth.[1]

The major deficiency of the preoperational program is a lack of population dynamics data on the fish in the Illinois and Kankakee Rivers. Such information is essential in the evaluation of the significance of any fish kill by impingement on the screens.

6.1.2 Radiological Surveys

The present radiological background of the region about the Station, and the Federal and State stations within 300 km (186 miles), were described in Section 2.8. The information available from these sources extends backwards for over two decades, and is quite adequate for characterization of the radiological conditions of the region.[4]

At the Station itself, radiological surveys have been in progress for over a decade in connection with the Dresden No. 1 nuclear power facility. These include not only those done by the Applicant and his contractors, but by independent State and Federal agencies as well.[5,6] In addition, a particularly intensive monitoring program for the area has been in progress for over two decades, centered at the Argonne National Laboratory (30 miles northeast).[7] The list of sampling sites, methods, organisms, trophic chains, etc., is too extensive for inclusion here, and the reader is referred to the references cited. In any case, the data available, especially with the extensive cross-checking achievable because of the multiplicity of samplers, samples, and sampling methods, provide an adequate picture of preoperational conditions.

6.2 OPERATIONAL PROGRAMS

6.2.1 Nonradiological Studies

a. River Program

The Applicant's aquatic (river) monitoring program, begun in late 1970, is conducted by Industrial Bio-Test Laboratories, Inc. The methods used during the first year of operation of Units 2 and 3 are described below.

(1). Field and Analytical Procedures[8]

A series of biological, chemical, and physical measurements were made in the Des Plaines, Illinois, and Kankakee Rivers near the Dresden Nuclear Power Station (Figs. 6.1 and 6.2). Sampling locations were selected to represent different environmental conditions and to permit comparison of the data obtained from previous studies in the area. Sampling dates were August 11, 1970, November 12, 1970, May 18, 1971, August 11, 1971, and November 22, 1971. A separate fish collection was made on June 1, 1971.

(2). Physical and Chemical Analyses[8]

Physical and chemical measurements were made for water samples collected at locations shown in Figs. 6.1 and 6.2.

Meteorological conditions, current velocity, temperature, turbidity, alkalinity, dissolved oxygen (DO) and pH were measured at the sampling locations in the field. For laboratory analyses, water samples were collected with a lucite Kemmerer water sampler, preserved by appropriate techniques (see Table F-1 of Appendix F) and transported to the BIO-TEST facilities. Table F-1 also lists the 43 water quality parameters measured and the method of analysis employed for each. The oxygen saturation value, calculated from the temperature and dissolved oxygen tables, is also included in this table.

Measurements taken in the field and not covered in Appendix F Table F-1 were as follows: current velocities, wind direction and speed, wet- and dry-bulb air temperatures. Relative humidity was calculated. A thermal plume survey was also conducted.

(3). Benthos Measurements[8]

Benthic organisms were collected with a Ponar dredge, one grab sample being taken per sampling location (Fig. 6.1). Samples were transferred in the field immediately after collection to heavy-duty plastic bags and thoroughly mixed with enough formaldehyde solution to bring the total mixture to between 10% and 20% formalin. Analysis of the samples is described in Reference 8.

(4). Phytoplankton Measurements[8]

Phytoplankton samples were collected at stations in the Des Plaines, Kankakee, and Illinois Rivers in the vicinity of the Dresden Nuclear

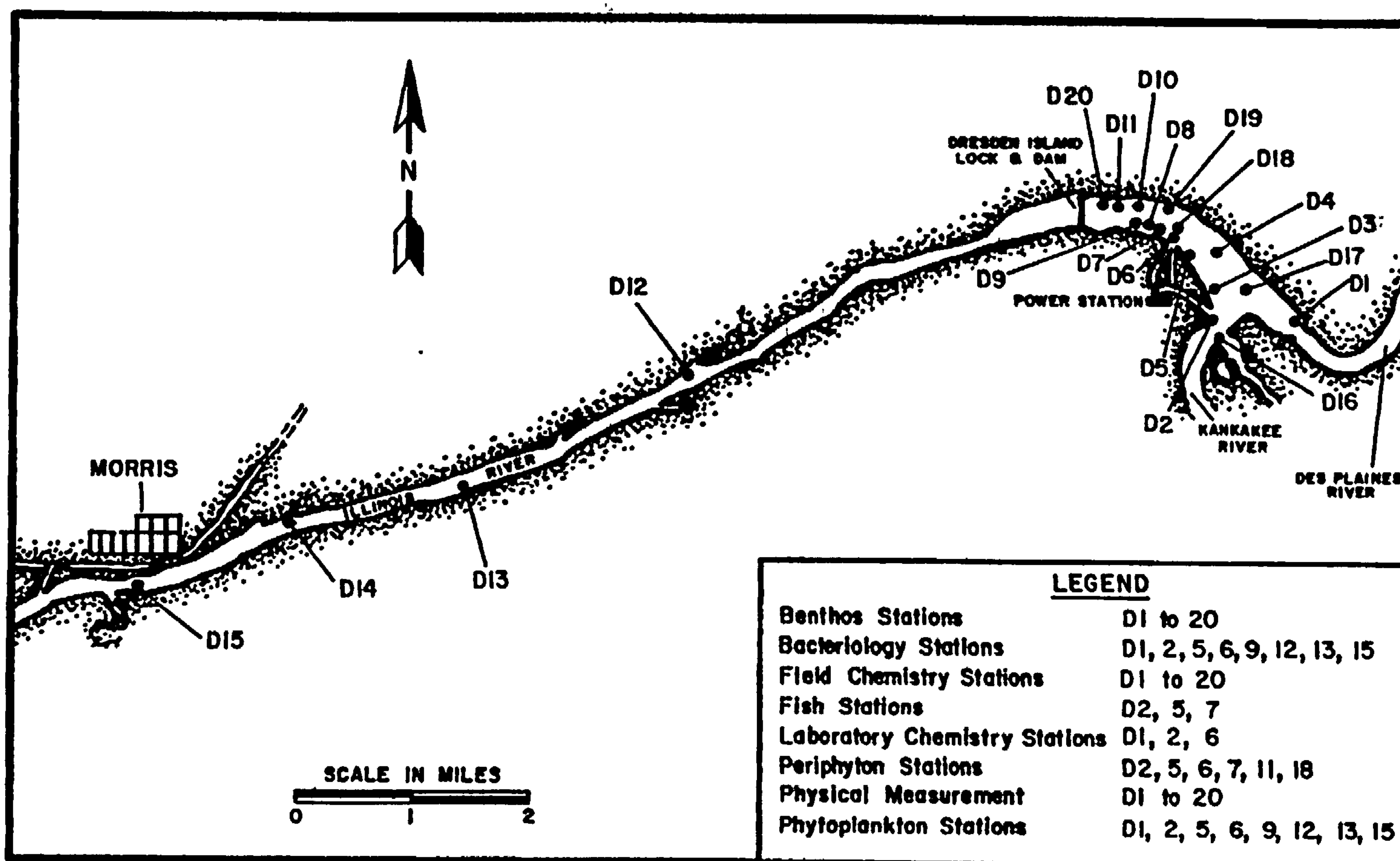

Fig. 6.1. Sampling Stations for Operational Monitoring in the Broad Vicinity of the Station from July 1970 to December 1971. From B. G. Johnson and L. P. Beer, "Environmental Monitoring of the Des Plaines, Kankakee, and Illinois Rivers near the Dresden Nuclear Power Station, July 1970-Dec. 1971," Industrial Bio-Test Laboratories, Inc.

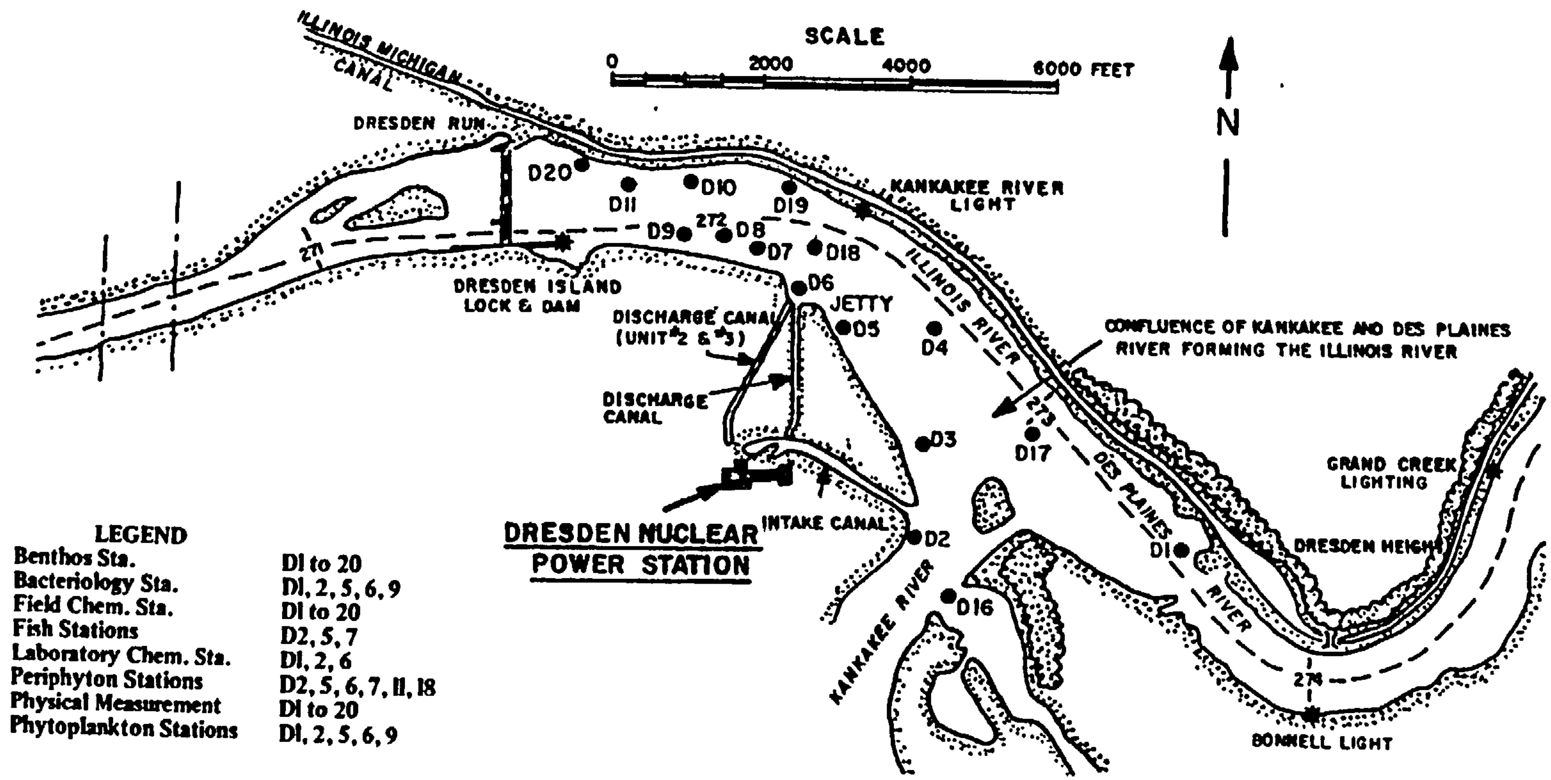

Fig. 6.2. Sampling Stations for Operational Monitoring in the Rivers in the Close Vicinity of the Station from July 1970 to December 1971. From B. G. Johnson and L. P. Beer, "Environmental Monitoring of the Des Plaines, Kankakee, and Illinois Rivers near the Dresden Nuclear Power Station, July 1970-Dec. 1971," Industrial Bio-Test Laboratories, Inc.

Power Station (Fig. 6.1). Samples were taken with a Kemmerer sampler from a depth of one meter and preserved in a 3% formalin mixture. Stations were sampled according to the following schedule:

	1970		1971
	Aug. 11	Nov. 12	May 18, Aug. 11, Nov. 22
Stations	1, 2, 6, 13	1, 2, 6, 13, 15	1, 2, 5, 6, 9, 12, 13

The exact methodology of sample preparation and analysis is presented in Reference 8.

(5). Periphyton Measurements[8]

Periphyton samples for algal identification were collected randomly from natural substrates at Locations D2, D5, D6, D7, D11, and D18 on the Kankakee, Illinois, and Des Plaines Rivers for five sampling periods. Each sample consisted of algal material from a 10-cm^2 area of the substrate. Biomass and chlorophyll a analyses were added to the program during the three 1971 sampling periods.

Periphyton samples for identification were preserved in a 4% formalin solution. The green and blue-green algae were identified from wet mounts, and the diatoms were processed for analysis by preparing Hyrax mounts. Identification of the periphytic organisms was done with standard identification aids (see citations in Reference 8) and reported according to the International Congress of Botanical Nomenclature. Relative abundance of periphyton organisms collected during the 1970 sampling period were subjectively classified as being rare, common, or abundant. In 1971, the relative abundance of the algal species was determined using a modified method of McIntire.[8] Species composition and relative abundance of the periphyton community were determined at each location.

