

DISTRIBUTION:

COMMENTS:

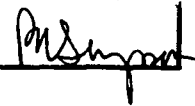
12/08/1972 - - Zion - Final Environmental Statement related to operation of Zion Nuclear Power Station Units 1 and 2.

FILE:

Zion : Environmental Issues :

Originator:

Simpson, Patrick



LICENSING DEPT.

72120801

72120801 ✓

DOCKET. 50295--74

RECEIVED BY TIC DEC 8 - 1972

Final

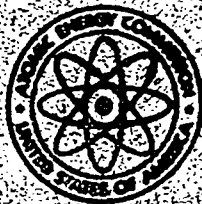
environmental statement

related to operation of

ZION NUCLEAR POWER STATION UNITS 1 and 2

COMMONWEALTH EDISON COMPANY

DOCKET NOS. 50-295 50-304



December 1972

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

MASTER

REPRODUCTION OF THIS DOCUMENT IS UNLIMITED

**WE REGRET THAT SOME OF
THE PAGES IN THE
MICROFICHE COPY OF THIS
REPORT MAY NOT BE UP TO
THE PROPER LEGIBILITY
STANDARDS, EVEN THOUGH
THE BEST POSSIBLE COPY
WAS USED FOR PREPARING
THE MASTER FICHE**

DOCKET. 50295--74

RECEIVED BY TIC DEC 8 - 1972

Final

NUS
EGG
FILE

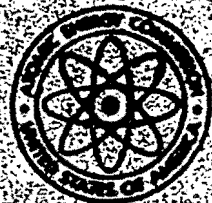
environmental statement

related to operation of

ZION NUCLEAR POWER STATION UNITS 1 and 2

COMMONWEALTH EDISON COMPANY

DOCKET NOS. 50-295 50-304



December 1972

UNITED STATES ATOMIC ENERGY COMMISSION

MASTERS OF THE ARTS

MASTER

REPRODUCTION OF THIS DOCUMENT IS UNLIMITED

SUMMARY AND CONCLUSIONS

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

1. This action is administrative.
2. The proposed actions are the continuation of construction permits CPPR-58 and 59 and the issuance of operating licenses to the Commonwealth Edison Company for the start-up and operation of the Zion Nuclear Power Station located in the State of Illinois, County of Lake, in the City of Zion. (Docket Nos. 50-295 and 50-304).

The Zion Station consists of two units (Unit 1 and Unit 2). Each unit utilizes a Pressurized Water Reactor (PWR) to produce about 3250 megawatts (MW) of heat to generate about 1100 MW of electricity. The balance of the energy (about 2150 MWt per unit) is discharged to Lake Michigan by a "once-through" cooling system, with a total Station flow capacity of 1,530,000 gpm.

3. Summary of environmental impact and adverse effects:

- a. Approximately 250 acres of beach and recreational dunes property bordering Lake Michigan and including about 2000 ft of shoreline have been converted to industrial use. A large portion of the Station site has been set aside as a natural habitat for small animals and plants native to the dune region.
- b. Access to the beach by the public at this site has been eliminated, and free passage along the beach from a public recreation area to the south of the site to private and public recreation areas to the north of the site has been restricted.
- c. Beach erosion has occurred in the Illinois Beach State Park immediately south of the site. It is thought to have been caused by the temporary breakwater used during construction. The applicant has taken steps to retard the erosion and is committed to correct the condition after construction is completed.
- d. The Station employs once-through cooling of the condensers and will discharge the heated water directly to Lake Michigan. At full power the total Station cooling water flow of 1,530,000 gpm (3410 cfs) will be heated about 20°F. The heated discharge will rise and form a surface plume. The area of lake surface enclosed by the 3°F excess (above ambient) isotherm is calculated to be as much as 920 acres.

MASTER

e. Juvenile and adult fish entrained by the intake flow will probably be trapped in the forebay or killed by impingement on the bar racks or traveling screens. Although the 2600 feet offshore intake location of the nets (which the applicant presently proposes to install surrounding the existing intake structure) will reduce such impingement, the intake flow velocity is very high in comparison with most other plants for which impingement data is available. At the existing intake structure the water flow velocity is calculated to be about 2.4 ft/sec maximum during normal, warm weather operation, and 3.7 ft/sec maximum during winter operation with deicing of the intake structure. The Station impingement kill will be seasonally variable and possibly high during the colder months.

f. A fraction of the aquatic animal life which passes through the Station's condenser cooling and service water systems will be killed. All aquatic life which passes through these systems will be subjected to mechanical and thermal (with intermittent chemical) stresses. Similarly, organisms entrained in, attracted to, or otherwise affected by the thermal discharge will be subjected to a complex set of direct and indirect influences, some of which are judged locally adverse. The biological effects of condenser passage and the thermal discharge, however, are not expected to produce major local degradation, and no significant adverse impact on lake populations is anticipated.

g. The Station employs a mechanical system for condenser cleaning and, as a result, only relatively small quantities of chemicals are required for operation of the service water and non-radioactive liquid waste systems. The controlled, intermittent releases of these chemicals and their dilution with the condenser cooling water will result in concentrations sufficiently low that measurable adverse impact on aquatic life is not expected.

h. The transmission lines construction involves only about 6 miles of new right-of-way out of about 89 circuit miles being constructed. These lines do not appear to have produced significant adverse impacts on the environment. The applicant will be required to comply with the Bureau of Sport Fisheries and Wildlife Resource Publication 48, Chemical Vegetation Control Manual for Fish and Wildlife Management Programs, on the use of herbicides and pesticides. In addition, the applicant will not be permitted to apply 2-4-5T herbicide near residences, food crops or water supplies.

i. The Station will discharge to the environment approximately 10 curies per year of radioactive liquid waste, in addition to about 2000 curies per year of tritium. Approximately 5700 curies per year

of gaseous wastes will also be discharged. These radioactive wastes will have a small impact on the environment and the general public compared to that experienced through natural background radiation.

j. A very low probability of risk of accidental radiation exposure to the population will be created.

k. Some beneficial effects on the local economy will result from operation of the plant.

4. Principal alternatives considered:

- a. Abandonment of the Station.
- b. Conversion of the Station to a fossil-fueled plant.
- c. Use of cooling towers (wet and dry types) to dissipate waste heat.
- d. Use of a cooling pond or spray cooling to dissipate waste heat.

5. Comments on the Draft Environmental Statement were received from the agencies and organizations listed below and have been considered in the preparation of the Final Environmental Statement. Copies of these comments are included as Appendices E through Q and discussed in Section XII.

Illinois Environmental Protection Agency
 Department of the Army (Corps of Engineers)
 Federal Power Commission
 Northeastern Illinois Planning Commission
 Environmental Protection Agency
 Advisory Council on Historic Preservation
 Department of Agriculture
 Department of Transportation
 Department of Commerce
 Commonwealth Edison Company
 The Metropolitan Sanitary District of Greater Chicago
 Two Members of De Paul University Faculty
 Department of the Interior

6. This Final Environmental Statement has considered the above mentioned comments and is being made available to the public, to the Council on Environmental Quality, and to other agencies in December 1972.

MASTER

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 Zion Nuclear Power Station, Units 1 and 2, against environmental and other costs and considering available alternatives, it is concluded that the actions called for under NEPA and Appendix D to 10 CFR Part 50 are the continuation of construction permits CPPR-58 and 59 and the issuance of operating licenses for the facility, subject to the following conditions for the protection of the environment:

a. Radiological and non-radiological Technical Specifications shall be prepared by the applicant and approved by the Regulatory Staff prior to the issuance of the operating licenses. These Technical Specifications shall cover, but not be limited to, the following:

(1) An extended operational monitoring program to determine the environmental impacts of Station operation. The program should determine the size, shape, and location of the thermal plume during different wind and weather conditions. The program should define the effects of Station operation on the aquatic ecosystem, including data on impingement of aquatic organisms on the bar racks and traveling screens.

(2) A basis for starting the deicing operation (pumping heated discharge water to the intake structure) only after there are positive indications that icing of the offshore intake structure is in fact taking place.

b. The development of design modifications to the condenser cooling water intake structure to reduce the effective water intake velocity to less than 1 foot per second (under winter deicing operations the present velocity is calculated to be over 3.7 fps; during non-winter operation it is calculated to be over 2.4 fps); or to otherwise minimize fish entrainment. The applicant will be required to submit such design modifications for staff approval by July 1, 1973. The applicant will be prepared to install the modifications within a specified time period if excessive numbers of juvenile or adult fish mortalities result from operation of the condenser cooling water system.

c. If important adverse effects or evidence of irreversible damage are detected by the monitoring programs, the applicant will provide to the staff an analysis of the problem and a plan of action to be taken to eliminate or acceptably reduce the detrimental effects or damage.

TABLE OF CONTENTS

	<u>PAGE</u>
SUMMARY AND CONCLUSIONS	i
TABLE OF CONTENTS	v
LIST OF FIGURES	xi
LIST OF TABLES	xii
FOREWORD	xiv
I. INTRODUCTION	I-1
A. Site Selection	I-3
B. Applications and Approvals	I-4
II. THE SITE	II-1
A. General	II-1
B. Location of the Station	II-1
C. Regional Demography and Land Use	II-1
D. Historical Significance	II-3
E. Environmental Features	II-5
1. Surface Waters	II-5
2. Groundwater	II-5
3. Climate	II-5
4. General Terrain Characteristics	II-8
5. Geology of Region at and Near the Site	II-8
6. Biota	II-9
7. Special and Unusual Features	II-9
F. The Ecology of Site and Environs	II-10
1. Coastal Areas	II-10
2. Lake Michigan	II-12

	<u>PAGE</u>
G. Economic Value of Fish and Wildlife	II-27
H. Recreational (Sport) Species	II-28
III. THE PLANT	III-1
A. External Appearance	III-1
B. Transmission Lines	III-1
C. Reactor and Steam-Electric System	III-5
D. Effluent Systems	III-8
1. Heat	III-8
2. Radwaste	III-15
3. Chemical and Sanitary Wastes	III-25
4. Other Wastes	III-29
IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND PLANT CONSTRUCTION	IV-1
A. Summary of Plans and Schedules	IV-1
B. Impacts on Land, Water, and Human Resources	IV-1
V. ENVIRONMENTAL IMPACT OF PLANT OPERATION	V-1
A. Land Use	V-1
B. Water Use	V-2
1. Source	V-2
2. Condenser Water Circulation and Thermal Discharge	V-3
3. Chemical Discharges	V-3
C. Biological Impact	V-4
1. Terrestrial Ecosystems	V-4
2. Aquatic Ecosystem	V-5
3. Biological Monitoring Programs	V-19
4. Conclusions	V-25
D. Radiological Impact on Man	V-26
1. Introduction	V-26
2. Radioactive Material Released to the Atmosphere.	V-27
3. Radioactive Material Released to Receiving Waters	V-27

	<u>PAGE</u>
4. Population Doses From All Sources	V-32
5. Evaluation of Radiological Impact	V-33
6. Radiological Environmental Monitoring	V-33
E. Transportation of Nuclear Fuel and Solid Radioactive Waste	V-37
1. Transport of Cold Fuel	V-37
2. Transport of Irradiated Fuel	V-37
3. Transport of Solid Radioactive Wastes	V-38
4. Principles of Safety in Transport	V-38
F. Radiological Impact - Transportation Exposures During Normal (No Accident) Conditions	V-39
1. Cold Fuel	V-39
2. Irradiated Fuel	V-40
3. Solid Radioactive Wastes	V-41
VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS	VI-1
A. Plant Accidents	VI-1
B. Transportation Accidents - Exposures Resulting from Postulated Accidents	VI-6
1. Cold Fuel	VI-6
2. Irradiated Fuel	VI-7
3. Solid Radioactive Wastes	VI-8
C. Severity of Postulated Transportation Accidents	VI-8
D. Alternatives to Normal Transportation Procedures ...	VI-9
VII. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED	VII-1
VIII. SHORT TERM USES AND LONG TERM PRODUCTIVITY	VIII-1
IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES.	IX-1
X. THE NEED FOR POWER	X-1

	<u>PAGE</u>
XI. ALTERNATIVES TO PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF THEIR ENVIRONMENTAL EFFECTS	XI-1
A. Summary of Alternatives	XI-1
1. Abandoning the Zion Station.....	XI-1
2. Alternative Fuels	XI-3
3. Alternative Heat Dissipation Systems.....	XI-4
4. Environmental Impacts of Alternative Cooling Systems.....	XI-11
5. Alternative Condenser Defouling.....	XI-16
B. Cost-Benefit Analysis	XI-17
1. Economic Benefits of the Station	XI-17
2. Environmental Benefits	XI-17
3. Economic Costs	XI-17
4. Environmental Costs	XI-18
C. Summary of Cost Benefits	XI-23
XII. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT.....	XII-1
A. Radiological Effects.....	XII-1
B. Transportation and Reactor Accidents.....	XII-4
C. Thermal Effects.....	XII-7
D. Biological Effects.....	XII-10
E. Chemical and Sanitary Wastes.....	XII-14
F. Alternatives and Cost-Benefit Analysis.....	XII-16
G. Diesel Generators and Starting Boilers.....	XII-17
H. High Voltage Transmission Line Effects.....	XII-17
I. Construction Cleanup and Landscaping.....	XII-19
J. Restoration of Project-Induced Beach Erosion.....	XII-19
K. Lake Michigan Basin Assessment.....	XII-19
L. Location of Principal Changes in this Statement in Response to Comments.....	XII-20

APPENDIX A

Table A-1	Check List of Animals Observed at Illinois Beach Nature Preserve

Table A-2	Check List of the Fish of Lake Michigan
Table A-3	Resident Bird Species in the Illinois Dunes State Park
Table A-4	Check List of the Vascular Plants of the Illinois Beach State Park

APPENDIX B

Table B-1	Climatic Summary for 1951-1960
Table B-2	Tornado Occurrences - Illinois

APPENDIX C

Figure C-1	Stratigraphy of Northeastern Illinois

APPENDIX D - Water Pollution Regulations of Illinois.....

Figure D-1	Water Temperature Records for Lake Michigan ..

APPENDIX E - Comments of Illinois Environmental Protection
Agency.....

APPENDIX F - Comments of Department of the Army.....

APPENDIX G - Comments of Federal Power Commission.....

APPENDIX H - Comments of Northeastern Illinois Planning
Commission.....

APPENDIX I - Comments of Environmental Protection Agency.....

APPENDIX J - Comments of Advisory Council on Historic
Preservation.....

APPENDIX K - Comments of Department of Agriculture.....

APPENDIX L - Comments of Department of Transportation.....

APPENDIX M - Comments of Department of Commerce.....

APPENDIX N - Comments of Commonwealth Edison Company.....

APPENDIX O - Comments of the Metropolitan Sanitary District
of Greater Chicago.....

APPENDIX P - ~~Comments~~ of Two Members of De Paul University
Faculty.....

APPENDIX Q - ~~Comments~~ of Department of the Interior.....

LIST OF FIGURES

	<u>PAGE</u>
I-1. Location of Zion Site	I-2
II-1. Zion Station and Environs	II-2
II-2. Zion Station and Environs (Expressway)	II-4
II-3. Gross Wind Rose	II-7
III-1. The Zion Site	III-2
III-2. Photo of Zion Station from Illinois Beach State Park (November 1971)	III-3
III-2A. Photo of Zion Construction Site Looking Northeast (January 1972)	III-4
III-3. Schematic Illustration of the Basic Features of P.W.R. Nuclear Power Generator	III-6
III-4. Cooling Water-Intake Structure	III-9
III-5. Traveling Screen	III-11
III-6. Discharge Structure	III-12
III-7. Analytical Model	III-14
III-8. Liquid Waste Disposal System	III-18
III-9. Gaseous Effluents from Zion Station Units 1 and 2 ...	III-23
V-1. Pathways of Radiation Exposures of Man	V-28
V-2. Location of Radwaste Monitoring Stations	V-36
VII-1. Probable Adverse Effects	VII-2

LIST OF TABLES

	<u>PAGE</u>
II-1. Chemical Measurements of Nearshore and Inshore Waters of Lake Michigan	II-14
II-2. Abridged List of Algae Species Found at Waukegan and Zion	II-16
II-3. List of Benthic Organisms Identified to Date in Zion - Waukegan Area (1969).....	II-19
II-4. Depth Distribution and Abundance of Lake Michigan Fish in Early Period (1787-1800) and Recent Period (last several decades).....	II-20
II-5. Ecology of Some Important Lake Michigan Fish.....	II-22
II-6. Average Annual Production of Major Species of Lake Michigan.....	II-25
II-7. Commercially Important Fish in Lake Michigan.....	II-26
III-1. Conditions Used for Each Unit in Determining Releases of Radioactivity in Effluents at Zion.....	III-17
III-2. Annual Release of Radioactive Material in Liquid Effluent from Zion 1 and 2.....	III-20
III-3. Calculated Annual Release of Radioactive Material in Gaseous Effluents from Zion 1 and 2.....	III-24
III-4. Estimated Chemical Usage Zion Units 1 and 2.....	III-26
V-1. Bioaccumulation Factors for Radionuclides in Fresh Water Species.....	V-17
V-2. Preoperational Environmental Surveys Conducted at the Zion Nuclear Power Station.....	V-20

	<u>PAGE</u>
V-3 Postoperational Environmental Monitoring Program for the Zion Nuclear Power Station.....	V-22
V-4 Annual Average Doses to Individuals Exposed to Liquid and Gaseous Effluents from the Station.....	V-29
V-5 Annual Average Dose to Individuals Exposed to Liquid Effluents from the Station.....	V-30
V-6 Estimated Annual Man-Rem Dose.....	V-34
V-7 Cumulative Population, Annual Man-Rem Dose and Average Annual Dose from Gaseous Effluent in Selected Circular Areas Around the Zion Station.....	V-35
VI-1 Classification of Postulated Accidents and Occurrences.....	VI-3
VI-2 Summary of Radiological Consequences of Postulated Accidents.....	VI-4
X-1 Commonwealth Edison Planned Addition and Retirement Program 1972-1980.....	X-2
X-2 Anticipated Capacity, Load and Reserve Margins Through 1980.....	X-3
XI-1 Estimated Increase in Annual Emissions From Fossil- Fueled Stations to Meet Anticipated Loads if Zion Station is Delayed.....	XI-2
XI-2 Cost of Cooling Systems for a 2200 MWe Nuclear Plant..	XI-10
XI-3 Summary of Regional Environmental Conditions, Costs, and Other Considerations.....	XI-19
XI-4 Cost-Benefit Summary.....	XI-25

FOREWORD

This Final Statement on environmental considerations associated with the proposed issuance of operating licenses for the Zion Nuclear Power Station (the Station), Docket Nos. 50-295 and 50-304, was prepared by the U. S. Atomic Energy Commission (Commission or AEC), Directorate of Licensing (staff) in accordance with the Commission's regulation, 10 CFR Part 50, Appendix D, implementing the requirements of the National Environmental Policy Act of 1969 (NEPA).

