Final

environmental statement

related to the proposed

BRAIDWOOD STATION

COMMONWEALTH EDISON COMPANY

DOCKET NOS: STN 50-456 and STN 50-457

U.S. Nuclear Regulatory Commission
Office of Inspection & Enforcement
Region III-Library
799 Roosevelt Road
Glen Ellyn, Illinois 60137

JULY 1974

UNITED STATES ATOMIC ENERGY COMMISSION
DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

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

1. This action is administrative.

2. The proposed action is the issuance of construction permits to the Commonwealth Edison Company for the construction of the Braidwood Station, Units 1 and 2 (Docket Nos. STN 50-456 and STN 50-457), located near the Kankakee River in Will County, Illinois, and scheduled for commercial service in early 1980 and late 1981.

Braidwood Station will employ two pressurized water reactors to produce up to 6850 megawatts thermal (MWt). Two steam-turbine generators will use this heat to provide 2240 MW (net) of electrical power capacity. The exhaust steam will be cooled by a once-through flow of water obtained from an artificial cooling lake. Makeup (93 cfs, avg.) will be drawn from the Kankakee River and blowdown (47 cfs, avt.) will be discharged to it.

3. Summary of environmental impact and adverse effects:

(a) Approximately 734 acres of agricultural land, 848 acres of woods and fallow field, and 2838 acres of strip-mine spoil will be required for the station and the cooling lake.

(b) Eleven farm residences will be displaced. Farming on part of the site will be suspended.

(c) Traffic on local roads will increase due to construction and commuting activities.

(d) Approximately 2376 acres of transmission line right-of-way will be on land used primarily for agriculture, with some woodland of which approximately ten acres will be used for tower bases. The remainder of the farmlands can remain in use.

(e) Minor and temporary impacts to the biota of the station area river bank will result from construction activities.

(f) The proposed station will withdraw up to 93 cfs of water from the Kankakee River and discharge about 46 cfs. The average net consumptive loss due to evaporation from the lake is estimated to be about 47 cfs.

(g) During the 7-day 10-year low flow periods of the Kankakee River, approximately 20% of the river flow and its entrained small biota will be diverted to the cooling lake. The staff expects that a large fraction of the organisms entrained in this fraction of river water would be lost due to thermal and mechanical shock. Losses of this magnitude might stress the river downstream of the station but the river ecosystem is expected to recover when normal flows return.

(h) An excessive growth of algae in the cooling lake might impose an adverse impact upon the Kankakee River below the discharge. Should this occur, the staff believes that by proper choice and use of control measures the algae growth could be controlled so as not to result in a significant disturbance of the river ecosystem.

(i) The risk associated with accidental radiation exposure is very low.

(j) No significant environmental impacts are anticipated from normal operational releases of radioactive materials within 50 miles. The estimated dose to the offsite population within 50 miles from operation of the station is less than the normal fluctuations (5%) in the 610,000 man-rems/year background dose this population would receive.

4. Principal alternatives considered:

Purchase of power from outside sources.

Alternative energy sources.

Alternative sites.

Alternative methods of heat dissipation.

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

Advisory Council on Historic Preservation

Department of Agriculture

Department of the Army, Corps of Engineers

Department of Commerce

Department of Health, Education and Welfare

Department of Housing and Urban Development

Department of the Interior

Department of Transportation

Environmental Protection Agency

Federal Power Commission

Illinois Institute for Environmental Quality

Illinois Department of Public Health

Chairman, Will County Board of Supervisors

6. This Final Environmental Statement was made available to the public, to the Council on Environmental Quality, and to other specified agencies in July 1974.

7. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical, and other benefits of the Braidwood Station, Units 1 and 2, against environmental and other costs, and considering available alternatives, it is concluded 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 construction permits for the facility subject to the following limitations for the protection of the environment:

(a) The applicant shall take the necessary mitigating actions, including those summarized in Sec. 4.5 of this Environmental Statement, during construction of the station and associated transmission lines to avoid unnecessary adverse environmental impacts from construction activities.

(b) In addition to the pre-operational monitoring programs described in Sec. 6.1 of the Environmental Report, with amendments, the staff recommendations included in Sec. 6.1 of this document shall be followed.

(c) A control program shall be established by the applicant to provide for a periodic review of all construction activities to assure that those activities conform to the environmental conditions set forth therein.

(d) Before engaging in a construction activity that may result in a significant adverse environmental impact that was not evaluated, or that is significantly greater than that evaluated in this Environmental Statement, the applicant shall provide written notification to the Director of Licensing.

(e) If unexpected harmful effects or evidence of irreversible damage are detected during facility construction, the applicant shall provide to the staff an acceptable analysis of the problem and a plan of action to eliminate or significantly reduce the harmful effects or damage.

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FOREWORD

This environmental statement was prepared by the U. S. Atomic Energy Commission, Directorate of Licensing (staff) in accordance with the Commission's regulation, 10 CFR Part 50, Appendix D, which implements the requirements of the National Environmental Policy Act of 1969 (NEPA)

The NEPA 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 esthetically 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 which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

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

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

An environmental report accompanies each application for a construction permit or a full-power operating license. A public announcement of the availability of the report is made. Any comments by interested persons on the report are considered by the staff. 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 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. A summary notice is published in the Federal Register of the availability

of the applicant's environmental report and the draft environmental statement. Interested persons are requested to comment on the proposed action and 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 questions and objections raised by the comments and the disposition thereof; a final benefit-cost 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 the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered, the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license, or its appropriate conditioning to protect environmental values. This final environmental statement and the safety evaluation report prepared by the staff are submitted to the Atomic Safety and Licensing Board for its consideration in reaching a decision on the application.

Single copies of this statement may be obtained by writing the Deputy Director for Reactor Projects, Directorate of Licensing, U. S. Atomic Energy Commission, Washington, D. C. 20545. Dr. S. Stanley Kirslis is the AEC Environmental Project Manager for this statement. (301-443-6980).

1. INTRODUCTION

1.1 THE PROPOSED PROJECT

In accordance with the Atomic Energy Act of 1954, as amended, and the Commission's regulations in Title 10, Code of Federal Regulations, an application was filed by the Commonwealth Edison Company (hereinafter referred to as the applicant) for construction permits for two pressurized water nuclear reactors designated as the Braidwood Station, Units 1 and 2 (Docket Nos. STN 50-456 and STN 50-457). Each unit is designed for initial operation at approximately 1120 MWe. The proposed facilities are to be located near the small town of Braidwood, Illinois, about 50 miles southwest of Chicago.

Appendix D of 10 CFR Part 50 requires that the Director of Regulation, or his designee, analyze the report and prepare a detailed statement of environmental considerations. Acordingly, this environmental statement related to the construction of the Braidwood Station has been prepared by the Directorate of Licensing (staff) of the U. S. Atomic Energy Commission.

Major documents used in the preparation of this statement were the applicant's Environmental Report (ER), Preliminary Safety Analysis Report (PSAR), and supplements thereto issued for Braidwood. 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 Braidwood site and surrounding areas in October 1973. Although data from all of these sources was examined by the staff in making its assessments, only brief summaries of the most pertinent data are given in this statement. To avoid repetition, the staff has provided only references to the sources of detailed information, much of which is found in the applicant's Environmental Report.

As a 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 features that are salient to the anticipated environmental effects are repeated in this environmental statement.

Copies of the applicant's Environmental Report were sent to the appropriate agencies for comment. These and other documents were also deposited in the Commission's Public Document Room, 1717 H Street NW, Washington, D. C., and at Wilmington Township Public Library, 201 South Kankakee Street, Wilmington, Illinois. When the place and date for the public hearing before the Atomic Safety Licensing Board is established, an announcement will be published in the Federal Register and issued as an AEC press release.

1.2 STATUS OF REVIEWS AND APPROVALS

A listing of applications filed by the applicant to obtain permits and licenses from various governing bodies or agencies is given in Table 1.1. The current status of each application is given, when known.

Table 1.1. Licenses and Permits for the Braidwood Station*

Agency	Permit Required		Purpose of Action	Date (or estimated date) of Submission	Date Granted or Status
	Description	Authority			
U. S. Atomic Energy Commission	Construction Permit	Atomic Energy Act of 1954; 10CFR50	Construct Units 1 and 2	Feb. 26, 1973	Action pending
	By-product License	10CFR30	Possess nuclear by-products prior to operation	Late 1975	
	Materials License	10CFR70	Possess special nuclear materials prior to operation	Mid 1978	
	Operating License	Atomic Energy Act 1954; 10CFR50	Operate Units 1 and 2 (Submit FSAR and update ER)	Early 1977	
U. S. Army Corps of Engineers	Construction Permit	River and Harbor Act of 1899	Construct intake and discharge structures in Kankakee River	June 1974	
U. S. Environmental Protection Agency	Discharge Permit	Fed. Water Pol Control Act, amended 1972	Discharge of waste water	Oct. 1, 1974	
Federal Aviation Administration	Approval	Civil Aeronautics Act of 1938 as amended	Construction of meteorological tower	Feb. 2, 1973	Granted May 26, 1973
Ill. Commerce Commission	Certificate of Public Convenience and Necessity	Ill. Public Utilities Act, 1969	Construct, operate and Monitor Units 1 and 2	June 1, 1973	pending
	Construction Permit	Ill. Public Utilities Act, 1969	Construct transmission lines in ROW corridors	Future	
Ill. Environmental Protection Agency	Construction Permit	Environmental Protection Act 1971	Construct Units 1 and 2, sewage plant reservoir, etc.	June 1, 1974	

Table 1.1. (Cont'd)

Agency	Permit Required		Purpose of Action	Date (or estimated date) of Submission	Date Granted or Status
	Description	Authority			
	Operating Permit for Discharges	Environmental Protection Act 1971	Operate water-treatment facilities	Future	
	Construction and Operating Permits	Environmental Protection Act 1971	Construct and operate standby boilers and diesel-generators	Future	
Ill. Dept. of Transportation	Construction Permit	Ill. Commerce Act 1911	Construct intake and discharge structures in Kankakee River	May 1, 1974	
Ill. Dept. of Mines and Minerals	Permit	Ill. Act of July 1941	Drilling water wells	April-May, 1974	pending
Ill. Dept. of Public Health	Registration	Ill. Registration Act, July 1957	Registration of ownership or possession of, or equipment utilizing radioactive material	1978	
Ill. Dept. of Aeronautics	Permit	Ill. Rev. Stat. 1971	Construction of meteorological tower	Future	granted June 4, 1973
Grundy and Will Counties, Superintendent of Highway	Permit for roadwork	Ill. Commerce Act June 10, 1911	County roadwork	Not required	

*Modified from the applicant's Environmental Report.

2. THE SITE

2.1 SITE LOCATION

The Braidwood site covers approximately seven square miles in the southwest corner of Will County in north central Illinois, approximately 50 miles southwest of Chicago and 20 miles south-southwest of Joliet (see Fig. 2.1). It is on the Kankakee plain in a region characterized by abandoned strip mines. The irregular, sparsely vegetated piles of gray culm from strip mining interspersed with excavations containing stagnant water lend a generally desolate appearance to most of the site. Nearby towns, railroads, highways, roads, rivers, and streams are shown in Fig. 2.2 and an aerial photograph of the site itself is provided in Fig. 2.3. The site is near the Joliet arsenal; the minimum distance between their respective boundaries is eight miles.

The site is approximately 3 miles west of the Kankakee River at a point 14 miles upstream from its confluence with the Des Plaines River. The Mazon River and its branches (East Fork, Reddick Run, Crane Creek, and Granary Creek) are to the west, southwest, and south of the site, the Mazon River passing within one mile of the southwestern site boundary (see Fig. 2.2).

2.2 REGIONAL DEMOGRAPHY AND LAND USE

Except for a few small industries in Coal City and Wilmington, the region surrounding the proposed site is used primarily for agriculture. Land within two miles of the turbine building is shown in Fig. 2.4. According to the 1970 census, there was a resident population of 8892 persons in the area within a five-mile radius of the point where the building of the reactors is planned.

The town of Godley (pop. 242) is about one-half mile from this point. Within the five-mile radius there are the towns of Coal City (1970 pop. 3040) and Braidwood (1970 pop. 2323), 159 farms with 524 residents, and nine private sport and recreation clubs.

According to the calculations (Ref. 1, p. 2.2-2), the total resident population (1970) within the ten-mile radius is 22,116, averaging 70 persons per square mile. At the end of the assumed 30-year useful life of the plant, the resident population is expected to grow to 42,000. Nineteen private and public recreational facilities are located within the 10-mile radius, with a staff estimate of a total peak daily attendance of 40,000.[2,3] There are 23 schools within this radius with a total student-teacher population of 6923.

There are 17 "large" urban centers (populations over 25,000) within a 50-mile radius of the site: this includes part of the City of Chicago. The total population (1970) of 3,878,784 within the 50-mile radius is expected to expand to 7,000,000 in 2012 (Ref. 1, p. 2.2-32).

The nearest farm is 1850 ft WNW from the center of the turbine building while the nearest residence is 1550 ft north. It is estimated that 116 dairy cows and six dairy goats pasture within five miles of the turbine building.

2.3 HISTORICAL PLACES AND NATURAL LANDMARKS

The Illinois and Michigan Canal Lock No. 6 and the lock house in Channahon Parkway State Park (nine miles north of the site) are the closest National and Illinois State Historical Sites.[4] No National Register of Historic Places sites are found within the project boundaries of Braidwood Station (see Appendix D). An archeological survey of the Braidwood site area was completed by the applicant (Ref. 1, p. 14.7-11), and evidence of prehistoric occupation was found in 16 separate locations. The collections and their locations are on file at the Illinois State Museum. However, the debris density was extremely low compared with neighboring areas and further study was not considered fruitful by the applicant's consultant. An archeological assessment of the Braidwood site was prepared by the Illinois State Museum Society on September 15, 1973. They found that there would be insufficient impact of the plant on the archeological resources of the area to justify any salvaging project. This report was Appendix 7 in Ref. 1.

An unusual scientific interest attaches to some of the strip-mined areas in the vicinity of the proposed Braidwood Station in that strip-mining has exposed some unique fossils of soft-bodied fauna. One of the strip-mining pits most productive of these "Mazon Creek and Essex fauna" is in the area to be flooded by the proposed cooling lake. Further information on the fossils and on plans for paleontologists to recover them is given in Appendix G.

Two biologically unique nature preserves are located near the site--Goose Lake Prairie Nature Preserve (nine miles NNW), characterized by Prairie and Marsh communities believed to be characteristic of Illinois at the time of early settlement, and the Kankakee River Nature

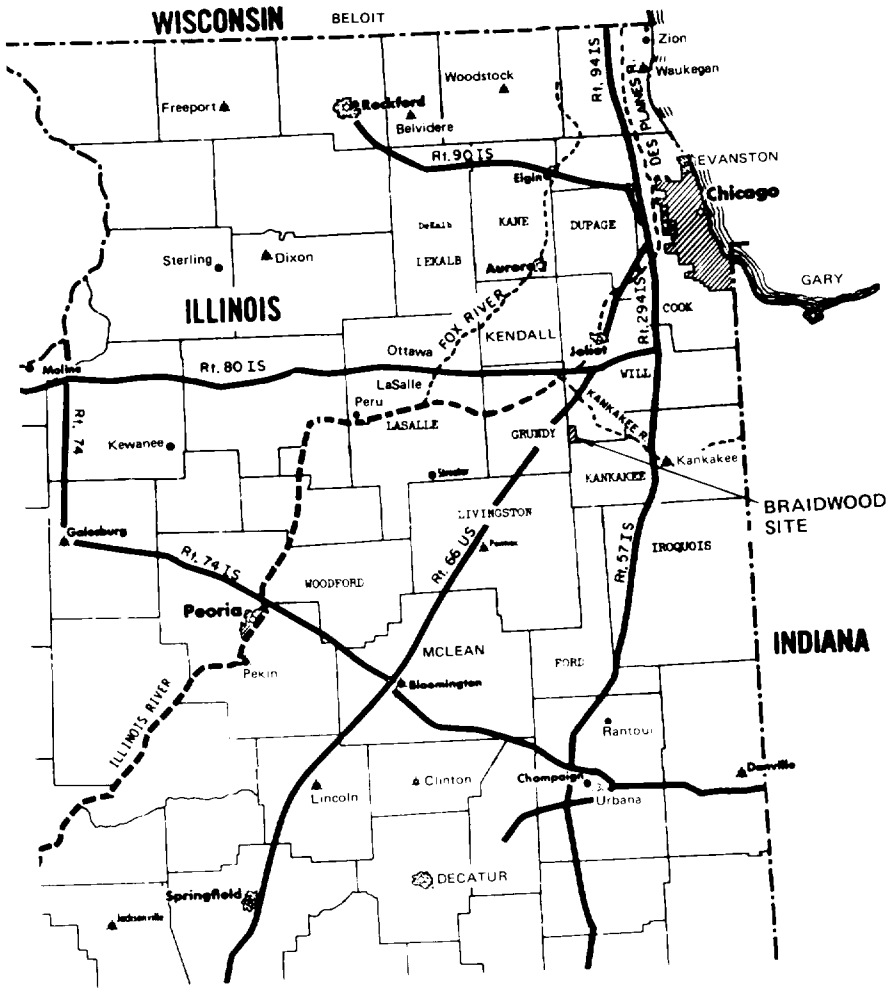

Fig. 2.1. Location of the Braidwood Site. From applicant's Environmental Report.

40 mi.

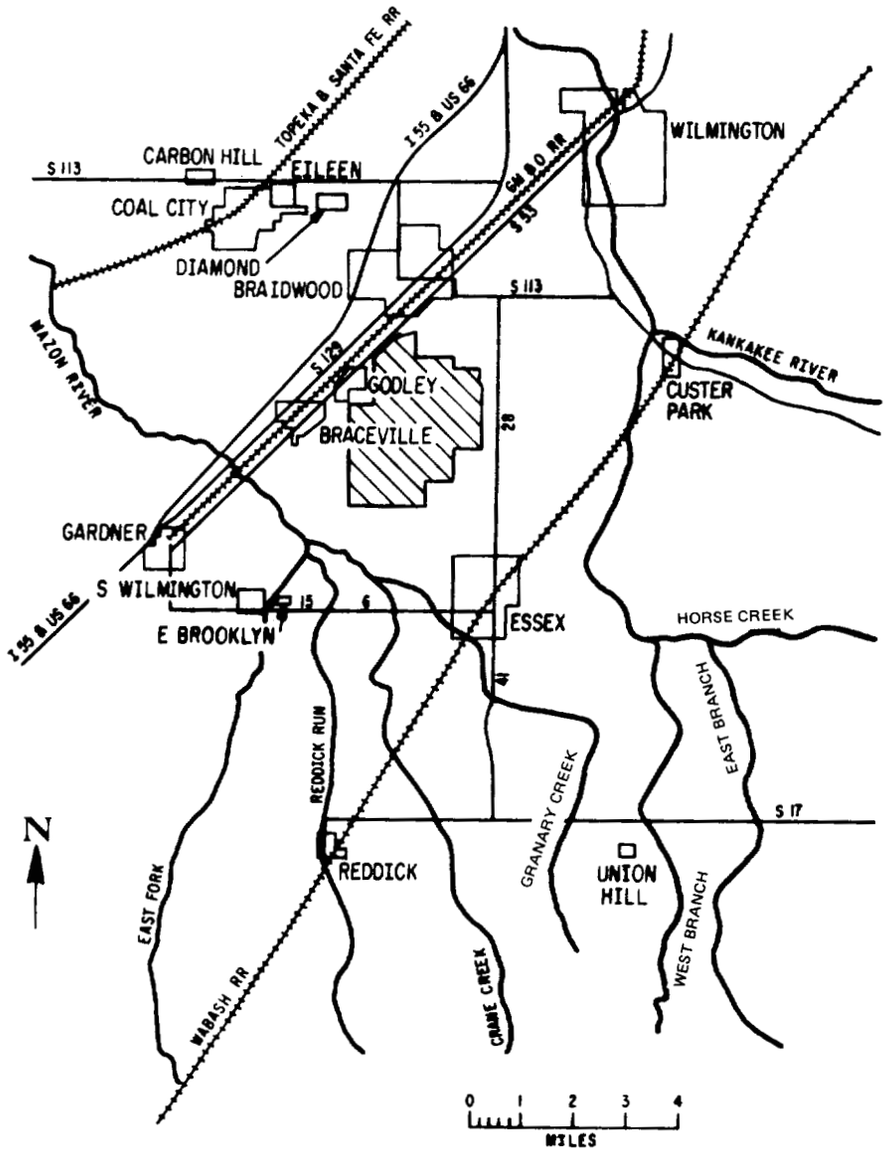

Fig. 2.2. The Braidwood Site Area. From applicant's Environmental Report.

Fig. 2.3.

Vertical Aerial Photo of the Site. From the applicant's Environmental Report.

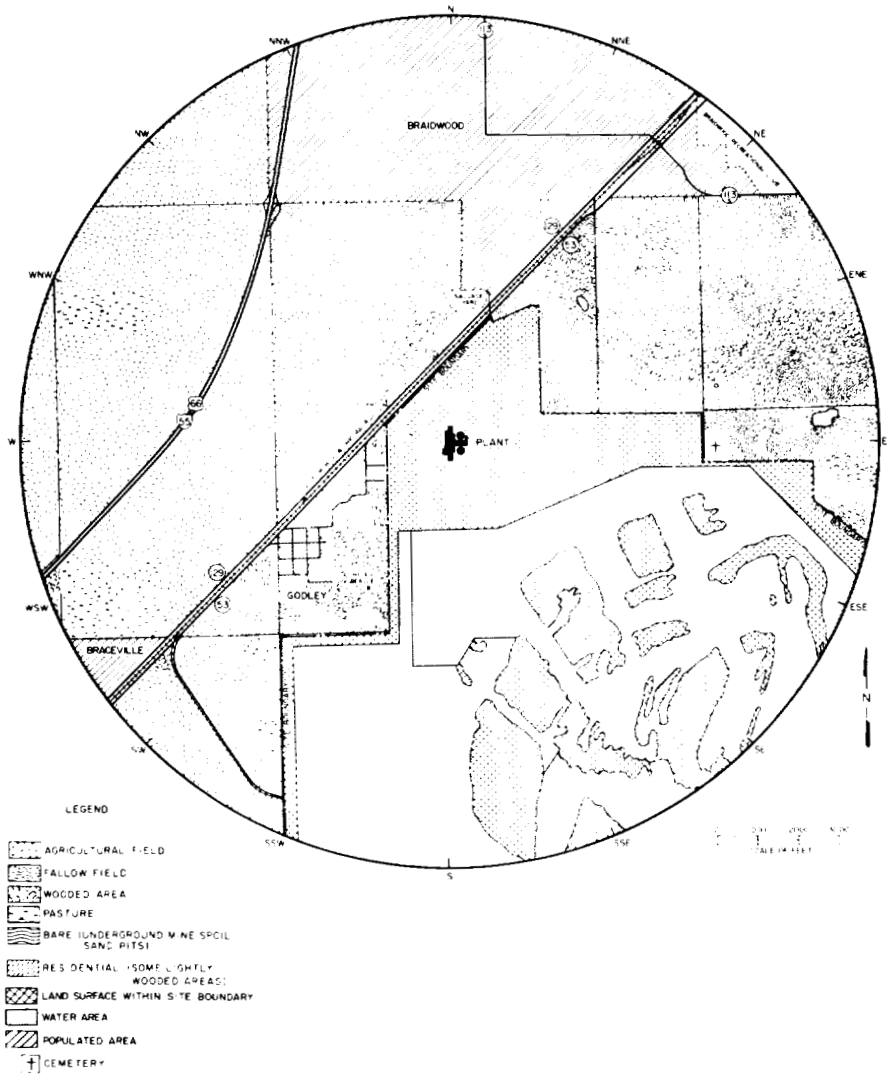

Fig. 2.4. Land Use within Two Miles of the Turbine Building. From applicant's Environmental Report.

Preserve (13 miles ESE), which is characterized by the only known natural occurrence of the "Kankakee mallow," *Iliamna remota*. The public is not admitted to the latter research preserve.

2.4 TOPOGRAPHY AND GEOLOGY

The site is located within the Kankakee Plain portion of the Till Plains section of the Central Lowlands Province. This section is characterized by widespread, variable deposits of glacial till, outwash, and lacustrine sediments assigned to Wisconsonian, Illinoian, Kansan, and Nebraskan glacial deposits. Site topography is low-lying and flat except where incised by such major streams as the Illinois, Kankakee, Des Plaines, and Mazon Rivers and their tributaries. Detailed information concerning site geology and topography is found in the applicant's Environmental Report.

The north central area of the United States is relatively low in seismic activity. The majority of large earthquakes are associated with geologic fault lines. Of 34 known earthquakes within a 200-mile radius of the site, 13 had an intensity of IV (Modified Mercalli Scale), 10 had an intensity of V, nine had an intensity of VI, and two had an intensity of VII. The relationship of site seismology to station safety and its design is being considered in detail by the staff in the safety review.

2.5 HYDROLOGY

2.5.1 The Kankakee River Near the Site

The Kankakee River is approximately 350 feet wide near the location of the discharge structure but widens to about 750 feet one thousand feet downstream. The average depth near the intake structure (about 125 feet from shore) is four feet (Ref. 1, p. 2.5-3).

Table 2.1 lists the estimated average and minimum monthly flows near the site. The average flow over the 1941-1971 period was 3923 cfs. Also shown in this table is the staff's estimate of the river velocity obtained from the statistically derived equation $V = 0.31\ Q^{0.232}$, where Q is the discharge of the stream in cfs and V is the mean velocity in feet per second.[5] The latter is a mean velocity for the stretch of the Kankakee River near the plant and does not predict velocities at specific locations. The velocity measured empirically near the plant at a particular flow resulted in good agreement with this equation.

The maximum recorded flood stage for the river (near Wilmington) occurred in July 1957 with a gage height of 11.4 feet and a discharge rate of 75,900 cfs. Higher gage heights have been recorded when flooding has been complicated by ice jams resulting in a record gage height of 16.7 feet in 1883 and again in 1887.

Over the period of 1941-1971, the historical low flow occurred during 1963-64. The average flow during this year at the Wilmington gage was 1407 cfs and minimum flow for the month of September was 350 cfs. The historical lowest daily flow was 204 cfs in August 1936. While historical data do not show a decreasing trend for low flows, if planned upriver water treatment facilities do not return treated effluents to the river, a decrease in minimum flows may occur (see Sec. 5.2.1). Water quality data for the Kankakee River near the site are shown in Table 2.2.

2.5.2 Groundwater

Approximately 0.67 cfs of groundwater will be drawn from the St. Peter sandstone stratum for the Station's makeup and potable water requirement (see Fig. 3.3). The overlying Pennsylvania bedrock and Quaternary drift formations are considered minor aquifers, but are used for the majority of the 24 private wells (not including sandpoint wells) within a two-mile radius of the site. Most municipal wells within a ten-mile radius of the site draw from deeper aquifers (Table 2.3). A generalized hydrogeologic column for the area is shown in Table 2.4.

The most pertinent features of the site hydrology are summarized by the staff in the above. Further details may be found in Ref. 1, Section 2.5.2.

2.6 METEOROLOGY

2.6.1 Regional Climatology

The climate of northeastern Illinois is continental, characterized by a large range in temperature extremes between the colder and warmer seasons and often rapid temperature changes. As a result, the region experiences hot summers and cold winters. During the winter, the predominant air mass type over the region is continental polar, and the predominant type in summer is maritime tropical. The predominant air mass type during spring and autumn is transitional as the boundary

Table 2.1. Kankakee River Monthly Flow Characteristics at the Intake Location

Month	Average for Water Years 1941-1971		Minimum	
	Q_{ave},[a] cfs	V_{ave},[b] ft/sec	Q_{min},[a] cfs (year)	V_{min},[b] ft/sec
Oct.	1748	1.75	470 (1963)	1.29
Nov.	2415	1.89	510 (1963)	1.32
Dec.	3052	1.99	480 (1953)	1.30
Jan.	4119	2.14	470 (1957)	1.29
Feb.	5465	2.28	588 (1945)	1.36
Mar.	6309	2.36	686 (1963)	1.41
Apr.	7307	2.44	1529 (1956)	1.70
May	6462	2.37	1245 (1964)	1.62
June	4356	2.17	830 (1963)	1.47
July	3066	2.00	498 (1965)	1.31
Aug.	1508	1.69	357 (1941)	1.21
Sep.	1274	1.63	343 (1964)	1.20
Annual	3923	2.11		

[a]From applicant's Environmental Report, Tables 2.5-2 and 2.5-2A.

[b]From formula: $V = 0.31\ Q^{0.232}$ (see text).

Table 2.2. Kankakee River Quality[a]
(Concentrations in mg/ℓ)

	1971			Period of Record, 1958-1971		
	Maximum	Average	Minimum	Maximum	Average	Minimum
Alkalinity as $CaCO_3$	130	130	130	220	178	116
Ammonia as N	10.1	2.8	0.3	10.1	1.0	0.0
BOD	-	-	-	30	3	1
Beta radiation, gross, pCi/ℓ	30	10	0	68	7	0
Chloride	25	25	25	56	21	9
Cyanide	-	-	-	0.00	0.00	0.00
Dissolved oxygen	13.4	10.7	5.4	14.6	10.1	5.4
Fluoride	-	-	-	0.4	0.2	0.0
Hardness, total, as $CaCO_3$	-	-	-	576	308	116
Iron	-	-	-	12.0	1.1	0.0
Nitrate as NO_3	6	2	1	24	6	0
pH	8.8	8.1	7.1	8.8	7.9	7.1
Phosphorous, total as PO_4	2.4	0.8	0.0	10	1.1	0
Sulfate	100	100	100	152	78	20
Total dissolved solids	525	336	170	530	362	170
Temperature, °F	78	53	32	86	57	32

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

Samples taken at Rt. 66 Bridge.

Table 2.3. Municipal Groundwater Supply Use within Ten Miles of the Site

Town	Location	Distance from Site, miles	Town Well No.	Aquifer	Pumpage, gpd
Braceville	T32N,R8E-26	1.5	1	St. Peter Sandstone	26,000
South Wilmington	T31N,R8E-11	2.5	1	St. Peter Sandstone	30,000
Braidwood	T32N,R9E-8	2.5	1 2	St. Peter Sandstone St. Peter Sandstone	150,000
Gardner	T31N,R8E-4	3.5	1 2 3 4	Dolomite (173 ft. deep) Dolomite (161 ft. deep) St. Peter Sandstone Ironton-Galesville Sandstone	1,500 9,000 5,400 34,000
Reddick	T30N,R9E-6	7	1	St. Peter Sandstone	16,000
Diamond	T33N,R8E-36	3.5	1	St. Peter Sandstone	20,000
Coal City	T32N,R8E-2	4	2 3 4	Dolomite (129 ft. deep) Dolomite (365 ft. deep) St. Peter Sandstone	300,000 103,000
Eileen	T33N,R8E-35	4	1	St. Peter Sandstone	37,000
Wilmington	T33N,R9E-25	6	2 3	Ironton-Galesville Sandstone Ironton-Galesville Sandstone	378,000
Carbon Hill	T32N,R8E-34	5	2 3	St. Peter Sandstone St. Peter Sandstone	30,000
Mazon	T32N,R7E-21	9.5	2 4 5	Drift (26 ft. deep) Drift (26 ft. deep) Drift (26 ft. deep)	70,000

From applicant's Environmental Report.

Table 2.4. Generalized Hydrogeologic Column

Unit	Approximate Thickness, ft	Approximate Depth to Top, ft	Hydrogeology
Quaternary drift	50	0	Minor aquifer
Pennsylvanian bedrock	150	50	Aquitard, Minor aquifer in places
Maquoketa Formation	120	200	Aquitard
Cambrian-Ordovician aquifer[a]	1500	300	Major aquifer
St. Peter Sandstone	200	700	Important aquifer unit
Ironton-Galesville Sandstone	175	1600	Most important aquifer unit
Eau Claire Formation	600	1800	Aquitard
Mt. Simon Sandstone	2700	2400	Aquifer, Brine

From applicant's Environmental Report.

[a]Only the two most important units are listed.

between the two air mass types shifts northward and then southward. During periods when a strong northeasterly flow of air is occurring, the effects of Lake Michigan result in some moderation of temperatures and an increase in cloudiness over northeastern Illinois.

Temperatures of 90°F or higher may be expected on 17 days of each year over the region, and temperatures may be expected to reach 0°F or lower on about 14 days annually.[6-8] Precipitation reaches a maximum in the summer and a minimum in winter.

2.6.2 Local Meteorology

Climatological data from Peoria, Rockford, Joliet, Chicago and Argonne, Illinois, have been used in the assessment of the meteorological characteristics, with the exception of wind flow over the site.[1,6-8] Wind flow was assessedd using wind data collected on a meteorological tower at the Dresden Nuclear Station, twelve miles northwest of the Braidwood site.[1]

The plant site lies along a storm track that large scale, cyclonic storms travel during the winter and spring as they form over the west-central plains of the United States and travel northeastward. This storm track moves to a position north of the site by summer, then shifts southward again in the autumn.

Data from Joliet, Illinois, 18 miles north-northeast of the site indicate that mean monthly temperatures range from 73°F in June to 24°F in January.[1] An extreme maximum temperature of 113°F was recorded at Peoria in June 1936, and an extreme minimum temperature of -27°F occurred in January 1884.[6] At Rockford, the extreme temperatures were 112°F in July 1936 and -25°F in February 1933.[7] Weather records indicate that at Joliet, the extreme maximum and minimum temperatures are 109°F and -25°F respectively.[1]

Precipitation is normally expected to be greatest during June in the vicinity of the site, with an average for the month of about 4.25 inches. February is usually the driest month, with an expected monthly average of about 1.75 inches. The maximum monthly precipitation recorded at Joliet, during the period 1941-1952, was 9.23 inches in April 1947 and the maximum 24-hour precipitation total for the same period at this location was 5.32 inches in September 1942.[1] Maximum monthly precipitation amounts for Peoria and Argonne are 13.09 inches and 13.17 inches respectively with corresponding maximum 24-hour precipitation amounts of 5.52 inches and 6.54 inches.[1,6] About 25 inches of snow can be expected annually at the site. Heavy fog (visibility one-fourth mile or less) occurs on an average of 24 days annually.

Wind data collected at the Dresden Nuclear Station (Fig. 2.5) indicate that, at the 35-foot level, winds from the northwest quadrant are most frequent in the vicinity of the Braidwood site.[1] The mean annual wind speed at this level was 7.8 miles per hour.

A summary of the climatological data from weather stations surrounding the site is given in Table 2.5.

2.6.3 Severe Weather

Severe weather occurrences at the Braidwood site are associated mainly with severe thunderstorms or with intense, large-scale cyclonic winter storm systems.

During the period 1955-1967, 43 tornadoes were reported in the one degree latitude-longitude square containing the site, giving a mean annual frequency of 3.3 and a computed recurrence interval for a tornado at the plant site of 385 years.[9,10]

There were nine reports of hail three-quarters of an inch in diameter or greater in the one degree latitude-longitude square containing the site during the period 1955-67 and 34 windstorms with wind speeds of 50 knots (58 mph) or greater.[9] Freezing rain or ice storms can be expected to have an annual frequency of 2.5 in the vicinity of the Braidwood site.[1] High air pollution potential (air stagnation) can be expected to occur on only one day during the year.[11,12]

2.7 ECOLOGY

2.7.1 Terrestrial Ecology

2.7.1.1 Flora

The climax community for the Braidwood site area has been primarily tallgrass prairie with some areas of deciduous forest. Trees in these forests commonly include sassafras, white, red, and black oak, and the Hortulan plum. The 4420-acre site itself includes coal strip-mine spoil, cultivated fields, fallow fields, and open woodlands; no climax communities are found within its boundaries.

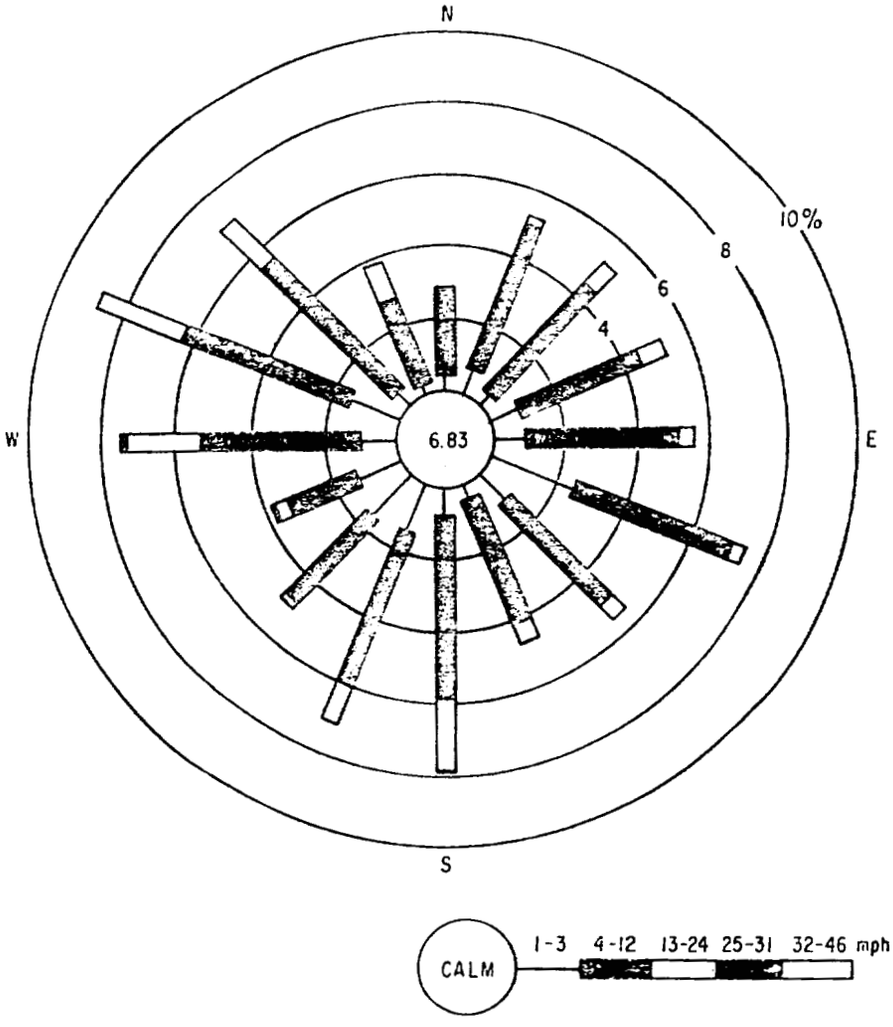

Fig. 2.5. Annual Windrose at Dresden--35-foot Level--July 1971-June 1972.

Table 2.5. Climatological Data from Weather Stations Surrounding the Braidwood Site

Parameter	Stations			
	Chicago	Peoria	Joliet	Argonne
Temperature, °F				
Annual average	50.8	51.4	48.9	47.7
Maximum	105	113	109	101
Minimum	-23	-27	-25	-20
Degree days	6155	6025	6612	6911
Relative Humidity, %				
Annual average at:				
0600 hr	75	83	85	87
1200 hr	58	62	58	62
Wind				
Annual average speed, mph	10.3	10.4	9.7	8.7
Prevailing Direction	W	S	WSW	SW
Fastest mile:				
speed, mph	87	75	--	60[a]
direction	NE	NE	--	
Precipitation, in.				
Annual average	33.18	34.84	36.26	31.49
Monthly maximum	14.17	13.09	9.23	13.17
Monthly minimum	0.06	0.03	0.25	0.03
24-hr maximum	6.24	5.52	5.32	6.54
Snowfall, in.				
Annual average	39.2	22.8	25.0	--
Monthly maximum	42.5	26.5	21.9	--
24-hr maximum	19.8	18.0	8.0	--
Mean Annual - No. of Days				
Precipitation $\geq$ 0.1 in.	120	110	110	110
Snow, sleet, hail $\geq$ 1.0 in.	12	8	9	--
Thunderstorms	38	48	40	--
Heavy fog	13	20	24	--
Maximum temperature $\geq$ 90°F	19	17	26	--
Minimum temperature $\leq$ 32°F	118	133	143	--

[a]Peak gust wind.
--Dashes indicate data not available.

About 2400 acres within site boundaries have been used for strip-mining since about 1940. Strip-mining is still being carried out on the proposed site and by the time the lake building program commences, an additional 438 acres of spoil land will exist. Since approximately 1961, reclamation programs have been instituted to top off mine spoil ridge peaks and to plant the resulting mesas and troughs with grasses, legumes, trees, and shrubs. The most successful species appear to be black locust, pine, and olive trees. Other planted species include sycamore, red cedar, and cottonwood. Although intentionally planted cottonwoods have had a low survival rate, naturally-occurring cottonwoods appear to have successfully invaded some of the strip-mine spoil areas. Other plants to be found on the spoil areas include tumbleweed, smartweed, sweet clover, wild lettuce, asters, barnyard grass, bluestem grasses, three-awns, black willow, and blackberry. These plants invaded the area naturally after the land was stripped for coal.

Farm crops in the area of the site usually have been rotated. Wheat, soybeans, and alfalfa are representative crops. Weeds commonly found in these fields are black nightshade, common thistle, asters, and morning glory. When cultivated fields in the area have been allowed to lie fallow, weeds such as frostweed, boneset, and common ragweed filled in, but were later replaced by grasses, which in turn are invaded by woody vegetation.

Approximately 6% of the site consists of woodlands and the trees have served as windbreaks against erosion of the sandy soil. The canopy is 35 to 40 feet high and is formed by trees which range in age to about 40 years; red and white oak predominate. The understory covers about 75% of the forest litter at the end of the growing season; smaller oaks, sassafras, prairie willow, and hazelnut predominate.

Herbaceous plants found typically in edge areas along side roads, fields, ditches, strip-mines, and railroads include Russian thistle, goosefoot, aster, goldenrod, beggar's tick, dandelions, chickory, foxtails, three-awns, panic grass, alfalfa, lambsquarter, and bindweed. Woody plants typical of the same habitats include red oak, eastern cottonwood, osage orange, silver and sugar maple, and black willow, as well as some man-planted windbreaks of lombardy poplar.

Some marsh areas are found on the site in ditches along roadsides, railroad tracks, and between fields. The broad-leaved cattail and the common reed are the most common herbaceous vegetation of these habitats. Woody species, when found, most commonly include sandbar willows and cottonwoods.

The flora at the site are briefly described by the staff in the above. A detailed list of site flora is given in Ref. 1, Sections 2.7.1.1 to 2.7.1.6.

2.7.1.2 Fauna

The mammalian habitats in the strip-mine spoil areas are different from those on the agricultural lands. The former, generally characterized by packed, infertile soils, low vegetation density, and access to water furnish habitats to animals such as muskrat, beaver, and mink. The agricultural lands are characterized by friable, tilled soil, food seeds, considerable edge habitat, trees, and shrubs, and they support those species of mammals which burrow, or which rest in tall vegetation.

Although few amphibians and reptiles or their signs were observed during the applicant's 1972 fall and early 1973 spring surveys, numerous species can be expected to reside on the site. Most amphibians and reptiles are not active during the cool weather of these seasons. Similar areas in Illinois are known to harbor amphibians and reptiles.

Eleven species of birds were observed in the applicant's winter 1973 terrestrial survey, and 58 in a spring 1973 survey. In summary, the least avian diversity was found in fallow fields and areas strip-mined from the 1960's to the present time, and the greatest in marshland and areas strip-mined in the 1950's and 1940's. Correlation is noted between those species favoring open or edge habitats, and strip-mined areas which are characterized by sparse vegetational cover (bromegrass).

In this brief summary by the staff, the principal species of fauna at the site are described. A more complete list of the site fauna is given in Ref. 1, Section 2.7.1.7.

2.7.2 Aquatic Ecology

The Kankakee River is the fill and makeup source proposed for the Braidwood cooling lake, and it has been rated "excellent" in regard to general water quality by the Illinois Natural History Survey Board.[13] The river water chemistry is summarized in Table 2.2.

Several Kankakee River aquatic surveys have previously been done in areas above and below the proposed site,[14-18] and the applicant is presently conducting an aquatic baseline pre-operational survey.

Diatoms are the most dominant river phytoplankton, but large seasonal fluctuations in abundance were observed. For example, diatoms were particularly abundant in December through April, blue-green algae were abundant (30%) in early October, green algae were numerous (24%) in October-November, and flagellates (Euglenophyta) were quite numerous (45%) in February. In some areas, for example Horse Creek, diatoms comprised nearly 100% of the total number of observed phytoplankton. Characteristic of other temperate-zone rivers, the highest total numbers of phytoplankton were observed in the spring, and the lowest in winter; during the winter season the majority of observed phytoplankton were diatoms.

Less information is presently available on periphyton, but again the diatoms are more numerous than either the green or blue-green algae. Several indicators of organic enrichment were present including the diatoms *Gomphonema olivaceum*, *Navicula accomoda cryptocella*, *Nitzschia filiformis*, and *Nitzschia palea*. *Oscillatoria*, highly tolerant to organic enrichment, were also reported. In an ongoing periphyton study, the applicant concludes that the river provides an "extremely rich and diverse periphyton community."

As with phytoplankton, the greatest numbers of zooplankton (over 125 species, mostly of crustaceans and insects) were observed in the spring. A large component of these was mollusc larvae (glochidia). On the basis of these observations, it is likely that a substantial mollusc population exists upstream in Horse Creek. Excepting the glochidia, the dominant zooplankters in these rivers in the spring were crustaceans, particularly of the family Cyclopidae and the order Ostracoda. During several fall observations, the dominant zooplankter was the mayfly *Stenonema*.

Benthic species of five phyla were collected during the Braidwood aquatic study in 1972 and 1973 (Ref. 1, Table 2.7-29e). The aquatic insects predominated, with 18 species of Diptera from one family alone (Chironamidae). Representative types of invertebrate organisms collected in the benthic study include caddisflies, mayflies, midges (bloodworms), Tubifex worms, snails, clams, and crayfish.

Macrophytes were observed in narrow bands of mud bordering the Kankakee River. The most common of the eight species were the American waterwillow (*Dianthera americana*), and buckwheat (*Polygonum* sp.). Some waterwillow extended out into the river as much as 75 feet. No macrophytes were observed in a survey of Horse Creek.

In a 1972-1973 aquatic survey conducted by the applicant, 37 species of fish (Ref. 1, p. 2.7-327) were collected in the Kankakee River and Horse Creek, including a specimen (Horse Creek) of a gilt darter (tentative identification, *Percina evides*) which is rarely collected in Illinois waters. Using the classification scheme of the Illinois Natural History Survey, of the 37 fish species identified, 16 are gamefish (43%), 10 are commercial fish (27%), 9 are forage fish (24%), and 2 are predators (6%). The most abundant fish of this study were rock bass, golden redhorse, white crappie, smallmouth bass, carp, and redfin pickerel. At least seventy-two fish species have previously been reported in the Kankakee-Iroquois River system. However, this is a composite number obtained from numerous data sources.

This brief summary by the staff describes the aquatic ecology of the Kankakee River. More detailed information on aquatic biota and ecosystems in the Kankakee River may be found in Ref. 1, Section 2.7.2.

2.8 RADIATION BACKGROUND

2.8.1 Natural Radiation Background

The United States Environmental Protection Agency has estimated the annual average background radiation dose to the individual in Illinois to be 135 mrem per year.[19] Table 2.6 gives the breakdown of this dose into its individual components.

The applicant's Environmental Report and References 20 and 21 indicate that the natural terrestrial activity at Braidwood may be lower than the value of 65 mrem/yr in Table 2.6. Direct radiation measurements during the pre-operational monitoring program should define the actual values for background dose for the Braidwood station.

2.8.2 Radiation Background due to Nearby Nuclear Facilities

There are five other nuclear power plants either in operation or expected to be in operation by 1979 within 50 miles of the proposed Braidwood Station. The Midwest Fuel Recovery Plant, soon to be placed in operation by the General Electric Co., is about 11 miles NNW of the Braidwood site. The staff estimate, obtained from the Final Environmental Statements for these facilities indicates that the additional background dose for the Braidwood site may be increased by 0.25 mrem/yr.

Table 2.6. Estimated Natural Radiation Whole-Body Doses in Illinois

Type of Radiation	Average Annual Dose, mrem/yr
Cosmic radiation	45
Natural terrestrial radioactivity	65
Subtotal	110
Internal radiation	
Tritium	0.004
Carbon-14	1.0
Potassium-40	17
Rubidium-87	0.6
Polonium-210	3.0
Radon-222	3.0
Subtotal	25
Total	135

From EPA Report ORP/CSD 72-1.

References

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14. "Interim Report for Dresden Lake Biological Study," prepared for Commonwealth Edison Co. by Environmental Analysts, Inc., Sept. 1972.

15. Dresden Nuclear Power Station Semi-Annual Report, "Environmental Monitoring (Thermal) of the Des Plaines, Kankakee and Illinois Rivers near Dresden Nuclear Power Station, July 1970 through December 1971," IBT No. W 9882, prepared by Industrial Bio-Test Laboratories, Inc. for Commonwealth Edison Co.

16. Dresden Nuclear Power Station Semi-Annual Report, "Pre-operational Environmental Monitoring (Thermal) of the Illinois River near Dresden Nuclear Power Station, July 1969 through June 1970," IBT No. W 7658, prepared by Industrial Bio-Test Laboratories, Inc. for Commonwealth Edison Co.

17. L. P. Beer and W. O. Pipes, "A Practical Approach to the Preservation of the Aquatic Environment--The Effects of Discharge of Condenser Water into the Illinois River," Industrial Bio-Test Laboratories, Inc. 1969.

18. R. Evans, Ill. State Water Survey Board, letter of Oct. 25, 1972, to G. P. Kincaid, WESD, Data collected by the U. S. Geological Survey during Oct. 7, 1971 through April 30, 1972.

19. A. W. Klement, Jr., et al., "Estimates of Ionizing Radiation Doses in the United States 1960-2000," U. S. Environmental Protection Agency Report ORP/CSD 72-1, August 1972.

20. M. J. Shmuklarsky, "Environmental Radioactivity in Illinois, 1970," Radiation Data and Reports, Vol. 13, No. 11, November 1972.

21. D. T. Oakley, "Natural Radiation Exposure in the United States," U. S. Environmental Protection Agency Report ORP/SID 72-1, June 1972.

3. THE STATION

3.1 EXTERNAL APPEARANCE

The principal buildings of the Braidwood Station will be: (1) two reactor containment buildings (each housing a pressurized-water reactor and its associated steam-producing system), (2)a turbine building (consisting of two steam turbine-generators and an associated cooling system), (3) a service building (for office and other related service functions), (4) an auxiliary building, (5) a fuel storage and handling building, and (6) a solid radioactive waste storage building. Other facilities will consist of a 2640-acre cooling lake, a train washdown shed, a switchyard, lake intake structure, and a river screen house and discharge structure on the Kankakee River. A layout of the station is shown in Fig. 3.1 and an artist's rendering of the station and lake is shown in Fig. 3.2. The station's exterior will have colored metal siding.

3.2 REACTOR AND STEAM-ELECTRIC SYSTEM

Braidwood Station will use two pressurized-water reactor (PWR) units manufactured by Westinghouse Electric Corporation. The steam supply system will drive two tandem compound turbines, each employing one high-pressure and three low-pressure stages mounted on a common shaft. The average net electrical output will be 1120 MWe from each reactor. The turbine generators will be supplied by Westinghouse Electric Corp., which, along with Sargent and Lundy, Engineers, will participate in the design and construction of each unit.

3.3 STATION WATER USAGE

Condenser cooling will be the primary use for water in the station. At full power the turbine-generators will use 3250 cfs of cooling water, which will be warmed by 20.9°F. The applicant anticipates a net average water consumption from the Kankakee River of 47.3 cfs; the total water intake will be 93.3 cfs, but the blowdown of 46.0 cfs will be returned to the river.[1] The applicant has stated that net water withdrawal from the Kankakee will be limited to a maximum of 10% of the river flow, requiring some drawdown of Braidwood Lake if the river flow drops below 473 cfs (Ref. 1, p. 2.5-7). The 7-day 10-year recurrence low flow at the intake point is 442 cfs (Ref. 1, Table 2.5-2B), and may become still lower if planned upriver water treatment facilities do not return treated effluents to the river (see Sec. 5.2.1).

The station potable water and makeup water for the steam cycle will be obtained from two deep wells on the plant site. Each well will be capable of producing 0.67 cfs. One well will always be a spare, as both wells cannot simultaneously deliver 0.67 cfs. The withdrawal of the water will comply with the applicable federal, state, and local regulations. All the well water will be passed through 3 manganese greensand filters, for iron and manganese removal, into a 150,000 gallon filtered water storage tank. From this tank 15,000 gallons per day will be drawn off for processing through the potable water system. The treatment will consist of chlorination and softening of the water.

There will be two identical demineralizer trains, each capable of producing a net daily average of 150 gpm of makeup water. One train will serve as a backup during normal operation. Each train will consist of, in order: weak acid cation unit, primary strong acid cation unit, secondary strong acid cation unit, one common decarbonator, weak base anion unit, strong base anion unit, and a mixed bed unit. Regeneration of the exhausted resins will take place once per day. During regeneration, which will last about six hours, the only chemicals that will be added are sulfuric acid (H_2SO_4) and caustic (NaOH).

A flow sheet of the water usage is shown in Fig. 3.3.

3.4 HEAT-DISSIPATION SYSTEM

Operating at full power, the station will produce 1.6×10^{10} Btu/hr of waste heat, which will be transferred to the cooling water circulating at 3250 cfs through the condensers. The temperature of the cooling water will rise approximately 21°F during passage through the condensers. The waste heat will be dissipated to the atmosphere by evaporation from the surface of an off-stream

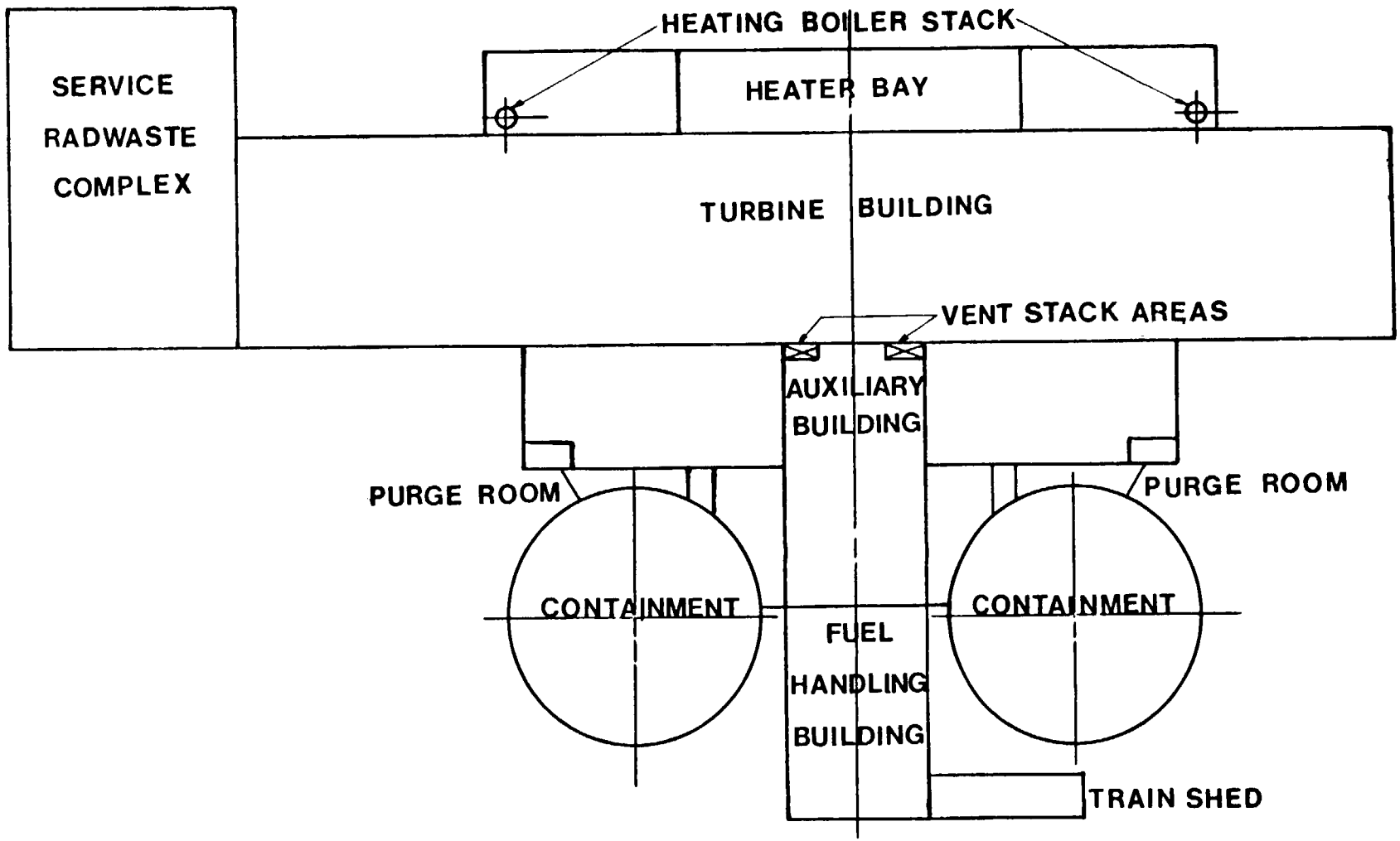

Fig. 3.1. Braidwood Station Plan. From the applicant's Environmental Report.

Fig. 3.2. Architect's Drawing of the Braidwood Station. From a color print in the applicant's Environmental Report.

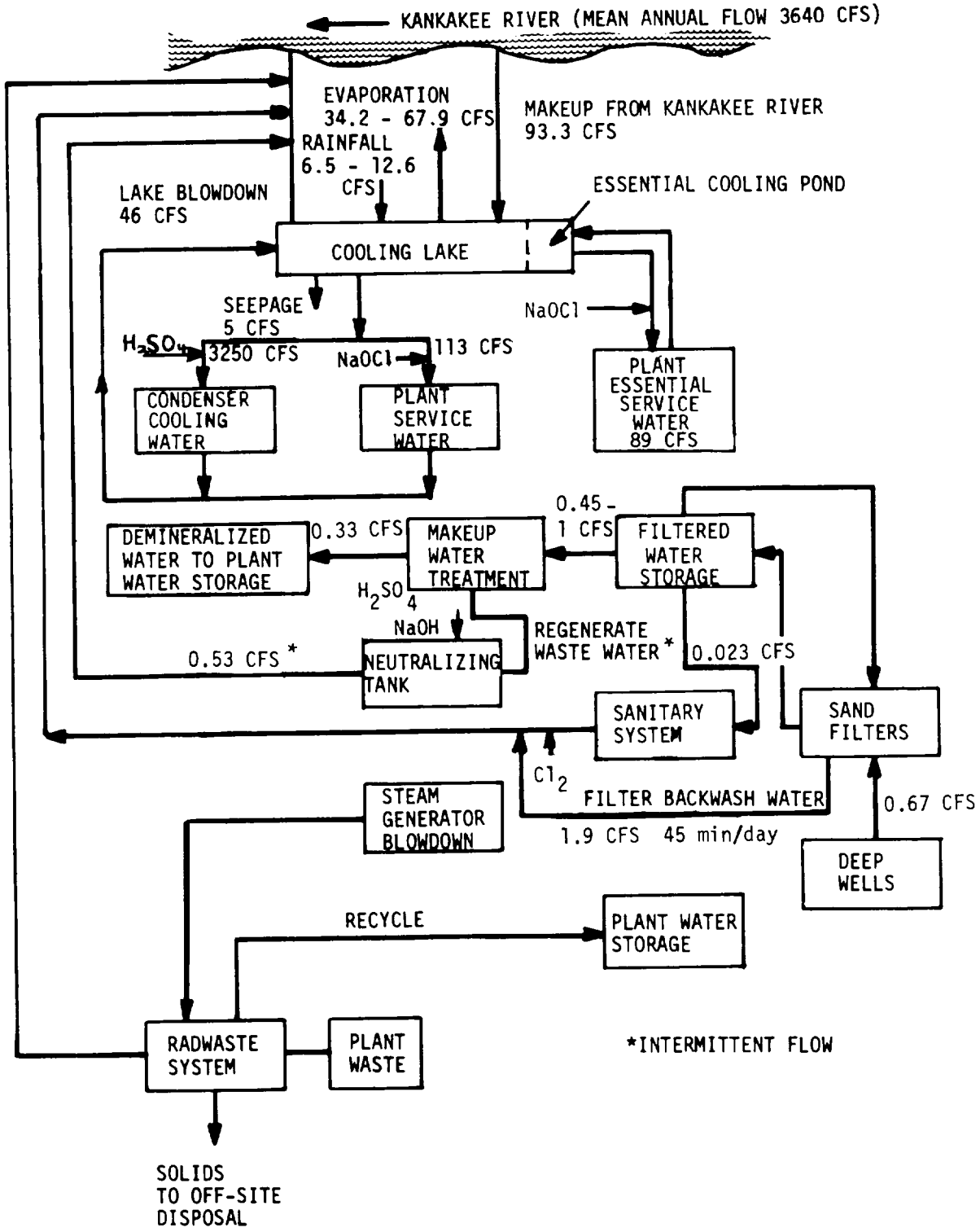

Fig. 3.3. Braidwood Station Water Usage Flow Diagram. From the applicant's Environmental Report.

artificial cooling lake (Fig. 3.4) with a surface area of about 2640 acres. Water depth in the cooling lake will vary between 5 and 100 feet, averaging 9.5 feet. Internal dikes that guide the flow of water will prevent short-circuiting of the cooling water, so that the average circulation time will be about four days.

3.4.1 Intake and Discharge Structures

The makeup water will be pumped through an intake structure similar to that shown in Fig. 3.5. This structure will house three intake pumps of 53.5 cfs capacity each. Two will be used to supply water during normal operation while the third will be used to fill the lake and will serve as a standby for the other two. Water velocity at the intake structure will be about 0.5 ft/sec when both units are operating.

The blowdown from the cooling lake will be discharged to the Kankakee River through an open-channel discharge similar to that shown in Fig. 3.6. This structure will be located approximately 500 feet downstream from the intake and will be oriented perpendicular to the river. The velocity of the discharge will be approximately 2 ft/sec.

3.4.2 Thermal Assessment

3.4.2.1 Cooling Lake Blowdown

The staff has calculated the expected temperatures at the cool end of the lake near the point from which the blowdown will be released. Figure 3.7 shows these predicted temperatures with the plant operating at full power. Calculations were made for two flow conditions; slug flow (D = 1.0, see Appendix A) and the case where some mixing at the entrance of the lake occurs (D = 1.5). For each of the above flow conditions, calculations were made for extreme and average meteorological conditions. Details of the analysis are discussed in Appendix A.

The crosses on Fig. 3.7 are the applicant's temperature predictions for the same conditions as those for the lowest curve. The agreement is quite good. Table 3.1 gives the staff's expected blowdown temperatures in tabular form for the various months for normal and extreme meteorological conditions. Also included in the table are the monthly river temperature extremes near Wilmington, about 5.5 miles downstream from the site. It should be noted that both methods of calculation shown lead to conservatively high estimates of blowdown temperature excess over river temperature.

3.4.2.2 River Discharge (Thermal Plume)

The applicant has assessed the effect of the blowdown from the cooling lake upon the Kankakee River using an analytical plume model developed by Sargent and Lundy, Engineers.[2] This analysis was applied only for the case of average meteorological conditions and average river temperatures and river velocities. The results of these calculations, in the form of areas within isotherms, are found in Table 5.1-1a of the Environmental Report (p. 5.1-30). Under average meteorological conditions, the 5°F isotherm encloses the maximum area in December, 0.45 acres.

Numerous analytical models have been proposed to describe the physical characteristics of thermal discharges, but none has been adequately field tested.[3] The Motz-Benedict model[3,4] was chosen by the staff to calculate the size of the thermal plume, using the value of 0.15 for the entrainment coefficient. With this estimate of the coefficient, the calculated plume areas are conservatively high.

Table 3.2 lists the area enclosed by different isotherms for each month of the year for two cases:

Case 1: Blowdown for extreme meteorological conditions, maximum ambient river temperatures, minimum monthly river velocities.

Case 2: Blowdown for normal meteorological conditions, minimum ambient river temperatures, minimum monthly river velocities.

Figures 3.8 and 3.9 show the 5°F and 10°F isotherms for two of the entries in Table 3.2--Case 1, February, and Case 2, July.

It is evident from these tables and figures that the applicable State thermal standards (Table 3.3) can be met under all conditions considered. Thus, the largest area encompassed by the 5°F excess isotherm is only 0.85 acres (Case 2, May), which is more than an order of magnitude smaller than the State Standard (25.96 acres); in no case is the maximum allowable river temperature exceeded outside the mixing zone. Also it is seen from the figures that the zone of passage for aquatic life exceeds 85% of the river. It should again be emphasized

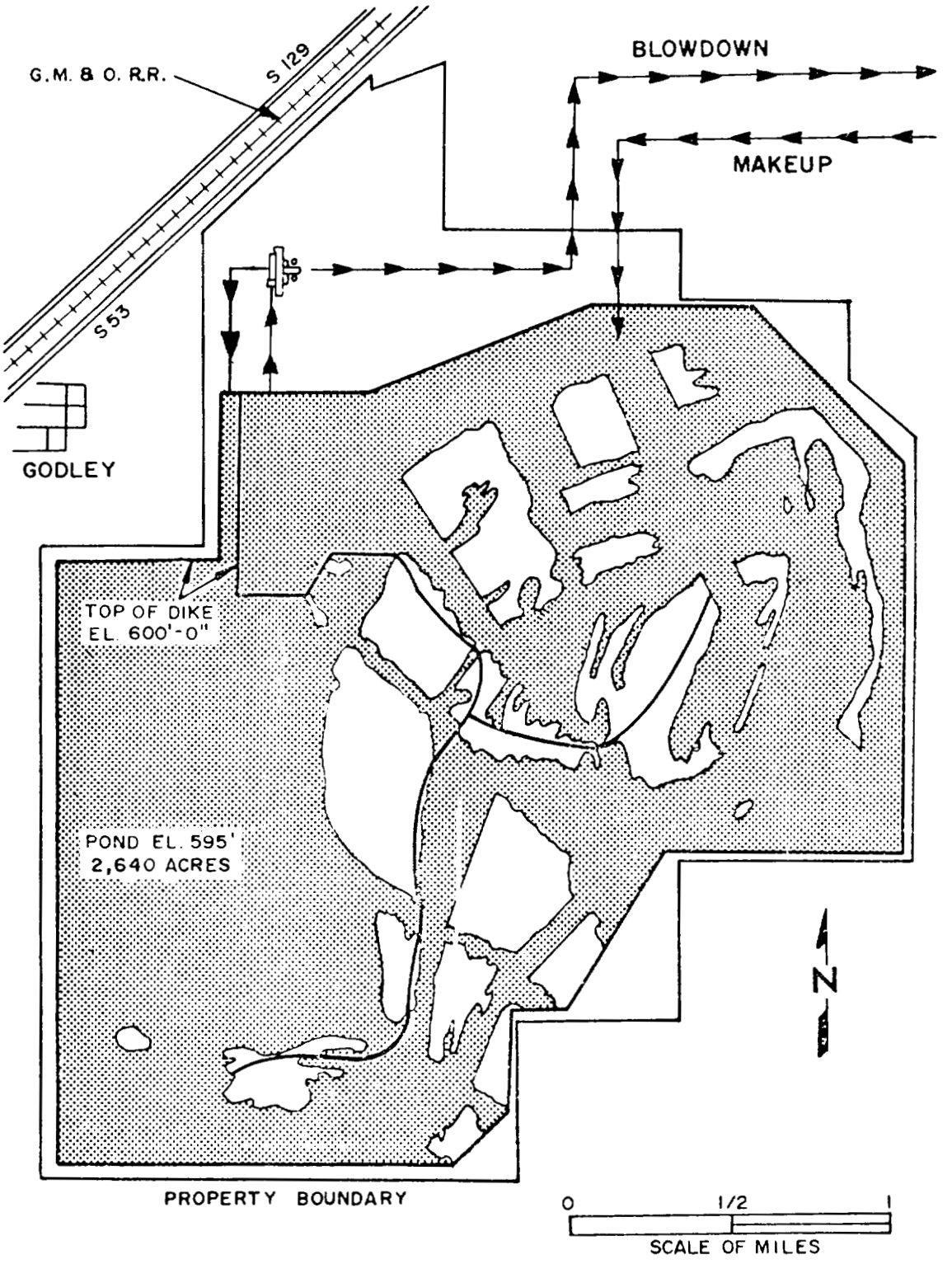

Fig. 3.4. Braidwood Cooling Lake. From applicant's Environmental Report.