Biomass samples, which were collected in quadruplicate from each location, were processed (see Reference 8) and reported in milligrams ash-free dry weight per square decimeter (mg/dm^2).

Chlorophyll a samples, which were collected in quadruplicate from each location, were analyzed and concentrations were calculated (see Reference 8). Chlorophyll a concentrations were reported in micrograms per square decimeter ($\mu g/dm^2$).

(6). Fish Measurements[8]

Fish collections were made at sampling locations D2, D5, D7 on June 1, August 11 and November 22 of 1971 only. Sampling was accomplished by shoreline seining with a 25-foot, 3/8-inch mesh seine. Fish collected were immediately preserved in formalin and labeled for later examination. Length was measured to the nearest millimeter and weight was determined to the nearest gram. Stomach contents were examined under a dissecting microscope.

In 1972, the river monitoring program noted above was modified as indicated in Tables 6.1 and 6.2. A special study was begun in April 1972 to determine the numbers of fish by species and size removed from the Station intake water and collected in trash baskets of Units 1, 2, and 3. The Applicant continued these 1972 programs through March 1973.[9] After this date, the program outlined in Table 6.3 will continue through December 1973. The Applicant does not mention any river monitoring program after this date.

(7). Conclusion

The Staff is of the opinion that the above program is satisfactory but should be expanded to include the following:

1. Sampling for all physical, chemical, and biological parameters listed in Table 6.2 except thermal plume measurements, at least eight times a year (at the beginning and middle of each season) or, preferably, once a month, except as noted below. Seasonal variations and variations within a given season will be difficult to characterize with a sampling frequency less than this. The surface and vertical extent of the thermal plume shall be determined for extreme and average river flows and lake blowdown temperatures for 1 year. The results will then be evaluated by the Staff and the requirement for additional plume measurements determined.

2. Diurnal (every four hours) plankton sampling at least at one location on the Kankakee and one on the Illinois River, at several depths at each sampling site on each sampling date.

3. Diurnal (hourly) measurements of dissolved oxygen at three locations (upstream in the Kankakee River, in the thermal plume, and downstream in the Illinois River before the Dresden lock and dam, at several depths once a month.

4. Modification of meroplankton sampling (see Table 6.3). The drift nets may not be adequate samplers (depending on the size of the net apertures), nor is the frequency of once a month sufficient to obtain a good representation of the meroplankton community, since some species may hatch and become nonplanktonic within a week or so. Use of a fixed net of suitable mesh (see Reference 10) placed at specific sites at several depths (rather than be allowed to drift) once a week during the spawning season (March to October) may be preferable.

5. Count of dead fish collected in trash baskets every 24 hours. Species identification and size measurements of fish collected in the baskets over an eight-hour period during the day, and over an eight-hour period during the night, at monthly intervals.

6. Assessment of fish populations in the Kankakee and Illinois Rivers in order to evaluate fish kills at the Station as either adverse or insignificant.

7. Periodic measurement of total chlorine in the discharge to the river, using the amperometric method or a method of equal or better sensitivity. Total chlorine in the effluent to the river after Units 2

TABLE 6.1. The Dresden 1972 River Monitoring Program

Parameter	Sampling Frequency	Sampling Method	Analysis	Sampling Location*	Ancillary Measurements	Statistics
I. Physical 1) Temperature	Once every two months	Whitney thermometer	Temp. every meter	1,2,5,6,7,9, 10,12,16,17, 19,20	-	-
2) Plume ID	Twice/year	Whitney thermometer	Temp. every meter	60 sampling points in area of plume	-	-
II. Chemical	Once every two months	Kemmerer	(See Table 6.4)	1,2,6	Current, temp., water visibility	Anal. of variance
III. Biological 1) Phytoplankton	Once every two months	Kemmerer	Species ID, cell count	1,2,5,6,9,12	Current, temp.	Range, mean % of major species abundance
2) Periphyton	Once every two months	Natural substrates (Riprap)	Species ID, relative abundance, biomass, chlorophyll a	2,5,6,7,19	Current, temp., depth	Relative abundance, biomass-mg/dm^2
3) Benthos	Once every two months	Multiple core sampler	Species ID, abundance	5,7,9	Current, temp., depth, bottom type	-
4) Fish	Once every two months	Shoreline seine	Species ID, length, weight, relative abundance, stomach analysis	2,5,7	Current, temp.	Descriptive

Applicant's Environmental Report, Supplement IV, Jan. 15, 1973.

*Refer to Figs. 6.1 and 6.2.

TABLE 6.2. Water Quality Measurements Taken in Rivers near Dresden, Illinois, August 1970 to November 1971, and in the 1972 and 1973 Monitoring Program

Temperature	Phenols
Dissolved oxygen	Methylene blue active substances (MBAS)
Percent oxygen (calculated)	Total phosphorus
Biochemical oxygen demand (BOD)	Orthophosphate (soluble)
Chemical oxygen demand (COD)	Turbidity
Total organic carbon (TOC)	Total dissolved solids
Ammonia	Total suspended solids
Nitrate	Specific conductance
Nitrite	Ferrous iron
Total organic nitrogen (TON)	Total iron
Total alkalinity	Copper
Total hardness	Hexavalent chromium
Calcium	Total chromium
Magnesium	Zinc
Chloride	Lead
Sodium	Manganese
Sulfate	Barium
Silica	Arsenic
pH	Cadmium
Total coliform bacteria	Threshold odor
Fecal coliform bacteria	Color
Fecal streptococci bacteria	Mercury
Selenium	Secchi disk

From Applicant's Environmental Report, Supplement IV, Jan. 15, 1973.

TABLE 6.3. The Dresden 1973 River Monitoring Program after March, 1973

1. Continuation of 1972 Program, beginning after March 1973.
2. Continuation of the following measurements added to 1972 Program in November 1972.

a. Biological

Parameter	Sampling Frequency	Sampling Method	Analyses	Sampling Location*	Ancillary Measurements	Statistics
Zooplankton	Once every two months	Net tows	1) Species Composition 2) Relative Abundance 3) Species Diversity 4) Biovolume 5) Biomass Periodic checks to be made on duplicate samples	1,2,5,6,9,12	Depth, temp. and velocity measurements at the time of sampling.	Biovolume to be determined by the Lackey method of analysis. Biomass will be calculated from biovolume using the conversion factor 1 gm = 1 cm^3.
Fish	Once every two months	D.C. electro-shocker, metered-tows, minnow seine.	1) Species Composition 2) Length-weight 3) Condition Factor 4) Stomach content of five key species (10 individuals per species).	2,5,7	Depth, temp., velocity and turbidity in general collection area.	Special notes as to catch per unit effort.
Mero-Plankton	Once a month from March to October	Drift Nets	1) Species Composition 2) Relative Abundance	2,5,7	Velocity, temp.	

b. General Addition

Replicate samples for biological parameters will be collected in order to detect 50% change in population levels with 95% confidence.

From Applicant's Environmental Report, Supplement IV, Jan. 15, 1973.

*Refer to Figs. 6.1 and 6.2.

and 3 have mixed with Unit 1 must not exceed 0.1 ppm during intermittent discharges (a maximum of two hours per day).

8. Justification and demonstration of adequacy for the particular sampling design selected for all the parameters to be measured, and specification of data analysis technique.

Periodically, the results of the program will be reviewed by the Staff and modifications in the program may be made (e.g., certain sampling sites and/or measurements may be removed from the program and/or others added) as experience indicates.

b. Lake Program

A biological study of the Dresden cooling lake was begun in July 1972, when the lake was operating in the open-cycle mode. The program is conducted for the Applicant by Environmental Analysts, Inc. Biological features under evaluation are fish species in the lake and their movements in response to temperature regimes, characteristics of benthos, periphyton, zooplankton and phytoplankton communities, and productivity of the lake as a function of temperature and turbidity gradients.[11] A summary of sampling frequency is given in Table 6.4.

A water chemistry program for the cooling lake is conducted by the Applicant's Operational Analysis Department, and Suburban Laboratories, Inc., using, in general, methods described in Reference 12. Table 6.5 lists the sampling sites and parameters presently measured.[13]

After March 1973 the Applicant plans to combine lake biological and chemical monitoring with river monitoring, under a general aquatic program.[9] The modified lake program (see Table 6.6) will continue through December 1973. The Applicant does not mention any lake programs subsequent to that date.

The Staff finds the lake monitoring program is acceptable if monthly water quality sampling is continued, except for fecal coliforms which shall be determined weekly in the lake intake and discharge canals. In addition, fecal streptococci determinations shall be included at these sampling stations. All parameters of Table 6.5 shall be measured at the lake intake canal between the station discharge and first sprays. Sampling at the lake intake before the lift station (see Table 6.5) is no longer considered necessary.

TABLE 6.4. Schedule of Sampling for the Dresden Lake Biological Survey

Monthly	Every Other Month
Electrofishing	Benthos
Gill netting	Zooplankton
Seining	Phytoplankton
Periphyton on rip-rap	
Periphyton on diatometers	**Aperiodically**
Chlorophyll A	Emergent insects
Turbidity	Emergent aquatic plants
Conductivity	Siltation rates
Light penetration	Waterfowl usage of the lake and feeding of waterfowl on adjacent croplands
Oxygen	
Temperature	

From "Interim Rej ·· for Dresden Lake Biological Study," Environmental Analysts, Inc., Sept. 1972.

These programs shall continue for a period of at least two years after the start of closed-cycle operation. At the end of this period, the data collected shall be used as a basis for setting up a modified lake monitoring program that will continue throughout the lifetime of the Station.

c. Terrestrial Program

The Applicant has not indicated any plans for terrestrial nonradiological environmental monitoring. Since the Staff does not expect any adverse effects of Station operation on the terrestrial environment if requirements made in Section 5.5.3(e) are complied with, no formal monitoring program is presently considered necessary. The Department of Agriculture has suggested that a surveillance program for the inspection of the vegetative cover in the vicinity of the cooling lake embankment be undertaken (see Appendix M).

TABLE 6.5. Water Quality Sampling Program for the Dresden Cooling Lake

Sampling Locations	Parameters
Lake intake before lift station. Lake discharge after lift station. Des Plaines River, at Joliet Yacht Club. Kankakee River, at County Line Bridge.	Temperature pH Total coliform/100 ml Fecal coliform/100 ml Cu, soluble Zn, soluble P, total, soluble P, ortho, solbule Total organic carbon Chemical Oxygen Demand Biochemical oxygen demand Dissolved oxygen Ammonia, NH_3 as N NO_3, soluble NO_2, soluble Organic N, soluble Total N, soluble Na, soluble Ca, soluble Mg, soluble Si, soluble Cyanide, total Hg, total SO_4, soluble Total dissolved solids Total suspended solids Free CO_2 Alkalinity as $CaCO_3$ Free Chlorine Chloramines Chloride, Cl
Lake intake canal between station discharge and first sprays.	Temperature pH Dissolved oxygen Free CO_2 Ammonia, NE_3 as N Free chlorine

TABLE 6.6. The 1972 and Continuing 1973 Dresden Lake Monitoring Program

Parameters	Sampling Frequency	Sampling Method	Analyses	Location	Ancillary Measurements	Statistics
Periphyton	Once a month (Once every two months after March 73)	Diatometers, Ruth Patrick design, Charles Reimer design limestone substrates.	Species composition, relative abundance biomass, biovolume, unitarea. Emphasis on diatoms. Biovolume will be converted to biomass.	Pool #1, #3 and #5	Light penetration, velocity depth of diatometer	Counts in report will represent means of the three samples.
Benthos	(Once every two months)	Ponar dredge and artifical samples made of bushel baskets C̄ golf balls inside. Rip-rap samples and seine samples. Insect traps.	Species composition, relative abundance. Diversity indices will be computed, biomass dry weight. To determine possible nuisance emergence of insects and recommend control.	All pools	Velocity, depth and bottom type.	Calculations will be made to determine number of samples required to obtain a confidence interval ±5% of the population mean.
Plankton (phyto- and zoo-)	Once a month (Once every two months after March 73)	Dip sample, 2 liter sample volume. Straining 60-liter through 20-mesh net.	Carbon-14 light and dark bottle technique used to determine productivity. Species composition, relative abundance, biovolume, biomass total counts.	Pools #1 and #5	Velocity and depth.	Calculations will be made to determine numbers of samples required to obtain a confidence interval ± 5% of the population mean.
Macrophytes	(3 times a year after March 1973)	Identify species, abundance and distribution and development.	Species composition, relative abundance.	All pools	Depth	Descriptive relative abundance.
Fish	Monthly (4 times a year after March 73, May, July, Sept., November)	Seines, trap-nets, minnow traps, electroshocking, gill netting.	Species composition, length - weights, relative abundance, catch per unit effort. Determine if fish are leaving lake thru spillway.	All pools	Temperature, general habitat, DO velocity.	Descriptive

TABLE 6.6. (Contd.)