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

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

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

- (1) 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 irremediable commitments of resources which would be involved in the proposed action should it be implemented.

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

When application is made for a construction permit or a full power operating license, the applicant submits an environmental report to the AEC. The staff evaluates this report and may seek further information from the applicant, as well as other sources, in making an independent assessment of the considerations specified in Section 102(2)(C) of NEPA and Appendix D of 10 CFR Part 50. This evaluation leads to the publication of a draft environmental statement, prepared by the Directorate of Licensing, which is then circulated to Federal, State and local governmental agencies for comment. Interested persons are also invited to comment on the draft statement.

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

In addition, in a proceeding such as this which is subject to Section C of Appendix D of 10 CFR Part 50, the final detailed statement includes a conclusion as to whether, after weighing the environmental, economic, technical and other benefits against environmental costs and

considering available alternatives, the action called for as regards the previously issued construction permit is the continuation, modification or termination of the permit or its appropriate conditioning to protect environmental values.

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

Mr. Charles R. Domeck is the AEC Environmental Project Manager for this statement. (301-973-7731)

I. INTRODUCTION

This Final Statement on environmental considerations is associated with the final construction and proposed operation of the Zion Nuclear Power Station (the Station) (Docket Nos. 50-295 and 50-304) by the Commonwealth Edison Company (the applicant).

The major documents used in this review were the applicant's Environmental Report¹ (ZION/ER) and the Preliminary² (ZION/PSAR) and Final Safety Analysis Reports³ (ZION/FSAR). These documents are available in the AEC Public Document Room, 1717 H Street, Washington, D. C. and in the Waukegan Public Library, 128 N. County Street, Waukegan, Illinois. The Illinois Pollution Control Board documents are available at its office, 309 W. Washington Street, Chicago, Illinois.

The Directorate of Licensing, on June 28, 1972, issued a Draft Environmental Statement. Notice of availability of that Draft Environmental Statement, with a request for comments, was published in the Federal Register (37 F. R. 12982) on June 30, 1972. Copies of the Draft Statement, with requests for comments, were sent to appropriate Federal, State and local agencies.

This Final Environmental Statement takes into account the applicant's and agencies' comments on the Draft Environmental Statement, and the applicant's reply to agency comments.

A Notice of Consideration of Issuance of Facility Operating Licenses and Opportunity for Hearing was published in the Federal Register (37 F. R. 12982) on June 30, 1972. Two petitions to intervene were filed in response to this notice. On September 29, 1972, the Commission issued a Memorandum and Order concluding, among other things, that a hearing should be held on the applicant's request for operating licenses. Notice of the time and place of the hearing will be published in the Federal Register when such information becomes available.

The Zion Nuclear Power Station, owned and to be operated by Commonwealth Edison Co., is located on a 250-acre site on the western shore of Lake Michigan, in Zion Township, Lake County, Illinois (Fig. I-1). It is on the extreme eastern edge of the City of Zion, Illinois. The Station, as planned, will contain two pressurized water reactors which are designated as Unit 1 (southernmost unit) and Unit 2. The AEC construction permits for the Unit 1 and Unit 2 reactors were issued December 26, 1968, after a series of prehearings and hearings

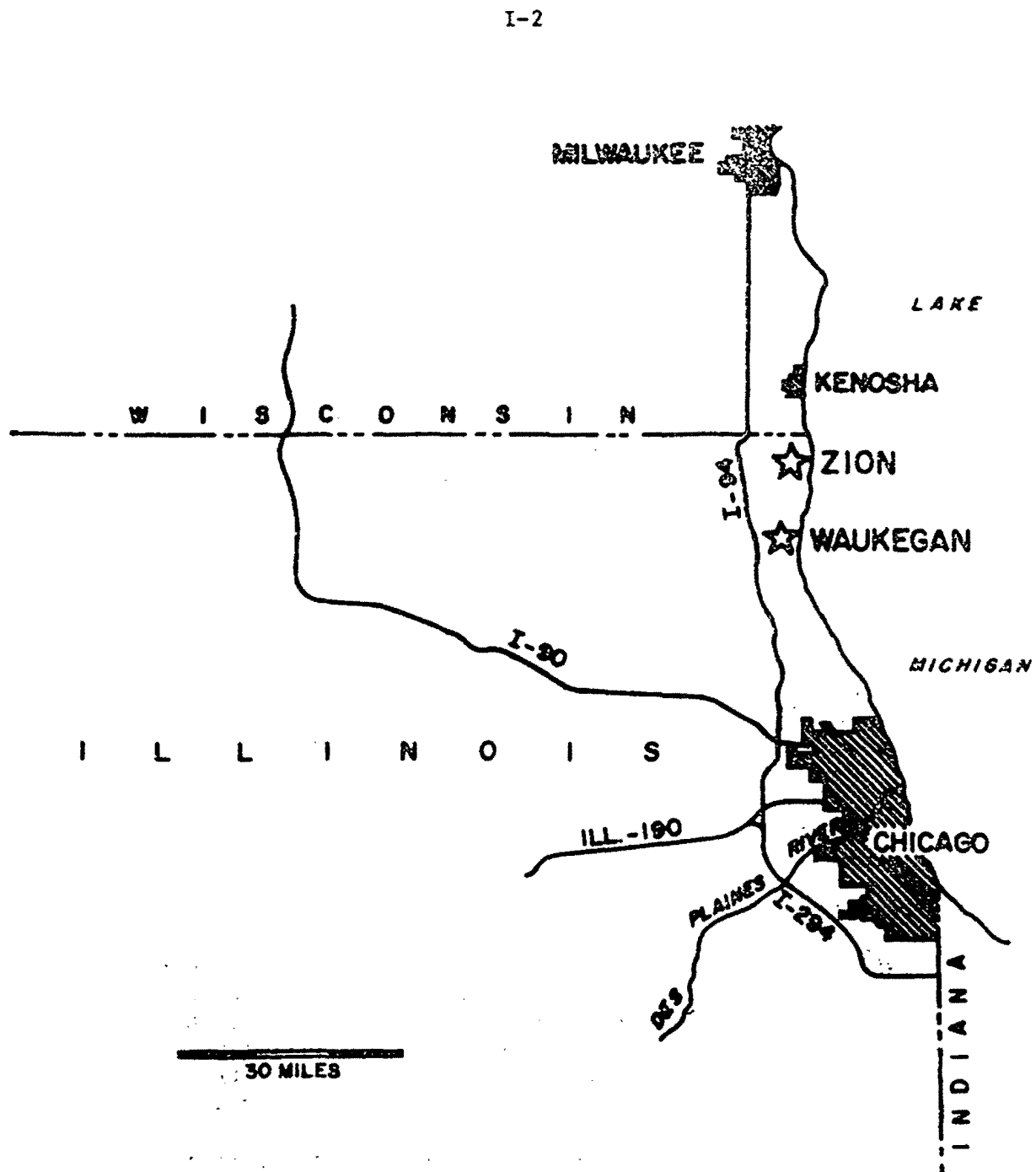


Fig. I-1. Location of Zion Site¹

1. Zion/ER, page 2.1-2, May 1971.

before an Atomic Safety and Licensing Board on September 10, September 24-26 and December 17, 1968. Applications for the licenses required to operate Unit 1 and Unit 2 are presently pending before the Commission. Fuel loading and initial operation of Unit 1 is expected in early 1973, and operation of Unit 2 is expected in late 1973.

A. SITE SELECTION

The site for the Station was primarily selected by the applicant on the basis of four major considerations:

1. The applicant's prior ownership of 200 of the 250 acres on which the Station is being built (acquired in 1955).
2. The ability of the applicant to acquire an additional 50 acres adjoining the site through a land trade agreement with the City of Zion for other land which the applicant owned and which adjoined the City of Zion.
3. The availability of Lake Michigan adjoining the site as a source of condenser cooling water.
4. The need for an additional large power generating station in the northeastern section of the applicant's distribution system.

The Station site is geographically located in the far north suburban region of the Chicago area (approximately equidistant between Chicago, Illinois, and Milwaukee, Wisconsin). Present air and water pollution loads in the immediate area are relatively low due to the semi-rural nature of the vicinity. Average annual air pollution emission rates (excluding the major industrial sources) for the 10-mile by 10-mile area (northeast corner of Illinois, which contains the Station site, and southeast corner of Wisconsin) were 1.17 ton/day for SO_2 and 1.12 ton/day for particulates in 1968.⁴ The major industrial pollution loads for 1968 within 5 miles of the Station site are located south of the site, specifically, in the Waukegan, Illinois, lake shore industrial region. The combined air pollution load from these sources was 264.32 ton/day SO_2 and 21.23 ton/day for particulates. (It is interesting to note that 258 tons/day SO_2 and 16.93 ton/day particulates of the above-noted figures originate from the applicant's fossil-fueled power plant in Waukegan. This is approximately 97% of the SO_2 load and 75% of the particulate load for the entire area.)

Continued on following page

The Lake Michigan open water quality and lake bed quality have been the subjects of extensive investigations for the past few years. The 1969 Survey of Lake Michigan Open Water Quality and Lake Bed⁵ states that 16 of 21 tested water and lake bed quality parameters in the Waukegan area complied with applicable State of Illinois standards while the five quality parameters of total phosphates, ammonia nitrogen, sulfates, filterable residue, and methylene blue active substances did not. The probable effects of the Station operation upon the water and lake bed quality are discussed later in this statement.

The applicant stated that before the start of construction:⁶

1. An attempt was made to reduce damage to the environment by assisting naturalists and conservationists in moving valued plants, seeds, and animal life from the site.
2. Construction was planned to maintain a natural environmental setting.
3. Buildings were designed with aesthetics in mind.
4. Consultation was held with independent groups and institutions regarding the appearance and conservation matters.

B. APPLICATIONS AND APPROVALS

The following is a chronological listing of permits and licenses required for the construction and operation of the Station:

3/11/68	City of Zion Building Permit was issued.
9/10/68	Atomic Energy Commission prehearing and
9/24-26/68	public hearings on construction permit
12/17/68	application.
12/26/68	AEC permit to construct a nuclear reactor was issued.
3/12/69	Illinois Department of Public Works and Buildings, Division of Waterways, permit to construct intake and discharge structures in Lake Michigan was issued.
3/21/69	Army Corps of Engineers permit to construct public works in a harbor was issued.

1/11/71	Illinois Environmental Protection Agency (IEPA) permit to install a boiler for auxiliary heating purposes was issued.
Filed June 1971 and October 1971 but not issued	Army Corps of Engineers permit to allow controlled discharge of refuse (heated water) to navigable waterways.
Pending	AEC license to operate a nuclear reactor.
7/11/72 Filed	Illinois Environmental Protection Agency discharge permit.

REFERENCES FOR SECTION I

1. "Zion Nuclear Power Station Environmental Report." Commonwealth Edison Co., Chicago, Ill., May 17, 1971 (Supplement I - Nov. 8, 1971; Supplement II - Dec. 3, 1971; Supplement III - Feb. 1972; Supplement IV - April 1972; Supplement V - May 1972).
2. "Zion Station Preliminary Safety Analysis Report - Vol. I to VI." Commonwealth Edison Company, Chicago, Ill., 1967.
3. "Zion Station Final Safety Analysis Report - Commonwealth Edison Co., Chicago, Ill., Nov. 25, 1970.
4. "Air Pollution Survey for 1968 (unpublished)." Argonne National Laboratory, Center for Environmental Studies, Argonne, Ill.
5. Illinois Sanitary Water Board. Springfield, Ill. June 1971.
6. ZION/ER, Section 2.3.9. May 1971.

II. THE SITE

A. GENERAL

The Station is situated on a low shoreline sand dune on the Illinois shore of Lake Michigan approximately 3.2 miles south of the Illinois-Wisconsin state line (see Fig. II-1). The terrain in the area consists of low marsh lands isolated 100-2000 feet inland by the shoreline sand beaches and dunes. The presence of the intervening marshes has discouraged extensive past development of the general shoreline. Except for small settlements of private homes and summer cottages situated on the shoreline dune lands, the shoreline area is essentially undeveloped.

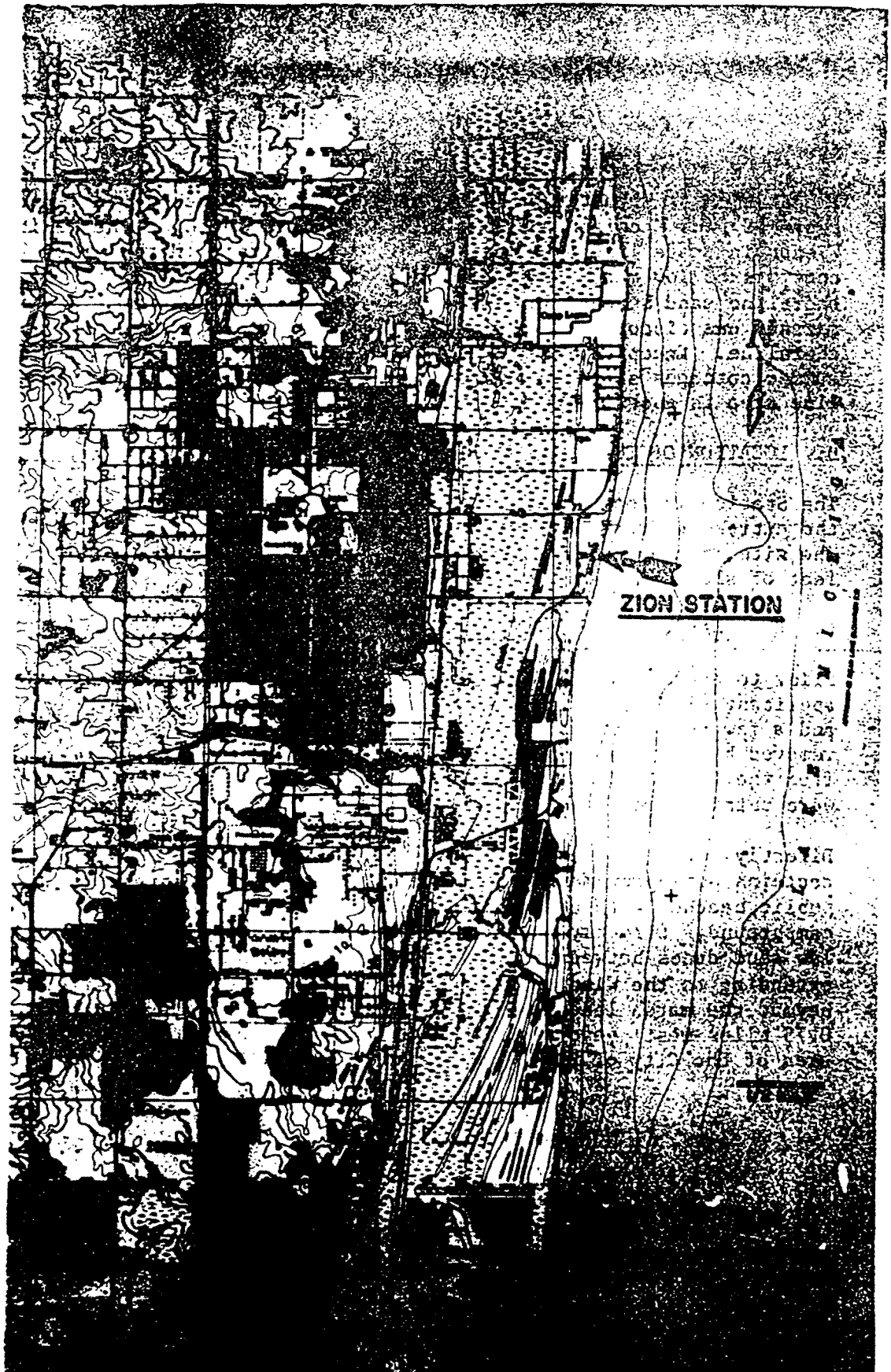
B. LOCATION OF THE STATION

The Station is located on a 250-acre site owned by the applicant in the extreme eastern edge of the City of Zion, Lake County, Illinois. The site fronts on Lake Michigan and includes approximately 2000 feet of shoreline.

C. REGIONAL DEMOGRAPHY AND LAND USE

Prior to acquisition of the original 200 acres of the site by the applicant (1955), the area contained approximately 27 summer cottages and a few dedicated streets. Both the cottages and the streets were removed by the applicant (permission to remove the streets was obtained from the City of Zion). The additional 50 acres of the 250-acre site were obtained in a land trade with the City of Zion.

Directly south of the site is the Illinois Beach State Park which contains an approximately 1651-acre tract of nature preserve, public beaches with change houses, refreshment stands, and a campground. Directly north of the site is a 3.2-mile long area of low sand dunes between the lake (east) and marsh lands (west) extending to the Wisconsin border. Directly west of the site beyond the marsh land is a small industrial area (approximately 0.75 miles west) beyond which is the eastern edge of the residential area of the City of Zion (approximately 0.9 miles west).



Within the next few years two major land use changes are planned in the area. First, the State of Illinois expects to acquire from the Federal Government the land presently containing Camp Logan. Through purchase they also propose to acquire the remaining land east of the Chicago Northwestern Railroad track and north of the Illinois Beach State Park to the Wisconsin border. This entire area, except for the Zion Station site and the small industrial site, would then become the expanded Illinois Beach State Park. Second, the State of Illinois plans to construct a limited access highway (tentatively called the Lake Front Expressway) which would run north and south through the area between the site and the small industrial area to the west of the site (Fig. II-2). If these plans materialize, public recreational areas will exist to the north and south of the site, a small industrial area to the west (separated by an expressway and marsh land) and the lake to the east.