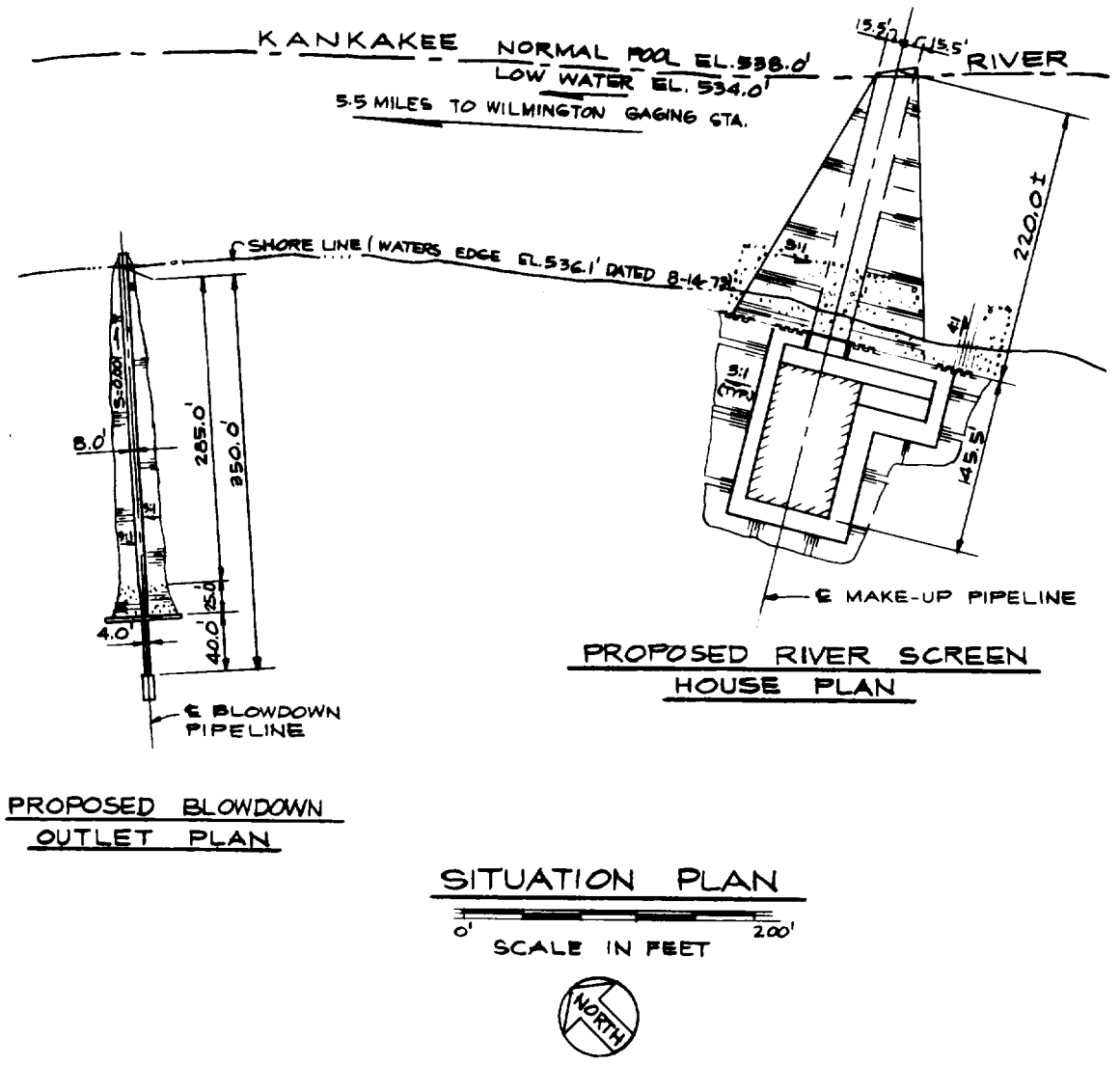

Fig. 3.5. Location of Intake and Blowdown Structures on the Kankakee River. From the applicant's Environmental Report.

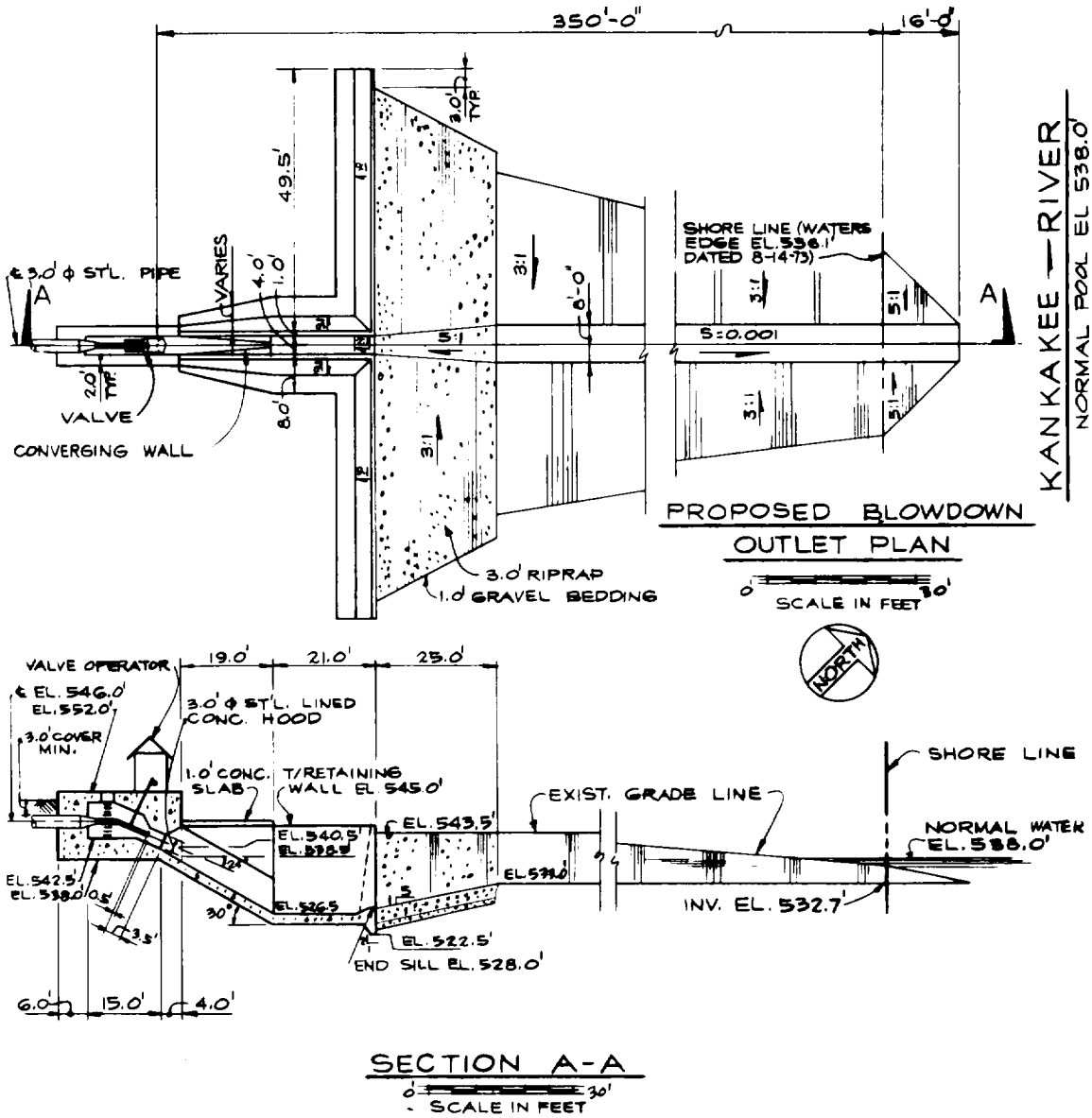

Fig. 3.6. Braidwood Station Proposed Discharge Structure. From the applicant's Environmental Report.

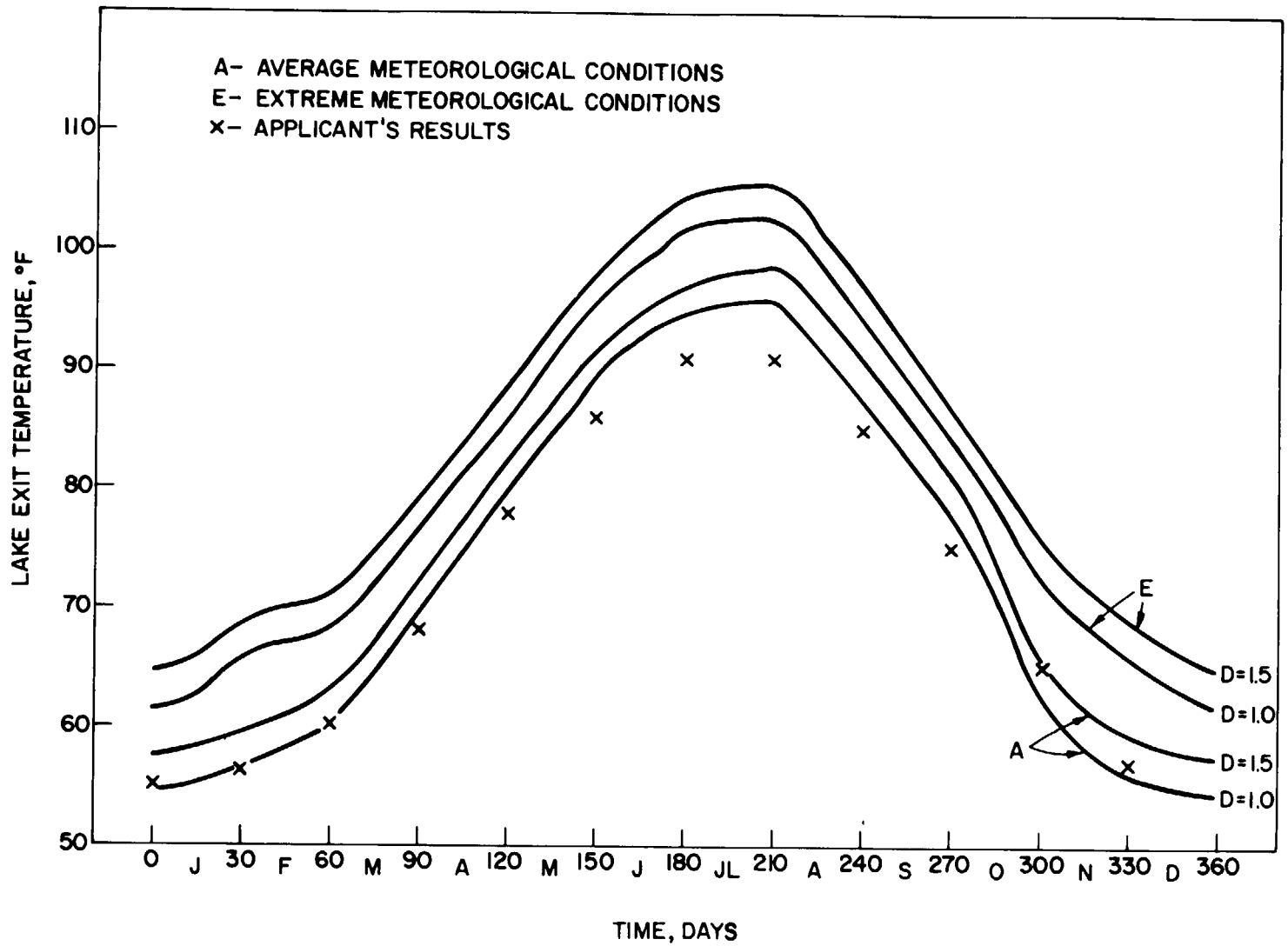

Fig. 3.7. Variation of Blowdown Temperature from Braidwood Cooling Lake.

Table 3.1. Blowdown and River Temperatures

Month	T_B	$(T_B)_e$	$(T_a)_{min}$[a]	$(T_a)_{max}$[a]	ΔT	$(\Delta T)_d$
Jan.	58.5	66	32	37	26.5	29
Feb.	61	70	32	36.5	29	33.5
Mar.	68	75	34	42.5	34	32.5
Apr.	77.5	84	41	54.5	36.5	29.5
May	87.5	93.5	42.5	73	45	20.5
June	95	101.5	61.5	87	33.5	14.5
July	98	105.5	64	81	34	24.5
Aug.	95	101.5	64	84	31	17.5
Sep.	86	92	62	75	24	17
Oct.	74	81.5	52	68	22	13.5
Nov.	62	72	42	56	20	16
Dec.	58.5	66.5	32	37	26.5	29.5

T_B = Blowdown temperature for normal meteorological conditions, °F.

$(T_B)_e$ = Blowdown temperature for extreme meteorological conditions, °F.

$(T_a)_{min}$ = Minimum ambient river temperature, °F.

$(T_a)_{max}$ = Maximum ambient river temperature, °F.

$\Delta T = T_B - (T_a)_{min}$, °F.

$(\Delta T)_d = (T_B)_e - (T_a)_{max}$, °F.

[a]The data cover the period from 1957 to 1972 but appear to be temperatures for a random sampling of days in each month. The two questionable temperature values (followed by a question mark in the applicant's Table 2.5-5) have not been included in the above.

Table 3.2. Staff's Estimate of Thermal Plume for Different Conditions

Month	Excess Isotherm, °F	Case 1 Plume Area, Acres	Case 2 Plume Area, Acres
Jan.	15	0.022	0.015
	10	0.078	0.061
	5	0.42	0.22
	3	1.2	1.0
Feb.	15	0.037	0.023
	10	0.11	0.079
	5	0.55	0.40
	3	1.6	1.17
Mar.	15	0.035	0.040
	10	0.11	0.12
	5	0.50	0.55
	3	1.4	1.5
Apr.	15	0.035	0.061
	10	0.094	0.15
	5	0.37	0.55
	3	0.96	1.42
May	15	0.007	0.094
	10	0.035	0.22
	5	0.18	0.85
	3	0.50	2.2
June	15	-	0.040
	10	0.007	0.11
	5	0.081	0.49
	3	0.26	1.4
July	15	0.004	0.038
	10	0.027	0.12
	5	0.19	0.59
	3	0.59	1.7
Aug.	15	0.001	0.026
	10	0.014	0.093
	5	0.13	0.51
	3	0.44	1.6
Sep.	15	0.001	0.009
	10	0.012	0.044
	5	0.12	0.28
	3	0.42	0.90
Oct.	15	-	0.006
	10	0.004	0.034
	5	0.064	0.22
	3	0.23	0.69
Nov.	15	-	0.004
	10	0.010	0.025
	5	0.10	0.18
	3	0.34	0.56
Dec.	15	0.023	0.015
	10	0.082	0.061
	5	0.43	0.34
	3	1.3	1.0

Case 1: Blowdown for extreme meteorological conditions, maximum ambient river temperatures.

Case 2: Blowdown for normal meteorological conditions, minimum ambient river temperatures.

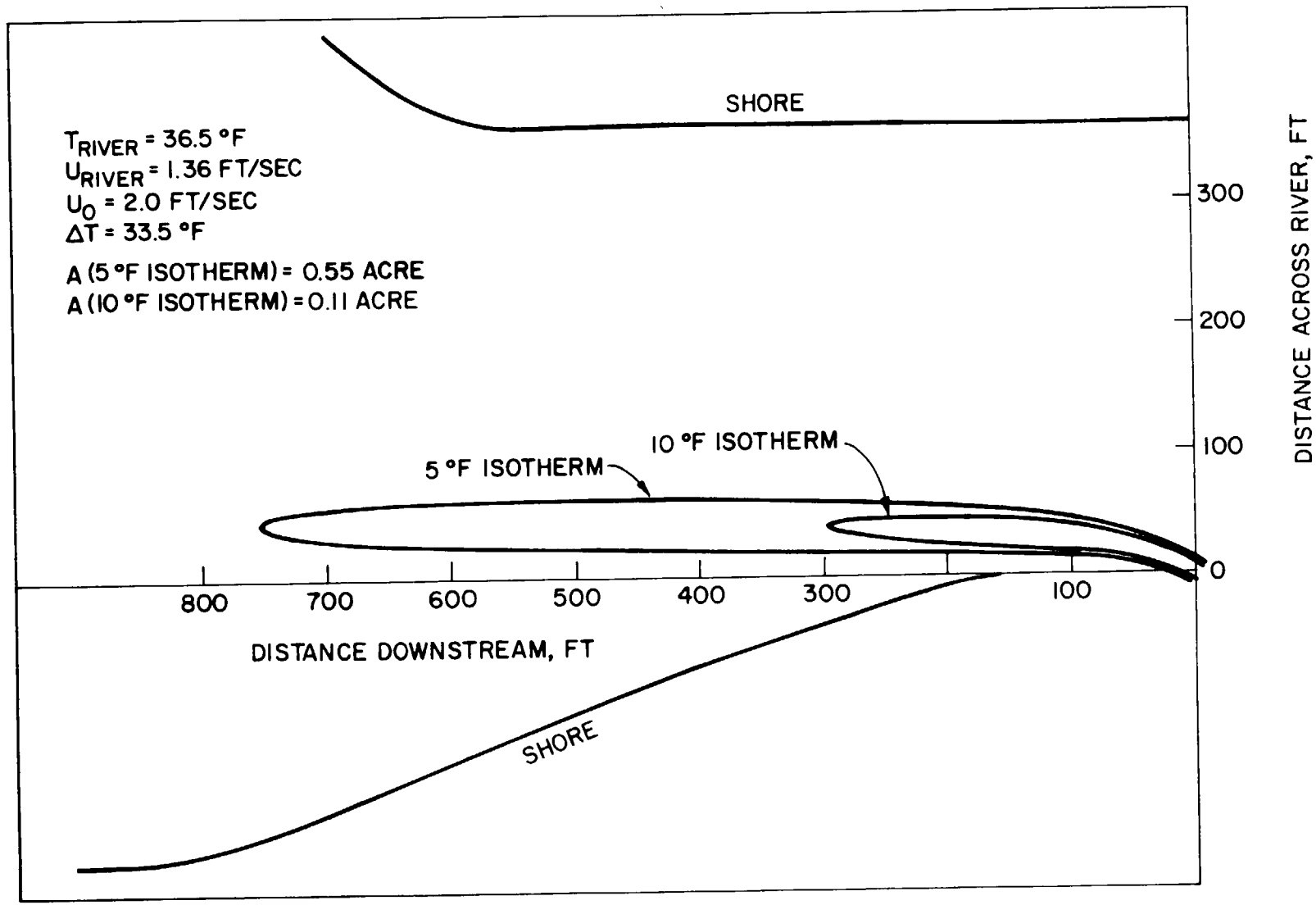

Fig. 3.8. Winter Isotherms from Braidwood Station (extreme meteorological conditions).

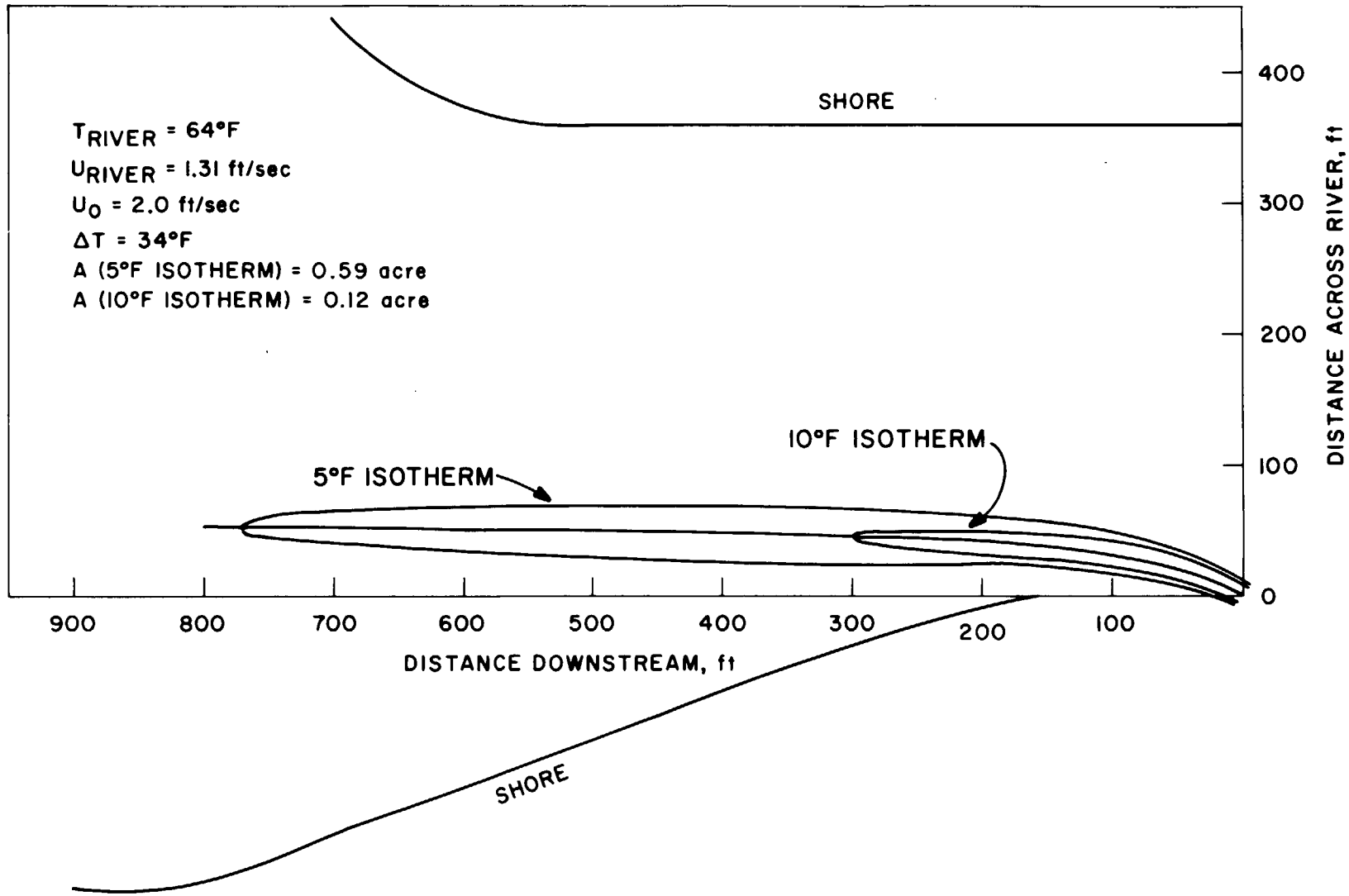

Fig. 3.9. Summer Isotherms from Braidwood Station (normal meteorological conditions).

Table 3.3. Temperature Standards Applicable to Braidwood Station[a]

1. The maximum river temperatures allowable are 60°F in December, January, February and March, and 90°F during the remainder of the year.

2. No single mixing zone shall exceed the area of a circle with a radius of 600 feet (25.96 acres).

3. The mixing zone shall be so designed as to assure a reasonable zone of passage for aquatic life.

4. The maximum temperature rise outside the mixing zone shall not exceed 5°F.

5. The maximum permissible river temperature may be exceeded by no more than 3°F no more than 1% of the hours in any 12-month period.

[a]State of Illinois Pollution Control Board, "Water Pollution Regulations of Illinois," July 1973.

that all assumptions were chosen to be extremely conservative so that the areas enclosed by the isotherms are probably upper values. The applicant will be required to monitor the thermal discharge to assure that the State thermal standards will be met.

One final point should be made. The above model does not take into account the sinking plume phenomenon. This phenomenon occurs when the density of the warm effluent is greater than that of the ambient river water (water has a maximum density at about 39°F). Although it is expected that the area encompassed by a given isotherm will increase as it sinks to the bottom of the river, the extent of this increase cannot be quantified because no existing analytical model takes account of this phenomenon. However, it is estimated that the area within the 5° or 3° isotherm would approximately double as the plume sinks to the bottom of the river.

3.5 RADIOACTIVE WASTES

During the operation of Braidwood Station, radioactive materials will be produced by fission and by neutron activation of corrosion products in the reactor coolant system. From the radioactive material produced, small amounts of gaseous and liquid radioactive wastes will enter the waste streams. These streams will be processed and monitored within the station to minimize the quantity of radionuclides ultimately released to the atmosphere and to the Kankakee River.

The waste handling and treatment systems to be installed at the station are discussed in the applicant's Preliminary Safety Analysis Report and Environmental Report, both dated September 20, 1973 and in Supplement II to the Environmental Report dated Jan. 8, 1974. In these documents, the applicant has prepared an analysis of his treatment systems and has estimated the annual radioactive effluents.

In the following paragraphs, the waste treatment systems are described and an analysis is given based on the staff's model of the applicant's radioactive waste systems. The staff's model has been developed from a review of available data from operating nuclear power plants, adjusted to apply over a 40-year operating life. The coolant activities and flows used in this evaluation are based on experience and data from operating reactors. As a result, the parameters used and the subsequent calculated releases vary somewhat from those given in the applicant's evaluation. The resulting differences are not considered to be important. The liquid source terms are calculated by means of a revised version of the ORIGEN code.[5] The gaseous source terms are calculated by means of the STEFFEG code.[6] The principal parameters used in the source term calculations are given in Table 3.4. The bases for these parameters are given in WASH-1256, Vol. 2, Appendix B. Based on the following evaluation, we conclude that the liquid, gaseous, and solid waste treatment systems are acceptable and that the effluents meet as low as practicable levels in accordance with 10 CFR Part 50.34(a).

3.5.1 Liquid Wastes

The liquid radioactive waste treatment system will consist of process equipment and instrumentation necessary to collect, process, monitor, and recycle or dispose of radioactive liquid wastes. Prior to releasing liquid waste, samples will be analyzed to determine the type and amounts of radioactivity present. Based on the results of these analyses, the wastes will be released under controlled conditions to the Kankakee River, after being diluted with cooling lake blowdown, or retained for further processing. A radiation monitor will automatically terminate liquid waste discharge if radiation measurements exceed a predetermined level in the discharge line. A simplified diagram of the liquid radwaste treatment systems is shown in Fig. 3.10.

The liquid radioactive waste treatment systems will be divided into three principal systems and will be shared by Units 1 and 2: the Steam Generator Blowdown (SGB), the Radioactive Waste Drains (RWD), and the Radioactive Laundry Waste (RLW) systems. The SGB will be processed continuously through the blowdown evaporator and polishing demineralizers; this water will be reused in the plant. The RWD system collects water in individual tanks from floor drains, equipment leakage and chemical operations. After sampling and analysis, RWD water will be processed batchwise with the appropriate combinations of filtration, evaporation and ion exchange. RWD water may be reused in the plant or discharged after treatment. RLW water will be treated by reverse osmosis (RO) and evaporation to remove radionuclides and detergents. The permeate will be analyzed to determine if it is suitable to reuse or will be retreated or discharged.

In addition to the preceding three systems, the Chemical and Volume Control System (CVCS) and the Boron Recycle System (BRS) are considered in our evaluation. The CVCS and BRS process reactor grade water to control boron concentration and reactor coolant purity.

3.5.1.1 Steam Generator Blowdown (SGB)

The SGB system will process steam generator blowdown from both units, and will have a capacity of 120 gpm. The blowdown water will pass through filters, an evaporator and, as needed, through mixed bed demineralizers. After treatment the stream will be returned to the condensate storage

Table 3.4. Principal Parameters and Conditions Used in Calculating Releases of Radioactive Material in Liquid and Gaseous Effluents from Braidwood Station (per unit)

Reactor power level (MWt)	3565
Plant capacity factor	0.80
Failed fuel[a]	0.25%
Primary system	
Mass of coolant (lb)	5.34×10^5
Letdown rate to CVCS (gpm)	61
Shim bleed rate (gpm)	1.5
Leakage rate to secondary system (lb/day)	110
Leakage rate to Containment Building (lb/day)	240
Leakage rate to Auxiliary Building (lb/day)	160
Frequency of degassing for cold shutdowns (per year)	2
Secondary system	
Steam flow rate (lb/hr)	1.5×10^7
Mass of steam/steam generator (lb)	9.1×10^3
Mass of liquid/steam generator (lb)	1.17×10^4
Secondary coolant mass (lb)	5.05×10^5
Rate of steam leakage to Turbine Building (lb/hr)	1.7×10^3
Steam generator blowdown rate (lb/hr)	7.7×10^3
Dilution flow (gpm)	4.4×10^3
Containment Building volume (ft^3)	2.93×10^6
Frequency of containment purges (per year)	4
Iodine partition factors (gas/liquid)	
Leakage to Containment Building	0.1
Leakage to Auxiliary Building	0.005
Steam leakage to Turbine Building	1
Steam generator (carryover)	0.01
Main condenser air ejector	0.0005

Decontamination factors (DF) for liquids

	Boron Recycle	Equipment Drains	Waste Drains
I	1×10^5	1×10^3	1×10^3
Cs, Rb	2×10^3	1×10^4	1×10^4
Mo, Tc	1×10^5	1×10^6	1×10^6
Y	1×10^4	1×10^4	1×10^5
Others	1×10^5	1×10^5	1×10^4

	All Nuclides Except Iodine	Iodine
Waste evaporator DF	10^4	10^3
BRS evaporator DF	10^3	10^2

	Cation[b]	Anion[b]	Cs, Rb
Mixed bed demineralizer (Li_3Bo_3) DF	10	10	2
Mixed bed demineralizer (H^+ OH^-) DF	10^2(10)	10^2(10)	2(10)
Cation demineralizer DF	10^2(10)	1(1)	10(10)
Anion demineralizer DF	1(1)	10^2(10)	1(1)

(Note: For the two demineralizers in series, the DF for the second demineralizer is given in parentheses.)

	Removal Factor
Removal by plateout	
Mo, Tc	10^2
Y	10
Containment Building internal recirculation system	
Flow rate	1.6×10^4CFM
Operating period/purge	16 hours
Mixing efficiency	70%

[a]This value is constant and corresponds to 0.25% of the operating power fission product source term.

[b]Does not include Cs, Mo. Y, Rb, Tc.

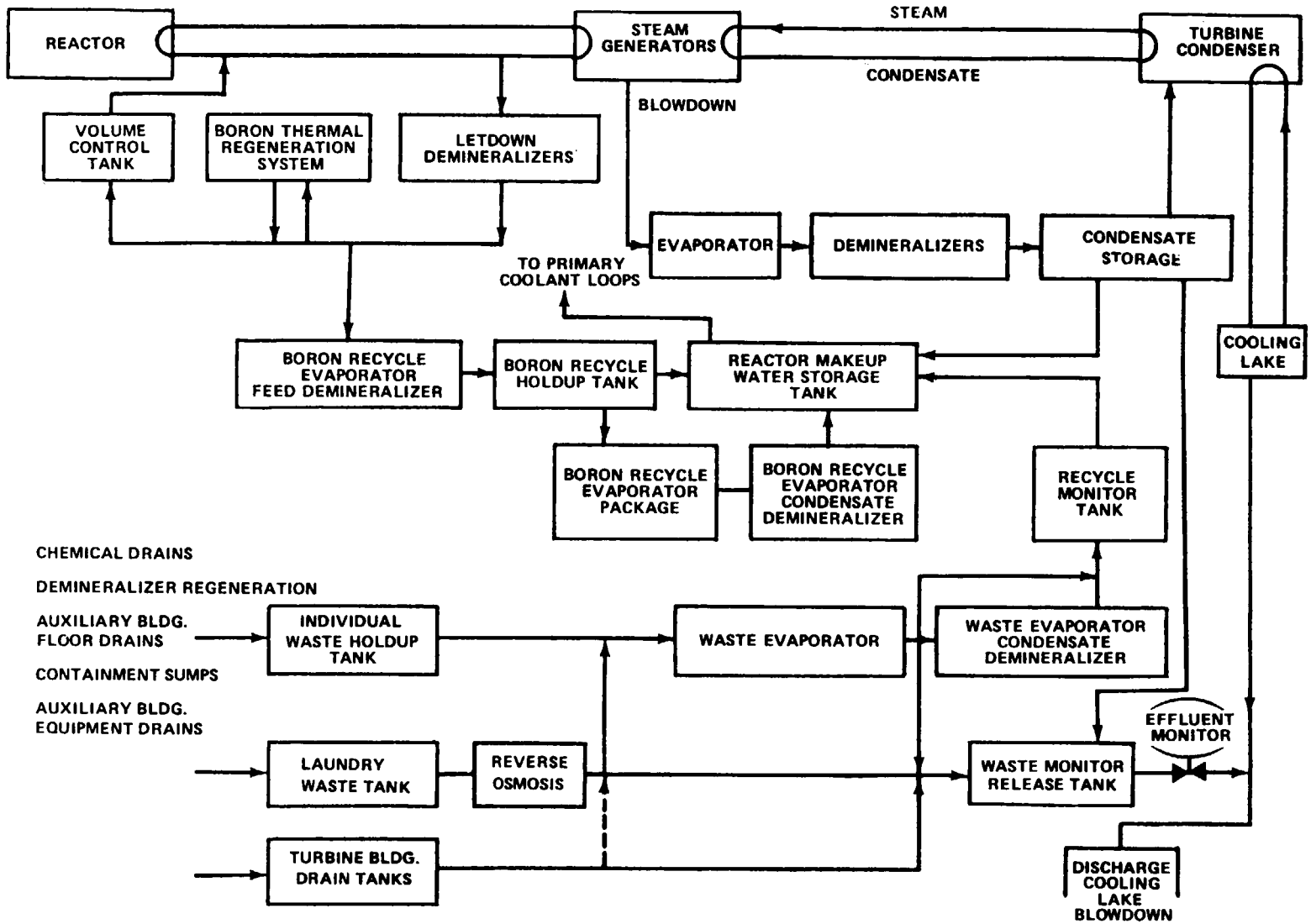

Fig. 3.10. Liquid Waste Treatment Systems.

tank for reuse. Although the staff calculates that the SGB treatment system will have sufficient capacity to allow essentially total recycle of the blowdown stream, the analysis assumed the release of 100 percent of the treated stream since it will contain less than 0.01 curie (Ci)/yr/unit, excluding tritium and noble gases. Radionuclide removal by the demineralizers was not included in the evaluation since the applicant indicated that demineralizers would be used primarily to reduce the effect of operational occurrences and not for routine processing. The applicant assumed 20% of the treated blowdown will be discharged releasing 0.0005 Ci/yr/unit other than tritium and noble gases.

3.5.1.2 Radioactive Waste Drains (RWD)

The RWD system will collect liquid from the containment sumps, auxiliary building floor drains, turbine building floor drains auxiliary building equipment drains, turbine building equipment drains, demineralizer regeneration waste drains and chemical drains. Each of these substreams will be collected in its respective drain analysis tanks where its radioactivity level and chemical composition will be ascertained and an appropriate treatment method determined. With the exception of the turbine building drains, liquid radioactive waste will normally pass in batches through a 50-gpm evaporator. The evaporator condensate will be processed through a demineralizer. The treated waste will then be discharged, reprocessed or reused based on its radioactivity content and plant water balance requirements. Liquids from the turbine building drains, which are expected to have negligible activity, will be monitored and will be treated, if required, prior to discharge.

The staff's evaluation assumed that all of the water from the RWD system will be discharged. This discharge will be approximately 1400 gpd/unit of treated water containing 0.01 Ci/yr/unit except tritium and noble gas, and 7200 gpd of untreated turbine building water containing an additional 0.04 Ci/yr/unit excluding tritium and noble gas. The release values were calculated using the parameters in Table 3.4. Radionuclide removal by the polishing demineralizer was not included in the calculations since the applicant indicated that the demineralizer would be used primarily to reduce the effect of operational occurrences and not for routine processing.

The applicant estimates the release of 1100 gpd of treated RWD water containing 0.006 Ci/yr/unit, excluding tritium and noble gases. The applicant also estimates the release of 300 gpd/unit of untreated turbine building liquid containing 0.0004 Ci/yr/unit, excluding tritium and noble gases.

3.5.1.3 Laundry Waste Subsystem (LWS)

Laundry wastes will be collected in the 4000-gallon laundry waste tank and processed by reverse osmosis to remove detergents and particulate matter prior to treatment in the waste evaporator. The staff estimated that the laundry tank activities would be equivalent to 10^{-10} Ci/cc prior to treatment and the generation rate to be 450 gpd/reactor. The applicant assumed that 20 percent of the treated laundry waste would be released. The staff finds this assumption to be reasonable and concludes that the release of radioactivity from the LWS will be negligible.

3.5.1.4 Boron Recycle System (BRS)

Primary coolant will be withdrawn from the reactor coolant system at approximately 61 gpm and processed through the Chemical and Volume Control System (CVCS). The letdown stream will be cooled, reduced in pressure, filtered, and processed through one of two mixed bed demineralizers. Approximately 12 percent of this letdown stream will be passed through an additional cation demineralizer to remove excess lithium and cesium. Radionuclide removal by the CVCS was evaluated by assuming 61 gpm letdown flow at primary coolant activity (PCA) through one mixed bed demineralizer (Li_3BO_3 form) and 7.5 gpm flow through one cation demineralizer in series with the mixed bed. The CVCS will be used to control the boron concentration in the primary coolant by passing a portion of the letdown stream through the boron thermal regeneration system. A side stream of approximately 1.5 gpm of the treated letdown stream is diverted to the BRS as shim bleed. In the boron thermal regeneration system, boron will be either absorbed from or desorbed into the letdown stream, depending upon the stream temperature. Since the thermal regeneration demineralizer resins will desorb as well as absorb radioactivity, this system was given no credit for radionuclide removal. However, use of the thermal regeneration system will reduce the quantity of liquid waste generated from boron control.

Shim bleed from the letdown stream will be processed through one of two mixed bed demineralizers (Li_3BO_3 form) and routed to the recycle holdup tanks. Valve leakoffs and equipment drain wastes in the reactor containment as well as excess spent fuel pit water will be transferred to the recycle holdup tank and combined with the shim bleed. These streams from each reactor will form the principal inputs to the BRS and will be processed batchwise from the recycle holdup tanks. The shim bleed input activity was calculated by applying the decontamination factor (DF) for a mixed bed demineralizer in the Li_3BO_3 form to the shim bleed stream, and assuming 1.5 gpm/reactor flow and CVCS output activity. The reactor coolant drain tank input

flow to the BRS was taken to be 360 gpd/reactor at PCA based on the applicant's assumption, which was found to be reasonable. Radioactive decay during collection in the recycle holdup tank is included in the ORIGEN code. The collection time was calculated to be 18 days assuming the 112,000 gallon recycle holdup tanks will be filled to 80 percent capacity by the combined shim bleed and reactor coolant drain tank flows from both reactor units. Radionuclide removal was based on the parameters in Table 3.4 for an evaporator and an anion demineralizer in series. Additional credit for radioactive decay time during processing of the contents of the recycle holdup tank through the two recycle evaporators has been given. In the evaluation, it was assumed that equipment downtime and anticipated operational occurrences will result in approximately 10 percent of the evaporator condensate stream being discharged with the cooling lake blowdown to the Kankakee River. The applicant assumed that the BRS stream will be recycled and did not specify a discharge fraction in his evaluation.

3.5.1.5 Liquid Waste Summary

The staff calculated the releases of radioactive materials in the liquid wastes to be 0.1 Ci/yr/reactor, excluding noble gases and tritium. Based on previous experience at operating reactors, the staff estimated the tritium releases to be 350 Ci/yr/reactor. The applicant estimated the releases to be 0.001 Ci/yr/reactor, excluding tritium; the tritium release was estimated to be 102 Ci/yr/reactor. The differences between the staff's values and those calculated by the applicant are due largely to the quantity of BRS waste recycle in the respective models. The staff assumed 10 percent of the BRS stream would be discharged over the life of the plant due to equipment downtime and anticipated operational occurrences, whereas the applicant assumed total recycle of this stream.

Based on the staff's evaluation, the radioactivity in liquid effluents from Units 1 and 2, exclusive of tritium and dissolved noble gases, will be less than 5 Ci/yr (see Table 3.5).

3.5.2 Gaseous Waste

The gaseous waste treatment and ventilation systems will consist of equipment and instrumentation necessary to reduce releases of radioactive gases and airborne particulates from equipment and building vents. The principal source of radioactive gaseous waste will be gases stripped from the primary coolant in the CVCS and BRS. Additional sources of gaseous wastes will be main condenser vacuum pump offgases, ventilation exhausts from the auxiliary, radwaste, fuel handling and turbine buildings, and gases collected in the reactor containment building. The principal system for treating gaseous wastes will be the gaseous waste processing system (GWPS). The GWPS will collect and store gases stripped from the primary coolant in a continuously recirculating nitrogen loop containing two compressors and six pressurized storage tanks. The GWPS will be shared by Units 1 and 2. The ventilation exhaust from the auxiliary, radwaste, and fuel handling buildings will normally be processed through HEPA filters before release to the atmosphere. Since the ventilation exhaust can also be processed through charcoal filters, such flow was assumed to meet AEC as low as practicable guidelines. Offgases from the main condenser vacuum pump exhausts and the turbine building will be processed through a HEPA filter, monitored, and passed through a charcoal absorber, if necessary, prior to release. The containment atmosphere will be recirculated through filters and charcoal adsorbers prior to purging through HEPA filters to the atmosphere.

The steam generator blowdown treatment system will cool the blowdown in heat exchangers to prevent flashing. The blowdown condensate will be collected in the condenser hotwell where degassing occurs due to the relatively low pressure in the condenser. The gaseous waste treatment systems are shown schematically in Fig. 3.11.

3.5.2.1 Gaseous Waste Processing System (GWPS)

The gaseous waste processing system will be designed to collect and process gases stripped from the primary coolant of the CVCS, BRS, and miscellaneous tank cover gases. The GWPS will contain nitrogen which will be recirculated continuously as a carrier to transport radioactive gases removed from the primary coolant. Hydrogen cover gas from the volume control and reactor coolant drain tanks, and gases stripped in the BRS degassifier will enter the nitrogen loop. The nitrogen, hydrogen and radioactive gases will be collected, compressed and stored in one of six pressurized storage tanks. After holdup, to allow short-lived radionuclide decay, the nitrogen, hydrogen, and long-lived nuclides will be reused in the loop or discharged to the environment if sufficient decay has occurred.

The applicant considers the system to be capable of retaining radioactive gases for at least 45 days. This estimate was considered to be reasonable and calculations were based on release after 45 days holdup, which will leave Kr-85 (10.7-yr half life) and Xe-133 (5.27-day half life) as the predominant radionuclides. The GWPS releases were calculated to be 1110 Ci/yr/reactor for noble gases and negligible for iodine. The applicant's corresponding estimates were 6600

Table 3.5. Braidwood Liquid Radioactive Source Terms

Radionuclide	Ci/yr/unit	Radionuclide	Ci/yr/unit
Br-82	0.00001	Cs-134	0.00594
Sr-89	0.00001	Cs-136	0.00090
Y-91	0.00009	Cs-137	0.00459
Mo-99	0.00002	Ba-137m	0.00430
Tc-99m	0.00002	Ba-140	0.00001
Te-127m	0.00001	La-140	0.00001
Tc-127	0.00001	Cr-51	0.00003
Te-129m	0.00005	Mn-56	0.00001
Te-129	0.00003	Fe-55	0.00003
Te-131m	0.00002	Fe-59	0.00002
Te-132	0.00037	Co-58	0.00028
I-130	0.00005	Co-60	0.00004
I-131	0.06245	W-187	0.00001
I-132	0.00087		
I-133	0.01738		
I-135	0.00237		
H-3	350	All others	0.00008
		Total	0.10000

Table 3.6. Braidwood Gaseous Radioactive Source Term, Ci/yr/unit

Radionuclide	Decay Tanks	Building Ventilation Reactor	Building Ventilation Auxiliary	Building Ventilation Turbine	Air Ejector Offgas	Total
Kr-83m	a	a	1	a	1	2
Kr-85m	a	a	7	a	7	14
Kr-85	960	14	7	a	7	988
Kr-87	a	a	4	a	4	8
Kr-88	a	a	12	a	12	24
Kr-89	a	a	a	a	a	a
Xe-131m	29	2	6	a	6	43
Xe-133m	a	1	13	a	13	27
Xe-133	120	170	1,025	1	1,036	2,357
Xe-135m	a	a	1	a	1	2
Xe-135	a	a	20	a	20	40
Xe-137	a	a	1	a	1	2
Xe-138	a	a	3	a	3	6
I-131	a	0.001	0.01	0.03	0.01	0.05
I-133	a	0.001	0.01	0.02	0.01	0.04

a - < 1 Ci/yr/unit noble gases, < 10^{-4} Ci/yr/unit iodine.

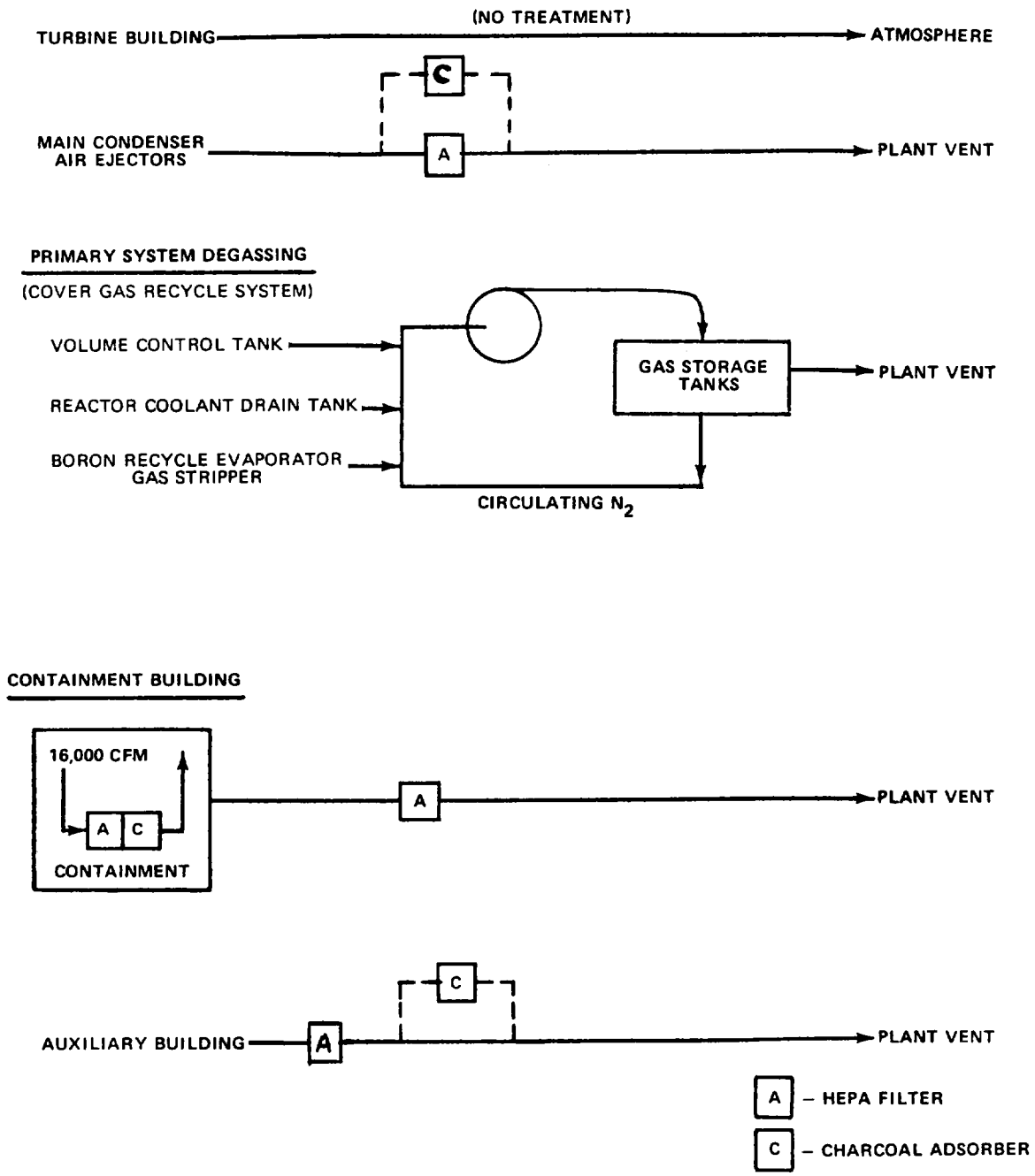

Fig. 3.11. Gaseous Waste Treatment Systems.

Ci/yr/reactor and a negligible amount of iodine. The applicant's more conservative estimate is based on operation with one percent of the operating power fission product source term while the staff's analysis used 0.25 percent of the operating power fission product source term.

3.5.2.2 Containment Purges

Radioactive gases will be released inside the reactor containment when primary system components are opened or when leaks occur in the primary system. The gaseous activity will be sealed within the containment during normal operation but will be released periodically during containment purges. Prior to purging, the containment atmosphere will be recirculated through HEPA filters and charcoal adsorbers for particulate and iodine removal. Following this recirculation procedure, the containment will be purged to the atmosphere through HEPA filters. Calculation of the airborne activity was based on the parameters listed in Table 3.4 for primary coolant leakage to the containment. Radionuclide removal was based on 16 hours of recirculation system operation, 70 percent mixing efficiency, and a DF of 10 for the recirculation charcoal adsorber. Assuming four containment purges per reactor per year, the staff calculated the releases to be 190 Ci/yr/reactor of noble gases and 0.001 Ci/yr/reactor of iodine-131. The applicant estimated a release of 560 Ci/yr/reactor of noble gases and 0.008 Ci/yr/reactor of iodine-131 based on a conservative assumption of 10 purges per year for each reactor.

3.5.2.3 Auxiliary and Fuel Handling Building Vent Releases

Radioactive gases will be released to the auxiliary and fuel handling buildings due to leakage from primary system components. These two buildings will share a common ventilation system designed to ensure that air flow will be from areas of low potential to areas having a greater potential for the release of airborne radioactivity. Ventilation air will be exhausted through HEPA filters for particulate removal. The ventilation air can also be continuously exhausted through charcoal; this operation was assumed by the staff. Releases were based on the auxiliary building leakage rate and iodine partition factor listed in Table 3.4 with credit given for the charcoal adsorber in the operating stream. The staff thus calculated the auxiliary building releases to be 1100 Ci/yr/reactor of noble gases and 0.01 Ci/yr/reactor for iodine-131. The applicant estimated the releases to be 0.015 Ci/yr/reactor of iodine-131 and "small quantities of noble gases."

3.5.2.4 Turbine Building Vent Releases

Radioactive gases will be released to the turbine building from secondary system steam leakage. The turbine building ventilation system exhausts will not be treated prior to release. The calculated release values are based on 1700 lb/hr/reactor of steam leakage to the turbine building assuming that all of the noble gases and iodine remain airborne. On this basis, the turbine building vent release was calculated to be negligible for noble gases and 0.03 Ci/yr/reactor for iodine-131. The applicant estimated 0.001 Ci/yr/reactor for iodine-131 and did not specify a noble gas release.

3.5.2.5 Steam Releases to the Atmosphere

The capacity of the turbine bypass to the condenser will be 40 percent of the flow. Analysis indicates that steam releases to the environs due to turbine trips and low power physics testing will have a negligible effect on the calculated source term.

3.5.2.6 Main Condenser Offgas Releases

Offgas from the main condenser vacuum pump exhausts will contain radioactive gases resulting from primary to secondary system leakage. Iodine will be partitioned between the steam and liquid phases in the steam generators and between the condensing and non-condensable phases in the main condensers and vacuum pumps. The major concentration of iodine present in the vacuum pump exhaust will be released through a charcoal adsorber to the plant vent. The staff used 20 gpd/reactor of primary to secondary leakage, partition factors of 0.01 and 0.0005 for iodine in the steam generators and main condenser vacuum pumps, respectively, a DF of 10 for the charcoal adsorbers and calculated the main condenser vacuum pump releases to be approximately 1110 Ci/yr/reactor for noble gases and 0.01 Ci/yr/reactor for iodine-131. The applicant estimated this release to be 16,275 Ci/yr/reactor for noble gases and 0.001 Ci/yr/reactor for iodine-131. The applicant's estimated releases are somewhat higher than those calculated by the staff because a more conservative model was used. The applicant's estimate was based on operating with one percent of the fission product source term; the staff's analysis used 0.25 percent. The applicant also assumed a leak rate equivalent to 68 gpd/reactor primary to secondary leak rate, whereas the staff assumed 20 gpd/reactor.

3.5.2.7 Gaseous Waste Summary

Based on the parameters given in Table 3.4, the total radioactive gaseous releases were calculated to be approximately 3500 Ci/yr/reactor of noble gases and 0.05 Ci/yr/reactor of iodine-131. The principal sources and isotopic distributions are given in Table 3.6. The applicant has calculated an overall release of approximately 23,400 Ci/yr/reactor of noble gases and 0.03 Ci/yr/reactor of iodine-131.

3.5.3 Solid Waste

Solid waste containing radioactive materials will be generated during station operations. Solid wastes will be categorized as "wet" or "dry" based upon the need for moisture absorption and solidification during processing. The solid waste system will consist of a waste drumming subsystem for dry solid waste.

Wet solid wastes will consist mainly of spent demineralizer resins, filter sludges, evaporator bottoms, reverse osmosis concentrates and chemical drain tank effluents. These wastes will be combined with a cement and vermiculite mixture to form a solid matrix and sealed in 55-gallon steel drums. Since the majority of the radioactivity entering the liquid waste streams will be removed by demineralizers, evaporators, or filters and become wet solid wastes, these wastes are considered to have been stored on site for a least 180 days for radioactive decay prior to shipment off site.

Dry solid wastes will consist of ventilation air filters, contaminated clothing and paper and miscellaneous items such as tools and laboratory glassware. Dry solid wastes will be compressed into 55-gallon drums using a hydraulic press-baling machine. Since dry solid wastes will contain much less activity than wet solid wastes, no on-site storage of dry solid wastes was included in the evaluation.

Based on the staff's evaluation of similar reactors and operating reactor data, it was estimated that approximately 600 drums of wet solid waste containing approximately 12 Ci/drum, and 450 drums of dry solid waste containing less than 5 Ci total, for each reactor, will be shipped off site annually. More than 90 percent of the radioactivity associated with the solid waste will be long-lived fission and corrosion products, principally Cs-134, Cs-137, Co-58, Co-60, and Fe-55. The applicant estimates that approximately 1060 drums of wet solid waste with activities ranging from 2 to 260 Ci/drum, and 180 drums of dry solid waste with activities ranging from negligible to 3.40 Ci/drum will be shipped off site annually.

3.5.3.1 Solid Waste Summary

All containers will be shipped to a licensed burial site in accordance with AEC and DOT regulations. The solid waste system will be similar to systems which have been evaluated and found to be acceptable in previous license applications. Based on its similarity to acceptable systems, the staff considers this solid waste system to be acceptable.

3.6 CHEMICAL AND BIOCIDE SYSTEMS

Sulphuric acid will be added to the cooling water for the main condensers to prevent scale buildup. The total average feed rate will be 235 gal/hr of 66° Baumé acid.

The principal other chemicals expected to be used during the routine operation of the station are sulphuric acid and sodium hydroxide for regeneration of resins used in the makeup water demineralizers. Waste from this system will be sent to a neutralizer tank, and after the pH is adjusted, it will be discharged to the river via the blowdown line.

The maximum and average concentrations of chemicals from the makeup system in the water discharged are shown in Table 3.7. Also shown in the table are the concentrations of boric acid and phosphate expected by the applicant in lake blowdown. The former is used in the primary coolant system as a chemical shim while the latter is used in the steam system to control scaling and corrosion.

The applicant states that the service water for essential (safety related) and nonessential (auxiliary) systems will be hypochlorinated to prevent biological growths in the cooling equipment (Ref. 1, p. 3.6-2). The applicant proposes to add hypochlorite three times a day for about half-hour periods. During each chlorination of the essential service water, approximately 20 gallons of 15% NaOCl will be used, and approximately 25.5 gallons will be used for the nonessential service water. The total amount of 15% NaOCl solution used each day will be approximately 140 gallons. Since there is no accurate way to predict the chlorine demand of the lake water, the quantity of NaOCl used may be changed. After the service water is discharged into the lake, the residual chlorine will have about four days of aeration and reaction with the lake bottom and chlorine demand constituents of the lake water before reaching the blowdown point.

Table 3.7. Applicant's Estimates of Effluent Water Composition[a]

	Concentration, mg/l			
	Ambient River	Neutralizing Tank Effluent[b]	Average Lake Blowdown	Average Discharge to River[b]
Alkalinity (as $CaCO_3$)	187	0	37	36
Calcium	78.5	191	158	158
Chlorides	14.2	665	28	34
Magnesium	27.2	89	55	55
Nitrates	8.5	-	17	17
Silica	8.8	29	17	17
Sodium	10	1795	20	38
Sulfates	113.2	3620	555	588
Total Dissolved Solids	386	6389	906	967
pH	8.0	~ 7	-	Within Standards
Phosphate (as PO_4)		-	1.1	1.2
Boron (as B)				5[c]

[a]These figures have been estimated with the following assumptions:

(1) Average blowdown = 51.4 cfs (23,050 gpm).

(2) Neutralizing tank discharge = 400 gpm, the estimated maximum discharge.

(3) The radwaste and sanitary systems discharges to the blowdown were considered negligible.

(4) The analysis of the neutralizing tank effluent was estimated assuming a 150-gpm makeup capacity with the deep wells supplying this water.

(5) The amount of water used during regeneration was 170,000 gallons.

(6) The maximum concentration in the lake blowdown will occur during the summer.

[b]Acid (93% H_2SO_4) added for regeneration = 4480 lb/day. Caustic (100% NaOH) added for regeneration ≈ 2676 lb/day.

[c]Intermittent discharge.

Complied from the applicant's Environmental Report.

The total residual chlorine concentration in the cooling lake blowdown released to the river is therefore expected to be below 0.001 ppm.

Mechanical cleaning will be used to control biological growth and slime buildup in the main condenser (Ref. 1, p. 3.6-2).

3.7 SANITARY AND OTHER WASTES

All sanitary wastes will be processed through a sewage treatment plant located within the station area. The sewage treatment plant will be of the extended aeration type and designed for a maximum water requirement of 15,000 gallons per day. The water will come from wells on site. The wastes will receive primary and secondary treatment and the effluent will receive a tertiary treatment consisting of filtration and circulation followed by chlorination for disinfection. The treated effluent will then be discharged into the river via the blowdown. The applicant expects the chlorine concentration in the effluent to be 1 ppm before it is mixed with the anticipated average blowdown of 46 cfs. Since the expected flow of treated sewage is only 0.023 cfs, its residual chlorine will be completely consumed by the chlorine demand of the blowdown water before it reaches the river.

During the station construction period, the sewage treatment plant will be operated as a contact stabilization unit, and the sewage will be treated in a manner that complies with the State of Illinois standards.

Trash and other objects collected on the preliminary screens and traveling screens will be removed by a licensed disposal service and shipped off site. The remainder of the plant non-radioactive waste, i.e., trash, shop and laboratory wastes, will be processed by normal industrial techniques for solid waste disposal by commercial scavenger service. Laundry wastes and wastes from chemical laboratory drains will be processed through the radwaste system described in Section 3.5.

Emergency power will be supplied by four diesel engines. These engines will exhaust directly to the atmosphere through a muffler system. As these units will be operated only on an intermittent basis for test purposes (except for emergencies requiring their use), the combustion products have not been considered in calculating plant effluents.

Two oil- or gas-fired auxiliary steam boilers, each rated at about 75×10^6 Btu/hr, will be used for plant startup and when the nuclear units are shut down. The applicant states that these boilers will be supplied with low-sulfur distillate oil or natural gas that will meet Illinois State emission standards for control of gaseous sulfur dioxide emissions. There are no standards applicable to gas-fired units under $250 \times 10^6 \times 10^6$ Btu/hr. When firing distillate oil, the standards limit SO_2 emissions to 0.3 lb per million Btu heat input.

3.8 TRANSMISSION SYSTEMS

The applicant has given a description of the transmission lines in the Environmental Report (Ref. 1, p. 3.9-1). The two new transmission corridors for the proposed lines are shown in Fig. 3.12. The routes will proceed from Braidwood Station to the existing Joliet Generating Station and the existing Crete Transmission Substation.

The "Braidwood to Joliet Generating Station" corridor is approximately 30 miles long. The first 3½ miles heading eastward from the Braidwood station will be a 215-foot multiple-use corridor of which approximately 145 feet will be reserved for a double circuit 345-kV line. The remaining width of the corridor will be used for a pipeline which will provide makeup water for the lake. Proceeding 2-3/4 miles northward, there will be a 145-foot right-of-way for a double circuit 345-kV line. The next 12-1/2 miles will require a 95-foot widening of a 145-foot right-of-way, which is being acquired at the present time for a project not associated with the Braidwood Station. A double circuit 345-kV line from Braidwood will be installed on part of this 240-foot right-of-way which follows the eastern boundary of the Joliet Arsenal. Along this portion the line will parallel the Norfolk and Western Railroad (N. & W.) for approximately five miles. The last 11½-mile section to the Joliet station will have a double circuit 345-kV line on a new 145-foot right-of-way. This section will parallel the Chicago, Milwaukee, St. Paul and Pacific Railroad (C.M.St.P. & P.) for 2-1/2 miles. All of the towers along the Braidwood to Joliet corridor will be lattice steel with concrete foundations and 20-foot square bases. The double circuit towers will be spaced at six per mile and the triple circuit towers spaced at eight per mile.

The right-of-way will cross nearly 23 miles (304 acres) of cleared farmland, 5-1/8 miles (58 acres) of open woodland and hedgerows, 3/4 mile (19 acres) of riparian woodland and 1-7/8 miles (22 acres) of discontinuous marshland. The right-of-way will also cross the

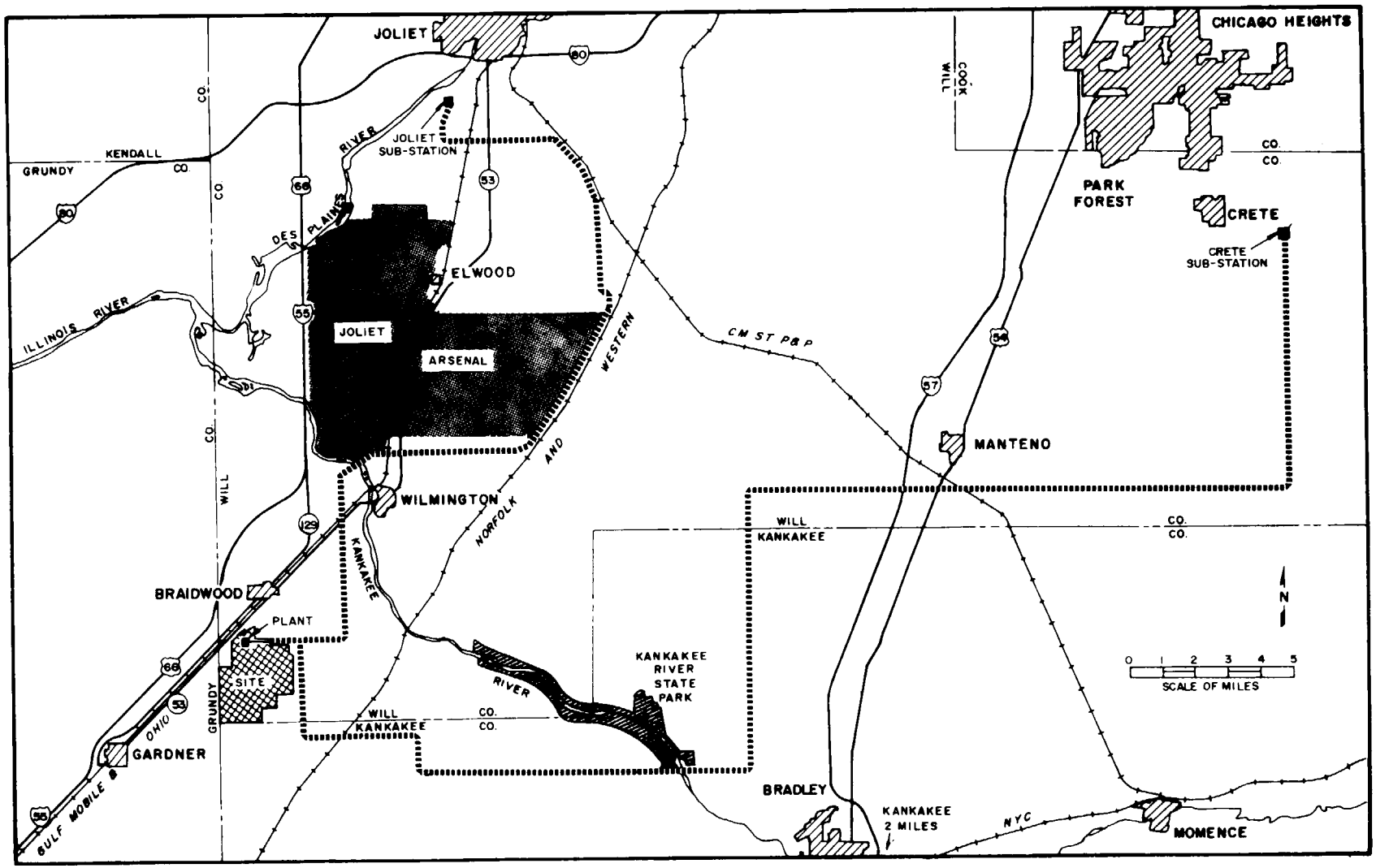

Fig. 3.12. Braidwood Station Transmission System. From the applicant's Environmental Report.

Kankakee River approximately 1.5 miles northwest of Wilmington, Illinois; seven creeks; 13 intermittent streams; the Gulf, Mobile, and Ohio Railroad (G.M. & O.); a U. S. Government railroad; and two State highways.

The total right-of-way acreage for this land is about 403. Less than two acres of land will be occupied by the tower bases.

The "Braidwood to Crete Substation" corridor will be approximately 54 miles long. The first 29 miles of the corridor will be 405 feet wide, providing for a double circuit 345-kV line and a future 765-kV line. This section of the line heads south into Kankakee County, east across the Kankakee River and then north to Wilton Township in Will County. The next 17 miles will involve a 180-foot widening of an existing 200-foot right-of-way. This 380-foot right-of-way will have a double circuit 345-kV line parallel to the existing 765-kV line between Wilton and Washington Townships. From Washington Township, 7-3/4 miles northward to the Crete Substation, there will be a new 190-foot right-of-way for a triple circuit 138/345-kV line and a future triple circuit 138/345-kV line. Except for the last 7-3/4 miles of the overall route, the towers will have 40-foot square bases and be spaced at 4½ towers to the mile. For the last 7-3/4 miles to the Crete Substation, the triple circuit towers will have 20-foot square bases and be spaced at eight towers per mile. All of these towers will be lattice steel with concrete foundations.

This route will cross through nearly 48 miles (1837 acres) of cleared farmland, 3-3/8 miles (74 acres) of open woodland and hedgerows and 2-3/4 miles (62 acres) of riparian woodland. The lines will cross the Kankakee River approximately seven miles northwest of Kankakee, Illinois. They will also cross 11 creeks and 18 intermittent streams. The total acreage for this corridor is 1973. About eight acres will be occupied by the tower bases.

Transportation route crossings will include the N. & W., C.M.St.P. & P., and the Chicago and Eastern Illinois (C. & E.I.) railroads, one interstate highway, two U. S. highways, and four State roads.

References

1. Commonwealth Edison Co., "Braidwood Station Environmental Report," including insertions, Vols. 1 and 2, Docket Nos. STN 50-456 and STN 50-457, Sept. 13, 1973.

2. L. A. Loziuk, J. C. Anderson, and T. Belytschko, "Hydrothermal Analysis by Finite Element Method," J. Hydraulics Division, ASCE, HY 11, November 1972.