Parameters	Sampling Frequency	Sampling Method	Analyses	Location	Ancillary Measurements	Statistics
Meroplankton	(Once a month from March to October 73)	Drift nets	1) Species composition 2) Relative abundance	Pool 1, 3, and 5	Temperature	Range mean % of major species abundance.
Waterfowl	Fall and winter	Bird watch	To determine if problems can be anticipated due to fecal material concentrations. General census.	All pools and banks.	- - - -	Descriptive.
Water Chemistry (Refer to Table 6.5)	(Once every two months in 73)	- - - -	- - - -	Refer to Table 6.5	- - - -	Analysis of variance.

From Applicant's Environmental Report, Supplement IV, Jan. 15, 1973.

6.2.2 Radiological Monitoring

The operational environmental radiological monitoring program for the Dresden site has evolved over the years following the startup of Unit 1 in 1958. It was performed by several firms under contract to the Applicant:

1959-1961	Nuclear Science and Engineering Co.
1962-1966	Controls for Radiation, Inc.
1967-1968	Isotopes, Inc.
1968-1970	Eberline Instrument Co.
1971-1972	Industrial Bio-Test Laboratories
1973-	Eberline Instrument Co.

The current version,[14] beginning in January 1973, is conducted by the Eberline Instrument Company and is jointly sponsored by the Commonwealth Edison Company for the Dresden Nuclear Power Station and by the General Electric Company for the Midwest Fuel Recovery Plant. It is a somewhat expanded version of the program found in the Unit 3 Technical Specifications.[15]

Samples collected by the Eberline Company are to be delivered to its new West Chicago, Illinois, laboratory for analyses. Until this laboratory is completed, some of the analyses will be done at Eberline's laboratories in Columbia, South Carolina, and in Santa Fe, New Mexico.

The analyses are done using established procedures (or equivalent) of the U. S. Department of Health, Education and Welfare.[16] Quality assurance is maintained in part by use of the Analytical Quality Control Service of the Environmental Protection Agency. Details regarding the analytical program may be found in a report from Eberline to the Applicant.[17]

The type of samples collected, locations and frequency of collection, and the analyses to be performed are listed in Table 6.7. Sampling locations are shown in Figs. 6.3 and 6.4.

The program deviates slightly from the proposed surveillance guide of the Environmental Protection Agency[18] in the placement of certain off-site air samples and in the sampling of certain minor pathways. The Staff believes the deviations are minor and the program is considered adequate. The program being carried out should provide the necessary information for assessing the status of public health and safety due to the Units 2 and 3 radwaste effluents.

6.3 RELATED ENVIRONMENTAL PROGRAMS AND STUDIES

6.3.1 Nonradiological Studies

The State of Illinois EPA, Division of Water Pollution Control, has water quality sampling stations close to the Station, one on the Kankakee River

TABLE 6.7. Sample Collection and Analysis - Environmental Monitoring Program

Sample Media	Type of Analysis	Collection Sites		Collection Frequency	Collection Dates
1. a. Airborne particulate (AP)	1. Gross beta	*GE-MFRP #1		Weekly	---
		Elwood	J-15		
		*Joliet	J-48		
		*Wilmington	464		
		*Lorenzo	J-54		
		Morris	016		
		Lisbon	024		
		Coal City	J-68		
		*Bennett Farm	BE		
		Hansel	HA		
		*Channahon	CH		
		Breen	BR		
		*McCabe	0672		
		Minooka	J-27		
		Goose Lake	J-21		
		On-site stations *1, 2, *3			
	2. Gross alpha	9 locations in 1. a. 1. marked with *		Monthly	First samples of the month
	3. Gamma scan	Same as 1. a. 1.		Monthly	Composite of all filters collected in a single week
	4. Plutonium	Same as 1. a. 1.		Monthly	Composite of all filters collected in the month
b. Airborne screen (in addition to airborne particulate)	I-131	Same locations as in 1. a. 1.		Bi-weekly	---
2. Gamma background (ion chambers)	Gamma	Same locations as air particulate stations		Weekly	---
3. Gamma background (TLD)	Gamma	Same locations as air particulate stations		Quarterly Annually	

TABLE 6.7. (Cont'd)

Sample Media	Type of Analysis	Collection Sites	Collection Frequency	Collection Dates
4. Fallout - airborne solids and liquids (WF)	Gross beta, Tritium (actual) Gamma scans (special)	Brandon lock and dam. Dresden on-site Station #2, Milk stations (2)	Monthly	---
5. Fallout - soil (SO)	Gross beta Gamma scans (1) Sr-89, Sr-90	1. Davidson Farm 2. One vegetable farm within 5 miles 3. One vegetable farm at approx. 15 miles	Quarterly	---
6. a. Fallout - cattle feed (CF)	Gross beta Sr-89, Sr-90 Gamma scan (2)	Milk stations	Monthly	November - March
b. Fallout - grass (GF)	Gross beta Sr-89, Sr-90, Cs-137 Gamma scan (3)	Milk stations	Monthly	April - October
	I-131	I-131 at closest milk station to Dresden only		
c. Fallout - foodstuffs (FF) (3 varieties at least)	Gross beta Sr-89, Sr-90, Cs-137 Gamma scan (4)	Truck farms	3 times/year	Summer and early fall
7. Surface water (SW)	1. a. Gross beta *Gross gamma Gross alpha Gamma scans (special)	*Dresden inlets (2) *Discharge canals (2) EJ&E RR bridge station	Weekly composite	---
	b. Sr-89, Sr-90 Tritium		Quarterly composite	
	2. Gross beta, Tritium Gamma scans (special)	Corp of Eng. pump. station	Quarterly	---

TABLE 6.7. (Cont'd)

Sample Media	Type of Analysis	Collection Sites	Collection Frequency	Collection Dates
	3. a. Gross beta b. Tritium Gamma scans (special)	Illinois River at Morris (State of Ill. sample)	a. Semi-monthly composite b. Quarterly composite	Supplied by State
	4. a. Gross beta b. Tritium	Dresden lake	a. Weekly b. Quarterly composite	
	5. Tritium	Pond west of MFRP	Quarterly	March - June September - December
8. Bottom sediments (SI)	Gross beta Gamma scans (1) Sr-89, Sr-90	1. Kankakee River downstream of Goose Lake pumping station but above inlet canal 2. Des Plaine River area of Joliet Yacht Club 3. Dresden lock and dam	Quarterly	February - May August - November
9. Periphyton (SL)	Gross beta Gamma scans (5)	Same as (8).	Quarterly	February - May August - November
10. Well water (WW)	Gross beta Gamma scans (special)	Dresden lock and dam (DL)	Monthly	---
		Hansel (HA)	Quarterly	January - April July - October
		Olson (OL)		February - May -- August - November
		Bennett (BE)		January - April -- July - October
		Breen (BR)		February - May -- August - November
		Anderson (AN)		February - May -- August - November
	Tritium	MFRP well	Quarterly	March - June September - December

TABLE 6.7. (Cont'd)

Sample Media	Type of Analysis	Collection Sites	Collection Frequency	Collection Dates
	Gross beta, Tritium, Gamma scans (special)	Dresden well #1 (W1) Thorsen	Quarterly	January - April -- July - October
		Dresden well #2 (W2)		February - May -- August - November
	Gross beta Gamma scans (special)	Drinking fountain - Unit #1 (DF-1)		
11. Milk (M)	a. I-131 b. Sr-89, Sr-90, Cs-137 (6)	Davidson (DA) and Dhuse (DH)	a. Weekly b. Monthly composite	---
	c. Tritium		Semiannual	June and September
12. a. Fish b. Sediment c. Water	Gross beta, Sr-89, Sr-90 Gamma scan	Dresden lock and dam pool (routine), Brandon lock and dam pool and County Line bridge (special)	Semiannual	---
d. Aquatic plants	Gross beta, Sr-89, Sr-90, Gamma scan	Dresden inlet and discharge canal (general area)	Semiannual	---
13. Special analysis	Sr-91, Air particulate Sr-89, -90, Air particulate I-131, Rainfall Sr-89, -90 Rainfall			
14. Rabbit a. Blood b. Thyroid c. Muscle d. Bone	a. Tritium b. I-129, I-131 c. Cs-137 d. Sr-90	MFRP site	Semiannual	a. March; September b. September c. September d. September

TABLE 6.7. (Cont'd)

Sample Media	Type of Analysis	Collection Sites	Collection Frequency	Collection Dates
15. Grass	Tritium	Behind GE simulator	Quarterly	March - June September - December
16. Soil - moisture content	Tritium	Same as 15 (soil plug between depths of 10 to 15 cm)	Quarterly	March - June September - December
17. Grass	Fluorides (soluble)	300 meters east of MFRP plant, west of MFRP plant at site boundary, and 10 other locations on MFRP site	Monthly	May through October collected between the 11th and 17th of the month
18. Strip samplers	Fluoride	Dresden on site at 1, 2, 3, Coal City Morris Lisbon Channahon Plainfield Joliet Elwood Wilmington MFRP near plant	Quarterly	

From Applicant's Environmental Report, Supplement III (Oct. 18, 1972).

Notes:
(1) Fall samples only
(2) January or February samples only
(3) June or July or August samples only
(4) Third collection of samples only
(5) August samples only
(6) After chemical separation of Cs-137 and Cs-134, counting of radioactivity must be done with multichannel analyzer.

Legend to Table 6.7. Sample Coding System - Environs Program

Sample Types

AP	Air Particulate
SW	Surface Water
WW	Well Water
WF	Fallout Water
SI	Silt
SL	Slime
M	Milk
GF	Grass
VF	Vegetation
CF	Cattle Feed
iF	Foodstuffs
SO	Soil
FP	Fish Prog ...

Sample Location

J15	Elwood
J48	Joliet, Brandon Road
464	Wilmington
016	Morris
024	Lisbon
J68	Coal City
BE	Bennett Farm
PP	Prairie Park
PT	Pleasant Trail
0773	Collins Rd.
CH	Channahon
0672	Goose Lake Village
J27	Minnoka
J21	Clay Products
A	On-Site Monitor Station #1
B	On-Site Monitor Station #2
C	On-Site Monitor Station #3
M	Morris (on Illinois River)
K	Kankakee River (at inlet canal)
D	Des Plaines River (at discharge canal)
RR	EJ&E Railroad Bridge (Illinois River)
MS	Morris (Illinois River - State)
DL	Dresden Locks
W1	Dresden Well #1
W2	Dresden Well #2
DF	In-Plant Drinking Fountain - Unit #1
TH	Thorsen Farm
AN	Anderson Farm
OL	Olson
DA	Davidson Farm
DH	Dhuse Farm

From Applicant's Environmental Report, Supplement III (Oct. 18, 1972).

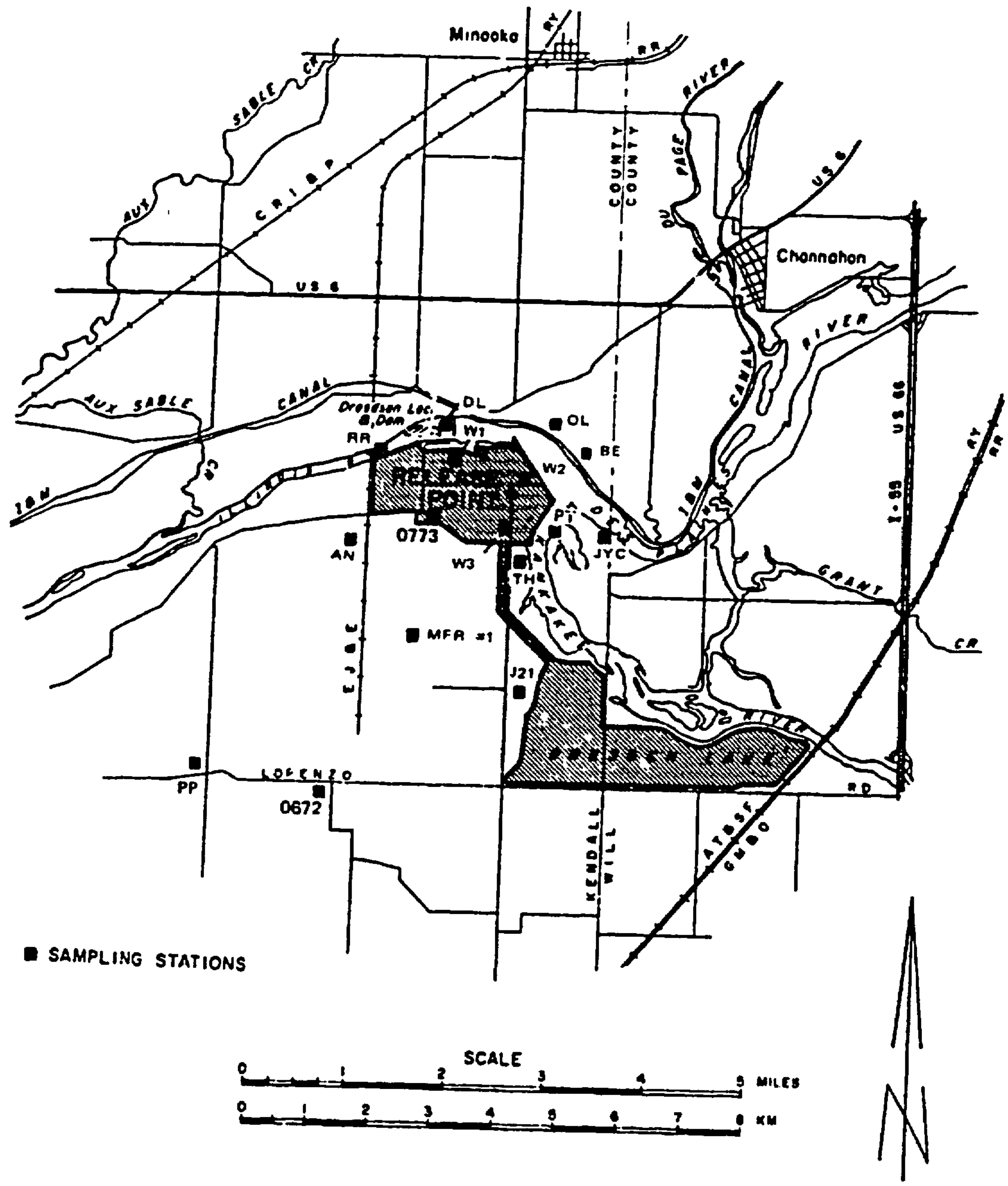

Fig. 6.3. Detailed Location of Radiological Sampling Stations.