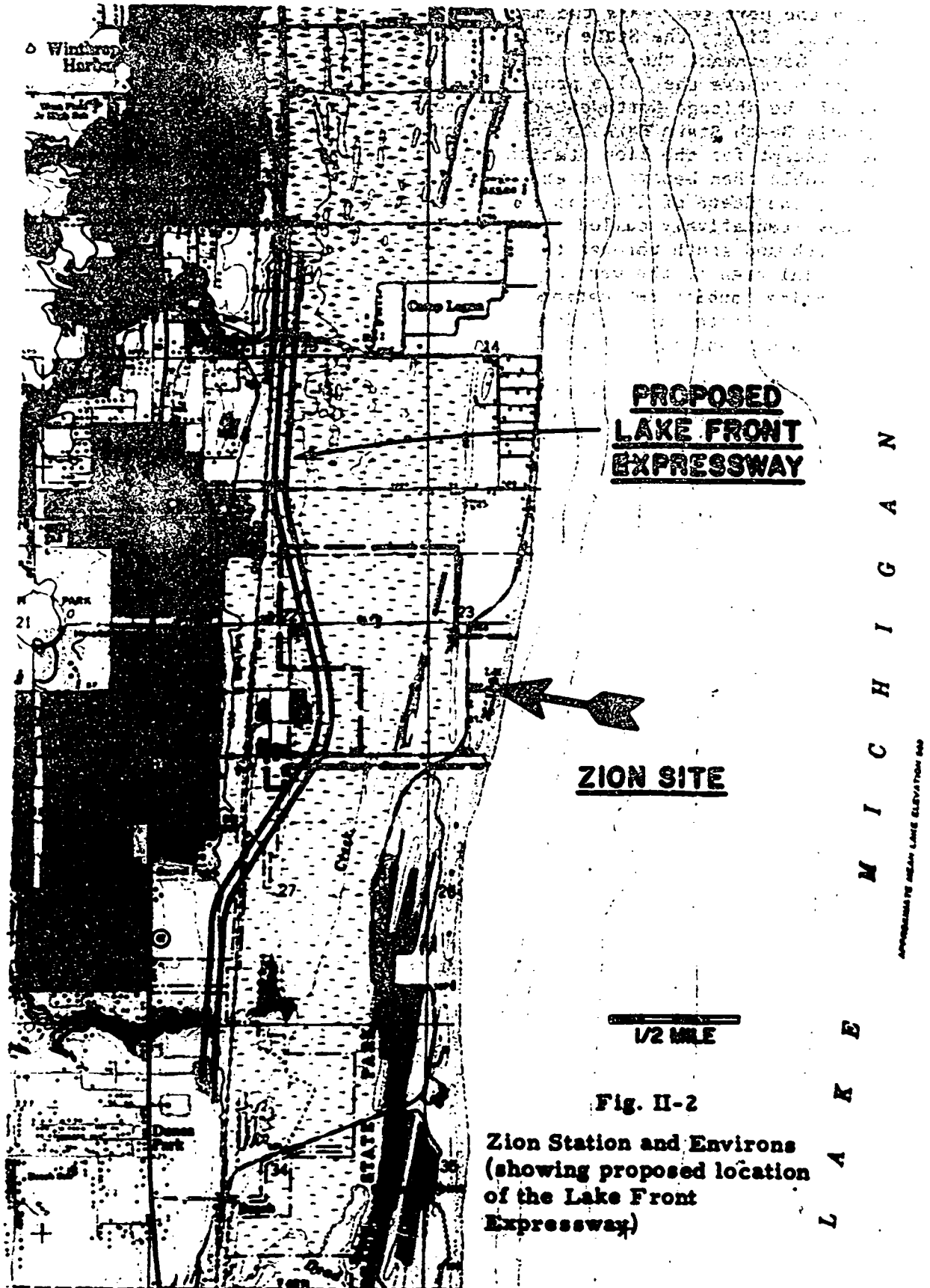
The population center closest to the Station is the City of Zion, the residential center of which is approximately 1.5 miles west of the site. The 1970 population of the City of Zion¹ was 17,126. Total 1970 population² within a 5-mile radius of the Station was:

<u>Distance from the Station</u> <u>(miles)</u>	<u>Population</u>
0-1	789
0-2	6,930
0-3	18,833
0-4	33,195
0-5	46,196

Assuming that the 92% population growth forecast for Benton Township as estimated by the Lake County Regional Planning Commission³ is generally applicable over the 0-5 mile distance from the Station, the year 2000 population for the 0-5 mile distance around the Station would be about 88,700 persons.

D. HISTORICAL SIGNIFICANCE

A few historical sites exist in the area which are of significance to the residents of Zion and the members of the Christian Catholic Apostolic Church, whose founder, Dr. John Dowie, founded the city in 1900. These sites, however, are all within the central section of the city which is approximately 1.5 miles west of the Station. No



other known historical sites exist in the area; none are listed in the National Register of Historic Places. The Field Museum (Chicago), Geology Department, confirmed that no archaeological sites or fossil deposits have been found or are reasonably expected to be found in the area of the site. Contact with historic preservation offices of the State of Illinois has confirmed the above information. (Appendix J)

E. ENVIRONMENTAL FEATURES

1. Surface Waters

The surface waters in the region of the site include two terrestrial drainage streams besides Lake Michigan itself, Dead River and Kellogg Ravine. These streams flow irregularly into the lake, with their greatest flow during periods of rain (see Section II.F).

2. Groundwater

Lake County, and the Chicago region as a whole, are favorable areas for the development of groundwater in Illinois.⁴ In general, the sandstone formations which lie at depths of 500 feet or more have been prolific sources of water for over a century, and there are water-yielding glacial deposits and creviced dolomitic bedrock at lesser depths from 100 to 150 feet. The shallow dolomites are mainly of Silurian age; these aquifers and those of the glacial drift are connected hydrologically. In Lake County, water is drawn from wells drilled as deep as 1055 feet (average 288 feet) into the Glenwood-Saint Peter Sandstones, and from wells at depths of 1255 to 2153 feet in the Cambrian-Ordovician/Mount Simon aquifers. Formerly, the Zion city water supply was drawn from two wells sunk into shallow dolomite but, because of a drop in the water table, it is now supplied from Lake Michigan. The geological structure in northeastern Illinois provides for an eastward flow of groundwater down-dip along the bedding plane tilt. The Zion area lacks regions of complex faulting which would tend to modify the direction of flow.⁵

3. Climate

The climate at Zion is similar to that for the Chicago region as a whole.⁶ It is typed as continental with cold winters and warm summers. The major influencing factors are the general storms which move eastward along the northern tier of the United States, and those that move northeastward from the southwestern part of the nation to the Great Lakes.

Data amassed for a 10-year period at stations in Chicago (4) and Wisconsin (2) from 1951-1960 (Appendix B) show that there are few, if any, dry seasons. The annual precipitation is of the order of 29.5-33.5 inches with seasonal highs during the summer (May through August) and seasonal lows during the winter months. The average annual snowfall is about 37 inches, but there has been as much as 68 inches and 77 inches in Chicago and Milwaukee respectively (1959). At nearby Kenosha and Waukegan the annual mean daily maximum temperature is about 57°F and the annual mean daily minimum temperature is about 38°F. The highest temperatures are about 100°-102°F in July and August, while the lowest temperatures are as low as -24°F and occur in January.

Lake Michigan is an important climatic modifier, and the marked cooling of the daytime temperatures in spring and summer are due to wind shifts from westerly and easterly directions. The wind regimes (5-year average) at Milwaukee, Waukegan and Chicago are fairly uniform (Zion/ER, Fig. 5). Calm periods are few (perhaps 3% on the average). There is a general tendency for winds to blow from the southwest. These general conditions prevailed in the Zion area during 1970 (Fig. II-3). But these data are quite minimal and the conditions must be evaluated over a period of many years if the conclusions are to have meaning in the statistical sense. Based on work by Thom,⁷ the maximum expected wind speeds determined for the Zion site are:

<u>Maximum Speed</u> <u>(mph)</u>	<u>Probability</u>	<u>Recurrence Interval</u> <u>(years)</u>
48	.50	2
60	.10	10
69	.04	25
70	.02	50
80	.01	100

These data show that winds in excess of 60 mph are rarely attained. Tornadoes do occur in northeastern Illinois, but they are more frequent in the southern part of the state. Tornadoes were recorded⁸ during the period 1916-1969 in the five-county region as follows:

Lake County	3
McHenry County	4
Kane County	9
DuPage County	8
Cook County	22

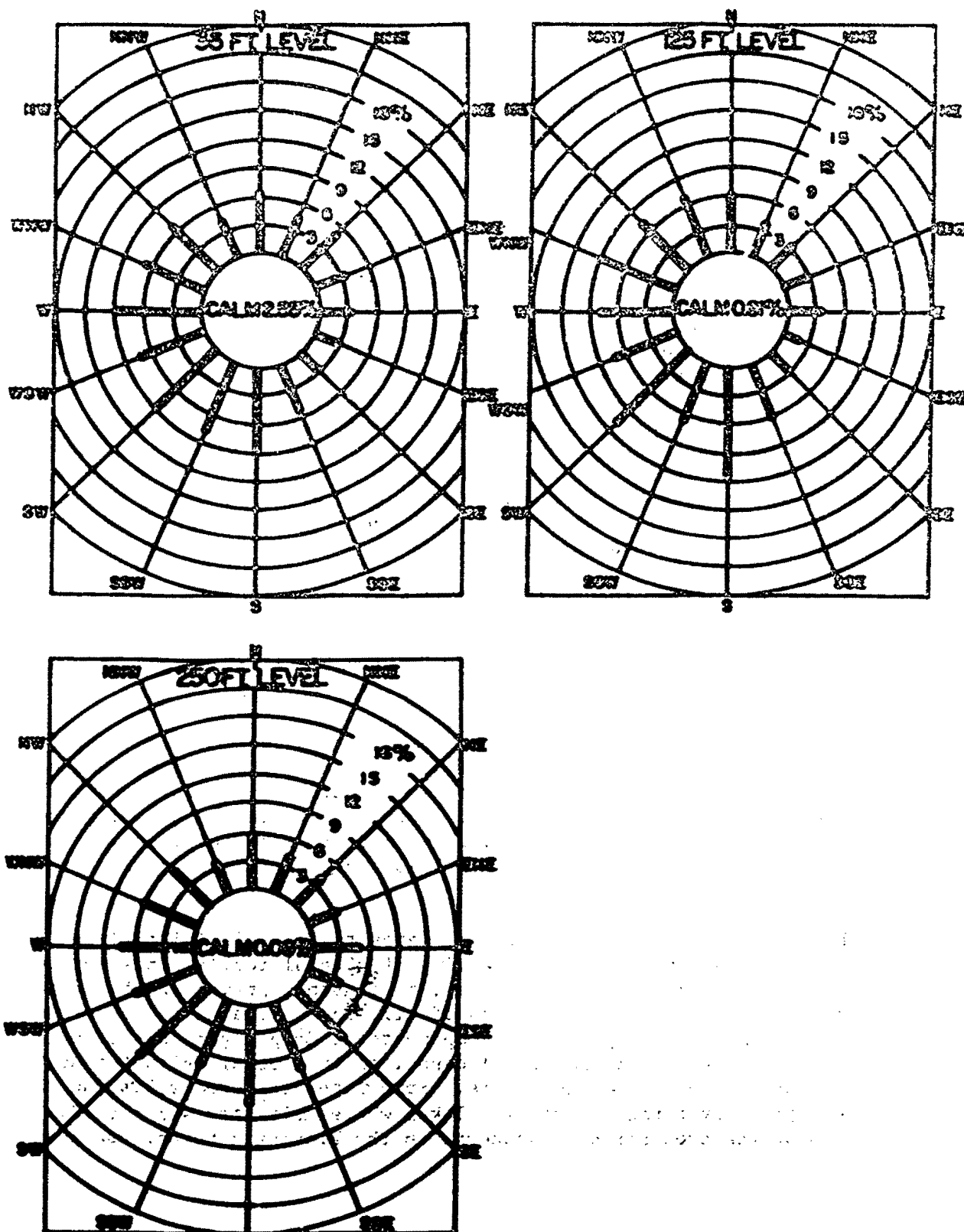


Fig. II-3. Gross Wind Rose. Zion Site 1970 Annual Average.¹
(Wind blows towards center)

1. Zion/ER, page 2.1-26, May 1971.

Weather Bureau statistics⁹ for the period 1916-1949 show that Illinois had an average of 4.9 tornadoes per year, but their frequency at a particular site is small (area of Illinois = 56,400 square miles). More recent data on tornado occurrence⁷ in Illinois from September 1959 to July 1969 are shown in Appendix B (Table B-2).

4. General Terrain Characteristics

Lake County lies on the Chicago Lake Plain, a subdivision of the physiographic Central Lowland Province which is a glaciated lowland.¹⁰ The Chicago Lake Plain is a low flat surface, 700-900 feet above sea level, sloping gently toward the lake interrupted by a few low ridges and knolls and by a few large valleys. One of these valleys is the Des Plaines River Valley to the west of Zion. This terrain is characterized topographically by broad parallel morainic ridges, lakes, and swamps, suggesting that much of the country is without natural or integrated drainage. The site lies next to Lake Michigan and consists of a series of low dunes intermingled with low marshy areas which run parallel to the shore. The specific characteristics of the area are covered in detail in Section II F.

5. Geology of the Region at and Near the Site

The generalized geologic section for the area around the site is shown in Appendix C. The sequence consists of lake plain sediments over glacial deposits over dolomite bedrock of Silurian age.

The lake plain sediments¹⁰ were deposited as a consequence of post-glacial lake activity. They include the lake bottom and the beach and dune deposits which consist of sand admixed with finer grained silts, clay and organic deposits. Coarser textured sands and gravels are restricted in their distribution, but are reported locally. Core borings in the Waukegan area show 32-34 feet of fine to coarse grained sands at the surface.

The major component of the glacial deposits is a glacial till deposited in place by the slow melting of glacial ice.¹¹ This may be an unsorted, unbedded mixture of clay, silt, sand, gravel and boulders, or there may be alternating beds of till and bedded silts and clays (lacustrine deposits). Minor components at Camp Logan consist of a coarse textured sand and gravel deposited in glacial meltwater as outwash in rapidly moving waters. Some finer textured silts and clays were probably formed in glacial lakes where meltwater was pooled. Because the area north of Waukegan to the Wisconsin border had been

subjected to several advances and retreats of glacial ice, most of the glacial deposits have been preloaded by the ice and have a relatively high density and compressive strength.

The thickness of the lake plain and gravel deposits overlying the bedrock range from 95-150 feet because of the irregularities of the surface of the dolomite bedrock. The glacial erosion often created deep valleys, many of which are now filled with glacial drift. The bedrock is deepest (132-150 feet) immediately to the east of the site; it is 128-141 feet deep at the Wisconsin state line.

The dolomite bedrock underlying the glacial deposits in the area is 100-150 feet thick. In their upper parts, these rocks are jointed and creviced without extensive development of solution cavities (vugs), and are water bearing. Thick Cambrian and Ordovician dolomites and sandstones underlie the entire region.

6. Biota

The region around the site involves both terrestrial and freshwater habitats, within which there is a substantial diversity of animal and plant life. The terrestrial environments provide a beach succession series--dunes, swales, peat bogs, as well as zones of prairie, each with its distinctive flora and fauna. Freshwater habitats include two drainage streams and Lake Michigan. The former provide sanctuary for a variety of invertebrate and vertebrate life, while the latter consists of planktonic and benthic communities and an extensive fish life. Each of these provinces and their ecologic interrelationships are discussed in detail in Section II.F.

7. Special and Unusual Features

The terrain along the lake shore in northern Illinois features the only dunes in the state.^{12,13} These are of such a special and unique nature that the State of Illinois has set aside a 3-mile tract of shoreline and adjacent territory as a state park (Illinois Beach State Park). Only a small portion of the park is available for recreational purposes. Most of the land has been designated a nature preserve which is maintained for its educational value as a teaching and research resource. Other more limited tracts of marshy land north of the site are being utilized by the University of Wisconsin for somewhat similar purposes, although the ecologic diversity is more

limited. Currently the State of Illinois is negotiating for the purchase of the remaining shoreline properties from the site to the Wisconsin border to extend the educational and recreational facilities.

7. THE ECOLOGY OF SITE AND ENVIRONS

The environs of particular interest near the Station are those of the near lake shores and Lake Michigan. The topographical details of the site prior to the development of the power station were similar to those of the Illinois Beach State Park. The ecosystem of the Hoeh Prairie to the west and north of the site will be described below in terms of the floristic and faunistic composition of the park itself.

1. Coastal Areas

The terrain in general consists of a series of low dunes or sand ridges (former Lake Michigan sand bars) running parallel to the lake shore and interspersed with marshes (Fig. II-1). Further inland, there is the residuum of a tall grass prairie. The terrestrial areas of primary concern are the 1651 acres in the state park itself and the 3-4 miles of shore land both north and south of the Station. The vegetative types include forest, prairie, marsh, dune and beach shore complexes. The aquatic environments include a stream (Dead River), Lake Michigan, marsh and artificial ponds (gravel pits). Each of the ecosystems has its own characteristic flora and fauna, although some of the fauna would be expected to move freely throughout the surrounding areas.

The site is unique in being the only remaining dune area in Illinois. The Illinois Beach State Park provides camping grounds (500-600 camp sites), swimming facilities with several permanent bath houses, and developed nature trails. The park attracts over 1 million visitors each year. The beaches and dunes are primary attractions to the public, and are often trampled, with resultant erosion which requires regular maintenance. The southern end of the park has been set aside as a nature preserve. The diversity of environments within the park proper provides an area which has served and can serve in the future as an outdoor laboratory for ecological research.^{12,14-20}

Illinois Beach State Park has approximately 3.5 miles of sandy shoreline along Lake Michigan. The forebeach is visited principally

by insects which feed on carrion cast up on the shoreline and pavement. These in their turn are preyed upon by shore birds and other insects. Rooted plant life per se is essentially nonexistent. Most land vertebrates are merely transients, and a large variety of birds use the shore of the lake as a path for migration. Further inland, the mid-beach supports a few hardy pioneer species such as the cocklebur and sea rocket.

The dunes rise about 10 feet above lake level, and their flora is rather typical of a beach succession ecosystem.²¹ The forbidding sands are stabilized by clump grasses such as little bluestem, sand reed and beach rye. The sand ridges are dominated by extremely old black oaks as well as sand prairie forms featuring big blue stem grasses, prickly pear cactus, and shrubs such as choke cherry, creeping and common juniper.