3. A. J. Policastro and J. V. Tokar, "Heated-Effluent Dispersion in Large Lakes: State-of-the-Art of Analytical Modeling. Part 1." Argonne National Laboratory Report ANL/ES-11, Jan. 1972.

4. H. Motz and B. A. Benedict, "Heated Surface Jet Discharged into a Flowing Ambient Stream," U. S. Environmental Protection Agency, 16130 FDQ, March 1971.

5. "Oak Ridge Isotope Generation and Depletion Code," Oak Ridge National Laboratory, Report ORNL-4628.

6. F. T. Binford et al., "Analysis of Power Reactor Gaseous Waste Systems," 12th Air Cleaning Conference.

4. ENVIRONMENTAL EFFECTS OF CONSTRUCTION

4.1 IMPACTS ON LAND USE

The following tabulation shows the character of the land that will make up each component of the new site when strip-mining operations currently underway are completed:

MAIN STIE			4320 acres
Area affected by plant building activities		130 acres	
Woods	35 acres		
Cultivated	70		
Fallow	25		
	130 acres		
Area occupied by lake, islands, and dikes		3540 acres	
Strip-mine spoil	2838 acres	(in various stages of reclamation, see Sec. 2.7.1)	
Cultivated	381		
Fallow	204		
Woods	117		
	3540 acres		
Area to be undisturbed		650 acres	
Cultivated	200 acres		
Woods and fallow fields	450		
	650 acres		
		4320 acres	
PIPELINE CORRIDOR AND RIVER SITE			100 acres
Intake and discharge structure site		12 acres	
Cultivated	12 acres		
Pipeline corridor		88 acres	
Cultivated	71 acres		
Woods	17		
	88 acres		
		100 acres	
		Total	4420 acres

The loss of 734 acres of cultivated land is considered by the staff as an adverse impact. Since the remainder of the land is either fallow land, land which will be disturbed only temporarily, or land which will be undisturbed, no long-term adverse impacts on these lands should result.

The diversion of 734 acres from agricultural use to industrial use will result in a yearly loss of commodities such as corn, soybeans, wheat, etc. Assuming a yield of 120 bu/acre for corn or 55 bu/acre for wheat or soybeans, the commodity loss for the 734 acres would be about 88,080 bushel of corn, or about 40,370 bushels of wheat or soybeans per year. (This would be a very conservative upper limit estimate of commodity yield since average yields for the soils involved would be less than those assumed.) The attendent economic loss resulting from such agricultural diversion at current market prices is estimated by the staff to be no more than $200,000 per year. A more realistic estimate based on present-day average costs and yields would be about 1/2 the above commodity and economic loss.

Because of recent increased grain exports, the amount of federally supported set-aside acreage was reduced to zero in 1974. For Will County it was reduced to 6891 acres in 1973 from 23,896 in 1970. For the three-county area of Will, Kankakee, and Grundy the set-aside acreage for feed grain was reduced to 19,332 acres in 1973 from 93,182 in 1970. The loss of 734 acres of producing agricultural land to power-plant use represents, therefore, a more significant agricultural loss than when it was only a small fraction of the set-aside acreage for the area.

The applicant states that eleven permanent residences and two temporary dwellings involving a total of 32 persons will be displaced by site acquisition (Ref. 1, p. 8.0-3). The applicant states that the residents will be given sufficient time for relocation.

4.1.1 Agricultural Energetics

Acreage, yield, and production for major crops of Will County are given in Table 4.1 for the period 1970-1973. Land devoted to corn production during that period varied from 124,500 to 140,400 acres. The variation is due primarily to yearly variations in anticipated returns by farmers at the time of planting and the incentives then acting for their participation in feed-grain set aside programs. The 734 acres to be taken out of production by the Braidwood nuclear plant is less than the normal variation in acreage which takes place in the county through action of market processes. Similar arguments hold in the cases of soybeans, grains, and hay. The diversion of 734 acres from crop production in Will County would not affect the marginal value of crops produced in the county. Production of major crops for the State of Illinois is given in Table 4.2. The values for 1972 (the latest year for which state-wide data are available) show that over 1 billion bushels of corn were produced. Further increase in state-wide production can be anticipated in 1974 and subsequent years due to the termination of payments under the federally subsidized feedgrain set-aside program for 1974. The staff's estimate of 88,000 bushels of corn to be lost on the Braidwood project constitutes only 0.01% of the state production. The lost production is 0.8% of the county totals for 1973.

[Recent production statistics do not indicate changing trends in the acreage devoted to various crops in the county or the state.] Corn remains a preferred crop by farmers because of well developed markets and because of the high yield potential relative to other crops. There is considerable potential for increasing the yield of corn and other major crops through added technological inputs as indicated in Table 4.3. Technological inputs are achieved primarily in the form of added energy subsidies which go into the production of fertilizers, machinery, pesticides, and fuel.

The principal economic inputs to corn production are given in Table 4.4. Inputs are given in units of energy (K Cal/acre) in order to facilitate comparison of one factor to another and to emphasize the fact that the high yields of modern agricultural production are highly dependent on technological energy subsidies. These energy subsidies constitute only 11% (in 1970) of the total solar energy involved in production but these are the inputs which are under man's control and which are primarily responsible for the dramatic increase in corn yield during the period 1950-1970. Overall energy inputs increased by 140% during this period while overall corn yields increased by 113%. This indicates that a diminishing returns relationship may exist between energy input and energy return in corn production. The 1970 figures show however that production was still an energy favorable enterprise since the caloric ratio of output to input had a value of 2.82. The diminishing returns relationship cannot be avoided unless there is some new technological breakthrough in crop production. However, the present favorable output-input ratio and the favorable biological margin for potential increases in corn and other crops (Table 4.3) suggests that it will be feasible to continue investing increasing increments of energy in corn production in the future with the expectation that yields will continue to increase for some time. This assessment is clouded to some extent by the uncertain availability of fossil fuels required for both on-the-farm consumption and for the production of fertilizers. Thus, while it is clearly feasible to increase yields through added energy inputs, actual yields may not increase in the future if the inputs are not available. Agriculture accounts for about 2.3% of the total electrical consumption on a national basis and about 10% of the total energy expenditure for corn production in 1970 was in the form of electricity. This does not account for the electrical energy used in fertilizer or machinery production so it seems reasonable to assume that electrical energy plays a much larger role in crop production than the above figures indicate.

In Will County Illinois the loss of 88,000 bushels of corn not produced on 734 acres of land could be replaced by an increase in production of only 0.8% based on 1973 acreage. At constant acreage this would require a yield increase from 79 to 79.6 bu/acre based on 1973 production values. This increase is within the normal year to year variation in yield and would be detectable only in long-term analysis. Historical yield increases have been much larger than this (Tables 4.2 and 4.4).

In view of the efficacy of energy input in increasing the yield of corn, the favorable output-input yields, and the prominent role that electrical energy plays in agricultural production, it is not clear that the construction of an electricity producing plant constitutes an adverse impact on agricultural production when minor amounts of productive land are preempted.

Table 4.1. Recent Agricultural Production in Will County, Illinois

Corn	1970	1971	1972	1973
Acres	139,500	139,400	124,500	140,400
Bu/Acre	70	92	101	79
Production(bu)	9,807,000	12,822,000	12,544,000	11,121,300
Soybeans				
Acres	108,500	107,800	166,900	135,900
Bu/Acre	28	27	31	25
Production(bu)	3,017,200	2,891,000	3,588,900	3,393,700
Wheat				
Acres	5,800	5,900	6,500	6,400
Bu/Acres	40	36	46	40
Production(bu)	231,100	212,600	300,500	254,600
Oats				
Acres	14,900	15,600	9,700	10,000
Bu/Acres	55	48	56	45
Production(bu)	821,900	747,300	541,900	447,600
Hay				
Acres		15,100	14,800	10,400
Yield (tons/acre)		2.92	3.15	2.79
Production (Tons)		44,100	46,600	29,000

Source: Illinois Agricultural Statistics: Farm Income and Marketing for 1972 with comparisons. Illinois Coop. Crop Reporting Service Bull. 73-74.

Table 4.2. Recent Production of Major Crops in Illinois

	1965	1966	1967	1968	1969	1970	1971	1972
Corn ($\times 10^6$ bu)	919	848	1,122	908	989	736	1,067	1,004
Soybeans ($\times 10^6$ bu)	178	160	186	210	229	211	236	262
Wheat ($\times 10^6$ bu)	56.8	61.0	71.9	51.2	48.4	38.1	46.8	54.0
Hay ($\times 10^6$ tons)	4.3	3.7	3.8	3.6	3.3	3.3	3.2	3.4

Table 4.3. Average, Top, and Record Crop Yields in the USA (Bushels per acre) in 1973

Crop	Average	Top	Record
Corn	94	230	306
Wheat	32	135	216
Oats	49	150	296
Soybeans	28	80	110
Sorghum	63	200	320

Source: Wittwer, S. H., Maximun Production Capacity of Food Crops, Bioscience 24, pp. 216-224, 1974.

Table 4.4. Energy Requirements for the Production of the United States Average Corn Crop. (Kcal/acre)

Input	1950	1959	1970	% Change, 1950 to 1970
Labor	9,800	7,600	4,900	- 200
Machinery	250,000	350,000	420,000	+ 68.0
Gasoline	615,800	724,500	797,000	+ 29.4
Nitrogen	126,000	344,400	940,800	+ 647
Phosphorus	15,200	24,300	47,100	+ 210
Potassium	10,500	60,400	68,000	+ 548
Seeds	40,400	36,500	63,000	+ 55.9
Irrigation	23,000	31,000	34,000	+ 47.8
Insecticides	1,100	7,700	11,000	+ 900
Herbicides	600	2,800	11,000	+1733
Drying	30,000	100,000	120,000	+ 300
Electricity	54,000	140,000	310,000	+ 474
Transportation	30,000	60,000	70,000	+ 133
Total Input	1,206,400	1,889,200	2,896,800	+ 140
Corn Yield	3,830,400	5,443,200	8,164,800	+ 113
Energy return/unit input	3.18	2.88	2.82	- 11.3

Source: Pimentel, David, L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Sholes and R. J. Whitman. Food Production and the Energy Crisis, Science 182, pp. 443-449, 1973.

The staff doesn't believe that the foregoing analysis would be valid for the indefinite future. It has already alluded to the apparent diminishing returns relationships between energy input and output in the form of food. The day will come when the costs of energy input will no longer be repaid in the value of food energy output. In that case, the only option for increasing total production would be to increase the acreage under cultivation.

The staff concludes that that situation does not obtain at present. Agricultural yields are highly dependent on energy inputs and substantial gains are still technologically and bioligically feasible. Although the exact future allocation of energy from the Briadwood facility is not known, it is reasonable to assume that additional increments of available energy will have a positive effect on agricultural production which may compensate for the losses due to the preemption of relatively minor amounts of productive land.

4.1.2 Onsite Construction

Construction of earthen dikes to retain the lake will require extensive and prolonged earth-moving operations, including excavations to depths of about 60 ft and some dynamiting. No extensive hauling of earth from other areas with its attendant traffic and safety problems is anticipated. Both dike fill and topsoil for a vegetative cover will be obtained from within the site boundaries. The most economical method of constructing the dike is to excavate the subsoil from the area immediately adjacent to and inside of the dike. In such cases, the dike can, upon completion of its useful life, be stripped of its topsoil, bulldozed into the excavated pit and the filled pit then re-covered with the topsoil. Such techniques are commonly used in modern strip-mining operations. The staff recommends that wherever possible the topsoil be conserved.

The applicant has indicated that trash, debris, and waste materials generated during construction will be removed from the site and disposed of in accordance with applicable local, State and/or Federal regulations. No burning of paper, wood, etc., will be carried out (Ref. 1, p. 4.1-9).

All concrete batch plant equipment, and other particulate processing and storage devices shall be adequately covered and shielded to assure that windblown particulate emissions are minimized. The applicant plans to control and monitor the area to assure compliance with appropriate standards and regulations governing these operations.

The effects of excavation, disposal of debris, dust, increased traffic noise and heavy equipment will be generally confined to the site, and, with the precautions recommended by the staff and proposed by the applicant, negligible impact on the surrounding communities will occur. The installation of about 4.5 miles of buried piping for the station's water intake and blowdown system will require excavation work in the corridors (130 to 215 feet wide). Most of the corridor area is located on cleared and cultivated farmland (∿83 acres) but some wooded areas (∿17 acres) will be traversed. Short-term adverse environmental effects will result, particularly to the wooded areas (see Sec. 4.3).

The applicant's commitment (Ref. 1, pp. 4.1-1 & 4.1-8) to maintain erosion gradients, to restore contours, and to reseed in problem areas should reduce the adverse impacts due to erosion. Existing roads will be used for access to the site (Ref. 1, p. 4.1-6). Some 31,000 linear feet of onsite roads will be constructed.

The applicant plans to contact the Will County Soil and Water Conservation District and will become a "cooperator" with the district for its site and transmission line corridor land planning, both during and after construction.

On the basis of the surveys reported in Section 2, it was concluded that construction of the station will have no significant impact on the archeological or cultural resources of the area (Ref. 1, p. 4.7-1), except on fossil-collecting in the strip-mined area to be flooded by the cooling lake. The measures taken by the applicant to mitigate this impact are described in Section 11. See also Appendix G.

4.1.3 Transmission Line Construction

The area affected by the transmission lines is described in Section 3.8. The construction will not affect any historical sites or existing public parks.

The applicant has not indicated if herbicides will be used to clear the vegetation in the transmission right-of-way. The staff will require that, should it prove necessary to use herbicides they be used at State or Federally approved rates; for spot, not broadcast application, and not in the vicinity of houses, bodies of water, food supplies, domestic animals or recreation areas. The staff will require that if 2,4,5-T is selected the content of the impurity dioxin (2,3,7,8-tetrachlorodibenzo-1, 4-dioxin) be limited[2,3] to a concentration no greater than 0.1 ppm of the undiluted 2,4,5-T.

During construction, temporary disruption of agriculture will result from the movement of vehicles along the right-of-way and the temporary storage of tower materials. After completion of construction, the ground surface will be graded, planted, and otherwise treated or prepared so that the effects of vehicular movement will not cause erosion or will not affect restoration to agricultural use. There appears to be little requirement for the construction of access roads which would require additional land to be taken out of production permanently. Most impacts can be minimized or eliminated by following published guidelines for construction of transmission facilities. The applicant shall follow appropriate sections of AEC Regulatory Guideline 4.2 and Guidelines for the construction of Transmission Facilities of the U.S. Department of Interior.[4]

Where transmission lines traverse wooded areas, the areas will be reseeded with sod-forming grasses to help control erosion and hold down growth of undesirable species.

The staff visited the site October 24, 1973, and reviewed the proposed routing. It was noted that an effort was made to put transmission corridors along quarter- and half-section lines wherever possible, and to avoid placing the towers on the residents' property. Other than the esthetic effects, these measures should assure minimal impacts to the present and future activities of the area residents.

The staff concludes that transmission line construction can be accomplished without a significant long-term or permanent adverse effect on agricultural production along the right-of-way and adjoining properties. A small area of land (ten acres) will be taken out of agricultural production permanently.

4.2 IMPACTS ON WATER USE

At least 75 private wells exist within two miles of the station (Ref. 1, p. 2.2-19). Many of these wells obtain water from sandpoint-driven wells in the glacial drift aquifer. Dewatering of the building site during construction could produce a short-term adverse effect on this water supply. The applicant estimates that under the worst conditions (severe drought) during dewatering, water levels may be lowered at most by about two feet in the nearest sandpoint. The staff considers this may cause a temporary adverse impact but expects normal levels to be reestablished after dewatering operations are terminated.

A continuous check of the area groundwater supply will be made during plant dewatering operations to assure that no hydraulic coupling of pumped-out water and the groundwater table exists. The staff will require that the level of the water table be monitored and, if necessary, corrective measures taken to assure that no wells in the neighborhood of the site be materially affected.

Construction of the intake and discharge structures is not expected to have an impact on navigation other than the exclusion of pleasure craft from the immediate area of construction. There is no commercial shipping. Increased turbidity of the river as a result of dredging will temporarily prevent people from swimming in this area.

Sanitary wastes occurring during construction will be treated in a temporary sewage disposal plant. Soaps and detergents which will be used in conjunction with construction activities will not be released directly to the Kankakee River or to the groundwater system, but will be treated in the construction sanitary system or processed through a waste disposal system (Ref. 1, p. 4.1-1a).

With these construction practices, the staff does not expect the dewatering of the building site or the sanitary wastes to have any adverse effect upon the Kankakee River, nor upon the quality of the groundwater.

4.3 ECOLOGICAL EFFECTS OF CONSTRUCTION

A number of construction activities referred to above can be expected to impact the biota on and near the site. The following discussion considers the impact of these activities upon the biota in the vicinity of the station.

4.3.1 The Cooling Lake

The immediate and permanent effect of flooding the acreage necessary to build the cooling lake will be the exclusion or loss of existing land biota and the destruction of land habitats. This may result in a net reduction of land species diversity for the site environs. The habitats to be affected, as described in Section 4.1, include cultivated fields (381 acres), fallow fields (204 acres), woodland (117 acres), and strip-mine spoil (2838 acres).

All vegetation in the flooded area will be immediately lost except for those trees near the periphery of the lake with root crowns above the waterline. These may survive for varying periods of time up to several years, depending upon species and age. Some water-tolerant trees such as black willows may live for longer periods if they set adventitious roots. Invertebrate species dependent upon the flooded flora will also be displaced or lost.

The majority of site fauna will have the capacity to migrate to dry areas as flooding takes place. However, some of these animals will be lost from the ecosystem because of a possible reduction in their rates of reproduction in new habitats. Those which are able to establish territories in new habitats may displace and exclude similar organisms.

The Braidwood site is not unique in terms of the above terrestrial habitats with their associated flora, and fauna; the site area constitutes a small fraction of such habitats in the region. Therefore, the loss of land habitats resulting from the formation of the cooling lake will not be significant in terms of area ecosystems.

Lake flooding will create new habitats such as open water and marshland which will support ducks, geese, herons, shorebirds, amphibians, amphibious reptiles and aquatic mammals. Once the lake is filled, a lake ecosystem will eventually become established.

Clearing, grading, and excavating activities elsewhere on the site will also disturb or destroy existing habitats. Again, since the site habitats are common, the impact on area ecosystems will not be significant.

Potentially injurious chemicals to be used on site during construction include trisodium phosphate, soaps and detergents, paints, organic cleaning fluids, concrete components, fly ash, sweeping compounds, oils and fuels. The applicant has stated that any chemicals used for cleaning will be either released to the site environs according to State and Federal regulations, or disposed of off site by an independent contractor, or processed through a waste disposal system (Ref. 1, p. 4.1-1).

4.3.2 Pipeline and Transmission Lines

The pipeline right-of-way involves about 100 acres of which 17 are open woods, hedgerows, and the wooded riparian zone along the Kankakee River adjacent to the intake and discharge pump house locations. The remaining 83 acres are farmlands.

Pipeline installation will cause only a temporary disturbance to agricultural activity because the pipes will be subsurface. Wooded areas will require clearing along the pipeline route. All disturbed areas shall be revegetated following the procedures given in the Soil Conservation Service Technical Guide for Will County. The only area where there will be a permanent commitment of a woodland resource (less than one acre) will be under the physical structures of the pump house. Pipeline construction will temporarily disturb wildlife along the proposed route. The immediate effect will be a loss of animals from the area. With revegetation the wildlife should return; thus the permanent impact will be small.

As described in Section 3.8, most of the transmission lines will traverse either nearly flat land that has already been cleared for agricultural purposes, or they will be placed along existing railroad and power line rights-of-way. Very little new clearing will be necessary and the applicant will be required to clear woodland only to the extent required to maintain transmission security. No permanent disruption of wildlife will occur. The two river crossings will be the most sensitive areas in regard to ecological disturbances, but damage is expected to be minimal. The riparian zone along the northern crossing of the river involves about one acre, whereas the southern crossing entails about 7-1/2 acres, just south of the Kankakee River State Park. The marshlands are small, discontinuous, and will be spanned without the need for tower bases wherever possible.

4.3.3 Intake and Discharge Structures

Dredging for construction will disrupt the aquatic organisms and their habitats and cause some downstream siltation. The applicant will be required to minimize this impact by reducing siltation to a minimum and controlling the release and erosion of dredging spoils. The proposed location of the intake and discharge structures (about 1500 feet downstream from Horse Creek) is characterized by a natural narrowing of the river. The river bottom composition at this location, mostly cobble and gravel, is presumably influenced by higher than average water velocities which prevents silt from settling. It is unlikely that the limited dredging in this area will have a significant impact upon biological communities outside of the dredging zone or downstream. Kankakee River water is often naturally characterized by high silt loads (transparency, as measured by Secchi disc, six inches or less) and a temporary increase should have little permanent effect upon pelagic communities. Downstream, much of the silt can be expected to settle where the river velocity is lower. These areas are already highly silted and are characterized by benthic organisms such as tubificid worms and mayfly larvae. These organisms are known to burrow to the surface of accreted silt, and little adverse impact is expected.

No rare or endangered animal species are known to inhabit the area proposed for the site or the transmission corridors.

4.4 SOCIAL AND ECONOMIC EFFECTS

The proposed site will be located in an area served by both highway and rail transportation facilities. Route I-55 (U. S. 66) is less than two miles WNW of the proposed plant and Illinois State Routes 53 and 129 are located less than one mile NW. Illinois State Route 113 located approximately two miles north also provides access to the interstate and state routes.

At present, there is very limited rail freight traffic, and there is little truck and passenger car traffic in the vicinity of the proposed site. After construction begins, heavy passenger traffic is expected on work days at starting and quitting times. Also, truck traffic will increase greatly, and rail traffic will increase from very light to light limited freight. At the peak of the construction period approximately 1500 workers will be employed. An estimate of the number of passenger vehicles is 600 based on an average of 2.5 workers per vehicle at peak time. This number may have a significant effect on the use of public facilities in the area. Because of the increased traffic, additional maintenance will be required on roads and railroad grade crossings.

The noise associated with construction will have little effect on the residents in the area, particularly since the nearest farm is located 1500 ft from the proposed station (Ref. 1, p. 4.1-7). The applicant must control blasting noise by the use of small multiple charges.

The economic impacts of construction range from negligible to significant. The areas affected and the impact upon them are as follows:

(1) Local taxes: The applicant will pay taxes in increasing amounts as the construction of the station progresses. Annual taxes for the station in 1976 are estimated by the applicant to be $660,000 and $3,218,000 in 1981. The taxes will be a benefit to the local community, but the benefit is at the expense of those who pay for the power produced at Braidwood.

(2) New jobs: The applicant's estimate of the average construction force indicates that about 6200 man-years of work will be required to complete the construction of the station. Since most workers will come from the Chicago area there will be a definite positive impact on the level of employment in the area. The applicant's estimate for construction wages is $81,319,000 (1972 values) which will be spread over a five- to six-year construction period. This impact is expected to be significant to the economy of the region.

(3) Community services: Inasmuch as the majority of construction workers are expected to be drawn from the region and commute to the job site, construction activities will have little impact on local schools, hospitals, or housing.

In summary, the staff believes that only small adverse social or economic effects of construction will occur and that these will not continue beyond the construction period.

4.5 MEASURES AND CONTROLS TO LIMIT ADVERSE EFFECTS DURING CONSTRUCTION

4.5.1 Applicant Commitments

The following is a summary of the commitments made by the applicant to limit adverse effects during construction of the proposed Braidwood Station.

(a) During the construction phase, sewage will be treated by the contact stabilization process. The wastes will be treated to comply with State of Illinois standards. After the construction, the sewage treatment plant will operate as an extended aeration plant for permanent station service.

(b) Special care will be exercised to prevent introduction of potential contaminants to the groundwater system.

(c) Observation wells will be used to demonstrate that dewatering operations will not cause a significant lowering of the existing groundwater level in the surrounding area. If necessary, corrective measures will be taken to assure that wells and vegetation in the site vicinity will not be affected.

(d) Blasting noise will be minimized by use of small multiple charges.

(e) Erosion will be minimized as soon as possible during construction by landscaping of borderlands, blacktopping of road areas and minimizing slope gradients.

(f) The general contours of land affected by construction will be restored with surface seeding as required for erosion control, and the gradients will be maintained.

(g) Dust control measures will be used during the construction period, and entry of cement dust, fly ash etc., into the air will be minimized.

(h) All spoil from the site preparation will be used for land fill at the plant site and dike construction.

(i) Trash and solids and non-radioactive chemical wastes will be disposed of offsite by an independent contractor. No burning of paper cardboard or wood will be permitted. Trees and brush will be disposed of by chipping. Daily policing of the area will take place.

(j) For transmission corridors:

(1) As a general practice, woods will be mechanically trimmed using minimal clearing practices to save as many trees as practicable. The rights-of-way will be feathered back by careful topping and pruning of vegetation so as to avoid a notched or tunnelled appearance.

(2) If the use of herbicide is necessary, the herbicide will be selected from 2.,4-D, 2,4,5-T, Dibar, or Ural in compliance with and approval of the appropriate State of Illinois authorities. The tree or brush will be cut at the ground line and the stumps will be sprayed locally.

(3) The amount of land committed to the use of access roads will be minimized; there will be little need to construct any new access roads.

(4) Erosion problems will be handled on an individual basis as they arise; existing grades will be maintained along the routes. Towers will be set back from the stream banks far enough to minimize erosion. Secondary roads will be used to cross streams with construction equipment.

(5) Any debris resulting from the construction operation is to be collected, immediately removed from the right-of-way, and disposed of in accordance with Illinois Air Pollution Regulations.

(6) The applicant will contact the Will County Soil and Water Conservation District to cooperate in land planning for the site and transmission line corridors during and after construction.

4.5.2 Staff Evaluation

The staff has reviewed the anticipated construction activities and the expected environmental effects therefrom, and has concluded that the measures and controls as summarized above, are adequate to ensure that adverse environmental effects will minimal with the following additional precautions:

(a) Topsoil will be removed, set aside and protected for reuse, as practical.

(b) Groundwater in the observation wells will be monitored for quality as well as level. Remedial action should be taken to protect off-site groundwater users should detrimental changes be detected.

(c) If herbicides are used in clearing the vegetation in the transmission right-of-way, they must be used according to State and Federal guidelines. If 2,4,5-T is selected, the impurity dioxin (2,3,7,8-tetrachlorodibenzo, 4-dioxin) must be limited to a concentration no greater than 0.1 ppm of the undiluted 2,4,5-T.

(d) The guidelines of the U.S. Dept. of the Interior and the U.S. Dept. of Agriculture regarding routing and construction of transmission lines shall be followed.

(e) Siltation and washout resulting from work at the riverbank will be controlled by the use of a temporary cofferdam, if necessary.

(f) Ditches to drain the dikes and plant area into the Mazon River will be constructed so that area drainage will not be adversely affected.

(g) A control program during the construction of the slurry trench will be followed to assure that seepage will be as low as designed. The control program shall include monitoring of seepage from the lake. Necessary measures such as riprapping and planting of grass will be taken as required to prevent erosion of the dike.

(h) All cleared or disturbed areas will be revegetated according to the procedures given in the Soil Conservation Technical Guide for Will County.

References

1. Commonwealth Edison Co., "Braidwood Station Environmental Report," including insertions, Vols. 1 and 2, Docket Nos. STN 50-456 and STN 50-457, Sept. 13, 1973.

2. K. S. Khera et al., "Pre- and Post-natal Studies on 2,4,5-T and 2,4,-D and Derivatives in Wistar Rats," Toxicology and Applied Pharmacology Abstracts, 10th Annual Meeting 19:369-370, 1971.

3. J. E. Johnson, The Public Health Implications of Widespread Use of the Phenoxy Herbicides and Picloram, Bioscience 21(17):599-905, 1971.

4. "Guide to the Preparation of Environmental Reports for Nuclear Power Plants," USAEC (1972) and "Environmental Criteria for Electric Transmission Systems," U.S. Dept. of Interior (1970).

5. ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 IMPACTS ON LAND USAGE

5.1.1 Station Operation

The primary impact on land use will be the change in 734 acres from agricultural use to industrial use. About 381 acres of the agricultural land will be inundated by the cooling lake. The lake will also inundate 2838 acres of strip-mine spoil and 321 acres of fallow fields and marshlands. As noted in Section 4.1, the staff considers the diversion of the agricultural land to be minor relative to the amount of land available in Illinois for agriculture. Further, the additional energy available from the proposed station is expected to compensate for the removal of land from agricultural production. The cultivated land in the transmission line and pipeline corridors is considered by the staff to still be useful for crop production.

No plans for secondary public use of the station site have been made by the applicant, except for the arrangements discussed in Section 11 to allow continued fossil collecting. See also Appendix G.

There are no landmarks nor places of historic or archeological interest in the site area (see Section 2.3). Some sites of cultural interest are located between 10 and 20 miles from the station (Ref. 1, p. 2.3-7), but the staff does not believe they will be affected by its operation.

5.1.2 Visual Impact

The station will be visibile on the relatively flat terrain. However, the clustering of component structures in a coordinated arrangement will tend to reduce the impact. It is expected that the conversion of the unsightly strip mine land to a lake will be regarded by most of the public as an esthetic improvement although the lake will not be visible from off site because of the surrounding dike. The dike will be seen from off site as a grass-covered hill varying in height from about 0-20 feet.

The usual adverse esthetic impact of the transmission lines will be present. However, most highways will be crossed by the lines at acute angles and at no time will any rights-of-way run adjacent and parallel to any primary roads. Existing transmission line corridors as well as railroad rights-of-way will be used whenever possible. The lines will traverse lands that are either free from residences or are sparsely populated.

5.2 IMPACTS ON WATER USE

5.2.1 Surface Water

The average net loss of water from the Kankakee River due to the operation of Braidwood Station is estimated by the applicant to be 47.3 cfs (Ref. 1, pp. 2.5-3, -4, -6, -9, and -22). This water loss is about 1% of the average flow and 11% of the 7-day 10-year recurrence low flow of the river at the Station's intake. The only other major use of water downstream from the station to the confluence of the Illinois River, a distance of about 14 miles, is that by the Joliet Arsenal, which uses 38.7 cfs of water from the Kankakee River. Thus, the total net water loss from the two major users of the Kankakee River is about 86.0 cfs and represents about 2% of the average river flow and about 19% of the 7-day 10-year recurrence low flow.

The major consumptive user upstream from the proposed intake is the Kankakee Water Company, situated about 20 miles from the station. At present, the net consumptive use is 3.1 cfs. A new water treatment plant,* expected to be installed 1° miles from the Braidwood intake, is expected to become operational in 1976. Consumptive use by this new plant is forecasted to be 232 cfs in 2020 if the sewage effluent is not returned to the Kankakee River. Thus, near the end of the station's 40-year projected life, the 7-day 10-year recurrence low flow near the station's intake could be reduced to 210 cfs. As the applicant intends to limit its net use of makeup water to 10% of the flow, only about 21 cfs would be used for makeup water at such

times. Since the station's water requirement due to evaporation and seepage is 57 cfs (10 cfs is restored on the average by rainfall), curtailments of plant operation or drawdown of the lake might be required during periods of low flow. As indicated by the applicant (Ref. 1, p. 2.5-6), during a 50-year drought condition, with two units operating at 100% load factor, the water level in the lake would be lowered to a minimum elevation of 592.95 feet over a period of about five months. This would be necessary in order to limit the net water makeup to 10% of the available flow in the Kankakee River. This capability for the plant to continue operating during drought conditions is an important advantage of the cooling lake design.

The operation of Braidwood Station will not have an adverse impact on recreational use of the Kankakee River.

The construction of the dikes or levees for the cooling lake, and other related plant construction, may be expected to increase the speed at which rainfall will runoff. The applicant proposes to construct a system of collector channels around the outside of the cooling lake levee, and from the plant site area, and to clean out and maintain the connecting stream channel from the area to the Mazon River. The collector channels are to be sized to pass the runoff from rainfall events as severe as those with a 100 year frequency. The drainage areas contributing to both the collector ditch system and the connecting channel to the Mazon River consist of approximately 2465 acres, 1906 acres of which will belong to surrounding property owners. The staff considers that such a system will not only drain the applicant's property adequately, but can be expected to improve the drainage of the contributing watershed. In view of the lack of good farm drainage in the area, the staff concludes the construction and proper maintenance of the drainage facilities will result in a positive impact. Decreased drainage capacity downstream on the Mazon and Kankakee Rivers is not expected because of the relative size and location of the improved drainage.

5.2.2 Groundwater

The station's process water makeup and potable water supply will be provided from deep wells at the site. Indications are that the deep ground water supply is adequate for this purpose; the staff does not anticipate significant impairment of the supply for nearby wells to result from these usages (see however, Section 4.2).

The applicant has proposed a control method (Ref. 1, p. 2.5-18, p. 3.3-5) to reduce seepage from the dike structure and on the basis of its computation expects the water loss to be less than 5 cfs. Also, the applicant expects that the cooling lake will have little effect on the surficial sand aquifer or on the Cambrian-Ordovician aquifer. The applicant's slurry trench test program indicates that construction of the lake dikes employing such a method may be expected to control seepage, but the staff will require a control program during construction and monitoring of groundwater levels near the dike, particularly in the vicinity of the underground mines, to assure that the desired effects have been achieved. With the dike drainage ditch proposed by the applicant it is not expected that seepage of this order will significantly affect area drainage problems. The applicant states that the control of seepage by the slurry trench design will prevent the type of dike failure which occurred at Dresden.

5.2.3 Water Quality

The State of Illinois requires that the quality of the water in rivers be maintained to certain standards and that additional standards for effluents be met. Whenever a water quality standard is more restrictive than an effluent standard, a mixing zone is allowed within which the water quality standard need not be met. The size of the mixing zone is set on a case-by-case basis to meet the purpose of the regulation; it normally will not be allowed to exceed the area of a circle with a radius of 600 feet. The water quality standards apply at all times except during periods when flows are less than the average minimum seven day low flow which occurs once in ten years.

Two specific restrictions or standards of the "Water Pollution Regulations of Illinois," which were adopted by the State of Illinois Pollution Control Board in 1973, apply to the waters of the Kankakee River at the Braidwood Station. These are (a) General Standards, Section 203, and (b) Public and Food Processing Water Supply maximum permissible levels identified in Section 204 based on U. S. Public Health Service Drinking Water Standards. These restrictions are itemized in Table 5.1. Wherever the same substance is restricted in both sections of the Regulations, the more restrictive limit is cited. The monthly temperature limits "shall not (be exceeded) during more than one percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum (monthly) limits by more than 3°F."

Table 5.1. Standards Applicable to the Kankakee River from Water Pollution Regulations of Illinois

Substance Regulated	Concentration not to Exceed	Section of Reg. More Restrictive
Unnatural sludge, bottom deposits, floating debris, visible oil, odor, unnatural plant or algal growth, unnatural color or turbidity	None	203
pH	6.5-9.0[a]	203
Dissolved oxygen	5.0 mg/l always 6.0 mg/l 16/hrs/day	203
Ammonia nitrogen	1.5 mg/l	203
Arsenic (total)	0.01 mg/l	204(b)
Barium (total)	1.0 mg/l	204(b)
Boron (total)	1.0 mg/l	203
Cadmium (total)	0.01 mg/l	204(b)
Chloride	250 mg/l	204(b)
Carbon chloroform extract	0.2 mg/l	204(b)
Chromium (total hexavalent)	0.05 mg/l	203
Chromium (total trivalent)	1.0 mg/l	203
Copper (total)	0.02 mg/l	203
Cyanide	0.01 mg/l	204(b)
Fluoride	1.4 mg/l	203
Iron (total)	0.3 mg/l	203
Lead (total)	0.05 mg/l	204(b)
Manganese (total)	0.05 mg/l	204(b)
Methylene blue active substance	0.5	204(b)
Mercury	0.0005 mg/l	203
Nickel (total)	1.0 mg/l	203
Nitrate plus nitrite (as N)	10.0 mg/l	204(b)
Phenols	0.001 mg/l	204(b)
Selenium (total)	0.01 mg/l	204(b)
Silver (total)	0.005 mg/l	203
Sulfate	250 mg/l	204(b)
Zinc	1.0 mg/l	203
Total Dissolved Solids	500 mg/l	204(b)
Fecal coliform bacteria	200/100 ml (Geometric mean) 400/100 ml (10% of samples)	203
Toxic Substances	0.1 of 48-hour TLm for fish or fish food organisms	203
Temperature	5°F above natural; also monthly maximum[b] as follows:	203

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
60°	60°	60°	90°	90°	90°	90°	90°	90°	90°	90°	60°

[a]Except from natural causes.

[b]See text for actual restrictions.

Effluent standards are applicable directly to plant discharges on the basis of 24-hour composite samples. In addition, no contaminant shall at any time exceed five times the numerical standard. Compliance is "not required when effluent concentrations in excess of the standards result entirely from influent contamination, evaporation, and/or the incidental addition of traces of materials not utilized or produced in the activity that is the source of the waste." Applicable restrictions on effluents, from Sections 403-408 of the Regulations, are given in Table 5.2.

Referring to the chemical releases identified in Section 3, no violation of the standards for the Kankakee River (Table 5.1) or for the plant effluent (Table 5.2) is anticipated. The concentration of total dissolved solids in the blowdown discharged to the Kankakee River is expected by the applicant to average 967 ppm. The staff has calculated that this will increase the average TDS of the river from 362 to 369 ppm at the average river flow of 3923 cfs. At the low river flow of 350 cfs, the TDS will increase to 439 ppm. These concentrations are below the allowable limit of 500 ppm. It is not likely that this limit will be exceeded except momentarily during maximum neutralizing tank discharge rate at extremely low river flow. The blowdown TDS will also be lower than the permitted effluent concentration of 3500 ppm.

Discharge of the sanitary wastes will be to the Kankakee River via the cooling lake blowdown. Prior to discharge these wastes will be processed through a modern sewage treatment plant constructed expressly for that purpose. Designed for processing 15,000 gpd (0.02 cfs) (Ref. 1, p. 3.7-1), the sewage treatment plant will be an extended aeration type facility. The effluent will be given tertiary treatment (filtration and recirculation) and will be chlorinated to 1 ppm effluent chlorine concentration before being mixed with the cooling lake blowdown. The 1 ppm chlorine concentration will be reduced by dilution with the 46 cfs blowdown by a factor of about 2000, resulting in a chlorine concentration of about 0.0005 ppm in the mixture. Considering the presence of materials in the blowdown water capable of reacting with the chlorine, the staff does not expect any residual free chlorine will reach the Kankakee River. Thus, no adverse impact on downstream water quality is anticipated by the staff.

Conformance to thermal standards is considered in Section 3.4.

The staff has evaluated the chemical alteration of the Kankakee River as a result of the blowdown and concludes that the Braidwood Station can be operated in a manner that will permit compliance with the above standards. The staff also concludes that the impact of operation of the plant on water usage is acceptably small.

5.3 RADIOLOGICAL IMPACTS

5.3.1 Impact on Biota other than Man

5.3.1.1 Exposure Pathways

The pathways by which biota other than man may receive radiation doses in the vicinity of a nuclear power station are shown in Fig. 5.1. Two recent comprehensive reports[2,3] have been concerned with radioactivity in the environment and these pathways. They can be read for a more detailed explanation of the subjects that will be discussed below. Depending on the pathway being considered, terrestrial and aquatic organisms will receive either approximately the same radiation doses as man or somewhat greater doses. Although no guidelines have been established for desirable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for these species.[4] An estimate of the occupational radiation exposure received in operating the station has been made. This estimate is based on experience at comparable operating reactors.

5.3.1.2 Radioactivity in the Environment

The quantities and species of radionuclides expected to be discharged annually by the Braidwood Station in liquid and gaseous effluents have been estimated by the staff and are given in Tables 3.5 and 3.6, respectively. The basis for these values is discussed in Section 3.5. For the determination of doses to biota other than man, specific calculations are done primarily for the liquid effluents. The liquid effluent quantities, when diluted in the Braidwood Station discharge, would produce an average gross activity concentration, excluding tritium, of 4.6×10^{-3} picocuries per milliliter in the plant discharge area. Under the same conditions, the tritium concentration would be 17 pCi/ml. Additional discussion concerning liquid dilution is presented in Section 5.3.2.2.

Table 5.2. Standards Applicable to Braidwood Effluents from Water Pollution Regulations of Illinois

Substance Regulated	Concentration not to Exceed	Pertinent Section of Regulations
Settleable solids, floating debris, visible oil, grease, scum, or sludge solids.	None	403
Color, odor, turbidity	Obvious levels	403
5-day BOD	30 mg/l	404(a)
Suspended solids having oxygen demand	37 mg/l	404(a)
Fecal coliform bacteria	400/100 ml	405
Arsenic (total)	0.25 mg/l	408(a)
Barium (total)	2.0 mg/l	408(a)
Cadmium (total)	0.15 mg/l	408(a)
Chromium (total hexavalent)	0.3 mg/l	408(a)
Chromium (total trivalent)	1.0 mg/l	408(a)
Copper (total)	1.0 mg/l	408(a)
Cyanide	0.025 mg/l	408(a)
Fluoride (total)	2.5 mg/l	408(a)
Iron (total)	2.0 mg/l	408(a)
Iron (dissolved)	0.5 mg/l	408(a)
Lead (total)	0.1 mg/l	408(a)
Manganese (total)	1.0 mg/l	408(a)
Mercury (total)	0.0005 mg/l	408(a)
Nickel (total)	1.0 mg/l	408(a)
Oil (hexane solubles or equivalent)	15.0 mg/l	408(a)
pH	range 5-10[a]	408(a)
Phenols	0.3 mg/l	408(a)
Selenium (total)	1.0 mg/l	408(a)
Silver	0.1 mg/l	408(a)
Zinc (total)	1.0 mg/l	408(a)
Suspended solids other than those having oxygen demand	15 mg/l	408(a)
Total dissolved solids	750 mg/l above background with exceptions[b]; 3500 mg/l, no exception	408(a)

[a]The pH limitation is not subject to averaging and must be met at all times.

[b]Unless caused by recycling or other pollution abatement practices.

Doses to terrestrial animals such as rabbits or deer due to the gaseous effluents are quite similar to those calculated for man. For this reason, both the gaseous effluent concentrations at locations of interest and the dose calculations for gaseous effluents are discussed in detail in Section 5.3.2.

5.3.1.3 Dose Rate Estimates

The annual radiation doses to both aquatic and terrestrial biota including man were estimated on the assumption of constant concentrations of radionuclides at a given point in both the water and air. Referring to Fig. 5.1, radiation dose has both internal and external components. External components originate from immersion in radioactive air and water and from exposure to radioactive sources on surfaces, in distant volumes of air and water, in equipment, etc. Internal exposures are a result of ingesting and breathing radioactivity.

Doses will be delivered to aquatic organisms living in the water containing radionuclides discharged from the power station. This is principally a consequence of physiological mechanisms that concentrate a number of elements that can be present in the aqueous environment. The extent to which elements are concentrated in fish, invertebrates, and aquatic plants upon uptake or ingestion has been estimated. Values of relative biological accumulation factors (ratio of concentration of nuclide in organisms to that in the aqueous environment) of a number of waterborne elements for several organisms are provided in Table 5.3.

Doses to aquatic plants and fish living in the discharge region due to water uptake and ingestion (internal exposure) were calculated to be 4.2 and 7.4 mrads/yr, respectively, for the Braidwood Station operation. The discharge region concentrations were those given above and it was assumed that these organisms spent all of the year in water of maximum concentrations. All calculated doses are based on standard models.[5] The doses are quite conservative since it is highly unlikely that any of the mobile life forms will spend a significant portion of their life span in the maximum activity concentration of the discharge region. Both radioactive decay and additional dilution would reduce the dose at other points in the river.

External doses to terrestrial animals other than man are determined on the basis of gaseous effluent concentrations and direct radiation contributions at the locations where such animals may actually be present. Terrestrial animals in the environs of the station will receive approximately the same external radiation doses as those calculated for man. Table 5.4 lists the doses due to the gaseous effluents.

An estimate can be made for the ingestion dose to a terrestrial animal such as a duck which is assumed to consume only aquatic vegetation growing in the water in the discharge region. The duck ingestion dose was calculated to be about 25 mrads/yr, which represents an upper limit estimate since equilibrium was assumed to exist between the aquatic organisms and all radionuclides in water. A nonequilibrium condition for a radionuclide in an actual exposure situation would result in a smaller bioaccumulation and therefore in a smaller dose from internal exposure.

The literature relating to radiation effects on organisms is extensive, but very few studies have been conducted on the effects of continuous low-level exposure to radiation from ingested radionuclides on natural aquatic or terrestrial populations. The most recent and pertinent studies point out that, while the existence of extremely radiosensitive biota is possible and while increased radiosensitivity in organisms may result from environmental interactions, no biota have yet been discovered that show a sensitivity to radiation exposures as low as those anticipated in the area surrounding the Braidwood Station. In the "BEIR" report[6] it is stated in summary that evidence to date indicates that no other living organisms are very much more radiosensitive than man. Therefore, no detectable radiological impact is expected in the aquatic biota or terrestrial mammals as a result of the quantity of radionuclides to be released into the Kankakee River and into the air by the Braidwood Station.

5.3.2 Impact on Man

5.3.2.1 Exposure Pathways

Routine power generation by the Braidwood Station will result in the release of small quantities of fission and activation products to the environment. This evaluation will provide dose estimates which can serve as a basis for a determination that releases to unrestricted areas are as low as practicable in accordance with 10 CFR 50 and within the limits specified in 10 CFR 20. The AEC staff has estimated the probable nuclide releases from the Braidwood Station based on experience with comparable operating reactors and an evaluation of the radwaste system. These releases have been discussed in Section 3.5.

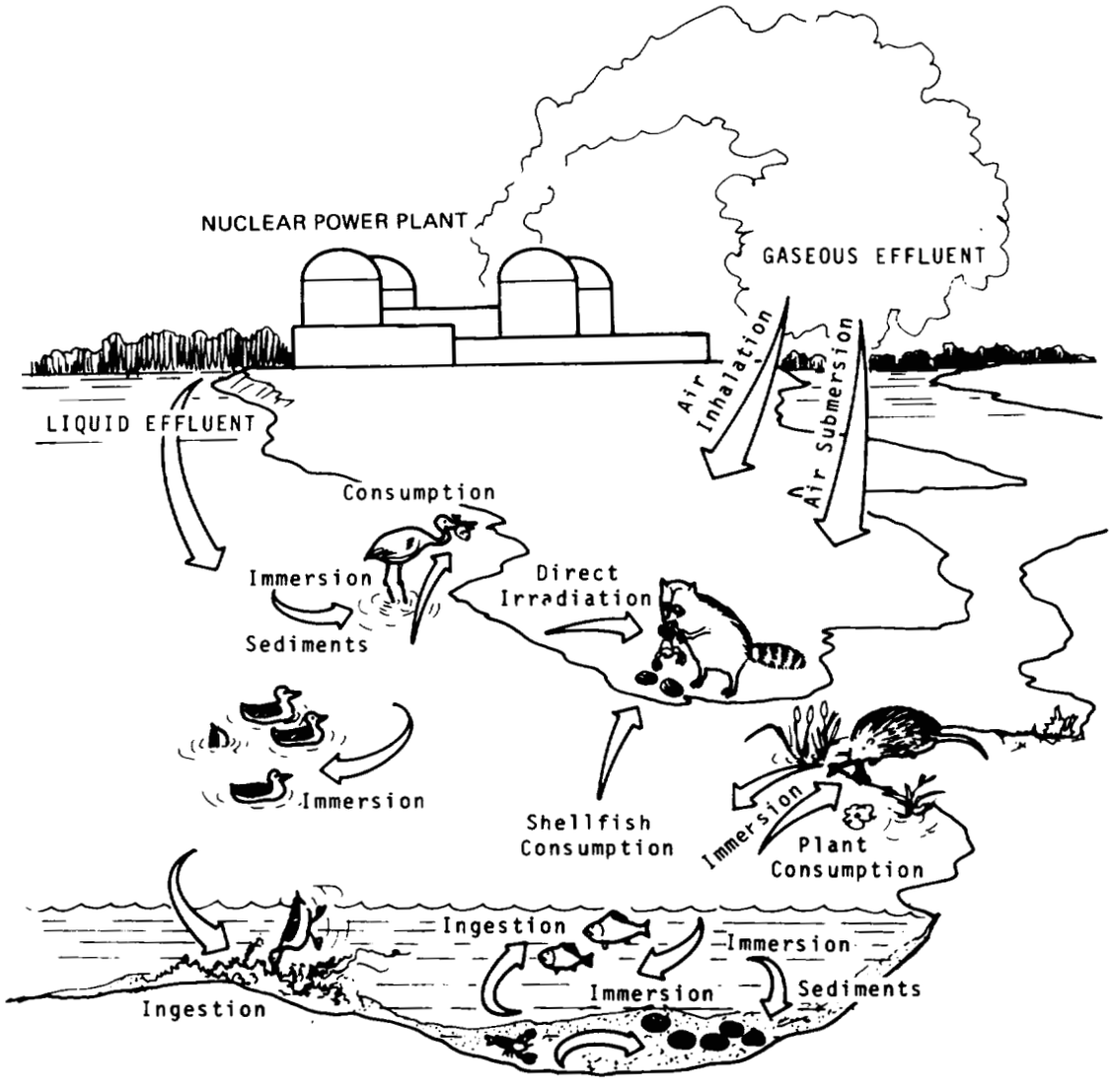

Fig. 5.1. Exposure Pathways to Biota Other Than Man.

Table 5.3. Freshwater Bioaccumulation Factors

Element	Fish	Invertebrates	Plants
	(pCi/kg organism per pCi/liter water)		
C	4,550	9,100	4,550
Na	100	200	500
P	100,000	20,000	500,000
Sc	2	1,000	10,000
Cr	200	2,000	4,000
Mn	400	90,000	10,000
Fe	100	3,200	1,000
Co	50	200	200
Ni	100	100	50
Zn	2,000	10,000	20,000
Rb	2,000	1,000	1,000
Sr	30	100	500
Y	25	1,000	5,000
Zr	3	7	1,000
Nb	30,000	100	800
Mo	10	10	1,000
Tc	15	5	40
Ru	10	300	2,000
Rh	10	300	200
Ag	2	770	200
Sn	3,000	1,000	100
Sb	1	10	1,500
Te	400	150	100
I	15	5	40
Cs	2,000	100	500
Ba	4	200	500
La	25	1,000	5,000
Ce	1	1,000	4,000
Pr	25	1,000	5,000
Nd	25	1,000	5,000
Pm	25	1,000	5,000
Sm	25	1,000	5,000
Eu	25	1,000	5,000
Gd	25	1,000	5,000
W	1,200	10	1,200
Np	10	400	300
Pu	4	100	350
Am	25	1,000	5,000
Cm	25	1,000	5,000

From Report UCRL-50564, Rev. 1.

Estimations were made of radiation doses to man at and beyond the site boundary via the most significant pathways among those diagrammed in Fig. 5.2. The calculations are based on conservative assumptions regarding the dilutions of effluent gases and radionuclides in the liquid discharge, and the use by man of the plant surroundings. Radiation doses calculated by the AEC staff are intended to apply to an average adult. Specific persons will receive higher or lower doses, depending upon their age, living habits, food preferences, or or recreational activities.

An estimate of the occupational radiation exposure received in operating the plants was made. This estimate was based on exposures received at comparable operating reactors.

5.3.2.2 Liquid Effluents

Expected nuclide releases in the liquid effluent have been calculated for the Braidwood Station and are listed in Table 3.5. In the immediate vicinity of the Braidwood Station discharge, the gross activity concentration, exclusive of tritium, is estimated to be 4.6×10^{-3} pCi/ml. Under the same conditions, the tritium concentration would be 17 pCi/ml, as stated in Section 3.5.

During normal reactor operations, a fraction of the noble gases produced will be released in the liquid effluent and subsequently discharged into the Kankakee River. The staff has analyzed operating reactor radioactive liquid effluent for noble gas content and under conditions of highest annual average noble gas concentrations in the discharge water, no significant doses would be delivered to human beings.

Table 5.4 Annual Individual Doses Due to Gaseous Effluents

Location	χ/Q sec/m³	Dose, mrem/yr		
		Total Body	Skin	Thyroid
Site boundary[a] (0.34 mi WNW)	2.2E-05[f]	1.3E 00	4.9E 00	1.0E 00[c]
Nearest farm[b] (1.8 mi WSW)	5.8E-07	2.8E-02	1.2E-01	2.8E 00[d]
Nearest residence (0.40 mi WNW)	1.7E-05	9.07E-01	3.7E 00	7.8E 00[e]
Nearest park	1.2E-07	4.2E-03	2.1E-02	3.9E-03[c]

[a]The gamma and beta air doses at the site boundary are 1.8 and 6.9 mrad/yr, respectively.

[b]With a milk animal.

[c]Inhalation by an adult.

[d]Cow-milk-child pathway.

[e]Adult consumption of leafy vegetables.

[f]The notation 2.2E-05 signifies 2.2×10^{-5}, which is equal to 2.2 x 0.00001 or 0.000014. Similarly, 1.3E 00 means 1.3×10^{0}, which is equal to 1.3.

Consumption of water represents a potentially significant exposure pathway to the population. However, there are no drinking water supplies within 100 miles downstream of the plant that could be affected by the effluents.

Other pathways of relative importance involve recreational use of river in the vicinity of the discharge zone. Individual doses from consuming fish caught in the immediate discharge area were evaluated using the biological accumulation factors listed in Table 5.3 and standard models.[5] Swimming, boating, and fishing in the discharge region were also included in the evaluation.

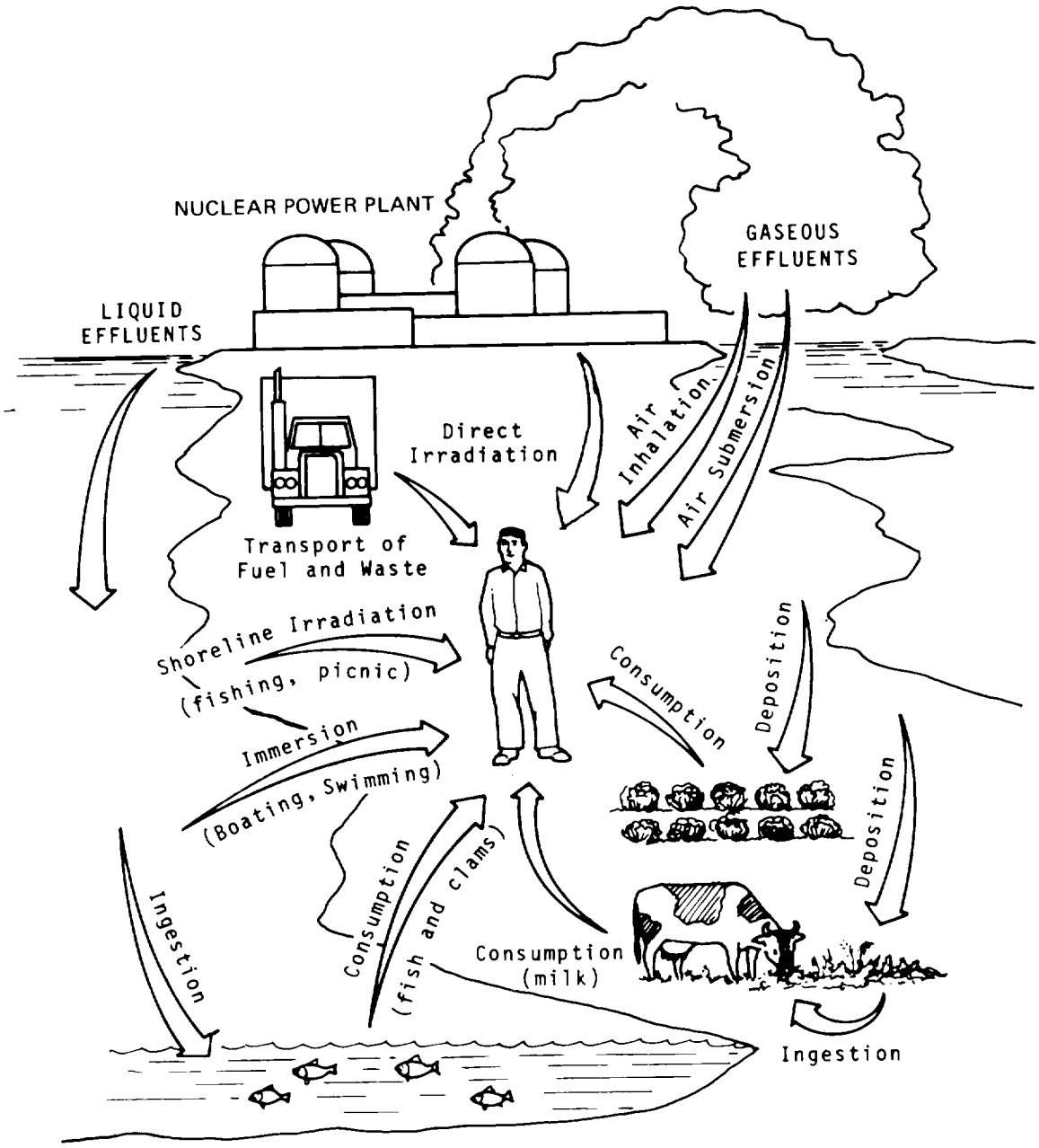

Fig. 5.2. Exposure Pathways to Man.

Table 5.5 summarizes the potential individual doses from the liquid effluent.

Based on the staff's evaluation, the radioactivity in liquid effluents from Units 1 and 2, exclusive of tritium and dissolved noble gases, will be less than 5 Ci/yr (see Table 3.5). The whole body and critical organ doses will be less than 5 mrem/yr. The staff concludes that the liquid radwaste treatment systems will reduce liquid radioactive effluents to as low as practicable levels in accordance with 10 CFR 50.34(a).

5.3.2.3 Gaseous Effluents

Radioactive effluents released to the atmosphere from the plant are a significant exposure pathway to the public. The staff estimates of the probable gaseous and particulate releases listed in Table 3.6 were used to evaluate potential doses. All dose calculations were performed using annual average site meteorological conditions* and assuming that releases occur at a constant rate. Radioactive gases are released near ground level from the plant. Thus, doses result from immersion in the dispersed radioactive gases.

The primary food pathway to man involves the ingestion by dairy cows of radioiodine deposited onto grazing areas. Consumption of milk from these cows can result in exposure to the human thyroid. Doses to a child's thyroid which would result from consuming one liter of milk daily from a cow grazing six months annually were calculated for the nearest farm, using recognized models.[7,8]

Another food pathway to man of secondary importance involves the consumption of leafy vegetables subject to deposition of the radionuclides released to the atmosphere. The thyroid dose to an adult from consumption of leafy vegetables grown at the nearest residence during a three-month growing period was evaluated.

All doses due to gaseous effluents are summarized in Table 5.4.

Based on evaluations of the gaseous waste treatment systems, the staff calculated that the release of radioactive materials in gaseous effluents from the operation of both reactors will result in a whole body dose of less than 5 mrem/yr to individuals at or beyond the site boundary, and a dose of less than 15 mrem/yr to a child's thyroid through the pasture-cow-milk cycle from the first real cow, located 1.8 miles WSW of the site. These calculations indicate that the proposed gaseous radwaste systems, as evaluated, will reduce radioactive effluents to as low as practicable levels in accordance with 10 CFR Part 50.34(a), and therefore the staff concludes that the proposed gaseous radwaste systems are acceptable.

5.3.2.4 Direct Radiation

5.3.2.4.1 Radiation from the Facility. The plant design includes specific shielding of the reactor, holdup tanks, filters, demineralizers and other areas where radioactive materials may flow or be stored, primarily for the protection of plant personnel. Direct radiation from these sources is therefore not expected to be significant at the site boundary. Confirming measurements will be made as part of the applicant's environmental monitoring program after plant startup. Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 mrem/yr at the site boundary.

5.3.2.4.2 Transportation of Radioactive Material. The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the AEC report entitled "Environmental Survey of Transportation of Radioactive Materials to and From Nuclear Power Plants". The environmental effects of such transportation are summarized in Table 5.6.

5.3.2.4.3 Occupational Radiation Exposure. Based on a review of the applicant's Safety Analysis Report, the staff has determined that individual occupational doses will be maintained within the limits of 10 CFR 20. Radiation dose limits of 10 CFR 20 are based on a thorough consideration of the biological risk of exposure to ionizing radiation. Maintaining radiation doses of plant personnel within these limits ensures that the risk associated with radiation exposure is no greater than those risks normally accepted by workers in other present-day industries.[9] Using information compiled by the Atomic Energy Commission[10,11] and others[12,13] of past experience from operating nuclear reactor plants, it is estimated that the average collective dose to all on-site personnel at large operating nuclear reactor plants will be approximately 450 man-rem per year per unit. The total dose for the Braidwood Station will

*Meteorological data collected at the Dresden site from July 1971 through June 1972 were used for meteorological dispersion determinations. Onsite data are now being collected. A Gaussian diffusion model, with adjustments for building wake effects, was used to make estimates of atmospheric dispersion values at the various distances and directions from the site.

Table 5.5. Annual Individual Doses from Liquid Effluents

Location	Pathway	Dose, mrem/yr			
		Total Body	GI Tract	Thyroid	Bone
Coolant discharge region	Fish ingestion	1.5E 00	7.5E-02	1.5E 00	1.1E 00
	Swimming (100 hr/yr)	4.6E-04			
	Boating (100 hr/yr)	2.3E-04			
	Fishing and sun bathing	4.4E-02			

Table 5.6. Environmental Impact of Transportation of Fuel and Waste to and from One Light-water-cooled Nuclear Power Reactor[a]

Normal Conditions of Transport			
			Environmental Impact
Heat, weight, and traffic density			- Negligible
Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals[b] (per reactor year)	- Cumulative Dose to Exposed Population (per reactor year)[c]
Transportation workers	200	0.01 to 300 millirem	4 man-rem
General public			
Onlookers	1,100	0.003 to 1.3 millirem)	3 man-rem
Along route	600,000	0.0001 to 0.06 millirem)	

[a]Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants," WASH-1238, December 1972.

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

[c]Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem in each case would be 1 man-rem.

be influenced by several factors for which definitive numerical values are not available, but which in aggregate are expected to lead to lower doses to onsite personnel than estimated above. Improvements in systems to maintain offsite population doses as low as practicable may cause small increase to onsite personnel doses, if all other factors remain unchanged. However, the applicant's implementation of Regulatory Guide 8.8[14] and other guidance provided through the staff review process is expected to result in an overall reduction of total doses from those currently experienced.

5.3.3 Summary of Annual Radiation Doses

The combined dose (man-rem) due to gaseous effluents to all individuals living within a 50-mile radius of the plants was calculated using the projected 1980 population data furnished by the applicant (Ref. 1, Sec. 2.2). Values for the man-rem doses at various distances from the plants are summarized in Table 5.7.

The cumulative dose resulting from the consumption of fish harvested from the Kankakee River was estimated. It was conservatively assumed that 10% of the population within 50 miles of the plant consumed 5 grams of fish per day. It was also assumed that the fish lived in a region where liquid effluent discharge was diluted by the average flow (3640 cfs) of the Kankakee River.

The population doses from all sources including natural background, cloud immersion, consumption of fish, transportation, and occupational exposures are summarized in Table 5.8.

5.3.4 Evaluation of Radiological Impact

The average annual dose from gaseous effluents to persons living in unrestricted areas within 50 miles of the plant is less than 0.001 mrem/yr as shown in Table 5.7. Maximum individual doses due to gaseous and liquid effluents releases are less than 5 mrem/yr as seen in Tables 5.4. and 5.5. These values are only a few percent of the natural background exposure of 0.135 rem/yr,[15] and are below the normal variation in background doses.

Using conservative assumptions, the total man-rem in unrestricted areas from all effluent pathways, received by the estimated 1980 population of 4,500,000 persons who will live within a 50-mile radius of the Braidwood Station, would be about 16 man-rem per year. By comparison, an annual total of about 610,000 man-rem is delivered to the same population as a result of the average natural background dose rate of about 0.135 rem per year in the vicinity of the plant. Operation of the Braidwood Station will result in a minor contribution to the dose that persons living in the plant area receive from natural background radiation. The estimated radiation doses to individuals and to the population from normal operation of the Braidwood Station support the staff's conclusion that the releases of radioactive materials in liquid and gaseous effluents are as low as practicable.

The 900 man-rem received as occupational onsite exposure is a small percentage of the annual total of about 610,000 man-rem delivered to the 1980 population living within a 50-mile radius of the Braidwood Station.

5.4 NONRADIOLOGICAL EFFECTS ON ECOLOGICAL SYSTEMS

5.4.1 Terrestrial Environment

5.4.1.1 Cooling Lake Environs

After the filling of the lake, trees and other vegetation around the future Braidwood Lake and its islands will develop from the spread of plant life already present in the area, and from new seeds that come in with the Kankakee River water. Cattail will likely be one of the first plants to become established in the first two years after flooding. Cattail grows in swampy areas, along lakeshores and in island areas where the drop-off is gradual. In similar shallow areas, dense growths of smartweed, pondweed, coontail, duckweed, and algae will probably occur.[17,18]

Marshes may develop in those areas on the islands of the Braidwood Lake where the water table is raised to the surface. Trees, shrubs, and berbaceous vegetation that are normally not adaptable to aquatic habitats will die. Those plants that are able to grow and reproduce in pond and marsh areas will probably survive if the flood water depth is not excessive.

As cattail growth appears and other marsh vegetation grows along the shorelines of the lake and on the islands, muskrat populations should develop from species now present. Mink, which prey on these muskrats and smaller rodents, will also grow in number. As frogs and other aquatic animals become more abundant, ground-denning raccoons will probably move into the area. Some striped skunks and opossum will no doubt inhabit some of the site area on the periphery of the

Table 5.7. Cumulative Population, Annual Cumulative Dose, and Average Annual Total Body Dose Due to Gaseous Effluents in Selected Annuli About the Plant

Cumulative Radius, miles	Cumulative Population	Annual Cumulative Dose, man-rem	Average Annual Dose, millirem
1	193	0.03	1.7E-01
2	2566	0.14	5.4E-02
3	4716	0.17	3.8E-02
4	6261	0.18	3.0E-02
5	11076	0.22	2.0E-02
10	27709	0.29	1.0E-02
20	119473	0.42	3.5E-03
30	420941	0.63	1.5E-03
40	1539713	1.1	7.1E-04
50	4554274	1.8	3.9E-04

Table 5.8. Summary of Annual Total Body Doses to the Population Within 50 Miles

Category	Cumulative Dose, man-rem/yr
Population dose from background	610,000
Restricted area Occupational radiation exposure	900
Unrestricted area Transportation of nuclear fuel and wastes [a]	14
Gaseous cloud	1.8
Fish ingestion	0.24

a. Not limited to a 50 mile radius, includes all transportation exposure.

new lake. Small rodent populations should maintain their population densities except in the flooded areas, and possibly increase at least temporarily in the nonflooded areas due to immigration. Cottonwood and willow trees will become established. The deer mouse will probably dominate for the first 15 to 30 years after island formation, after which the white-footed mouse may become more abundant.[19]

After the lake is flooded, waterfowl may use it during the fall and spring migrating seasons. After the aquatic and terrestrial vegetation is substantially developed, resident waterfowl populations may become established.

Because the thermal effluent from the Braidwood Station will prevent complete icing of the lake, the lake might become an important overwintering area for waterfowl if sufficient food is available.[20,21] Waterfowl feed on waste grain from agricultural crops, as well as the seeds and foliage of aquatic, marsh, and terrestrial plants.[22] Several bushels of corn and soybeans are left per acre by combines used in the harvest of these grains in Illinois. Mallards, black ducks, and geese feed on these waste grains extensively.[23] Other waterfowl species including the divers, which feed on benthic biota, fish and zooplankton, etc., make little use of agricultural crops in Illinois.[24]

In the Braidwood area, fall plowing of one-half to three-fourths of the corn and soybean fields greatly reduces the amount of waste grain available for waterfowl use. The natural Illinois food plants for ducks are the moist-soil-growing species including duck millet, nutgrasses, water hemp, teal grass, large-seeded and nodding smartweeds.[23,24] However, these moist-soil plants develop on mud flats exposed by retreating water in shallow-basin lakes. Water levels in the new Braidwood Lake will be stabilized, thus it is not expected that an abundance of moist-soil plants will grow. This will reduce the potential for large overwintering waterfowl populations.