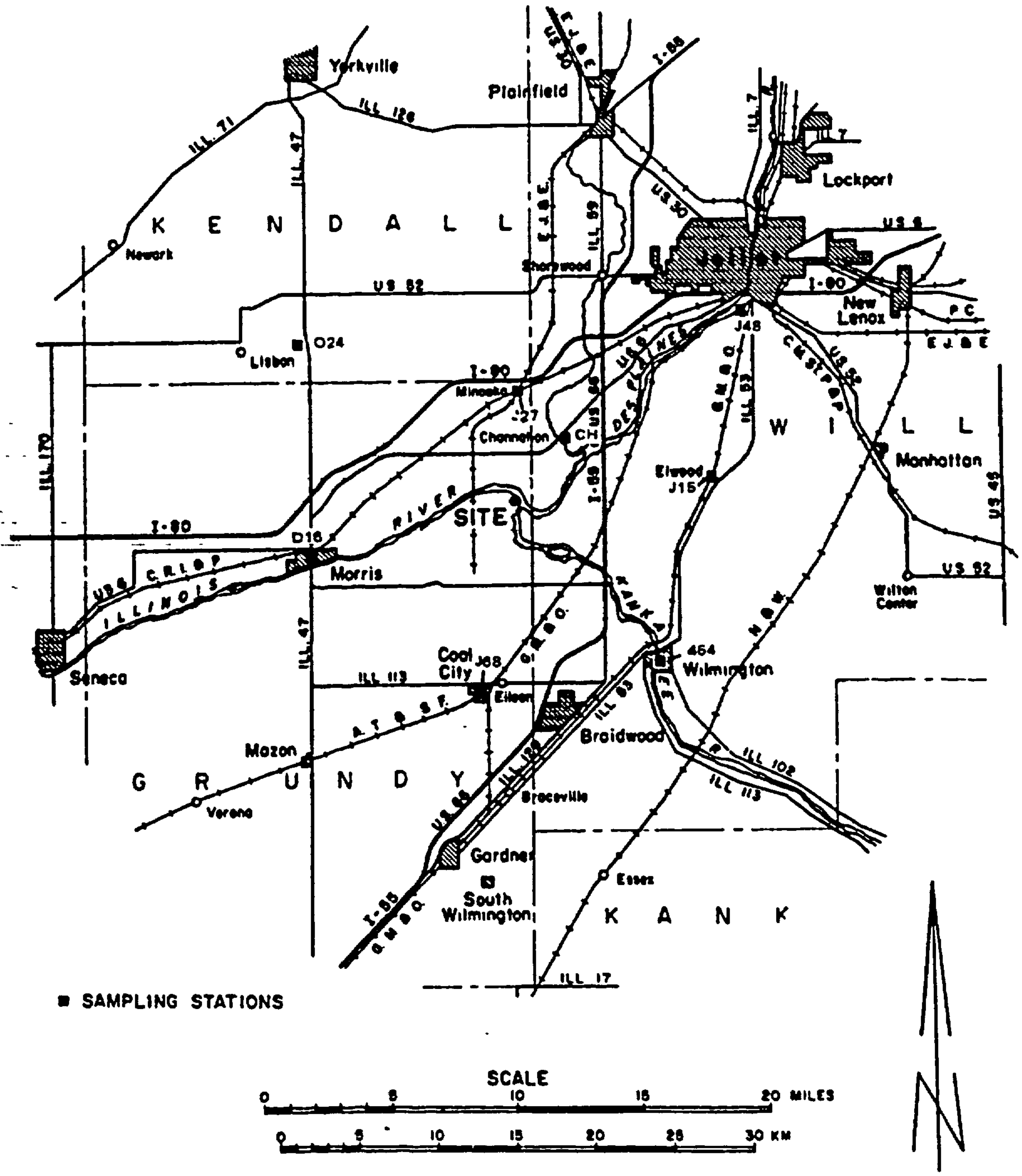

Fig. 6.4. General Location of Radiological Sampling Stations.

(Route 66 bridge) and one on the Illinois River at Morris (Route 47 bridge). Data summaries are available at the end of every year.[19]

The Illinois Natural History Survey Division, Aquatic Biology Section, conducts periodic studies of fisheries and other aquatic biology on the Illinois Waterway.[20]

The Illinois Nature Preserves Commission is responsible for the preservation and management of the Goose Lake Prairie Nature Preserve. Yearly records will be assembled by the Park Ranger.[21] Studies on particular aspects of the Preserve are conducted by the staff and students of several colleges and universities.

Environmental Analysts, the Applicant's consultant, is conducting aquatic and terrestrial studies for Commonwealth Edison's Collins Station to be constructed near Morris, Illinois. Details of the study, which will be conducted for approximately one year, can be found in Reference 22.

6.3.2 Radiological Surveys

Most of the related radiological environmental programs and studies noted in Sections 2.8 and 6.1.2 of this report are ongoing programs. As such these programs should continue to supply supplementary data and information regarding radiological background in the region and will be of assistance in characterizing the radiological conditions which result from future Station operation.

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18. "Environmental Radioactivity Surveillance Guide", ORP/510/72-2. Environmental Protection Agency, Washington, D. C. (draft June 1972).

19. "Summary of Data, 1971" Vol. 1. Illinois Environmental Protection Agency, Water Quality Network, Springfield, Illinois.

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21. "Master Plan for Goose Lake Prairie State Park and Nature Preserve". Illinois Department of Conservation (April 1971).

22. Scope of aquatic and terrestrial studies at Collins Station. Environmental Analysts, Inc. (Nov. 3, 1972).

7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

A high degree of protection against the occurrence of postulated accidents in the Dresden Station - Units 2 and 3 is provided through correct design, manufacture, and operation, and the quality assurance program used to establish the necessary high integrity of the reactor system, as considered in the Commission's Safety Evaluation for Unit 2 dated October 17, 1969, and Safety Evaluation for Unit 3 dated November 18, 1970. Deviations that may occur are handled by protective systems to place and hold the plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accidents might occur, even though they may be extremely unlikely; and engineered safety features are installed to mitigate those postulated events which are judged credible.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using best estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the Commission's safety review, extremely conservative assumptions will be used for the purpose of comparing calculated doses resulting from a hypothetical release of fission products from the fuel against the 10 CFR Part 100 siting guidelines. Realistically computed doses that would be received by the population and environment from the accidents which are postulated would be significantly less than those presented in the Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971, requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The Applicant's response was contained in the "Supplement I to Dresden 3 Nuclear Power Station Environmental Report," dated November 8, 1971.

The Applicant's report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment to Appendix D of 10 CFR Part 50 by the Commission on December 1, 1971. Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a low occurrence rate. The examples selected by the Applicant for these cases are shown in Table 7.1. The examples selected are reasonably homogeneous in terms of probability within each class.

Commission estimates of the dose which might be received by an assumed individual standing at the site boundary in the downwind direction, using

TABLE 7.1 Classification of Postulated Accidents and Occurrences

Class	AEC Description	Applicant's Examples
1	Trivial incidents	Not considered
2	Small releases outside containment	Reactor coolant leaks outside containment
3	Radioactive waste system failure	Abnormal release from offgas system and release from holdup system via purge valve operation
4	Fission products of primary system (BWR)	Fuel failure during normal operation
5	Fission products to primary and secondary systems (PWR)	N. A.
6	Refueling accident	Design basis refueling accident involving a fuel assembly dropping onto the reactor core
7	Spent fuel handling accident	Movement of spent fuel cask outside containment and onsite
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Loss of coolant accident, steam line break accident, and control rod drop accident
9	Hypothetical sequence of failures more severe than Class 8	Not considered

TABLE 7.2 Summary of Radiological Consequences of Postulated Accidents[1]

Class	Event	Estimated Fraction of 10 CFR Part 20 limit at site boundary[2]	Estimated Dose to Population in 50 mile radius man-rem
1.0	Trivial incidents	3	3
2.0	Small releases outside containment	3	3
3.0	Radwaste System failures		
3.1	Equipment leakage or malfunction	0.087	17
3.2	Release of waste gas storage tank contents	0.35	69
3.3	Release of liquid waste storage contents	<0.001	<0.1
4.0	Fission products to primary system (BWR)		
4.1	Fuel cladding defects	3	3
4.2	Off-design transients that induce fuel failures above those expected	0.004	1.8
5.0	Fission products to primary and secondary systems (PWR)	N. A.	N. A.

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

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

[3]These releases are expected to be a small fraction of 10 CFR Part 20 limits for either gaseous or liquid effluents.

TABLE 7.2 (cont'd)

Class	Event	Estimated Fraction of 10 CFR Part 20 limit at site boundary[2]	Estimated Dose to Population in 50 mile radius man-rem
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.002	0.4
6.2	Heavy object drop onto fuel in core	0.015	3.0
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.003	0.66
7.2	Heavy object drop onto fuel rack	0.006	1.2
7.3	Fuel cask drop	0.13	26
8.0	Accident initiation events considered in design basis evaluarion in the SAR		
8.1	Loss-of-Coolant accidents		
	Small break	<0.001	<0.1
	Large break	0.26	41
8.8.1(a)	Break in instrument line from primary system that penetrates the containment	<0.001	<0.1
8.2(a)	Rod ejection accident (PWR)	N. A.	N. A.
8.2(b)	Rod drop accident (BWR)	0.004	2.1
8.3(a)	Steamline breaks (PWR's outside containment)	N. A.	N. A.
8.3(b)	Steamline break (BWR)		
	Small break	0.003	0.6
	Large break	0.015	3.1

the assumptions in the proposed Annex to Appendix D of 10 CFR 50,* are presented in Table 7.2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table 7.2. The man-rem estimate was based on the projected population within 50 miles of the site for the year 1980.

To rigorously establish a realistic annual risk, the calculated doses in Table 7.2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operations; and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures the events in Classes 3 through 5 are not anticipated during plant operation; but events of this type could occur sometime during the 40 year plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table 7.2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered in the design bases of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is judged so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain a high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

The AEC is currently performing a study to assess more quantitatively these risks. The initial results of these efforts are expected to be available in early 1974. This study is called the Reactor Safety Study and is an effort to develop realistic data on the probabilities and sequences of accidents in water cooled power reactors, in order to improve the quantification of available knowledge related to nuclear reactor accidents probabilities. The Commission has organized a special group of about 50 specialists under the direction of Professor Norman Rasmussen of MIT to conduct the study. The scope of the study has been discussed with EPA and described in correspondence with EPA which has been placed in the AEC Public Document Room (letter, Doub to Dominick, dated June 5, 1973).

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*The meteorological conditions indicated in this annex approximate the dispersion conditions which would prevail at least 50% of the time.

As with all new information developed which might have an effect on the health and safety of the public, the results of these studies will be made public and would be assessed on a timely basis within the regulatory process on generic or specific bases as may be warranted.

Table 7.2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the site boundary to concentrations of radioactive materials that are within the Maximum Permissible Concentrations (MPC) of Table II of 10 CFR Part 20. The table also shows that the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity. The exposure from naturally occurring radioactivity corresponds to approximately 1,100,000 man-rem per year within a 50 mile radius based on a natural background of 135 mrem/year When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small, and need not to be considered further.

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVE MATERIALS

Based on recent accident statistics,[1] a shipment of fuel or waste may be expected to be involved in an accident about once in a total of 750,000 shipment-miles. Based on regulatory standards and requirements for package design and quality assurance, results of tests, and past experience, Type B packages are likely to withstand all but very severe, highly unusual accidents. The probability of a Type B package being breached is low, so low that detailed consideration is not required in this analysis. Although the consequences of a release could be serious, the probability of occurrence is small, and therefore the risk or impact on the environment is very small. Based on data developed in Section 3.5, the Staff estimates that a maximum total of 2.2 million shipment-miles of irradiated fuel and solid radioactive waste could be accrued during the 30-year lifetime of Units 2 and 3.