Low areas (swales) in the park support a peat bog fauna and flora with rushes, sedges, mints, wild iris, meadowert, ferns, and the marsh grass pink orchid, which is a relatively rare species in Illinois. The trees are dwarf birch and cotton-wood. Mosquitoes are abundant.

Hosack Prairie to the north of Illinois Beach State Park and the Zion site is a remnant of a tall grass prairie assemblage which consists of bluestem and star grasses, indian paint brush, bedstraw, spiderwort, prairie flower, sunflowers, cornflowers, anemones and others. The mammals are chiefly squirrels, rabbits and mice as the primary consumers, and these are preyed upon by foxes, skunks, and a pair of coyotes which moved into the park after 1966. Birds such as the meadowlark, bobolink, and grouse nest in the grasses. Hawks are common predators on the smaller animals.

The pine woodlands (introduced) harbor a large number of invertebrates due to the variety of microenvironmental situations provided by rotting logs, small areas under rocks, fallen needles and branches in the forest litter. Beetles, leafhoppers, walking sticks, and spiders can be expected to find shelter and breeding areas here during certain seasons of the year, along with their attendant predators.

The marshes, peat bogs and low areas drain into Lake Michigan via Dead River (2.5 miles long in the park), which ranges in depth from 4 feet (at peak flow) to 6 inches. The stream supports fish (goldfish, bluegills), crayfish, turtles, muskrats, frogs and other

amphibians, and is bounded by dense vegetation offering cover to water-fowl (e.g., ducks, great blue heron). Siltling is not a problem although, in times of storm, currents along the beach play the mouth of the river with sand. Heavy rain raises the level of the river to the top of the sand, and the water washes through so that the river eventually returns to the level of Lake Michigan.

A partial list of the plants and animals has been tabulated in Appendix A. Heavy concentrations of bird migrants—some 150 species—occasionally develop within the park. Permanent bird residents, those in the park longer than 3 months each year, number some 37 species, and 26 of these are known to either nest or breed in the park.²² The bald eagle and Wilson's phalarope are among the breeders and are listed as endangered species in Illinois.²³ Some of the bird migrants are also on the endangered species list.

2. Lake Michigan

Lake Michigan is the third largest of the Great Lakes with an area of 22,400 square miles and a volume of 173 trillion cubic feet of water.²⁴ Water levels are highest in summer and lowest in late winter and early spring. The surface of the lake lies on average 578.8 feet above mean sea level. Maximum depth is 923 feet; mean depth is 276 feet. The shoreline extends 1660 miles (including Green Bay) over a four-state area of Wisconsin, Illinois, Indiana and Michigan.

For convenience, the lake's name has been divided arbitrarily so that volume of water between the shoreline and the 100-foot depth contour,^{24, 27} those waters now used by man for drinking water, recreation (fishing, swimming), and industry. It has an average width of 3 miles, an area of 3040 square miles, and contains 45 cubic miles of water. In terms of the entire lake (including Green Bay) this represents 21% of the total area. Near the shore, there are only two streams (Grand River and Kallagay River). While these function in surface drainage and discharge into the lake, their flow is negligible except after heavy rains.

The beach water zone is a sub-area of the lake's zone which extends to the 30-foot depth contour.²⁵ Its surface area (including Green Bay) is 1677 square miles or 7% of the lake surface, and its water volume is 0.3% of the entire lake. The endmost cooling water intake and discharge structures are in this zone. Normal shoreline water temperatures range from a low of 32°F to a high of 82°F, and the water may be periodically covered with ice from January to March. Bottom temperatures change of as much as 18°F within 24 hours have been produced by wind induced internal waves (seiches).²⁶ The temperatures of

the inshore waters exhibit large changes during the period of thermal stratification due to short-term wind effects. Winds can blow the warmer surface waters away from shore, causing upwelling of cooler waters, or, conversely, warm surface water may accumulate near shore by action of onshore winds.

At the depths where the intake and discharge structures lie, prevailing wind driven currents are parallel to the shoreline. The most frequent wind direction at the 35-foot height of the Station meteorological tower has been from the southeast.²⁵ Current drogue measurements at the site range from 0.07 feet per second to 1.09 feet per second, with the most common range being 0.2 to 0.5 feet per second.²⁷ The waters are frequently turbid due to wave action on the bottom sediments.²⁷

Table II-1 lists the chemical measurements of inshore (1969)²⁷ and nearshore (1962-63)²⁴ waters of Lake Michigan. Some of these data, particularly with reference to phosphate, are subject to seasonal variation. It should be emphasized that in Table II-1, the FWPCA data²⁴ are based on samples taken within 10 miles of the lake shoreline at unspecified depths. One hundred-foot depths are not uncommon 10 miles from shore. Most of the available information on inshore water chemistry at the Zion site has been collected by the applicant's consultant and represents sampling from beach zone waters (depths up to 30 feet).

Lake Michigan is generally described as an oligotrophic body of water, i.e., a lake with low nutrient concentration and biological productivity, but local inshore areas exist which tend toward being mesotrophic-eutrophic.⁵³ Zion inshore waters have been characterized as mesotrophic or intermediate, with respect to nutrients.²⁷

Lake Michigan water, with the exception of Green Bay and some harbors, is near saturation with respect to dissolved oxygen everywhere in the lake. The percent saturation of dissolved oxygen in all samples collected to the 20-foot depth contour off the site in August, October and December 1969 was at all times well above the 80% saturation minimum limit for single values.²⁷ The values ranged from 100% to 116% during August, and from 95% to 103% in October and December.²⁷ The data were similar at sampling stations north (Camp Logan) and south (Illinois Beach State Park and Hankoan) of the site. Data collected from 1970-1972 by the applicant's consultant also are similar.⁵⁴

Lake Michigan waters have a bicarbonate buffering system with a pH which varies from 7.8-8.3 in the Zion area.²⁴ 28-31 Some of the published data on lake water chemistry tends to be variable, because the concentrations of chloride, sulfate and total dissolved solids

(30087) 3 2000 740

TABLE II-1

CHEMICAL MEASUREMENTS OF WARSWICK^{a,b} AND INDIAN^{b,c} WATERS OF LAKE MICHIGAN

Characteristic	No. of Samples	Average	Range	At Zion ^{b,c}	
				Average	Range
Dissolved Oxygen	2,541	10	3.7-16		9.7-13.8
Saturation (%)	1,701	102	43-148		95-116
BOD	730	1.4	ND-8.6	2.2	0.2-6.2
NH ₃ -N	1,751	0.13	ND-1.4	0.05	0.01-0.14
NO ₃ -N	1,654	0.14	ND-0.90	0.31	0.06-7.5
Organic-N	529	0.21	0.01-0.70		
Total PO ₄	1,382	0.04	ND-5.0	0.06	0.004-0.24
SiO ₂	645	1.7	0.4-4.4	1.0	0.3-1.8
Na	400	4.0	1.8-7.5	4.9	4.1-6.9
K	453	1.2	0.5-3.8		
Dissolved solids	976	175	86-810		
Specific conductance (micromhos per centimeter)	2,452	285	33-1130	270	250-307
pH (pH units)	2,113		6.4-9.3	8.0	7.3-8.7
Alkalinity	2,169	105	70-210	106	90-144
Ca	616	35	17-40	36	30-55
Mg	898	12	7-14		
Cl	1,611	7.1	1.5-94	8.7	6.5-12.5
SO ₄	1,547	20	10-76		16-19
Phenols (micrograms per liter)	1,033	2	ND-32		

(Values for average and range are in milligrams per liter unless otherwise indicated; ND - not detectable at sensitivity of test).

^aPhysical and Ecological Effects of Waste Heat on Lake Michigan, U.S. Department of the Interior, Fish and Wildlife Service, 1970 (from samples taken within 10 miles of shore in 1962-63).

^bPreoperational Environmental Monitoring (Thermal) of Lake Michigan Near Zion Station 1 July 1969 - December 1969. Prepared for Commonwealth Edison Co. by Industrial Bio-test Laboratories, Inc., Northbrook, Ill. (IBT W7658 & W8096).

^cComment on Draft Environmental Statement, Appendix H (September 5, 1972).

have been increasing substantially over the past 90 years.²⁹ Calcium and perhaps magnesium levels have remained constant during this period. Available chemical data are not sufficient to demonstrate a lakewide increase in dissolved phosphate (seasonally variable), but there is considerable evidence that increasing levels of phosphorus have been entering the lake in recent years. Table II-1 also shows some of the chemical characteristics of the lake inshore waters with particular reference to Zion.

Plankton is seasonally abundant in Lake Michigan and is important to the biological productivity of the lake. The spring thermal bar (a horizontal thermal discontinuity) has been described as inhibiting horizontal mixing between the open lake and the inshore waters so that the nutrient rich waters may be trapped inshore during brief periods.³² Others contend, however, that the shearing stress resulting from vertical flow at the bar interface results in some transport of material across the bar. It is noted in this regard that inshore-offshore differences are frequently reported features of Lake Michigan.⁵⁹ The zooplankton is an important food source utilized by all Lake Michigan fish species at some time during their life cycle.^{33, 34, 59} Controlling factors governing the distribution of plankton include light intensity, currents, nutrients, turbidity, grazing and fungal parasitism.^{33, 34}

The Lake Michigan phytoplankton species are in general those characteristic of large and deep lakes, although certain species more typical of shallow and mesotrophic-eutrophic environments are becoming more populous (e.g., Stephanodiscus hantzschii (and tenina), Tubellaria flocculosa, Fragillaria crotonensis).⁵⁵ Table II-2 lists algae in the area. Diatoms usually have been reported as the dominant constituents of the phytoplankton in the lake, and in some areas such as Grand Haven, Michigan, they form 30%-50% of the particulate mass.^{29, 35} The applicant's consultant has reported that diatoms have comprised 75%-90% of the total phytoplankton sampled in Zion inshore waters²⁷, although in mid-lake (southern basin) the proportion of diatoms has been reported to range as low as 10%.⁶⁰ The remainder of the phytoplankton biomass consists of blue-green and green algae.

Copepods make up the bulk of the zooplankton species,³⁶ but rotifers and cladocerans are also present. The opossum shrimp is also an important constituent of the zooplankton and exhibits a greater amplitude of vertical migration than any of the other species.^{29, 31, 37} During the non-winter months, the migrations to the surface occur at mid-day and the animals return to the lake bottom at nightfall. When ice covers the lake, however, copepods and rotifers exhibit a reverse nocturnal migration.^{36, 37}

Coliform bacteria are organisms present normally in the digestive tract of human and other vertebrates, and may thus be introduced into

Table II-2

Abridged List of Algae Species Found at Waukegan and Zion¹Amphora sp.Anabaena sp.Ankistrodesmus falcatus (Corda) RalfsAnkistrodesmus falcatus var. mirabilis (West and West) G. S. WestAnkistrodesmus spiralis (Turner) LemmermannAphanotheca nidulans P. RichterAsterionella formosa Hass.Caratium hirsutinella (O. F. Muell) DujardinClosteriopsis longissima LemmermannClosteriopsis longissima var. tropica West and WestCocconeis spp.Cosmarium sp.Cyclotella bodanica Eulenst.Cyclotella meneghiniana KutzCyclotella ocellata Pant.Cymatopleura solea (Breb.) W. Sm.Cymbella sp.Diatoma tenueDiatoma vulgare Bory.Dictyonhectium ehrenbergianum HaegeliDischryon cylindricum ImhofDischryon divergens ImhofDischryon sociale EhrenbergFragillaria crotonensis KittonFragillaria pinnata Ehr.Gomphonema acuminatum Ehr.Isaeteridium ciliata (Lag.) ChodatLynceus sp.Malocitira islandica O. Muell.Malocitira italica (Ehr.) Kutz

Zion/ER, p. 2.3.6-60, May 1971.

Malozira sp.
Navicula spp.
Nitzschia acicularis W. Smith

Nitzschia angustata (W. Smith) Grun.
Nitzschia spp.
Ocellularia falcatus

Ocellularia spinata Meneghini
Ocellularia limnetica Lemmermann
Ocellularia tenuis C. A. Agardh

Pediastrum boryanum (Turp.) Meneghini
Plectonema sp.
Radiofilus irregularis (Wille) Brunnthaler

Rhizocolenia eriensis H. L. Smith
Scenedesmus quadricauda (Turp.) de Brabizson
Selenastrum gracile Reinsch

Spirulina subaerea Oersted
Stephanodiscus sp.
Stephanodiscus hantzschii Grun.

Stephanodiscus tenuis Hust. et Skabitschewsky
Stephanodiscus transylvanicus
Synedra acus Kutz.

Synedra ulna (Witz.) Ehr.
Tabellaria flocculosa (Roth) Ktz.
 Unidentified Green Flagellate

Lake Michigan via feces and raw sewage. Their distribution is influenced greatly by the action of currents. Monitoring by membrane filter techniques at several times of the year in 1969²⁷ has revealed coliform counts inshore at the site which are well below the Illinois water quality standards for both inshore recreational (1000/100 ml) and open water zones (200/100 ml for average annual values). The concentrations of coliform bacteria have generally tended to increase from August to December at sampling stations sited along 5 to 35-foot depth contours in a north-south direction from Camp Logan to Waukegan (north and south of the site respectively). The organisms were concentrated more heavily north of Waukegan during December than at any other time of year and their prevalence seemed to parallel the phytoplankton most closely, due presumably to lake currents and/or nutrient enhancement.

The near-shore, shallow water sediments at the site are rather typical of the entire lake. They are principally sands and silty sands, but gravels may be intermixed with the sand at some months of the year. The organic carbon content of the sediments may range from 0.12% inshore to 0.37% and 1.25% at greater depths.³³

Table II-3 lists the benthic organisms identified by the applicant's consultant in the Zion area.²⁷ Ninety-four percent of the organisms consist of burrowing amphipods, tubificid worms, and fingernail clams, in order of decreasing abundance. In open waters, burrowing amphipods totalled slightly more than 65% of the total population.^{39,40} Snails are frequent but they rarely constituted more than 15% of the benthos sampled at Zion.²⁷

Midge larvae are the most numerous benthic organisms out to the 12-foot and 15-foot depth contour lines at Zion.²⁷ Oligochaete worms which feed on detritus and algae (and some crustaceans) become important benthic components in the sediments from the 16-foot to 20-foot depths. The more common species of worms in the Waukegan area are characteristic for the lake as a whole.⁴¹

The benthic crustacean population was somewhat variable as noted in a survey carried out in 1969,²⁷ but generally the forms were important components of the bottom communities in waters 18-40 feet deep. No distinct seasonal differences in benthic crustacean species abundance was described.

Lake Michigan is an important game fishing resource.²⁴ The populations of many of the native species of fish of commercial and sport importance (whitefish, trout) were severely reduced as a result of lamprey and alewife invasions from 1952-1956 (Table II-4), as well as other factors.

TABLE II-3

List of Benthic Organisms Identified in Zion-Waukegan Area¹ (1969)

OLIGOCHAETA

LIMBICULIDAE

Limnolaima horisiana

HAIRY

Haire simplexHaire uncinataHaireaster sp.

TUBIFICIDAE

Tubificoides americanusT. clavataT. cristatus angustripesT. caryiT. hirsutiorT. h. VariantT. stenoscolicaT. caryi variantT. sp.T. sp.T. sp.T. sp. (immature)T. sp.T. sp.T. sp.T. sp.T. sp.T. sp.T. sp.

EPODELLIDAE

Epocheila microstoma

EPODELLIDAE (cont)

Macrocheila

GLOSSIPHONIIDAE

Halobdella stansalisGlossiphoniaGlossiphonia complanata

NINUDIDAE

PISCICOLIDAE

Pisicola caudata

HAUSTORIIDAE

Pontocoreia affinis

GAMMARIDAE

Gammarus fasciatus

ASELLIDAE

Asellus intermedius

HYSIDACEA

Hyale relicta

CHIRONOMIDAE

Chironomus (Chironomus)" deformedChironomus(Cryptochironomus)Chironomus puraChironomus adultDiamesa cf. longicauda

CHIRONOMIDAE (cont)

MicrosectraParacladopelmaProcladiusProcladius cf.BathypelmaStictochironomusHeterotrissocladius(Metriocnemus)

SPHAERIIDAE

Sphaerium nitidumSphaerium striatumPsidium sinicaPsidium inchoataPsidium

VALVATIDAE

Valvata cf. perdepressaValvata sinceraValvata tricarinata

LYMEAEIDAE

Lymeae curiculariaLymeaeLymeae borealis

AMNICOLIDAE

GonatoryrusAmnicola

PHYSIDAE

Physa¹ Zion/ER, p. 2.3.6-74, May 1971.

TABLE II-4

Depth Distribution and Abundance of Lake Michigan Fish in Early Period (1787-1800) and Recent Period (last several decades)¹

Species	Inshore						Value and Use
	Shallow		Intermediate		Open Lake		
	Early	Recent	Early	Recent	Early	Recent	
<u>Native shallow</u>							
Emerald shiner	A	VR					Valuable forage
Lake herring	A	VR	A	VR			Valuable forage and food
Sturgeon	A	VR					Valuable food
Common sucker	A	R					Low value food
Sturgeon sucker			A	VR			Low value food
Yellow perch	A	R					Valuable food and recreation
Walleye	A	VR					Valuable food and recreation
Whitefish	A	VR	A	R			Valuable food
<u>Native deep</u>							
Burbot	A	VR	A	VR	A	VR	Low value food
Chubs (7 species)					A	R	Valuable forage and food
Deepwater sculpin					A	R	Valuable food
Lake trout	A	VR	A	R	A	R	Valuable food and recreation
<u>Exotic</u>							
Alewife		A		A		A	Nuisance, fish meal, valuable forage
Carp		A					Low value food
Coho salmon		A		A		A	Valuable food and recreation
Smelt		A		A			Valuable food and recreation

Note: A = abundant; R = reduced; VR = very rare

¹ Physical and Ecological Effects of Waste Heat on Lake Michigan, U.S. Department of the Interior, Fish and Wildlife Service, 1970.