5.4.1.2 Fog

The evaporation rate from the lake will vary seasonally with weather conditions, and with the plant load factor. There will be some steam fog over the lake whenever the air is sufficiently colder than the surface lake water. The layer of air near the water surface is then heated and moisture is absorbed. As this air mixes with the colder air above, supersaturation and condensation occurs, forming steam fog. Further vertical mixing tends to reevaporate the fog. Steam fog is quite common in this region of the country because of the frequent movement of cold air masses over open water. Steam fog occurs as a result of increased water temperatures in cooling ponds, when conditions would not favor its formation over unheated water bodies.

Studies made at existing cooling ponds indicate that steam fog is usually thin and wispy and does not move inland more than 100 to 600 feet. Cooling ponds do not appear to be a major source of surface fog. As the steam fog moves across the nearby land areas, some droplets will be deposited on vegetation and other surfaces causing an increase in humidity and dew, and during periods of freezing weather a layer of low-density rime ice may occur. The staff anticipates no problems resulting from steam fog at the Braidwood site nor is damage to property or vegetation or animal life due to higher-than-normal humidity expected.

5.4.1.3 Transmission Lines

5.4.1.3.1 Maintenance. As described in Section 4.1, most of the transmission line will traverse either nearby flat land that has already been cleared for agricultural purposes or they will be placed along existing railroad and power line rights-of-way. The transmission lines will be patrolled by aircraft on a monthly basis, and the applicant does not plan to build maintenance roads. As the transmission line extends primarily through cultivated farmland, the use of herbicides is expected to be limited. It is the opinion of the staff that there will be no detrimental herbicide impact of importance.

5.4.1.3.2 Production of Ozone. Ozone is recognized as a major component of the photochemical air pollution-oxidant complex and is known to be extremely toxic to a wide range of plant species. The generation of ozone as a result of corona generated by transmission lines has recently been experimentally investigated in the laboratory and field.[25,26] These investigations indicate that, for transmission lines up to 765 kV, the maximum ground level ozone concentration will be well below federal standards. The National Primary Air Quality Standard for photochemical oxidants, as issued by the Environmental Protection Agency, is 0.08 ppm by volume for a one-hour concentration, not to be exceeded more than once per year. Laboratory studies have indicated that 0.0193 ppm by volume of total oxidants might be expected at ground level. Field studies with equipment sensitive to 0.002 ppm by volume indicated no measurable oxidants at either ground or transmission line wire level. Based on these and other data, the staff anticipates no adverse environmental effects as a result of ozone created by the high voltage transmission lines.

5.4.1.3.3 Radiated Electrical and Acoustical Noise. The applicant states that acoustical and electrical noise will be held to a low level by engineering methods which include the selection of the conductor diameter sufficiently large to hold corona discharge and line losses to a low level.

5.4.1.3.4 Inductance on Railways and Interference with Railroad Communications. Induced or conducted currents at or below ground level can become important if there are extensive cables, pipes, rails, etc. close to the transmission lines. The induced and conducted current in a ground structure of this kind is dependent upon the current in the overhead transmission lines, the distance these lines are above the ground, soil characteristics if the structure is below the surface, and the extent of parallelism between the transmission lines and the conductors in which the current is induced. The Braidwood transmission lines will pass primarily through rural countryside and induced ground currents are not expected to cause a problem.

5.4.1.4 Summary of Nonradiological Impacts on Terrestrial Ecology

The staff concludes that the operation of the Braidwood Station is expected to have no sustained non-radiological impacts on the local terrestrial ecosystem.

5.4.2 Aquatic Environment

There are two aquatic environments which must be considered when evaluating potential operating effects of the Braidwood Station: (1) the cooling lake, from which the cooling water will be drawn and to which the heated water will be returned, and (2) the Kankakee River, from which the makeup water for the lake will be drawn and into which blowdown from the lake will be discharged.

5.4.2.1 Predictions of the Ecology at the Braidwood Cooling Lake

It is necessary to analyze the probable ecological characteristics of the Braidwood Lake since its effluent will be released to the Kankakee River. However, it is not possible to do this with a high degree of confidence since artificial lake ecosystems are highly site specific, and many variables interact to influence lake biotic development and maintenance. Some of these variables change from day to day and/or from season to season. They include weather, source-water quality, biocide usage, interactions with wildlife, quantity and quality of introduced seed organisms, biotic life cycles, vagaries of station operation, and so on. Cooling lake ecology may also undergo significant changes between the time when the lake is filled and the time the plant begins operating: turbidity and siltation will be very high initially as the lake is filled, but will probably decrease after station operation begins; ambient water temperatures will be significantly elevated once station operation begins, and the reverse will be true during periods of reactor shutdown. The numbers of sewage bacteria in the lake will initially reflect Kankakee River values, but should decrease with the passage of time.

5.4.2.1.1 Applicant's Analysis. The applicant predicts that the aquatic life of Braidwood Lake will be similar to that presently in the Dresden cooling lake principally because Braidwood will draw water from the Kankakee River as does Dresden (Ref. 1, p. 2.7-38). Although a preliminary analysis of Dresden lake biology is available for study at the present time[27] and can provide some insights to the Braidwood Lake ecosystem, the staff does not agree with the applicant's prediction because of the following differences between the two cooling lakes:

a. That the water of Dresden lake is not recirculated as is planned at Braidwood. After leaving the condensers, the Dresden water resides in the lake for a single transit of approximately 2.7 days. Thus, Dresden Lake biology more reflects Kankakee River characteristics than the development of a unique lake ecosystem as expected to occur at Braidwood.

b. That the total surface area of Dresden Lake (1275 acres) and its volume (14,025 acre-feet) is considerably less than that planned for Braidwood (2640 acres and 25,080 acre-feet). Lacustrine biotic composition is significantly influenced by the water body surface area and volume and the ratio of these two parameters.

c. That the morphometry as well as bathymetry and bottom composition of Braidwood Lake will differ markedly from that at Dresden. In addition to the knowledge that biotic species composition, abundance, and distribution are functions of water depth and bottom composition, water circulation patterns as well as related chemical and physical parameters are also known to be influenced by water depth. At Braidwood, the approximately 100-foot depths (strip-mine floors) anticipated at some parts of the lake will favor seasonal thermal stratification and overturn with their attendant characteristics. At Dresden, with its more uniform and shallow 11-foot average depth, such phenomena are not expected.

5.4.2.1.2 Summary and Conclusions of the Staff's Analysis. The staff assessment of projected Braidwood cooling lake ecology results from evaluations of preliminary data as well as predictions and estimates involving nutrients, water quality, thermal loading, chlorine usage, meteorology, laboratory observations, and the application of general biological principles and experience (see Appendix B). The staff anticipates the following general characteristics for the cooling lake:

a. The biotic species composition of the lake will derive mainly from that of the Kankakee River because the majority of the seed organisms will enter with the fill and makeup water. These organisms will be mainly the following smaller biota which pass through the intake screen: small fish, fish fry, and fish eggs; larval mayflies, caddisflies, stoneflies, nematodes, flatworms, annelids; larval crustacea, molluscs, and snails; zooplankton; phytoplankton; protozoans; bacteria and fungi; and cattails, reeds, sedges, and grasses.

b. Macrophytes characteristic of the upriver Kankakee will become established along the lake periphery during the first spring after filling commences.

c. The lake will consist of generally similar habitats (and composition) throughout the shallow areas, but will contain numerous subhabitats in deeper areas, in thermally dissimilar regions, and in regions characterized by eddies. Fish will tend to avoid the hottest regions of the lake during the warmer months.

d. Yearly average turbidity will probably be lower than that of the Kankakee, especially in areas of the lake characterized by lower water velocities.

e. Algal blooms will occur occasionally in shallow areas characterized by low water velocity and low turbidity. Such blooms will not be prevalent through the year, but probably during warm (not hot) weather when there is adequate solar radiation. Areas of the lake immediately adjacent to the condenser discharge area are apt to have such blooms more frequently than elsewhere in the lake. Algal primary productivity will be higher lakewide for a longer period than in natural lakes in the Braidwood region.

f. Blue-green algal species will tend to dominate during the summer season and will tend to replace green species. Few diatoms will be present during the hottest months of the year.

g. Algal masses will die off periodically, resulting in local reductions of DO and of water quality. Mobile organisms such as fish avoid these areas.

h. Local areas of the lake may greatly decrease in water quality because of algal overgrowths and decomposition, and this may, to a smaller extent, affect the lake in general. However, dilution of lake blowdown in the river should render such deficiencies undetectable a short distance downriver of the discharge structure.

i. Nutrient concentrations will exceed values found in known eutrophic water bodies and will probably not be a limiting factor for phytoplankton productivity.

j. Condenser effects will tend to simplify zooplankton species composition and abundance, especially during the hottest months; also, few benthic organisms are expected to thrive in the hottest part of the lake during this period. These factors may result in poorer than normal nutrition for fish which utilize these food sources.

k. Resident fish may show more signs of stress during the warmer months than similar fish in unheated lakes in the station vicinity or the Kankakee River. Such stress may increase the incidence of fish disease and parasitism in the lake, but the staff does not anticipate an increased incidence of fish disease or parasitism in the Kankakee River as a result of operation of the cooling lake.

l. The transmission of waterfowl disease could be higher than at other area lakes if large numbers of birds are attracted to and stay in the heated, open water during fall migration. Should such occur, the staff's opinion is that it will not be significantly reflected in less dense native populations along migration corridors.

m. Chlorine treatment of station service water will have local adverse effects upon lake biota until free chlorine disappears and its associated chloramines are reduced. No direct adverse effects from this source are anticipated in the river.

The staff concludes that in toto the cooling lake and the cooling lake blowdown are not likely to have adverse effects upon the Kankakee River detectable a short distance downstream of the station. However, controls and monitoring will be required by technical specifications in the operating license to detect unanticipated adverse effects. In this event action on the part of the applicant will be required to ameliorate such conditions.

5.4.2.2 Impact of the Braidwood Station upon the Aquatic Environment of the Kankakee River

The impact of the proposed station upon the Kankakee River will be different during the lake-filling phase than during the period of station operation. During the former, the major impacts will be the consumptive removal of water with its entrained biota from the river, and impingement deaths of some fish at the intake point. During station operation approximately one-half of the volume of entraining water will be returned to the river as blowdown. In spite of this, the simplifying assumption is made for the purpose of this analysis that all entrained organisms are lost from the river ecosystem because (1) mechanical and thermal effects from the cooling system will reduce the abundance of entrained organisms and (2) chemical, thermal, and biological effects in the lake will tend to simplify river water species composition. The blowdown will carry heat and exogenous ions. In addition, it will reflect cooling lake composition and characteristics including living and dead lake biota, dissolved oxygen, turbidity, products of biological and chemical activity, and so on. The impact of blowdown water quality upon the river will be summarized in Section 5.4.2.2.3 (Discharge Effects).

5.4.2.2.1 Entrainment. At the station intake, the average Kankakee River flow will be 3923 cfs. The intake withdrawal during operation of 93.3 cfs will result in the entrainment of approximately 2.4% of river plankton. Loss of these phytoplankton during average river flow is not considered important because the generation time of such organisms is on the order of hours to days, assuring rapid replenishment. Similar losses of zooplankton also appear not to be adverse because they are expected to be replaced by a compensatory increase in population growth of the remaining zooplankton. It has been shown that river zooplankton turnover times are generally short as the result of intense predation by other species; that population densities of zooplankton are relatively constant in spite of high rates of natural predation and mortalities caused by passage of zooplankton through a power plant; and that populations of these organisms have considerable resilience to moderate increases in predation rates.[28] Furthermore, although indigenous plankton are important in the food webs of the river, the majority of food substances utilized by fish and other organisms in the Kankakee are allochthonous, that is, they originate in marginal sloughs, marshes ponds, and ditches[29] which enter the river in stream flows and during periods of rainfall. Thus, during the majority of the year, biological compensation and allochthonous foodstuffs should render insignificant any nutritional deficit due to entrainment of river organisms.

During the reproductive period for most Kankakee River fishes (May-June), some fish eggs, fry, and small juveniles (Ref. 1, App. 14.1, and Ref. 30) will be killed in the station cooling water system. The number is expected to be small in relation to the total number of similar organisms in the river in the vicinity of the station since almost all eggs, fry, and young juveniles are found in close proximity to plants, and the river bottom and do not occupy that portion of the water likely to be entrained. Thus, the impact of fish entrainment should be small.[30]

In summary, during the lake-filling period with average river flow, the staff expects no adverse impacts to the Kankakee River ecosystem due to entrainment. Similarly, since intake withdrawal volume will be essentially the same during station operation, the entrainment effects during this phase are also considered negligible.

The calculated seven-day 10-year recurrence low flow of the Kankakee River near the site is 442 cfs. At this flow rate, approximately 21% of entrained plankton will be removed from the river. It is the opinion of the staff that a removal of river plankton of this magnitude might stress the river ecosystem in the vicinity of the station. Low flows occur during the hottest, driest, months of the summer when desirable food chain plankton are scarce due to predation, warm water, and less than optimal water quality. Furthermore, if rainfall is insufficient, the supply of allochthonous food will also be scarce. If biological compensatory mechanisms are not adequate there may be insufficient food in the vicinity of the station, downstream of the discharge, to provide optimal nutrition for fishes and other biota. This will be reversed when rainfall and river flow increase later in the year, or can be prevented by allowing lake draw-down during the low-flow periods.

The staff believes that there will be negligible entrainment mortality of fish eggs or fry during the low flow period since spawning is usually completed for most species before the onset of the low-flow season, and most such biota are generally not found in the portion of river water entering the intake structure.

A further consideration is that river water usage by the station during periods of low flow (approximately 20% for lake filling and 10% for station operation) will cause a narrowing of the river below the site and will result in a temporary loss of benthos and macrophytes in the drained areas. Such communities provide food and protection for fish and would be relatively slow to reform once river flow returns to average values.

For these reasons, it appears to the staff that the proposed station water intake of 93.3 cfs during periods of low flow will cause more significant deterioration of downstream biotic quality than similar usage during other times of the year. If important adverse effects are detected, the staff will require pumping from the river to be decreased or halted until the period of low flow passes. Such short-term adverse station effects can be minimized by proper lake management procedures so that entrainment will not cause long-term adverse effects upon the Kankakee River, downstream of the station.

5.4.2.2.2 Impingement. Some fish in the Kankakee River will be drawn to the vertical traveling screens as water flows into the structure. They may be captured, injured or killed if they are pulled against the screens by the velocity of the water. Fish mortality on intake screens is a function of a number of factors including intake design, volume, and water velocity, screen location, fish size, fish species, fish health, and season of plant operation. The Braidwood intake structure will consist of two 14-foot wide channels with the bottom elevated 8.5 feet below normal water level. The elevation of the intake is designed to exclude debris floating down the river. The expected maximum intake water velocity (both nuclear units) is 0.5 fps. Impingement mortality is a function of intake water velocity. Most adult fish will be able to avoid the intake if they are healthy, due to the low velocity. On the other hand, fish fry and some entrained juvenile fish will be unable to swim strongly enough to leave the intake water currents and will be captured on the traveling screens. These fish will be lost from the river ecosystem. The smallest fish may pass through the screens and enter the lake via the makeup water pipeline.

It is not possible to predict with a high degree of certainty the magnitude of fish kill by impingement at the intake screens. The types and numbers of fish killed will reflect the types and sizes of fish present during different seasons of the year, fish health, river flow rate, etc. A preliminary survey of fish captured near the Braidwood site is tabulated in Table 5.9. Some smaller fish of these species will probably be removed from the river by the intake screens. Although limited fish mortality studies are available for the month of September 1972 for the Dresden Station intake 11 miles downstream from the Braidwood site, such data are not reliably comparable because fish species abundances differ at the two locations. This is probably influenced by the dam at Wilmington, which prevents upstream migration of fish such as shad, which are in abundance at the Dresden site but not at Braidwood. However, assuming a uniform distribution of fish (excepting shad) along the Kankakee River in the vicinity of both the Dresden and Braidwood sites, Table 5.10 (modified by the staff from a Dresden study) may be indicative of intake screen fish mortality which may occur at Braidwood. The species most often encountered will probably be bluegill, pike, sunfish, smallmouth bass, sucker, carp, and catfish. The average aggregate number of all species captured at Dresden during the month of September varied from approximately 39 fish per 24 hours to 192, with catfish being the predominant species. However, the water velocity at the Dresden intake screen is about 1.8 fps,[31] while 0.5 fps is expected at Braidwood. Therefore, the impingement impact at Braidwood should be less than that observed at Dresden.

As the results of aquatic sampling studies become available, it will be possible to predict intake mortalities with more confidence. At the present time, based upon available data, the staff is of the opinion that impingement and entrainment mortality will not significantly deplete fish species and abundance downstream of the station. Removal of some members of density-dependent species may actually result in the growth of larger, better quality fish. This would be considered a desirable impact by sportsmen. There is no commercial fishery on the Kankakee River. The staff recommends that impingement data be gathered as soon as lake filling operations begin to determine the magnitude of fish kills. If future impingement mortality data suggests an adverse impact upon the Kankakee River, corrective measures will be required.

5.4.2.2.3 Discharge Effects.

a. Thermal. The blowdown to the Kankakee River will conform to Illinois standards (see Section 3.0). The shoreline discharge isotherms are illustrated in Fig. 3.8 and Fig. 3.9. During the warmest month, August, ambient river temperature 77°F, the temperature of the blowdown will be approximately 95°F. Some fishes residing in the Kankakee River near the discharge will be able to acclimate to the blowdown during this period as shown in Fig. 5.3). Other fishes, such as white sucker (lethal temperature 88°F or higher) are expected to avoid the hottest water and to seek out cooler areas of the river. Under the worst expected meteorological conditions in August, when the blowdown temperature will be approximately 102°F, almost all fish

Table 5.9. Preliminary Survey of Fish Collected near the Braidwood Site in Horse Creek and the Kankakee River, October 1972-May 1973

Common Name	Latin Name	Common Name	Latin Name
Forage		Game (cont'd)	
Pirate perch	*Aphredoderus sayanus*	Orangespotted Sunfish	*Lepomis humilis*
Gizzard shad	*Dorosoma cepedianum*	Bluegill	*Lepomis macrochirus*
Emerald shiner	*Notropis atherinoides*	Longear sunfish	*Lepomis megalotis*
Spotfin shiner	*Notropis spilopterus*	Smallmouth bass	*Micropterus dolomieui*
Sand shiner	*Notropis stramineus*	Largemouth bass	*Micropterus salmoides*
Golden shiner	*Notemigonus crysoleucas*	White crappie	*Pomoxis annularis*
Pugnose minnow	*Opsopoeodus emiliae*	Black crappie	*Pomoxis nigromaculatus*
Gilt darter	*Percina evides*	Walleye	*Stizostedion vitreum vitreum*
Bluntnose minnow	*Pimephales notatus*		
Predators		Commercial	
Bowfin	*Amia calva*	River carpsucker	*Carpiodes carpio*
Longnose gar	*Lepisosteus osseus*	Quillback carpsucker	*Carpiodes cyprinus*
Game		White sucker	*Castostomus commersoni*
Rock bass	*Ambloplites rupestris*	Carp	*Cyprinus carpio*
Warmouth	*Chaenobryhus coronarius*	Yellow bullhead	*Ictalurus natalis*
Redfin pickerel	*Esox americanus americanus*	Channel catfish	*Ictalurus punctatus*
Grass pickerel	*Esox americanus vermiculatus*	Spotted sucker	*Minytrema melanops*
Northern pike	*Esox lucius*	Silver redhorse	*Moxostoma anisurum*
Muskellunge	*Esox masquinongy*	Northern redhorse	*Moxostoma aureolum*
Green sunfish	*Lepomis cyanellus*		
Pumkinseed	*Lepomis guibbosus*	Golden redhorse	*Moxostoma erythrurum*

Table 5.10. Number of Fish Killed per 24-hour Basis on the Intake Screens of the Dresden Power Plant

Date	Species							24-hour Total
	Blue Gill	Pike	Sunfish	Smallmouth Bass	Sucker	Carp	Catfish	
9/ 1/72	1	1	4	1	7	12	166	192
9/ 8/72	0	0	0	5	6	10	70	91
9/15/72	2	0	0	0	0	4	54	60
9/22/72	2	3	0	0	10	0	26	41
9/29/72	1	0	0	0	4	5	29	39

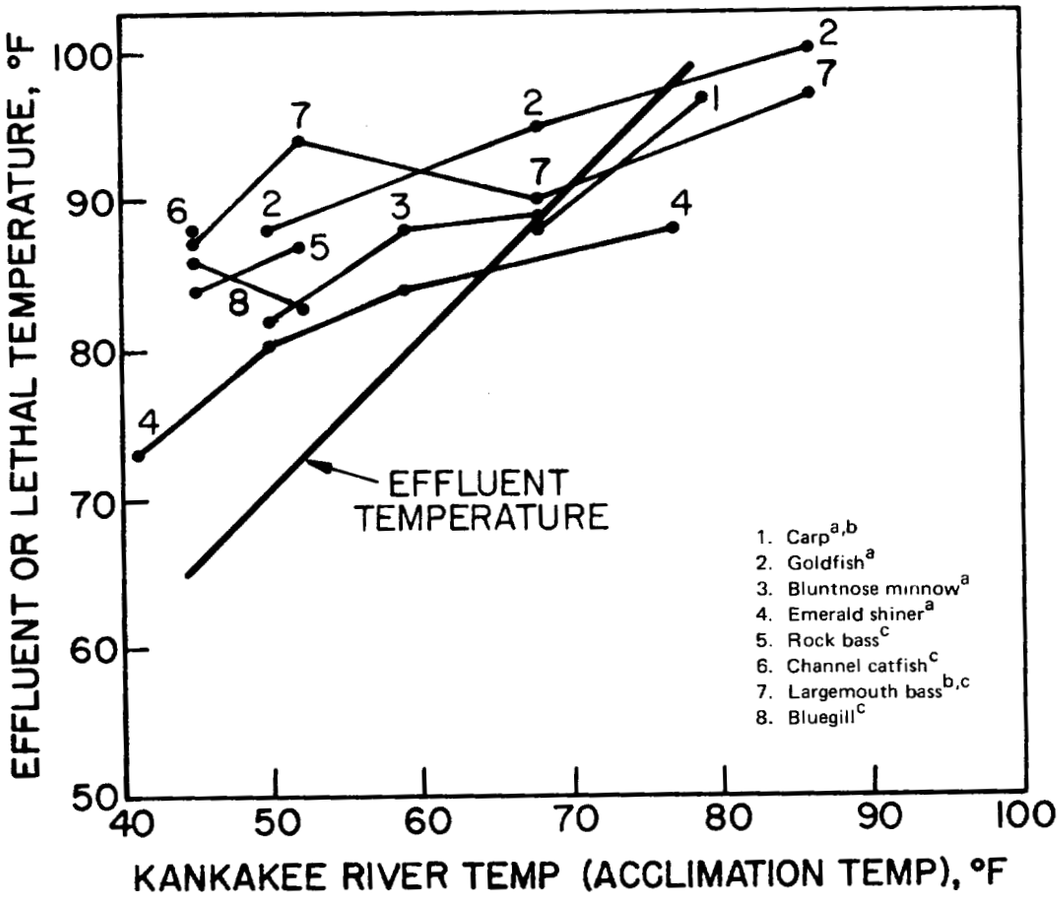

Fig. 5.3. Predicted Maximum Temperatures of the Effluent from Braidwood Station and Lethal Temperatures for Some Fishes in the Kankakee River. The effluent temperatures are based on a constant 21°F increase of the combined effluent from Units 1 and 2 over the ambient river temperature.

[a]P. L. Altman and D. S. Dittmer, Eds., "Environmental Biology," Fed. Am. Socs. Exp. Biol., 1966.
[b]J. R. Jones, "Fish and River Pollution," Buttersworth Inc., Washington, D.C., 1964.
[c]F. J. Trembly, "Research Project on Effects of Condenser Discharge on Aquatic Life," Prog. Rpt., 1960, Inst. of Research, Lehigh Univ., Apr. 21, 1961.

species are expected to exhibit such avoidance behavior.

Discharge temperatures during part of May and in June through August are likely to inhibit the spawning of most fishes in the immediate area of the discharge. On the basis of the staff's calculations, the 3°F isotherm during this period will occupy less than two acres. The elevated temperatures over this small area are expected to have immeasurably small impact on the success of overall fish spawning in the Kankakee River and will have little, if any, adverse thermal effects upon other downriver biota.

It is likely that some river fish will congregate in the near vicinity of the discharge structure as has been observed at other power station outfalls. This factor must be assessed in conjunction with possible sudden reactor shutdowns in winter. At plants where cooling water discharges are hot, such shutdowns have been known to result in "cold-kill" deaths of fish acclimated to the artificially warmed water. At Braidwood, however, the staff does not anticipate such problems since the cooling lake from which blowdown occurs will cool slowly on shutdown. Thus, fish acclimated to warmer waters near the discharge will have sufficient time to re-acclimate to the water cooling at a rate less than 2°F/hr.

The dissolved oxygen in the Kankakee River in the vicinity of the discharge is expected to be near or above saturation. At saturation, the heated water would contain slightly less oxygen than at the lower temperature. This small decrease in the oxygen content that may occur in the discharged water is not expected to affect the aquatic life in the area. Such a reduction in the amount of oxygen might be compensated to a certain extent by dissolution of bubbles in the discharged water as it cools.

b. Chemical.

i. Chlorine. For reasons discussed in Section 3.6, the staff expects about 0.001 ppm of residual free chlorine to be present in the blowdown as a result of the chlorination of nonessential service water for the station. While chloramines may be present as a result of the combination of free chlorine with ammonia, the staff concludes that dilution with the lake water, and then of the blowdown with the river, will render such compounds undetectable. Similarly, no free residual chlorine is expected to be discharged to the river as a result of the treatment of sanitary wastes; therefore the staff does not anticipate adverse impacts to the Kankakee River from this source.

ii. Other Chemicals. Table 3.7 is a listing of chemicals, excepting chlorine, expected to enter the blowdown as a result of station operation either as additives or from the concentration of dissolved solids in the Kankakee fill or makeup water. At these concentrations no deleterious effects are expected from the discharge of these substances in the blowdown.

c. Cooling Lake Blowdown Water Biological Quality. As indicated in Section 5.4.2.1 and Appendix B, the staff concludes that, *in toto*, the water quality and characteristics of Braidwood Lake blowdown should not measurably affect the Kankakee River ecosystem below the discharge. However, blowdown water monitoring will be included in the technical specifications of the Operating License to assure that significant adverse impacts do not occur in the Kankakee River.

5.5 IMPACTS ON PEOPLE

5.5.1 Physical Impacts

The site is sufficiently remote that the noise of operating machinery should not be audible to local residents. The air pollution resulting from occasional operation of the diesel engines on emergency equipment will not be significant.

The applicant does not expect any pollution of ground water resources. Provisions will be made for sanitary treatment of sewage using tertiary treatment which will preclude pollution of the blowdown into the Kankakee River.

Transportation of operating personnel is expected to have only a minor impact on traffic. There will be some continuing esthetic impacts where the Braidwood transmission lines are visible from roads and residential areas.

5.5.2 Social Impacts

The applicant estimates that an annual operating force of about 200 persons will be employed at the station during its operating life and that an annual payroll of $3 million will be created (Ref. 1, p. 8.0-1). Assuming that 15% of these jobs will be filled from the local population and that the newcomers average four persons per family, an increase of 680 persons in the area due directly to the creation of the new jobs at Braidwood can be expected. The staff anticipates

that this projected population increase will be dispersed over a wide area, because commuting 20 miles to the site would not be unusual. The staff does not expect large population shifts due to the influx of plant operating personnel and their families. Thus, impacts to the area schools, housing, hospital and public facilities should be minor.

The Will County area in general and the Joliet region in particular has become increasingly industrialized over the past decade. This trend towards increased industrialization is expected to continue whether the Braidwood station is located in the area or not. It is doubtful that any industrialization trend in the immediate vicinity of the station will occur unless the appropriate public bodies actively promote such growth. No facet of station operation has been identified which would hamper or discourage the present agricultural activities or existing way of life of the area.

5.5.3 Conclusions

The staff concludes that the impacts on the community as a result of operation of the station are acceptable.

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6. ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PRE-OPERATIONAL PROGRAMS

6.1.1 Meteorological

The applicant has recently initiated an onsite meteorological program with the installation of a 320-ft high, instrumented tower. Wind speed and direction, temperature, and humidity are measured at the 30- and 199-ft levels as well as the temperature difference between the 30- and 199-ft levels. Data are recorded in digital form on magnetic tape and, concurrently as a backup procedure, in analog form on strip charts. A precipitation gauge is also installed onsite. All instrumentation conforms to the recommendations of Regulatory Guide 1.23.[1]

The relative atmospheric dispersion (χ/Q) values, calculated from the data collected at Dresden, will be verified by the staff as soon as at least one full year of data (with a joint data recovery rate of at least 90 percent) becomes available from the onsite meteorological measurements program at Braidwood.

6.1.2 Radiological

The applicant has proposed an off-site pre-operational monitoring program to provide background information for the operational radiological monitoring program required by Safety Guide 21.

A summary description of the applicant's proposed program is presented in Tables 6.1 and 6.2. More detailed information on the applicant's radiological monitoring program is presented in Section 6.1.5 of the applicant's Environmental Report. The report includes discussion of the selection of sampling locations, the collection frequency, and the type of sample measurement. The program will be supplemented by the operational monitoring program for the Dresden Nuclear Power Station.

The staff will require the pre-operational program to be initiated at least two years before plant operation is scheduled to begin. The iodine-131 measurements in milk must be at a sensitivity of 0.5 pCi/l as discussed in Regulatory Guide 1.42, Appendix D, and soil sampling must be included in the program. With these additions, the staff finds the base-line radiological program to be adequate.

6.1.3 Hydrological

Physical, chemical, and biological water quality parameters of this river along transects shown in Fig. 6.1 are being and will be measured. Similar measurements will be made in the artificial cooling lake. The parameters that will be measured and the sampling frequency are shown in Table 6.3 here and in Table 6.1-1 of Ref. 2. Lists of analyses (e.g., Ref. 2, Tables 2.7-40 for chemical and bacteriological, 2.7-43 for D.O., 2.7-45 for nutrients, and 2.7-46 for miscellaneous parameters) include those items generally accepted by State and Federal regulatory bodies as measures of the physical, chemical and biological quality of the water. Cross checks on water chemistry samples will be made regularly by sending water samples to other qualified laboratories such as the Pennsylvania EPA Laboratory. Samples for heavy metals will be taken in November 1973 and March, May, August, and November 1974. The applicant will also determine the concentration of pesticides in the Kankakee River near the site and in Horse Creek.

Base-line data on level and water quality will be obtained from the observation wells and nearby private wells prior to any dewatering activities or to pumping from the station's new wells.

As part of the design evaluation of the dike, the applicant has constructed a prototype slurry trench in the lake area.[3] Pumping tests in observation wells will be carried out to determine the average permeability of in-place slurry backfill materials. The results of the tests will indicate the effects of seepage through the dike on the surrounding groundwater table. When the cooling lake has been filled, monitoring of observation wells surrounding the dike, particularly in the area of former deep mines, will be continued to detect excessive seepage.

Table 6.1. Pre-operational Radiological Sampling Program for the Braidwood Site

Parameter	Analysis	Inst. or Method	Location	Sampling Frequency	Remarks
Radiation	External gamma	Thermoluminescent dosimetry (TLD)	Six points in the vicinity of the plant including monitoring stations at Braidwood, Godley, South Wilmington and Essex	Quarterly, annually	The Dresden operational monitoring program will provide complimentary data at other points including Wilmington, Coal City and Elwood.
		Paired 10-mR ion chamber	Same as above	Weekly	
		Field survey w/pressurized ion chamber & NaI spectrometry	Same as above	Once during program	
	Airborne particulate matter	Gross beta Gross alpha Gamma spectrum Radiostrontium	Same as above Same as above Same as above Same as above	Weekly Monthly Monthly composite Quarterly composite	
	Milk	Gamma spectrum Radiostrontium Radioiodine	One sample from nearest dairy and one sample from local milkshed	Monthly Monthly Monthly	
	Ground-water	Gross beta Gamma spectrum and tritium Radiostrontium	Samples from two nearest wells, one well in the direction of groundwater flow and one in the opposite direction from the plant	Quarterly	
	Surface	Gross beta, alpha Gamma spectrum Radiostrontium Tritium	Five samples from Kankakee River (2 above intake, one at and one below intake, and one at Wilmington Dam).	Monthly Quarterly composite Quarterly composite Quarterly composite	
	Sediment and benthic organisms	Gamma spectrum	Same as above	Quarterly	
	Fish	Gamma spectrum	Four samples of various species - two upstream and two downstream of intake	Semiannually	

Table 6.1. (Cont'd)

Parameter	Analysis	Inst. or Method	Location	Sampling Frequency	Remarks
Radiation	Food crop	Gamma spectrum, Radiostrontium	Two farms near points of annual maximum concentration and local farms using Kankakee River for crop)	Annually (just prior to harvest)	
	Public water supplies	Gross beta	Braceville, S. Wilmington	Monthly	
		Gamma spectrum	Braidwood, Gardner	Quarterly composite	
		Radiostrontium	Coal City, Wilmington	Quarterly composite	
		Tritium	Reddick, Diamond	Quarterly composite	

Table 6.2. Typical Analytical Sensitivities for Radiological Monitoring[a]

Analysis (media)	Inst. or Method	Sample Size	Sensitivity
External gamma	TLD	NA[b]	10-20 mR/quarter
	Ion chamber	NA[b]	1 mR/week
Airborne particulates	Gross beta	300 m^3	1×10^{-2} pCi/m^3
	Gamma spectrum[c]	1200 m^3	1×10^{-2} pCi/m^3
Milk	Gamma spectrum	3.5 liters	5 - 10 pCi/liter
	Radioiodine	4 liters	<1 pCi/liter
Water	Gamma spectrum	3.5 liters	10 - 20 pCi/liter
	Gross beta	500 ml	5.0 pCi/liter
	Tritium	10 - 15 ml	200 pCi/liter
Benthic organisms, fish, shellfish	Gamma spectrum	200 grams	10 - 160 pCi/kilogram
Sediments	Gamma spectrum	200 grams	5 pCi/gram
			1 pCi/gram
Food crops	Gross beta	10 grams	0.2 pCi/gram
	Gamma spectrum	1000 grams	40 pCi/kilogram

[a]From applicant's Environmental Report.

[b]Not applicable.

[c]Gamma spectrum sensitivities refer to various isotopes of reactor origin which might be detected in media.

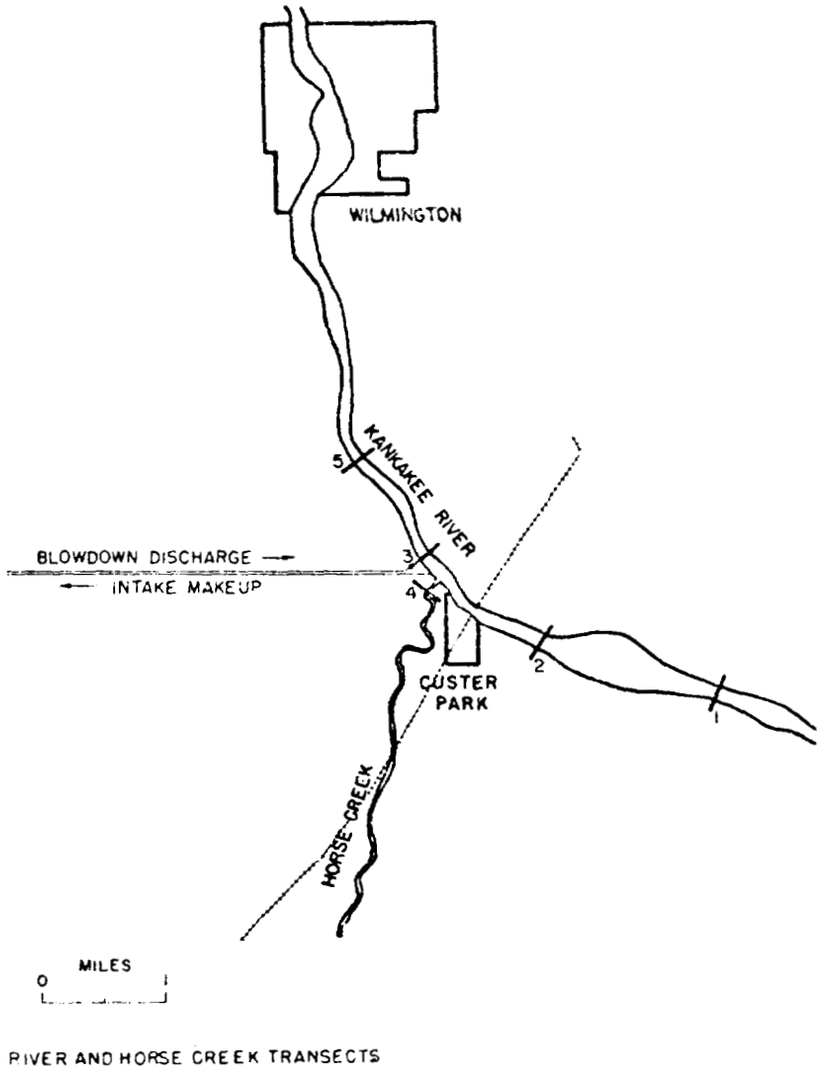

Fig. 6.1. Locations of Aquatic Transects and Sampling Stations for the Braidwood Site. Modified from applicant's Environmental Report.

Table 6.3. Physical Parameters and Water Chemistry

The parameters that will be determined are shown below. Sampling stations are shown in Fig. 6.1. Sampling frequencies are shown in Ref. 5, Table 6.7-1. Analytical procedures will follow "Standard Methods for the Examination of Water and Waste Water," 13th Edition, American Public Health Association, 1971. Ancillary measurements which are performed at the time of collection are made with the following:

Velocity	-	Standard Gurle meter
D. O.	-	YSI dissolved oxygen meter
Temperature		
pH	-	Beckman portable pH meter
Turbidity	-	Secchi disc

Parameters to be determined

Total solids	Total phosphates
Total dissolved solids	Ortho phosphates
Total suspended solids	Total alkalinity
Total volatile solids	Total acidity
B.O.D.	Total hardness
C.O.D.	Chlorides
T.O.C.	Sulfates
D.O.*	Fe (total)
Turbidity*	Fe (soluble)
Field pH*	SiO_2
Specific conductivity	
Nitrates	Heavy metals
Nitrites	Cd Mn
Ammonium	Cr (total) Hg
Sodium (Na^+)	Co Ni
Potassium (K^+)	CN Zn
Magnesium (Mg^+)	Fe (total)
Calcium (Ca^+)	Pb

*Field measurements

The staff has reviewed the applicant's base-line hydrological program and found it to be adequate to determine the impacts that may occur as a result of construction and operation.

6.1.4 Ecological

6.1.4.1 Terrestrial

The terrestrial program is essentially concerned with the quantification of plant and animal life on the Braidwood site and nearby areas, both of which include a high proportion of strip-mined land. The applicant's program was started in October of 1972. Field investigations have been conducted by the applicant to characterize the vegetation, bird, mammal, and insect components of the Braidwood site; four seasonal surveys have so far been conducted at the site during 1972-1973.[2] These surveys were defined along selected transects (Fig. 6.2) on the Braidwood site (Ref. 2, Tables 6.1-5, 6.1-5a, 6.1-5b). Transects for vegetation analyses were selected to be representative of various ecological communities.

The 1974-1975 terrestrial sampling program (Table 6.4) will again concentrate on four primary groups of organisms: vegetation, invertebrates, birds, and mammals. During construction, monitoring may be modified to some extent based on new information obtained during the pre-construction study.

The staff finds that the base-line terrestrial ecological program accomplished to date and plans for the remainder of 1974 and 1975 are adequate to determine the possible changes that may occur as a result of construction and operation.

6.1.4.2 Aquatic

The applicant's aquatic biology monitoring program in the Kankakee River and Horse Creek is designed to identify the species and sample the populations of the phytoplankton, zooplankton, fish larvae, macrophyton, periphyton, benthic invertebrate and fish communities. The program is designed to take into account seasonal variation of species composition. The relevant ancillary measurements at the time of sampling will be taken to relate biological observations to physical and chemical features of the environment at the time of study.

Most of the aquatic monitoring studies will be done in the Kankakee River near the intake and discharge along transects shown in Fig. 6.1, including a transect across the mouth of Horse Creek. A summary of the field data collection program is shown in Ref. 2, Tables 6.1-1 and 6.1-2. The 1974-1975 pre-operational aquatic monitoring program is given in Table 6.5.

The staff finds that the pre-operational aquatic monitoring program as discussed in the applicant's Environmental Report will provide adequate background data to characterize the areas which might be adversely affected by the construction and operation of the station, with the additional requirements that (1) fish larvae sampling both upstream and downstream from the proposed intake and discharge structure will be extended for an additional six weeks from mid-July through August, if fish eggs and larvae are found in early July and (2) that fish kills by impingement on the intake screens be monitored during the filling of the lake.

6.2 APPLICANT'S PROPOSED OPERATIONAL MONITORING PROGRAMS

The operational radiological, chemical effluent, thermal effluent, meteorological, hydrological and ecological monitoring programs will evolve from the pre-operational monitoring programs described in the applicant's Environmental Report. Since the present action pertains to issuance of a construction permit, detailed staff evaluation of the operational program will be done at the time of application for an Operating License, and monitoring requirements will be included in the Environmental Technical Specifications of the Operating License.

6.3 RELATED ENVIRONMENTAL PROGRAMS AND STUDIES

Data have been obtained for two of the Illinois Environmental Protections Agency's regular water quality sampling stations located downstream (I-55 bridge) and upstream (at the Kankakee-Will County Line road bridge) from the station.

These data were obtained on June 30, 1973, and include the following parameters: water temp., field D.O., pH, total phosphate, fecal coli., ammonia nitrogen, nitrate nitrogen, turbidity, sulfates, boron, oil, phenol, etc.

These data show that water in this reach of the Kankakee River is of rather high quality relative to most other Illinois streams and rivers.[2,4]

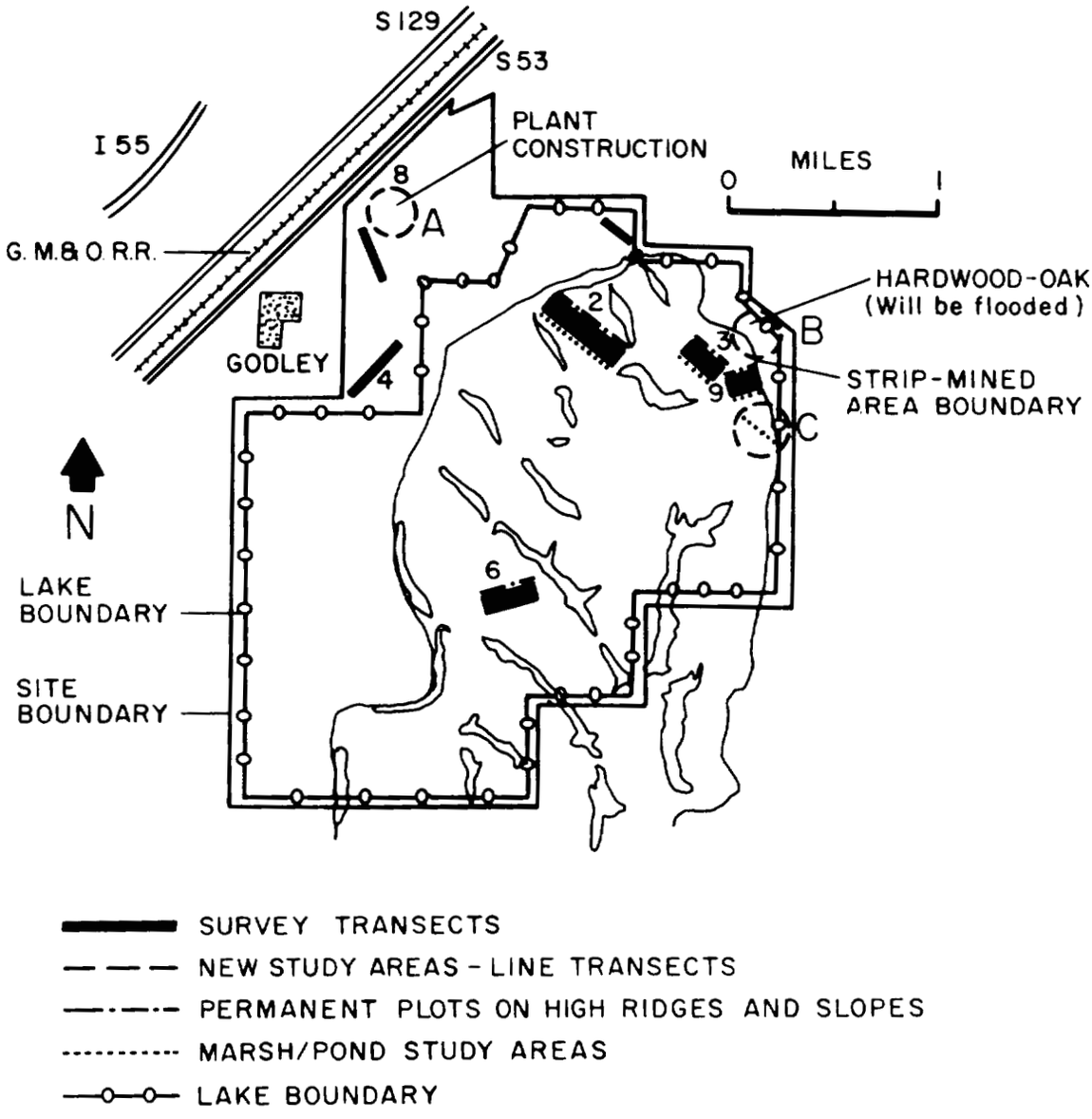

Fig. 6.2. Locations of Terrestrial Transects on the Braidwood Site. Study areas A, B, and C replace transects 5, 7, and 10. From the applicant's Environmental Report.

Table 6.4. Summary of the Terrestrial Monitoring Program for the Braidwood Site (1974-1975)

Parameters	Sampling Frequency	Sampling Method	Sampling Location	Statistics	Analyses
Vegetative Survey	Two surveys per year (spring and fall seasons)	Permanent study plots.	On high ridges and slopes on Transects 2, 3, 6, and Area C.	Calculations to determine relative frequency, density, and importance.	Identification of various cover, successionary trends, seed dispersal mechanisms, and primary food source adequacy.
	Two surveys per year (spring and fall)	Line transects	Area A		
	One survey (summer)	Fixed radius plot	Areas A, B		
Mammal Survey	Quarterly (to include major seasons)	Live trapping (random and grid) for small mammals. Direct observation and secondary signs such as dens, scats, and tracks.	Transects 3 and 6 for live traps, Transects 2, 3, 4, 6, and 9 for walking observational routes.	Calculations to determine relative population estimates.	Species identification, vigor, sex, weight, migratory potential, and annual species fluctuation.
		Small mammal snap trapping (line placement), direct observation, and secondary signs.	Transect established within Area A.		
		Direct observation and secondary signs.	Transects established within Areas B and C.		
Bird Survey	Quarterly (to include major seasons and migratory periods)	Direct observation and calls (no head counts).	2, 3, 4, 6, 9 and Areas A, B, and C.	Relative onsite abundance.	Species tabulation, habitat adequacy for waterfowl utilization, and annual species fluctuations.
Vegetative Survey	Two surveys per year (spring and fall seasons)	Line transects on pond banks and on slope gradients.	Selected marsh/ponds in transect Areas 2, 3, 6, 9, and C.	Calculation of relative cover, density, and importance.	Identification of various cover, successionary trends, seed dispersal mechanisms, and primary food source adequacy for waterfowl and other water associated organisms.
Amphibian and Reptile Survey	Five surveys during warmer months	Collection by loop traps, trammel nets, and hand. Biotelemetry, dissection, and gonadal examination.	Same locations as used for vegetational analyses.	Calculation of scute-body length, growth rates, home range, and relative abundance.	Species identification, limiting factors, habitat suitability, migration, and reestablishment potential of turtles.

Table 6.4. (Continued)

Parameters	Sampling Frequency	Sampling Method	Sampling Location	Statistics	Analyses
Bird Survey	May-Sept. Once each month for five days	Direct observation and calls (no head counts)	Same location as used for vegetational analyses.	Relative onsite abundance.	Species tabulation and habitat adequacy for waterfowl utilization.
Insect Survey	May-Sept. Once each month for five days	Direct observation qualitative Light trapping	Same location as used for vegetational analyses.	Relative abundance for major types.	Food source diversity for fish, amphibians, reptiles, and birds.

Table 6.5. Aquatic Parameters for the Braidwood Site (1974-1975)

Parameter	Sampling Frequency	Sampling Method	Sampling Location	Analyses
Macrophyton	Once each month in May and August.	Mapping by the transect system.	Macrophyte map for area from Transect 2 to 5, including Horse Creek.	Species identification when plants are developed sufficiently to allow it.
		Collection of plants by quadrant.	Standing crop estimates made at regular intervals along both sides of river and Horse Creek.	Relative abundance (percent coverage) Standing crop - expressed as g dry wt/m^2. Plants are dried at 105°C before being weighed.
Benthos (dredging)	Once each month in March, May, July, August, November, and March.	Ponar or Smith-MacIntyre Dredge	Collections will be made at Transects 2, 3, 5, and 6 at Stations .1, .5, and .9; at Transect 4, Station .5.	Species identification, when practical. Relative abundance (number of individuals of a particular species/number of individuals of all species) Density (number of organisms/unit area) General bottom type (mud, mud-sand, gravel, etc.) Species diversity (Shannon-Weaver)
Benthos (artificial substrate)	Once each month in March, May, July, August, November, and March.	Chicken wire baskets filled with substrata similar to that of the Kankakee River bottom. Baskets placed along shoreline.	On both sides of the river at Transects 2, 3, and 5 (Stations 0.0 and 1.0); Transect 4 in the center of the creek (.5)	Species identification, when practical. Relative abundance (number of individuals of a particular species/number of individuals of all species) Density (number of organisms per basket) Species diversity (Shannon-Weaver)
Adult Fish (electro-shocking)	Once each month during March, May, June, July, August, November, and March.	240 volt DC, 12 Amp. electroshocking apparatus	On both sides of the river, from points 500 feet upstream to 500 feet downstream of transects in the river, along shoreline. Horse Creek - 1000 feet upstream on creek from mouth	Species identification Standard length (to the nearest mm) and weight (to the nearest 0.5 g) Relative abundance (number of individuals of a particular species/number of individuals of all species) Condition factor for all fish weighed and measured of the six major species. Species diversity (Shannon-Weaver)

Table 6.5. (Continued)

Parameter	Sampling Frequency	Sampling Method	Sampling Location	Analyses
Stomach and Parasite Analyses	Quarterly			Stomach contents - identification of food organisms to species, if practical. Ectoparasite infestation - identification of external parasites to species, if practical. Sex determination of all fish examined for stomach content, providing fish are sexually developed.
Seining	Once during June, July, and August.	50-100 feet seine with 1/4 inch bar mesh	On both sides of the river, from points 100 feet upstream to 100 feet downstream in the river. In Horse Creek, four collections within the area where electroshocking is conducted.	Same as numbers 1-5 above
Baited Hoop Nets	Once during June, July, and August.	Anchored nets placed parallel to river flow	Center of the river (Station .5) at river Transects 2, 3, and 5.	Same as numbers 1-5 above
Gill Nets	Once during May, June, and July.	Experimental gill net; 125 feet with five 25 foot panels. Mesh sizes range from 3/4-2 inches.	Two locations: across the mouth of Horse Creek and at Transect 4 in Horse Creek.	Same as numbers 1-5 above
Fish Population Estimate	Once each month during May and August.	DC electroshocking equipment	Two locations: at or below Transect 3 and one location in the shocking area of Horse Creek	Mark - recapture: combination of DeLury and Peterson methods.
Fish Eggs and Larvae	Once each week during May and June and first two weeks in July.	Metered stationary tows using #0 (569μ) mesh plankton net Submersible pump with water filtered through a #0 (569μ) plankton net	Stationary tows - surface and bottom at Transects 2, 3, and 5, Stations .1 and .9; at Transect 4 in Horse Creek, Station .5. Submersible pump - bottom samples only at the above locations.	Count of eggs and larvae Identification of life stage

Table 6.5. (Continued)

Parameter	Sampling Frequency	Sampling Method	Sampling Location	Analyses
Physical Hydrolab	Once each time a field trip is conducted.	Field measurements	Transects 2 and 3 at Stations .1, .5, and .9 at 20% and 60% of river depth; Transect 4 and 5 at mid-river at depth above.	River velocity as feet/second - measured by Gurley velocity meter. Temperature as degrees Centigrade, oxygen as mg/l, pH as pH units, conductivity as μmho, depth - all measured by Hydrolab.
Bacteria	Once each month during March, May, August, November, and March.	Sterilized bacteriological bottles	Surface samples at Transects 2, 3, 4, and 5, Station .5.	Total plate count Total coliform Fecal coliform Fecal streptococcus All counts expressed as colonies/100 ml
Phytoplankton	Monthly - Nov. (1973) March, Nov. Bi-weekly in May-Aug.	Species composition Relative abundance Species diversity Biovolume (Lackey) Biomass	Midstream on each transect	Diurnal sampling in spring (1974) and summer (1974)
Zooplankton	As above	Species composition Relative abundance Total plankton Count (Sedgewick-Rafter cell)	Midstream on each transect	
Periphyton	As above	Species composition (R. Patrick) Relative abundance Species diversity Biovolume Biomass	2 diatometers on each transect, approximately 20 feet from either shore.	

Table 6.5. (Continued)

Parameter	Sampling Frequency	Sampling Method	Sampling Location	Analyses
Routine Water Chemistry	Once each month during March, May, June, July, August, November, and March.	Collection made by Van Dorn bottle	Transects 2, 3, 4, and 5 at Station 0.5; surface collection.	Total solids (mg/l)
				Total dissolved solids (mg/l)
				Total volatile solids (mg/l)
				Total suspended solids (mg/l)
				Total alkalinity as $CaCO_3$ (mg/l)
				Hardness as $CaCO_3$ (mg/l)
				Turbidity (JTU units)
				Color (color units)
				NO_2-N (mg/l)
				NO_3-N (mg/l)
				NH_3-N (mg/l)
				Total PO_4-P (mg/l)
				Ortho PO_4-P (mg/l)
				SO_4 (mg/l)
				SiO_2-Si (mg/l)
				Ca (mg/l)
				Mg (mg/l)
				Na (mg/l)
				K (mg/l)
				BOD (mg/l)
				COD (mg/l)

Table 6.5. (Continued)

Parameter	Sampling Frequency	Sampling Method	Sampling Location	Analyses
Heavy Metals	Once each month during March, May, August, November, and March.	PVC collection bottle	Surface samples at Transects 3 and 4, Station .5.	Total Fe as mg/l Mn as mg/l Co as mg/l Ni as mg/l Total Cr as mg/l Hg as μg/l Zn as mg/l CN as mg/l Pb as mg/l Cd as mg/l Cu as mg/l
Pesticides	Once each month in May and August.	PVC collecting bottle	Surface samples at Transects 3 and 4, Station .5.	Two pesticides and one herbicide, dieldren, DDT, and silvex, respectively, were selected for study. The selection was based on those pesticides and herbicides in common usage on agricultural lands bordering the Kankakee River and Horse Creek.
Crayfish Study	Once each month in May, June, July, and August.	Specially constructed wire-mesh trap	Shoreline stations (0.0 and 1.0) at Transects 2, 3, 4, and 5.	Species identification Sex Biomass (wet weight in grams)

References

1. Regulatory Guide 1.23, "Onsite Meteorological Programs," Directorate of Regulatory Standards, U. S. Atomic Energy Commission, Washington, D. C., 1972.

2. Commonwealth Edison Co., "Braidwood Station Environmental Report," including amendments Vols. 1 and 2, Docket Nos. STN 50-456 and STN 40-457, Sept. 13, 1973.

3. Commonwealth Edison Co., "Preliminary Safety Analysis Report," Vol. 1, p. 2.4-31, Docket Nos. STN 50-457 and STN 50-457, Sept. 13, 1973.

4. Daniel J. Goodwon, Manager, Performance Measurement Section, Division of Water Pollution Control, Illinois Environmental Protection Agency, 2200 Churchill Road, Springfield, Illinois 62706. Letter and data enclosures dated November 19, 1973.

7. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A high degree of protection against the occurrence of postulated accidents in the Braidwood Station 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 will be considered in the Commission's Safety Evaluation. 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 the consequences of 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 are 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 Braidwood Station Environmental Report, dated September 13, 1973.

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 and those on the low potential consequence end have a higher 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 the assumptions in the proposed Annex to Appendix D, 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 2020.

To rigorously establish a realistic annual risk, the calculated doses in Table 7.2 would have to be multipled 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 and some steam generator leakage, 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 they 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 these risks more quantitatively. The initial results of these efforts are expected to be available in early 1974. This study is called the

TABLE 7.1. Classification of Postulated Accidents and Occurrences

Class	AEC Description	Applicant's Examples
1	Trivial incidents	Included in the evaluation of routine releases.
2	Small releases outside containment	Included in the evaluation of routine releases.
3	Radioactive waste system failure	Waste gas and liquid decay tank failures. Equipment leakage or malfunctions.
4	Fission products to primary system (BWR)	Not applicable.
5	Fission products to primary and secondary systems (PWR)	Fuel cladding defects and steam-generator tube leak; steam-generator tube rupture.
6	Refueling accident	Fuel bundle drop and heavy object drop onto fuel in core.
7	Spent fuel handling accident	Fuel assembly drop in fuel storage pool. Heavy object drop onto fuel rack.
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Loss of coolant accident, steam line break, and rod ejection accidents.
9	Hypothetical sequence of failures more severe than Class 8	Not considered.

TABLE 7.2. Summary of Radiological Consequences of Postulated Accidents[a]

Class	Event	Estimated Fraction of 10 CFR Part 20 Limit at Site Boundary[b]	Estimated Dose to Population in 50-mile Radius, man-rem
1.0	Trivial incidents	c/	c/
2.0	Small releases outside containment	c/	c/
3.0	Radwaste system failures		
3.1	Equipment leakage or malfunction	0.11	10
3.2	Release of waste gas storage contents	0.45	40
3.3	Release of liquid waste storage contents	0.013	1.1
4.0	Fission products to primary system (BWR)	N. A.	N. A.
5.0	Fission products to primary and secondary systems (PWR)		
5.1	Fuel cladding defects and steam generator leaks	c/	c/
5.2	Off-design transients that induce fuel failures above those expected and steam generator leak	0.003	0.023
5.3	Steam generator tube rupture	0.15	13
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.024	2.1
6.2	Heavy object drop onto fuel in core	0.41	37
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel rack	0.015	1.3
7.2	Heavy object drop onto fuel rack	0.060	5.3
7.3	Fuel cask drop	N. A.	N. A.
8.0	Accident initiation events considered in design basis evaluation in the SAR		
8.1	Loss-of-coolant accidents		
	Small break	0.25	40
	Large break	2.5	1300
8.1(a)	Break in instrument line from primary system that penetrates the containment	N. A.	N. A.
8.2(a)	Rod ejection accident (PWR)	0.25	130
8.2(b)	Rod drop accident (BWR)	N. A.	N. A.
8.3(a)	Steamline breaks (PWR's outside containment)		
	Small break	<0.001	<0.1
	Large break	0.002	0.13
8.3(b)	Steamline break (BWR)	N. A.	N. A.

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

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

[c]These releases are expected to be in accord with proposed Appendix I for routine effluents (i.e., 5 mrem per year to an individual from either gaseous or liquid effluents).

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 accident 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 is described in correspondence with EPA, which has been placed in the AEC Public Document Room (letter, Doub to Dominick, dated June 5, 1973).

As with all newly developed information which might have an effect on the health and safety of the public, the results of the study will be made public and will 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 which are less than or comparable to those which would result from a year's exposure to the Maximum Permissible Concentrations (MPC) of 10 CFR Part 20. The table also shows the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident. Any of these integrated exposures would be much smaller than that from naturally occurring radioactivity. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is a small fraction of the annual exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small and need not be considered further.

8. THE NEED FOR POWER

This section of the Environmental Statement contains an evaluation of the applicant's need to have additional generating capability in the period of 1980 through 1982. The applicant's projected need for both the Byron Station and the Braidwood Station is evaluated herein because the stations were proposed for licensing in a single application. The summer capability of the four units in these plants is 4420 MWe. The year-round capability is 4480 MWe. Included in the analysis are: demands for both peak power and total energy, characteristics of the applicant's system, reserve margins needed for reliable generation and relationships of the applicant'with the other regional utilities.

8.1 DESCRIPTION

8.1.1 Applicant's Service Area

The applicant's service area covers about 13,000 square miles, primarily in the northern third of Illinois (Ref. 1, Fig. 9.2-1). Included are the northern Illinois area with metropolitan Chicago and three separate smaller, and less densely populated areas in central Illinois. Figure 8.1 is a geographical map showing the service areas.[2] At the present time, the three small areas are served by generating capacity outside the applicant's system. The applicant has sold his facilities and franchise for these three areas subject to FPC review and approval of sale.[3]

In the service area, which contains approximately eight million people, residential, commercial, and industrial customers have about equal electrical energy consumption. The following list gives the percentage breakdown of the 53 billion kWh sales for 1972:

Residential	28.2%
Commercial	30.6
Industrial	29.9
Other (Public Authority, Electric Railroads, Sales for Resale)	11.4
Total	100%

On a per capita basis, the average use was slightly less than 7000 kWh/yr.

For comparison, the U. S. with over 200 million people in 1972 had total sales of about 1600 billion kWh with a somewhat comparable breakdown into categories.[4] Expressed in percent the values are:

Residential	32%
Commercial	23
Industrial	40
Other (Streets, Highway and Public Authority, Railways, etc.)	5
Total	100%

Although there are uncertainties in defining the bounds for the various categories, the percentages of the kWh sales to the residential customers for the applicant's system and for the total U. S. are very similar. Because of the large commercial activities of metropolitan Chicago, the percentage of sales in this category is greater than for the U. S. The average of per capita sales for the applicant's area is about 15% below that for the U. S.

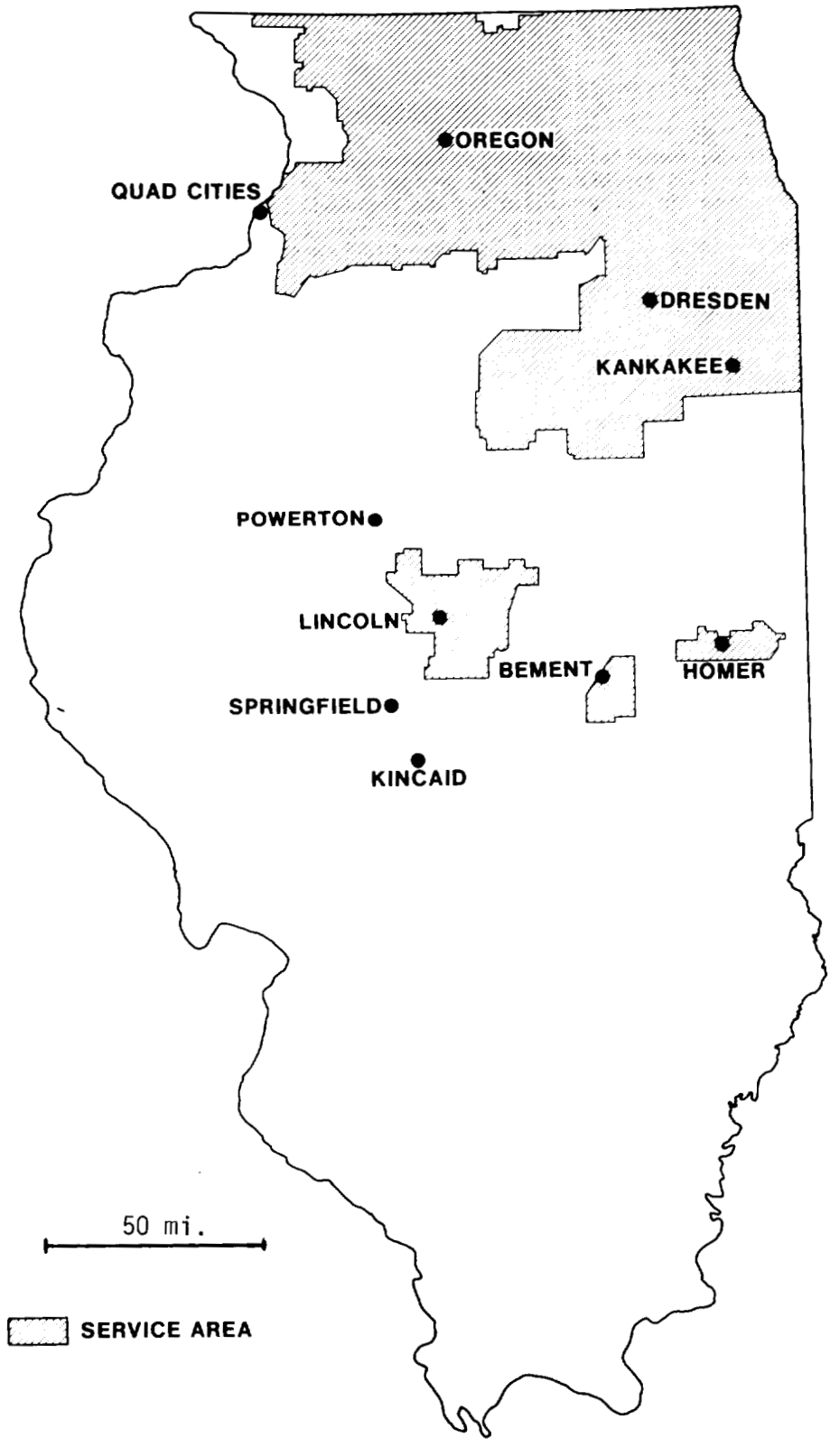

Fig. 8.1. Commonwealth Edison's Service Areas.

8.1.2 Applicant's Power System

Commonwealth Edison is one of the largest utilities in the U. S. with an installed capacity of about 15,900 MWe in January 1974. Both fossil and nuclear units supply the base load; the intermediate range load is supplied by fossil-fueled units. Gas turbines and the older, smaller fossil units are used to meet the remaining portion of the demand. The generating stations, together with the fuel used and capacity, are listed in Table 8.1. The applicant's power generating system is almost entirely within the State of Illinois; the only exception is the State Line Station, which is located near Hammond, Indiana.

Coal, oil, gas, and nuclear fuels are currently used; however, the preponderance of the electrical energy is obtained from coal and uranium. In 1973 about 61% of the energy generated was from coal and 29% from nuclear fuel. At present, the annual system peak demand occurs in the summer; the winter peak is about 80% of the summer peak. The annual load factor for the system is about 53%.

Commonwealth Edison has an extensive transmission system to deliver bulk power to load centers. The Kincaid, Powerton, and Dresden generating stations are located to the south of the main load centers. The Zion and Waukegan stations are located to the north of the load centers. Quad Cities station, which is a joint venture with the Iowa-Illinois Gas and Electric Company, is on the western border of the applicant's territory. Taking into consideration the planned retirement and reduced usage of many of the generating units within the matrix of the load centers as well as the expected increased demand, the applicant has built up an extensive transmission system to carry power from the outlying stations to the load centers of the Chicago metropolitan area. This is shown in part in Fig. 8.2. Another function of the transmission system is to provide the capability to carry bulk power to and from surrounding utilities in order to provide for interchanges of low cost power and to increase the reliability of the applicant's and the adjoining utilities' systems.