Provisions in transportation regulations are designed to assure maximum containment of wastes and minimum contamination from wastes in accidents. Shipments of wastes are likely to be made by exclusive-use truck, which means that the vehicle is loaded by the consignor and unloaded by the consignee. In most cases the shipments are made in closed vehicles. Since the shipment is exclusive-use, the shipper can provide specific instructions to carrier personnel regarding procedures in case of accidents.

Commission and Department of Transportation regulations[2] provide specific instructions to carriers for segregating damaged and leaking packages, keeping people away from the scene of an accident, and notification of the shipper and the Department of Transportation.

Each package containing radioactive material is labeled with the radioactive material label, a distinctive label which identifies the material and provides a visual warning. The regulations[3] specify placarding on the outside of the truck for identifying the presence of shipments of large quantities of radioactive materials. An extensive program has been carried out over the past several years by which emergency personnel, including police departments, fire departments, and civil defense offices, have been advised of procedures to follow in accidents involving radioactive materials and other hazardous materials. Specific instructions with regard to radioactive materials have been provided through the AEC's efforts as well as those of carrier organizations such as the Bureau of Explosives of the Association of American Railroads, the American Trucking Association, and the Air Transport Association. An intergovernmental program to provide personnel and equipment is available at the request of persons (truck drivers, police, bystanders, or other persons) at the scene of such accidents.

The waste itself is confined either in the form of solidified materials, such as concrete, or compacted solids. The low level of radioactivity in the waste together with the form of the waste serves to minimize the contamination in the unlikely event that there is a spill in an accident.

The procedures prescribed by existing applicable regulations, together with the other precautions discussed above, are considered by the Commission to be adequate to mitigate the effects of infrequent accidents which might occur involving shipments of wastes from the Station.

7.2.1 New Fuel

Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and the low specific activity of the fuel limit the radiological impact on the environment to negligible levels.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel assemblies under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which is unlikely to happen in other than an extremely severe accident. The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote.

If criticality were to occur in a transportation accident, persons within a radius of about 16 feet from the accident would receive a fatal or near-fatal exposure unless shielded by intervening material. Exposure levels drop off rapidly with distance (exposure is approximately 20 rem at a radius of 50 feet), and are of the order of 100 mrem at a radius of 100 feet from the accident. No detectable radiation effects are expected at distances greater than 100 feet. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reactions would stop. The reaction would not be expected to continue for more than a few seconds nor to recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at three feet and there would be very little dispersion of solid radioactive material.

7.2.2 Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel have been estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

(a) Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 30-year life of the plant.

Leakage of liquid at a rate of 0.001 cc per second or about 80 drops/hour is about the smallest amount of leakage that can be detected by visual observation of a large container. If undetected leakage of contaminated liquid coolant were to occur, the amount would be so small that the individual exposure would not exceed a few mrem and only a very few people would receive such exposures.

(b) Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

In such an accident, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major f:·e. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[4] of the Environmental Protection Agency.

7.2.3 Solid Radioactive Wastes

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 30-year life of the plant. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur, but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant. Other solid radioactive wastes will be shipped in Type B packages. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

In either case, spread of the contamination beyond the immediate area is unlikely and, although local cleanup might be required, no significant exposure to the general public would be expected to result.

7.2.4 Severity of Postulated Transportation Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and their consequences could be severe. Quality assurance for design, manufacture, and use of the packages, continued surveillance and testing of packages and transport conditions, and conservative design of packages ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk is extremely low. For those reasons, more severe accidents have not been included in the analysis.

7.3 COOLING LAKE DIKE FAILURE[5]

The Dresden cooling lake was evaluated from a hydrologic standpoint to determine whether overtopping or dike failures from other means could create a major hazard to the public. The consequences of dike failures were evaluated in a preliminary manner, limiting the study to only those locations where dike failure could potentially cause problems to local residents. To determine the locations that should be studied, the investigations and evaluations performed by the staff on the foundations beneath the perimeter dike were used as guides. In addition, the study also included the consequences of a dike failure which could be caused by a rupture of the 36-inch, high-pressure natural gas pipeline at either of its intersections with the perimeter dike.

7.3.1 Dike Failures Caused by Overtopping

For the evaluation of the lake for overtopping, the 48-hour local probable maximum precipitation (PMP) was conservatively estimated for the site, based on the U. S. Weather Bureau's (now NOAA) Hydrometeorological Report No. 33, as approximately 35 inches. (The probable maximum precipitation is defined as the maximum precipitation considered reasonably possible in the hydrologic region.) Assuming that no releases would be made from the lake during the storm, and severe wind and wave activity could occur coincident with the storm, the staff considers the dikes safe from overtopping since approximately two feet of freeboard would be available between the maximum water surface elevation of about 525 feet MSL and the top of the dikes at 527 feet MSL.

7.3.2 Dike Failures Caused by Natural Gas Pipeline Explosions

A buried 36-inch, high-pressure natural gas pipeline transects the area occupied by the cooling lake, passing directly underneath the south and west perimeter dikes. Although the possibility of an explosion somewhere along the pipeline would, in general, fall within normal design and accident assessment probability limits, the probability of an explosion in the immediate vicinity of either intersection would be quite low. Nevertheless, a preliminary analysis was performed to evaluate the consequences of dike failures caused by such explosions. For the west dike, the study indicated that considerable damage could be caused by a flood wave resulting from such an explosion to the access road paralleling the dike in this area. However, since no permanent residences are located in this general vicinity, the possibility of loss of life is extremely small. The only danger would be to traffic on the road at the time the flood wave arrived. The water would tend to accumulate in the area bounded by the road on the west, the perimeter dike on the east, and the small dike protecting the discharge canal of the lake on the north. The natural drainage in this area is to the north where the water is collected in a drainage channel that transports it to a siphon under the plant discharge canal and thence to the Goose Lake Pumping Station on the Kankakee River. Pondage in this area from water issuing from any potential dike failure is likely to remain for sometime due to the relatively low pumping rates in relation to the large volume of water in the cooling lake (approximately 12,250 acre-feet). Therefore, some inconvenience would be likely for local traffic on the access road.

For the south dike, the major concern was whether a failure of the dike due to an explosion would create a major hazard to the children in the Goose Lake School which normally holds about 20 elementary students (see Fig. 3.8 for location). The natural drainage in this area is from east to west (toward the school) with higher ground generally south of the road. Our evaluation indicated that no serious problem to the school would occur. Since the differential elevation of the water behind the dike in the area of the pipeline is only about 5 feet, the flood wave from the assumed breach would be about 2 feet high at the road paralleling the dike. The distance from the assumed breach to the school is approximately 6,600 feet and the school is located on the opposite side of the road from the dike. In addition, the drainage channel at the toe of the dike varies from 15 to 22 feet wide. The combined effect of all these factors is that by the time a flood wave could reach the vicinity of the school, it will be contained in the drainage channel and will not pose a threat to the school in the form of a sudden rush of water which could imperil children.

7.3.3 Dike Failures Caused by Foundation Conditions

The geologic evaluations by the staff of the cooling lake perimeter dikes recommended a number of areas for further investigations and monitoring programs by the applicant. The staff's hydrologic evaluations of the consequences of potential dike failures were limited to these potential areas.

For the south dike the portion in the vicinity of the Goose Lake School was identified as a potential problem area. If a failure were to occur here the consequences could be very serious. Directly across the road from this area is Goose Lake School, and a dike failure could cause a flood wave as high as approximately four feet to strike the school. It is very likely that the damage could be extensive and possibly result in injury and/or loss of life to any occupants.

For the other potential problem areas along the south dike, it was determined that no serious consequences of a postulated dike failure would occur. The staff has estimated that, in the event of a failure, most of the cooling lake water would be carried by the drainage channel at the toe of the dike (probably washing out the culvert under Will Road) to the Goose Lake Pumping Station on the Kankakee River.

For the west dike, a number of problem areas were identified. However, the hydrologic evaluation of dike failures in these areas indicated no serious consequences would probably occur. This is due to the fact that, although the lake is the deepest in this area, there are no permanent residences close enough to be damaged. Water issuing from dike failures in this area will be collected by the drainage channel to the siphon under the lake discharge canal. It is then pumped into the Kankakee River at Goose Lake Pumping Station. Some pondage may occur near the siphon, but this should present no serious problem.

For the north dike, problem areas were identified due to possible seepage and the possibility of the extention of an abandoned coal mine under the dike. Most of the potential failure areas have been stabilized by sheet piling extending into relatively impervious clay or bedrock. The consequences of postulated dike failures along this dike would be quite serious since a number of both permanent and seasonal residences are located on the banks of the Kankakee River, just north of the dike. The staff has estimated that flood waves as high as 5 feet could impinge on these residences, causing serious damage and possibly injury and/or loss of life to residents.

The Staff concludes however, that the potential for dike failure will be reduced by the requirements in Section 5.1.4. Also, the required dike surveillance program should provide an early warning of potential failure and allow mitigating actions to be taken.

References

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2. 49 CFR Parts 171, 174, 177.

3. 49 CFR Parts 173 through 177.

4. "Background Material for the Development of Radiation Protection Standards; Protective Action Guides for Strontium 89, Strontium 90, and Cesium 137", Federal Radiation Council Report No. 7, May 1965.

5. E. F. Hawkins, "Hydrologic Engineering Evaluation of Dresden Cooling Lake - TAR-374," USAEC, Directorate of Licensing, April 20, 1973.

8. IMPLICATIONS OF THE PROJECT

8.1 THE REQUIREMENT FOR POWER

The Applicant supplies electricity to approximately 7.8 million people in northern Illinois including the City of Chicago and the surrounding densely populated metropolitan area. The average growth in peak load on the system is estimated by the Applicant to be about 7-1/2% per year, increasing from 12,610 MW in 1973 to 24,950 MW in 1982. The program of installation (and retirement) shown in Table 8.1 has been developed by the Applicant to keep pace with this continually increasing demand.

Table 8.2 shows the projected capability, peak load, and reserves from the Applicant's system through 1982. Also indicated in the table are the capability and reserve margin without the two units of the Dresden Station.

The Applicant is the largest single utility system in the Mid-America Interpool Network (MAIN), an association of electric power companies in the Midwest. MAIN's purpose is to coordinate the planning and operation of the power systems in the region. The projected capability, peak load, and reserves of MAIN are shown in Table 8.3.

Forecasts of electrical power system demands and capabilities must include reserves to cover contingencies such as forced outages, variations in demand, scheduled and unscheduled maintenance, and errors in forecasts. The Commonwealth system loads peak in summer, and the estimates of peak demand are based on a 50% confidence level; i.e., average summer weather conditions are assumed. During severe heat waves, peak loads may exceed the estimate by several hundred megawatts. The Applicant's experience and probability studies have indicated that a 14% reserve of the total peak load will provide for all reasonable contingencies. Among the considerations in arriving at this value are the strong interconnections with neighboring systems through association in MAIN. The minimum reserve margin for the MAIN region is currently under study by the MAIN council.

As can be seen in Table 8.2, the reserve margin for the Applicant's system is estimated to be very near the 14% goal in most years after 1975 even with Units 2 and 3 in full operation. Without these units, the reserve margins will be very low, forcing the Applicant to curtail service or to purchase power by drawing upon the MAIN pool, thus depleting the reserves of the pool. If this power was purchased by the Applicant, the MAIN pool's reserve margin would be between 11 and 13% after 1974, see Table 8.3. Although MAIN does not have a reserve criterion at present, the Staff considers these levels of reserve to jeopardize the reliability of the system. In fact, the Federal Power Commission in the 1970 National Power Survey has indicated that the reserve margin for this region should be about 19%. MAIN's function is to provide short-term emergency relief in the event of unforeseen contingencies not normally experienced, rather than to provide firm, base-load power to its members.

TABLE 8.1. Future Capacity Installations and Retirements

Unit	Location	Status**	Effective Date	Type	Net Capability, MW Summer	Net Capability, MW Winter
Zion 1* (85% capacity)	Zion, Ill.	C	8/73	N	935	935
Zion 1* (15% incremental capacity)	Zion, Ill.	C	3/74	N	154	165
Zion 2* (85% capacity)	Zion, Ill.	C	5/74	N	935	935
Powerton 1 and 2	Pekin, Ill.	R	10/74	F	120	126
Zion 2* (15% incremental capacity)	Zion, Ill.	C	3/75	N	154	165
Powerton 3	Pekin, Ill.	R	10/75	F	99	105
Powerton 6	Pekin, Ill.	C	11/75	F	840	840
Collins 3	Morris, Ill.	C	5/76	F	500	500
Powerton 4	Pekin, Ill.	R	10/76	F	113	119
Calumet 7	Chicago, Ill.	PR	10/76	F	116	121
Waukegan 5	Waukegan, Ill.	PR	10/76	F	129	129
Collins 4	Morris, Ill.	C	10/76	F	500	500
Collins 2	Morris, Ill.	C	3/77	F	500	500
Gas Turbines	Not determined	P	4/77	CT	570	600
Collins 5	Morris, Ill.	C	10/77	F	500	500
Dixon 4 and 5	Dixon, Ill.	PR	10/77	F	115	119
Crawford 6	Chicago, Ill.	PR	10/77	F	81	94
LaSalle County 1	Seneca, Ill.	C	12/77	N	1048	1078
Collins 1	Morris, Ill.	C	3/78	F	500	500
LaSalle County 2	Seneca, Ill.	C	9/78	N	1048	1078
State Line 1	Hammond, Ind.	R	10/78	F	206	206
Byron 1	Byron, Ill.	C	5/79	N	1120	1120
Braidwood 1	Braidwood, Ill.	C	10/79	N	1090	1120
State Line 2	Hammond, Ind.	R	10/79	F	150	150
Byron 2	Byron, Ill.	C	3/80	N	1120	1120
Braidwood 2	Braidwood, Ill.	C	10/80	N	1090	1120
Sabrooke 1, 2, 3 and 4	Rockford, Ill.	PR	10/80	F	146	146
Ridgeland 2	Stickney, Ill.	PR	10/80	F	152	158
New Nuclear Unit 1	Not determined	P	3/81	N	1070	1100
New Nuclear Unit 2	Not determined	P	10/81	N	1070	1100
Ridgeland 1	Stickney, Ill.	PR	10/81	F	152	158
New Nuclear Unit 3	Not determined	P	3/82	N	1070	1100
New Nuclear Unit 4	Not determined	P	10/82	N	1070	1100
Waukegan 6	Waukegan, Ill.	PR	10/82	F	119	119

*Commercial service date depends on receipt of license.