[illegible]

1104
00210

6110041

12130314

ALL HONOR

1

100-100000

TABLE II-5

Ecology of Some Important Lake Michigan Fish^{1,3}

Species	Life Stage	Fall	Winter	Spring	Summer	Principal Food Source ^{2,3}
Alewife	Adult	Deep water mid-depths	Deep water	Warm shallow water at 80'- 85' depths Migrating inshore in May and June	Warm shallow water, Spawn at 60-82°F in streams and unprotected lake shores. May return to cooler waters after spawning.	Zooplankton, benthic crustaceans, fish eggs and larvae, insects
	Juvenile	mid-depth				
Whitefish	Adult	Shallow water. Spawn in 8'-15' depths on current swept gravels and sands at approx. 42°F	Deep water	Warm shallow water	Deep water	Insect nymphs and larvae
	Juvenile				School at 8'-10' depths	
Cisco	Adult	Deep water. Spawn in November & December in inshore depths out to 90' (34-39°F)	Deep water	Deep water	Mid-depths (50-150')	Zooplankton <u>Daphnia</u> <u>Diaptomus</u> Rotifers Crustaceans Cyclopodia Calanoida

¹Coutant, C. C., Thermal Pollution - Biological Effects, J. Water Pollution Control Federation, 43:1292-1334, 1971

²Anderson, E.D., and L.L. Smith, Jr., A Synoptic Study of Food Habits of 30 Fish Species from Western Lake Superior, Tech. Bull. 279, Minn. Agric. Expt. Sta., St. Paul, Minn. 1971.

³Other sources used for supplementary information.

Table II-5 (continued)

Species	Life Stage	Fall	Winter	Spring	Summer	Principal Food Source ²
	Juvenile		Hatch at ~ 45°F		School in 8'-10' depths at 58°-65°F	Crustaceans Cyclopodia Calanoids Haptica
Perch	Adult	Mid-depths (> 60')	Deep water	Shallow water less than 40' deep. Spawn in weeds and rocky shallows at 45°-54°F (May July)	Mid-depths > 60'	Insect larvae and nymphs Cladocerans <u>Daphnia</u> <u>Sida</u> <u>Halopodia</u> <u>Alona</u> Amphipoda-Gammarus Snails Sphaeriidae Copepods, Water mites, Ostracods, Isopods, small fish (Alewite, Smolt)
	Juvenile				Shallow water 3'- 18' depths	Similar to adult fish
Bloater	Adult	Mid-depths (60' or more)	Mid-depths Spawn in 120' 180' depths (Feb.-March)	Shallow water	Mid-depths 46°-50°F Inshore	Crustaceans Mollusks Copepods Pentapora <u>Hysia</u>
	Juveniles				Mid-depths at 50°F	Gastropods-Valvata Sphaeriidae Sculpin and Bloater Eggs

Table II-5 (continued)

Species	Life Stage	Fall	Winter	Spring	Summer	Principal Food Source ²
Smelt	Adult	Water 50'-120' depths. Spawn at depths less than 90', 38°-39°F	Shallow water	Shallow water and streams	Deep water	Aquatic insects Crustaceans Copepods Cladocerans <u>Hyale</u> Amphipods-Cammarus <u>Pontoporeia</u>
	Juveniles			8-10' depth		Rotifers Cladocerans Copepods Small eggs
Lake trout	Adult	Deep water 120'-300' depth at 50°F	Deep water 120'-300' depth at 50°F	Deep water 120'-300' depth at 50°F	Spawning in a few inches to 100's of feet depth (clay bottom)	Fish of all sizes
	Juveniles					Crustaceans (<u>Hyale</u>) Insects Small fish (Sculpin)

Table II-6
Average Annual Production (thousands of pounds) of Major
Species of Lake Michigan ⁽¹⁾
⁽²⁾

Period	Native Species							New Species					Other ⁽³⁾ Species	Average
	Sturgeon	Lake Trout	Suckers	White- fish	Lake Herring	Wall- eye	Yellow Perch	Chubs	Carp	Smelt	Alewife	Coho Salmon		
1879-1900 ⁽⁴⁾	834	7,225	1,810	2,715	16,977	378	3,866	2,061	261	-	-	-	(5)	35,149
1910-1919 ⁽⁴⁾	13	6,763	4,035	1,670	8,642	189	2,411	3,525	247	-	-	-	(5)	27,059
1920-1929 ⁽⁴⁾	7	7,001	2,117	2,111	4,015	88	1,537	2,902	679	-	-	-	(5)	20,477
1930-1934 ⁽⁶⁾		5,342	2,258	3,370	4,985	111	1,199	4,367	769	425	-	-	354	23,540
1935-1939 ⁽⁶⁾		5,038	2,280	1,201	4,621	78	2,406	5,295	1,605	1,462	-	-	234	24,220
1940-1944 ⁽⁶⁾		6,579	2,125	1,351	1,830	49	2,729	1,971	1,702	2,913	-	-	425	21,674
1945-1949 ⁽⁶⁾		2,675	1,901	3,756	6,044	505	1,446	5,435	1,319	765	-	-	560	24,407
1950-1954	3	14	882	1,436	8,000	605	1,963	10,482	1,170	4,384	-	-	243	29,182
1955-1959	1	(7)	652	105	3,639	488	3,055	9,947	1,785	6,983	568	-	104	27,327
1960	1	(7)	767	124	232	118	3,285	12,659	1,416	3,267	2,369	-	73	24,311
1961	2	(7)	494	395	177	97	4,959	12,133	1,842	2,152	3,199	-	109	25,559
1962	1	(7)	263	266	116	67	4,050	11,115	1,206	1,546	4,742	-	103	23,475
1963	3	26	299	285	41	61	4,872	7,460	1,277	1,203	5,396	-	98	21,021
1964	3	(7)	215	777	34	35	5,835	5,172	1,320	969	11,744	-	97	26,201
1965	2	(7)	168	995	46	27	1,296	7,440	2,016	927	14,007	-	70	26,994
1966	(7) 2		404	1,422	49	24	736	7,228	2,714	1,110	29,004	-	71	42,764
1967		1	391	875	30	16	1,265	9,039	2,542	1,225	41,396	1,434	137	58,951
1968	2	73	465	893	53	10	631	10,183	2,352	1,789	27,194	1,999	166	45,810

1. Species that have had an annual production greater than one million pounds.
2. Physical and Ecological Effects of Waste Heat on Lake Michigan, U. S. Dept. of Interior, Fish and Wildlife Serv., 1970.
3. Includes species for which catches have always been less than one million pounds.
4. Average for years of record.
5. Incomplete data.
6. Fishing prohibited in Michigan 1929-1950 and in other states after 1929.
7. Less than 500 pounds.

TABLE II-7

COMMERCIALLY IMPORTANT FISH IN LAKE MICHIGAN

<u>Common Name</u>	<u>Scientific Name</u>	<u>Commercial Fish Production in Pounds-1968¹</u>
Alowife	<i>Alosa pseudoharengus</i> *	9,037,700
Gizzard shad	<i>Dorosoma cepedianum</i>	900
Bleater	<i>Coregonus hoyi</i> *	-----
Shortnose cisco	<i>Coregonus reighardi</i>	-----
Longjaw cisco	<i>Coregonus alpanae</i>	-----
Lake Herring	<i>Coregonus artedii</i> **	-----
Kiyi	<i>Coregonus kiyi</i>	31,900
Lake whitefish	<i>Coregonus clupeaformis</i>	886,000
Lake trout	<i>Salvelinus namaycush</i> *	67,900
American smelt	<i>Osmerus mordax</i> *	1,659,300
Spottail shiner	<i>Notropis hudsonius</i> *	-----
Emerald shiner	<i>Notropis antherinoides</i>	-----
Carp	<i>Cyprinus carpio</i> *	9,000
Quillback	<i>Carpiodes cyprinus</i> **	-----
White sucker	<i>Catostomus commersoni</i> *	21,100
Burbot	<i>Lota lota</i> **	33,300
Hinespine stickleback	<i>Pungitius pungitius</i> ***	-----
Trout-perch	<i>Percopsis omiscomaycus</i> **	-----
Johnny darter	<i>Etheostoma nigrum</i>	-----
Logperch	<i>Percina caprodes</i>	-----
Slimy sculpin	<i>Cottus cognatus</i> ***	-----
Spoonhead sculpin	<i>Cottus ricei</i>	-----
Fourhorn sculpin	<i>Myoxocephalus quadricornis</i>	-----
Coho salmon	<i>Oncorhynchus kisutch</i> *	1,970,400
Sauger	<i>Stizostedion canadense</i>	100
Sturgeon	<i>Acipenser fulvescens</i>	2,100
Yellow perch	<i>Perca flavescens</i>	177,900
Yellow pike	<i>Esox lucius</i>	5,400

* Frequent Near Zion Site } 2

** Rare Near Zion Site

*** Sporadic Near Zion Site

¹ Tody, W. H., Twenty-Fifth Biennial Report, Fish Div., Department of Natural Resources, State of Michigan (1969-70), 12 pp.

² Preoperational Environmental Monitoring (Thermal) of Lake Michigan near Zion Station/July 1969-/December 1969, Prepared for Commonwealth Edison Co. by Industrial Bio-Test Laboratories Inc., IBT Nos. W7658 and W8096.

Fish demand a variety of temperature range and water quality parameter criteria for their successful physiologic functions.⁴⁵ The temperatures suitable for spawning, egg incubation, and the survival of newly hatched fry, are not always those which are optimum for feeding and utilization of food for growth of the juvenile and adult fish. Fish are particularly sensitive to rapidly changing temperatures. The effects of temperature depend importantly on periods of exposure and prior thermal history of a fish. The various species have different thermal requirements, and the activities related to reproduction and growth may involve far-ranging annual movements from deep to inshore waters at different times of the year.⁴⁵⁻⁴⁷ Table II-5 presents information about the life histories of a few species.

G. ECONOMIC VALUE OF FISH AND WILDLIFE

Commercial fishing activities in the Zion area are quite limited. Many changes have taken place in Lake Michigan during the past 20 years, and factors such as alewife and sea lamprey invasion have served to deplete stocks of most commercially valuable native fish species. Common and scientific names of indigenous and introduced fish species in Lake Michigan are given in Table II-7.

Table II-7 also reports the 1968 commercial catch⁴⁸ in State of Michigan waters of the lake and may be compared to data published by the Department of the Interior for the years 1879-1968 (Table II-6).

The value of Lake Michigan commercial fisheries is now somewhat in excess of \$2 million per year. In recent years, the commercial use of salmonids for human consumption has been limited, not because the fish have been less plentiful, but because their flesh contains levels of DDT which exceed Food and Drug Administration regulations (i.e., more than 5 ppm DDT, which prohibits their sale in interstate commerce).

Since the introduction of effective measures to control the sea lamprey, attempts to rebuild populations of steelhead, brook trout, lake trout and salmon by hatchery propagation have been very successful. The 10-year hatchery goal in the State of Michigan is 30 million fish, and the estimated cost of this program is \$10 million.⁴⁹ Whitefish commercial catches have increased as well (Table II-6). These efforts have been directed toward anadromous species (spawn in tributaries), and programs are in force in Michigan to remove barriers to migration such as dams on streams of high spawning potential, and to establish additional hatcheries.

H. RECREATION (SPORT) SPECIES

Sport fishing opportunities on Lake Michigan provide recreational outlets to residents and nonresidents in the four-state area bordering the lake. The demand for a sport fishery is now large, and the State of Michigan is committed to an extensive federally funded program of lamprey control (with the participation of other agencies such as the Bureau of Sport Fisheries and Wildlife, and the Great Lakes Fishery Commission) and fishery management of coho, chinook salmon, steelhead and lake trout.^{24,49} It is hoped that the propagation of these fish-eating predators will help to control alewife populations. This program is also addressed to the problem of dam removal and other measures to improve the quality and accessibility of tributaries to the lake, to improve conditions for salmon and trout spawning. The eggs stripped from fish collected in the streams have enabled the Michigan hatcheries to carry on their important restocking program.^{48,50} Anglers are also attracted by the availability of yellow perch, walleye, smallmouth bass, northern pike, and muskellunge.⁴⁸

To meet the demand of sportsmen, the research budget for the State of Michigan in fiscal year 1971 was \$90,000.²⁴ The cost of the 1970 lake stocking program was \$270,000.²⁴

The popularity of the fishing activity can be measured in terms of the funds accrued from this activity. For the State of Michigan alone, this amounted to about \$9 million during 1970.^{50,51} This figure includes costs for transportation (oil, gas), lodging, boats, and rental fees. About 60% of the funds (about \$5 million) were spent by fishermen at or near the localities fished. The estimates of fishing activity are, however, only approximations since they usually depend upon the willingness of fishermen to return a mailed questionnaire, and the return is frequently less than 50%.^{57,58}

The net economic value of the sport fishery is difficult to estimate. "Demand curves" formulated by the Michigan Department of Natural Resources include considerations such as geographic distribution of the participating fishermen (their willingness to travel), activity at the site (dollars spent), and the "afterthought" (will they return?). The following data provides an approximate valuation for sport fishing in Michigan.⁵⁰

**Fishing Effort and Expenditures for Lake Michigan
Salmon and Trout by Michigan Resident
Fishermen, 1970**

<u>No.</u> <u>Steelhead</u> <u>Trout</u>	<u>No.</u> <u>Coho</u> <u>Salmon</u>	<u>No.</u> <u>Chinook</u> <u>Salmon</u>	<u>Angler</u> <u>Days per</u> <u>Fisherman</u>	<u>Expenditures per Fisherman</u>			
				<u>Expenditures</u> <u>per</u> <u>Angler/Day</u>	<u>At</u> <u>Fishing</u> <u>Locals</u>	<u>Enroute to</u> <u>Fishing</u> <u>Locals</u>	<u>Total</u>
275,000	437,000	168,000	9.7	\$9.27	\$55.32	\$34.53	\$89.80

Throughout the entire Great Lakes, most of the 1970 catch of Coho (30%) and Chinook salmon (90%) and steelhead trout (70%) come from Lake Michigan and its tributaries.

REFERENCES FOR SECTION II

1. U. S. Census Bureau (1970).
2. Zion/PCAR - Vol. 7, Table 2.4-2 (Amendment 14-Aug. 1971).
3. Zion, Illinois Comprehensive Plan Update, prepared by Lake County Regional Planning Commission, August 1, 1970, Table 7.
4. Suter, H., Bergstrom, R. E., Smith, H. F., Enrich, G. E., Walton, W. C., and Larson, T. E., "Preliminary Report on Ground Water Resources of the Chicago Region, Illinois," Cooperative Ground-Water Report 1 (1959).
5. Hughes, G. M., Krantz, P., and Landon, R. A., "Bedrock Aquifers of Northeastern Illinois," Illinois State Geological Survey Circular 406 (1966).
6. Climatic Summary of the United States, supplement for 1951 through 1960 for Illinois and Wisconsin (1963).
7. Zion/ER, p. 2.1-30, May 1971.
8. Wilson, J. W. and Chagnon, S. A., Jr., "Illinois Tornadoes," Illinois State Water Survey, Urbana, Ill. (1971).
9. Flora, S., Tornadoes of the United States, University of Oklahoma Press, Norman, Oklahoma (1933).
10. Willmen, H. E., "Summary of the Geology of the Chicago Area," Illinois State Geological Survey Circular 460, Urbana, Ill. (1971).
11. Hackett, J. E., Ill. State Geological Survey, letter to Commonwealth Edison Company dated Jan. 4, 1966 dealing with the subsurface geology of the Zion region.
12. Evers, R. A., "Some Unusual Nature Areas in Illinois and a Few of Their Plants," Illinois Natural History Survey, Biological Notes No. 50 (1963).
13. Ross, H. E., "The Dunesland Heritage of Illinois," Illinois Natural History Survey Circular No. 49 (1963).
14. Gates, F. C., "The Vegetation of the Beach Area in Northeastern Illinois and Southeastern Wisconsin," Illinois Lab. Nat. His. Bull. 9 (5), pp. 255-372 (1912).

15. Rodley, E. B. and Levin, D. A., "Habitat Differences of Three Liatris Species and Their Hybrid Derivatives in an Interbreeding Population," American Journal of Botany, Vol. 53, No. 5, pp. 550-559 (1967).
16. Kerster, H. W., "Population Age Structure in the Prairie Forb, Liatris aspera," EvoScience, Vol. 18, No. 5, pp. 430-432 (1968).
17. Kerster, H. W. and Levin, D. A., "Neighborhood Size in Lithospermum carolinianum," Genetics 60, pp. 577-587 (1968).
18. Levin, D. A., "The Breeding System of Lithospermum carolinianum: Adaptation and Counteradaptation," The American Naturalist, vol. 102, p. 927, pp. 427-441 (1968).
19. Soil Survey, Lake County, Illinois, USDA Soil Conservation Service and Illinois Agricultural Experiment Station (1970).
20. Swink, F., Plants of the Chicago Region, The Morton Arboretum (1969).
21. Costing, H. J., The Study of Plant Communities, W. H. Freeman and Co., San Francisco (1956).
22. Smith, E. T. and Beecher, W. J., Chicagoland Birds, Where and When to Find Them, Chicago Natural History Museum Publ. (1963).
23. George, W. G., "Vanished and Endangered Birds of Illinois: A New 'Black List' and 'Red List'," Audubon Bull. No. 153, pp. 2-11 (1971).
24. Physical and Ecological Effects of Waste Heat on Lake Michigan, U. S. Department of the Interior, Fish and Wildlife Service (1970).
25. Platman, G. W., "The Prediction of surges in the Southern Basin of Lake Michigan, Part III, The Operational Basis for Prediction," Monthly Weather Review 93 (1965).
26. Zion/ER, Fig. 6, May 1971.
27. Preoperational Environmental Monitoring (Thermal) of Lake Michigan Near Zion Station/July 1969-December 1969, prepared for Commonwealth Edison Company by Industrial Bio-Test Laboratories, Inc., IBT W7658 and W8096.
28. Beston, A. M., "Changes in the Environmental and Biota of the Great Lakes," Eutrophication, Nat'l. Acad. Sci., Washington, D. C. (1969), pp. 150-187.