8.1.3 Regional Relationships

The applicant is a member of the Mid American Interpool Network (MAIN), which is one of the nine Regional Reliability Councils of the National Electric Reliability Council. MAIN's purpose is to promote regional coordination of the planning, construction and operation of the members' generating and transmission facilities;[5] emphasis is on reliability and economy. The following is a list of the groups, including their associate members, of the MAIN council and their installed capacity as of January 1974:[6]

Commonwealth Edison	15,900 MWe
Illinois Group	6,300 MWe
Missouri Group	7,200 MWe
Wisconsin-Upper Michigan Systems Group	6,400 MWe
Total	35,800 MWe

The MAIN Council region is contiguous with four other council regions. Coordinated planning is carried out among these councils; in addition, purchases and sales of electricity take place between certain of the utilities in these other councils and some utilities in the MAIN council.

The applicant's electrical system is connected with its neighboring utilities and depends upon these interconnections in planning the required generating capacity. Although the total interconnection capability is large, only about 3000 MW could be transferred simultaneously. The dependable amount of this transfer capability in time of emergency is usually much less, due to generating conditions and loads in neighboring utilities. At the present time MAIN has no reserve margin requirement for its members, but a criterion is being developed. However, as reported by MAIN, load flow and stability studies of the council's network are made to test the performance of the projected interconnected transmission system when subjected to extreme disturbances.[7]

Table 8.1. Commonwealth Edison's Generating Units and Their Approximate Capability for Summer Peak Service (1973)

Name	No. of Units	Location	Steam Electric Summer Capability, MW			
			Coal	Gas Coal[d]	Oil	Nuclear[e]
Calumet	(1)	Chicago		120		
Crawford	(3)	Chicago		650		
Dixon	(2)	Dixon		120		
Dresden	(3)[a]	Morris				1760
Fisk	(2)[b]	Chicago		480		
Joliet	(4)[b]	Joliet	1680			
Kincaid	(2)	Kincaid	1230			
Powerton	(5)	Pekin	1170			
Quad Cities	(2)[c]	Cordova				1170
Ridgeland	(4)	Stickney			570	
Sabrooke	(4)	Rockford		150		
State Line	(3)	Hammond, Ind.		940		
Waukegan	(4)	Waukegan		950		
Will County	(3)	Lockport	1050			
			5130	3410	570	2930
Total steam electric						12040
Gas turbines (oil & gas fueled at many locations)						1600
Diesel (oil fueled)						20
Total for applicant						13660
Ludington pumped hydro[f]						520
Total						14180

[a]Two units are not fully operational

[b]An 11-MWe diesel is also located at this site

[c]Applicant's portion of the two units

[d]Two units (Calumet # 7 and Crawford # 6) can only burn gas.

[e]In 1973 a portion of the nuclear capacity is under trial operation; for various reasons 500 MW was unavailable for the summer peak.

[f]Part of output from the Ludington pumped hydro facilities is available to the applicant under a 15-year agreement. (An additional 104 MW became available after the summer peak.)

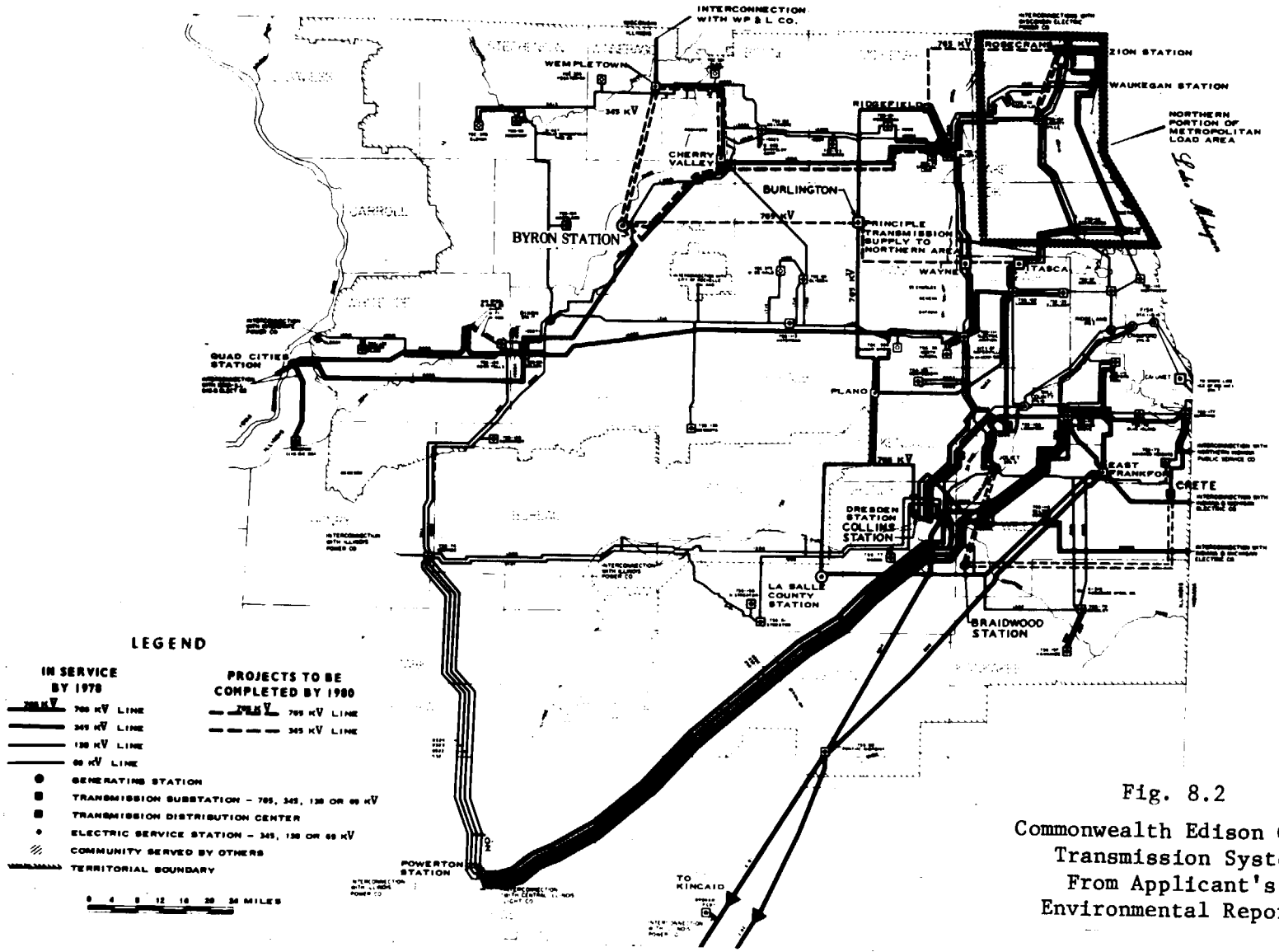

Fig. 8.2

Commonwealth Edison Outer Transmission System. From Applicant's Environmental Report.

8.2 HISTORIC DEMANDS AND CAPABILITY

8.2.1 Peak Power Demand and Generating Capability

8.2.1.1 Peak Power Demand

The annual peak power demand on the applicant's system occurred during the summer in recent years; however, prior to 1964 the peak occurred during the winter. The relative demands by various classes of the consumer at the time of peak demand is not well known because daily power demand is only recorded for a few large industrial customers, although some sampling of power demand is conducted among other classes of consumers. The summer peak demand since 1959 is plotted in Fig. 8.3. The slope of the line representing the past peak loads in this figure corresponds to a growth rate of slightly over 8% per year. For comparison the U. S. had a growth rate of the noncoincident peak of slightly less than 8% per year from 1962 through 1972. For the 1968 through 1973 interval, the applicant's annual growth rate (including demand not met due to disconnection of some interruptible load and to a voltage reduction) was slightly less than 8%, whereas for the U. S. the growth rate for the noncoincident peak was slightly greater than 8%. In general, the annual growth rate of the summer peak for the Commonwealth Edison system is very similar to that for the United States.

8.2.1.2 Generating Capability

The generating capability in the past has been based on coal-fired units. The use of gas-fired units increased during the 1960's. Environmental pressures promoted the use of oil-fired facilities starting in 1969; however, for the last two years nuclear plants have been the main generating additions. Gas-turbine units, which have a low capital cost and can be installed quickly, were about 12% of the 1973 summer peak capability. The magnitude of the generating capability for any year is based on peak power demand plus a reserve margin.

8.2.1.3 Reserve Margin

The applicant's policy on reserve capability is that the required reserve margin be 14% of the total of the peak load minus firm purchases, diversity interchanges, and 5/6 Ludington purchase.[6] The Federal Power Commission (FPC) considers a reserve margin in the range 15-25% of the anticipated peak load to be adequate.[8] The purpose of the reserve margin is to assure a reliable generation system by allowing for forced outage of units, and uncertainty in load forecasts. It is the applicant's practice not to schedule plant maintenance and reactor refueling during the season when the peak load occurs. The magnitude of the reserve margin depends upon the interconnections with other utilities and their projected ability to supply power in emergencies.

Based on data given in the applicant's Environmental Report, calculations show that during the last six years the reserve margin varied from 7 to 24%. The average was 14.5%. During this period there were no blackouts in the system; however, voltage reduction, disconnection of interruptible load, and special purchases at the time of the system peak did occur.

The needed generating reserve for a given reliability criterion is determined in part by anticipated equipment forced outage rates (product of outage frequency and downtime during the outage). In the past, projected forced outage rate estimates used in reliability calculations were based on reasonably firm data, although uncertainties in the data for new large fossil units became more prominent in the last few years. Estimates of forced outage rates for the large nuclear units coming on line in 1972 and 1973 are also tenuous because of the lack of operating experience.

8.2.1.4 Operating Reserve

Due to equipment outages and variable weather and business conditions (which strongly influence demand), the actual operating reserve (that is, the available capability on the system) at the time of peak gives an indication of the effectiveness of the utility's planning methods. At the request of the staff the applicant estimated the following operating reserve:

Year	Total Peak, MW	Operating Reserve, MW	Operating Reserve, % of peak
1969	9,419	447	4,7
1970	10,049	75	0.7
1971	10,973	449	4.1
1972	11,991	973	8.1
1973	12,703	264	2.1

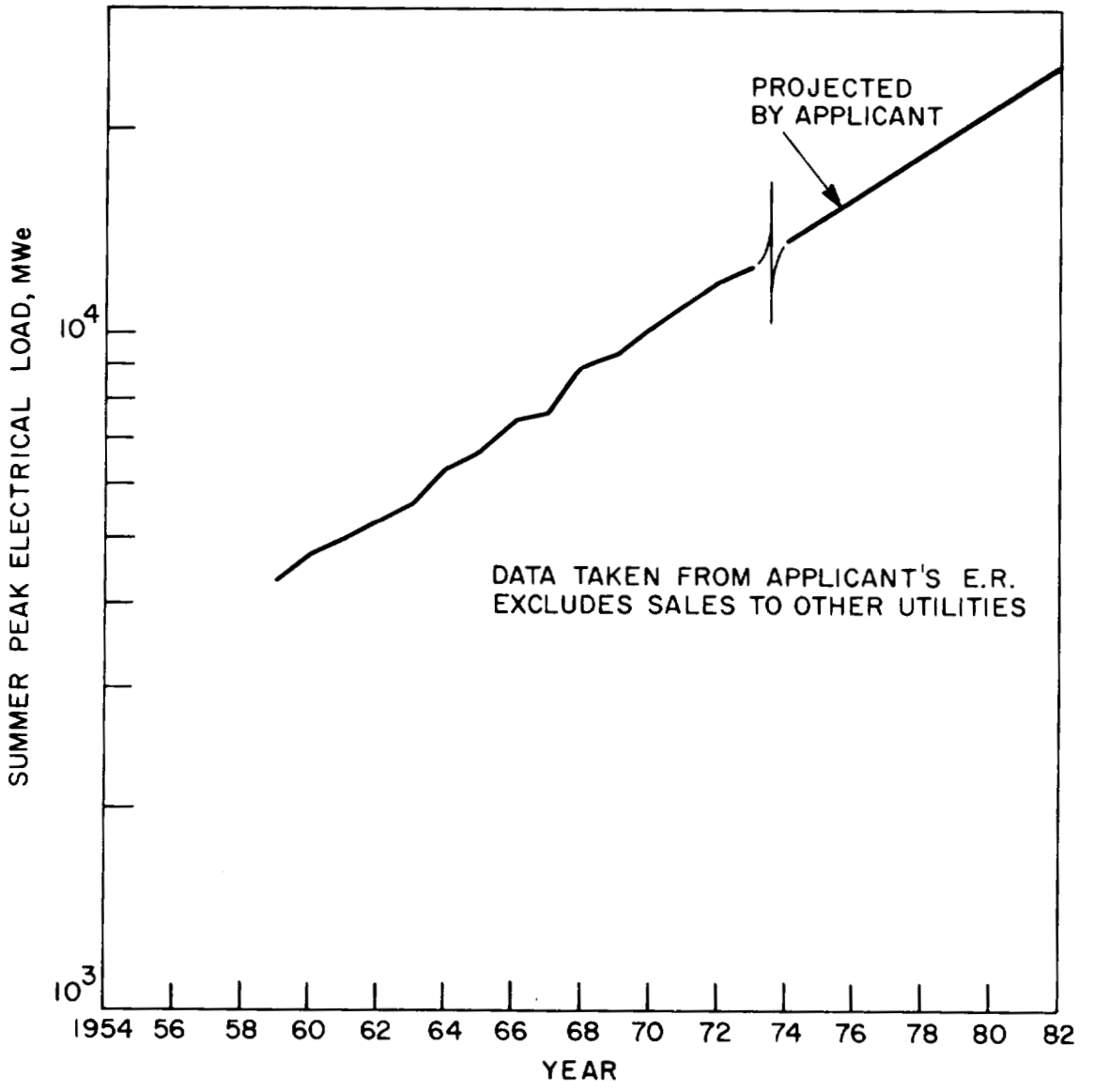

Fig. 8.3. Historic Summer Peak Power Demand.
From the applicant's Environmental Report.

In 1970 and 1973 the applicant reduced the voltage during the time of the peak. Also in 1973 customers having contracts that allowed interruption of power were disconnected to reduce the load; net purchases of capacity by the applicant were 1173 MW at the time of peak. The applicant has been able to sustain required loads, but the operational reserves were rather small.

8.2.2 Energy Demand

8.2.2.1 Electrical Energy Generation

The annual generation of electrical energy has not grown as rapidly as the annual peak power demand in recent years. Figure 8.4 shows annual generation from 1960 through 1972 as given by the applicant. Over this period the growth rate was about 7% per year; for the U. S. the growth rate was slightly higher. The trend and magnitude of the applicant's growth appears reasonably consistent over the 12-year period. Since 1964, when the annual power peak started to occur in the summer, the energy growth rate has been 7.1% per year, whereas the peak load growth rate (excluding sales) was 8.1% per year.

8.2.2.2 Load Characteristics

The applicant's Environmental Report (Ref. 1, Fig. 1.1-1) displays annual load duration curves for 1968 through 1971. These curves are very similar in shape with no apparent trend with time; in fact the applicant states that the annual system load factor, which may be determined from the curves, will be about constant in the near future. In the past the annual load factor has decreased and now is in the 52-54% range. In the applicant's display, the base load capacity is 57% of the annual peak load.

8.2.2.3 Fuel Sources

Historically, coal has been the applicant's main fuel. Natural gas was also used but this was mainly during the summer. Because of the natural gas shortage, this use is severely curtailed. Fuel oil was practically never used, but conversion of some of the coal units to fuel oil started to occur in 1969 because of environmental pressures. The following table displays the recent trend in fuel use; expressed as percent:

	Coal	Gas	Oil	Nuclear
1968	86	12	0*	2
1969	83	14	1	2
1970	65	23	6	6
1971	60	19	12	9
1972	57	10	11	22
1973	61	3	7	29

*Negligible

With the present oil shortage and the proposed federal directive for utilities to convert from oil to coal where possible[9] and with the rulings in the priorities of natural gas use not favoring electrical utilities,[10] the applicant's use of coal and uranium for fuel can be expected to increase.

8.3 PROJECTED DEMANDS

8.3.1 Introduction

The projected need for new generating capacity rests largely on the prediction of future demands. In this section, not only will future electrical power demand be discussed, but also future electrical energy demand. Energy demand estimates are, of course, needed for proper selection of the type of generating capacity to be added. How best to meet these demands depends on the economic and environmental costs of alternatives. The consideration of alternatives for this station is given in Section 9.

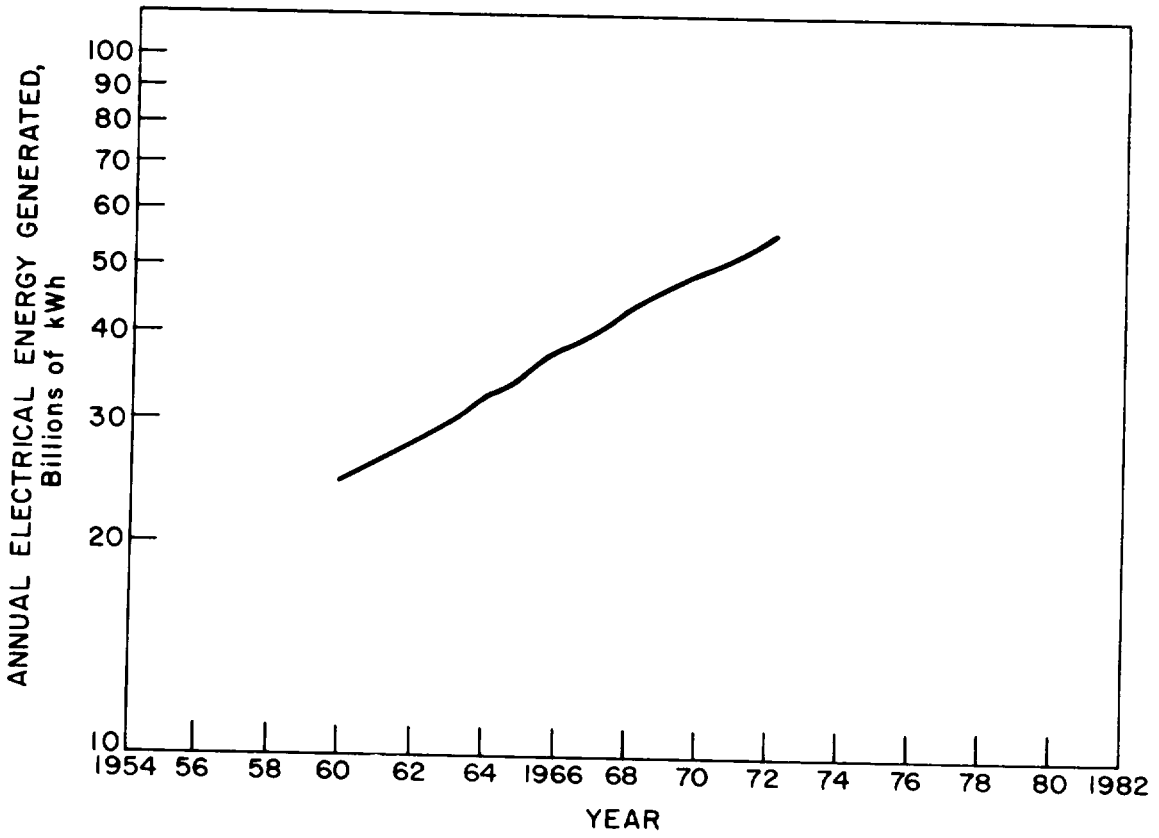

Fig. 8.4. Annual Electrical Generation.

There are many forecasting methods in use in electrical planning. The methodology of load forecasting, as of 1969, has been described in "The 1970 National Power Survey".[11] This work has been updated[12] and in addition there are other reports on the subject.[13] Under a National Science Foundation program an econometric analysis has been used to study electricity demand.[14,15]

The staff has not used any particular methodology to project demands but rather has reviewed the applicant's projections for aptness of method considering the current state of the art for making projections and for suitability of information used.

8.3.2 Energy

The applicant did not directly project the future electrical energy demand using any complex methodology; however, he did state that the annual load factor in 1979 should be nearly equal to that in 1971.

Econometric modeling of electrical energy supply and demand is an active investigative field. A recently published study by Asbury of ANL reviews past studies and presents an independent analysis.[16] Econometric modeling has been based mainly on energy rather than on power demand relationships with the variables. Some of the explanatory variables, or econometric factors, in these studies are: electricity price, natural gas price, heating oil price, consumer income and electrical appliance prices. The impact on demand caused by changes in the values of the econometric factors takes time to be fully reflected in consumption.[14] Thus, past and possible future price increases by the applicant can influence demand at the time of startup of these units. There appears to be little doubt that on a national basis electricity price is a very important econometric factor. These models predict that increases in electricity price will decrease demand. Counter-factors are the increasing income of consumers and the increasing prices of fuel oil and natural gas. These tend to increase demand for electricity; however, their elasticities are probably less than the electricity price elasticity.[15]

Basically, energy and power demands may follow the same trends, but the magnitudes of the trends may be different. If good energy demand models with suitable data existed, these could be used to gain better insights into the power demand trends than is available from present projection models and data. It should be noted, however, that some of the econometric factors in present projections by utilities are expressed explicitly while others are used in implicit form.

The current state of the art of econometric analysis is summarized in the following extracts from the Asbury report.

"A number of investigators have recently reported results of econometric studies of the market for electrical energy.[17-24] The studies have attempted to explain temporal and inter-market variations in electricity consumption in terms of variables which, on a priori grounds, might be expected to affect electricity demand. Using multiple regression techniques, the investigators have examined the dependence of electricity consumption on such variables as: electricity price, population, personal income, climate variables, degree of urbanization, the price of electric appliances, and the price of natural gas. Although most of the studies have concentrated on the residential market for electricity, results have been reported for the commercial and industrial markets as well.

"Selected results from several previous studies of electricity demand are presented in Table 8.2. The table lists estimated demand elasticities for three explanatory variables: electricity price, income, and natural-gas price.

"Despite differences in underlying assumptions, methodology, and data base, the studies all indicate that electricity price is the most important determinant of electricity demand. The results of Wilson, Halvorsen, and Chapman, Tyrrell, and Mount for the residential market indicate a price elasticity of demand of about -1.25. Stull and MacAvoy find a similar elasticity value for the whole U. S. electricity market, and Anderson's result for the residential market is not in too serious disagreement.

"Although the econometric approach to the analysis of the market for electrical energy has provided considerable insight into the causal factors underlying electricity supply and demand, none of the models developed to date provides a reliable method for estimating future demand. The existing dynamic models fail to incorporate the supply relation, while the static supply-demand models are ill suited to situations involving changes in long run supply and demand trends."

Table 8.2

Elasticity Estimates from Previous Studies of Electricity Demand

Study (Reference)	Model	Market	Elasticities*		
			Electricity Price	Income	Gas Price
Mount, Chapman, Tyrrell[17,19]	Dynamic, Single Equation	Residential	-1.3+	+0.3+	+0.15+
		Commercial	-1.5+	+0.9+	+0.15+
		Industrial	-1.7+	+0.5+	+0.15+
Anderson[18]	Static, Single Equation	Residential	-0.85	+0.94	+0.21
Halvorsen[20]	Static (+ Time Trend), Supply-Demand	Residential	-1.2	+ .61	+ .036
Wilson[21]	Static, Single Equation	Residential	-1.33	- .46	+ .31
Stull, MacAvoy[22]§	Static Single Equation	Combined	-1.24	+0.86	-

+Elasticities estimates for constant elasticity model (Reference 19). See Reference 17 for variable elasticity estimates.

§Capacity demand model.

*The three elasticities are defined as the relative change of demand with the relative change of electricity price ($\Delta D/D \div \Delta E/E$), of income ($\Delta D/D \div \Delta I/I$) and of gas price ($\Delta D/D \div \Delta G/G$).

Thus, based on Asbury's analysis, the staff finds that it is premature to make analyses using any of these correlations. It should be noted that elasticity coefficients for the models as they apply to the applicant's would have to be developed, if a correlation were to be used. In addition, the projection of the existing econometric data is necessary in order to use these correlations.

The staff has reviewed the applicant's statement that the load factor remained constant between 1971 and 1979, and the projection of electrical energy inherent in that statement. In addition, the staff has reviewed the applicant's projected energy growth as it appears in Appendix A of the MAIN report to the FPC.[6] As explained below, these considerations lead the staff to believe that the applicant's projections of energy demand are too high.

As given in Reference 6, the applicant's 1982 peak power demand is 24,350 MWe and the net output to the load is 116 billion kilowatt hours. This corresponds to an annual load factor of about 54.6%. In the same reference, the 1974 projections were 13,760 MWe peak power and 64.4 billion kilowatt hours net output, which corresponds to a load factor of 53.4%. The energy growth rate during this period is calculated to be 7.7% per year. During the 1962-1972 period, the applicant's energy growth rate was 7.0%/yr. This was a high growth period for the applicant both in energy and power. Considering that the peak power growth rate from 1973 to 1982 will probably not match the rate from 1960 to 1972 of about 8%/yr, and considering the consumer's response to the energy shortage in recent months, the staff believes that the energy growth rate will average no higher than 7%/yr between 1973 and 1982. On this basis, the energy demand will be about 95% of that projected by the applicant.

8.3.3 Power

The electrical power users in the applicant's area largely determine the demand placed on the generating units; to a small extent power use outside of the applicant's system also contributes to the demand. The applicant is required to estimate consumer demand. In these days of expensive and scarce capital for electrical utilities, high estimates of demand can be costly not only to the consumer, who of course must ultimately pay the tariffs, but also to the utility, which must bear the burden of reduced earnings prior to rate adjustments. Under the present social pressure to conserve energy, the utility can do little to increase demands. A low estimate of power demand also places a burden on the utilities by requiring short-term purchases (or in some cases power and energy exchanges) of often expensive electricity from other utilities.

The applicant's method to forecast peak load is based on two factors, business conditions and weather. The relationship and selection of the specific variables were obtained by reviewing and correlating past statistical data for his system. The applicant uses an analytical model incorporating these variables to make projections for up to ten years into the future. Projected loads are based on a 24-year average of peak-making summer weather conditions. It is thus apparent that, in addition to the uncertainties in the model, uncertainties in the weather and future business conditions also contribute to the inaccuracy of the long-term forecast.

The projection of the 1973 peak (made prior to the actual peak, and given in the Environmental Report) was checked against the actual peak given in the FPC News.[25] The agreement was very good: 12,750 MWe projected demand vs. 12,834 MWe actual demand including estimates of load not met. Thus, the applicant's model worked well for this short-term forecast.

The power projections given by the applicant correspond to an annual growth of 7.5% from 1973 through 1982. As stated previously, the actual annual growth of the applicant's summer peak from 1964 through 1973 was about 8.1%. For comparison, the estimated annual growth for U.S. from 1973 through 1980 is 7.5%.[4] Thus, the applicant, with general electrical conditions representative of the U.S., projects a growth rate representative of the national average rate. The 1982 peak demand projected by the applicant is 24,350 MWe.

Energy availability and price have undergone some significant changes in the last year due to many factors. In the future, energy will be more expensive than in the recent past. After a long period of a downward movement in the real price of electricity, its price has started to increase. Although in this "need for power" section the main concern is with power not energy, estimates of future demand for most consumers is invariably linked to the cost of energy; however, there does not need to be a one-to-one correspondence between power and energy. Indeed, air conditioners, which are a principal cause for the summer peak, may be used in the very hot weather even though their annual energy consumption may be reduced. Thus the consumer stock plus the future availability of electrical appliances can contribute to peak demand even though their annual usage may decrease. Increased manufacturers' shipments of electrical ranges, dryers, and water heaters occurred in 1973; shipments of corresponding gas-fired units remained the same or decreased during the same period when compared with the previous year.[26]

In the staff view, the downward electrical energy and power use in the U.S. is more than a passing phenomenon. Projections of power demand for 1982 are very uncertain. The applicant in a recent letter to the AEC has stated in the period of December 1973 through April 1974 there has been a 6% decrease in the expected demand for power.[27] In the U.S. the cumulative energy output from January 1, 1974 to May 18, 1974 was only 0.1% higher than last year during the same period.[28] As discussed in Section 8.3.4, there are a number of reasons for this decrease in demand.

The staff believes that the applicant's estimate of about 7.5% per year growth from a base of 12,703 MW in 1973 to 24,350 MW in 1982 is an upper level of the projection for peak summer power demand. Until more certainty exists and trends are better indicated, it appears prudent to view the 24,350 MWe projection (and the corresponding values for 1980 and 1981) as an upper value for planning.

8.3.4 The Impact of Energy Conservation and Substitution Measures on Need for Power

Recent energy shortages have focused the Nation's attention on the importance of energy conservation as well as measures to increase the supply of alternative energy sources. The need to conserve energy and to promote substitution of other energy sources for oil and gas have been recommended by the Report to the President on the Nation's Energy Future as major efforts in regaining national energy self-sufficiency by 1980.[29] In the following sections, the staff considers conservation of energy as related to the need for the electricity to be produced by the Byron and Braidwood plants.

8.3.4.1 Recent Experience

Implementation of energy conservation measures by households, business, and government has already contributed to less growth than projected in the consumption of electricity nationally since the third quarter of 1973. For the applicant, lack of growth also could be attributed to economic slowdown, self-imposed voltage reductions, and a somewhat milder winter than anticipated. Consumption of electricity in the applicant's service area has been less than the forecasted consumption by an average of about six percent during the period December 1973 to April 1974. Monthly peak load demand also was less than the forecast by an average of about six percent during the same period.

Milder than anticipated weather accounts for an insignificant percent of the deviation from the monthly peak load demand forecast. Deviation is also attributed to the economic slowdown. A very rough approximation indicates that the remaining 80% of the deviation is attributed to energy conservation and changes in econometric factors such as price.

The interpretation of the significance of such limited data on energy conservation impacts on the forecasted need for power in the applicant's general service area over the next six to ten years is uncertain. For instance, although conservation effects on peak load demand have been observed during the winter months, it is not known if such effects will continue during the hot summer months when the applicant's system peak load occurs. Much will depend, of course, on the future decisions of consumers and governmental agencies in responding to the energy crisis and potential developments in energy supply and demand factors which might ease the energy crisis or cause it to worsen. Only actual data on power demand in the applicant's general service area will provide a reasonable basis for demand projections which include conservation decisions.

8.3.4.2 Promotional Advertisement and Conservation Information Services

In the past, Commonwealth Edison Company has attempted, through advertising, to increase the demand for certain uses of electricity in its service area. A major thrust of advertising was to promote demand during off-peak periods, for electritity uses such as water heating and space heating.

The applicant terminated promotional advertising and began advertising the efficient use and conservation of electricity in 1973. Monthly reports to the Federal Power Commission indicate that Commonwealth Edison Company is sponsoring T.V., radio and newspaper advertising, publishing booklets and sponsoring industry programs aimed at conserving electricity.

On a national basis, an estimated $450 million was spent on promotional advertising in 1972 by manufacturers of electrical applicances and equipment;[30] this advertising has not been curtailed. The manufacturer and utility programs tend to offset each other and the net effect on future demand is uncertain.

8.3.4.3 Change in Utility Rate Structure

The Federal Power Commission regulates the rates for interstate wholesale electric energy, while the Illinois Commerce Commission regulates the rates utilities charge the ultimate consumer in the applicant's service area.

Historically, utility rate structures were designed to encourage consumption of electricity by using declining block rates, which reflected the declining average cost of furnishing additional kilowatt hours of electrical energy to each customer. Until recently, the economic logic for declining block rates was never seriously disputed. Today, however, under conditions of increasingly scarce fuel resources, declining block rates, by lowering the price of each additional kilowatt hour, tend to encourage greater use of electricity by individual consumers and also to encourage individual consumers to use more electricity instead of other energy sources.

The tendency in rate making is towards a more level set of rates. However, in an Oak Ridge National Laboratory study of the effect of rate structure on electrical energy consumption, it was concluded (for the U.S.) that equalized rates for all classes of consumers would not materially change the aggregate electrical energy demand.[31]

8.3.4.4 Load-Shedding, Load Staggering and Interruptible Load Contracts to Reduce Peak Demand

Load shedding is an emergency measure to prevent system collapse when peak demand placed upon the system is greater than the system is capable of providing. This measure is usually not taken until all other measures are exhausted. The Federal Power Commission's report on the major load shedding that occurred during the Northeast Power Failure of November 9 and 10, 1965, indicates that reliability of service of the electrical distribution systems should be given more emphasis, even at the expense of additional costs.[7] This report identified several areas that are highly impacted by loss of power, such as elevators, traffic lights, subway lighting, prison and communication facilities. It's the serious impact on areas such as these that result in load shedding as only a temporary method to overcome a shortage of generating capacity during an emergency.

Load staggering has also been considered by the staff as a possible conservation measure. Basically this alternative involves shifting the work hours of industrial or commercial firms to avoid diurnal or weekday peaks. However, this involves customer and worker preferences external to the utility industry and is beyond the bounds of utility industry action.

For interruptible load contracts to be effective in system planning, the load reduction must be large enough to be effective in system stability planning. Thus, this type contract is primarily related to industrial customers. At the present time three of Commonwealth Edison's industrial customers are supplied a portion of their services under Rider 17, Electric Furnace Interruptible Service. Power interruptions are being practiced by the utility at times of peak demand. The amount of power involved in small (<100 MWe).

8.3.4.5 Energy Use Efficiencies

Due to energy shortages and higher energy costs in the U.S. economy, an emphasis recently has been placed on increasing the efficiency of energy use. In the past, the selection of efficiencies by utilities was normally carried out on a cost effectiveness basis, i.e., the operations to produce electrical energy should result in the lowest cost product. A brief review of efficiencies involved in the use of coal and nuclear fuel is appropriate.

Two efficiencies of interest are the generating plant efficiency and the fuel system efficiency. For the generating plant, the overall net heat rate expresses the efficiency of fuel conversion to electrical energy. With present design practices, coal-fired plants have higher efficiencies than the LWR nuclear plants. Per kilowatt hour electrical output, the coal-fired plant needs only 4/5 the thermal input that a nuclear plant does. The fuel system efficiency includes not only the energy used to convert fuel in the generating plant but also the energy for mining, preparation, and transportation of fuel, In addition the transmission losses to the customer are included. Neglecting the unrecovered coal and uranium in mining and material losses in processing, it has been estimated that the coal system only needs 3/4 of the heat input that a nuclear system does per kWh of electrical energy to the consumer.[32]

Although important in assessments, energy use efficiencies based on thermal input requirements are not the only criteria in judging the effectiveness of man's use of resources. The efficiency of labor and capital to construct facilities must also be considered and this is

generally done in the context of dollars. Environmental costs throughout the energy system must also be included when considering alternative fuels. With the increase in fossil fuel prices, which are expected to exceed the increase in capital costs on a percentage basis, future designs of power plants can be expected to incorporate the latest technology that gives increases in efficiency.

8.3.4.6 Factors Affecting the Efficient Utilization of Electrical Energy

During the past two years, much of industry, the Federal Government and many State and local governments have made the promotion of energy conservation a priority program. The Department of Commerce has developed a departmentwide effort to: (1) encourage business firms to conserve energy in the operation of their own processes and building; (2) encourage the manufacture and marketing of more energy-efficient products; and (3) encourage businessmen to disseminate information on energy conservation. The National Bureau of Standards has been given a leading role in promoting the development and implementation of energy saving standards. Programs include: voluntary labeling of household appliances; research, development and education relative to energy conservation in building; efficient use of energy in industrial processes; and improved energy efficiency in environmental control processes. While considerable efficiencies in electricity usage have already been gained, and while further efficiencies will be realized, any present estimates of the magnitude of electricity savings to be realized over time must be treated as tentative and subject to continual reassessment.

Considerable efficiency can be achieved in space conditioning by improved insulation and the use of building materials with better insulation properties as well as by using equipment which transfers or stores excess heat or cold. For example, the seven story Federal Office Building to be built in Manchester, N. H. illustrates the potential for energy conservation in future commercial buildings using existing technology. For this particular building, energy savings are anticipated to be a minimum of 20 to 25 percent over a conventionally designed building in the same location. Heat savings alone are expected to be 44 percent because of better insulated walls, less window area, use of efficient heating and heat storage equipment, and the use of solar collectors on the roof.

In 1971, FHA established new insulation standards which were to reduce average residential heating losses by one-third. Studies have shown that it is possible to gain even greater reductions in heat loss through improved insulation at costs which are economical over a period of years. Improved insulation conserves not only in winter but also reduces the air conditioning burden in the summer.

Lighting, which has accounted for about 24 percent of all electricity sold nationally, is another area where savings are being realized. Many experts believe recommended lighting levels in typical commercial buildings have been excessive. It has been calculated that adequate illumination in commercial buildings can be achieved at 50 percent of current levels through various design and operational changes.

Another study indicated that if all households in 1970 had changed to fluorescent from incandescent lighting, the residential use of electricity for lighting would have been reduced approximately 75 percent and total electrical sales would be reduced approximately 2.5 percent.[33] However, since the majority of residential lighting occurs in off peak hours, the reduction on peak demand would be less than one percent.

The potential for greater energy efficiency in household appliances is well recognized. The National Bureau of Standards is working with an Industrial Task Force, from the Association of Home Appliance Manufacturers, in a voluntary labeling program which would provide consumers with energy consumption and efficiency values for each appliance and educate them as to how to use this information. Room air conditioners are the first to be labeled. The next two categories of house appliances which are to be labeled are refrigerators and refrigerator/freezers and hot water heaters.

The importance of energy efficiency labeling of appliances is that it will allow the consumer to select the most energy efficient appliance. A recent study titled, "The Room Air Conditioner as an Energy Consumer," has estimated that an improvement in average efficiency from six to 10 Btu/Watt-hr could hypothetically save electric utilities almost 58,000 MW in 1980.[33] Air conditioners which are more energy efficient require a combination of increased heat exchanger size and higher efficiency compressors resulting in higher initial cost. The consumer must be convinced that is is profitable for him in the long run to purchase the more expensive machine. Today, however, there is a high degree of uncertainty in predicting to what extent consumers will actually purchase these more expensive appliances. In addition, selection of central air conditioning by developers and many home owners has historically been based on minimizing front end costs consistent with meeting local building zoning requirements.

The realization of these potential energy savings depends upon many unpredictable economic, political and technological factors. Dependable forecasts of the efficacy of energy conservation measures require the accumulation of much more experiential information. Also, some programs beneficial to overall productivity require the expenditure of additional energy. For example, the National Institute of Occupational Safety and Health has recommended heat stress standards which would require a significant number of employers to air-condition their plants.[34] The combination of forces tending to increase energy use with the unpredictability of the factors which would help save energy makes any significant reduction in electrical demand due to more efficient use highly uncertain at this time.

8.3.4.7 Consumer Substitution of Electricity for Scarce Fuels

While conservation measures are rather quickly adopted in a "crisis" situation, the consumer's substitution of electrical energy for fuels such as oil or gas takes several years to result in a substantial upward impact on the need for power. The staff expects that substitution of electricity for scarce energy sources will increase in the applicant's service area because of the uncertainty of oil and gas supplies and the outlook for higher prices relative to the price of electricity produced from coal-fired or nuclear plants. For instance, in the applicant's service area, 3.9 percent of living units were electrically heated in 1970 and a projected 7.8 percent will be electrically heated by 1980. From 1970 to 1980, the use of electric water heaters is projected to increase from 9.0 to 10.8%, and that of electric ranges from 23.6 to 25.6%.

8.3.4.8 Summary on Conservation

The peak load in the applicant's area has decreased about six percent during the period December 1973 to April 1974. This is mainly due to weather factors, lower economic activity in the service area, changes caused by economic factors such as electricity price, and to energy conservation practices. It is believed that energy conservation has caused the largest part of the change in the demand.

A recent study of the potential reduction in overall U. S. fuel consumption led to the estimate that projected 1980 consumption of 96 quadrillion Btu (quads) could be reduced to 82 quads if all reasonable measures were instituted as rapidly as possible. It is far from clear that consumption of electric energy would be reduced to the same degree since many energy-efficient changes, such as increased provision and use of mass-transit facilities in urban areas, would actually increase consumption of electric energy. However, if the 1980 and later projections of the power demands as well as electrical energy were adjusted downward by 15 percent, the need for the station would be delayed by two years.

Economic growth in the United States may be slowed by the shortage of petroleum products and the resulting dislocations of the economy. The increased emphasis on the more efficient use of energy may lead to reduced consumption of electric energy for present uses, providing some margin for new uses without the construction of generating plants. However, the persistent shortage of petroleum fuels would also tend to induce additional use of electric energy as a substitute.

The conservation measures as well as other factors discussed in Sections 8.3.1, 8.3.2, and 8.3.3 show the uncertainties in the projections. These will be discussed in context with facilities to provide the needed capability in the next section.

8.4 NEEDED CAPABILITY

The applicant has changed his plans on the scheduling of two Byron and two Braidwood generating units. Now the first Byron unit and the first Braidwood unit are scheduled in May 1980 to provide power to meet the summer peak demand. The Byron Unit No. 2 will enter service in May of 1981 and be available for the summer peak of that year. The Braidwood Unit No. 2 will not enter service until October 1981, and thus will be available for the 1982 peak. The applicant has also changed his original schedule for the retirement of old units. Previously he had planned to retire 10 fossil-fired generating units that had a total summer capability of 980 MWe. Now he plans to only retire 4 units having a summer capability of 330 MWe prior to the service dates of Bryon and Braidwood units. In addition the applicant has cancelled some tentative plans to sell power during the summer peaks of 1981 and 1982. The staff views these changes as reasonable planning perturbations. Table 8.3 shows the applicant's projection of capability, demand, and reserves.

There are two main parts in the analytical development of estimated required capacity in future years for a utility: the power demand and reserve margin. The projected demand as well as the uncertainties in demand have been discussed. Future reserve margins necessary for reliable

Table 8.3. Commonwealth Edison's Capability, Demand, and Reserve Data[6A]

Year	1979		1980		1981		1982		1983	
S=Summer, W=Winter	S	W	S	W	S	W	S	W	S	W
A. CAPABILITY, MW										
(a) Owned capability	21,953	22,328	24,163	24,568	25,283	26,808	27,473	28,655	29,290	30,522
(b) Non-firm purchases (sales)	624	624	624	624	624	624	624	624	312	312
ADJUSTED CAPABILITY (a+b)	22,577	22,952	24,787	25,192	25,907	27,432	28,097	29,279	29,602	30,834
B. DEMAND, MW										
(a) Native	19,760	13,530	21,210	14,450	22,730	15,320	24,350	16,230	26,050	17,200
(b) Firm sales (purchases)	0	0	0	0	0	0	0	0	0	0
(c) Interruptible	-	-	-	-	-	-	-	-	-	-
ADJUSTMENT DEMAND (a+b+c)	19,760	13,530	21,210	14,450	22,730	15,320	24,350	16,230	26,050	17,200
C. RESERVE										
(a) MW (A-B)	2,817	9,422	3,577	10,742	3,177	12,112	3,747	13,049	3,552	13,634
(b) Percent $\left(\frac{A-B}{B} \times 100\right)$	14.3	69.6	16.9	74.3	14.0	79.1	15.4	80.4	13.6	79.3

systems will undoubtedly change. At the present time, the MAIN Reliability Council is attempting to develop criteria for reserves and for the assignments of reserves responsibility to its members. Transmission interconnections among utilities and generating unit forced-outage rates will be factors in this assignment.

The forced outage rates that will be experienced by large nuclear plants are uncertain. Poor experience would indicate a need to increase the reserve margin; counteracting this is the fact that as a system grows in size the needed reserve margin should decrease with the addition of constant size generating units. The applicant currently uses one of the lowest reserve margins in the utility industry. Part of the justification for this low margin is the number and strength of the interties with other utilities. Extensive interties increase the probability of obtaining outside help in emergencies. The reserve margin of 14% appears justified, based on the flexibility and experience of the applicant.

The major uncertainty in the need for power is the uncertainty in the projection of the peak power demand for 1980, 1981, and 1982. As previously stated the staff believes that the applicant's demand projection forms an upper bound.

From the staff's viewpoint it is reasonable for the applicant to defer the construction of the un-named fossil unit for April 1982 should demand not materialize; this would reduce the capacity by 1100 MW. Another adjustment that the applicant could make, if the demand did not materialize, would be to delay the construction schedule so that one unit would be completed one year later. The combined effect of these two procedures would reduce capacity by about 2200 MW. This corresponds to 9% of the applicant's projected summer peak (24350 MW) in 1982. In addition, the economic and environmental incentives to retire some additional older units, such as those indicated in the applicant's original retirement schedule, can be reviewed.

The reserves indicated by the applicant for 1980, 1981, and 1982 are 16.9, 14.0, and 15.4 percent. The staff finds that the critical item is the demand projections. Without the two Braidwood units the reserve for 1980 and 1982 would 11.6 and 6.3 percent. We believe that future information, especially the magnitude of the summer peak in this and next year, will allow timely adjustments to applicant's plans for power facilities. The sociological, economical, and environmental concerns can best be accounted for with such timely adjustments.

In view of the uncertainties in the demand projections, the staff concludes that the applicant's proposal to add the Braidwood and Byron Stations to its power system is a prudent one.

8.5 SUMMARY AND CONCLUSIONS

1. The applicant's historical growth (last 10 years) and the per capita use of electrical energy are very similar to those of the United States. The applicant's estimate of the future growth rate (percent power increase per year) of power demand, which was made after the national energy difficulties in late 1973 and early 1974, is about the same as estimates for the U. S., which were made prior to the energy shortage.

2. The applicant changed the proposed operational dates for the Byron and Braidwood units from the period of May 1979 through October 1980 in their initial Environmental Report, to May 1980 through October 1981 in an amendment. The applicant did not, however, change his estimate of peak power demands, but only stretched out the retirement schedule of the older facilities to meet these demands.

3. The applicant forecasts the peak power demand based on an economic and a weather component. Using expected values for the economic and weather variables, the applicant has had good success with this method of forecasting in the past. The staff has reviewed the econometric energy-forecasting method, which may be more suitable in these times of changing energy conditions because the explanatory variables may be adjusted for changing conditions, but the staff cannot confidently use such an approach because the elasticity information required for use of the method is not available for the applicant's service area; in addition, the projections of the economic variables themselves are uncertain.

Nevertheless, the staff wishes to emphasize that econometric studies to date have shown that electricity price is one parameter that strongly influences electrical energy demand. If this effect were not compensated by other variables that increase demand, after suitable time lags, a decrease in electrical energy consumption due to the real price increases in electrical energy would result.

4. The staff finds that the applicant's estimate of facilities to meet his projected power demand is a prudent estimate because the long lead time nuclear facilities must be scheduled before "the results are in" from our energy shortage. This estimate forms an upper bound. If the demand is less than anticipated, the un-named 1100 MW fossil unit (for 1982) can be deferred, and the nuclear plant construction slowed by one year. The action would reduce the summer peak capacity for 1982 by approximately 2200 MW, which is 9% of the presently projected peak demand for that year.

5. The staff finds that the annual electrical energy consumption projected by the applicant is high. The staff believes that from 1973 until 1982 the average annual growth rate of energy consumption will be no higher than it was in the period from 1960 through 1972; this corresponds to about 7%/yr. The 1982 energy consumption will be about 95% of the applicant's projections in its Environmental Report and in the MAIN Report to the FPC.

6. The staff concludes that in order to meet prudent estimates of power demand in the summers of 1981 and 1982, there is a need for the 4420 MWe of additional power capability represented by the Braidwood and Byron Stations.

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9. BENEFIT-COST ANALYSIS OF ALTERNATIVES

9.1 ALTERNATIVE ENERGY SOURCES AND SITES

9.1.1 Alternates Not Requiring Creation of New Generating Capacity

9.1.1.1 Purchased Power or Diversity Exchange

The expectation of continued growth of electric energy consumption is general throughout the U. S. so that nearly every electric utility plans to add generating capacity to meet its own load growth. A particular utility could avoid the construction of additional generating plants in the long term only if neighboring utilities consistently maintained capacity excess to their own needs.

As shown in Table 9.1, all of the larger MAIN companies and pools will require substantial capacity additions by 1981. Since the applicant is the largest midwestern electric utility, it would be particularly inappropriate for other smaller companies to add further capacity on the scale adequate to meet the applicant's need. (The total estimated reserve at the 1981 summer peak of MAIN companies other than the applicant is less than triple the capacity of the proposed Braidwood Station.)

Since midwestern utilities generally have summer-peaking loads, diversity exchange of power on the required scale is not feasible. The staff therefore considers that neither purchase nor exchange of power is a viable alternative.

9.1.1.2 Reactivating or Upgrading an Older Plant

The applicant does not have deactivated units of sufficient size to achieve 2240 MWe in generating capacity. Upgrading of existing units is not considered feasible because only the older and smaller of the applicant's generating units operate at sufficiently low efficiency for significant upgrading to be theoretically possible. Even if all of these could be increased in output by ten percent, only a few hundred MWe capacity would be added to the applicant's system. Moreover, the only practicable approach to "upgrading" would require replacement of boilers and turbines. The cost would probably be greater than that of new capacity while all output from the units would be lost during the protracted rebuilding.

The staff therefore considers that reactivating or upgrading existing plants is not a viable alternative.

9.1.1.3 Operating Peaking Units as Base Load Units

As discussed in Section 8.4, additional generating capacity as well as additional energy production will be needed by the applicant in about the same proportion. The base-load operation of existing peaking units would meet (in part, and uneconomically) only the latter need. It is, therefore, not a viable alternative.

9.1.2 Alternatives Involving Creation of New Generating Capacity

9.1.2.1 Energy Source Considerations

The staff believes that only nuclear- or coal-fueled plants are reasonable choices for a generating station planned at this time. Either type is feasible at any of the sites considered. The alternatives dismissed, and a brief discussion of each, are as follows:

(a) Natural gas. Additional supplies of this desirable fuel are not available to the applicant (Ref. 1, p. 9.2-5). Because of the probable long-term shortage of natural gas, the staff considers avoidable new industrial consumption of this fuel to be undesirable, in any case.

(b) Petroleum liquids. Because of the probable long-term shortage of petroleum fuels, the staff considers new consumption of these fuels to be undesirable where it can be avoided.

Table 9.1. Capability, Demand, and Reserve Projections for MAIN Member Groups (all values at summer peak, in thousands of MWe)

	Adjusted Capability			Adjusted Demand			1981
	1974	1981	Increase	1974	1981	Increase	Reserve
MAIN total	37.9	62.1	24.2	31.3	53.4	22.1	8.7
Applicant	16.3	26.5	10.2	13.4	23.1	9.7	3.4
MAIN less applicant	21.6	35.6	14.0	17.9	30.3	12.4	5.3
Illinois--Missouri Pool	11.2	18.8	4.4	9.6	15.6	9.2	3.2
Wisconsin--Upper Michigan Group	6.8	11.1	4.3	5.7	9.3	3.6	1.7

Source: MAIN's 1973 Reply to Appendix A of (FPC) Order No. 383 Mid-America Interpool Network, April 1973.

(c) Municipal solid wastes. The burning of municipal wastes as a power-plant fuel (mixed with coal) has been demonstrated in St. Louis.[2] The applicant has under consideration a program to use Chicago municipal wastes in this way. The staff considers this fuel only as a supplement to coal, since available supplies of waste will not meet the total demand for fuel.

(d) Hydroelectric power. There are no sites available near the applicant's service area where hydroelectric power in any significant amount can be generated.

(e) Geothermal energy. Geothermal energy is currently being developed as a power source in Europe and to a limited extent in the western part of this country. There are no known geothermal resource areas in Illinois.[3] Therefore, geothermal energy is not a viable alternative.

(f) Solar power. Solar power is also being studied at this time with increasing emphasis. Until low-cost methods of energy collection and storage can be coupled with solar units, this supply of energy will remain unsuitable as a source of base-load power.

(g) Wind power. Power from the wind has been demonstrated on a 1-MW scale in Vermont. Because wind power is intermittent, it is unsuitable as a source of base-load power.

Two advanced nuclear energy sources are the breeder reactor and the controlled thermonuclear reactor. Scientific feasibility of the latter has not yet been demonstrated. A demonstration breeder reactor plant is now in the design stage (the applicant happens to be the utility industry representative in this project) but demonstrated commercial feasibility is not expected for some years to come.

9.1.2.2 Regional Considerations

The applicant's strategy for site location is determined to a great extent by the concentration of load in the Chicago metropolitan area and by the limited available sources of cooling water. As shown in Fig. 9.1, existing or proposed plants are found on each of the larger rivers of Illinois and on Lake Michigan.

In order to reduce the risk of systemwide failure triggered by the outage of a single generating station or transmission line, the applicant limits the capacity planned for a single site to 10-20% of system capacity and tries to maintain roughly balanced use of the major transmission avenues into the metropolitan area (see Fig. 8.2). Considerations of this nature led to the choice of a Rock River site west of Chicago (Byron) and a Kankakee River site south of Chicago (Braidwood) for plants expected to begin operation in the 1979-1981 period. The choice reflects the need felt for geographical dispersion and the fact that the most recent plant additions prior to Byron and Braidwood will be Zion (1973, north), Collins (1976, southwest), and La Salle (1978, southwest).

The only feasible alternative subregion within the applicant's service area appears to be that along the Mississippi from Quad Cities north to the Wisconsin Border.* A new plant in the northern part of the Chicago metropolitan area would be well located from a systems-planning point of view but is probably not feasible because of the difficulty of acquiring a site and because of prohibitions on the use of Lake Michigan for cooling water.**

The staff sees no clearcut environmental balance favoring the Mississippi River subregion over the Kankakee subregion, or vice versa. Because of its greater flow, the Mississippi can more readily support the diversion of cooling water than can the Kankakee. On the other hand, the greater length of transmission line required for a site near the Mississippi would impose greater economic and environmental costs than for the Kankakee River location. On the whole, the applicant's strategy of using the several feasible subregions in turn seems reasonable and prudent both from environmental and systems-planning considerations.

9.1.2.3 Candidate Site-Source Alternatives

The applicant considered four sites along the Kankakee River (see Fig. 9.2). The staff considers each of them suitable for either coal-fueled or nuclear plants although not all cooling-system alternatives are viable at every site. They are:

(a) Momence site. The easternmost site considered is near the Illinois-Indiana border, three to four miles southeast of Momence, Ill., and about two miles south of the river. In Fig. 9.2, this site is identified as "Alternative I".

*The applicant has recently announced plans for a future plant near Savanna, Illinois, on the Mississippi about 50 miles west of the Byron site.

**Illinois has imposed a moratorium on once-through lake cooling of new plants while use of lake water for cooling-tower makeup would appear to violate the Great Lakes diversion limit set by the U.S.-Canada agreement.

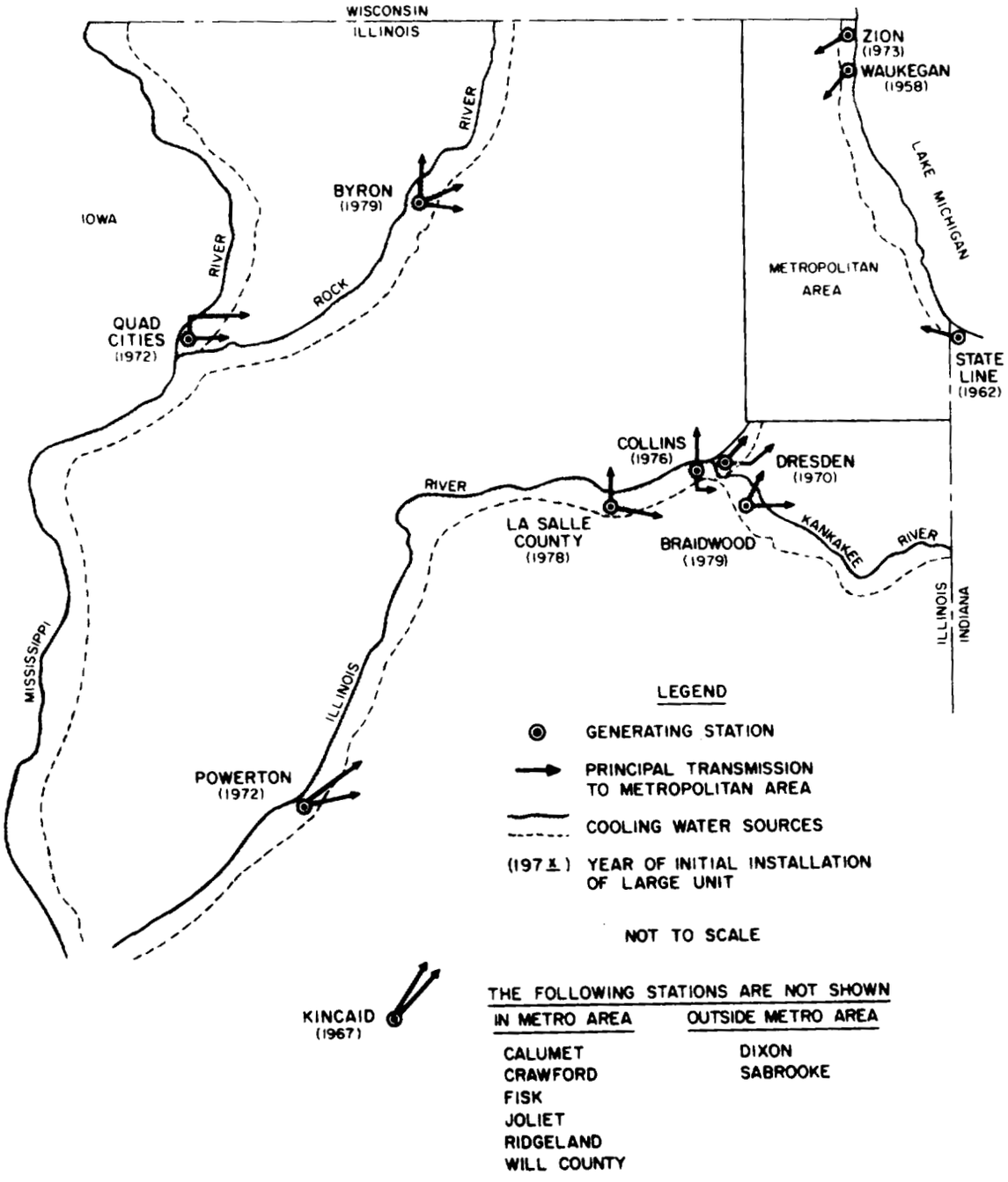

Fig. 9.1. Schematic Location of Inputs to the Metropolitan Area. From the applicant's Environmental Report.

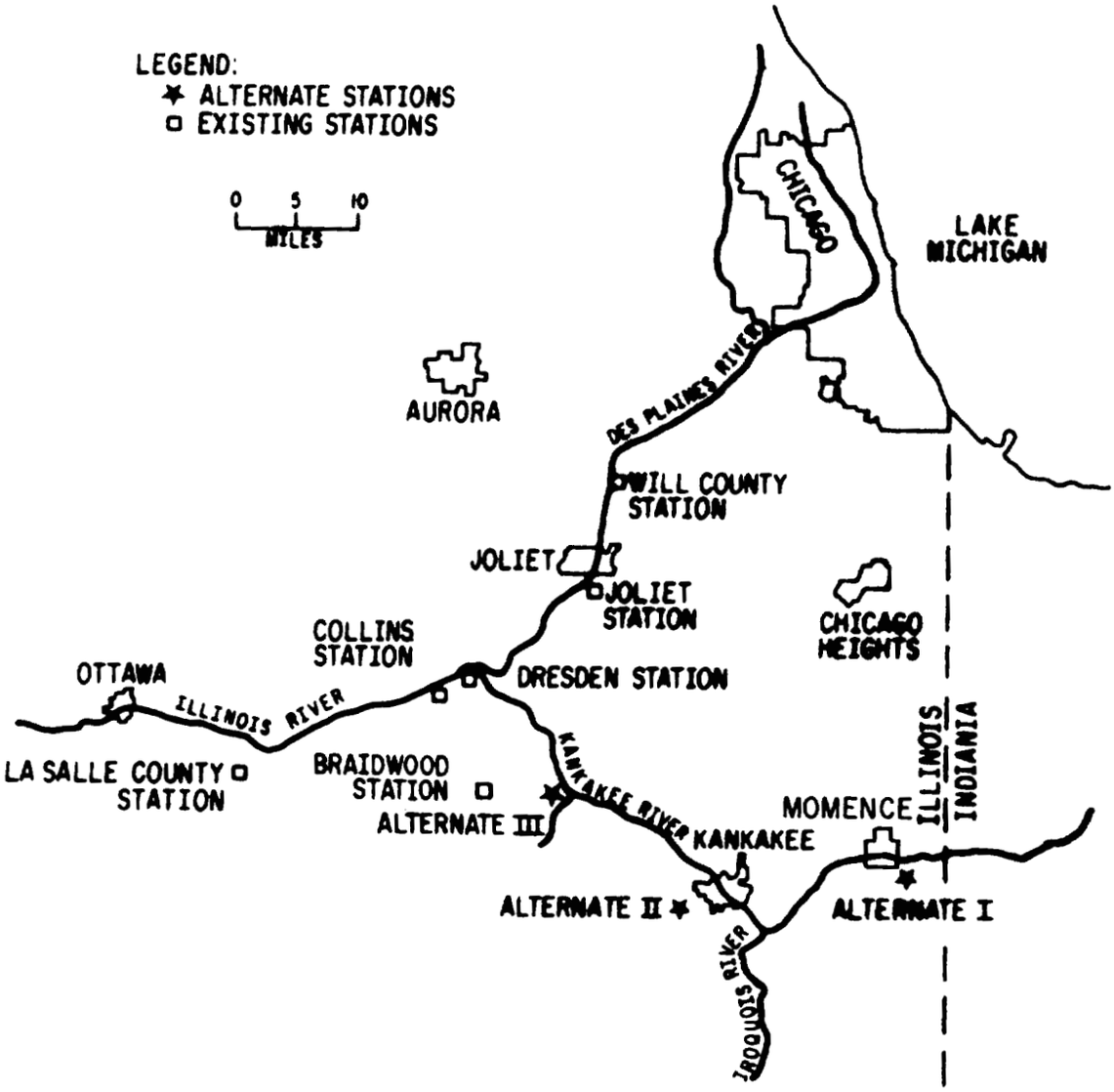

Fig. 9.2. Alternative Generating Station Sites. From the applicant's Environmental Report.

The present land use is mainly agricultural. The topsoil is sandy loam over about 25 feet of sand. Construction of a reasonably watertight cooling lake would be expensive and leaks might seriously disturb existing patterns of groundwater flow. For these reasons and because a lake would remove several thousand acres of crop land from production, a cooling lake would be inappropriate at this location.

Mean flow of the Kankakee River at Momence is about 1770 cfs with median flow about 1400 cfs.[4] The lowest recorded seven-day flow was 317 cfs in 1919 and the lowest one-day flow was 306 cfs in the same year. A 2240-MWe nuclear generating station cooled by wet towers or a spray canal would consume about 50 cfs at full power and an additional 25 to 50 cfs would be withdrawn but returned to the river as blowdown. Staff is of the opinion that ecological concern might require reduction of output level during extreme low-flow periods. A coal-fueled plant of equal capacity would consume less water, 35 to 40 cfs at full power.

(b) Kankakee site. This site, identified as "Alternative II" in Fig. 9.2, is a few miles west to southwest of Kankakee, Illinois. Land-use considerations would weigh against construction of a cooling lake since the present use is largely agricultural. A possible objection to the use of natural-draft wet towers at this site is that the prevailing wind could carry the plume over the city and/or airport. Low-flow problems would be less serious than at Momence because the confluence of the Kankakee and the Iroquois is upstream (mean flow of the Iroquois 473 cfs, lowest recorded seven-day flow 6.6 cfs).

(c) Horse Creek site. This site, identified as "Alternative III" in Fig. 9.2, is about four miles east of the reference Braidwood site, as shown in Fig. 9.3. Present land use is largely agricultural, with unmanaged woodland along the banks of the creek.

Because the mouth of Horse Creek is probably a spawning area for the Kankakee River fishery, creation of a cooling lake by a dam near the mouth would present an ecological problem. Because the lake would preempt most of the creek drainage area, flow below the dam would be greatly reduced unless blowdown were discharged to the creek, rather than directly to the river. In that case, however, temperature and water quality at the mouth would be controlled by the blowdown characteristics. Lake construction cost probably would be less than at Braidwood.

If wet towers were used, blowdown could be discharged directly to the river. The aquatic impacts would then be substantially the same for either the Horse Creek site or the reference site. Mean flow of the Kankakee River below Horse Creek is about 3900 cfs with median flow of about 2300 cfs. The lowest recorded seven-day flow was 347 cfs, in 1936.

(d) Braidwood site. The reference site is discussed in Section 2 and the expected impacts from station construction and operation are described in Sections 4 and 5. Considered as a site for a cooling lake, it has the advantage that about 80% of the proposed lake and dike area is now strip-mine spoil (see Fig. 2.3). With wet tower cooling, probably none of the mine spoil would be used, except perhaps as exclusion area. Of the remaining site area, about 790 acres, about 36%, is now or recently has been cultivated.

9.1.2.4 Evaluation of Site Alternatives

In most respects, each of the four sites considered presents much the same set of probable environmental impacts, those which arise from the change from agricultural to industrial use of the land and those due to the withdrawal, consumption, and return as warmed blowdown of river water. Quantitative differences appear with respect to land and water use. Selection of the Braidwood site, for any choice of cooling system, would result in the least withdrawal of productive land from agriculture. Many more miles of river would be affected by the aquatic impacts due to use of either of the upstream sites, Momence or Kankakee, than if Horse Creek or Braidwood were chosen. Also, the lower river flow at Momence would add to the ecological effect of the expected impacts, particularly under extreme low-flow conditions.

The staff has identified no class of environmental impact for which the Braidwood site would be inferior to any of the alternative sites considered or indeed to any site along the Kankakee. Moreover, as discussed below in Section 9.2.1.1, the staff concludes that the cooling lake alternative is preferable at any of the sites. For the lake, the Braidwood site is clearly the best because of the low value, ecologically and economically, of the mine spoil which would provide four-fifths of the lake and dike area and because of the minimal disruption of existing human activities which would result from construction of the lake.

9.1.2.5 Comparison of Coal and Nuclear Generating Stations

9.1.2.5.1 Economic. The comparative estimated 1980-1981 costs of construction and operation for 2240-MWe coal-fueled and nuclear plants are given in Table 9.2.* The staff estimates of construction costs are substantially higher than those of the applicant. For the

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*The terminology of Table 9.2 ("present value", "levelized", etc.) is explained in Appendix C.

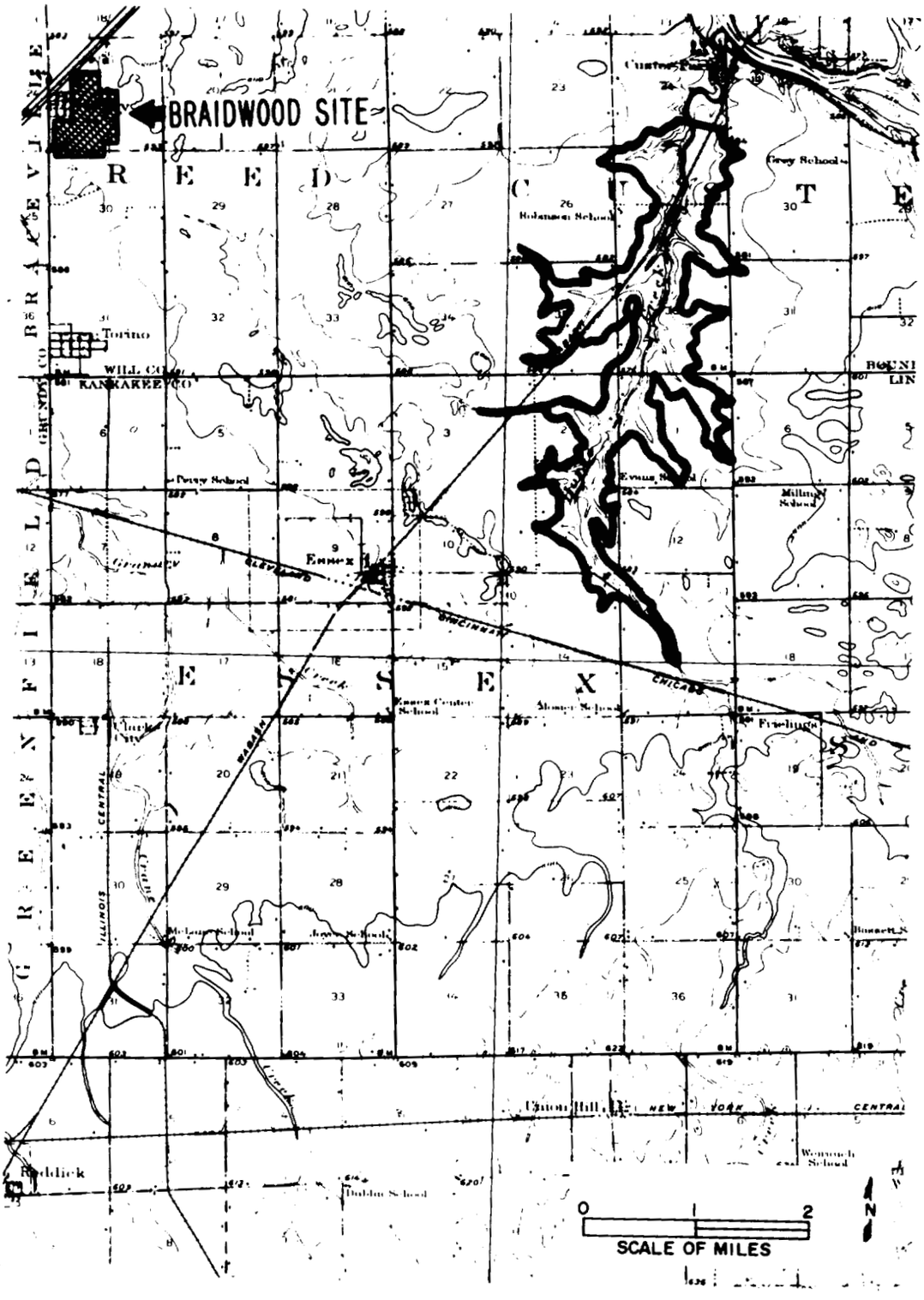

Fig. 9.3. Site Alternative III on Horse Creek. Modified from applicant's Environmental Report.