**Status:
- C = Committed
- P = Projected
- R = Retired

Prepared from: MAIN's 1973 Reply to Appendix A of Order No. 383, p. 42, April 1, 1973, submitted to the Federal Power Commission, Washington, D. C., by the Mid-America Interpool Network, Chicago, Illinois.

TABLE 8.2 Commonwealth Edison Co. Projected Capability, Peak Load, and Reserves

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
With Dresden 2 and 3										
Net total capability, MW	14,596	16,309	16,343	17,584	18,796	20,648	22,610	24,670	26,532	28,520
Net peak load, MW	12,610	13,470	14,210	15,280	16,520	18,140	19,760	21,210	23,130	24,950
Reserve margin, MW	1,986	2,839	2,133	2,304	2,276	2,508	2,850	3,460	3,402	3,570
Reserve margin, % of peak load	15.7	21.1	15.0	15.1	13.8	13.8	14.4	16.3	14.7	14.3
Without Dresden 2 and 3[a]										
Net total capability	13,036	14,749	14,783	16,024	17,236	19,088	21,050	23,110	24,972	26,960
Net peak load, MW	12,610	13,470	14,210	15,280	16,520	18,140	19,760	21,210	23,130	24,950
Reserve margin, MW	426	1,279	573	744	716	948	1,290	1,900	1,842	2,010
Reserve margin, % of peak load	3.4	9.5	4.0	4.9	4.3	5.2	6.5	9.0	8.0	8.1

Prepared from "MAIN's 1973 Reply to Appendix A of order 383 - April 1, 1973," submitted to the Federal Power Commission, Washington, D.C., by the Mid-America Interpool Network, Chicago, Illinois.

[a]Dresden 2 and 3 at 1620 MWe.

TABLE 8.3 MAIN Projected Capability, Peak Load, and Reserves

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
With Dresden 2 and 3										
Net total capability, MW	34,940	37,902	39,975	42,742	45,937	49,546	52,956	57,911	62,074	65,286
Net peak load, MW	29,117	31,389	34,082	36,541	39,321	42,924	42,228	49,506	53,397	57,313
Reserve margin, MW	5,823	6,513	5,893	6,201	6,616	6,622	6,728	8,405	8,677	7,973
Reserve margin, % of peak load	20.0	20.7	17.3	17.0	16.8	15.4	14.6	17.0	16.2	13.9
Without Dresden 2 and 3[a]										
Net total capability, MW	33,380	36,342	38,415	41,182	44,377	47,986	51,396	56,351	60,514	63,726
Net peak load, MW	29,117	31,389	34,082	36,541	39,321	42,924	46,228	49,506	53,397	57,313
Reserve margin, MW	4,263	4,953	4,333	4,641	5.056	5,062	5,168	6,845	7,117	6,413
Reserve margin, % of peak load	14.6	15.8	12.7	12.7	12.9	11.8	11.2	13.8	13.3	11.2

Prepared from "MAIN's 1973 Reply to Appendix A of Order 383 - April 1, 1973," submitted to the Federal Power Commission, Washington, D.C. by the Mid-America Interpool Network, Chicago, Illinois.

[a]Dresden 2 and 3 at 1620 MWe.

Commonwealth Edison Company and the American Electric Power Company (AEP) have a long-term contract to exchange 200 MW, Commonwealth receiving 200 MW from AEP in summer and supplying 200 MW to AEP in winter. An attempt is made to exchange equal amounts of energy. This exchange is possible because Commonwealth has a summer peak and AEP has a winter peak power demand. Other systems in the Midwest also have summer peaks and cannot exchange power with the Applicant.

Population growth is one factor used in forecasting future demands for electric energy. Projecting energy requirements for the future is not simply a matter of relating population growth to energy demand, as the energy consumption per capita is also increasing with time. However, for analyzing trends, these two factors provide an indication of the growth rate to be expected. Curves of growth of population projected for the Chicago area and for FPC Power Supply Area 14 show a slope similar to the Applicant's projections for peak load. It is the conclusion of the Staff that the generating capacity of Units 2 and 3 is needed by the Applicant in order to meet the public demand for power and to assure adequate system reliability with a sufficient reserve margin. The Federal Power Commission in its comments on the draft version of this statement, concludes that "The continued operation of Dresden Units 2 and 3 (is) essential to assist the Applicant in meeting its projected loads and to provide adequate reserve margins for reliability of electric service" (see Appendix G).

8.2 SOCIAL AND ECONOMIC EFFECTS

As noted in Sections 5.1 and 5.6, no serious impacts on the neighboring community are anticipated. The entire community served by the Applicant is affected, nevertheless, by the continued operation of the Station. The service area encompassed by the Applicant's system contains one of the largest population and manufacturing centers in the United States. The majority of the residents of this area can be classified as urbanites and suburbanites and thus their livelihoods and life styles are dependent to a large degree on the continued use of power. As noted in Section 8.1, the 1600 MWe generated by Units 2 and 3 represents a significant (13.3%) fraction of the present peak power demand of the region and, therefore, has a significant social and economic effect on the community.

The community in the immediate environs of the Station will benefit from the local taxes paid by the Applicant (about $1.3 million/yr[1]). A large fraction of these taxes support the local school systems. The children of the operating personnel of the Station attend various schools in the area of the Station; however, a comparison of the number of operating personnel (about 150) with the population within ten miles of the Station (about 32,000) indicates that no construction of new facilities was required to accomodate these students. It appears likely that the local school districts benefit to a considerable extent from the presence of the Station and its personnel. In a similar way it may be concluded that those taxing bodies which provide other community services, such as water, sewage, fire and police protection, etc., also receive a net benefit from the presence of the Station and its employees.

The Station's operating personnel, whose gross annual income is about $1.5 million, also contribute to retail sales, bank deposits, etc., in the local area and many are residents who increase service trade, occupy housing, and make other contributions to the economic viability of the region. A cultural effect which is difficult to assess, although it is considered to be beneficial, is the diversity of interests contributed by the new residents in the surrounding communities.

The larger community served by the Applicant also benefits from the continued operation of the Station. Although the taxes paid by the Applicant may be regarded as an internal transfer within this large area, there is an economic benefit to be derived from the operation of the Station. It is difficult to quantify the worth of the electricity produced to the service area consuming the energy, but a minimum value is given by the market price which consumers pay. For Dresden Units 2 and 3, current rates place this value at about $200 million per year.

The Staff concludes that the economic benefits to the community from the operation of Dresden Units 2 and 3 exceed the economic costs to the community. The basis for this conclusion is that the income received by the employees of the Station and the property tax income received by the governmental units will enable them and the school districts to provide general improvements in community services and in educational facilities. The taxes paid on the large Station-property value should more than cover the small increase in the cost of government which results from providing services to the Applicant and to the Applicant's employees and their families.

8.3 CONSEQUENCES OF POWER AVAILABILITY

The availability of power from Units 2 and 3 support the economic and industrial growth of the service area. This availability attracts production industries (especially those which are substantial consumers of electrical energy, e. g., the petrochemical industry) and attendant service industries. This is demonstrated by an increase in power consumption for the last decade (1961-70) for the Applicant's service area which was greater than that for the country as a whole, despite a population growth which was less than the national average.[1] More specifically, thousands of residential customers and hundreds of commercial and industrial customers were added to the CECO system when Units 2 and 3 became available.[1] In addition, increased demand for energy to improve the environment could be met, as well as increased demand from public facilities such as schools and hospitals. The Applicant projects a continued increase in demand for electrical energy in its area and the Staff concurs in the general conclusion of this projection.

The economic impact to the service area of not having the power produced by Units 2 and 3 would be considerable; it is likely that the cost of not having the power production is greater than the direct benefits accruing from the operation of the Station. Residential customers would probably be inconvenienced by voltage reductions as a minimal consequence and outages resulting from load-shedding as a maximal consequence. Other effects, such as load limitations and increased rates, can be foreseen. Commercial customers would suffer somewhat from voltage reductions and substantially from power interruptions; industrial customers would be more severely affected. It is clear that regional growth would be curtailed by the absence of the energy produced by Units 2 and 3.

The consequences of power availability from nuclear stations should reflect the costs of alternative sources of energy to the consumer. If the energy is electrical and produced by the burning of fossil fuels, the consequent air pollution, especially in metropolitan areas, must be considered. Pursuant to this, it may be noted that the activation of Units 2 and 3 allowed the retirement of some of the Applicant's older fossil fuel units. If the energy is non-electrical, the inconvenience and dislocations suffered by the consumer must be considered in addition to the purely economic costs of replacement of electrical appliances, etc.

In order for the general community served by the Applicant to function harmoniously and to enjoy the standard of living and freedom from want which are generally prevalent, the Staff concludes that the availability of power is essential and that it is altogether fitting and proper that the Station be located within the area served. Along with this availability are imposed certain impacts and attendant responsibility to both control and limit impacts which are the major consequences of having the demanded power available. Although some of the adverse impacts can be reduced by the exercise of due care and diligence in the operation of the Station, not all adverse impacts can be eliminated.

8.4 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The following is a list of the unavoidable adverse effects which the Staff postulates will result from the continued operation of Units 2 and 3.

8.4.1 Land Effects

For the 30 to 40 year life of Units 2 and 3, the approximately 2500 acres of land occupied by the Station will be unavailable for other productive uses. Upon decommissioning of the Station at the end of its useful life, a small fraction (estimated at about 1% or 25 acres) will be irretrievably committed and unavailable for future use (see Sections 5.1.1 and 8.5).

In addition, there will be a significant increase of fogging and icing in the vicinity of the cooling lake and spray modules. These occurrences will result in temporary disruptions of local highway traffic and increase the likelihood of traffic accidents (see Section 5.1.2). The moisture in adjacent fields will also be increased - increasing the probability of crop blight diseases (see Section 5.5.3).

8.4.2 Water Effects

Approximately 46,000 gallons per day (32 gpm) of water are withdrawn from the Cambrian-Ordovician aquifer. The use of the closed-cycle cooling system requires the withdrawal of about 66,000 gpm (about 4%) of the average flow of water from the Kankakee River and results in the evaporation of approximately 16,000 gpm to the atmosphere and the return of about 50,000 gpm of heated water through the Station. This will result in a loss of some fish from the river due to impingement on the intake screens, and a loss of small organisms such as fish larvae and zooplankton due to stress during entrainment (see Section 5.5.1).

Trace amounts of chemicals are released to the Illinois River, which might produce very localized adverse effects on sensitive organisms immediately adjacent to the discharge point (see Subsection 5.5.5).

Approximately 11.2 x 10^9 Btu/hr of waste heat is released to the environment during full power operation. Most of this heat is released to the atmosphere over the cooling lake. The remainder of the heat is released to the environment via the cooling lake blowdown to the Illinois River and could produce measurable but very localized adverse effects immediately adjacent to the discharge point (see Subsection 5.5.2). The dissolved oxygen concentration of the cooling lake blowdown may be below the intake concentration under certain conditions. This would cause a small, but measurable, decrease in the already low D. O. level of the receiving Illinois River.

8.4.3 Atmospheric Effects

The operation of Units 2 and 3 will release about 69 tons/yr of pollutants to the atmosphere from on-site oil fired equipment (see Section 3.7.2).

8.4.4 Radiological Effects

Based on normal operation of Units 2 and 3, the estimated radioactive releases could result in total body doses to individuals of 1.5 mrem/yr near the site boundary. The total man-rem dose per year from all effluent pathways, received by the approximately 8,100,000 persons who will live within a 50-mile radius of the plant would be about 160 man-rem. By comparison, an annual total of about 1,100,000 man-rem is delivered to the same population as a result of the average natural radiation background. Units 2 and 3 will be a minor contributor to the total radiation dose that persons living in the area normally receive. Fluctuations in the natural background dose may be expected to exceed the small dose increment contributed by the operations of Units 2 and 3.