29. Beaton, A. M. and Chandler, D. C., "The St. Lawrence Great Lakes," Limnology in North America (ed. D. G. Frey), U. of Wisconsin Press (1963).
30. Schlesche, C. L. and Stoermer, E. F., "Eutrophication, Silica Depletion and Predicted Changes in Algal Quality in Lake Michigan," Science 173, pp. 423-424.
31. Schlesche, C. L. and Stoermer, E. F., Phosphorus, Silica and Eutrophication, presented at the Am. Soc. Limn. Oceanogr. Symp. Nutrients and Eutrophication, February 11-12, 1971, at Michigan State University.
32. Stoermer, E. F., "Nearshore Phytoplankton Populations in the Grand Haven, Michigan, Vicinity During Thermal Bar Conditions," Proceedings 11th Conf. Great Lakes (1968), pp. 137-150.
33. Wells, L., "Seasonal Abundance and Vertical Movements of Planktonic Crustacea in Lake Michigan," Fishery Bull. No. 172 (1960), pp. 343-369.
34. Eddy, S., "The Plankton of Lake Michigan," Ill. Nat. Hist. Survey Bull., 17, pp. 203-232 (1927).
35. Holland, R. E., "Seasonal Fluctuations of Lake Michigan Diatoms," Limnology and Oceanography 14, pp. 423-436 (1969).
36. Robertson, A., The Distribution of Calanoid Copepoda in the Great Lakes, Publ. No. 15, Great Lakes Research Div., The University of Michigan (1966), pp. 129-139.
37. Marsolf, G. R., "Substrate, Relations of the Burrowing Amphipod *Pontoporeia affinis* in Lake Michigan," Ecology 46, pp. 579-592 (1965).
38. Powers, C. F. and Robertson, A., "Subdivisions of the Benthic Environment of the Upper Great Lakes, with Emphasis on Lake Michigan," J. Fish Res. Bd. Canad. 25, pp. 1181-1197 (1968).
39. Eggleston, F. E., "The Deep Water Bottom Fauna of Lake Michigan," Michigan Acad. Sci. Arts and Letters 21, 11, 599-612 (1936).
40. Eggleston, F. E., "Productivity of the Profundal Benthic Zone in Lake Michigan," Michigan Acad. Sci. Arts and Letters 22, pp. 593-611 (1937).

41. Hiltunin, J. K., "Some Oligochaetes from Lake Michigan," Trans. Amer. Micr. Soc. 86, pp. 433-454 (1967).
42. Letter to Dr. J. Marshall, Argonne National Laboratory from T. A. Edsell, Bur. of Sport Fisheries & Wildlife, Ann Arbor, Mich. (Oct. 1, 1971).
43. Ayers, J. C., "Lake Michigan Environmental Survey," U. of Michigan, Great Lakes Research Division, Spec. Rep. No. 49, p. 70 (1970).
44. Beeton, A. M., Species Report No. 11, Statement on Pollution and Eutrophication of the Great Lakes to the U. S. Senate Subcommittee on Air and Water Pollution of the Committee on Public Works (1970), 35 pp.
45. Coutant, C. C., "Thermal Pollution - Biological Effects," J. Water Pollution Control Federation, Washington, D. C., 43, pp. 1292-1334 (1971).
46. Raney, E. C., "Heated Discharges and Fishes in Lake Michigan in the Vicinity of the Donald C. Cook Nuclear Plant." Testimony presented at Michigan Water Resources Commission, June 24, 1971, 14 pp.
47. Wells, L., "Seasonal Depth Distribution of Fish in Southeastern Lake Michigan," Fish. Bull. 67, pp. 2-15 (1968).
48. Borgeson, D. O. and Tody, W. H., "Status Report on Great Lakes Fisheries," Fish Management Report No. 2, Fish Division, Michigan Department of Conservation (March 1967).
49. Tody, W. H., Twenty-Fifth Biennial Report, Fish Div., Dept. of Natural Resources, State of Michigan (1969-1970), 12 pp.
50. Ellefson, P. V. and Jansen, G. C., "Michigan's Salmon-Steelhead Trout Fishery: An Economic Evaluation," presented at the 75th Ann. Meet. Mich. Acad. Sci., Arts and Letters, Kalamazoo, Mich. (April 23, 1971).
51. Ellefson, P. F. and Jansen, G. C., Economic Appraisal of Michigan's Salmon and Steelhead Sport Fishery, Mich. Dept. Nat. Res., Research Development Rept. No. 244 (June 1970).
52. Zion/ER, Supplement IV, April 1972.

53. Holland, R. E., and A. M. Beeton. Significance to Eutrophication of Spatial Differences in Nutrients and Diatoms in Lake Michigan. *Limnol. and Oceanogr.* 17: 88-96 (1972).
54. Comments on Zion Station Draft Environmental Statement. CECO (Appendix N).
55. Cunningham, L. Vertical Migrations of Daphnia and Copepods under the Ice. *Limnol. and Oceanogr.* 17: 301-303 (1972).
56. George, M. F. and C. H. Fernando. Diurnal Migration in Three Species of Rotifers in Sunfish Lake, Ontario. *Limnol. and Oceanogr.* 12: 218-223 (1970).
57. McKechnie, R. J. California Inland Angling Survey for 1964. *Calif. Fish and Game*, 52: 293-299 (1966).
58. Topinot, A. C. The Illinois Angler: A Survey of 1965 Illinois Licensed Fisherman, Ill. Dept. Conserv., Springfield, Ill., 81 pp., (1967).
59. Final Environmental Statement Related to Operation of the Palisades Nuclear Generating Plant. U.S. Atomic Energy Commission, Washington, D. C. (June 1972).
60. Schelske, C. L., and E. F. Stoermer, Phosphorus, Silica, and Eutrophication of Lake Michigan, Symposium on Nutrients and Eutrophication, The Limiting Nutrient Controversy. American Society Limnology Oceanography Spec. Symp. No. 1. Allen Press, Lawrence, Kansas.

2

III. THE PLANT

A. EXTERNAL APPEARANCE

The major buildings of the Station will be the most prominent landmarks in the area due to their size and height--two reactor containment buildings each 147 ft in diameter and 189 ft high and the turbine building 774 ft long and 121 ft high (Fig. III-1). These structures will dominate the area and will be visible from all directions. It is reasonable to assume that the Station will become a landmark for boaters as well as commuters.

The plant architecture is modern and utilitarian in design (Fig. III-2 and III-2A) and represents a radical departure from conventional fossil-fueled power station design (for example, the Waukegan Station located 4 miles south of Zion). When completed and landscaped, the Station should be aesthetically attractive as compared to older conventional stations, but since aesthetics are a matter of personal preference it cannot be assumed that the Station will be attractive to everyone.

B. TRANSMISSION LINES

Six 345 kV transmission lines are being installed from the Station switchyard to connect with the applicant's existing transmission system and with the Wisconsin Electric Power Co. system. The Zion/ER, Supplement I, Attachment 3, shows the transmission system from the Station. The lines being constructed will meet all the requirements of the Illinois Commerce Commission General Order 160, which is identical to the National Safety Code for construction of transmission lines.

The lines total about 89 circuit miles. The applicant procured about 6 miles of new right-of-way for these lines. The two longest legs are those which connect to the substations at Northbrook and Libertyville. The route selected passes through farmland, unused fields and marshes, industrial land and in some instances through residential areas. The applicant will install modern single steel poles (with upswept arms) for over 60 circuit miles, while lattice steel towers will be used for the remaining miles. The single steel poles will be of double-circuit or triple-circuit design to minimize their numbers. Wherever possible the applicant will use vacant line positions on existing double-circuit steel towers.

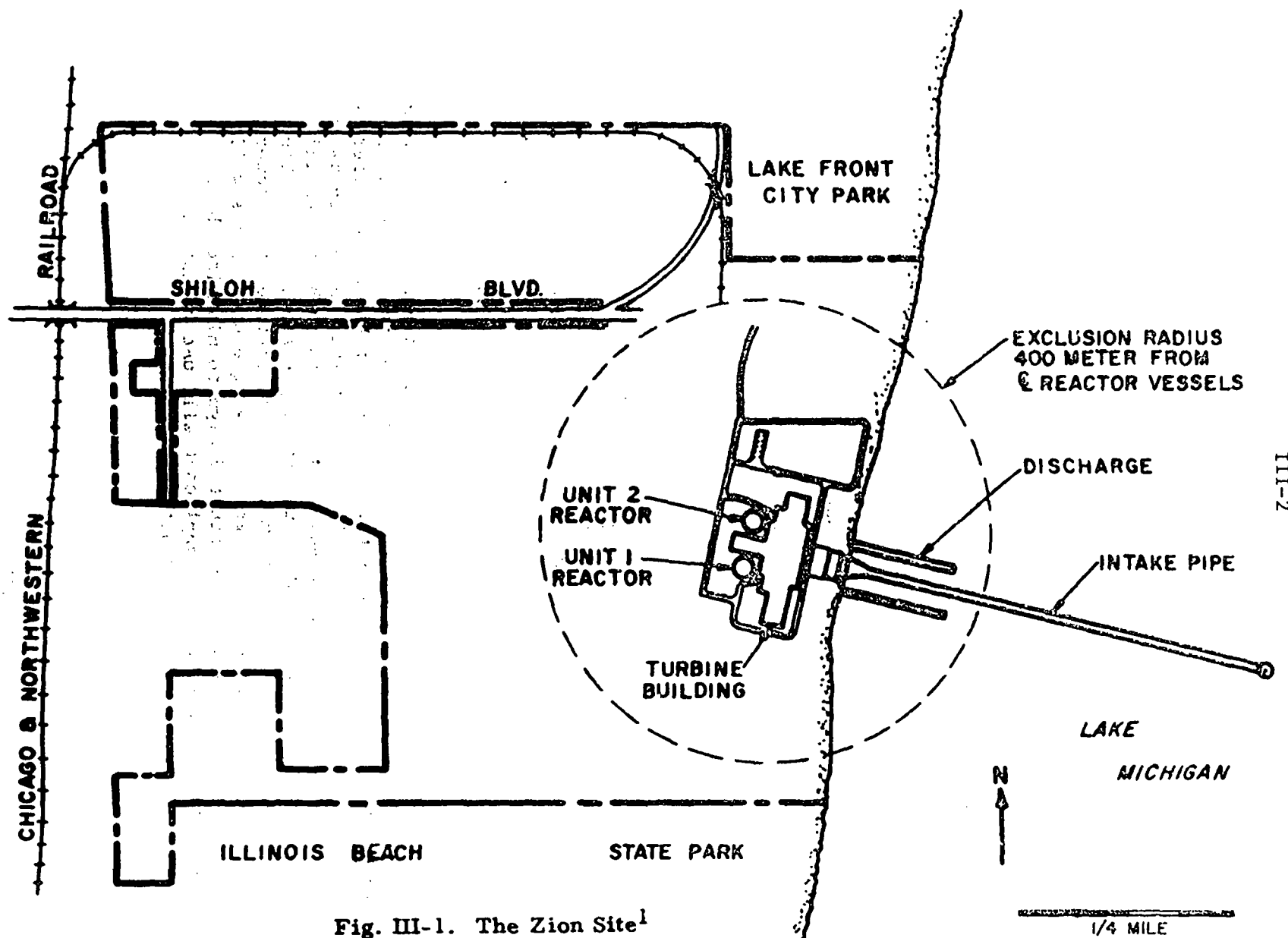


Fig. III-1. The Zion Site¹

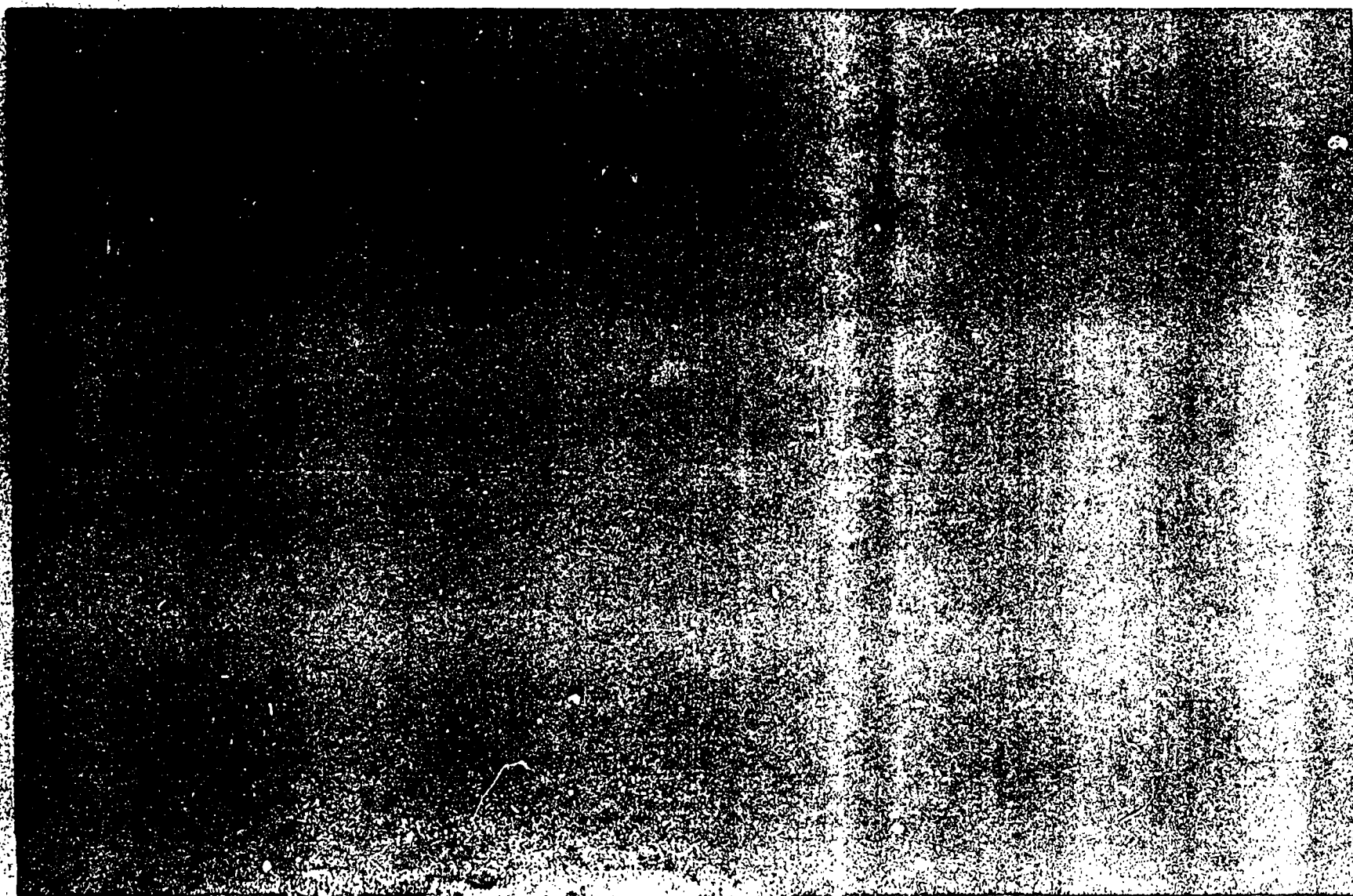


Fig. III-2. Photo of Zion Station from Illinois Beach State Park (November 1971)



III-4

Fig. III-2A Photo of Zion Construction Site Looking Northeast (January 1972)

C. REACTOR AND STEAM-ELECTRIC SYSTEM

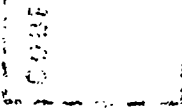
The Station utilizes two pressurized-water reactors (PWR's) as the energy source to generate steam to drive the turbine-generators (Fig. III-3). Westinghouse Electric Corporation is the supplier of the reactors, turbine-generators and major components of the "nuclear island." Sargent and Lundy is the Architect-Engineer firm. Commonwealth Edison Company maintains overall responsibility for coordination and construction of the plant and will operate the Station.

Each reactor has a design power rating of 3250 MWt (megawatts thermal) with a maximum rated capability of 3391 MWt. This heat energy is used to produce electricity and each unit has a design rating of 1085 MWe gross, with a maximum rated capability of 1129 MWe gross (1100 MWe net).

The reactor and primary coolant system operate at a pressure of 2250 psia with a nominal inlet temperature to the reactor of 530°F and outlet from the reactor of 594°F. The primary water is circulated through steam generators (shell and tube heat exchanger) to produce saturated steam at 720 psia. The steam drives a multi-stage triple compound turbine and is condensed in a four-section desuperating condenser. Cooling water drawn from Lake Michigan is pumped through the tubes of the condenser to remove the heat from, and thus condense, the steam after it has passed through the turbine. The condensate is then pumped (and raised in pressure to about 700 psia) back to the steam generator to be heated for another cycle.

Nuclear power plants operate on the same thermodynamic principle as fossil-fueled plants. Thermal energy is converted to mechanical energy which in turn is converted to electrical energy. Approximately 2/3 of the heat produced (in light-water-cooled reactors) must be rejected to the environment because of the inherent relatively low thermal efficiency of the heat cycle. Virtually all of the "waste heat" is rejected to the cooling water system.

A modern fossil-fueled station rejects less heat to the cooling water than a light-water-cooled reactor generating unit because: (1) it operates at higher steam temperature and pressure and thus operates on a higher efficiency heat cycle and (2) it rejects some of its heat directly to the atmosphere through the stack (this form of waste heat is known as "stack loss" and does not occur in nuclear plants). Thus a nuclear station will reject about 50% more heat to the cooling water per kw hour of electrical power generated than will a modern fossil-fueled station.