Table 9.2. Comparative Economic Costs for 2240-MWe Coal and Nuclear Plants at 65% Load Factor (in millions of dollars except as noted)

	Coal	Nuclear
Plant Construction		
Present value	820 (996)	922.4 (1213)
Levelized annual	78.1	87.8
Levelized mills/kWh	6.1	6.9
Plant Operation and Maintenance		
Present value	156	208
Levelized annual	14.9	19.8
Levelized mills/kWh	1.2	1.6
Fuel Consumption		
Present value	1326	337
Levelized annual	126.2	32.1
Levelized mills/kWh	9.9	2.5
Decommissioning		
Present value	1.7	16.6
Levelized annual	0.1	0.6
Levelized mills/kWh	.005	0.05
Total Life-of-plant Cost		
Present value	2304	1484
Levelized annual	219	140.3
Levelized mills/kWh	17.2	11.0

Notes: Values in parentheses are staff estimates. All others are based on applicant's estimates (Environmental Report, Table 9.3-2), adjusted to the following assumptions:

a. Taxes are not considered.

b. Discount rate is 8.75%.

c. Escalation of operation and maintenance costs is 5%.

d. Decommissioning costs in 1980-1981 would be $5 million for the coal plant, $50 million for the nuclear plant, with subsequent escalation at 5%.

Note also that natural-draft wet tower cooling is assumed for both plants.

coal plant, this appears to reflect a larger allowance for stack-gas cleaning equipment. For both plant types the staff assumed higher escalation rates and interest rate during construction than did the applicant. For either the staff's or the applicant's choice of assumptions, the significant relative comparison of overall costs favors the nuclear plant.

Because the comparison of capital costs favors coal plants over nuclear plants while the comparison of fuel costs tends towards the opposite, the overall economic balance is sensitive to the assumed load factor. The assumed fuel costs themselves are projected from current values on the basis of assumed escalation rates. Moreover, the estimated capital costs reflect assumptions as to interest rates and future taxes. Also, the staff believes that for a NEPA review, the tax component of capital charges should not be considered* whereas, for the applicant, taxes are as real as any other cost component. The effect of varying these assumptions is displayed in Fig. 9.4. The figure shows that, for a fixed charge rate of 9.52% in comparison with a coal-fired plant operating at 80% load factor, the nuclear plant is competitive at all load factors above 35%, for the high set of cost assumptions. For the low set of cost assumptions, the nuclear plant is competitive for all load factors above 55%.

According to the calculations displayed in Fig. 9.4, the nuclear station would generate electric energy at lower cost than the comparable coal-fueled plant (for load factor 0.3 or greater) unless the future price escalation rate for nuclear fuel proves to be markedly higher than that for coal (say 6% for nuclear vs. 3% for coal). The staff finds no reason to expect this course of events, which is contrary to the historical trend of relative prices. Therefore, the staff concludes that the nuclear alternative is the more prudent choice, with respect to economic considerations.

9.1.2.5.2 Environmental. Modern fossil-fueled plants operate at higher thermal efficiency than most current nuclear plants. (The high-temperature gas-cooled reactor, whose efficiency is about the same as coal- or oil-fired plants, is beginning to come into commercial use.) Also, some of the heat is discharged with the other combustion products through the stack to the atmosphere. Consequently the heat release to cooling water is about two-thirds that for a nuclear plant of the same electrical capacity.

The natural radioactivity in at least some types of coal is sufficiently great so that stack emissions have been measurable[5] but the degree to which the effect varies with coal type is not known. The release of radioactivity from modern nuclear plants is required to be "as low as practicable" in accordance with Commission regulations. Any resulting increase in dose levels will normally be a small percentage of doses resulting from natural background.

Substantial quantities of dust, sulfur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons, and aldehydes are emitted from coal- and oil-fired plants. The Environmental Protection Agency (EPA) has set limits on emission of particulate matter (dust), sulfur dioxide, and nitrogen oxides for new generating plants.[6] The control equipment and procedures required to meet the EPA standards probably will also change the emission of the other substances to some degree. However, the available data for combustion without pollution-control equipment[7] gives a rough indication of the magnitudes.

For coal-fueled plants equivalent to the station (2240 MWe), operating at 65% load factor (and without emission controls), the expected values are: carbon monoxide, 6 tons/day; hydrocarbons, 1.8 tons/day; and aldehydes, 62 lb/day.

The expected environmental impacts which would result from operation of the station or a coal- or oil-fired plant of equal output are compared in Table 9.3. Radiological and cooling system impacts are less for the fossil-fueled plants, as is the consumptive use of water through evaporation. However, these impacts are of modest consequence to the environment for the station, according to the assessment given in Section 5. Either type of fossil-fueled plant would release on the order of 200 tons per day of chemical pollutants to the atmosphere, while the release from the reference plant would be nil. The last consideration appears to the staff to dominate the balance of environmental effects during operation, which then favors the nuclear plant.

The impacts associated with construction appear to be qualitatively the same for either the reference or alternative plant. Quantitatively, the overall impact would be greater for the coal-fueled plant since more "disturbed" acreage is needed to accommodate fuel and ash storage. With the cooling lake alternative, the smaller waste heat of the coal-fueled plant might reverse the relative overall land-use impact.

The staff concludes that the reference (nuclear) plant is superior to the alternative coal-fired plant with respect to both overall environmental cost and probable economic cost.

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*This question is discussed more fully in Appendix C.

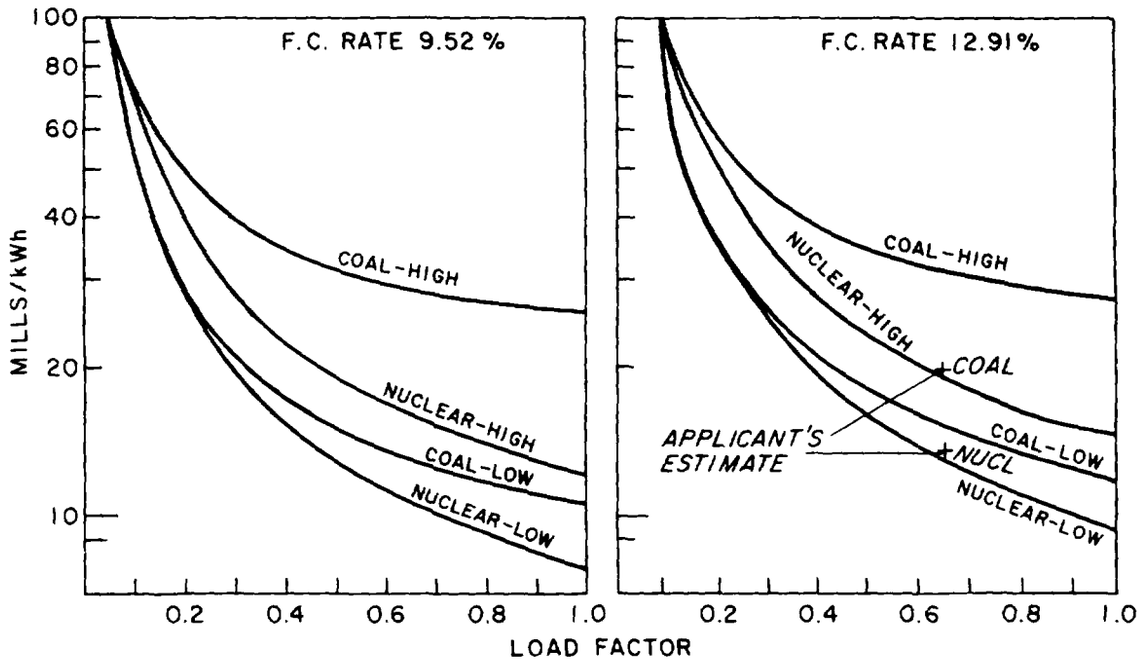

Fig. 9.4. Generating Cost Dependence on Load Factor for Alternative Coal and Nuclear 2240-MWe Plants. Values are plotted for fixed-charge rates of 9.52% (left diagram) and 12.91% (right diagram). The lower rate corresponds to the staff's uniform assumption of 8.75% discount rate and 30-year operating life with no allowance for property and corporate income taxes. See Appendix C. The higher rate is the applicant's value and includes estimated taxes. Other assumptions are given in the table below.

	Coal		Nuclear	
	Low	High	Low	High
Construction costs, millions of dollars	820	996	922	1213
Operation and maintenance costs, 1980-81, millions of dollars	8	15	10	13
Operation and maintenance escalation rate	5%	5%	5%	5%
Fuel costs, 1980-81, mills/kWh	4.5	9.0	2.0	2.5
Fuel escalation rate	3%	7%	3%	7%
Discount rate	8.75%	8.75%	8.75%	8.75%

Table 9.3. Comparative Environmental Costs for 2240-MWe Coal and Nuclear Plants at 65% Load Factor

Impact	Coal	Nuclear
Land Use		
Station proper, acres	ca 130	130
Fuel storage, acres	ca 70	minor
Waste storage, acres	ca 600	ca 50
Exclusion area, acres	not required	ca 1000[a]
Releases to Air		
Dust,[b] tons/day	20	none
Sulfur dioxide,[b] tons/day	240	none
Nitrogen oxides,[b] tons/day	140	none
Radioactivity, man-rem/year	small	small
Heat, billion Btu/day	170	240
Kankakee River		
Heat in blowdown, billion Btu/day	3.5	5
Chemicals dissolved in blowdown,[c] tons/day	70	100
Radioactivity, man-rem/year	none	0.24
Water consumed (evaporation) million gal/day	11	16
Fuel		
Consumed, tons/day	ca 13000	0.2
Ash, tons/day	ca 1300	0.2
Esthetic		
	Large industrial structures in both cases	
	Also coal yard, ash pit, 600-ft stack required	

[a]Non-exclusive use.

[b]Estimated on the basis that the plant just meets applicable EPA standards.

[c]Largely salts already present in river water but concentrated by about a factor two because of evaporative loss of water.

9.2 STATION DESIGN ALTERNATIVES

In this section possible modifications to the applicant's system are considered which might change significantly the balance between economic and environmental costs.

9.2.1 Cooling System Alternatives

Modern thermal electric generating plants (fossil-fueled or nuclear) discharge from 5100 to 7000 Btu of waste heat for each kilowatt hour of electrical energy generated. The higher figure is typical of current nuclear plants. (High-temperature gas-cooled reactor plants are expected to approach the efficiency of fossil-fueled plants.)

Of the established methods of large-scale cooling, the more widely used ones involve either (a) the transfer of heat (and water vapor) to the atmosphere by direct evaporation of water in "wet" cooling towers, spray ponds, or canals, or (b) discharge of heat to a body of water. Even in the latter case, the heat is eventually transferred to the atmosphere, chiefly by evaporation although radiation and convection play some part. Heat may also be transferred directly to the atmosphere, as in automobile radiators, by "dry" cooling towers.

The directly evaporative methods are commonly used in "closed-cycle" systems, in which most of the cooled water is recirculated. Additional water must be provided to make up for that evaporated (about 0.6 gallons per kilowatt-hour generated for a current nuclear plant). Since the original dissolved-salt content of the water evaporated is left in the system, the salt concentration in the recirculated water would rise continuously were not additional makeup water provided and a "blowdown" flow discharged from the system. Even if no dissolved salts were introduced in the plant, the concentration in the blowdown would exceed that in the makeup water by the inverse ratio of the flow rates.

In "once-through" or "open-cycle" cooling, all of the circulating cooling water is taken from a lake or stream and returned at a higher temperature to a point sufficiently remote from the intake so that little or no recirculation occurs. Except when the discharge stream is evaporatively cooled--such systems exist but are rare--no evaporation occurs within the plant but about 0.5 gallon per kilowatt-hour generated is eventually evaporated by the body of water with a corresponding increase in the concentration of dissolved salts (usually very small). With either open- or closed-cycle systems, it is usual for (relatively innocuous) chemical additions within the plant to increase the total salt content of the discharge appreciably.

9.2.1.1 Dry Cooling Towers

Dry cooling towers serve to transfer heat directly to the atmosphere without evaporation of a coolant and therefore have minimal impact on the environment. They have been used for several small thermal electric plants in arid regions, particularly abroad, but the high coolant-return temperature in hot weather results in a condenser back-pressure which is too high for any large (over 300 MWe) steam turbines currently available.[8]

Even if suitable turbines become available, a severe cost penalty would be incurred by the choice of dry-tower systems. On the basis of a recent study,[9] the staff estimates a cost penalty of about $160 million for an optimized dry-tower system relative to the reference system, assuming that the back-pressure-tolerant turbines were no more costly than those of the reference design.

9.2.1.2 Once-through Condenser Cooling

The flow in the Kankakee River is not sufficient to provide the 3250 cfs of water required continuously for such cooling.

9.2.1.3 Natural-draft Wet Cooling 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. Natural-draft towers have been chosen for many recently designed generating stations (e.g., the applicant's Byron Station) because they do not give rise to the ground-level fogging and icing which are sometimes troublesome with spray cooling or mechanical-draft wet tower systems. The natural-draft tower is also comparatively readily maintained and is quiet in operation.

The primary disadvantage is the great size required for effective units. A tower for a 1000-MWe nuclear unit is typically 500 feet high and 400 feet in base diameter. In flat or rolling terrain, such huge structures tend to dominate the landscape for miles.

9.2.1.4 Mechanical-draft Wet Cooling Towers

In mechanical-draft towers the air movement needed to produce the required evaporation from the cooling water stream is generated by motor-driven fans. The towers are much lower than in the natural-draft case and are cheaper to build. This advantage is largely offset by the cost of fan power and maintenance so that the overall life-of-plant cost is much the same for natural-draft and mechanical-draft tower closed-cycle systems.

Because of the smaller tower height, the probability of induced localized fogging and icing near mechanical-draft towers is markedly greater than for natural-draft towers.

The smaller towers are less conspicuous than natural-draft towers. On the other hand, they are much noisier, generating mildly irritating noise levels as far away as three to four thousand feet.

9.2.1.5 Spray Canal or Pond

A spray canal is an elongated pond and in the case of the station would be several miles in length. In contrast with cooling towers and ponds which have been used for decades, there has been little operating experience with large spray cooling systems, especially in winter, the season of greatest interest. Experience at a power plant with a spray cooling canal in northern Illinois indicated no serious environmental or fogging problem after two seasons of operation.[10-12]

Experience with spray canals in Michigan[13] and New Hampshire[12] are similar. As with cooling ponds, the fogging and icing effects decrease with distance; a study[13] indicates that a distance of 600 feet from the canal to public roads and switchyards was sufficient to preclude any hazardous conditions arising from the drifting spray.

From the limited experience to date, it is reasonable to expect that spray cooling systems will create more severe icing conditions near the spray canal during winter than mechanical-draft cooling towers and quiescent cooling ponds, with drift being the primary cause of the difference.

9.2.1.6 Cooling Lake

The cooling lake is a simple and easily maintained system (assuming favorable soil conditions, etc.) and little susceptible to storm or tornado damage. Because of the great heat capacity of the impounded water, system performance suffers very little in the short-term from extremely hot weather. Similarly, the lake system is tolerant of large temporary overloads. The chief disadvantage is the large land area which must be committed to the lake, typically from one to three acres per MWe plant rating.

9.2.1.7 Water Consumption Considerations

Kankakee River flow may be as low as 350 cfs (seven-day) during periods of extended drought. Diversion of 232 cfs for a proposed multi-city municipal water system has been authorized by the State of Illinois.* Although it is uncertain that this specific plan will be implemented, it is likely that substantial withdrawal of river water for municipal use will develop during the life of the proposed Braidwood station. The station itself would evaporate about 50 cfs of river water during full-power operation, if cooled by a wet-tower system.

Since it is conceivable that the actual extreme low flow of the river (after diversion of, say, 200 cfs to municipal supplies) will be 150 cfs, the further withdrawal of 70 cfs for station operation (20 cfs returned as warmed blowdown) might well be environmentally unacceptable. If the station were prohibited from operation during periods of extreme low flow, the applicant's ability to meet demand might be reduced at a time when demand was greatest, since extreme low flow often results from extended periods of hot, dry weather when air-conditioning load is high.

The dilemma can be avoided by the choice of a cooling lake, since the station would then be able to operate as a closed system without withdrawal of river water for a period of many weeks. (Three weeks of full-power operation would draw down a 2640-acre lake by about one foot.)

The staff considers that the ability to decouple the station from the Kankakee River during extreme low-flow conditions is a substantial environmental advantage for the proposed cooling lake. No balancing disadvantage has been identified.

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*See Appendix E for a summary description of the proposed system.

9.2.1.8 Economic Considerations

The applicant has estimated the comparative costs of the station for each of several choices of cooling systems, 4800-acre lake, natural-draft wet towers, mechanical-draft wet towers, and 2640-acre lake (Ref. 1, Tables 10.1.2 and 10.1.3). These estimates, which the staff considers reasonable, suggest that either type of tower system would be somewhat less costly than either size lake.

Cooling System	Total Station Cost, millions of dollars
4800-acre lake	930
Natural-draft towers	907
Mechanical-draft towers	901
2640-acre lake	919

9.2.1.9 Evaluation of Cooling System Alternatives

With present patterns of water use on the Kankakee River, the staff sees little to choose among the reasonable alternatives except that land use consideration weighs against the larger lake. However, considering the possibility that large withdrawals from the river will develop during the life of the station, the staff concludes that the 2640-acre lake is favored because its choice would minimize damage to the river ecosystem during extreme low-flow conditions.

9.2.2 Discharge Structure

The proposed discharge scheme consists of a shoreline outfall which allows the blowdown from the cooling system to enter the Kankakee River at the surface of the river. The staff evaluated the alternative discharge structures discussed by the applicant (Ref. 1, p. 10.3-1). The staff concludes that the alternative structures offer no significant improvement in the overall impact on the environment.

9.2.3 Chemical and Sewage System

No alternatives were considered, as the staff has found the proposed system environmentally acceptable.

9.2.4 Biocide System

The applicant proposes to use a mechanical method for controlling organic growth in the main condensers, thus obviating the need for large amounts of chlorine. The use of a mechanical tube cleaning system would not eliminate the need for biocide treatment in the plant, as such treatment would still be required in the station service and cooling water systems. Accordingly, this is more a technique for reducing the use of biocides in the plant than for replacing their use. Since the total residual chlorine concentration in the cooling lake blowdown is expected to be below 0.001 ppm, the proposed biocide system is acceptable.

9.3 ALTERNATIVES TO NORMAL TRANSPORTATION PROCEDURES

Alternatives such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station have been examined by the staff for the general case. It was concluded that the environmental impact of transportation under normal or postulated accident conditions is not considered sufficient to justify the additional effort required to implement any of these alternatives.

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12. J. E. Carson, "The Atmospheric Consequences of Thermal Discharges from Power Generating Stations," Annual Report, Radiological Physics Division, Argonne National Laboratory, 1971.

13. D. P. Hoffman, "Spray Cooling for Power Plants," American Power Conference, Chicago, May 1973.

10. CONCLUSIONS

10.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

10.1.1 Abiotic Effects

10.1.1.1 Land

Construction and operation of the Braidwood Station will result in the 30-40 year diversion of approximately 734 acres of agricultural land and 848 acres of woods and fallow fields to industrial use. In the strip-mine environs, the visual impact of the large plant buildings should not be unduly objectionable. The cooling lake dike will appear from offsite as a grass-covered ridge which should be more pleasing to view than much of the unsightly strip mine land which was flooded.

About 84 miles of transmission lines involving 2376 acres of right-of-way will be erected mostly through farmland and open fields that are sparsely populated. The lines and towers will be regarded by many as having an adverse esthetic impact.

Construction of the Braidwood Station and its associated cooling lake will affect 11 private dwellings and two mobile homes involving the relocation of 32 persons.

10.1.1.2 Water

About 57 cfs of water are expected to be lost from evaporation and seepage from Braidwood Lake during operation of the Braidwood Station. About 10 cfs will be restored by rainfall on the average, so that the net loss to the Kankakee River will be 47 cfs. About 0.67 cfs of water from the St. Peter sandstone stratum will be used for makeup water and potable water for the station.

10.1.1.3 Air

The construction of the station will cause dust within the construction area. During station operation there will be no adverse impact on the air quality.

Local fog may occur infrequently around the lake. It is not expected to interfere with traffic at the closest State or county road.

10.1.1.4 Noise

Construction activities, particularly blasting, will unavoidably generate objectionable levels of noise. During plant operation, offsite noise will be negligible.

10.1.2 Biotic Effects

Much of the vegetation and animal life in the Braidwood site will be displaced by construction work and flooding. Some of the animals will be lost. Animal displacement and loss will not endanger the species in the area.

During the construction phase, localized damage will occur in the areas where the intake and discharge systems will be constructed. Biota will be disturbed and in some cases destroyed. Although the extent of this damage cannot be predicted accurately, it is estimated that it will be relatively small and to some extent reversible.

During the 7-day 10-year recurrent low flow period, approximately 20% of the water and its entrained small biota will be diverted to the cooling lake. The staff considers that a large fraction of the organisms entrained in this fraction of river water would be lost. Losses of this magnitude might stress the river downstream of the station, but the river ecosystem is expected to recover when normal flow returns.

During operation of the station, the cooling lake blowdown will result in a thermal plume. The staff has calculated that during normal meteorological conditions the 3°F isotherm will encompass 1.6 acres. The staff anticipates that the aquatic impacts due to normal chemical releases combined with increased temperature are not expected to be detectable outside a mixing zone of about two acres.

The growth of algae in the cooling lake, if allowed to become excessive, could impose an adverse impact upon the Kankakee River below the discharge. Should this occur the staff will require that control of the the algae growth to prevent an adverse disturbance to the river ecosystem.

The staff does not believe that any adverse radiological effects will occur since the radioactive effluents are reduced to as-low-as-practicable. The 800-1000 man-rem/yr received as occupational on site exposure is 0.2 percent of the annual total to the 1980 population within a 50-mile radius and the risk associated with this exposure is no greater than those risks normally accepted by workers in other present day industries.

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

10.2.1 Summary

The National Environmental Policy Act (NEPA) requires the staff to consider specifically the long-term consequences to economic productivity of building and operating Braidwood Station, and of alternative "short-term uses of man's environment". In this context, short-term is taken to mean the period of construction and operation, and long-term to mean the period beyond the service life of the plant. In the case of nuclear power plants, there will be strong economic pressures to continue to use the chosen site (or adjacent ones) for power generation for several plant lifetimes. In this event, the later operational period may also be considered long-term.

The economic productivity of the site while it is used to generate electricity will be extremely large compared with the productivity from agricultural or other likely uses of the site. The resulting boost to the region's economy is expected to result in a corresponding large increase in the long-term productivity, compared to a smaller long-term effect for uses other than power generation. The principal effects of Braidwood Station inimical to long-term productivity are the consumption of depletable resources (see also Section 10.3) and the cost of decommissioning (Section 10.2.2.2). The overall conclusion of the staff with regard to long-term productivity is that the negative aspects of building and operating Braidwood Station are overbalanced by the positive long-term effects.

10.2.2 Enhancement of Productivity

The strong correspondence between gross national product and electrical energy sales is indicated in Fig. 10.1. The Braidwood plant will be capable of producing 2240 MWe of power, which is 16% of the applicant's installed capacity in 1973 serving 8,000,000 people. The effect of Braidwood nationally is not insignificant, its capacity amounting to nearly 1% of the national total in 1971. These facts bolster the conclusion in the summary above that the production of a large amount of relatively low-cost power may be expected to boost significantly the wealth-producing potential of the region and of the nation.

Within Will County, where the environmental impacts will be the greatest, the payment of taxes to the County is expected to result in increased local industrial activity, which should tend to enhance local long-term productivity.

At the end of the plant's useful life, valuable properties such as the cooling lake and transmission facilities would remain. If these facilities were continued in use for power generation and distribution, the region's long-term productivity would continue to be enhanced. When the site area is finally abandoned for power generation purposes, productive use of the cooling lake for recreation purposes can be envisioned. No productive use for the strip-mine area is forseen other than for constructing the cooling lake.

10.2.3 Curtailment of Long-Term Productivity

The consumption of depletable resources could adversely affect long-term productivity, but a more productive use than for power generation is not evident at this time. This subject will be considered in Section 10.3. Similarly, the costs of decommissioning must be charged against the long-term benefits to productivity. These costs will be discussed in Section 10.2.3.3.

10.2.3.1 Agriculture

An adverse effect of plant construction and operation on long-term productivity would be the removal of 734 acres of land from agricultural production. This includes 270 acres for the plant site, 381 acres inundated by the cooling lake, and a minor acreage occupied by transmission tower bases. At the termination of the operation of the Braidwood site for power generation, most of this land would have been altered so that it could not be returned to agricultural production.

10.2.3.2 Water Usage

If the Braidwood area were used on a long-term basis for power generation, the principal effects on the Kankakee River would be the evaporation of some cooling water and the loss of a small fraction of the river biota to the make-up water. The consumptive water use would stop and the small loss of river biota would cease on termination of plant operation.

10.2.3.3 Decommissioning

No specific plan for the decommissioning of the Braidwood 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 authorization from the AEC.

To date, experience with decommissioning of civilian nuclear power reactors is limited to six facilities which have been shut down or dismantled: Hallam Nuclear Power Facility, Carolinas Virginia Tube Reactor (CVTR), Boiling Nuclear Superheater (BONUS) Power Station, Pathfinder Reactor, Piqua 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 capt the pipes; and establish an exclusion area around the facility. The Piqua decommissioning operation was typical of this approach. (2) In addition to the steps outlined in (1), remove the superstructure and encase in concrete all radioactive portions which remain above ground. The Hallam decommissioning operation was of this type. (3) Remove the fuel, all super-structure, 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. 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 plus an annual maintenance charge in the order of $100,000.[1] 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.[2] At present land values, it is not likely that consideration of an economic balance alone would justify a high level of 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 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 regulations in effect at the time to protect the health and safety of the public.

10.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Numerous resources are used in construction and operation of a major facility such as this station. Some of these uses involve irreversible and irretrievable commitments

Irreversible commitments concern changes set in motion by the proposed action which at some later time could not be altered so as to restore the present order of environmental resources. Irretrievable commitments are the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization.

10.3.1 Commitments Considered

The types of resources of concern in this case can be identified as: (1) material resources--materials of construction, renewable resource material consumed in operation, and depletable resources consumed--and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources which, generally, may be irreversibly committed by the construction and operation are: (1) biological species destroyed in the vicinity, (2) construction materials that cannot be recovered and recycled with present technology, (3) materials that are rendered radioactive but cannot be decontaminated, (4) materials consumed or reduced to unrecoverable forms of waste, including uranium-235 and -238 consumed, (5) the atmosphere and water bodies used for disposal of heat and certain waste effluents, to the extent that other beneficial uses are curtailed, and (6) land areas rendered unfit for their original uses.

10.3.2 Biotic Resources

Construction of the station and the cooling lake will result in the permanent loss of terrestrial habitat. Much of this habitat is the result of recent land disturbance due to coal strip-mining and is in stages of early successional flux; thus, it is difficult to evaluate the intrinsic value of the existing ecosystem(s). No rare or endangered species are known to occupy the site. The staff is of the opinion that the loss of such habitats will not adversely affect the ecology of the Braidwood region. Although there will be an irretrievable loss of some aquatic biota, the staff does not believe that the biotic populations of the Kankakee River will be significantly damaged or reduced as a result of construction and operation of Braidwood Station during normal river flows.

10.3.3 Material Resources

10.3.3.1 Construction Materials

Materials of construction are almost entirely of the depletable category of resources. Concrete and steel constitute the bulk of these materials, but there are numerous other mineral resources incorporated in the physical plant. No commitments have been made on whether these materials will be recycled when their present use terminates.

Some materials are of such value that economics clearly favors recycling. Plant operation will contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed in order to reclaim and recycle the consitutents. Some parts of the plant will become radioactive by neutron activation. Radiation shielding around each reactor and other components inside the dry-well portion of each containment structure constitute the major materials in this category, for which it is not feasible to separate the activation products from the base materials. Components that come in contact with reactor coolant or with radioactive wastes will sustain varying degrees of surface contamination, some of which could be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry. Quantities of materials used in other nuclear plants of about the same power output as the Braidwood Station but not necessarily of the same typical design are shown in Table 10.1. Production, consumption, and reserves are also given.

Construction materials are generally expected to remain in use for the full life of the plant, in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend upon need.

10.3.3.2 Replaceable Components and Consumable Materials

Uranium is the principal natural resource material irretrievably consumed in plant operation. Other materials consumed, for practical purposes, are fuel cladding materials, reactor control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion exchanger regeneration, ion exchange resins, and minor quantities of materials used in maintenance and operation. Except for the uranium isotopes 235 and 238, the consumed resource materials have widespread usage; therefore, their use in the proposed operation must be reasonable with respect to needs in other industries. The major use of the natural isotopes of uranium is for production of useful energy.[3]

TABLE 10.1. Estimated Quantities of Materials of Construction of Water-Cooled Nuclear Power Plants

Material	Approximate quantity used in plant[a] (kg)	World production[b] (metric tons)	U.S. consumption[b] (metric tons)	U.S. reserves[b] (metric tons)	Strategic and critical material[c]
Aluminum	90,000	9,089,000	4,227,000	8,165,000	Yes
Asbestos	90,000	2,985,000	712,000	1,800,000	Yes
Beryllium	600	288	308	72,700	Yes
Cadmium	5	17,000	6,800	86,000	Yes
Chromium	300,000	1,590,000	398,000	2,000,000	Yes
Copper	4,000,000	6,616,000	1 905,000	77,564,000	Yes
Gold	1	1,444	221	9,238	No
Lead	15,000	3,329,000	1,261,000	32,024,000	Yes
Manganese	800,000	7,711,000	1,043,000	907,000	Yes
Mercury	30	9,837	2,727	703	Yes
Molybdenum	5,000	64,770	23,420	2,858,000	No
Nickel	200,000	480,000	129,000	181,000	Yes
Platinum	2	46.5	16.0	93.3	Yes
Silver	2,000	8,989	5,005	41,057	Yes
Steel	20,000,000	574,000,000	128,000,000	2,000,000,000	No
Tin	100	454,200	82,100	47	Yes
Tungsten	10	35,000	7,300	79,000	Yes
Zinc	200,000	5,001,000	1,630,000	30,600,000	Yes

[a]Quantities used are compiled from various sources for two-unit plants of about the same power rating as Braidwood Station.

[b]Production, consumption, and reserves were compiled, except as noted, from the U.S. Bureau of Mines publications *Mineral Facts and Problems* (1970 ed., Bur. Mines Bull. 650) and the *1969 Minerals Yearbook*. They are expressed in terms of contained element, regardless of the form. "Production" usually includes material recovered from both primary ores and secondary sources such as scrap recovery. Production and consumption figures are for 1969 unless otherwise noted. Estimates of reserves were published in 1969 but are based on data compiled over a number of years. The reserves stated are the quantities extractable at currently competitive prices; they include inferred as well as measured and indicated ores, when such information was available. Usually, resources recoverable with advanced methods or at greater cost are much greater than the reserves listed.

[c]Designated by G. A. Lincoln, "List of Strategic and Critical Materials," Office of Emergency Preparedness; *Fed. Regist.* 37(39): 4123 (Feb. 26, 1972).

The two reactors in the plant will be fueled with uranium enriched in the isotope 235. After use in the plant, the fuel elements will still contain uranium-235 slightly above the natural fraction. This slightly enriched uranium, upon separation from plutonium and other radioactive materials (separation takes place in a chemical reprocessing plant), is available for recycling through the gaseous diffusion plant. Scrap material containing valuable quantities of uranium is also recycled through appropriate steps in the fuel production process. Fissionable plutonium recovered in the chemical reprocessing of spent fuel is valuable as fuel for power reactors.

If the two units of this plant operate at 70% of capacity, about 8350 metric tons of contained natural uranium in the form of U_3O_8 must be produced to feed the plant for 30 years. The assured U.S. reserves of natural uranium recoverable at (1) a cost of $8 or less per pound of U_3O_8 are 277,000 metric tons of uranium and (2) a cost of $10 or less per pound of U_3O_8 are 340,000 metric tons of uranium.[4] In addition to the assured reserves, the potential uranium resources in conventional deposits recoverable at (1) $8 or less per pound of U_3O_8 are estimated to be 450,000 metric tons of uranium and (2) $10 or less per pound of U_3O_8 are estimated to be 700,000 metric tons of uranium, but this increment will require a major effort in exploration and development to bring it into production.[5] The long-term uranium resource situation in the U.S. will be dependent upon the larger expected reserves of ord recoverable at greater cost and upon utilization of breeder reactors. Plutonium produced in light water reactors, if recycled as fuel to these same reactors, will reduce the requirements for uranium by 15 to 20 percent.

The 8350 metric tons of mined natural uranium required to feed the fuel cycle for this two-reactor plant consists of 59 metric tons of uranium-235, with the balance uranium-238. In the power plant itself, 43 metric tons of uranium-235 will be consumed by fission. Uranium consumption in the proposed operation is considered by the staff to be a reasonable productive use of this resource.

Reactor fuel and control rod materials consumed in a station similar to Braidwood are listed in Table 10.2. In view of the quantities of materials in natural reserves, resources, and stockpiles, and the quantities produced yearly, the expenditure of such material is justified by the benefits of the electrical energy produced.

10.3.4 Water and Air Resources

Because of the rapidly renewable nature of the Kankakee River and the regenerative powers and vast dispersive capacity of the atmosphere, the use of these resources to dilute and disperse the effluents of heat, chemicals, and radioactive materials from the operation of Braidwood Station is not considered to represent irreversible or irretrievable commitments of these resources.

10.3.5 Land Resources

The staff has identified the following irreversible and irretrievable commitment of land resources: (1) a small area to store the station's radioactive components at the end of its service life, (2) about ten acres of land for the transmission tower bases, and (3) 381 acres of agricultural land inundated by the cooling lake. The latter loss may be offset to some extent by the potential use of the cooling lake for recreational purposes.

10.3.6 Societal Commitments

No irreversible long-term societal commitments, including continued use of the site after decommissioning for the purpose of generating power, are expected by the staff. Some of the highly radioactive wastes of the station, will, however, be added to the existing and future wastes of other nuclear programs and as such will constitute a long-term commitment on future societies. This aspect of nuclear activities is the subject of separate commission regulations and controls and is, therefore, considered outside the scope of this statement.

10.4 BENEFIT-COST BALANCE

The staff estimates of the environmental and economic benefits and costs, to be expected from construction and operation of the proposed nuclear power station, have been developed in earlier sections of the statement. These estimates are reviewed and classified in Section 10.4.1 below. The staff assessment of the balance between benefits and costs is developed in Section 10.4.2. It supports the conclusion that construction and operation of the proposed station is desirable.

Table 10.2. Consumption of Materials Used in a 2300-MWe PWR (40 years)

Material	Quantity used in fuel and control rods (metric tons)
Cadmium	1.1
Indium	2.9
Silver	22
Tin	9.2
Uranium	
U-235	65
U-238	180
Zirconium	605

10.4.1 Benefits, Costs, and Transfers

Benefits, costs, and transfers (e.g., tax payments) are summarized in Tables 10.3 through 10.6. Certain matters of explanation and interpretation are treated for each table in the subsections below.

10.4.1.1 Primary Benefits

The direct objectives of the applicant are to produce relatively low-cost electrical energy and to provide additional generating capacity to meet peak demand with adequate reserves (Table 10.3). The benefit/cost analysis should consider also the effect of an increased energy supply on economic growth. The historical correlation between electrical energy consumption and gross national product (GNP), shown in Fig. 10.1 implies that continued economic growth requires an increasing supply of electrical energy. Of course, many other inputs such as raw materials, labor, etc. are needed as well. Despite the substantial uncertainty of the evaluation, the staff believes that a rough assessment is preferable to ignoring the need of increased electrical energy supplies for continued economic growth. The desirability of further economic growth and the value of GNP as an indicator of national well-being are themselves under some public challenge at present. However, the staff has found no reason to doubt the continued acceptance by the public of reasonably full employment and (at least) the maintenance of the present "standard of living" as appropriate national goals. That these goals are achievable without average increases of a few percent per year (in constant dollars) of GNP is not evident.

10.4.1.2 Environmental Costs

a. Costs Related to Production of Energy. The environmental costs associated with the nuclear fuel cycle have been treated generically.[6] Since these costs are largely independent of the design and location of any particular nuclear generating plant, they are not considered here and do not appear in Table 10.4.

b. Costs Related to Consumption of Energy. Environmental costs associated with the consumption of electrical energy are not considered elsewhere in this statement because they are in no sense specific to the proposed station. Since these costs do tend to balance the benefits shown in Table 10.3, however, they are listed in Table 10.4 on the basis of the following discussion.

TABLE 10.3. Primary Benefits from Station Construction and Operation

Description	*Reference Section*
Literal statement:	
Annual production of about 12.5 billion kWh of electric energy	8
Contribution to system reliability of 2240 MWe generating capacity	8
Alternative interpretative statement:	
Economic activity associated with $4 to $6 billion GNP (1958 dollars) for the life of plant	10.4.1.1

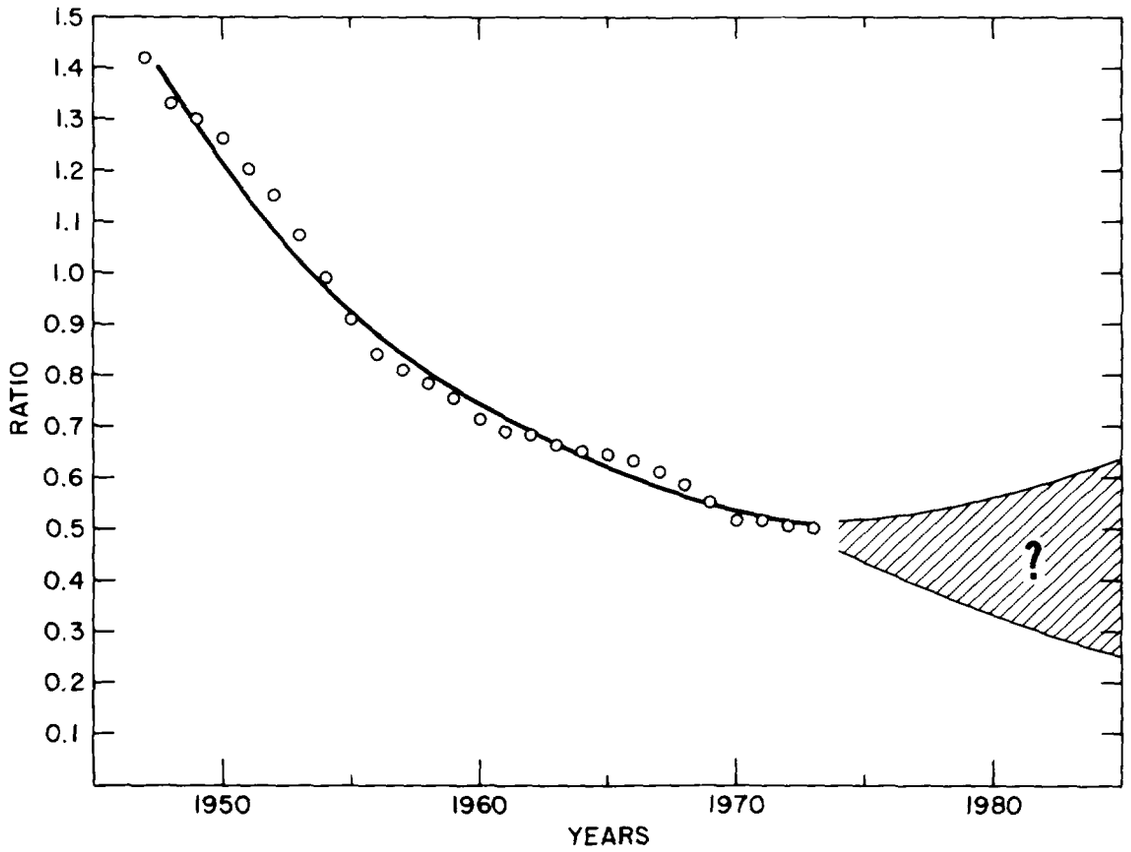

Fig. 10.1. Ratio of GNP to Electric Energy Sales (1958 dollars/kWh).

Table 10.4. Braidwood Station Environmental Costs

Effect	Reference Section	Summary Description
Land use:		
Erosion	4.1.1, 4.1.2	Minor erosion during construction, will be minimized by construction practices.
Loss of agricultural production	4.1	Station proper, 70 acres (reversible); exclusion area, 200 acres (reversible); pipeline corridor and river site, about 83 acres (partially reversible); lake, 381 acres (doubtful reversibility); transmission tower bases, 10 acres.
Visual	5.1.2	Station proper consists of large industrial-type structures discordant with rural surroundings; about 84 miles of transmission line generally regarded as visually unappealing.
Water use:		
Evaporative consumption	5.2.1	About 47 cfs, 1% of normal Kankakee River flow, 11% of (seven-day 10-year) low flow.
Salts discharged to Kankakee River	3.6, 5.2.3	104,000 lb/day in excess of normal river concentration in blowdown--leads to 4 ppm increase in river TDS.
Thermal plume in Kankakee River	3.4.2.2	Maximum area of 5°F isotherm: 2 acres
Radiological impact:		
Cumulative population cost (50-mile radius)	5.3	15 man-rem/yr
Whole-body dose to nearby residents	5.3	Less than a few percent of natural background.
Occupational	5.3	1,000 man-rem/yr
Ecological impacts:		
On aquatic life	5.4.2.2	Destruction of approximately 3% plankton in river cross section at intake--rapid downstream recovery--possible 20% loss at low river flow.
	5.4.2.2	Some entrainment mortality of fish at intake--will not significantly affect fish population.
	5.4.2.2.3	Possible attraction of fish to discharge plume--effect on fish populations probably undetectable.
		Growth of algae if excessive could impose adverse effect on river--can be controlled.
		Temporary disturbance of aquatic communities during construction of intake and discharge.
On terrestrial life	4.3.1	Some animals will be lost.
Social and economic effects:		
During construction	4.4	Greatly increased traffic on certain roads, possible social problems in nearby towns connected with short-term population increase.
During operation	5.5	Slight population increase in nearby towns because of plant employment.
Consumption of electric energy produced by system	10.4.1.2	Heat equivalent to most of energy produced is transferred to atmosphere--micrometeorological effects due to urban "heat islands" may be enhanced.

Major direct uses of electric energy are lighting, the production of mechanical work via electric motors, energizing of control and communications equipment ("electronics"), electrochemical processing, and heating. Except for electrochemical processes (a small fraction of the applicant's load), the only significant waste product due to these direct uses is heat. However, the transformation of electric energy into light, mechanical work, signal amplification, and localized heating is generally more efficient than alternative means, where these exist. Also, most practicable alternative lights, motors, and heaters involve combustion processes, and yield combustion waste products locally as well as waste heat. Therefore, for the same end results (production of light, mechanical work, desired heating, etc.) the consumption of electric energy (distinguished from generation) gives rise to reduced environmental effects relative to available alternatives.

In absolute terms, the only significant environmental effect to be expected directly from the use of the electricity produced by a generating station will be the increased discharge of waste heat to the environment. Probably the only environmental impact will be a relatively modest enhancement of the micrometeorological effects associated with urban "heat islands".

10.4.1.3 Economic Costs

The estimated costs of station construction and operation for 30 years are presented in the table in two alternative forms: as "present value" at the estimated date of first commercial operation, and in "annualized" form, giving the annual payment required during each year of plant operation to cover costs of operation and to repay an appropriate fraction of the cost of construction (with interest). (See Appendix C for further discussion.)

Taxes paid directly by the applicant are excluded from the cost estimates of Table 10.5, giving rise to rather large discrepancies between the applicant's estimates (Ref. 1, Table 10.1-1) and those given here. This difference is discussed in Appendix C. Taxes are included in Table 10.6 discussed below.

10.4.1.4 Economic Transfers

As noted above, tax payments do not enter into a national benefit-cost analysis since they neither create nor consume resources. The amounts involved, however, are large and of some natural interest, moreover, the taxes paid to local governments would enter into a local benefit-cost analysis, tending to balance the environmental costs which accrue mainly to the local area. For these reasons, the estimated tax payments which would result from construction and operation of the proposed station are given in Table 10.6.

10.4.2 Benefit-Cost Balance

The basis on which the balance is made is described in Appendix C.

10.4.2.1 Balance for Braidwood Station

The environmental and economic effects to be expected from the station if built and operated are given summarily in Tables 10.3 through 10.6.

The major benefit expected will be the production of about 12.75 billion kWh of electrical energy each year over the anticipated 30-year operating life of the station and the maintenance of an adequate reserve margin of generating capacity (see Section 8.2.1.3). On the basis of the historical correlation between GNP and electric energy production discussed in Section 10.4.1.1, the staff expects that the station will support (along with necessary inputs of labor, raw materials, etc.) the economic activity associated with $4 to $6 billion (1958 dollars) per year of GNP.

The date of need for the generating capacity which the station would provide must be considered somewhat uncertain because of factors brought to the fore by the current "energy crisis." On the one hand, economic growth in the U. S. may be slowed by the shortage of petroleum products and the resulting dislocations of the economy, and increased emphasis on the more efficient use of energy may lead to reduced consumption of electric energy for present uses, providing some margin for new uses without the construction of generating plants. On the other hand, the persistent shortage of petroleum fuels would tend to induce additional use of electric energy as a substitute while inhibiting the operation of oil-fired generating capacity. The staff concludes that it would be prudent to complete the station according to schedule.

The economic cost of the proposed station is large, about $1 billion capital investment and about $200 million per year for fuel, operation and maintenance, taxes, interest, and depreciation. These large sums are, however, associated with the production of correspondingly large amounts

Table 10.5. Braidwood Station Economic Costs[a]

Description	19801981 Present Value	Annualized (30 years) (millions of dollars)	Mills/kWh
Plant construction	919	87.4	6.87[b]
Fuel consumption	350[c]	33.4	2.62
Plant operation and maintenance	242[c]	23.1[d]	1.81[b]
Decommissioning	22[e]	2.1	0.16[b]
Total	1533	146.0	11.5

[a]Based on applicant's estimates (Braidwood Environmental Report, Tables 9.3-2, 10.1-1, and 11.2-2), adjusted to exclude taxes and using a different interest-rate assumption as discussed in Appendix A.

[b]Assumes annual output of 12.75 billion kWh (65% load factor).

[c]Assumes 30-year life.

[d]Levelized value reflecting 6% per year assumed escalation. 1980-1981 estimate is $11.684 million.

[e]Assumes 1980-1980 estimate of $50 million (staff estimate), escalated at 6% per year but discounted at 8.75% per year for net discount rate of 2.75% per year.

Table 10.6. Braidwood Station Estimated Tax Payments[a]

	1980-1981 Present Value (millions of dollars)	Annual Levelized (millions of dollars)	Levelized Mills/kWh[c]
Corporate income tax[b]	402	38.3	3.0
Real property taxes	25	2.4	0.19

[a]Based on applicant's estimates (Braidwood Environmental Report, Tables 9.3-2, 10-1.1, and 11.2-2), adjusted for 8.75% discount rate in present value computations.

[b]Assumes combined state and federal rate of 50% on corporate profits, 46.5% equity financing at 12.68% return on equity, and 30-year straight-line depreciation.

[c]Assumes annual output of 12.75 billion kWh (65% load factor).

of electric energy, some 13 billion kWh per year. The "busbar" cost (i.e., not including transmission and distribution costs) of the station output will be about 2 cents per kWh. The conclusion of Section 8 is that a market for the output will exist over the life of the plant; thus the large cost of the plant will be balanced by the large value of the output.

The material resource costs of the station have been considered in Section 10.3.4. Plant construction will require the partly irretrievable commitment of substantial quantities of metals and materials of construction. However, relative to capital investment and contribution to GNP, this commitment appears to be typical of capital intensive basic industries.

Plant operation will irreversibly consume substantial quantities of uranium, particularly of the relatively rare mass-235 isotope. However, U. S. uranium reserves appear adequate to support nuclear power at least through the life of plants coming into operation before the middle or late 1980's and for very much longer (centuries) if timely introduction of commercially successful breeder reactors is achieved.

The environmental costs of the proposed station exclusive of the cooling lake are typical of a large, carefully planned industrial enterprise. Some 130 acres, about half of it now cultivated, will be converted to industrial use. An additional 650 acres, of which 200 are now cultivated, will serve as "exclusion area" for the station. This land will probably be allowed to revert to natural conditions, providing unmanaged wildlife habitat. Various effects of construction activity during a five-year period are foreseeable (see Section 4), but none that would not normally accompany large-scale construction and none with unacceptable environmental impact. Operation of the plant will add a few hundred residents to the population within 20 miles.

The cooling lake and its dikes will require another 3540 acres. Four hundred acres of this land is now cultivated. Most of the remainder is strip-mine spoil. Although only the lake dikes will be generally visible, appearing as low grassy ridges, most viewers will probably consider this superior esthetically to the "mountains of the moon" spoil area which will be eliminated. The lake itself is expected to support an interesting although limited ecosystem.

Other environmental effects specific to the proposed type of plant (nuclear power station with cooling lake) include consumptive use of water from and discharge of blowdown to the Kankakee River, release of small amounts of radioactivity and direct radiation to the environment, and esthetic and land-use effects of the associated new transmission lines. The evaluation of the impacts on the Kankakee River indicates that they are likely to be more marginally perceptible against the normal fluctuations of the environment only during periods of extreme low flow. By proper management during low-flow conditions as discussed in Section 5.4.2.2, the impacts on the river ecosystem can be held to an acceptably low level.

10.4.2.2 Conclusion

As stated in Section 9, the staff believes that there would be no reduction in overall costs by the use of an alternative site, the use of an alternative generating system, the use of alternative plant designs, or the use of any combination of these. The staff evaluation of alternative cooling systems indicated that the use of a small (1.2 acres/MW) cooling lake is as environmentally acceptable as any of the alternatives and minimizes the impact of Kankakee River biota during extreme low flow-periods. The staff concludes that the proposed Braidwood Station is a system with a benefit to cost ratio at least as high as that of any alternative system.

In the staff's opinion, the benefits of increased availability of electrical energy and improved system reliability in the applicant's service area outweigh the economic and environmental costs caused by the station when it is constructed and operated in accordance with the conditions listed in the Summary and Conclusions.

References

1. Atomic Energy Clearing House, Congressional Information Bureau, Inc., 17(6) p. 42, 17(10) p. 4, 17(18) p. 7, 16(35) p. 12.

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

3. "Mineral Facts and Problems," Bureau of Mines, U.S. Dept. of the Interior, p. 230, 1970 ed.

4. Atomic Energy Commission press release T-133, dated March 27, 1974.

5. "Statistical Data of the Uranium Industry--January 1, 1972," Grand Junction Office, Report GJO-100, U.S. Atomic Energy Commission, Grand Junction, Colo.

6. Environmental Survey the Uranium Fuel Cycle, USAEC, WASH 1248, April 1974.

11. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

11.1 INTRODUCTION

Pursuant to Appendix D of 10 CFR Part 50, the Draft Environmental Statement (DES) was transmitted in February 1974 with a request for comment to the Federal, State and local agencies listed in the summary at the beginning of this final statement. In addition, the AEC requested comments on the Draft Environmental Statement from interested persons by a notice published in the Federal Register on February 21, 1974.

Letters in response to these requests were received from the following:

Department of Agriculture, Agricultural Research Service (ARS)
Department of Agriculture, Forest Service (FS)
Department of Agriculture, Soil Conservation Service (SCS)
Department of Transportation (DOT)
Department of Housing and Urban Development (HUD)
Department of the Interior (DOI)
Department of Commerce (DOC)
Department of Health, Education, and Welfare (HEW)
Advisory Council on Historic Preservation (ACHP)
Federal Power Commission (FPC)
Department of the Army, Corps of Engineers (CE)
Environmental Protection Agency (EPA)
Upper Mississippi River Basin Commission (UMRBC)
Illinois Archaeological Survey (IAS)
Illinois Natural History Survey (INHS)
Illinois State Geological Survey (ISGS)
Northeastern Illinois Planning Commission (NIPC)
Illinois Department of Mines and Minerals (IDMM)
Geothermal Energy Institute (GEI)

The letters are reproduced in Appendix F of this Statement. The staff's consideration of the issues raised in these letters is reflected in this Section and by changes in the text. The abbreviations and associated Appendix F page numbers refer to the specific comments received from the various agencies and sources.

11.2 DEPARTMENT OF AGRICULTURE, FOREST SERVICE

11.2.1 Impact of Transmission Line and Pipeline Corridors on Woodland (FS, F-1)

Some discussion of this subject was added to Section 4.1.2. The applicant indicated a policy of locating corridors along the edges of woods so as to avoid traversing woodland, if feasible. It also stated a policy of planting sod-forming grasses on cleared areas to retard erosion.

11.3 DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

11.3.1 Diversion of Agricultural Land (SCS, F-2)

The discussion of agricultural energetics in Section 4.1.1 indicates that the loss of agricultural production due to the diversion of farmland to power plant use may be compensated by the gains in agricultural production due to added energy input made available by the plant.

11.3.2 Drainage (SCS, F-2)

The staff has expanded its consideration of seepage and drainage effects, as reported in Section 5.2.

11.4 DEPARTMENT OF TRANSPORTATION

11.4.1 Impact of Construction Traffic (DOT, F-3)

The textual discussion was expanded. The applicant has stated its intention of cooperating with local county and state transportation agencies to minimize the effects of increased traffic during the construction of Braidwood Station. It expects to meet local limits on loads and traffic and to reach equitable agreements on maintenance.

11.5 DEPARTMENT OF THE INTERIOR

11.5.1 Brevity of Descriptive Material (DOI, F-5)

It is the staff's practice to reduce the costly transfer of large quantities of data from the applicant's Environmental Report by summarizing the important information and providing reference to the source. The Department of Interior is furnished twenty (20) sets of the applicant's Environmental Report.

11.5.2 Recreation Facilities within 10 Miles (DOI, F-5)

The distances and directions of these facilities from the proposed plant are given in the applicant's Environmental Report in Table 2.2-7.

11.5.3 Archaeological Testing (DOI, F-5)

Appendix 7 in the applicant's Environmental Report provides further detail on the archaeological testing done at the Braidwood site. A further comment is provided by the letter on page F-20 from the Illinois Archaeological Survey.

11.5.4 Topography, Geology and Seismology (DOI, F-5)

The information on geology and seismology in the environmental statement is not intended to be sufficient for an independent assessment of the adequacy of the facility design with respect to the the geologic environment. Such adequacy is determined by the AEC in its safety evaluation of the proposed station. The primary purpose of including ecosystem descriptions in the environmental statement is to permit an evaluation of how the construction and operation of the proposed plant might have an adverse impact on some element of the ecosystem or its interactions. For this purpose, the staff believes the descriptions of geology and seismology in the statement are sufficient.

The applicant has stated that all deep trenches and deep underground mines in the dike vicinity would be filled with impermeable material prior to filling the cooling lake, so that there would be no possibility for water to leak under the dike in these locations. The staff has obtained additional information from the applicant on the permeability of the materials to be used in the slurry trench construction, on current tests in the strip-mine on the slurry trench technique, and on the dike design and method of sealing to underlying impermeable strata. The question of sealing the lake is receiving further study by the staff in connection with the safety evaluation.

11.5.5 Loss of Woodland to the Lake (DOI, F-6)

See response 11.5.1. Some revegetation has occurred on some of the older strip-mined land and on the land reclaimed after mining according to laws passed in 1961. The flora and fauna are briefly described in Section 2.7.1 with references to more detailed data. The applicant states that the area of woodland to be inundated is 117 acres rather than the apparent 1000 acres in Fig. 2.7-3 of the applicant's Environmental Report.

The revegetation in the mined areas, where it exists, is sparse. The applicant reported the results of ecological surveys in 1972 and 1973 in its Environmental Report. The inundation of these areas by the proposed cooling lake represents a definite loss of habitat for wildlife and of possibilities for hunting. The sparseness of the revegetation makes the loss of the flora in these areas less serious.

11.5.6 Transmission Line Construction (DOI, F-6)

Only about 10 acres of farmland will be taken out of agricultural production by transmission line construction. This area will be occupied by the bases of transmission towers. Most of the remainder of the 2,376 acres of new right-of-way will traverse farmland, with an effort by the applicant to locate the corridors along quarter- and half-section lines wherever possible. The effect of the lines on wildlife on farmland should be minimal. Where the lines crossed woodland, there would be an exchange of wood habitat for edge habitat, which is preferred by many species of wildlife.

11.5.7 Best Use of Spare Land (DOI, F-7)

The applicant is working with the Will County Soil and Water Conservation District to determine the best use of spare land.

11.5.8 Construction of Intake and Discharge Structures (DOI, F-7)

In order to get a permit from the Corps of Engineers for building the intake and discharge structures (application submitted June 19), the design and construction procedures, such as the disposal of dredged material, must meet that agency's standards. A cofferdam will be build to divert most of the river flow around the construction area. The contractor will be advised by the applicant to follow procedures which minimize siltation. The contour of the river bottom will be restored after the cofferdam is removed.

11.5.9 Dike Integrity (DOI, F-7)

See response 11.5.4. The dike is planned to be 14 feet wide on top with a 30% slope on each side, and will be compacted to engineering standards and seeded with grass. The applicant expects that mud flow will not be serious problem with this design. The staff is considering the question of dike design and integrity in its safety review.

11.5.10 Effects of Site Dewatering (DOI, F-7)

The staff has required and the applicant has committed (Sections 4.2 and 4.5.1(c)) to monitor groundwater levels in the vicinity of the station during dewatering operations and to take corrective measures if necessary. The original plan of the applicant was to draw 20 gpm of water from shallow wells for station potable water. According to the plan described in Supplement 4 of the Environmental Report, both makeup water and potable water will be drawn from deep wells, with less impact on local aquifers.

11.5.11 Kankakee River Water Use at Low Flow (DOI, F-7)

AS stated in Sections 3.3 and 5.2.1, and in the applicant's Environmental Report, the applicant's policy is to limit net water use from the Kankakee River to 10% of the flow during periods of low flow (below 470 cfs). Water will be used from the volume stored in the cooling lake to make up the difference from 47 cfs.

11.5.12 Effects of Chlorine in the Cooling Lake (DOI, F-7)

In Fig. 3.3, it is shown that chlorinated plant service water is diluted by about 30 times its volume of condenser cooling water before it reaches the cooling lake. The resulting small chlorine content would be expected to have minor effects on lake biota. In any case, the residual chlorine content would be removed in a few hours of the several days required for the water to circulate around the cooling lake.

11.5.13 Premature Spawning (DOI, F-8)

The staff has found no documented evidence that premature spawning of pelagic fish occurs as a result of thermal discharges in rivers; however, some fishery biologists believe that this may occur. If such spawning does occur, the eggs might not be fertilized, or might fail to hatch if conditions outside the plume were not in phase with the advance in season mimicked by the thermal input to the water. An example would be low water temperature outside the plume.

No transformation of the eggs to fry could occur during the brief transit through the thermal discharge plume in the river at the Braidwood site. At the average Kankekee River flow of 3923 fps, the water velocity is approximately 2.1 fps. The extent of the 5°F isotherm in February (worst case) is predicted to be approximately 750 ft. from the discharge (Fig. 3.8). The calculated transit time of 6 minutes is clearly too short to permit the hatching of any eggs deposited in the plume. Similarly, a maximum residence time of 6 minutes in the plume is insignificant as measured against the 2-3 day minimum time required for hatching to occur -- thus, if water temperatures and other physical conditions outside the plume are favorable for embryogenesis, hatching should occur unimpeded by the brief residence in the warmer water of the plume.

Only a very small portion of the pelagic fish of the Kankakee River in the vicinity of the Braidwood Station would be expected to congregate near the discharge. Thus, even if abnormal spawning were induced by the heated water, little or no adverse impact would occur to the aquatic ecosystem.

11.5.14 Recreation (DOI, F-8)

Sections 4.1.2, 5.1.1 and Appendix G indicate the arrangements to allow continued fossil collecting in the strip-mined areas of the site during and after lake construction. The applicant is cooperating with the Will County Soil and Water Conservation District to determine the best use of spare land. At present, the applicant has not committed to any public use of the proposed cooling lake.

11.5.16 Visual Impact (DOI, F-8)

A large part of the site area was strip-mined before 1961, when the reclamation laws were passed. Much of this area remains a barren, ugly landscape.

11.5.17 Leaching of Lake Bottom by Heated Water (DOI, F-8)

A study by the applicant's consultant of leaching at higher water temperatures of typical area soils indicated small differences from leaching by cooler water. Similarly, little difference in the chemical composition of the lakes in the strip-mined area was noted in summer and winter. The leaching studies in the laboratory and continued sampling of the stagnant lakes indicated that the water composition became constant in the first year after fresh soil was exposed. That is the basis for the conclusion that leaching is a short-term phenomenon. The consultant's data indicated that lake concentrations of dissolved chemicals were not appreciably changed by leaching.

11.5.18 Comsumptive Water Use (DOI, F-8)

The wording of Sections 5.2.1 and 10.1.1.2 was changed to make it clearer that the 57 cfs included evaporation (52 cfs) and seepage (5 cfs), while the 47 cfs was the net consumptive use when a correction of 10 cfs was subtracted from 57 cfs to account for average rainfall.

11.5.19 Loss of Cooling Lake Water by Waves (DOI, F-8)

Very little overtopping of the dike by wind-generated waves is expected by the applicant. In any case it is not expected that overtopping would cut the dikes. The staff is considering this question in greater depth for the safety review.

11.5.20 Cumulative Impacts on Water Quality (DOI, F-8)

Total dissolved solids concentration (TDS) for Illinois rivers varies with the seasons and often exceeds the 500 ppm yearly average limit in summers. Therefore, water quality criteria are written for yearly average concentrations. The yearly average TDS concentrations before operation of the Dresden plant for the Kankakee, Des Plaines and Illinois Rivers were 362,491 and 448 ppm, respectively. The operation of Braidwood Station would raise the downstream TDS concentration of the Kankakee River to 369 ppm on the average. The combined operation of Braidwood and Dresden would raise the TDS in the Illinois just below Dresden to 451 ppm. Thus it may be seen that the cumulative effect of several plants on this river system will not be serious under average flow conditions, and water quality criteria will easily be met.

In summers, the TDS is considerably increased, principally because plant effluents are less diluted by lower river flows. For example, the staff calculated that the TDS below Braidwood would rise to 439 ppm when the Kankakee flow dropped to 350 cfs. Even so, the staff estimates that the increased salinity of the Illinois River when Braidwood, Dresden and Collins Stations are operating will not seriously affect aquatic biota in the river.

11.5.21 Radioactive Discharges (DOI, F-9)

The radioactive discharges to the atmosphere were assumed to be vented at ground level.

11.5.22 Radiological Accidents (DOI, F-9)

As stated on page 7-1, initial results of the Reactor Safety Study are expected to be available in 1974. The staff position regarding Class 9 accidents is given in Section 7.

11.5.23 Alternative Sites (DOI, F-9)

The suggested ecological evaluation of alternative sites would have contributed, if the data had been available, to a more precise comparison of alternative sites. In the absence of obvious ecological deficiencies of the proposed site such evaluations of alternative sites are not usually performed.

11.5.24 Comparison of Coal and Nuclear Generating Stations (DOI, F-9)

In Section 9.1.2.5.2, the staff did refer to the natural radioactive material (mainly radium and thorium isotopes) that is released during combustion. The economic comparison (Table 9.2) considered the average case of a coal plant.

The expected emission quantities of carbon monoxide, hydrocarbon and aldehydes in Table 9.3 were taken from the EPA report given in Reference 7 to Section 9 of this statement.

Since stack-gas cleaning systems are in an early stage of development, the height of stack required is not definitely fixed. Presumably, stack height could be lowered from 600 ft. if efficient gas cleaning could be continuously relied upon.

11.6 DEPARTMENT OF COMMERCE

11.6.1 Intake and Discharge Structures (DOC, F-10)

See response 11.5.8.

11.6.2 Ecology of the Cooling Lake (DOC, F-10)

The staff is of the opinion that Braidwood Lake will not be an "acid lake" even at the time of its filling. Although local areas of inundated mine spoil may initially contribute acidic components, these will be diluted in the large volume of water that will fill the lake. After acidic components are leached from the lake bed, and the lake chemical composition reaches equilibrium, their concentrations in the water should be immeasurably small.

The above opinion is supported by the applicant's leaching tests and water analyses in the area. Most of the mine soils of the site and waters of existing ponds in the spoil area were found to have a neutral or alkaline pH. Some of the older ponds are characterized by developing vegetation and fish.

11.6.3 Entrainment (DOC, F-10)

The number of organisms expected to be entrained at the Kankakee intake is a function of the volume of water pumped, the period of time during which entrainment occurs, and the numbers of organisms contained in the water. Although relatively accurate estimates of the first two parameters can be made, it is difficult to predict the biotic composition of the water except in a general manner since plankton densities vary markedly according to species, year, season, time of day, water quality, and other parameters.

From data obtained by the applicant, the staff's estimates of the number of organisms expected to be entrained at the Braidwood intake are as follows:

Staff Predictions of Numbers of Organisms Expected to be Entrained at the Braidwood Intake

	Per meter^3		Per second	
	Maximum	Minimum	Maximum	Minimum
Phytoplankton	3.74×10^9	1.8×10^7	9.87×10^9	4.75×10^7
Zooplankton	1.04×10^4	9.15×10^8	2.75×10^4	2.42×10^1

The above organisms represent only about 2.4% of the total number that would pass by the intake structure during an average river flow of 4923 cfs. No adverse impact on the river ecosystem would be expected, even if 100% mortality of entrained organisms is assumed.

The species of fish found in the Kankakee River near Braidwood are described in Section 2.7.2.2.6 of the applicant's Environmental Report. The more abundant species are rock bass, golden redhorse, white crappie, smallmouth bass, carp and redfin pickerel.

11.6.4 Cooling Tower - Small Reservoir Alternative (DOC, F-10)

The staff considers (as does the applicant) that the combination of cooling towers with a small reservoir would be an unrealistically expensive alternative compared to the proposed design. The combination would decouple the station from the Kankakee River during drought conditions, but the expense would not be justified because these conditions have occurred so infrequently. Large-scale withdrawal of Kankakee River water for municipal use upstream of Braidwood is being tentatively considered for the future. In that event, the cooling tower design would require a reservoir.