Transportation to and from the plant of nonirradiated and irradiated fuel and solid radioactive wastes which are packaged and shipped in federally approved containers and shielded casks will be subject to both the Commission's regulations in 10 CFR 70 and 71 and the Department of

Transportation (DOT) regulations in 49 CFR 170-179. The probability of accidental release of any radioactivity during transport is sufficiently small, considering the form of the transported material and its packaging, that the likelihood of significant radiation exposure is remote. With the use of proper containers, continued surveillance and testing of packages, and conservative design of containers, the environmental risk is small.

The potential exposures to the population from postulated accidents during operation of the plant will depend on the type and magnitude of the accident. As indicated in Section 7.1, the different types of accidents when multiplied by their respective probabilities of occurrence, result in a very small annual radiation exposure risk to the population. In fact, the potential exposure from all the postulated accidents is well within the naturally occurring variations in the background radiation. From the results of the realistic analysis it is concluded that the environmental risks due to postulated accidents involving abnormal releases of radioactivity during operation of the plant are exceedingly small.

Approximately 30 metric tons of uranium 235 will be consumed during the lifetime of Units 2 and 3 (see Section 8.6).

8.5 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

On a scale of time reaching into the future through several generations, the life span of Units 2 and 3 would be considered a short-term use of the natural resources of land and water. The resource which will have been dedicated exclusively to the production of electrical power during the anticipated life span of these units will be the land itself and the uranium consumed. No significant commitment of water use will have been made, since in the foreseeable future the Illinois and Kankakee Rivers will continue to be seasonally renewed. No deterioration of water quality is anticipated to occur due to the effluents discharged by the nuclear power units.

Approximately 2500 acres adjacent to the Illinois River and Kankakee River will be devoted to the production of electrical energy for the next 30 to 40 years. This use of the land does, however, conform to the physical plan for Grundy County as noted in the Comprehensive County Plan, Grundy County, Illinois, 1967.

At some future date, Units 2 and 3 will become obsolete and be retired. Many of the disturbances of the environment will cease when the units are shut down, and a rebalancing of the biota will occur. Thus, the "trade-off" between production of electricity and small changes in the local environment is somewhat reversible. Recent experience with other experimental and developmental nuclear plants has demonstrated the feasibility of decommissioning and dismantling such a plant sufficiently to restore the site to its former use. The degree of dismantlement, as with most abandoned industrial plants, will take into account the intended new use of the site and a balance among health and safety considerations, salvage values, and environmental impact.

No specific plan for the decommissioning of the Dresden Station has been developed. This is consistent with the Commission's current regulations which contemplate detailed consideration of decommissioning near the end of a reactor's useful life. The licensee initiates such consideration by preparing a proposed decommissioning plan which is submitted to the AEC for review. The licensee will be required to comply with Commission regulations then in effect and decommissioning of the facility may not commence without Commission authorization.

To date, experience with decommissioning of civilian nuclear power reactors is limited to seven facilities which have been shut down or dismantled: Hallam Nuclear Power Facility, Carolina Virginia Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua Reactor, Saxton Reactor, and the Elk River Reactor.

There are several alternatives which can be and have been used in the decommissioning of reactors: (1) Remove the fuel (possibly followed by decontamination procedures), seal and cap the pipes, and establish an exclusion area around the facility; (2) in addition to the steps outlined in (1), remove the superstructure and encase in concrete all radioactive portions which remain above ground; or (3) remove the fuel, all superstructure, the reactor vessel and all contaminated equipment and facilities, and finally fill all cavities with clean rubble topped with earth to grade level. This last procedure is being applied in decommissioning the Elk River Reactor. The Piqua decommissioning operation was typical of approach (1). The Hallam decommissioning operation was typical of approach (2). Alternative decommissioning procedures (1) and (2) would require long-term surveillance of the reactor site. After a final check to assure that all reactor-produced radioactivity has been removed, alternative (3) would not require any subsequent surveillance. Possible effects of erosion or flooding will be included in these considerations.

Estimated costs of decommissioning at the lowest level are about $1 million/unit plus an annual maintenance charge in the order of $100,000/unit.[3] Estimates vary from case to case, a large variation arising from differing assumptions as to level of restoration. For example, complete restoration, including regrading, has been estimated to cost $70 million.[4] At present land values, it is not likely that consideration of an economic balance alone would justify a high level or restoration. Planning required of the Applicant at this stage will assure, however, that variety of choice for restoration is maintained until the end of useful plant life.

The Applicant has estimated the cost of permanently shutting down each unit and placing it in a safe condition to be $900,000/unit and the cost of maintaining the plant in a safe shutdown condition each year thereafter to be $300,000/unit. The Applicant estimated the present value of these costs to perpetuity to be less than the $10 million net salvage value of each reactor core estimated to be available at the time of shutdown.[5]

The degree of dismantlement would be determined by an economic and environmental study involving the value of the land and scrap value versus the complete demolition and removal of the complex. In any event, the operation will be controlled by rules and regulation to protect the health and safety of the public that are in effect at the time.

The Staff concludes that the benefits derived from Units 2 and 3 in serving the electrical needs of the area outweigh the short-term uses of the environment in its vicinity.

8.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Numerous resources are involved in construction and operation of a major facility such as the Station. These resources include the land upon which the facility is located, the materials and chemicals used to construct and maintain the Station, fuel used to operate the Station, capital, and human talent, skill and labor.

Major resources to be committed irreversibly and irretrievably due to the operation of Units 2 and 3 are essentially the land (during the life of the Station) and the uranium (U-235) consumed by the reactors. Only that portion of the nuclear fuel which is burned up or not recovered in reprocessing is irretrievably lost to other uses. This will amount to approximately 30 metric tons[2] (conservative estimate) of uranium-235, assuming a 30-year lifetime for the units. Most other resources are either left undisturbed, or committed only temporarily during construction or during the life of the units and are not irreversibly or irretrievably lost.

Of the land used for plant buildings, it would appear that only a small portion beneath the reactor, control room, radwaste and the turbine-generator buildings would be irreversibly committed. Also, some components of the facility such as large underground concrete foundations and certain equipment are, in essence, irretrievable due to practical aspects of reclamation and/or radioactive decontamination. The degree of dismantlement of the units, as previously noted, will be determined by the intended future use of the site, which will involve a balance of health and safety considerations, salvage values, and environmental effects.

The use of the environment (air, water, land) by the units does not represent significant irreversible or irretrievable resource commitments, but rather a relatively short-term investment. The biota of the region have been studied, and the probable impact of the plant is presented in Sections 4 and 5. In essence, no significant short- or long-term damage or loss of the biota of the region has occurred or is anticipated.

Should an unanticipated significant detrimental effect on any of the biotic communities appear, the monitoring programs are designed to detect it, and corrective measures would then be taken by the Applicant.

The Staff concludes that the irreversible and irretrievable commitments are appropriate for the benefits gained.

References

1. Dresden Nuclear Power Station Environmental Report (DNPS/ER), Supplement II. Commonwealth Edison Co. (CECO), Chicago, Illinois (November 8, 1971).

2. DNPS/ER, Supplement IV. CECO (January 15, 1973).

3. Atomic Energy Clearing House, Congressional Information Bureau, Inc., Washington, D. C., Vol. 17, No. 6, p. 42; Vol. 17, No. 10, p. 4; Vol. 17, No. 18, p. 7; Vol. 16, No. 35, p. 12.

4. Pacific Gas and Electric Company, Supplement No. 2 to the Environmental Report, Units 1 and 2, Diablo Canyon Site, July 28, 1972.

5. Letter, Byron Lee, Jr., Assistant to the President, CECO, to Dr. P. A. Morris, Director, Division of Reactor Licensing, USAEC (August 11, 1970).

9. ALTERNATIVES TO THE PROJECT

The Dresden Nuclear Power Station has been in operation for more than ten years. Unit 1 began commercial service in 1960, Unit 2 in December 1969, and Unit 3 in January 1971. It is thus clear that choices among alternatives have long since been made. These include, but are not limited to, alternative selections of site, energy source, plant size, and plant design. The discussions in Sections 9.1 and 9.2 enumerate some of the options available to the Applicant at the time the choices were made, but the Staff believes that there is no longer a reasonable opportunity or need to revise the choices.

The alternatives which will be considered here are:

(a) Abandonment of Units 2 and 3.
(b) Conversion of Units 2 and 3 to fossil fuels.
(c) Use of cooling towers to dissipate waste heat.
(d) Use of mechanical condenser cleaning techniques.

9.1 ABANDONMENT AND ALTERNATIVE ENERGY SOURCES

9.1.1 Abandonment

The Dresden site was chosen 10-15 years before a NEPA Review was required. If Units 2 and 3 were abandoned, Unit 1 would still be in operation, although the cooling lake would no longer be required. The lake could then be used for recreation purposes or it could be drained and used for other purposes. Purchased power from other systems is very limited as noted in Section 8.1. Part of the projected load growth until a new replacement plant was completed, would, therefore, have to be provided by additional power production from the Applicant's existing plants, which are primarily fossil-fueled. This is true even if the Zion Nuclear Power Station begins operation in 1973 as presently scheduled. Extensive use would have to be made of older plants, which presently have little in the way of emission control equipment. Consequently, discharges of fly ash, sulfur dioxide, and nitrogen oxides to the atmosphere would be considerably increased, or extensive backfitting of pollution control devices would be required. The cost of this delay would ultimately be borne by the industrial, commercial, and residential customers of the Applicant's system.

The most severe problem, however, would be the lack of adequate reserve margins in generating capacity to meet peak load demand. This could result in less reliable service and possibly power rationing or brown-outs.

Because Units 2 and 3 have been in operation for more than three and two years, respectively, the environmental impacts associated with their construction and operation and with the transmission line rights-of-way have already occurred. If these units were to be abandoned and equivalent units constructed elsewhere, impacts at least equivalent to those imposed by Units 2 and 3 would then be incurred at another location. The costs associated with abandoning Units 2 and 3 would include the cost of (1) dismantling the facilities; (2) decontaminating and restoring the land or maintaining the facilities in a safe condition in perpetuity; (3) building either a nuclear- or fossil-fueled plant at another site; (4) purchasing substantial quantities of base-load power from others for a period of about five years; and (5) losing some operating reliability as a result of the reduction in reserve capability during the period between the shutdown of Units 2 and 3 and the startup of the replacement units.

The Staff concludes that these considerations and others discussed in Sections 3.1, 3.8, and 8.1 show that abandonment of Units 2 and 3 could be justified only by the need to avoid significant and irreparable environmental damage and no such damage is anticipated at the Dresden site.

9.1.2 Alternative Energy Sources

Fossil-fueled plants have some environmental advantages over current nuclear plants. The thermal efficiency of a modern fossil-fueled plant approaches 40 percent, compared to 33 percent for light water nuclear plants. [High-temperature gas reactors (HTGR) and sodium-cooled reactors have ~40 percent efficiency, but these technologies were still under development at the time that Units 2 and 3 were selected.] In addition, about 15% of the waste heat in a fossil-fueled plant is released through the stack with the other combustion products. Thus, the heat released to the condenser cooling water of a fossil-fueled plant is only about 63 percent of that for present-day nuclear plants of the same generating capacity.

A major disadvantage of fossil-fueled plants is that the combustion of coal or oil produces objectionable by-products (e.g., particulate matter, sulfur dioxide, and nitrogen oxides) which pollute the air. While natural gas is much better in this respect, it is not available as power station fuel in this region due to its short supply. Because of the growing national shortage of natural gas, the situation is expected to persist. Other environmental disadvantages associated with the use of coal or oil are the very large amounts of fuel which must be transported and stored. For a normal 80-day supply, a pile of coal 100 feet high and 15 acres in area would be needed in addition to approximately 60 acres for ash disposal. Oil storage tanks would similarly require considerable storage area.

It should be mentioned that such alternatives are apparently not undue hardships since the Applicant plans to construct a five-unit oil-fired plant approximately two miles downstream of Dresden, south of the Illinois River.[1] The first of these five units is scheduled for service on May 1, 1976, and the last by March 1, 1978.

The Dresden Station was designed and constructed for the use of nuclear fuel, and has been operating in this manner for several years. A change to fossil fuel would essentially involve closing down the plant and constructing another on the same site for operation with fossil fuel.

Since the units have been operating, decontamination would be required. Most of the presently invested capital cost would be lost and there still would be a nuclear plant (Dresden Unit 1) on the site. The most significant factor, however, is that Units 2 and 3 are an integral part of the Applicant's present system and severe effects on the Applicant's reserve capacity and peak load capability would result as noted in Section 8.

A tabulation of the estimated incremental costs and impacts of the alternatives of fossil fuel and cooling towers, relative to costs and impacts of the chosen plant design, are given in Table 9.1. The alternatives are appraised with the assumption that they would be incorporated at the Dresden site. The costs have been computed by using the information in the Dresden Environmental Report[2] as to costs of Units 2 and 3 and for the addition of a cooling tower. It should be noted, however, that the cooling tower costs are an adaptation of the costs computed in the Quad-Cities Environmental Report.[3] The costs for an equivalent fossil-fueled plant are computed from data given in the Zion Environmental Report.[4] These indirect procedures which were followed since direct data were not available to the Staff, are considered reasonable. The alternative of purchase of power is not considered by the Staff to be an acceptable alternative because of the resulting low reserve margin of the MAIN pool (see Section 8.1).