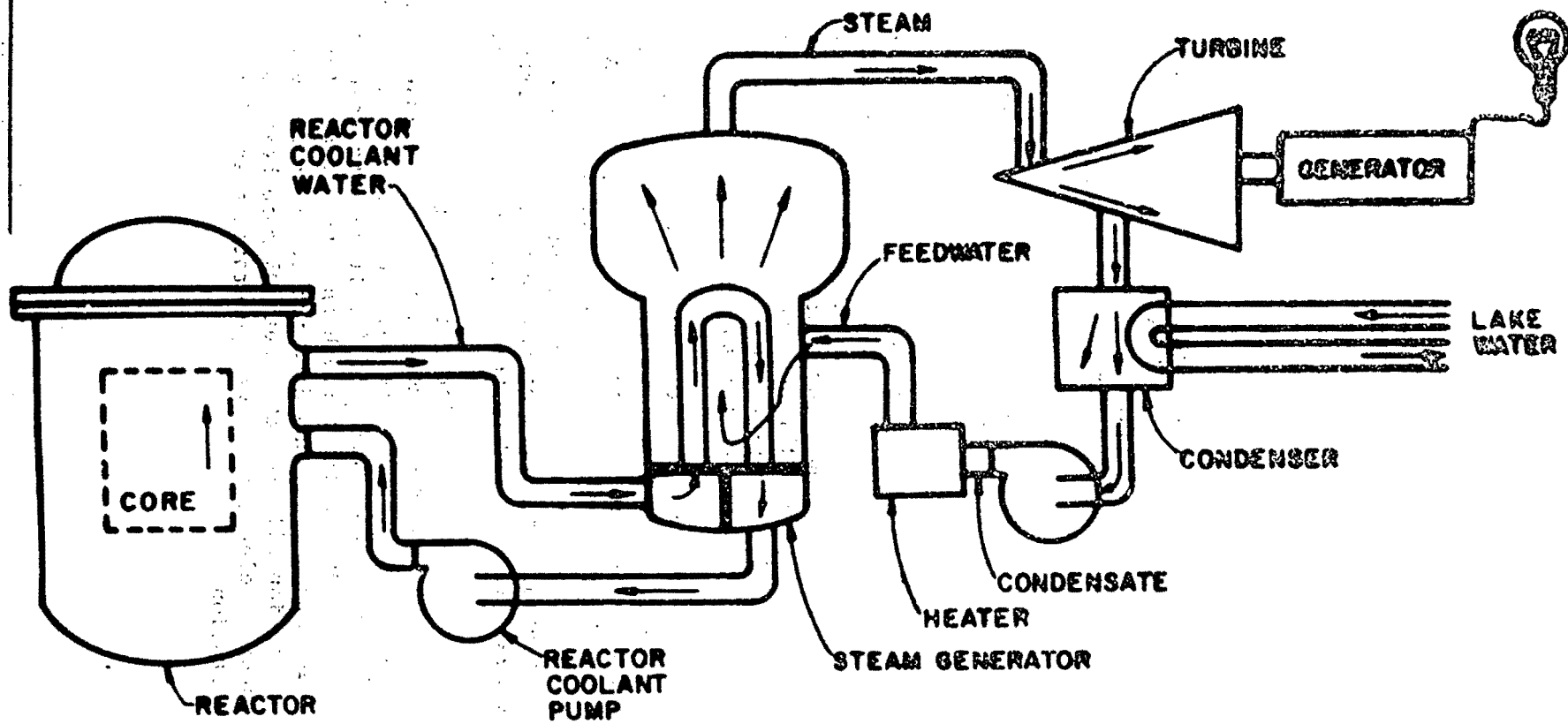


Fig. III-3. Schematic Illustration of the Basic Features of P.W.R. Nuclear Power Generator¹

The reactor fuel consists of slightly enriched uranium oxide pellets sealed in Zircaloy-2 tubes. Water flows around the outside of these tubes and carries away the heat generated inside due to fission of the uranium. This primary water is circulated by pumps and transports the heat to the steam generators. The primary water circuit is sealed and the primary water is maintained at a very high purity by circulation through a demineralizer system.

Radioactive fission products are formed inside the uranium-oxide pellets and are normally contained within the sealed fuel tubes. If a fuel tube leaks, fission products can enter the primary water system. Because the primary system is a sealed system, fission products are contained in it unless there are leaks. If a steam generator leaks, fission products can be released to the steam system. If the steam system condenser leaks, however, no fission products should enter the cooling water and consequently the lake due to the negative pressure on the steam side of the condenser. Three fission product barriers are thus provided between the fuel pellets and the lake cooling water: the fuel element tube, the primary water system (and steam generator), and the steam system (and condenser).

Each reactor and its primary system are housed within a "containment building" which is designed to retain the fission products, as well as the significant stored energy in the high temperature-high pressure primary water system. The design of these systems and their functional reliability under abnormal conditions are subject to extensive review as a part of the licensing process.

D. EFFLUENT SYSTEMS

1. Heat

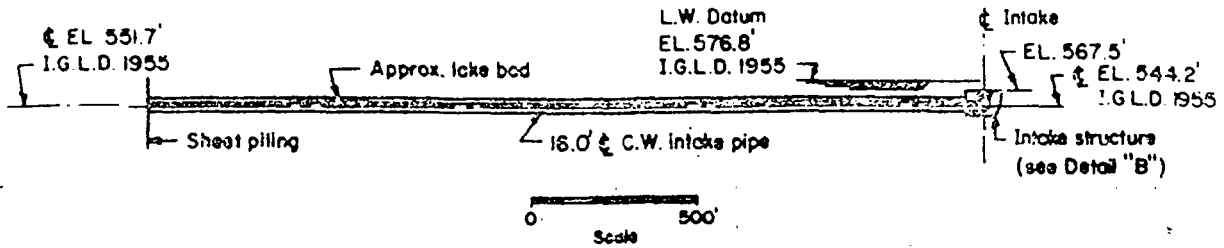
Each reactor will produce a design maximum of 3391 MWt at full power, of which approximately 1100 MW will be converted into electric power; the balance (except for small in-plant losses) will be discharged to Lake Michigan. This transfer of heat to the lake will be accomplished by the circulation of water which is taken from the lake, passed through the condensers, and returned to the lake. At maximum power operation of the two reactors, the Station condenser cooling water system will transfer 4520 MW of heat to the lake by circulation of 1,530,000 gallons of water per minute (gpm) through the plant, returning the water to the lake with a temperature increase of 20°F. At full station power operation, waste heat will be discharged to the lake at a rate of 15 billion Btu per hour. The lake serves as a temporary sink for this heat, since most of it is transferred to the atmosphere within a few days. No substantive warming of the lake as a whole is expected as a result of Zion Station operation.¹

a. The Condenser Cooling Water System (Warm Weather Operation)

The cooling water enters the system through the intake structure (Fig. III-4) which is located 2600 ft offshore. The top of the vertical inlet pipes is at an elevation of 560.7 ft, which is about 17 ft below normal lake level (16 ft below minimum recorded low water level, 23 ft below maximum recorded high water level).² Water enters vertically downward through two large diameter pipes near the center of the intake structure and through 45 small diameter ports which are spaced around the periphery of the intake structure. Each of the two large pipes has a conical entrance 24 ft in diameter flaring into and adjoining 13 ft diameter pipe. The pipes are spaced 27 ft apart, equally distant from the center line (13-1/2 ft either side of the center of the structure). A "roof structure" is located above the large inlet pipes to prevent vortex formations in the inlet water. The top of the roof structure is at elevation 568.5 ft, which is about 9 ft below normal lake level. The effective vertical clearance (for lateral water flow) between the underside of the roof structure and the top of the large intake pipes is about 5-1/2 ft. The intake annulus is located about 4 ft above the lake bottom. The water that enters through the 45 small diameter ports at the periphery of the intake structure passes to an annular plenum (thawing box), and then to a third intake pipe. (This system performs a de-icing function during winter and is described in Section III D.1.b.)

III-9

Note: Pipes shall have a minimum 3.0' cover



16.0 ft. is outside diameter of intake pipes

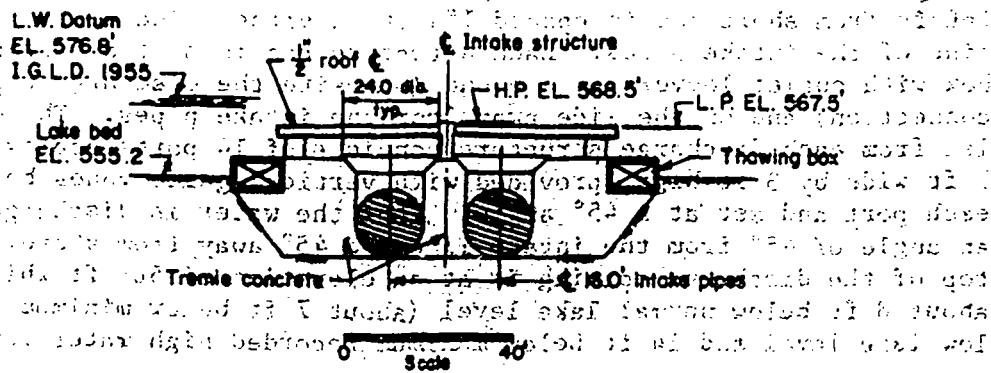
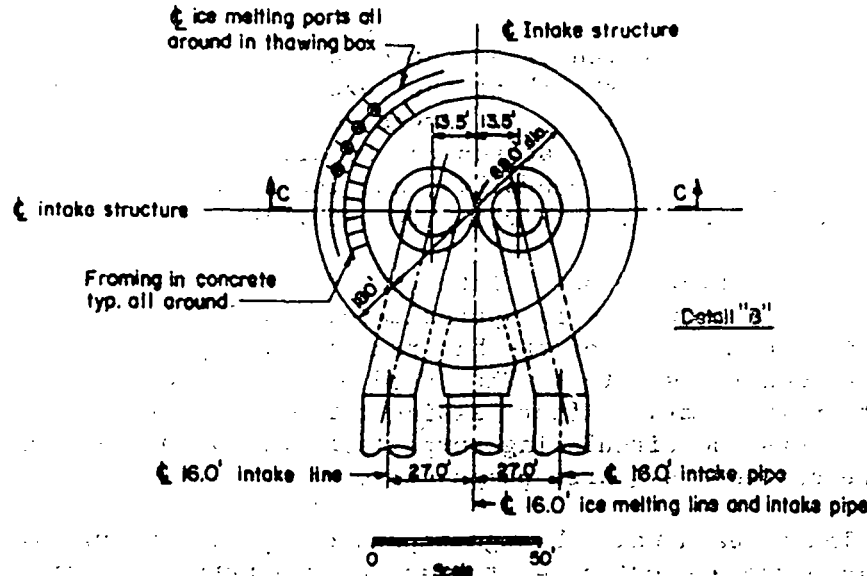


Fig. III-4. Cooling Water-Intake-Structure

1. Zion/ER, Supplement II, Fig. 4.4.

The cooling water flows by gravity through the three intake pipes to the forebay of the crib-house. It is pumped from the forebay (causing a drawdown of water level in the forebay of approximately 9 ft at maximum flow) through a bar rack and then through a traveling screen (Fig. III-5) to the circulating pumps. The bar rack consists of 1/2 in. by 5 in. cross section bars spaced vertically on 2-1/2 in. centers resulting in nominal 2 in. openings between bars. The bar rack is intended to stop large debris which can be removed vertically by lifting manually along the vertical bars. The bar rack will also prevent passage of any fish which cannot pass through a 2 in. opening. The traveling screen is constructed of 12 gauge wire mesh with 3/8 in. square openings. The screen is a continuous unit constructed of screening panels with a "shelf" at the lower edge of each panel. As debris collects on the screen, it causes an increase in the pressure drop across the screen. The screen can be driven vertically (either initiated automatically or manually), and the shelves are cleared as they move over the top by high velocity water jets.

The maximum water flow velocity into the offshore intake structure during non-winter operation is approximately 2.47 ft/sec, while the flow velocity at the face of the bar rack is 1.2 fps and at the traveling screen it is 2 fps. The speed of the traveling screen is approximately 10 ft/min. After passing through the traveling screen, the water enters the circulating pumps (six total) and is pumped through the condensers (three pumps serve each unit).

The water leaves each unit through separate piping, through valves in the crib house and out a 14 ft diameter discharge pipe and discharge structure. Each discharge structure (Fig. III-6) is located 760 ft from shore and is spaced 154 ft on either side of the center line of the intake pipes. Each structure consists of a rectangular box with outlet louvers on the end (opposite the discharge pipe connection) and on the side away from the intake pipes. The outlet from each discharge structure consists of 14 ports approximately 7 ft wide by 3 ft high, provided with vertical guide vanes between each port and set at a 45° angle. Thus the water is discharged at an angle of 45° from the intake line and 45° away from shore. The top of the discharge opening is at an elevation of 569 ft which is about 8 ft below normal lake level (about 7 ft below minimum recorded low lake level and 14 ft below maximum recorded high water level).²

At maximum power operation the average velocity of the water at the face of the outlet ports is about 9.5 ft/sec. This high velocity jet discharge is designed to enhance mixing with ambient lake water,

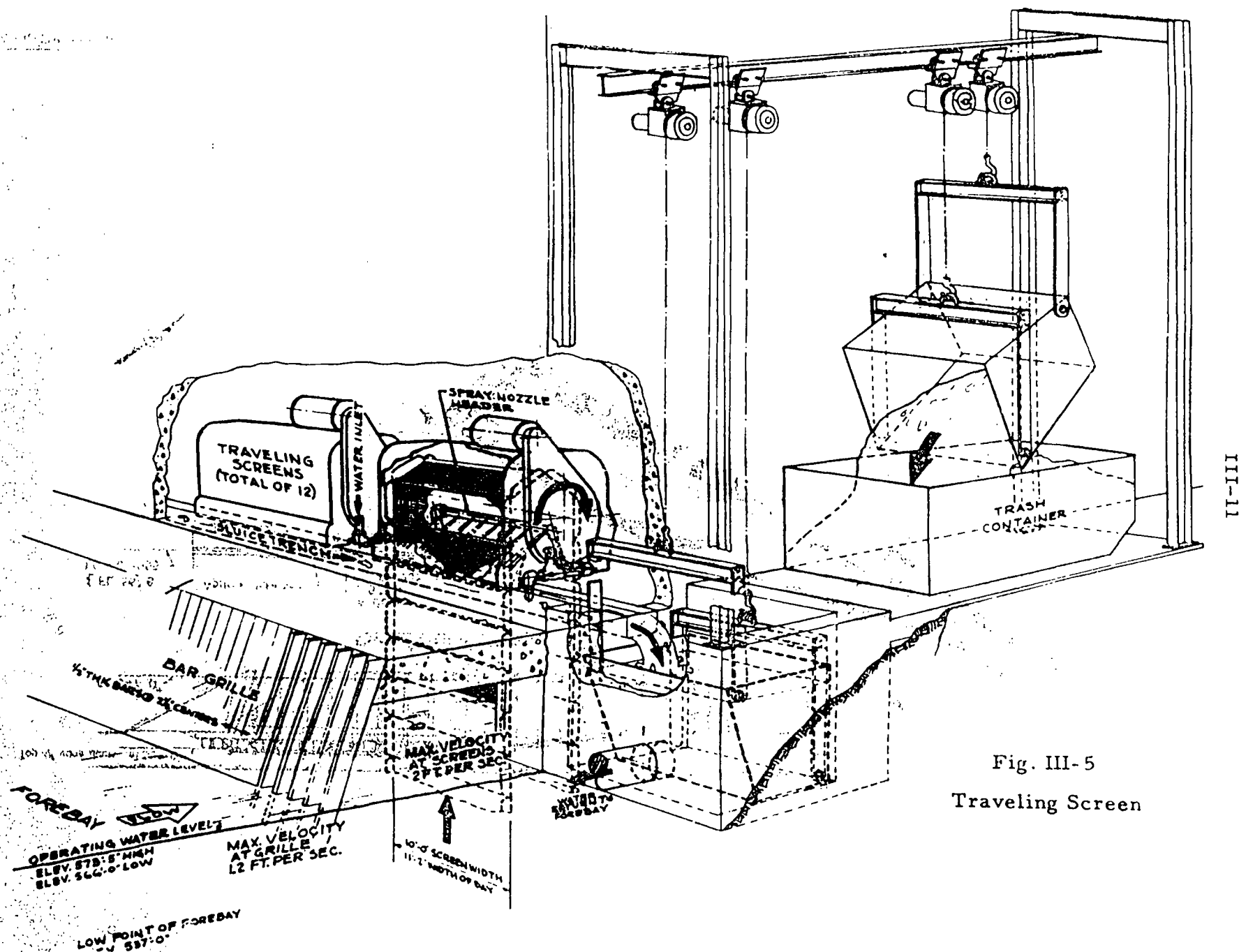
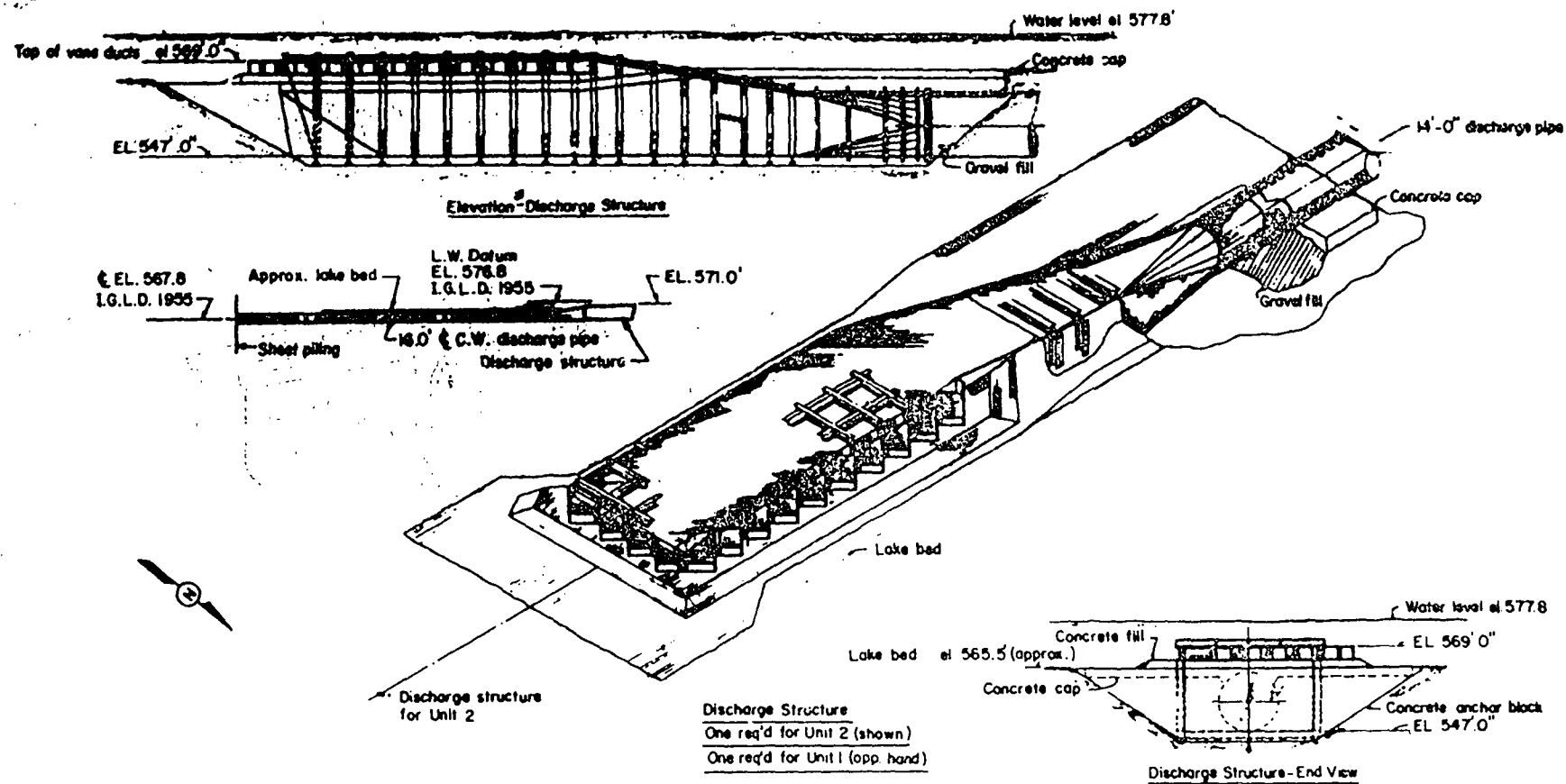


Fig. III-5
Traveling Screen



III-12

Fig. III-6. Discharge Structure¹

1. Zion/ER, Supplement II, Fig. 4.5.

thereby promoting rapid temperature reduction of the discharged water.