11.6.5 Long-term Storage of Gaseous Radioactive Wastes (DOC, F-10)

The release rate of radioactive gaseous waste to the atmosphere will be governed by the limits specified in the Technical Specifications for this station. The staff assumed the release of gaseous effluents will occur over a period of days. Therefore, the staff use of the annual average dispersion factor to calculate annual total body and skin doses is deemed to be appropriate.

11.7 DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

11.7.1 Location of Health Faculities and Schools (HEW, F-11)

The location of health facilities and schools in the immediate area is described in considerable detail in the applicant's Environmental Report. The text is on page 2.2-8. For schools, Table 2.2-8 gives the distance, direction and number of pupils. For hospitals, Table 2.2-9 gives the distance, direction and number of beds.

In the applicant's Preliminary Safety Analysis Report, the applicant commits to implement an emergency plan involving these facilities.

11.7.2 Use of Herbicides (HEW, F-11)

As suggested, the recommendations on the use of herbicides were made requirements.

11.7.3 Swimming during Construction (HEW, F-11)

The added turbidity of river water near construction activity will make swimming unattractive in these areas.

11.7.4 Loss of Animals during Pipeline Construction (HEW, F-11)

If the carrying capacity of surrounding land is full, the displacement of animals by pipeline construction might lead to their death. When construction is finished, the surrounding populations should expand back into this habitat.

11.7.5 Radioactivity Downstream from Braidwood (HEW, F-11)

It would be very difficult to detect any Braidwood effluents 100 miles downstream of the plant. As stated in paragraph 2 of Section 5.3.2.1 and in paragraph 3 of 5.3.2.2, the staff is concerned with significant exposure pathways. When the dose to humans exposed directly to the effluent in the coolant discharge region is on the order of 1 mrem/yr or less, it is not considered that drinking water >100 miles downstream is a significant effluent exposure pathway, for the effluents are diluted by the 3923 cfs average flow of the Kankakee River (p. 5-13) and by the average flow of the Des Plaines River as it joins the Kankakee to form the Illinois River. Human consumption of wild animals that drank Kankakee River water, likewise, is not considered to be a significant exposure pathway.

11.8 FEDERAL POWER COMMISSION

11.8.1 Need for Power (FPC, F-14)

The Federal Power Commission comments substantiate the need for power from Braidwood and Byron Stations in 1980 through 1982.

11.9 ADVISORY COUNCIL ON HISTORIC PRESERVATION

11.9.1 Archaeological Report and Plans (ACHP, F-14)

The Illinois State Museum made an archaeological assessment of the Braidwood site and reported (Appendix 7 of the applicant's Environmental Report) that the debris density was low compared with neighboring areas and that they did not consider further study fruitful (See Section 2.3).

A concurring assessment was made by the Illinois Archaeological Society (See letter on page F-20).

11.10 DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

11.10.1 Cumulative Effects (CE, F-15)

The geographical separation of the four power plants mentioned is shown in Fig. 9.1. Cumulative effects on water quality are discussed in Section 11.5.20. Downstream radiological effects are indicated to be insignificant in Section 11.7.5. This staff conclusion is supported by the more general considerations in the report: WASH-1209, "The Potential Radiological Implications of Nuclear Facilities in the Upper Mississippi River Basin in the Year 2000", January 1973. The zones of effects of airborne effluents will overlap, but the separations indicated in Fig. 9.1 are large enough so that combined effects will not result in significant radiological exposures. The combined thermal effects of the several facilities on the Kankakee and Illinois Rivers are small, since the nuclear facilities possess their own cooling facilities, releasing only blowdown to the rivers.

11.10.2 Permit for Construction of Intake and Discharge Structures (CE, F-15)

The permit was applied by Commonwealth Edison Co. on June 19, 1974.

11.11 ENVIRONMENTAL PROTECTION AGENCY

11.11.1 Water Use Limitations (EPA, F-16, F-18)

Low flows in the Kankakee River are relatively rare (Ref. 1, Tables 2.5-2; 2.5-2A; 2.5-2B). Furthermore, the applicant is committed to restricting the net consumptive use of river water to 10% of low flows less than 473 cfs (Environmental Report, p. 2.5-6,7). Because of the exposure of the river bottom edges, natural low river flows tend to reduce populations of some benthic and macrophyte species (Environmental Report, pp. 2.7-46 to 49). Water use by the Braidwood Station during low flow conditions will tend to increase, to a minor extent, the losses of some benthic and macrophytic species downstream. During normal flows these losses will be replaced by seeding from midstream and upstream areas. The use of low flow river water by the Braidwood Station is not expected to affect the phytoplankton, zooplankton, or fish. Normally, most fish will have spawned, and the young will have become strong swimmers each year before the time of a low flow, if it occurs.

Although the staff's evaluation does not indicate any important ecological damage to the Kankakee River during low flows, the operational aquatic monitoring program should detect such damage. In this event, further restrictions on water withdrawal may be required.

11.11.2 Cooling of Blowdown Discharge (EPA, F-16, F-19)

The expense of installing additional cooling facilities on the blowdown discharge would be not inconsiderable, whereas the expected benefit would be small since the expected thermal plume is small (see Table 3.2) and its effect on aquatic biota would be correspondingly small.

The staff's plume predictions on page 3.11 were calculated assuming the river velocity was at the minimum monthly value observed, (see Table 2.1). Therefore, the August and September plumes represent the case in which the river flow was at its 7 day once-in-10 year low flow.

It is true that if one uses the Motz-Benedict model with the suggested entrainment coefficient 0.4, the plume size can be underestimated. The staff has, however, chosen a value of 0.15 in order to prevent such an underestimate. Furthermore, as noted on page 3-10, the ΔT's used in the calculation are considered to be extreme values, thus making the estimate of actual plume size more conservative. At this time, no other river model appears to be any better than that used, and the staff does not feel that another calculation is warranted.

11.11.3 Radioiodine Exposures (EPA, F-16)

The staff calculated thyroid dose via the cow-milk-child pathway for milk from the nearest real cow at 1.8 miles from the plant. The EPA calculation was based on the nearest potential pasture at 1900 feet. The dose calculated by the AEC, 6.5 mrem/yr, was acceptable. The use of the HERMES code in the analysis is internally consistent with the method described in the revised Regulatory Guide 1.42.

1.11.4 Thyroid Dose Estimates from Goat's Milk (EPA, F-16)

For the Braidwood Station, there are no goats pasturing near enough to the proposed plant for the goat's milk pathway to be a significant one. The usual conditions for an Operating License provide for taking a periodic census of milk-producing animals, including goats, in the vicinity of the plant.

11.11.5 Main Condenser Off-Gas Treatment (EPA, F-19)

As pointed out, Fig. 3.11 was incorrect. It has been corrected.

11.11.6 Use of Charcoal Adsorbers (EPA, F-19)

Technical Specifications for the Operating License will be written so as to preclude releases to the atmosphere which would result in doses in excess of those specified in the proposed Appendix I of CFR Part 50.

The off-gases from the main condenser will be added to those from the condenser air ejector and are included in the values in this column of Table 3.6.

11.11.7 Distances to Pastures and Residences (EPA, F-19)

The discrepancies noted have been corrected. The nearest residence was taken as that with the lowest dilution factor (X/Q).

11.12 ILLINOIS ARCHAEOLOGICAL SOCIETY

11.12.1 Archaeological Interest of Braidwood (IAS, F-20)

The evaluation of the Illinois State Museum regarding the paucity of items of archaeological interest in the Braidwood area was supported.

11.13 ILLINOIS NATURAL HISTORY SURVEY

11.13.1 Division of Agricultural Land (INHS, F-21)

See Section 11.3.1. Even though the value of more than a square mile of agricultural land is high, the economic productivity of the land when used for power production is higher by orders of magnitude.

11.13.2 Impingement (INHS, F-21)

It is general biological knowledge that in nature, among many species including the fishes, more progeny are produced than can be supported as adults by the carrying capacity of the ecosystem. Such unbalanced fish populations are apparently unable to produce annual crops on a continuing basis.[1] Overcrowding can cause stress, excessive competition for food organisms, and other adverse conditions which can lead to poor fish condition factors.[2] A principal control mechanism for this imbalance is predation of the young by fish and other organisms; this reduces the population toward the carrying capacity of the system and reduced the degree of overcrowding. Entrainment predation at the Braidwood intake, although expected to be small in relation to natural predation, will somewhat reduce the population of larval fishes and eggs and, to this degree, overcrowding, with a probable result in the growth of larger, better quality fish, especially if other population control parameters are faulty.

11.14 ILLINOIS STATE GEOLOGICAL SURVEY

11.14.1 Earthquakes (ISGS, F-21)

The statement that, "The majority of earthquakes are associated with geologic fault lines" is not true for small tremors but is more true for large events. The subject is covered more thoroughly in the applicant's Preliminary Safety Analysis Report in Section 2.5, p. 130 et seq. Seismology of the site is being considered in detail in the safety analysis.

11.15 NORTHEASTERN ILLINOIS PLANNING COMMISSION

11.15.1 Fossils in the Braidwood Area (NIPC, F-22)

Paleontologists consider the unique fossils of soft-bodies marine animals, which have been found in the strip-mined area near Braidwood, a valuable scientific resource. The scientific groups are making arrangements with Commonwealth Edison Co. to continue collecting these fossils during and after the construction of Braidwood Lake (See letters in Appendix G).

11.16 ILLINOIS DEPARTMENT OF MINES AND MINERALS

11.16.1 Fossils in the Braidwood Area (IDMM, F-24)

See Section 11.15.1.

11.16.2 Recreation Use of Braidwood Lake (IDMM, F-24)

The applicant has made no plans for the recreational use of Braidwood Lake.

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[1] George A. Rousefell and W. H. Everhart, "Fishery Science," John Wiley and Sons, Inc., pps. 129-136, 1953.

[2] Clinton Power Station, Units 1 and 2, Draft Environmental Statement.

11.17 GEOTHERMAL ENERGY INSTITUTE

11.17.1 Validity of Economic Costs (GEI, F-24)

The corrected quantities of assured uranium reserves and potential resources given in this final statement (Section 10.3.3.2) are the latest estimates reported by the AEC. The development of breeder reactor technology is expected to relieve the potential uranium shortage which might otherwise develop in a few decades.

The practicality, cost and impact of long-term radioactive waste disposal is discussed in detail in the following report: WASH-1248, "Environmental Survey of the Uranium Fuel Cycle", April 1974.

APPENDIX A. THEORETICAL PREDICTIONS OF COOLING LAKE PERFORMANCE

There are two extreme classifications of cooling lakes. In a *completely mixed* pond, the flow between the intake and discharge, combined with wind effects, tends to maintain the pond at nearly uniform temperature throughout. In a *flow-through* (plug-flow) pond, the temperature decreases continually along the flow path from intake to discharge. Any given lake will fall somewhere between these two extremes. Braidwood Lake, as a result of the internal diking, is expected to perform more like a flow-through pond.

The principal mechanisms by which heat is exchanged between the water and the atmosphere are:

a. incoming short-wave solar radiation,

b. incoming long-wave atmospheric radiation,

c. outgoing long-wave back radiation,

d. reflected solar and atmospheric radiation,

e. heat loss due to evaporation, and

f. heat loss or gain by conduction.

The equilibrium temperature, E, is defined as the temperature a body of water would eventually reach when cooled or heated naturally under constant meteorological conditions. A body of water at a temperature different from E will tend to approach E asymptotically. The equilibrium temperature is not a constant but varies throughout the day and throughout the year as the meteorological variables change.

Although the temperature of a natural body of water continually approaches the equilibrium temperature, it lags behind the short-term changes. It is usually close to the equilibrium temperature during the summer and winter, lower during the spring and higher during the fall.

The simplified model for predicting temperatures in a cooling pond assumes that the net rate of heat exchange, ΔH, across the surface of the pond is proportional to the difference between the surface temperature of the lake, T_s, and the equilibrium temperature, E.

$$\Delta H = -K(T_s - E) \tag{1}$$

The proportionality factor, K, is a complicated function of the meteorological variables, as is E. When appropriate averages are used (e.g., monthly averages), the temperature T_s may be calculated within about $\pm$ 5°F.

For a flow-through pond, the differential equation that relates the transient temperature response to the heat input to the lake is[1]

$$\rho C_p L \frac{dT}{dt} = -K(T - E) , \tag{2}$$

where ρ = density of water (62.4 lb/ft^3),
C_p = specific heat of water (1 Btu/lb-°F),
L = average depth of lake (ft),
T = surface water temperature, and
t = time.

In Eq. 2, ρ and C_p are assumed to be constant.

If K and E are constant throughout the period of interest, the solution of Eq. 2 is

$$\frac{T - E}{T_o - E} = \exp -K(t-t_o)/\rho C_p L , \tag{3}$$

where T and T_o are the surface temperatures at times t and t_o, respectively. If T_o is the

discharge temperature (at time t_o), T_F is the temperature at the end of the lake and $t - t_o = t_F$ (resident time), then

$$\frac{T_F - E}{T_o - E} = \exp\left(-Kt_F/\rho C_p L\right) \tag{4}$$

If the analysis is extended to a closed-cycle pond, then the water that has cooled to a temperature T_F now passes through the condenser and its temperature is increased to $T_F + \Delta T_C$, where ΔT_C is the temperature rise across the condenser. The above equations may then be reapplied.

Thackston and Parker have calculated the equilibrium temperatures and heat exchange coefficients for 88 locations throughout the country.[2] Figure A.1 is a plot of these parameters for Springfield for the twelve months of the year. The solid curve contains the values that correspond to average meteorological conditions. The dashed curve corresponds to extreme meteorological conditions, and results from assuming that all meteorological variables are at the values which are exceeded only once in ten years. The probability that all these variables are at the extremes simultaneously is small. The uncertainty in E is typically ± 5°F, the uncertainty in K approximately ± 40%. One of the largest contributors to the uncertainty is the specific form chosen for the wind formula for determining the heat loss due to evaporation. Thackston and Parker have employed a very conservative formula so that it is not unreasonable to expect that there will be more cooling than predicted using their values.

The residence time, t_F, in Eq. 4 is given by

$$t_F = \frac{V}{Q} = \frac{AL}{Q}, \tag{5}$$

where V = volume of lake (ft^3),
A = surface area of lake (ft^2),
L = average depth of lake (ft), and
Q = flow rate (ft^3/day).

Using the values appropriate to Braidwood Lake,[3] the residence time is found to be approximately four days.

If one applies Eq. 4 starting with January 1 with $T_o = E_{JAN} + 22°F$, $t_F = 4$ days, and $K = K_{JAN}$, then T_F corresponds to the temperature of the water at the cooler end of the lake. The water then passes through the condenser at which point the water temperature becomes $T_F + 22°F$. We next increment E_{JAN} and K_{JAN} by $(E_{FEB} - E_{JAN})/7.5$ and $(K_{FEB} - K_{JAN})/7.5$, respectively. In other words, we are allowing E and K to change as they might be expected to do, rather than assume that they are constant for the entire month. This type of analysis continues until we obtain the temperature T_F at 4-day intervals throughout the year. In actuality the analysis must be continued for more than a year since the assumption $T_o = E_{JAN} + 22°F$ was just an initial value needed to begin the process.

The analysis so far has assumed that Braidwood Lake is a perfect flow-through pond. No account has been made for the entrance mixing that occurs at the point where the heated effluent enters the lake. We define the dilution D_S by the relationship

$$D_S = \frac{Q_S}{Q_o}, \tag{6}$$

where Q_S = total flow rate (outlet flow plus entrained flow), and
Q_o = outlet flow.

For no entrance mixing $D_S = 1$. Ryan and Harleman state that in the field, the minimum value of D_S to be expected is about 1.5.[4]

The lake temperature predicted by the entrance-mixing model used is given below.[5]

$$\frac{T_F - E}{T_o - E} = \frac{\exp - r/D_S}{D_S - (D_S - 1)\exp -r/D_S}, \tag{7}$$

where

$$r = \frac{Kt_f}{\rho C_p L} = \frac{KA}{\rho C_p Q_o}. \tag{8}$$

As previously mentioned, $D_S = 1$ corresponds to the flow-through case. The other extreme, $D_S >> 1$, corresponds to a fully mixed pond. Figure A.2 displays the results of this calculation for

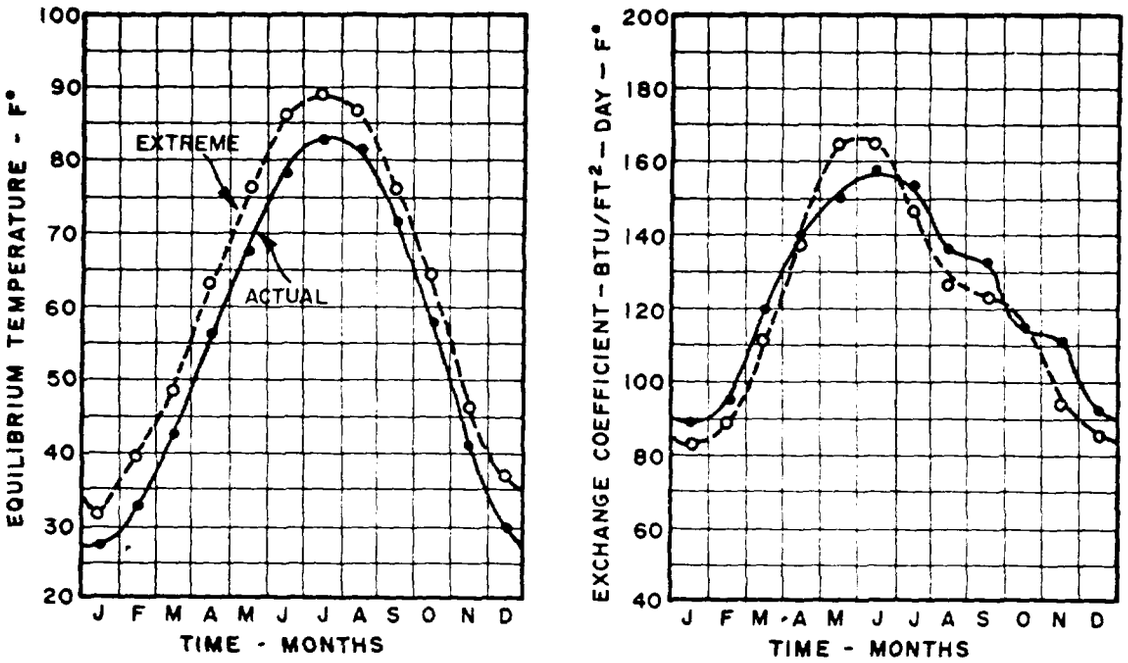

Fig. A.1. Equilibrium Temperatures and Heat-Exchange Coefficients for Springfield, Illinois. From E. L. Thackston and F. L. Parker, "Effects of Geographical Location on Cooling Pond Requirements and Performance," Vanderbilt University, March 1971.

D_s = 1 and D_s = 1.5 for both average and extreme meteorological conditions. The X's on the graph are the results of the applicant's calculations.

The numerous islands in the flow path of the water can promote internal mixing which will reduce the heat loss to the atmosphere. This effect has been neglected in the calculations leading to the results shown in Fig. A.2.

References

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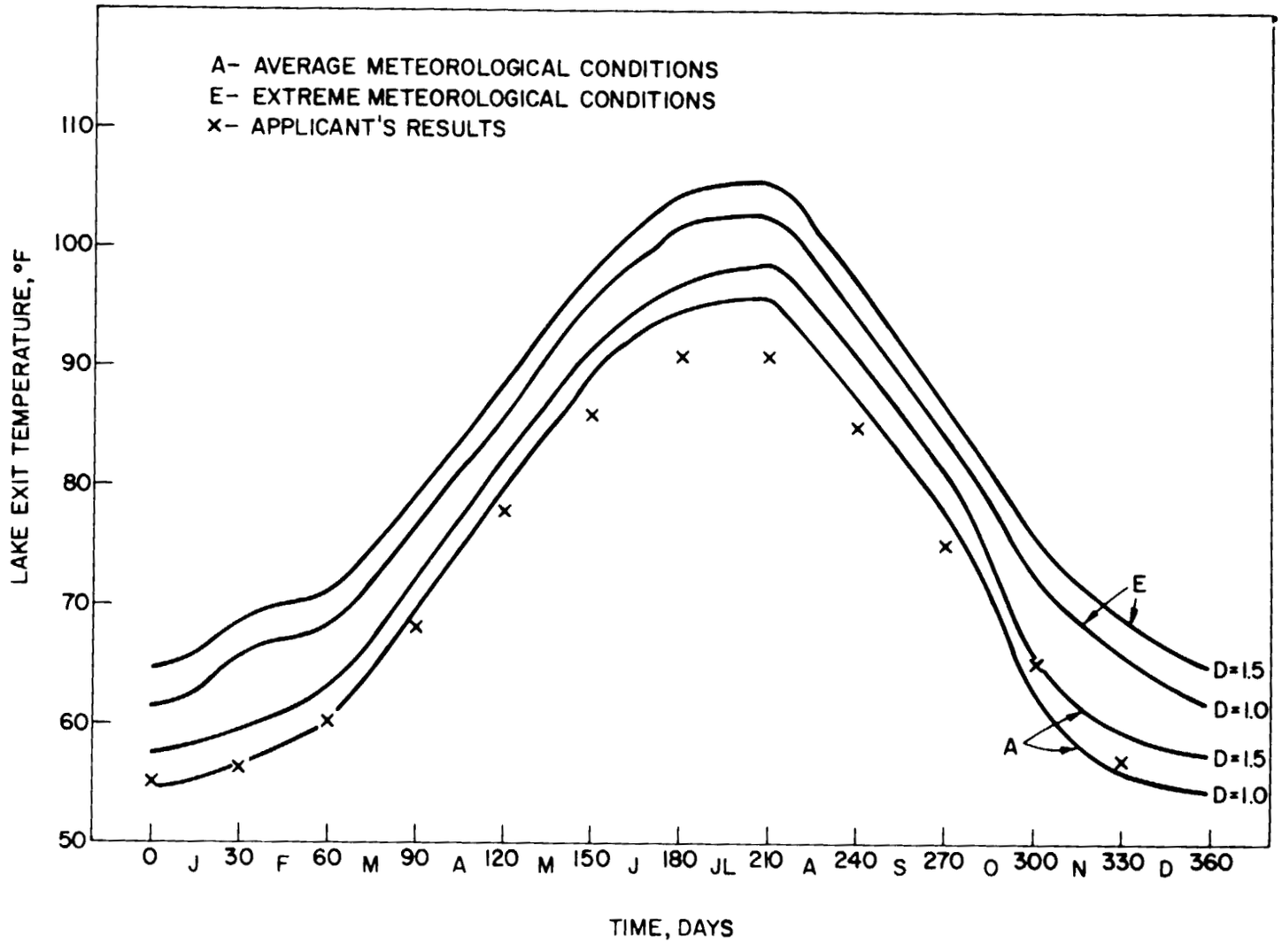

Fig. A.2. Variation of Blowdown Temperature from Braidwood Cooling Lake.

APPENDIX B. PREDICTIVE ANALYSES OF THE BRAIDWOOD COOLING LAKE ECOLOGY

The following staff analysis predicts some elements of Braidwood Lake ecology on the basis of preliminary data and estimates involving nutrients, water quality, thermal loading, chlorine usage, meteorology, laboratory observations, and the application of general biological principles and experience. Knowledge of other artificial lakes, such as Lake Sangchris,[1] are also considered in this analysis; however, data from other cooling lakes are of only marginal value. In view of these difficulties, the staff analysis will require confirmation and refinement by monitoring data which the applicant will be required to provide during lake construction and operation.

a. Nutrients and Algal Productivity. The nutrient status of a lake is an important determinative parameter in the development of lake biota. The applicant has considered four factors in predicting lake water quality, which are: nutrients of the Kankakee, leaching of mine spoils, concentration of dissolved solids by evaporation, and nutrients from waterfowl excreta. The applicant predicts an initial nitrogen level of approximately 8 ppm and a phosphorus level of approximately 1 ppm. In the opinion of the staff, lake nitrogen levels may be somewhat higher because; (1) initially, nitrogen will be released from the soil of flooded farmlands and from the vegetation of flooded woodlands, not considered by the applicant, (2) nutrient input from the excreta of visiting waterfowl may be slightly underestimated, and (3) blue-green algae may add nitrogen to the lake by the fixation of atmospheric nitrogen.[2] While sufficient information is not available to evaluate the possible nitrogen contribution by blue-green algae, the staff estimates that approximately 1 ppm will be added to the lake from the first two sources. This, added to the 8 ppm predicted by the applicant yields an initial value of 9 ppm of nitrogen. The staff agrees with the applicant that the phosphorus value of the lake will not exceed 1 ppm. The staff also agrees that the initial predicted nutrient levels are conservative and that after station operation begins they will decrease because of the dilution dynamics of lake makeup and blowdown and the eventual leaching-out of nutrients from the inundated lands. Thus, the above values should represent the highest levels that will be observed. Nutrient levels, even if they fall to one-half of the predicted initial values are considered high; they are characteristic of eutrophic to hypereutrophic lakes where nutrient levels are not limiting.[3] Such lakes are characterized by energetic phytoplankton growth and high "primary productivity" (which may be defined as the biological transformation of inorganic carbon to organic carbon). The applicant has stated that on the basis of predicted lake nutrient content, nuisance algal blooms could occur, but that they are not expected because they have not occurred at Dresden Lake. The staff agrees that on the basis of nutrient content alone an abundant growth of algae (and other autotrophic organisms) could occur in Braidwood Lake. The staff does not believe, that current Dresden Lake observations provide valid biological comparisons with the closed-cycle lake proposed for Braidwood because Dresden has been operated as an essentially open-cycle system with respect to the Kankakee; at Dresden, even in the presence of optimal nutrients, light, and temperature, it is doubtful that algal reproduction could reach nuisance proportions before the circulating water is discharged to the river. Furthermore, the average annual turbidity at Braidwood is expected to be less than that at Dresden because of the greater deposition of silt and other particulate matter, resulting in greater utilization of ambient sunlight by photosynthetic organisms. During the spring, the thermal input to Braidwood Lake may act in tandem with high lake nutrient content and reduced turbidity to stimulate algal blooms. The fraction of the year during which such blooms may occur may also be increased. It is possible that algal species composition will shift to some extent from green to blue-green during the summer months when water temperatures are high. Such observations are common in the field, and have been confirmed in laboratory experiments.[4] Although an excess of either is undesirable, blue-green algae are considered less desirable than green ones. Since the blue-greens are not utilized as efficiently as a food source, they can produce algal toxins which are poisonous to higher forms, and they can also "fix" atmospheric nitrogen which tends to augment eutrophication.

Algal blooms can affect water quality in other ways under certain conditions. When the algal population of an enclosed body of water grows large, and light is abundant, dissolved oxygen (DO) will tend to increase due to photosynthesis; however when light is inadequate, or during the evening hours, the DO can be reduced due to aerobic respiration. Such reduction in DO can lead to locally hypoxic lake conditions which may stress fish in the area as well as other aerobic biota. This hypothetical condition would be more serious during the hottest months of the year when high ambient temperatures plus the additional thermal load from the reactors will raise the respiration rate and oxygen requirements of fish and certain other biota. During such periods, biota stressed by the high water temperatures would be less likely to tolerate decreases in DO than in the cooler seasons.

Algal dieoffs occur after large blooms. Most dead organisms are bacterially decomposed, leading to a reduction of DO in the vicinity of the bloom. The reduction can range from a minor amount to effectively anaerobic values, depending upon the size of the algal mass, the volume of water affected, and other factors. Under severe conditions, which could be precipitated by mass dieoffs of a multiplicity of algal blooms, fish and other organisms in the vicinity could be devitalized. A possible secondary effect would be a decrease in lake pH, which could further stress the biota. Such effects could be avoided by mobile organisms, such as fish, by migration to more suitable areas of the lake.

Unpleasant odors are sometimes associated with large algal dieoffs. Since the entire cooling lake will be within the station property lines, odor would not appear to be a problem to the general public even if it occurred, unless it was transported to the Kankakee via the blowdown.

The operation of the cooling lake must be managed properly, and this should include methodology for the control of excess algal and weed growth, if these tend to occur. Methods are available for chemical and physical control of aquatic phytoplankton and macrophyton.[5-8]

b. Sewage Bacteria. Sewage bacteria, some potentially pathogenic for humans, will enter the lake in the Kankakee River water. The persistence of such forms is a function of temperature; survivorship is lower in warm waters. The staff predicts that the heated waters of the cooling lake will decrease the persistence of entrained sewage bacteria, and that fewer will be found in the blowdown than in the intake water. Nevertheless, the applicant will be required to monitor the blowdown water for such organisms. Should the bacterial content of the blowdown water exceed State standards, or appear to threaten an adverse impact on the river downstream from the station, remedial measures will be required which may include treatment of the blowdown water.

c. Health of Fish, Waterfowl, and Other Wildlife. Little information is currently available concerning the diseases of resident fish and visiting waterfowl of artificial cooling lakes in the Braidwood region. Some studies of parasitism, growth, and reproduction[9] of fish in artificial lakes have been performed, but these are not reliably predictive of fish health in Braidwood Lake since few of the involved parameters are similar. A consideration of texts covering fish disease[10-12] by the staff, and of temperature optima for various fish pathogens (parasites, bacteria, and fungi) suggests that artificially warmed water might be more a problem than cooler water, and that the thermal input from cooling condensers might extend the length of time when certain fish pathogens could be a problem (as compared to nearby lakes at ambient temperatures). Fish pathology depends on a number of conditions other than temperature and it is not possible to predict fish health on the basis of thermal input alone. Thus, the specific incidence of fish disease in Braidwood Lake cannot be accurately predicted in advance. After the lake is filled and the operation of the Braidwood Station begins, the applicant will be required to monitor for fish disease and parasitism. If such studies suggest a potential, significant adverse impact upon fish in the Kankakee River below the station, preventative measures will be required of the applicant, which may include treatment of the blowdown water and prevention of lake fish from entering the river via the blowdown.

It is not possible to accurately predict how many birds will use Braidwood Lake. If enough are attracted by the warmed waters and the surrounding grain fields to cause overcrowding, an increased incidence of waterfowl disease may occur. If the presence of the lake results in significantly increased waterfowl disease incidence, the applicant will be required to ameliorate the condition. The staff does not anticipate such problems at the present time.

Other wildlife will also inhabit shoreline of the lake and the islands. The general health of such populations will require assessment after the station is put into operation. However, after the lake is filled, the staff does not anticipate an adverse impact on such wildlife, but expects increases in populations such as muskrats, which will probably inhabit newly-formed water edge habitats.

d. Impacts of the Cooling System upon Entrained Organisms. The following organisms are representative of the types expected to be entrained at the intake structure on the Kankakee River: small fish, fish fry, fish eggs; accidental drifting benthic organisms such as larval mayflies, larval caddisflies, larval stoneflies, nematodes, flatworms, annelids; larval crustacea, moluscs, snails; zooplankton such as copepods, ostracods, amphipods, microcrustacea, rotifers; phytoplankton such as green algae, blue-green algae, diatoms; protozoans; bacteria; fungi; and macrophyte seeds and fragments from cattails, reeds, sedges and grasses. Such biota will be drawn to and are small enough to pass through the intake traveling screens. Adult fish and larger juvenile fish are expected to be able to avoid the relatively low velocity (0.5 fps) intake flow if they are healthy. Benthic invertebrates feed and dwell upon the bottom and few would be expected to be in the river water near the intake.

The entrained organisms will experience mechanical shocks and abrasions due to collision with pump parts and irregular surfaces, turbulence, cavitation, and rapid pressure changes during pipeline transit to the cooling lake. The susceptibility of organisms to mechanical shock is, in part, dependent upon species, size, and shape. Small organisms such as bacteria are highly resistant. On the other hand, organisms such as the larger zooplankters and fish fry are more fragile and their mortality will be relatively high.

Studies at the Waukegan power plant* have shown that the susceptibility of zooplankters to mechanical shock is highly size-dependent; the smaller organisms were more resistant than larger ones.[13] In these studies it was shown that condenser passage mortality of organisms smaller than 0.9 mm was less than 5%, while the mortality of larger ones was 17%, the average being 6%. Since mechanical shock along the intake and pipeline is expected to be less than that in the Waukegan plant, and since in the mixed zooplankton population of the Kankakee River and of Lake Michigan there are many more individuals of smaller sizes than larger, 6% or less of all entrained organisms are expected to be killed in their transit to the Braidwood cooling lake.

Living organisms will enter the lake and will admix with "resident" organisms to initially become part of the existing lake ecosystem. Dead or damaged organisms will also enter the lake as nutrient sources at various trophic levels, or may later leave the lake in plant blowdown and serve as nutrient sources in the Kankakee River. Once in the cooling lake, entrained organisms will circulate with the water for approximately 30 hours toward the reactor cooling condensers situated about a mile away. During transit to the condensers, additional living organisms will die due to delayed entrainment mortality. In part compensating for such losses, some devitalized organisms shocked during pipeline passage will recover and some organisms with short reproductive times will increase in numbers; compensatory mechanisms depend upon a number of factors, including species, food availability, water temperature, biological predation, and water quality, thus, the degree of compensation will vary from one period to another.

Upon passage through the condensers, entrained biota will once again be subjected to mechanical shock, but will also be subjected to thermal stresses. The mortality rate expected from a combination of both will be higher than that from mechanical shock alone. The severity of thermal shock due to condenser passage is dependent upon a number of parameters including ΔT of the condenser system, maximum water temperatures attained, ambient cooling water temperatures, water quality, species, age, and residence time at elevated temperatures. Although the residence time of entrained biota in the condensers is brief, the organisms will be exposed to elevated temperatures (condenser ΔT, 20°F) for a much longer period as the water cools during its circuit through the cooling lake. For example, in July and August, the hottest months of the year in the Braidwood area, warm water exiting from the condensers at 114°F (estimated) will require four days to cool to 98°F. Such lengthy exposure to high temperatures will be lethal to most entrained zooplankton, fish fry, and other small animals including the benthic organisms that are exposed. During the cooler months of the year, November to March, the mortality will be less, but it will be higher than that which would be due to mechanical shock alone.

Phytoplankton growth and productivity will probably be partially inhibited (15-50%) by condenser passage during the warmer months of the year when ambient water temperatures are high. On the other hand, in cooler ambient waters, productivity may be stimulated. Observations at other power plants indicated that condenser transit inhibited phytoplankton productivity when ambient water temperatures exceeded 68°F.[14,15] Stimulation was observed when the intake temperature was below 61°F.

Species composition of entrained phytoplankton is also likely to change as a result of the thermal influence of the condensers. Diatoms are the most thermally sensitive phytoplankton species; during the warmest months of plant operation, few individuals are likely to survive condenser passage and cooling lake transit at water temperatures exceeding 90-95°F. Green algae are more sensitive to heated waters than blue-green species, and few are expected to survive waters of 110°F or warmer. Certain *Euglena* should survive in such waters. As lake water temperature increases during the hottest weather, it is likely that blue-green algal species, such as *Oscillatoria*, will become dominant. Laboratory studies[4] support field observations which suggest that many more blue-green species prefer temperatures exceeding 95°F than green species.

Theoretically, the condenser passage of entrained lake biota, primarily the plankton, will occur once every four days (the cooling lake period of cycle). Thus, the majority of entrained organisms

*Condenser tube configurations and diameters in the Waukegan plant probably provided a greater mechanical shock and abrasion hazard than the relatively straight-path, large-diameter makeup water pipeline proposed for the Braidwood Station.

will experience a sharp temperature rise followed by a decay period, about every four days. The condenser, under these circumstances, may act like a selective predator of entrained populations and will thus tend to simplify the species composition of the lake water to those organisms which are tolerant of such temperature regimens. Not all lake plankton will be exposed to condenser predation with regularity. The bottom topography of Braidwood Lake will most likely provide localized niches and will lead to water temperature stratification, both favoring the maintenance of more or less stable populations not subject to the cooling lake temperature cycle. Such populations will, however, tend to slowly change with trends in seasonal water temperature and with changing water quality.

Sodium hypochlorite will be used in the Braidwood plant to prevent biological growth and slime accumulation in the nonessential service water system. This water will eventually be returned to the cooling lake after chlorination and will contain chloramines and some free chlorine. These biocides are inhibitory to biota at low concentrations, and toxic at higher levels. They will kill resident lake organisms until their effective concentrations are lower than the lethal concentrations for each species entrained in the water. The toxicity of the treated service water effluent when returned to the lake will depend upon the ratio of free chlorine to chloramines; this in turn depends upon the concentration of ammonia in the water, the pH, the temperature, and the time over which the two components interact. These parameters tend to vary in an unpredictable fashion, therefore it is not possible to quantify the effect of hypochlorite usage upon cooling lake biota with any degree of certainty; it is reasonable to expect, however, that chlorination will tend to further simplify species composition and reduce species abundance in the lake, but due to the relatively small amount of water to be chlorinated, this will not occur.

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APPENDIX C. SOME ASPECTS OF BENEFIT-COST ANALYSIS METHODOLOGY

1. BASIS FOR BALANCE

In Appendix D of 10 CFR 50, the AEC has required that a benefit-cost analysis (BCA) be prepared for each nuclear plant considered for licensing. A benefit-cost analysis involves two major phases. First, all of the significant* benefits and costs to be expected from the proposal must be identified and assessed. Second, the favorable consequences (benefits) must be compared with those unfavorable (costs). If the benefits clearly exceed the costs, to a degree greater than the likely uncertainty in the estimates of each, the proposed course of action is desirable. The reverse case, of course, leads to the opposite conclusion. Indeterminate cases must be resolved by sharper analysis, or by other means.

Prior to the promulgation of Appendix D, the use of BCA was largely confined to cases where it was considered appropriate to assign dollar values to every benefit and cost item. In such cases, the comparison phase involved only the use of arithmetic. Virtually all of the effort addressed to BCA went to the assessment phase and differences of opinion concerning the adequacy of analysis centered on assessment, with the comparison phase largely taken for granted.

Appendix D, however (and the spirit and language of NEPA which it implements), requires consideration of virtually all effects on the broadly-defined environment. (For a detailed list of effects, see the Table of Contents of this Statement.) No method for assigning dollar values to such diverse considerations now commands general acceptance. Therefore, the required benefit-cost balance may not rest on simple and indisputable arithmetic. Ideally, the balance struck should be that which the American public, or an appropriate body representing the public would reach after study of the assessment presented in this statement and after appropriate discussion and deliberation. In an effort to attain this ideal, the staff's determination of the benefit-cost balance is based on the NEPA, legislated by Congress, as implemented in Appendix D of 10 CFR 50.

2. TERMINOLOGY AND CALCULATION PROCEDURES

Several specialized terms occur in Tables 9.2, 10.5, and 10.6 such as "present value", "levelized annual", "discount rate", "escalation rate". The need for the concepts so labeled arises when the time dimension is suppressed in order to simplify an economic comparison. For example, consider the comparison of coal and nuclear plants given in Table 9.2. The underlying estimates indicate that

(a) construction cost of the nuclear plant is about $100 million more than that of the coal plant;

(b) fuel cost for the coal plant will exceed that for the nuclear plant by about $36 million during the first year of operation; and

(c) coal cost will rise more rapidly (by about 5% per year) than nuclear fuel cost during the subsequent years of operation.

How should the fuel-cost saving which favors the nuclear plant but varies from year to year be balanced against the construction-cost penalty?

The usual resolution of the problem involves transforming the time-dependence of one or both types of cost so that they become similar in time dependence, via the concept of compound interest. Thus the 30-year stream of escalating fuel cost payments may be transformed to its <u>present value</u> at the time of first commercial operation, say, and added directly to the construction cost to give a <u>total</u> cost for each type of plant.** The present value of a future payment is the discounted value of the payment, i.e., the sum which deposited at interest at the reference time will with accumulated compound interest just cover the payment when due. The present value of a sequence of future payments is just the sum of the present values of the individual payments.

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*"Significant" here means large enough to possibly influence the final decision.
**Other elements such as operating and maintenance cost should also enter into the total, of course.

With equal validity, the annual charges which would serve to repay the construction costs (with interest and "*return on equity*") over the expected life of the plant may be calculated. In the simplest case of uniform annual payments, the calculated payment stream is just that whose present value would equal the construction cost. Similarly, a time-varying payment stream may be replaced by the uniform-payment stream with equal present value. The resulting levelized annual costs may then be summed to obtain "levelized total annual" costs for comparison among alternatives.

The mathematical statement of the above definition of present value is

$$PV(\{p_k\}, I, N) = \sum_{k=1}^{N} p_k(1+I)^{-k} \qquad (C.1)$$

where p_k is the face amount of the k-th payment, i is the interest (or "discount") rate defined in terms of the interval between successive payments (taken to be uniform) and N is the total number of payments expected.

For example, the present value "now" of 51 successive weekly payments of $1 beginning one week from "now", at a discount rate of 0.1834 percent per week (compounds to 10 percent per year) is

$$PV(1, 0.0018346, 52) = \$1x\{(1.0018346)^{-1} + (1.0018346)^{-2} + \cdot\cdot\cdot\cdot\cdot + (1.0018346)^{-51}\} = \$48.64 \ .$$

When the payments are uniform, as in this example, the sum in Eq. C.1 can be evaluated agebraically with the result

$$PV(p_o, I, N) = p_o\left[1 - (1+I)^{-N}\right]/I \ . \qquad (C.2)$$

The product of the present value by the discount rate, $I \cdot PV(1,I,N)$, depends mainly on the product $N \cdot I$, as shown in Fig. C.1, from which reasonably close estimates of the present value for any (reasonable) N and I may be made.

If the amount of the payment increases regularly (uniform escalation), the present value of the payment stream is numerically equal to that corresponding to uniform payments each equal to the first payment p_o and to a discount rate reduced by the escalation rate E. One has

$$PV(\{p_o(1+E)^k\}, I, N) = PV(p_o, I-E, N) = p_o\left[1 - (1+I-E)^{-N}\right]/(I-E) \qquad (C.3)$$

The corresponding levelized payment, P_1, is

$$P_1 = L \cdot p_o, \quad L = PV(\{(1+E)^k\}, I, N)/PV(1,I,N) = \frac{I}{I-E}\,\frac{1-(1+I-E)^{-N}}{1=(1+I)^{-N}} \qquad (C.4)$$

Values of the levelizing factor L are plotted in Fig. C.2.

3. SOURCES OF DISAGREEMENT AND UNCERTAINTY IN ECONOMIC COMPARISONS

The methods described above permit tidy and objective comparison of economic alternatives. However, the accuracy of the comparison can be no better than that of the input estimates. In particular, the apparent relative importance of capital and running costs is sensitive to the choice of discount and escalation rates and to the assumed operating life of the plant considered.

In the interest of uniformity, the staff has generally used the value of 8.75 percent as the appropriate discount rate for investor-owned utilities. This value corresponds to a debt-equity mix of 2:1 with 7.125 percent interest on debt and 12 percent return on equity. These figures are typical of values for individual utilities in recent years but of course will differ somewhat from those of a particular applicant at a given time.

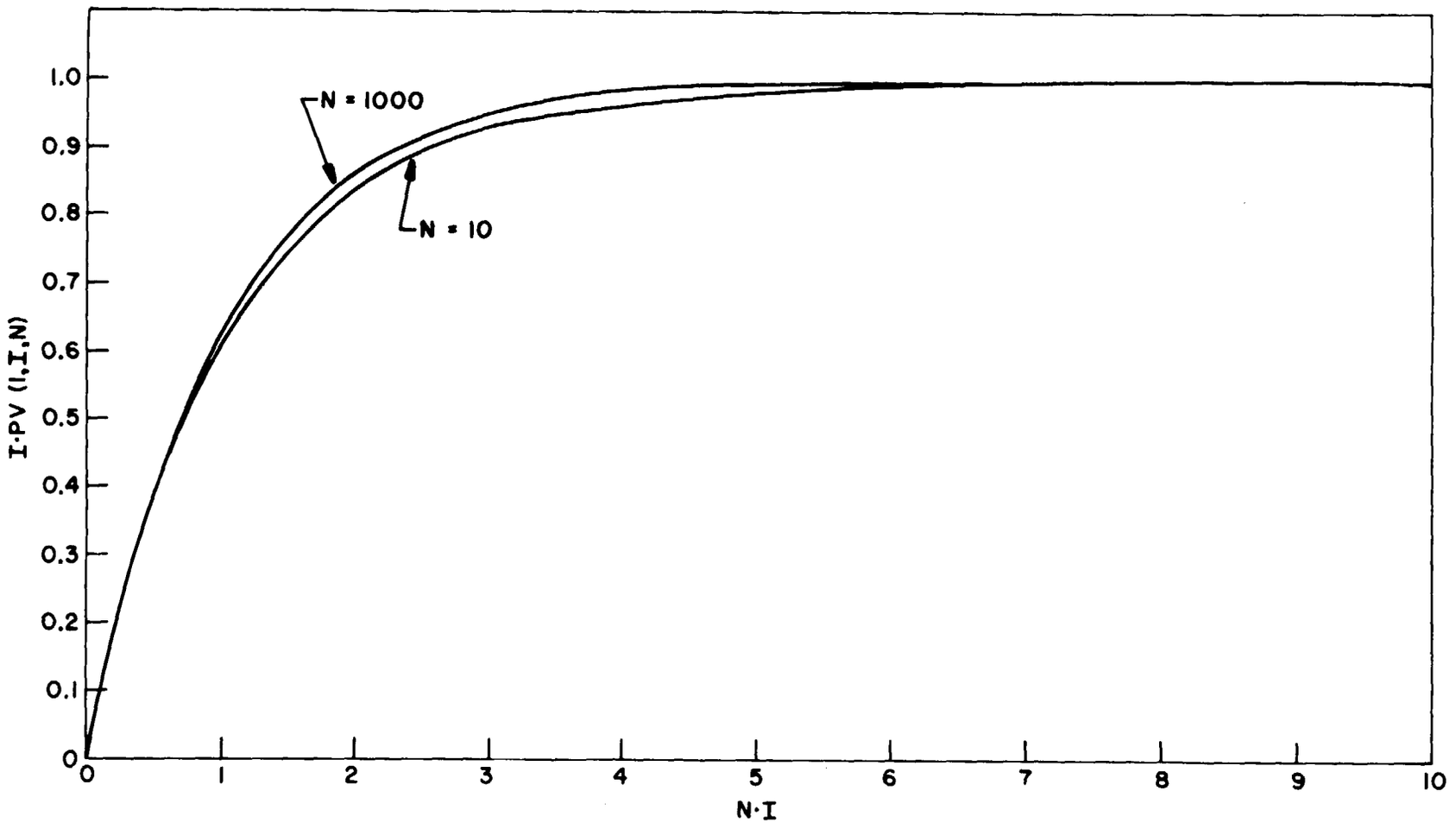

Fig. C.1. Present-Value Function. The quantity plotted is the product of the interest rate I by the present value PV(1,I,N) of N successive payments of one unit each versus the product of I by N. Labeling of the axes is correct for I stated as a decimal fraction.

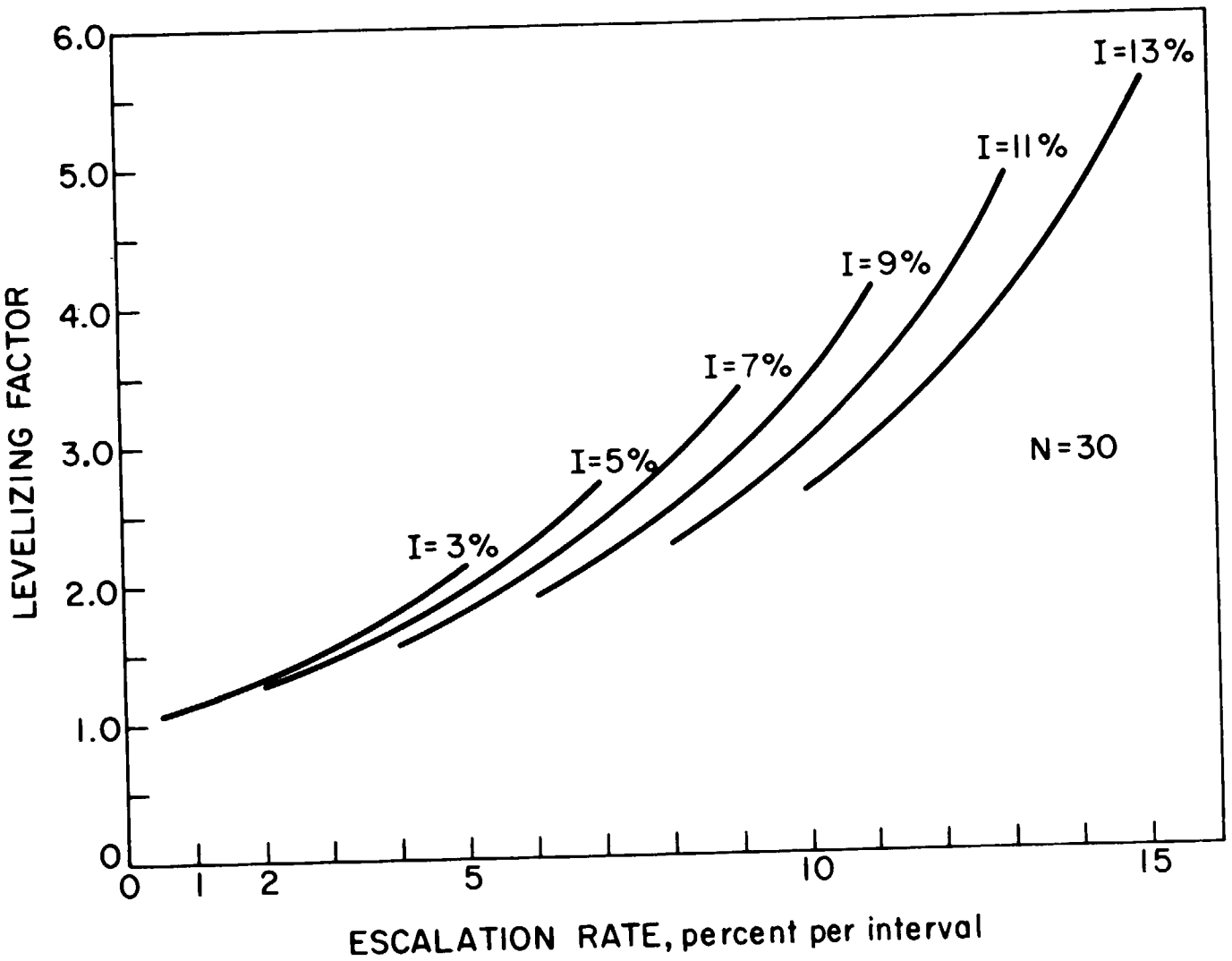

Fig. C.2. Levelizing Factor vs. Escalation Rate.

Corporate profits are taxed by the Federal government and by many of the States, with the combined rate approximating 50 percent. As a result, return on equity of 12 percent (after tax) requires a pre-tax return of about 24 percent. If the corporate income tax component were considered, the staff discount rate would rise to 12.75 percent. Consideration of real property taxes might make the rate 13 percent. However, the staff excludes taxes from consideration on the basis that, although taxes are very real costs for the applicant, they should not enter into a national benefit-cost analysis since they neither create nor consume resources. The monies paid as taxes by the applicant are recovered in the form of higher rates from consumers of electric energy. The spending ability gained by the governments is lost by the consumers and the net national spending power is unchanged.

This difference in point of view may lead to rather large discrepancies between estimates of total cost by applicant and by staff. For example, the first-year tax component of annual cost is presently estimated as about $40 million for a 2200-MWe plant.

The choice of assumed operating life also influences the calculated values of total life-of-plant costs to some degree. The staff assumes uniformly that the economic life of proposed plants will include 30 years of operation, although the operating license, if issued, will be for 40 years beginning with the date of issuance of the construction permit. Actual economic life is determined by the balance between the higher operating and maintenance costs of older plants, and the capital cost of a replacement plant. These costs are not predictable with any great confidence several decades in the future. However, the estimate of 30 years is reasonably consistent with past experience for fossil-fueled generating plants.

APPENDIX D

STATE OF ILLINOIS
DEPARTMENT OF CONSERVATION
SPRINGFIELD 62706

RECEIVED
FEB 27 1974

RECEIVED
FEB 15 1974

Docket Nos.: STN 50-454, STN 50-455
STN 50-456, STN 50-457
STN 50-461, STN 50-462

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

The environmental reports prepared by Commonwealth Edison on Braidwood Station (Units 1 and 2, Will County) and Byron Station (Units 1 and 2, Ogle County) and Illinois Power Company's environmental report on the Clinton Power Station (Units 1 and 2, De Witt County) have been reviewed. This review was made to determine what effect, if any, undertaking the Byron, Braidwood, or Clinton projects would have on cultural and historical sites of significance within or adjacent to project work boundaries.

Archaeological studies conducted on the project sites by members of the Illinois Archaeological Survey for Illinois Power and Commonwealth Edison indicate the existence of archaeological sites within the boundaries of each of the three projects. Results of the archaeological surveys for each site should be included in the final environmental statements. The final statements should also indicate Commonwealth Edison's and Illinois Power's plans for archaeological salvage of the located sites and their plans for recording and salvage of archaeological sites which may be discovered during project construction.

It has been determined that, with the exception of the aforementioned archaeological sites, no cultural or historical sites of significance are located within the projects' boundaries. No National Register of

Historic Places sites are found within the project boundaries of the Braidwood, Byron, or Clinton Power Stations.

Sincerely,

Anthony T. Dean
Director
State Historic Preservation Officer

ATD:gjf

cc. Mr. George Montet, Building 11A, Environmental Statement Projects, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

Mr. Charles Bareis, Illinois Archaeological Survey, 109 Davenport Hall, University of Illinois, Urbana, Illinois 61801

Mrs. Ann Webster Smith, Director, Office of Compliance, Advisory Council on Historic Preservation, Washington, D. C. 20240

APPENDIX E. PROPOSED MUNICIPAL WATER SUPPLY FROM THE KANKAKEE RIVER

The Public Water Commission of Frankfort, Joliet, Lockport, Mokena, New Lenox, Rockdale, and Romeoville commissioned a "Preliminary Engineering Report on Kankakee River Water Supply System." A report of that title, dated June 1972, was prepared by a consulting engineer.* The plans described in that report are summarized below. It is to be noted that final engineering work has not been authorized by the participating municipalities, as of March 1, 1974. Presently there is no certainty that this plan will ever be implemented. However, the basic problem, dropping groundwater levels in northeastern Illinois because of excessive withdrawal, will worsen with time until alternative sources of surface water are developed.

The plan described calls for a pumping station on the Kankakee River with a softening and filtration plant and an appropriate transmission-main system to serve the member municipalities and, perhaps, the cities of Bolingbrook, Chicago Heights, and Park Forest. The proposed system is shown in Fig. E.1. The estimated population and water consumption for the subject municipalities are given in Table E.1. The estimated average and maximum water consumption for certain future years is summarized below.

	Water Consumption, cfs	
Year	Average	Maximum
1980	53.4	89.9
1985	63.0	107.1
1990	73.0	125.3
2000	92.2	159.0
2010	111.8	193.4
2020	134.0	231.9

*Consoer, Townsend and Associates, 360 E. Grand Ave., Chicago, Ill. 60611.

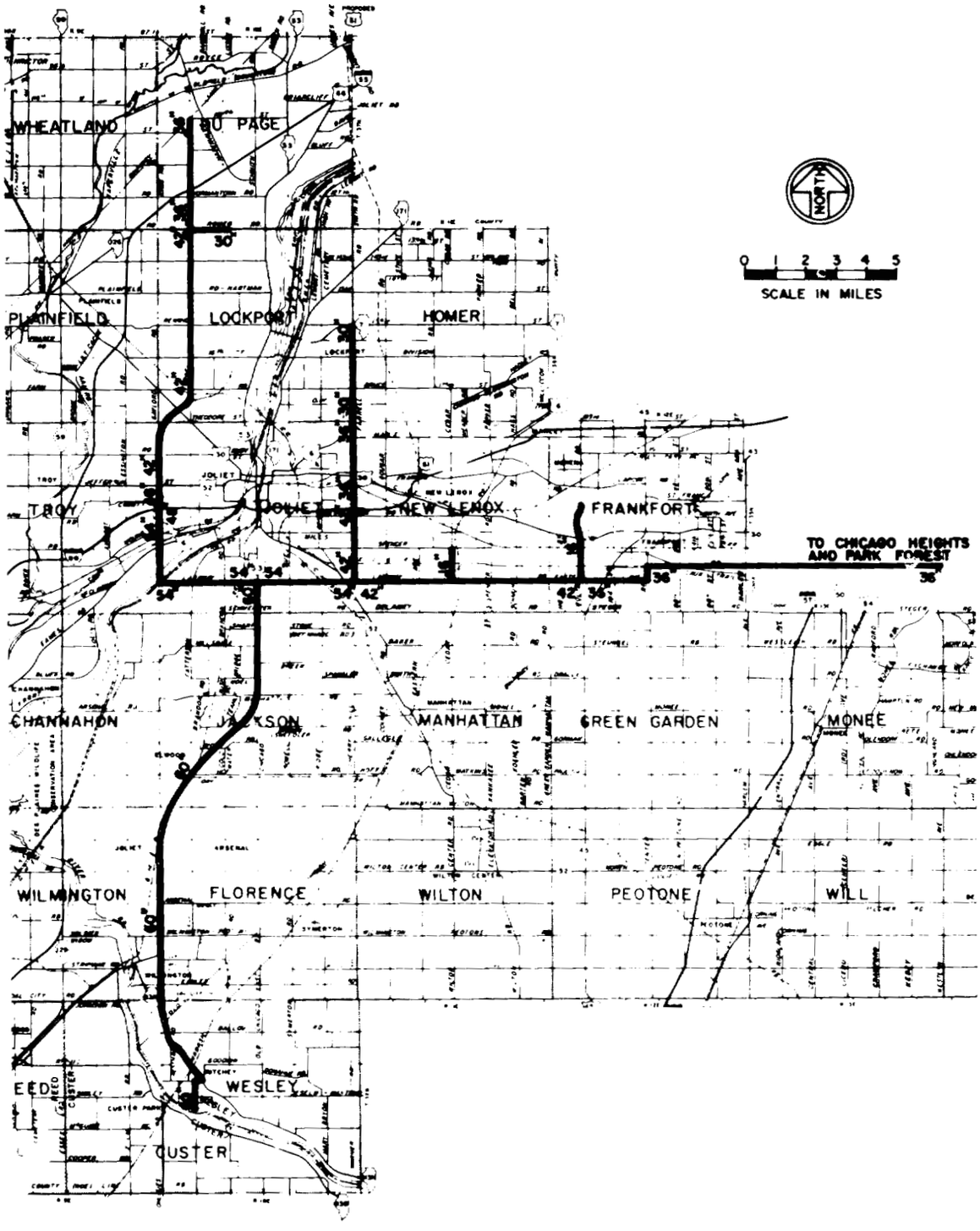

Fig. E.1. Proposed Water Transmission Mains. From "Preliminary Engineering Report on Kankakee River Water Supply System for Public Water Commission of Frankfort, Joliet, Lockport, Mokena, New Lenox, Rockdale, and Romeoville," Consoer, Townsend & Associates, June 1972.

Table E.1. Population and Water Consumption Forecast for Member Municipalities Plus Chicago Heights, Park Forest and Bolingbrook

	1970	1976	1980	1985	1990	2000	2010	2020
FRANKFORT								
POPULATION	2,325	5,130	7,000	9,000	11,000	15,000	19,000	23,000
PER CAPITA USE ... gpcpd	115	119.8	123	126	129	135	141	147
AVERAGE DAILY DEMAND ... mgd	0.27	0.61	0.86	1.13	1.42	2.02	2.68	3.38
MAXIMUM DAILY DEMAND ... mgd	0.46	1.11	1.55	2.04	2.55	3.64	4.82	6.08
JOLIET								
POPULATION	80,378	88,550	94,000	102,000	110,000	130,000	150,000	175,000
PER CAPITA USE ... gpcpd	126	129.6	132	135	138	144	150	156
AVERAGE DAILY DEMAND ... mgd	10.10	11.48	12.41	13.77	15.18	18.72	22.50	27.30
MAXIMUM DAILY DEMAND ... mgd	14.11	16.07	17.37	19.28	21.25	26.21	31.50	38.22
LOCKPORT								
POPULATION	9,985	13,900	16,500	28,250	40,000	50,000	60,000	70,000
PER CAPITA USE ... gpcpd	91	94	96	99	102	108	114	120
AVERAGE DAILY DEMAND ... mgd	0.91	1.31	1.58	2.80	4.08	5.40	6.84	8.40
MAXIMUM DAILY DEMAND ... mgd	1.88	2.61	3.17	5.59	8.16	10.80	13.68	16.80
MOKENA(1)								
POPULATION	1,643	2,460	3,000	3,750	4,500	6,000	7,500	9,000
PER CAPITA USE ... gpcpd	78	82.8	86	89	92	98	104	110
AVERAGE DAILY DEMAND ... mgd	0.12	0.20	0.26	0.33	0.41	0.59	0.78	0.99
MAXIMUM DAILY DEMAND ... mgd	0.24*	0.41	0.52	0.67	0.83	1.18	1.56	1.98
NEW LENOX(2)								
POPULATION	2,855	5,280	6,900	8,950	11,000	14,000	17,000	20,000
PER CAPITA USE ... gpcpd	104	107.6	110	113	116	122	128	134
AVERAGE DAILY DEMAND ... mgd	0.08	0.57	0.76	1.01	1.28	1.71	2.18	2.68
MAXIMUM DAILY DEMAND ... mgd	0.12	0.85	1.14	1.52	1.91	2.56	3.26	4.02
ROCKDALE								
POPULATION	2,085	2,510	2,800	3,250	3,700	5,000	6,500	8,000
PER CAPITA USE ... gpcpd	172	175.6	178	181	184	190	196	202
AVERAGE DAILY DEMAND ... mgd	0.36	0.44	0.50	0.59	0.68	0.95	1.27	1.62
MAXIMUM DAILY DEMAND ... mgd	0.55	0.68	0.77	0.91	1.06	1.47	1.97	2.50
ROMEOVILLE								
POPULATION	12,674	18,870	23,000	28,500	34,000	45,000	56,000	67,000
PER CAPITA USE ... gpcpd	67	78.4	86	89	92	98	104	110
AVERAGE DAILY DEMAND ... mgd	0.85	1.48	1.98	2.54	3.13	4.41	5.82	7.37
MAXIMUM DAILY DEMAND ... mgd	0.87	2.96	3.96	5.07	6.26	8.82	11.65	14.74
TOTAL								
POPULATION	111,945	136,700	153,200	183,700	214,200	265,000	316,000	372,000
AVERAGE DAILY DEMAND ... mgd	12.69	16.09	18.35	22.17	26.18	33.80	42.07	51.74
MAXIMUM DAILY DEMAND ... mgd	18.23	24.69	28.48	35.08	42.02	54.68	68.44	84.34
CHICAGO HEIGHTS								
POPULATION	40,900	43,960	46,000	49,000	52,000	58,000	64,000	70,000
PER CAPITA USE ... gpcpd	152	165.8	175	175	175	175	175	175
AVERAGE DAILY DEMAND ... mgd	6.23	7.29	8.05	8.58	9.10	10.15	11.20	12.25
MAXIMUM DAILY DEMAND ... mgd	9.76	12.10	13.36	14.23	15.11	16.85	18.59	20.34
PARK FOREST								
POPULATION	30,638	32,360	33,500	35,000	36,500	39,500	42,500	45,500
PER CAPITA USE ... gpcpd	79	83.2	86	89	92	98	104	110
AVERAGE DAILY DEMAND ... mgd	2.42	2.69	2.88	3.12	3.36	3.87	4.42	5.00
MAXIMUM DAILY DEMAND ... mgd	4.12	5.38	5.76	6.23	6.72	7.74	8.84	10.01
BOLINGBROOK								
POPULATION	8,504	20,000	61,000	77,000	93,000	120,000	140,000	160,000
PER CAPITA USE ... gpcpd	-	83	86	89	92	98	104	110
AVERAGE DAILY DEMAND ... mgd	-	1.66	5.25	6.85	8.56	11.76	14.56	17.60
MAXIMUM DAILY DEMAND ... mgd	-	3.32	10.49	13.71	17.11	23.52	29.12	35.20
TOTAL								
POPULATION	191,987	233,020	293,700	344,700	395,700	482,500	562,500	647,500
AVERAGE DAILY DEMAND ... mgd		27.73	34.53	40.72	47.20	59.58	72.25	86.59
MAXIMUM DAILY DEMAND ... mgd		45.49	58.09	69.25	80.96	102.79	124.99	149.89

From "Preliminary Engineering Report on Kankakee River Water Supply System for Public Water Commission of Frankfort, Joliet, Lockport, Mokena, New Lenox, Rockdale and Romeoville.

(1) Mokena: 1970 Population Served = 1,600
(2) New Lenox: 1970 Population Served = 800
* Estimated

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

May 1, 1974

50-456
50-457

Mr. D. R. Muller, Assistant Director
for Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

The Agricultural Research Service has reviewed the Draft Environmental Statement related to the proposed Braidwood Station of the Commonwealth Edison Company, Docket Numbers STN 50-456 and STN 50-457.

We have no comments to make at this time.

Sincerely,

H. L. Barrows

H. L. Barrows
Acting Assistant Administrator
National Program Staff

3871

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
NORTHEASTERN AREA, STATE AND PRIVATE FORESTRY
6816 MARKET STREET, UPPER DARBY, PA. 19082
TELEPHONE (215) XXXXXXX 597-3772

8400
May 10, 1974

Daniel R. Muller, Assistant Director
Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Re: Docket No. STN 50-456, STN 50-457
Draft Environmental Statement, Braidwood
Station, Units 1 & 2

Dear Mr. Muller:

The above Draft Environmental Statement on two Atomic Energy Units in Will County, Illinois, has been forwarded to us for review and comment because no National forest lands are involved.

Loss of woodland to transmission lines is difficult to estimate from descriptions on pp. 3-25 and 3-27. A total of 132 acres of "open woodland and hedgerows" is described.

Where transmission lines traverse wooded areas, some seeding with sod-forming grasses would help control erosion, hold down growth of other species with a beneficial effect on wildlife, and aid in economy of maintenance of the corridor.

Although there are approximately 169 acres of woodland affected at the site and along the pipeline corridor (p. 4-1), discussion of impact concentrates on cropland. Effect on forested land is not described in as much detail.

We appreciate the opportunity to review and comment on the draft.

Sincerely,

Robert McDonald

for ROBERT D. RAISCH
Director

4278

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P.O. Box 678, Champaign, Illinois 61820

May 17, 1974

RECEIVED MAY 21 1974

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

The draft environmental statement for the proposed construction by Commonwealth Edison of the Braidwood Station, Units 1 and 2, Docket Nos. STN 50-456 & STN 50-457, in Will County, Illinois, that was addressed to this office on April 4, 1974, has been reviewed as requested.

Out comments are attached.

We appreciate the opportunity to review and comment on the proposed project.

Sincerely,

Orlan L. Hansen, Acting

Howard W. Busch
State Conservationist

Attachment

4556

USDA-SOIL CONSERVATION SERVICE
COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT FOR THE PROPOSED CONSTRUCTION BY COMMONWEALTH EDISON OF THE BRAIDWOOD STATION, UNITS 1 AND 2, DOCKET NOS. STN 50-454 & STN 50-457, DATED APRIL 1974, LOCATED IN WILL COUNTY, ILLINOIS.

Due to the limited amount of information relating to the soils of the area it is difficult to fully evaluate the problems that may be encountered. Many of the soils in the area may be sandy and if found on the high ground may be highly susceptible to wind and water erosion. These are generally difficult to stabilize once the top soil is removed. Detailed soil information, which includes interpretation, is available at the Soil Conservation Service Office in Joliet, Illinois.

Page 4-2, Item 4.1.1, On Site Construction, fifth paragraph, says "The applicant has stated that, upon completion of construction, they will cooperate with the Will County Soil and Water District to assure the best use of spare land." We would suggest that the applicant cooperate with the Will County Soil and Water Conservation District during planning and construction.

Page 4-4, Item 4.3.2, Pipeline and Transmission Lines, second paragraph, second sentence, reads "Although wooded areas will require clearing along the pipeline route, revegetation will proceed naturally after the pipes are buried." Suggest it read "Vegetation will be reestablished on all disturbed areas following appropriate procedures as given in the Soil Conservation Service Technical Guide for Will County."