Since the alternative actions offer no overall improvement in environmental benefits and cost more than the actions taken, the Staff concludes that the continued operation of Units 2 and 3 is reasonable and justified. For the alternative of abandonment, the impaired service to customers during the anticipated five-year delay period of conversion to a fossil-fueled plant and the large economic penalties to the Applicant's customers are considered unwarranted.

9.2 ALTERNATIVE PLANT DESIGNS

9.2.1 Alternative Heat Dissipation Systems[5-12]

Cooling Towers

Cooling towers are described on the basis of design and operating characteristics as "dry" or "wet" and as "mechanical-draft" or "natural-draft." A dry-type cooling system operates on the same principle as an automobile radiator, i.e., the cooling water never comes in direct contact with the air and all of the heat is rejected through fin tube exchangers. Thus, there are no evaporative losses, which require makeup water.

In a wet cooling tower, all of the heat rejection takes place by direct contact of the cooling water with the air. The water is pumped through the cooling tower where it is broken up into small drops by splashing down through the "packing" or "fill" of the tower. More than 75 percent of the heat is dissipated by the evaporation of a portion of the circulating water, while the remaining heat is lost as sensible heat transfer to the air.

TABLE 9.1 Balance of Alternatives for Dresden Units 2 and 3

	Dresden Units 2 and 3	Incremental Changes: Conversion to Fossil Plant with Cooling Lake	Incremental Changes: Natural-Draft Wet Cooling Towers	Incremental Changes: Abandonment
<u>Monetary Costs ($10^6)</u>				
Capital	243	329 (less salvage)	16	(Salvage)
Operation and maintence	4.5/yr	0	0	(4.5)*
Fuel	23.4/yr.	23.4	0	(23.4)*
<u>Environmental Costs</u>				
Land use, site	1573 acres	0	(1573)	(1573)
New right-of-way	120 acres	0	0	(120)
Fogging and icing	Occasional severe localized effects.	Slightly less.	Much less localized effects.	(Occasional severe localized effects.)
Water use, consumptive	23 mgpd	(9 mgpd)	0	(23 mgpd)
Chemical discharge	2 tons/day	Less $SO_4^{=}$	0	(2 tons/day)
Thermal discharge	22 x 10^9 Btu/day	(8 x 10^9 Btu/day)	0	(22 x 10^9 Btu/day)
Air use, plumes	None	Visible	Visible	0
Effluents	Negligible	199.9 Tons/day SO_2 ** 116.2 Tons/day NO_2 ** 16.2 Tons.day particulates **	Very small	(Negligible)
Biological impact	Small and localized.	0	0	(Small and localized.)
Radiological impact				
Whole body dose (≤5mi.)	<1% bkgd	Less	0	(<1% bkgd)
Cumulative dose (≤5 mi.)	160 mrem/yr	Less	0	(160 mrem/yr)
Appearance	Neutral	Tall stack(s)	Large towers (lake)	0 (lake)

*These savings would be overbalanced by the cost (about $60 million per year for a five-year period[3] of purchasing power during the construction of an alternative plant.

**Assumes a net electrical output of 1620 MWe at a 40% overall thermal effeciency with stack emissions at the allowable limits of 40CFR60.

Parenthesis indicate a savings

If the cooling process is assisted by fans that move the air past the water or cooling fins, this type of system is referred to as a mechanical-draft tower. A natural-draft tower requires no fans, but uses the tower height to produce a "chimney effect" to move the air.

(1) Dry Cooling Towers

The heat rejection performance of the tower and the thermodynamic performance of the turbine are the two most significant interdependent factors in the operation of a dry-type condensing system. The return temperature of a dry tower can, at best, approach the "dry-bulb" air temperature, which is always equal to or higher than the "wet-bulb" temperature (the lowest temperature to which water can be cooled by evaporation into the surrounding environment). Thus, the water returning to the condenser from a dry tower is hotter than it would be if any other method of cooling were used. This in turn results in an increased turbine exhaust pressure. Exhaust pressures as great as 10 inches Hg can occur in hot weather while 5 inches Hg is the limit of exhaust pressure recommended by turbine manufacturers. It is estimated that turbines designed to operate at high exhaust pressures will not be commercially available before 1976.[5]

The advantages of dry cooling towers are:

1. They create no problems of fogging, icing, and drift.

2. They eliminate water problems such as availability, evaporative loss, blowdown, and heat rejection to lakes, rivers, and ponds.

The disadvantages are:

1. Capital costs are substantially greater than for other methods.

2. Larger volumes of air must be circulated.

3. Plant output decreases at high dry-bulb temperatures.

4. Larger land area is required than for wet towers.

5. Dry towers are susceptible to damaging winds and tornadoes (particularly true for natural draft).

6. If forced draft is used, maintenance costs are high and towers are subject to mechanical failure.

No established technology now exists for dry towers appropriate to large modern generating stations. The largest dry tower, built in the Union of South Africa, serves a fossil plant of 200-MWe capacity. This method of cooling is perhaps the best from an environmental standpoint; however, the technology for constructing a large facility of this type has not as yet been developed and thus imposition of this alternative at the Dresden Station is considered by the Staff to be technically unfeasible.

(2) Wet Mechanical-Draft Towers

Evaporation is induced in wet mechanical-draft towers by forcing the air through the heated condenser discharge water with large fans. The return temperature of the water approaches the wet-bulb temperature, which is lower than the dry-bulb temperature. About one percent of the circulating water is lost due to evaporation and drift. Another one to two percent is lost due to blowdown (required to prevent buildup of dissolved solids). This amount of makeup water can be quite considerable in large towers.

The advantages of mechanical-draft wet towers are:

1. Positive control over air supply.

2. Close control of return cold water temperature.

3. Generally low pumping head.

4. Ambient relative humidity has a minimal effect on tower performance.

The disadvantages are:

1. The towers are subject to mechanical failure.

2. The operation and maintenance costs are higher than for natural-draft towers and quiescent cooling ponds.

3. They are likely to cause localized icing and fogging.

4. They require blowdown to prevent salt buildup.

5. They may cause deposition of salts on surrounding land from drift.

Of the various evaporative cooling systems discussed in this section, this type of tower has the highest potential for creating significant amounts of low-level fogging and icing. Mechanical-draft towers release large amounts of heat and water vapor over relatively small areas at low levels where wind speeds are lower and the saturation deficit is less than that of natural-draft towers. Tower drift potentials are also higher with mechanical towers. As a result of the high exit speeds (about 30 ft/sec), high turbulence levels (due to the fans), high entrainment rates, and larger surface/volume ratios, plume rise is less for a mechanical-draft tower than it is for a natural-draft tower.

(3) Wet Natural-Draft Towers

In this type of tower air moves upward as a result of the chimney effect (natural draft) created by the difference in density between the warm moist air inside the tower and the colder, denser air outside.

The advantages of wet natural-draft towers are:

1. They have fewer mechanical or electrical components than mechanical-draft cooling towers.

2. Maintenance costs are lower than for mechanical-draft towers.

3. They require less land area than other towers.

4. They will rarely, if ever, cause fogging and icing in level terrain areas.

The disadvantages are:

1. The great tower height necessary to produce draft results in huge structures.

2. The precise control of outlet water temperature is more difficult than with mechanical-draft towers.

3. Such towers may cause deposition of salts on surrounding land from drift.

4. They can generate large airborne vapor plumes which may occasionally extend for 10-20 miles in the downwind direction.

5. They require blowdown to prevent salt buildup.

6. They are susceptible to damaging winds and tornadoes.

(4) Discussion

Four 350-foot or three 500-foot natural-draft wet cooling towers would be required to dissipate 11.2×10^9 Btu per hour of heat.[13] About 75% of the cooling would be accomplished by evaporating ~13,500 gallons of water per minute.

A visible vapor plume almost always forms when the moist, warm effluents from wet towers mix with the cooler ambient air. The dimensions of the visible plume would vary considerably and would depend on the local weather conditions.

All of the evaporative cooling systems have a higher potential for creating extended vapor plumes and/or surface fogging and icing than does the once-through cooling.[14] Operational experience both in the United States and in Europe has shown that natural-draft cooling towers have the lowest adverse meteorological impact of all evaporative cooling systems.[14-17]

Natural-draft cooling towers have been used for at least two decades in Europe, particularly in England. Decker[15] has made a survey of European operating experience and has found little evidence of adverse weather modifications attributable to natural-draft cooling towers. Experience in the United States to date has not revealed any significant weather modification problems.[14,17-20]

The Staff has found only one reported instance of the plume from a natural-draft cooling tower returning to the ground.[18]

The Staff has found no reported cases of icing from a natural-draft cooling tower. The low frequency of plumes intersecting trees, other vegetation and structures, and the small droplet size in the plume (diameter less than 100 microns) contravene the formation of ice.

Photographs taken at cooling tower installations often show the plume leaving the tower and rising. It is generally separated completely from the surface fog which is assumed to be of independent origin since the aerodynamic downwash is not observed.[21]

The most frequent atmospheric impact of wet natural-draft tower operation would be the formation of extended plumes aloft. Plumes longer than 10 miles have been observed.[14,18,20]

The existing cooling lake and spray canals at the Dresden site, when operated in the committed closed-cycle mode, will have the following advantages over cooling towers:.

1. The system is expected to comply with the state 26-acre mixing-zone requirement.

2. There will be significantly less salt drift.

3. The system is less susceptible to damage from high winds.

4. No large vertical structures are required.

5. The environmental disturbance due to construction has already occurred.

6. The capital expenditure for installation has already occurred.

The disadvantages of this system are:

1. It required removal of 1575 acres of land from other use.

2. It creates fogging and icing problems on two roads.

3. It is subject to dike failure and resulting flooding.

(5) Cost Comparison

The tabulation below compares the capital cost for various cooling methods as determined by several authors. The capital cost includes the price of the condenser, its associated pumps and piping, the heat rejection unit and its accessories. The figures do not include the cost of loss of capability.

The values presented below were adjusted by the Staff to reflect the costs for 1618 MWe. Some of the papers quoted were written two or more years ago, and no cost escalation factor was applied to the figures. Thus, the costs quoted are probably lower than they would actually be at this date. Dry cooling tower costs were not included since present-day turbine technology would prohibit their economic use for the Dresden Station. The purpose of this table is to present a relative price comparison of the various alternative methods of cooling and not to present data for use in estimating the costs of an alternative at the Dresden Station.

Cost of Cooling Systems for a 1618-MWe Nuclear Plant
(millions of dollars)

Cooling System	Tichenor[6]	Dynatech[8]	Woodson[10]	Jimeson[12]
Once-through	12.0	8.5	12.5	4.8 - 8.1
Cooling pond	18.0	12.1	19.4	10.1 -15.2
Spray pond	20.0	13.1	-	-
Natural-draft (wet)	28.8	18.6	28.3	15.2 -22.0
Mechanical-draft (wet)	20.7	15.2	19.0	13.5 -18.6

(6) Conclusion

In view of the environmental impacts which are mitigated by the use of the closed-cycle cooling rather than the use of open-cycle cooling, the Staff concludes that some form of closed-cycle cooling must be used.

It is the conclusion of the Staff that imposition of cooling towers upon a station that is converting to a closed-cycle cooling pond is not warranted by any postulated environmental impacts of the system or any beneficial effects of the alternative cooling systems.

9.2.2 Alternative Condenser Cleaning Techniques

Several of the Applicant's most recently designed nuclear power stations (e.g., the Zion Station and the LaSalle Station) have incorporated the use of mechanical condenser cleaning systems instead of the chemical (sodium hypochlorite) systems that are used in Dresden Units 2 and 3.

One type of available mechanical system uses hundreds of plain and abrasive rubber balls slightly larger than the internal diameter of the condenser tubes. These are injected into the condenser inlet pipe and carried through with the cooling water. An automatic collector extracts the balls from the tail-pipe flow and returns them to the injector for reuse. Field tests of the system have shown a reduction of tube wall thickness, exclusive of any pitting. Continued operation in this manner could result in a substantially shortened tube life. The life of a sponge rubber ball is, on the average, a few days or less due to loss from the system or disintegration.

Another mechanical condenser tube cleaning system uses plastic or fiber brushes which are propelled back and forth over the entire tube length when the cooling water flow is reversed. This backwashing is accomplished using external piping and reversing valves. In tests using the system, tube thinning has been observed. The brushes wear with time and must be replaced. Apart from the apparent shortening of tube life, the use of either of the two mechanical cleaning methods described would seem to entail small but poorly identified environmental consequences. On the other hand, the undesirable consequences of the use of chlorine for this purpose can be reduced to an acceptable level by adherence to proper chlorination procedures. The Applicant will be required to limit the use of chlorine as described in Section 5.5.5. The Staff finds that the environmental impact due to chlorination, when done in the prescribed manner, will be at an insignificant level, and concludes that the requirement of a mechanical cleaning method would be unwarranted.

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