Page 5-1, Item 5.1.1, Station Operation, first paragraph, indicates the diversion of agriculture land to be minor relative to the amount of land available in Illinois for agriculture. The loss of prime agriculture land is recognized in the statement, however, we are concerned about the continued and accumulative effects of using prime agriculture land for other uses.

Care should be taken to avoid adverse effects to surface or sub-surface drainage.

There may be a need for draining low areas. In some cases, this may overdrain the higher ground making it more susceptible to wind and water erosion.

If you have questions relating to the soils, vegetating the dikes and disturbed areas, fertilization, woody plantings, drainage, erosion control, or any soil and water conservation practice, don't hesitate to get in touch with the District Conservationist, Allan D. May, Soil Conservation Service, 100 Manhattan Road, Joliet, Illinois 60433, telephone 815-723-5078.

We appreciate the opportunity to review and comment on the proposed project.

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS
U.S. COAST GUARD (G-WS/73)
400 SEVENTH STREET S.W.
WASHINGTON, D.C. 20590
PHONE (202) 426-2262

22 MAY 1974

RECEIVED

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

STN 50-456/457

Dear Mr. Muller:

This is in response to your letter of 4 April 1974 addressed to Mr. Benjamin O. Davis concerning the draft environmental impact statement for Braidwood Station, Units 1 and 2, Kankakee River, Will County, Illinois.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. The Federal Highway Administration commented as follows:

"We have reviewed the information relating to siting of the proposed Braidwood generating stations, and we believe the long and short-term impacts on local transportation systems need additional discussion. Evidence of early coordination with the Illinois Department of Transportation and other impacted transportation agencies is substantially missing from the reports. In particular, the following items should be discussed:

(1) The effect of increased temporary traffic volume on I-55 and its interchanges near Braidwood. These relatively low-order, rural interchanges appear to be the prime points of traffic movement to the generating station sites during and after construction.

(2) Significantly increased traffic across the GM&O Railroad grade crossings will apparently result from construction traffic and possibly from permanent traffic flow to the stations. The potential for a severe hazard may be present, and the need for improvements should be explored.

(3) Unusually heavy loads associated with construction would likely travel both the Interstate highway and the local road systems. The impact of increased heavy traffic on maintenance requirements should be discussed.

"We believe these preceding points should be coordinated with local and State highway officials, and we recommend that such coordination be undertaken as soon as possible."

The Department of Transportation has no other comments to offer nor do we have any objection to this statement. However, the concerns of the Federal Highway Administration should be addressed in the final environmental impact statement.

The opportunity to review this draft statement is appreciated.

Sincerely,

R. H. PRICE
Capt., U.S. Coast Guard
Deputy Chief, Office of Marine
Environment and Systems
By direction of the Commandant

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
CHICAGO AREA OFFICE
17 NORTH DEARBORN STREET
CHICAGO, ILLINOIS 60602

REGION V
300 South Wacker Drive
Chicago, Illinois 60606

MAY 23 1974

IN REPLY REFER TO:
5.2PP:Downing

Mr. Daniel R. Muller, Assistant Director
for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

Subject: Draft Environmental Statement
Commonwealth Edison Company
Braidwood Station, Units 1 & 2
Docket Numbers: STN-50-456 & STN-50-457, (Will County, Ill.)

This is to notify you that the above referenced Statement has been received by this agency. We hereby transmit the following response.

The proposed action is the issuance of a construction permit to the Commonwealth Edison Company for the construction of the Braidwood Station, Units 1 and 2, located near the Kankakee River in Will County, Illinois.

Braidwood Station will employ two pressurized water reactors to produce up to 6850 megawatts thermal (MWt). A steam turbine-generator will use this heat to provide 2240 MW(net) of electrical power capacity. The exhaust steam will be cooled by a once-through flow of water obtained from an artificial cooling lake. Makeup (93 cfs,avg.) will be drawn from the Kankakee River and blowdown (46 cfs,avg.) will be discharged to it. Two underground pipelines will connect with the Kankakee River. Two lengthy transmission lines will be involved.

The following are some of HUD theoretical areas of jurisdiction by law or special expertise which will be involved in the project:

(1) Energy. Environmental Aspects of Electric Energy Generation and Transmission.

(2) Land Use and Management

(3) Noise

(4) Urban

These HUD concerns are primarily urban. Although the proposed project site is located in a non-urban area, it is true that the environmental effects and the pipelines and transmission lines will have urban relationships.

Due to staff and workload considerations, however, this office of HUD, especially at the present time, is unable to offer any comments on the project in general or on special HUD concerns. We add these suggestions and/or requests.

1. According to our present information, (Northeastern Illinois Planning Commission) the Regional Planning Commission which includes the proposed site in its planning area, which is also the Metropolitan Clearinghouse, has not received this Draft Environmental Statement. They have however, transmitted to your Agency a review of the related environmental report prepared by the Commonwealth Edison Company. This review may be of some help to you.

2. Your Draft Environmental Statement does not include in its distribution list other local or areawide planning agencies and local executives which should be concerned.

3. We wish to be informed of any issues which you consider important for HUD. We will respond if possible.

4. Before approval is given for licensing, many technical experts should be involved, including technical experts who are able to decide that environmental safeguards will not be sacrificed to meet energy needs.

Sincerely,

John L. Waner
Director

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

In reply refer to:
PEP ER 74/465

STN 50-456/457

MAY 31 1974

Dear Mr. Muller:

Thank you for your letter of April 4, 1974, transmitting copies of the Atomic Energy Commission's draft environmental statement for the Braidwood Station, Units 1 and 2, Will County, Illinois.

Our comments are presented according to the format of the statement or according to subject.

General

Essential environmental information in this draft statement has been presented in a cursory manner or mentioned by reference. The reader is constantly referred to other documents, notably the applicant's environmental report and the staff's safety review for essential environmental data. We believe the final statement should include all data directly relevant to the evaluation of the potential environmental impacts.

Regional Demography and Land Use

The statement is made that there are 19 private and public recreation facilities located within a 10-mile radius of the nuclear plant site and that their total peak daily attendance is 40,000. We suggest that these recreation areas be listed and identified on a map in the final statement.

Historical Places and Natural Landmarks

It is apparent from the text that some or all of the archeological sites located in the area were tested. The extent of testing should be defined in the final statement. The recommendations of the Illinois State Historic Preservation Officer located in Appendix D is endorsed.

JOHNNY HORIZON 76

Let's Clean Up America For Our 200th Birthday

4969

The final statement should also reflect a firm plan for mitigation or salvage of any unrecorded archeological remains which may be encountered during the course of project development.

Topography, Geology and Seismology

The brief paragraphs on topography, geology and seismology on page 2-6 are inadequate for an assessment of these three aspects of the environment relevant to the design, construction, and operation of Units 1 and 2. These subjects are not properly described.

We believe geologic conditions to be directly relevant to evaluation of the potential environmental impact of a nuclear facility, as illustrated in the following paragraphs, which take into account pertinent information in the applicant's environmental report (ER).

The area of the proposed four-square-mile cooling lake is characterized by strip-mining trenches up to 100 feet deep, by extensive deep deposits of strip-mining spoils, and by at least two underground mines. Four or five of the deep trenches cross the southern perimeter of the proposed lake, which would have a depth of about 100 feet in the floors of the abandoned strip mines as noted on page 5-16. The largest underground mine underlies about 2,500 feet of the southwestern perimeter of the cooling lake as indicated on Figure 2.5-1a of the applicant's environmental report (ER). Of the several lakes that now exist within the area of the proposed cooling lake, the one closest to the underground mine is commonly at an elevation of about 523 feet, whereas the cooling lake would raise this level by about 72 feet to an elevation of about 595 feet. No discussion of the underground mine has been presented in the environmental report and the draft environmental statement fails to mention the mine, despite the fact that it underlies more than 150 acres within the area of the proposed cooling lake, extends beneath the proposed dike, and underlies an appreciable area outside the plant property line.

As a minimum, the environmental statement should include information on the type and thickness of surficial deposits along the proposed alignment of perimeter dikes, information on the approximate depth of excavation required, and design of the dikes in problem areas. At present, only highly

generalized information is provided on surficial deposits and practically no information is provided on the varying local thickness of strip-mine spoils or their physical properties. The geologic data provided in the draft statement are largely concerned with the reactor site, while the more complex geology of the cooling-lake area has not been discussed. For example, surficial deposits are described as Quaternary drift approximately 50 feet thick in Table 2.4, whereas surficial deposits within the site boundary evidently include several square miles of strip-mine spoils that appear to reach thicknesses of nearly 100 feet.

It is surprising that even in the applicant's environmental report the most detailed geologic map is at the very small scale of about 1:3,600,000 in Figure 2.4-2. The scale should be from 20 to 100 times larger in order to provide a basis for independently assessing probable impacts of dike construction. Because of the nearby cooling-lake dike failure under conditions that appear to have been potentially no more troublesome than those at the Braidwood Station, we recommend that it be mandatory that the relevant geologic data be provided in the draft statement. Requisite data include the source of fill material to be used for the clay core of perimeter dikes (ER, Figure 2.4-11). The environmental impacts have apparently been evaluated on the assumption that suitable clay fill would be obtained entirely within the area of the proposed cooling lake as indicated on page 4-2. However, in view of the probable need for dikes as high as 100 feet in places, and the apparent unsuitability of most strip-mine spoils to serve as clay cores, adequacy of the proposed source for clay fill needs to be substantiated by additional data.

Although no information has been provided on either the depth of the mine beneath the surface or on its elevation, we presume that the underground mine has its floor at [illegible] the same geologic stratum as the strip mines. This [illegible] be confirmed by the fact that the "limits of probable future strip mining" shown on ER figure 2.5-1a coincide with the northeastern boundary of the underground mine and with the approximate limits of former strip mining [illegible] fairly closely with its southeastern boundary. The [illegible] lake at 523 feet, referred to above, which [illegible] bottom of a deep strip-mine trench, is within 220 feet of the underground mine at one point. An unidentified point [illegible] line on the map connects the lake with the mine, so [illegible] that underground drainage may follow [illegible]

excavation in that area. Although no information has been provided on the location of former mine portals, on the precise extent of the mine, or on its present condition, the environmental statement should provide assurances that the abandoned mine workings will not become an avenue for underground drainage from the cooling lake and will not constitute a risk to the integrity of the perimeter dikes. We urge that all of the above-mentioned information gaps related to the large underground mine, and also to smaller underground mine(s) within the cooling lake area, need to be examined and assessed in the final environmental statement. Related impacts and proposed mitigative measures should also be discussed. The effects on levels as much as 72 feet need to be evaluated as well.

Impacts on Land Use

Data presented on page 4-1 that will be occupied by the lake, islands and dikes are misleading. From information provided in ER figure 2.7-3, we have calculated that nearly 1,000 acres of woodland presently exist instead of the 117 acres as indicated by the staff. The discrepancy apparently stems from the staff's classification of 2,838 acres as "strip-mined spoil". We suggest the final statement categorize in detail the strip mined lands into habitat types, or vegetation types. These descriptions also should include a detailed discussion regarding their relative values to wildlife.

The paragraph beginning "The loss of 734 acres . . ." found on page 4-1 does not describe the total area impacted by the proposed. As stated above, we believe 1,000 acres should be classified as woodland habitat. An additional 650 acres contain some cover, both herbaceous and woody. This combination of habitat types adjacent to agricultural and the fallow areas provide habitat for numerous important birds, mammals and other species. The loss or disruption of all these habitats by construction, clearing, and/or inundation is an adverse impact and should be described.

Transmission Line Construction

The discussion of transmission line construction does not adequately address the effect of the clearing practices, involving 2,375 acres of right-of-way, on wildlife. These practices, together with the lands to be permanently taken from agricultural production, should be considered as adverse impacts.

Ecological Effects from Construction

Upon completion of construction of the nuclear power plant, the applicant, Commonwealth Edison Company, has indicated it "...will cooperate with the Will County Soil and Water District to assure the best use of spare land" at the Braidwood site. We suggest that the final EIS indicate the uses it anticipates that the District would suggest for the "spare land."

Categorizing 2,838 acres simply as "strip-mine spoil" does not present the reader with an accurate picture of any reclamation which has taken place including existing vegetative units and their value as wildlife habitat. Thus the full magnitude of the wildlife habitat losses cannot be grasped if the classification of reclaimed lands is not expanded.

Statements in this section imply that the destruction of over 3,000 acres of habitat associated with inundation and dike construction is acceptably small when placed in perspective with available terrestrial habitat in the area. Rationalization of such habitat destruction should be omitted. The loss of habitat and its affect on the area's wildlife should be described without qualification.

This section should describe in greater detail the adverse environmental impact associated with construction of the intake and discharge structures, including the effects of temporarily increased turbidities on the aquatic biota of the area. Should construction occur during the spring spawning season, substantial losses of fish eggs and fry may result.

The integrity of the proposed cooling lake dikes is a matter of concern. It is noted that the Braidwood Station would be situated about 10 miles upstream from the Dresden Nuclear Power Station, and in a setting that is similar in many respects. It is stated on page 5-2 that the "slurry trench technique" for sealing the Braidwood dikes would prevent the type of dike failure that occurred at Dresden, resulting in a total loss of impounded water on October 13, 1972 (Dresden Environmental Impact Statement, page 3-5).

In this technique, excavations for seepage barriers beneath the dikes would be extended down to the first principal local aquiclude, which lies at an average depth of 20-30 feet (ER, page 4.1-2). However, little or nothing has been said about problems that may result from strip-mining spoils along the dike alignment, from the considerable depths of strip-mine trenches that traverse the perimeter at several places, or from the underground mine workings that have been discussed above. Potential problems arise from the stated fact that "the spoil of the site area is among the most difficult calcareous spoil to reclaim in Illinois" and the fact that "there is enough sand to give it a slush-like consistency during wet periods and 'mud' flows may occur in times of heavy rainfall" (ER, page 2.7-5). In lieu of an adequate discussion of the problems concerning dike construction and integrity in such materials, further information is required to support an independent assessment of the potential impacts of dike construction and the adequacy of proposed mitigative measures.

During construction the foundation excavation is proposed to be dewatered to a depth of about 60 feet below the land surface. The applicant has estimated that the effects of dewatering during the worst conditions would be a lowering of the water level at the nearest well of about 2 feet. The AEC staff has concluded, on basis of this estimate, that this adverse effect is acceptable. We suggest that dewatering could have a more noticeable effect on nearby wells such as the 20 sand points at the trailer park 1,500 feet to the west. The effect of dewatering should be more fully investigated.

Impacts on Water Use

If the applicant actually proposes not to withdraw or discharge water during extreme low flow periods, as indicated on page 9-13, then this fact should also be stated in Section 5. Otherwise a discrepancy exists in the information that has been provided.

The final statement should more fully discuss the "...local adverse effects upon lake biota..." associated with the use of chlorine as indicated on page 5-17.

The presence of an abnormally warm region in the Kankakee River below the discharge point, as indicated on page 5-22, might induce premature spawning by certain pelagic spawners. This section should describe the probable effects on the eggs and fry of these species when they drift out of the warmer mixing zone.

Recreation

Although it is stated on page 5-1 that the power company has made no plans for secondary public use of the station site, the staff commented on page 10-6 that the cooling lake has potential for recreation use. It may be noted that Illinois has prepared a statewide outdoor recreation plan in order that the state may participate in the Land and Water Conservation Fund Program, administered by this Department. The plan indicates a need by 1985 for Planning Region 2, in which Will County is located, of 316,263 acres of water for recreation use. There is also a very great demand in Planning Region 2 for nature study, hiking, and picnic areas. We strongly urge that consideration be given to the utilization of a portion of the 4,420-acre Braidwood Station site for public day-use outdoor recreation activities, consistent with Atomic Energy Commission health and security restrictions.

Visual Impact

The staff contention that a cooling lake is more aesthetically pleasing than strip-mine lands should be qualified. Strip-mine reclamation laws require rehabilitation of these lands which, given time and proper management, have been proven to transform unsightly spoil into aesthetically attractive areas supporting a variety of fish and wildlife resources.

Cooling Lake Operations

The circulation through this lake of 3,250 cfs of water heated by 22°F raises the concern that the heated waters would leach out chemicals at an accelerated rate from the spoil banks of the strip-mined area, leading to a buildup in the lake of acid water high in dissolved solids. The draft statement fails to discuss or evaluate this problem.

The applicant's environmental report discusses the leaching effect on lake-water chemistry (ER Sections 7.5.1.4.2 and 5.4.1) and concludes that it will be a short-term phenomenon that will not be significant. We know of no basis for this conclusion.

Should this buildup occur, there would be concern about the discharge of blowdown water from the lake into the Kankakee River as well as contamination of nearby shallow wells. Seepage from the lake may be extensive despite the proposed slurry trenching around the dikes, and we do not agree with the applicant's assessment (ER, Section 2.5.2.4) that the effects of seepage of water high in dissolved solids will be quickly dissipated by dilution from rainfall recharge. The draft statement implies that discharge into the river of chemicals that are not utilized or produced by the effluent stream that is the source of water is not covered by effluent standards. It is not clear whether this is intended to cover chemicals leached from the strip-mined area. In any case, an assessment of this problem should be included in the final statement, together with a discussion of possible alternatives.

Net water loss to the river is given variously; thus, on page 1, item 2, it is (93-46 cfs =) 47 cfs; on page 10-1, it is about 57 cfs. We believe the latter figure to be more realistic. However, we also agree with the staff assessment that in periods of drought the cooling lake presents an advantage over cooling towers in its ability to operate for several weeks without drawing on the river. This would offset the slightly higher average water consumption of the cooling lake as compared to cooling towers.

The normal water-surface elevation of the cooling water lake is given as 595 feet MSL and the top of the dikes as 600 feet MSL, giving a free-board of 5 feet. The possibility that wind-generated waves could overtop and cut the dikes should be investigated.

Cumulative Impacts

We urge that the future cumulative effects of the Braidwood, Dresden, and Collins Power Stations on the water quality and fishery resources of the Illinois River be assessed and included in the final statement. The inferior water quality of the blowdown from all three stations could have a significant effect on the aquatic biota of the river, particularly during periods of future low flows.

Radioactive Discharges

There is insufficient information in the draft statement to determine if the radioactive gases from the proposed nuclear powerplant would be vented through a tall stack or at ground level.

Environmental Impact of Postulated Accidents

In the discussion of postulated accidents it is stated on page 7-1 that "the probability of occurrence of accidents and the spectrum of their consequences have been analyzed using best estimates of probabilities". However, only qualitative data on probability have been presented, including such statements as "the probability of occurrence of large class 8 accidents is very small". Other than the fact that examples of accidents have been arranged in approximate order of probability, no quantitative data on probability have been included. Consequently, the environmental risk, combining both consequences and probability, has not been assessed. The statement is made on page 7-4 that "it is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small and need not be considered further". However, in view of the fact that class 9 accidents have not been considered in the evaluation as indicated on page 7-27 and that risks have not been quantitatively evaluated, that conclusion needs qualification.

It should be noted that the environmental risks consider only "postulated accidents," the staff having assumed that the most serious class 9 accidents need not be postulated for purposes of evaluating environmental impact. That assumption has only been supported by very generalized and qualitative reasons in the present statement or in other documents seen to date. We recommend that the effects of class 9 accidents should be considered in the final statement.

Candidate Site-Source Alternatives

The reference on page 9-8 to the "...low value, ecologically and economically, of the mine spoil..." should be changed. A site-by-site comparison of habitat types, fish and wildlife resources, and human use of these resources would present a more accurate basis for site selection, particularly if proper reclamation procedures had been instituted.

Comparison of Coal and Nuclear Generating Stations

The reference on page 9-9 to the greater efficiency of a high temperature gas-cooled reactor has no bearing on the environmental effects from this proposed pressurized water reactor.

It is not clear if the coal used in the comparison contains natural radioactive material that is released during combustion, or if this is the worst case for a coal-fired plant compared to the best case for a nuclear plant.

The expected emission quantities of carbon monoxide, hydrocarbon, and aldehydes from the equivalent size coal-fired plant are not typical of a properly operated coal-fired plant.

Table 9.3 does not explain why a 600-foot tall stack would be used on a powerplant equipped with a stack gas cleaning system.

Abiotic Effects

This Section should include a discussion of the loss of annual production of wildlife resources and the human use of these resources for the life of the project. In addition, the loss of fish and wildlife resources which could inhabit the strip-mined land following any mandatory reclamation measures also constitutes an unavoidable loss and should be included in the final statement. The statement that "...some displace animals may become re-established in surrounding lands..." is misleading without detailed information concerning present wildlife carrying capacities for those areas.

We hope that these comments will be helpful to you in the preparation of the final statement.

Sincerely yours,

Secretary of the Interior

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

STN-50-456
STN-50-457

May 29, 1974

RECEIVED
MAY 30 1974
U.S. Atomic Energy Commission
Regulatory
Mail Section

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

The draft environmental impact statement for Braidwood Station, Docket Nos. STN 50-456 and STN 50-457, which accompanied your letter of April 4, 1974, has been received by the Department of Commerce for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

Page 4-4. Intake and Discharge Structures. This section mentions the fact that the applicant will be required to minimize the impact of siltation on the aquatic community. It would be helpful if a complete description of the proposed method for accomplishing this purpose could be included.

Page 5-16. Predictions of the Ecology at the Braidwood Cooling Lake. This section should discuss the potential effects on aquatic life of acid mine drainage from the open pit mine which, in part, will be used for the cooling lake.

Page 5-18. Entrainment. The second paragraph in this section refers to numbers of organisms expected to be entrained. It would be helpful if some relative order of magnitude could be applied to this estimate.

It would be useful to add the following to Table 6.5: (1) the names of the five key species to be examined for condition and stomach contents; and (2) fish sampling in January, if possible, to determine areas of concentration and preference during this time of year. In addition, the number of samples taken at each station on the transect should be included, with

4817

a minimum of two replicate samples required at each station.

Page 9-13. Water Consumption Considerations. This section should be expanded to include the alternative of natural draft wet cooling towers in combination with a small water storage reservoir. This alternative would allow for decoupling the station from the Kankakee River during extreme low-flow conditions while, at the same time, minimizing the large land area which must be committed to the lake. Considerable public benefit might accrue from this alternative cooling design. As a possibility, management of the storage reservoir for multiple-use could be delegated to the appropriate resource management agencies and the Company could retain the right to utilize the reservoir as the source for makeup water during critical periods.

Finally, our interpretation of the description of the disposal of radioactive noble gases to the atmosphere is that approximately one-third of the total per year (1280 out of 3500 Ci/yr/reactor) is released very sporadically. Releases resulting from containment purges are estimated to occur ten times per year. Releases by way of the gaseous waste processing system occur from decay tanks having a 45-day holdup capacity before emission to the atmosphere. In both cases, no information was given on the length of the release period. Consequently, assuming each release lasts an hour, the total during the year would be about 20 hours. The use of annual average relative concentrations (see chi/Q values listed in table 5.4) are not appropriate for such sporadic releases.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving a copy of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

STN-50-456/457

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20201

MAY 20 1974

RECEIVED
MAY 21 1974
U.S. Atomic Energy Commission
Docket Control
Mail Section

Mr. Daniel R. Muller
Assistant Director for Environmental
Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

This Department has reviewed the draft Environmental Impact Statement for the Braidwood Station, Units 1 and 2. On the basis of information contained in this draft statement, it appears that the radiological impact on the population surrounding the site will be within the low-as-practicable criteria established by the Atomic Energy Commission. The dose to the thyroid of a child drinking 1 liter of milk per day from the farm nearest to the site would be 6.5 millirem per year. The total man-rem to the population living in the unrestricted area within 50 miles of the plant, using the estimated 1980 population of 4.5 million persons, would be about 16 man-rem per year.

The radiological consequences of postulated accidents for the eight classes normally considered are included within the draft report. The maximum doses would result from a loss-of-coolant accident involving a large break. This dose has been estimated to be 1.25 rem to an individual at the site boundary and a population dose of 1300 man-rem to the population within a 50 mile radius. These magnitudes of doses are acceptable based on the low probability of the occurrence of an accident of this type.

The draft Environmental Impact Statement needs to be more specific concerning the location of health facilities and schools in the immediate area. A ten mile radius is not specific enough.

Page 2 - Mr. Muller

In Section 4.1.2. it is stated "The staff recommends that, should it prove necessary to use herbicides they be used at State or Federally approved rates; for spot, not broadcast, application, and not in the vicinity of houses, bodies of water, food supplies, domestic animals or recreation areas." Instead of a recommendation, should this not be a requirement?

Section 4.2., paragraph 2 mentions increased turbidity of the river. Would this turbidity be somewhat hazardous to swimmers instead of merely an inconvenience? If so, what precautions are being taken?

In Section 4.3.2, paragraph 2, it is stated that pipeline construction will cause a temporary loss of animals in the area and an increase to edge area habitats. Will this increase be significant enough to cause an imbalance in the neighboring habitats? Will these animals have enough food?

Regarding Section 5.3.2.2, paragraph 3, what is the probability that water and effluents could be carried further than the 100 miles downstream mentioned in this paragraph? If there is a reasonable probability, what will be the effect on drinking water downstream and the commensurate risks to the health of the human and animal population? Also, is it not possible that wildlife could drink water within 100 miles of the site and pass this contamination on to humans?

Thank you for the opportunity to review this statement.

Sincerely,

Charles Custard

Charles Custard
Director
Office of Environmental Affairs

4551

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

MAY 16 1974

RECEIVED
MAY 21 1974
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Office of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

This is in response to your letter dated April 4, 1974, requesting comments on the AEC Draft Environmental Statement related to the proposed issuance of construction permits to the Commonwealth Edison Company (Applicant) for the construction of the Braidwood Station, Units 1 and 2 (Docket Nos. STN 50-456 and STN 50-457). The proposed 1,120-megawatt Braidwood Units 1 and 2 are scheduled for commercial service in May 1980 and October 1981, respectively. The proposed 4,420-acre site is located in a rural area near Braidwood, Will County, Illinois.

These comments by the Federal Power Commission's Bureau of Power staff are made in compliance with the National Environmental Policy Act of 1969 and the August 1, 1973, Guidelines of the Council on Environmental Quality, and are directed to the need for the capacity represented by the Braidwood units, and to related bulk power supply matters.

In preparing these comments, the Bureau of Power staff has considered the AEC Draft Environmental Statement; the Applicant's Environmental Report and supplements thereto; related reports made in accordance with the Commission's Statement of Reliability and Adequacy of Electric Service (Docket No. R-362); and the staff's analysis of these documents, together with related information from other FPC reports. The staff generally bases its evaluation of the need for a specific bulk power facility upon long-term considerations as well as upon the load-supply situation for the peak load period immediately following the availability of the new facility. The useful life of each of the Braidwood generating units is expected to be 30 years or more; and during that period, each unit will make a significant contribution to the reliability and adequacy of electric power supply in the Applicant's service area.

The Applicant is a member of the Mid-America Interpool Network (MAIN). MAIN coordinates the planning of the members' bulk power facilities serving the area which includes portions of Wisconsin, Upper Michigan, Illinois and Missouri. The Applicant's system is interconnected with adjoining utility systems of the MAIN region and adjoining regions, thereby providing for intra- and inter-regional power exchanges and operating contingency support.

The MAIN systems, including the Applicant, generally include in their consideration of the projected load-supply scheme several factors used by electric utility system planners, such as the probability of loss of load because of the unavailability of generation. The physical characteristics of the subject systems for the time period involved have generally produced calculated projected reserve generating margins of a magnitude toward the lower portion of the 15 to 25 percent range observed by the staff as prevailing throughout a major portion of the industry.

The following tabulations show the projected capabilities, loads, and reserve margins for the summer-peaking Applicant's and MAIN systems for the 1980 and 1982 summer peak periods and the effect of the capacity of the proposed Braidwood units on the reserve margins of these systems.

1980 SUMMER PEAK LOAD-SUPPLY SITUATION 1/

	Applicant's System	MAIN Systems
With Braidwood Unit 1 (1,120 megawatts)		
Total Capability - Megawatts	24,787	57,939
Load Responsibility - Megawatts	21,210	48,110
Reserve Margin - Megawatts	3,577	9,829
Reserve Margin - Percent of Peak Load	16.9	20.4
Applicant's Desired Reserve Margin (Based on 14 Percent of Peak Load) - Megawatts	2,969	6,735
Reserve Deficiency - Megawatts	-	-
Without Braidwood Unit 1		
Reserve Margin - Megawatts	2,457	8,709
Reserve Margin - Percent of Peak Load	11.6	18.1
Applicant's Desired Reserve Margin (Based on 14 Percent of Peak Load) - Megawatts	2,969	6,735
Reserve Deficiency - Megawatts	512	-

1/ Data Source: MAIN report submitted in response to FPC Docket No. R-362 dated April 1, 1974.

1982 SUMMER PEAK LOAD-SUPPLY SITUATION 1/

	Applicant's System	MAIN Systems
With Braidwood Units 1 and 2 (2,240 megawatts)		
Total Capability - Megawatts	28,097	65,512
Load Responsibility - Megawatts	24,350	55,001
Reserve Margin - Megawatts	3,747	10,511
Reserve Margin - Percent of Peak Load	15.4	19.1
Applicant's Desired Reserve Margin (Based on 14 Percent of Peak Load) - Megawatts	3,409	7,700
Reserve Deficiency - Megawatts	-	-
Without Braidwood Units 1 and 2		
Reserve Margin - Megawatts	1,507	8,271
Reserve Margin - Percent of Peak Load	6.2	15.0
Applicant's Desired Reserve Margin (Based on 14 Percent of Peak Load) - Megawatts	3,409	7,700
Reserve Deficiency - Megawatts	1,902	-

1/ Data Source: MAIN report submitted in response to FPC Docket No. R-362 dated April 1, 1974.

Based on above data, it is noted that if the 1,120 megawatt Braidwood Units 1 and 2 were not available on schedule, the Applicant's reserve margin would be reduced from the planned 16.9 percent to 11.6 percent of the 1980 summer peak load, and from the planned 15.4 percent to 6.2 percent of the 1982 summer peak load. Hence, reserve margins on the Applicant's system would not meet its stated criterion of 14 percent of the 1980 and 1982 summer peak loads. If the units should not be available on schedule, the reserve margins for the MAIN systems would be reduced from the planned 20.4 percent to 18.1 percent of the 1980 summer peak load and from the planned 19.1 percent to 15.0 percent of the 1982 summer peak load. Delay in commercial operation of other projected new capacity would reduce the Applicant's and MAIN's projected margins below levels sufficient to withstand contingencies that experience has shown to occur on interconnected electric bulk power systems.

The Bureau of Power staff concludes that additional capacity equivalent to that represented by the proposed Braidwood Units 1 and 2 is necessary to provide the level of reserve capacity the Applicant's criterion requires to meet normally encountered contingencies.

Very truly yours,

T. R. Phillips
Chief, Bureau of Power

Advisory Council
On Historic Preservation
1522 K Street N.W. Suite 430
Washington D.C. 20005

Docket No. STN-50-456/457

April 23, 1974

RECEIVED
APR 25 1974
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

This is in response to your request of April 4, 1974, for comments on the environmental statement for Braidwood Station Units 1 and 2, Will County, Illinois. Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Advisory Council on Historic Preservation has determined that your draft environmental statement appears procedurally adequate. However, we have the following substantive comments to make:

> The Advisory Council requests that the Final Environmental Statement on this undertaking contain a copy of the applicant's archeological report as well as a statement indicating "Commonwealth Edison's plans for archeological salvage of located archeological sites and their plans for recording and salvage of archeological sites which may be discovered during project construction," as requested by Mr. Anthony T. Dean, the Illinois Historic Preservation Officer, in his February 15, letter to your office (Appendix D of draft environmental statement).

Should you have any questions or require any additional assistance, please contact Jordan Tannenbaum at 202-254-3974 of the Advisory Council staff.

Sincerely yours,

Ann Webster Smith
Director, Office of Compliance

The Council is an independent unit of the Executive Branch of the Federal Government charged by the Act of October 15, 1966 to advise the President and Congress in the field of Historic Preservation.

3656

DEPARTMENT OF THE ARMY
CHICAGO DISTRICT, CORPS OF ENGINEERS
219 SOUTH DEARBORN STREET
CHICAGO, ILLINOIS 60604

NCCPD-ER

5 June 1974

RECEIVED JUN 14 1974

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

We have reviewed the EIS for the Braidwood Station (Docket Nos. STN 50-456 and STN 50-457), transmitted to our office with your 4 April 1974 letter. The following comments are limited to the Corps of Engineers functional area of responsibility and expertise, as identified in Appendix II of the 1 August 1973 CEQ guidelines.

The statement is well documented and appears to be an objective analysis of the probable impacts. However, additional information on the existing and planned generating stations, fired by either nuclear or fossil fuels for the applicant's service area, should be included along with an analysis of the cumulative impacts. This additional information should include any anticipated overlapping "zones of effect" of the airborne and waterborne effluents. Also acreages and locations of plant sites and transmission corridors and the generating capacities of each station should be provided. In particular, cumulative impacts of the closely situated La Salle, Collins, Dresden and Braidwood stations should be considered.

A Corps of Engineers permit will be required for any dredging and construction in the Kankakee River including the intake and discharge structures. To date, we have not received any requests for a permit for this station. Therefore, we are withholding any comments on the intake and discharge structures and any dredging until a request for a permit has been received and evaluated by this office.

The opportunity to review this statement is appreciated.

Sincerely yours,

Melvin H. Farrar

MELVIN H. FARRAR
LTC, Corps of Engineers
Deputy District Engineer
for Civil Works

534

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

3 JUL 1974

STN-50-456

STN-50-457

RECEIVED JUL 8 1974

Mr. L. Manning Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muntzing:

The Environmental Protection Agency has reviewed the Draft Environmental Impact Statement issued in conjunction with the application by Commonwealth Edison for a construction permit for the proposed Braidwood Station. Our detailed comments are enclosed.

Our major concern with the cooling system design is the impact that withdrawal of make-up water from the Kankakee River will have upon biota during low flow conditions. Therefore, we believe it more prudent to require pumping be discontinued or halted when withdrawal from the river exceeds acceptable biological limits. We are also concerned about the maintenance of the high water quality of the Kankakee River; consequently, we believe the application should give full consideration to cooling blowdown to ambient river temperatures.

In light of our review and in accordance with EPA procedure, we have rated the project ER (Environmental Reservations) and classified the draft statement Category 2 (Insufficient Information). If you or your staff have any questions concerning our classification or comments, we will be happy to discuss them with you.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

6076

ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

JULY 1974

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Braidwood Station, Units 1 & 2

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INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental statement issued by the U.S. Atomic Energy Commission in conjuction with the application of Commonwealth Edison Company for a construction permit to build Braidwood Station, Units 1 and 2. This plant will be located in Will County, Illinois near the Kankakee River. The following are our major conclusions:

1. To minimize the adverse impacts on the Kankakee River, we believe it more prudent to require pumping be decreased or halted when withdrawal of water exceeds a certain percent of the river flow, i.e., 10%.

2. Considering the high quality of the Kankakee River and the future consumptive uses of the river, we believe in order to maintain and protect a diversified and high quality fishery, the applicant should provide additional cooling of the blowdown discharge.

3. With the exception of gaseous radioiodine releases, the proposed gaseous and liquid waste treatment systems are expected to be capable of limiting radionuclide releases and, therefore, the related offsite doses to levels within the guidance of the proposed Appendix I to 10 CFR Part 50.

4. Based on EPA's independent analysis, the thyroid dose of 150 mrem/yr from radioiodine via the cow-milk-child pathway at the nearest potential pasture exceeds the guides in the proposed Appendix I, as given in the concluding statement for Regulatory Docket RM-50-2.

5. In the final statement, thyroid dose estimates within five miles of the turbine building due to milk consumption via the goat pathway and the location of goats should be included.

6. The applicant should develop a cow and goat surveillance program which should include periodic checks as to the location of the nearest cow or goat in order to assure that the real doses are maintained within the provisions of applicable regulatory limits and guides throughout the lifetime of the plant.

RADIOLOGICAL ASPECTS

Radioactive Waste Treatment

The proposed gaseous and liquid waste treatment systems are representative of "state-of-the-art" effluent control technology. As a consequence, the quantities and concentrations of radionuclides expected to be released from Braidwood Station will meet "the as low as practicable" design objectives as defined by the proposed Appendix I to 10 CFR Part 50, except for doses to a child's thyroid which could exceed the guide values if milk produced by a cow grazing at the nearest potential pasture were consumed by a child.

Dose Assessment

The calculated doses to individual receptors from radionuclides assumed to be discharged from the Braidwood Station are within the regulatory design basis objectives given in the proposed Appendix I, except for the potential thyroid dose. The estimated thyroid dose equivalent rate (150 mrem/yr due to milk ingestion via the cow pathway) to the most critical individual (an infant) due to the emission of radioiodine and subsequent transport to man through a potential pathway (nearest potential pasture--1900 feet WNW) indicates that the guidance in the proposed Appendix I may be exceeded. Also, thyroid dose estimates due to milk consumption via the goat pathway and the location of goats within five miles of the turbine building should be included in the final statement, since thyroid doses via the goat pathway are potentially much higher than via the cow pathway. In order to provide some verification that the thyroid doses are maintained within the provisions of the proposed Appendix I during plant operation, the applicant should include a periodic audit of the location of the nearest lactating cow or goat so that the critical pathway will be known throughout the plant lifetime. Furthermore, the EPA concurs with the AEC requirements to modify the preoperational radiological monitoring program as presented on page 6-1 in the draft statement.

The AEC, in its analysis of the plant, calculated a dose of 6.5 mrem/yr at the nearest farm with a milk producing animal. The method of analysis used was the HERMES code and not the method described in the interim Regulatory Guide 1.42 (Revision 1) or the proposed Regulatory Guide 1.AA, recently commented on by the EPA. The pertinent pathway transport parameters and internal dose parameters from the HERMES code that were utilized for the iodine pathway analysis should be presented in the final statement so that an evaluation of the iodine pathway dose model can be made.

The EPA expects that the results from current and planned joint EPA-AEC and industry cooperative field studies in the environs of operating

nuclear power facilities will greatly increase knowledge of the processes and mechanisms involved in the exposure of man to radiation produced through the use of nuclear power. We believe that, overall, the cumulative assumptions utilized to estimate various human doses are conservative. As more information is developed, the models used to estimate human exposures will be modified to reflect the best data and most realistic situations possible. Based on the results of these cooperative studies, it is possible that the scope and extent of present environmental monitoring programs may be relaxed.

TRANSPORTATION

EPA, in its earlier reviews of the environmental impact of transportation of radioactive material, agreed with the AEC that many aspects of this program could best be treated on a generic basis. The generic approach has reached the point where on February 5, 1973, the AEC published for comment in the Federal Register a rulemaking proposal concerning the "Environmental Effects of Transportation of Fuel and Waste from Nuclear Power Reactors." EPA commented on the proposed rulemaking by a letter to the AEC, dated March 22, 1973, and by an appearance at the public hearing on April 2, 1973.

Until such time as a generic rule is established, EPA is continuing to assess the adequacy of the quantitative estimates of environmental radiation impact resulting from transportation of radioactive materials provided in environmental statements. The estimates provided for this station are deemed adequate based on currently available information.

Reactor Accidents

EPA has examined the AEC analysis of accidents and their potential risks which the AEC has developed in the course of its engineering evaluation of reactor safety in the design of nuclear plants. Since these accident issues are common to all nuclear power plants of a given type, EPA concurs with the AEC's approach to evaluate the environmental risk for each accident class on a generic basis. The AEC has in the past and still continues to devote extensive efforts to assure safety through plant design and accident analyses in the licensing process on a case-by-case basis. EPA, however, favors the additional step now being undertaken by the AEC of a thorough analysis on a more quantitative basis of the risk of potential accidents in all ranges. We continue to encourage this effort and urge the AEC to press forward to its timely completion and publication. EPA believes this will result in a better understanding of the possible risks to the environment.

We are pleased to note in the draft statement the discussion of the Reactor Safety Study and the commitment for timely public presentation of its results. If the AEC's efforts indicate that unwarranted risks

are being taken at the Braidwood Station, we are confident that the AEC will assume appropriate corrective action. Similarly, if EPA efforts related to the accident area uncover any environmentally unacceptable conditions related to the safety of the Braidwood Station, we will make our views known. Furthermore, the discussion of the potential consequences of the failure of radioactive waste systems is recognized as a significant improvement which is responsive to EPA's request that plant specific considerations be amplified in individual draft statements.

NONRADIOLOGICAL ASPECTS

The Braidwood Station will consist of two identical pressurized water reactors rated at 3425 megawatts thermal each. As presently proposed by the applicant, condenser cooling will be accomplished by a once-through system with discharge to an adjoining artificial lake of approximately 2640 acres. Make-up water flow (93.3 cfs average) for the lake will be drawn from and blowdown (46.0 cfs average) discharged to the Kankakee River, with these flows adjusted as necessary to maintain lake water level and prevent the buildup of dissolved and suspended solids.

Plant Cooling System and FWPCA Requirements

With regard to the use of cooling lakes, a problem has recently arisen concerning the definition of navigable waters and its applicability to the cooling lake itself--particularly if additional benefits such as recreation are to be realized from the lake. The obvious problem is that if a cooling lake is declared "navigable," effluent limitations and water quality standards would apply to the cooling lake. A detailed discussion of this problem was contained in EPA's comments of May 10, 1974, on the Comanche Peak nuclear power station. Since the draft statement indicates, however, that the Braidwood cooling lake will be used only for cooling purposes, the effluent limitations will have to be met only at the point of discharge to the Kankakee River. A permit for this discharge will be issued under the National Pollutant Discharge Elimination System (NPDES)--Section 402 of the Federal Water Pollution Control Act Amendments of 1972 (FWPCA).

The following comments address the proposed plant as described in the draft statement and are based on the assumption that the cooling lake concept is approvable.

River Flows and Plant Impacts

It was indicated in the statement that the applicant has offered to restrict net water withdrawal to 10% of the river flow. However, the AEC staff noted approximately 21% of the river under low flow conditions would be diverted to the cooling lake. Such diversion could become a common occurrence if upstream consumptive use expands as proposed (p. 9-13). The staff has concluded the adverse effects (5-19) of this practice would be minimized by requiring that pumping from the river be decreased or halted until the period of low flow passes. It is our opinion that the proposal as outlined is not adequate to assure that the river will not suffer damage during low flow periods or as consumptive use increases. It is not clear, for instance, what "important adverse effects" are and what level of damage will be allowed before pumping from the river is decreased or halted.

If the AEC staff wishes to maintain this position, what "important adverse effects" are and how much of an impact will be tolerated must be more clearly defined. We believe it might be more prudent to require that pumping decrease or halt when it exceeds a certain percent

of the river flow, i.e., 10%. Set at an appropriately low percentage, it could be assumed that little or no damage is occurring. Studies should be done at that flow to determine if undesirable effects still occur. This alleviates that subjective decision as to what constitutes "important adverse effects."

Although the Illinois Water Quality Standards were recently revised (as required by Section 303(a) of FWPCA) and approved by EPA on June 6, 1974, it was noted in the letter of approval that the temperature standards were not adequate to fully protect aquatic life. It is expected that the State of Illinois will be requested to change the temperature standards at some future date. Any changes will be based on the Proposed Water Quality Criteria document published in October 1973 by EPA or the Water Quality Criteria document published by the National Academy of Science. The statement should discuss the ability of the Braidwood Station to protect indigenous aquatic life of the Kankakee River as determined by these two documents.

In light of the amended standards and possible future changes, the applicant should give full consideration to providing further cooling of blowdown discharges, i.e. discharge of blowdown at ambient river temperatures. By providing this additional cooling, the applicant would be able to meet future standards and eliminate more severe impacts upon the Kankakee River.

On page 3-8, there is a discussion of the plume resulting from the blowdown. However, there was no flow given for the river in this discussion. Calculations of plume configurations, acreage covered and the zone of passage available should be made for the 7-day-once-in-ten-year low flow. Furthermore, based on information in the statement, it is unclear to us how it is possible to mix 50 cubic feet per second (cfs) of blowdown water with a ΔT of 25°F into 350 cfs (442 cfs 7-day-once-in-ten-year low flow minus 93 cfs make-up water) of river water without causing a large plume and a relatively small zone of passage. This small zone of passage may be especially significant since the Kankakee River is a known spawning river for northern and walleye pike. During spawning periods, these fish cannot tolerate water temperatures above 48°F (9°C).

The Molz-Benedict model used to calculate the plume sizes found in table 3-2 can underestimate the plume size. The 5°F plume will probably exceed the low areas predicted in Table 3-2, but not exceed the Illinois Water Quality Standards of 26 acres. Therefore, we suggest other models be used and compared to verify the applicants conclusion.

ADDITIONAL COMMENTS

During the review, we noted in certain instances that the draft statement does not present sufficient information to substantiate the conclusions presented. We recognize that much of this information is not of major importance in evaluating the environmental impact of the Braidwood Station. The cumulative importance, however, could be significant. It would, therefore, be helpful in determining the impact of the plant if the following information were included in the final statement.

1. On page 3-19 of the draft statement, the AEC staff states that there will be no treatment of the offgases from the main condenser vacuum pump. But, on page 3-22, the staff has assumed that the radioiodine "present in the vacuum pump exhaust will be released through a charcoal adsorber to the plant vent." This statement is confirmed by Figure 3.11 on page 3-21. This discrepancy should be resolved.

2. The draft statement mentions on page 3-19 that the steam generator blowdown treatment system heat exchangers are degased. This source term should be included in Table 3.6 on page 3-20.

3. Where there is an option to use charcoal adsorbers, we strongly suggest that, whenever there is an iodine source term, they be used continuously in order to meet "as low as practicable" criteria. A firm commitment should be made by the applicant to utilize charcoal adsorbers continuously, under conditions in which there will be an iodine discharge.

4. On page 5-8 of the draft statement, the staff states that "Radiation doses calculated by the staff are intended to apply to an average adult." The EPA feels that the most critical individual should be considered when making dose estimates. If this approach is not taken, applicable standards or guides may be exceeded.

5. According to the draft statement (page 5-11), the nearest potential pasture is located 1040 feet ENE of the site while the Environmental Report (ER) states that the nearest potential pastures are 1900 feet WNW (overall closest) and 3000 feet in the ENE direction. Also, the draft statement assumes that the nearest residence is 1550 feet north while the ER states a value of 1550 feet to the west. These discrepancies should be clarified.

6. With regard to transmission lines, the issue of consequential damage to adjacent and abutting properties is not addressed. This issue along with other impacts of transmission lines should be fully addressed.

UPPER MISSISSIPPI RIVER BASIN COMMISSION
FEDERAL BUILDING, ROOM [illegible] FORT SNELLING, TWIN CITIES, MINNESOTA 55111 PHONE 612-725-4690
REG. OFFICE: ROOM [illegible] FEDERAL BLDG. COURTHOUSE, PARKERSBURG, W. VA. 26101 PHONE 304-232-5271 EXT. 5355

April 11, 1974

STN 50-456/457

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

The Draft Environmental Impact Statement on the Proposed Braidwood Station has been received and filed by this office.

At present, the Upper Mississippi River Basin Commission has not established a review procedure for such documents. Therefore, at this time, we have no comments on the Statement.

The material you provided does contain useful information for the Commission, and we request you continue to send us information and copies of similar material for our future use and consideration.

Thank you for the opportunity to comment.

Sincerely,

George W. Griebenow
Chairman

GWG:dm

ILLINOIS ARCHAEOLOGICAL SURVEY
109 DAVENPORT HALL UNIVERSITY OF ILLINOIS URBANA, ILLINOIS 61801

Cooperating Institutions:
University of Illinois
Southern Illinois University
Illinois State Museum

April 15, 1974

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
United States Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

Thank you for a Draft Environmental Statement of the Braidwood Station, Will County, Illinois, of the Commonwealth Edison Company. An archaeological assessment for this station was prepared by the Illinois State Museum, one of our affiliates, and your summary on Page 2-1 of their findings is adequate.

We appreciate your concern with preserving our archaeological environment.

Cordially yours,

Charles J. Bareis
Secretary-Treasurer

CJB:dg

3999

STATE OF ILLINOIS
DEPARTMENT OF
REGISTRATION AND EDUCATION
DEAN BARRINGER, *Director*
Springfield
BOARD OF NATURAL RESOURCES
AND CONSERVATION
DEAN BARRINGER, *Chairman*
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CHEMISTRY .... HERBERT S. GUTOWSKY
ENGINEERING ... ROBERT H. ANDERSON
BIOLOGY ..... THOMAS PARK
FORESTRY ..... CHARLES E. OLMSTED
UNIVERSITY OF ILLINOIS
DEAN WILLIAM L. EVERITT
SOUTHERN ILLINOIS UNIVERSITY
DEAN ELBERT HADLEY

ILLINOIS NATURAL HISTORY SURVEY

Natural Resources Building
Urbana, Illinois 61801

Telephone: 333-6880
Area Code 217

GEORGE SPRUGEL, JR., *Chief*

April 22, 1974

RECEIVED
APR 25 1974

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller: Ref: Docket No. STN 50-456, STN 50-457

As requested, the Survey has examined the Draft Environmental Statement prepared for the Braidwood Station of the Commonwealth Edison Company.

In our judgement, the Statement seems quite adequate in the areas of our competence to comment. We note an error in reference in lines 2 and 3, Section 2.7.2., Aquatic Ecology, on page 2-13. "Illinois Natural History Survey" should be inserted in place of "Illinois Water Survey Board."

The Survey is a bit surprised to note the almost-cavalier manner in which the diversion of 743 acres from agricultural use is disposed of on pages 4-1 and 5-1. The economic loss is calculated (generously, to be sure) for only one year at existing market prices. Since many of the other costs and benefits are calculated on the basis of the 30 years life of the installation, why not calculate the loss of food production to mankind from such diversion over the 30 years period as well? Current year prices cannot be used throughout, of course, because the tremendous demand of the greater human population in the year 2008 for food from production sources that have been consistently reduced by diversion of land to other uses must surely result in higher cost per unit of raw product available for food consumption or use in other forms. The statement in line 4 of 5.1.1. Station Operation, page 5-1., "...the staff considers the diversion of the agricultural land to be minor relative to the amount of land available in Illinois for agriculture" does not fortify the reviewer's confidence in the staff's understanding of the world-wide population--food supply problems expected in the near future.

Finally, in line 37, Section 5.4.2.2.2, Impingement, page 5-19, the statement "... may actually result in the growth of larger, better quality fish," is purely unfounded speculation unless appropriate studies of existing fish populations have been completed. We find no evidence, in the statement, that such detailed research on either the current population densities or growth rates of individual species have indeed been undertaken.

Sincerely yours,

George Sprugel, Jr.
Chief

GS:aa

3663

50-456
50-457

STATE OF ILLINOIS
DEPARTMENT OF
REGISTRATION AND
EDUCATION
DEAN BARRINGER
DIRECTOR SPRINGFIELD
BOARD OF NATURAL
RESOURCES AND
CONSERVATION
CHAIRMAN ..... DEAN BARRINGER
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ENGINEERING ..... ROBERT H. ANDERSON
BIOLOGY ..... THOMAS PARK
FORESTRY ..... CHARLES E. OLMSTED
UNIVERSITY OF ILLINOIS
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DEAN ELBERT H. HADLEY

ILLINOIS STATE GEOLOGICAL SURVEY

NATURAL RESOURCES BUILDING, URBANA, ILLINOIS 61801 TELEPHONE 217 344-1481

JOHN C. FRYE, CHIEF

May 22, 1974

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, DC 20545

Dear Mr. Muller:

We have reviewed the draft environmental statement for Commonwealth Edison Company, Braidwood Station Units 1 and 2, docket numbers STN 50-456 and STN 50-457. Our only comment is with reference to the statement on page 2-6, second paragraph, that "The majority of earthquakes are associated with geologic fault lines." This gives the implication that fault lines (which are commonly shown on geologic maps) are the loci of earthquake epicenters. This is not true in the middle-western and eastern United States. The epicenters of earthquakes in Illinois show no relationship to the fault lines observed at land surface. Presumably the earthquakes are produced by movements along deep faults that bear unknown relationships to faults at land surface.

Very truly yours,

Robert E. Bergstrom
Coordinator
Environmental Geology

10 south riverside plaza · chicago, illinois 60606 · (312) 454-0400

NORTHEASTERN ILLINOIS PLANNING COMMISSION

MATTHEW L. ROCKWELL
Executive Director

EARLE HARRISON
President
JACK PAHL
Vice President
IRA J. BACH
Secretary
WALDEMAR RAKOW
Treasurer

24. May 1974

RECEIVED
MAY 30 1974
U.S. ATOMIC ENERGY COMMISSION

Mr. B. J. Youngblood, Chief
Environmental Projects Branch No. 3
Directorate of Licensing
United States Atomic Energy Commission
Washington, D. C. 20545

Subject: NIPC Project No. 74-A-74, U. S. Atomic Energy Commission - Draft Environmental Statement
Braidwood Station of Commonwealth Edison
(Docket Nos. STN 50-456 and STN 50-457)

Dear Mr. Youngblood:

The NIPC staff previously reviewed the environmental assessment prepared for the Braidwood nuclear power station. The staff comments were transmitted to you on December 18, 1973. We feel that these comments, except for one major exception, adequately express our findings on the draft environmental statement.

Important new information has come to us, however, which indicates a significant deficiency in the draft environmental statement. The Francis Creek shale deposits unearthed at Pit 11 of the Peabody Coal Company are known worldwide for the richness of the Pennsylvanian fossil fauna and flora, and especially for the rare occurance of high quality fossils of soft-bodied marine animals. The significance of the area has been well documented by the Illinois State Geological Survey, the Chicago Natural History Museum and many other sources.

The impact of the proposed cooling lake upon this unique resource should be evaluated in the environmental statement. As Commonwealth Edison owns considerably more land than is proposed to be used by the plant or the cooling lake, consideration should be given to modification of the lake to avoid the prime fossil location. At the very least, full cooperation should be given to the concerned scientific institutions so that intensive fossil collection can occur prior to construction of the cooling lake. We understand that other organizations and individuals will be conveying to you information on the prime collecting areas, the nature of the fossil resources, and preferable modifications of the cooling lake.

As noted above, our comments on other aspects of the draft environmental statement are reflected in our earlier review which is attached (NIPC No. 73-262). Should you have need of any additional information relative to the above comments, please contact us.

Sincerely,

Phillip D. Peters

Phillip D. Peters
Assistant Director: Planning

PDP:kez

cc: Mr. Tom Murphy, Director
Will County Regional Planning Commission

Enclosure

4763

Relationship to Comprehensive Regional Planning

The Commonwealth Edison Company is proposing to construct two 1175 megawatt electrical, pressurized water reactor, nuclear units on a 6-square mile site in extreme southwest Will County near Braidwood. The plant will cost $ 965.7 million and is expected to be in operation by 1980. Also included in the project are a 2,640 acre cooling lake, two pipe lines to the Kankakee River and two transmission lines.

The subject site is located in an area that will result in minimal impact on the region's population. It does not infringe upon priority open space areas. The present land uses are predominantly former strip mining areas (approximately 60%) and therefore the proposed development will result in upgrading of these areas. Also the impact on agricultural land is expected to be minimal as only about 700 acres are currently under cultivation and none of this is prime agricultural land.

The location of the two transmission lines and the two pipelines to the Kankakee River have not yet been established. The Commission was urged that the design of these facilities be esthetically pleasing and their routing cause as little disruption as possible to existing land uses. Moreover, we would urge Commonwealth Edison to consult with the Commission so that the locations of these facilities can be coordinated with existing regional and local plans.

The existence of the cooling lake on the site is seen as providing substantial wildlife benefits. However, it would appear that public access will not be available. It would be of significant additional benefit if the site could provide for public accessibility in order that a portion of the unmet recreational needs in northeastern Illinois could be satisfied.

The Commission also has concern regarding the esthetic impact of the plant itself. We would encourage Commonwealth Edison to design the plant as attractively as possible, and visually blend it into the landscape through plantings and construction of earthworks.

The intake of water from the Kankakee River should be done in a manner that insures protection of aquatic life, and the discharge of heated water should avoid adversely affecting the ecology of the river which has significant potential for domestic water consumption and recreational use.

It would appear that from a cost standpoint the nuclear power plant proposed is the most economical method to meet the increasing energy demands of the region's population. The unavailability of some alternative fuel sources and the environmental unacceptability of others leaves nuclear energy virtually the only viable alternative at this time. The Commission, however, is not technically competent to comment on the other important environmental considerations such as the possibility of accidents and the disposal of radioactive wastes. These matters should be dealt with thoroughly and conclusively by the Atomic Energy Commission and other technical experts before approval is given for licensing.

In conclusion, we find the Braidwood Nuclear Power Station to be generally consistent with comprehensive regional planning. The following issues, discussed above, should be addressed in the final Environmental Assessment and the Environmental Impact Statement:

1. The ultimate location of the two pipelines to the Kankakee River and the two transmission lines,
2. Public accessibility to the cooling lake for recreational use,
3. The effect of water intake and discharge pipelines on the Kankakee River, and
4. Plant design.

STATE OF ILLINOIS

DEPARTMENT OF MINES AND MINERALS
SPRINGFIELD 62706

RUSSELL T. DAWE
DIRECTOR

SIN-50-456
June 10, 1974 SIN-50-457

RECEIVED JUN 12 1974

Mr. Daniel R. Muller
Assistant Director for Environmental Projects
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

The Department has reviewed the draft environmental statement concerning the Braidwood Station of the Commonwealth Edison Company.

The Department's comments pertain to the reclamation of the 2,838 acres of surface mined lands involved. Most of the surface mined land in this area has been reclaimed to be utilized as recreation land. An excellent area for fossil hunting is found within the proposed cooling lake.

No mention was made of the acreage of spoils to remain within the cooling lake above the 595' level or what possibility the cooling lake could be used as recreation land.

Sincerely yours,

Russell T. Dawe
DIRECTOR

RTD:slb
cc:P. Christy

GEOTHERMAL ENERGY INSTITUTE
680 BEACH STREET, SUITE 426
SAN FRANCISCO, CALIFORNIA 94109
(415) 474-0404

SIN-50-457

RECEIVED APR 23 1974 U.S. ATOMIC ENERGY COMMISSION Mail Section

April 17, 1974

U. S. Atomic Energy Commission
Washington, D. C.

Re: Draft Environmental Statement related to the proposed Braidwood Nuclear Power Plant, Will County, Illinois

Gentlepersons:

We submit the following comments on this DES for your consideration:

1. At page 9-4 the following independent assesment of geothermal alternatives appears:

> "Geothermal energy is currently being developed as a power source in Europe and to a limited extent in the western part of this country. There are no known geothermal resource areas in Illinois. Therefore, geothermal energy is not a viable alternative."

The geothermal potential of the State of Illinois has not been accurately determined. We believe, however, it has significant potential for a hot dry rock source, for a geothermal deep drilling project and perhaps for geopressured reservoirs.

We note that the U. S. Patent Office issued Patent No. 3,786, 858 entitled "Method of Extracting Heat from Dry Geothermal Reservoirs" and that this system is being tested by the Los Alamos Scientific Laboratory of the University of California and by Batelle Northwest Laboratories in Montana. LASL reported in February that "There are at least twenty or thirty relatively large, relatively hot geothermal anomalies in the western United States which apparently contain neither steam nor hot water, and together they represent a dry rock resource base that could supply the Nation's needs for at least a century." We suggest you contact the Illinois Geological

3595

Survey for their assessment of the State's geothermal potential.

2. Geothermal power was developed as a power source in Europe seventy years ago and has since been commercially put to use in the U.S.S.R., Mexico, Japan, New Zealand, Iceland and California. Geothermal power plants are also under construction in El Salvador and the Phillipines and are planned for Kenya, Ethiopia, Greece and Indonesia.

The technology for utilising both dry steam and wet steam geothermal sources is proven and commercially tested.

Binary-cycle systems have been successfully tested in the U.S.S.R., Japan and Italy and such plants are now planned for Heber, Long Valley and Sulphur Bank, California by San Diego Gas & Electric Company, Southern California Edison Company and Dow Chemical Company.

3. Geothermal energy sources have been used in several western States since the turn of the century for space heating and recreational purposes. The City of Klamath Falls, Oregon utilizes 400 geothermal wells to heat homes, schools, hospitals and offices at a fraction of the cost of fossil fuel heat.

4. We question the validity of the economic costs (Section 9.1.2.5). Presently known domestic uranium resources and exisiting production are admittedly inadequate to meet projected uranium demand. Nuclear Fuel Supply, AEC-WASH-1242 (1973). The AEC sees a uranium shortage as soon as 1982. F. T. Baranowski, 1974, Statement on Uranium Resources: U. S. Atomic Energy Commission. Recent sales of uranium were at $20/lb and we can expect to see higher prices shortly. The DES does not seem to clearly disclose whether the applicant has secured a fuel source or reprocessing capability.

The staff's estimate of $ 1.2 billionfor the cost of the plant seems low in view of the costs of plants now under design or construction. The

GEOTHERMAL ENERGY INSTITUTE

practicality, cost and impact of long-term radioactive waste disposal has not been weighed in the DES. If the people of Illinois are to export their radioavtive wastes to another State, this should be disclosed and the impact considered in detail.

Very truly yours,

Donald F.X. Finn

Donald F.X. Finn
Managing Director

CC: Council on Environmental Quality
Environmental Protection Agency
Governor, State of Illinois
Senator Charles Percy

United States Patent [19]
Potter et al.

[11] 3,786,858
[45] Jan. 22, 1974

[54] METHOD OF EXTRACTING HEAT FROM DRY GEOTHERMAL RESERVOIRS

[75] Inventors: Robert M. Potter; Eugene S. Robinson; Morton C. Smith, all of Los Alamos, N. Mex.

[73] Assignee: The United States of America as represented by the United States Atomic Energy Commission, Washington, D.C.

[22] Filed: Mar. 27, 1972

[21] Appl. No.: 238,435

[52] U.S. Cl. 165/1, 165/45, 166/247
[51] Int. Cl. F28d 21/00
[58] Field of Search 165/1, 45; 166/247

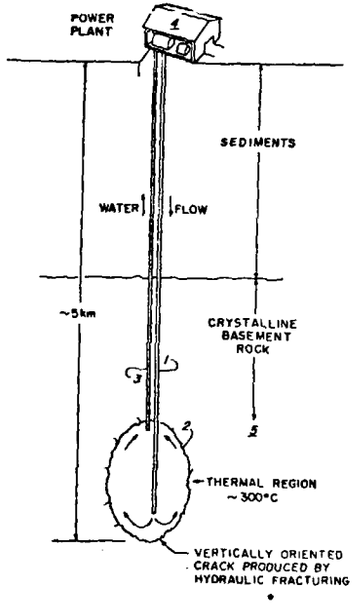
[56] References Cited
UNITED STATES PATENTS
3,640,336 2/1972 Dixon 165/1

Primary Examiner—Charles Sukalo
Attorney, Agent, or Firm—John A. Horan

[57] ABSTRACT

Hydraulic fracturing is used to interconnect two or more holes which penetrate a previously dry geothermal reservoir, and to produce within the reservoir a sufficiently large heat-transfer surface so that heat can be extracted from the reservoir at a usefully high rate by a fluid entering it through one hole and leaving it through another. Introduction of a fluid into the reservoir to remove heat from it and establishment of natural (unpumped) convective circulation through the reservoir to accomplish continuous heat removal are important and novel features of the method.

5 Claims, 2 Drawing Figures



APPENDIX G

FIELD MUSEUM
OF NATURAL HISTORY

May 16, 1974

Mr. Stanley Kirslis
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Kirslis:

Following our telephone conversation this afternoon, I enclose two publications concerning the fossils of Pit Eleven. Altogether, there have been perhaps 40 publications, on both the popular and the scientific levels.

The fossils that occur in Pit Eleven are of Middle Pennsylvanian age (300,000,000 years old). They represent a virtually complete sample of a shallow-water deltaic marine fauna, including soft-bodied animals not ordinarily preservable in the fossil record.

Specimens from the same fauna have been found at two small exposures in Grundy and Knox counties, Illinois, but Pit Eleven is overwhelmingly the most productive locality. Thanks to fifteen years of intensive fossil collecting by the Field Museum and by amateur collectors, more than a hundred species otherwise unknown to science have been recovered. Some of them are so rare that they are still represented only by single specimens. A salvage program centering at The Field Museum is proposed, with the cooperation of Commonwealth Edison, with the object of recovering the maximum number of fossils before flooding eliminates the locality.

Pit Eleven ranks as one of the world's most significant fossil localities. Papers on elements of the fauna have been published by specialists in England, Germany and Norway as well as this country. Scientists from those countries and Belgium, Japan, Czechoslovakia and others have visited the Pit. The fate of the Pit Eleven fossils is of real concern to a large scientific community.

ROOSEVELT ROAD AT LAKE SHORE DRIVE • CHICAGO, ILLINOIS 60605 • TELEPHONE 922-9410, AREA CODE 312

Thank you for your interest. I do expect valuable results through the cooperation of Commonwealth Edison.

Sincerely yours,

Eugene S. Richardson jr

Eugene S. Richardson, Jr.
Curator
Fossil Invertebrates

ESR:mla
Enclosure

cc: R.F. Inger
R.G. Johnson
E.L. Yochelson

Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address: Post Office Box 767
Chicago, Illinois 60690

June 13, 1974

Mr. B. J. Youngblood
Chief
Environmental Projects, Branch 3
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D. C. 20545

Re: Docket Nos. STN 50-456 and STN 50-457

Dear Mr. Youngblood:

In response to your recent letter of May 30th concerning scientific interest in fossils in the area of the Braidwood lake, Commonwealth Edison has been aware of this matter for some time. As a result, we have contacted Dr. Eugene S. Richardson, Jr., who is the Curator of Fossil Invertebrates at the Field Museum of Natural History and who has studied extensively the fossils found in the Braidwood area. During these conversations, we explored the significance of the fossils in the Braidwood area and methods to provide assurance that this resource is not unnecessarily lost.

We have learned that fossils of scientific interest exist throughout a substantial area both near and on the proposed lake site. The mining which has lessened the value of the land on the Braidwood site for other purposes has caused fossils to be exposed and accessible. None of these areas are permanently available for highly productive investigation without new digging or scraping because reclamation or natural growth of flora lessens the weathering which exposes fossils. Thus, the area planned for the lake would not be a permanent resource even if the lake were not built.

Since certain areas within the proposed dike are now particularly easy to search for fossils due to relatively recent mining and the absence of intensive reclamation, Commonwealth Edison has reached an agreement with Dr. Richardson to provide assurance that there is not a significant irreplacable scientific loss. While details remain to be developed, an outline of this program has been

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established. First, Commonwealth Edison will continue to allow collectors to search for fossils until construction commences, subject to registration and release of the Company from liability for injuries which could occur in the spoil areas. This permission will not be limited to individuals affiliated with the Field Museum. After construction commences, increased supervision will be necessary to minimize the possibility of injuries and to prevent interference with construction activities. Accordingly, access will then be limited to individuals connected with and subject to supervision by the Field Museum. However, it should be emphasized that the Museum cooperates extensively with amateur collectors so that the most responsible and serious amateurs will continue to have access under supervision. After the lake is filled, Museum personnel and affiliated amateurs will be allowed access to spoil islands which are expected to comprise in excess of 25 percent of the portion of the lake area now most extensively searched for fossils.

The excavation and scraping during the construction of the lake will expose fossils more extensively and rapidly than the normal erosion process. Dr. Richardson is applying to the National Science Foundation for a grant to allow him to intensify fossil hunting in the area which will be disturbed during construction in order to maximize the recovery of such fossils. Commonwealth Edison expects to assist in this program by providing a storage shed and instructing its construction superintendent to cooperate in providing access to construction areas to the extent practical.

The combination of intensive fossil hunting during construction, the preservation of islands which will constitute more than 25 percent of the best fossil hunting portion of the lake site and the availability of areas outside the lake for hunting by non-affiliated organizations provides assurance that any unique paleontological value of the Braidwood site will not be lost.

Three signed originals and 40 additional copies of this letter are submitted for your use.

Very truly yours,

Byron Lee Jr.

Byron Lee, Jr.
Vice President

Subscribed and sworn to before
me this 13th day of June, 1974.

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Notary Public