The behavior of the jet discharge as regards its mixing with the lake under various hydrological and meteorological regimes has been examined in considerable detail by both mathematical and hydraulic modeling studies. The mathematical modeling done by Pritchard³ indicates plume configurations shown in Fig. III-7 at the design power level of 3250 MWt. Furthermore, Pritchard calculates,⁴ for each unit, the areas on the lake surface with various isotherms under design operating conditions to be as follows:

<u>°F Above Ambient</u>	<u>Plume Area (Acres)</u>	<u>°F Above Ambient</u>	<u>Plume Area (Acres)</u>
14	0.5	5	5.7
12	1.0	4	8.8
10	1.3	3	13.6
8	2.0	2	76
6	4.2	1	106

The hydraulic modeling done by Alden Research Laboratories⁸ cannot be related directly to the plume configurations shown in Figure III-7 because of crosscurrent effects. Further, it is not possible to verify quantitatively the real extent of water at temperatures less than 8°F above ambient due to the restricted size of the hydraulic model. The inability to adequately compare the hydraulic and mathematical models suggests further caution in assigning rigorous numerical values to these model data. In addition, there is no operating experience with jet discharge systems of this size and design, hence there are no empirical data on which to base definitive conclusions.

Analysis of the Alden test data⁸ for the case of lake currents going against the direction of discharge indicates that there may be an interaction between the two discharges. Test 009, for instance, indicates that water from 4 to 10°F above ambient from one discharge structure will be found in the vicinity of the other discharge structure. Thus, the temperatures shown would be higher and the areas larger due to the presence of heated entrainment water by the discharge flow.

The relatively small areas within isotherms predicted by Pritchard are viewed with some skepticism. This skepticism is based primarily on intuition and observation of other thermal discharges. It is only fair to state, however, that intuition and other observations may

fail for the Zion Station because of its flow, unique design and placement. When the Pritchard analysis is applied to a thermal discharge where good field data are available, such as the Point Beach Nuclear Plant discharge, the comparison is reasonably good. For excess temperatures greater than 5°F, Pritchard predicts areas smaller than the average of the observed areas. For excess temperatures less than 3°F the trend is for Pritchard's analysis to predict larger areas than observed. In any event the areas predicted by Pritchard's model fall within the experimental scatter of the data. The Asbury-Frigo correlation (Asbury, J. G. and Frigo, A. A. A Phenomenological Relationship for Predicting the Surface Areas of Thermal Plumes in Lakes, ANL/ES-5, Argonne National Laboratory, April 1971), based upon data from 37 thermal plumes from 8 power plants on Lake Michigan (including the Point Beach Nuclear Plant), predicts areas considerably larger than does Pritchard's model for excess temperatures greater than 5°F. The correlation generally predicts smaller areas than Pritchard's model for temperatures less than 3°F. The Asbury-Frigo correlation also predicts larger areas than those observed at Point Beach, since the Asbury-Frigo correlation is based upon relatively low velocity and surface-shoreline type discharges. It therefore represents an upper limit for the areas to be expected in a thermal plume. In view of the uncertainty of the estimated areas within isotherms for the Zion plume, the following "upper limit" areas for each Zion unit for the discharge plume are calculated from the Asbury-Frigo correlation for the purpose of comparison:

<u>°F above ambient</u>	<u>Plume area (acres)</u>
14	8
10	38
5	191
3	460

It must be emphasized that the Zion Station discharge structure is a high velocity, submerged jet designed to promote mixing and rapid cooling, and will undoubtedly produce smaller areas than those calculated from the Asbury-Frigo correlation.

Obviously, the only way in which to obtain definitive information on plume dimensions is to measure them in the lake with the Station

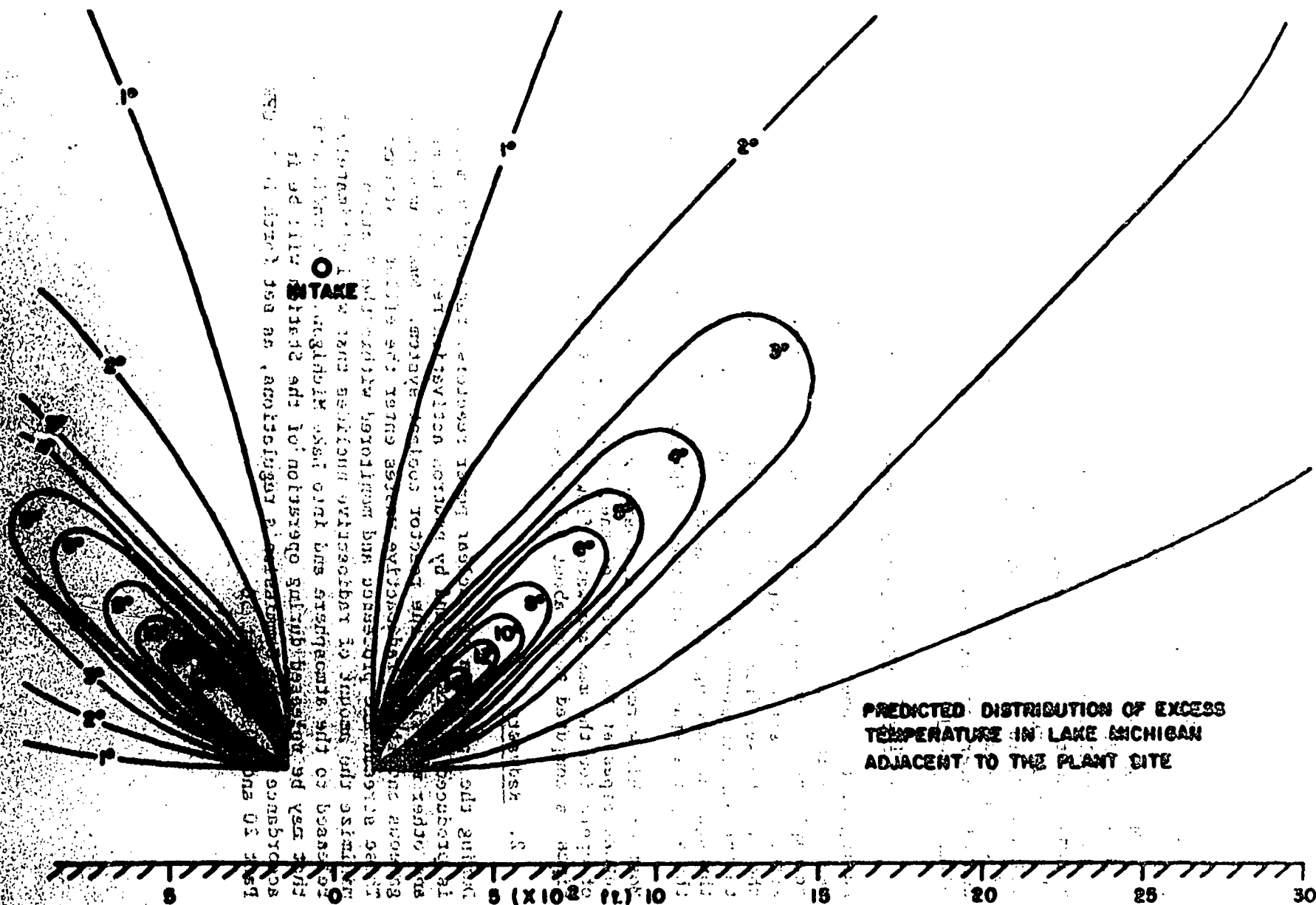


Fig. III-7. Analytical Model¹

1. Zion/ER, page 2.3.3-6, May 1971.

in operation. The applicant should be required to conduct detailed measurements of the thermal plume under various meteorological lake current and operating conditions as part of his postoperational monitoring program. Such monitoring data are a necessary adjunct to the meaningful assessment of biological impact. For information the current Illinois regulations regarding thermal discharge into Lake Michigan are attached as Appendix D to this Statement. These regulations define the size of the mixing zone, the maximum temperature above natural temperatures permitted outside the mixing zone, and the maximum limits for the temperature outside the mixing zone by month. The Illinois regulations also require future hearings before the Illinois Pollution Control Board to assess observed ecological effects of the heated effluent on the lake. For information the average monthly water temperatures observed near the Zion site are also given in Appendix D.

b. The Condenser Cooling Water System (Winter Operation)

During winter, operation of the cooling system is altered to prevent ice formation (or collection) at the intake structure. This is accomplished by returning part of the heated water to the intake structure. Part of the discharge flow is diverted (by valves at the crib house) from the discharge pipes to the intake pipe connected to the annular plenum at the intake structure. This flow passes through the thawing box and is discharged (vertically upward) through the 45 ports spaced around the periphery of the thawing box (Fig. III-4).

Most of this warmer water discharge will be drawn into the two large intake pipes at the center of the intake structure. During this mode of operation the maximum water flow velocity into the two large intake pipes is computed to be about 3.7 ft/sec.

2. Radwaste

During the operation of nuclear power reactors, radioactive material is produced by fission and by neutron activation reactions in metals and other material in the reactor coolant system. Small amounts of gaseous and liquid radioactive wastes enter the effluent streams. These streams are processed and monitored within the Station to minimize the amount of radioactive nuclides that will ultimately be released to the atmosphere and into Lake Michigan. The radioactivity that may be released during operation of the Station will be in accordance with the Commission's regulations, as set forth in 10 CFR Part 20 and 10 CFR Part 50.



The waste treatment systems, described in the following paragraphs, are designed to collect and process the gaseous, liquid, and solid waste which might contain radioactive materials. The waste treatment systems for Zion Units 1 and 2 have separate facilities for the reactor Chemical and Volume Control systems, and containment ventilation control; but use common systems for the reactor coolant waste, miscellaneous waste, and radioactive gas treatment. The assumptions used in determining the expected releases of radioactive effluents for each reactor are presented in Table III-1.

The waste handling and treatment systems currently installed at the Zion Station are discussed in detail in the applicant's Final Safety Analysis Report (November 25, 1970); and Environmental Report dated May 1971 and supplements to the Environmental Report.

a. Liquid Wastes

In each unit, a Chemical and Volume Control System (CVCS) maintains the water quality and boron concentration of the primary coolant by a letdown stream that is continuously cooled, demineralized in a mixed bed ion exchanger, filtered, and fed to the volume control tank from which it is returned to the reactor. The boric acid recycle portion of the CVCS consists of hold-up tanks, evaporator feed demineralizers (cation), boric acid evaporators, condensate demineralizers (anion) and monitor tanks, and boric acid storage tanks. For operational flexibility the equipment is interconnected and thus may be considered shared by both units.

During the fuel cycle the boron concentration in the coolant is gradually reduced. A portion of the letdown flow is diverted to the hold-up tanks; from these tanks it is fed to the boric acid evaporator. The condensate from the evaporator passes through an anion exchange demineralizer to monitor tanks from which it may be recycled or discharged. The staff evaluation assumes 90% of the flow is recycled and 10% is released through the lake discharge tank. This assumption is realistic based upon operating plants. The concentrated boric acid (evaporator bottoms) is stored for reuse in a subsequent fuel cycle or is sent to the radioactive waste drumming station for off-site disposal. Other waste waters containing boric acid from reactor shut-downs, start-ups and refueling are also processed through this equipment.

The Liquid Waste Disposal System (LWDS), shared by both units, is shown in Figure III-8. Liquid wastes from the turbine building

Table III-1

Conditions Used For Each Unit In Determining
Releases of Radioactivity in Effluents at Zion

1. Reactor Power, thermal megawatts	3,391
2. Fuel with defective cladding	0.25%*
3. Leak of primary coolant into the steam generator	20 gpd
4. Primary coolant leak to the containment	40 gpd
5. Primary coolant leak to the Auxiliary Building	20 gpd
6. Number of containment purges per year	4
7. Blowdown rate	10 gpm
8. Number of steam generators	8
9. Reactor coolant volumes degassed per year	20
10. Plant capacity factor	80%
11. Mass of water in each generator	88,500 lb
12. Steam flow	14×10^6 lb/hr
13. Containment volume	2.7×10^6 ft ³
14. Letdown flow	75 gpm

* This value is considered to be constant and is equivalent to 0.25% operating power in failed fuel rods.

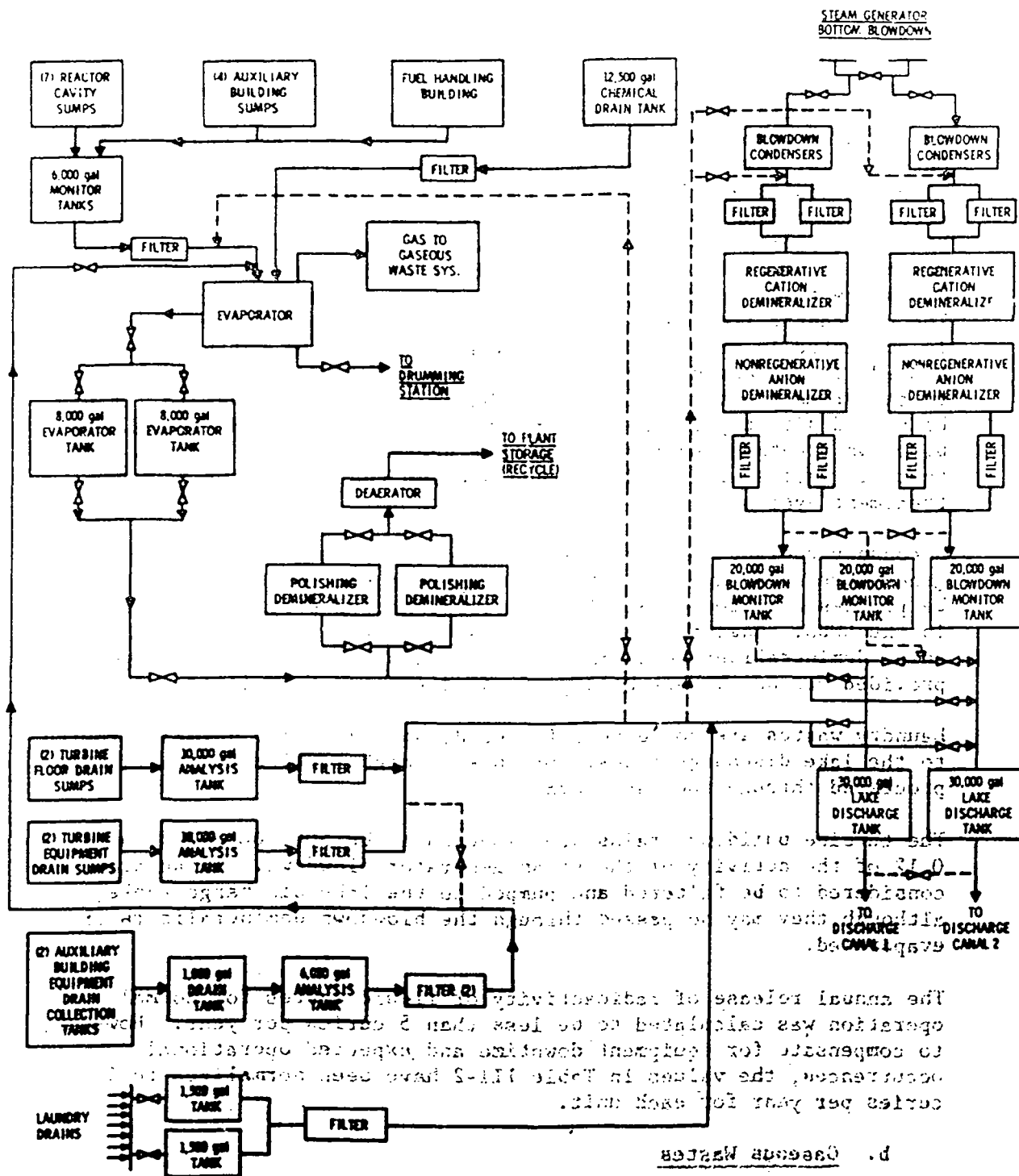


Fig III-8. Liquid Waste Disposal System

floor drains, equipment drains, auxiliary building equipment drains, auxiliary building and containment floor drains, chemical drains, and laundry wastes are collected in separate tanks and analyzed on a batch basis. All demineralizer regenerants, sluice water, and sampling wastes are included in the chemical wastes. Each batch is treated according to its activity level. Normally, all wastes except turbine building floor drains and laundry wastes will be evaporated. Batches of low level activities may be routed directly to the lake discharge tanks or through one of the blowdown demineralizer trains. The condensate from batches processed through the waste evaporator is collected in monitor tanks and analyzed. If the batch is to be reused, it is passed through a polishing (mixed bed) demineralizer to the primary water tank. If the batch is to be discharged, it may be pumped directly to the lake discharge tank or passed through the blowdown treatment system for further decontamination. It was assumed that all wastes will be discharged without the use of the blowdown treatment system.

Secondary coolant quality is maintained by blowing down the steam generators at an average rate of 10 gpm per reactor. These flows will be processed by two parallel and interconnected strings of equipment in the LWDS, consisting of condensers, filters, separate cation and anion demineralizer beds, and monitor tanks. Sufficient tankage is provided for an average holdup of one day prior to release.

Laundry wastes are collected, filtered, analyzed, and normally routed to the lake discharge tanks. Batches of high level activity will be processed through the waste evaporator.

The turbine building drains are expected to be 500,000 gal/yr at 0.1% of the activity of the steam generator blowdown. These are considered to be filtered and pumped to the lake discharge tanks, although they may be passed through the blowdown demineralizers or evaporated.

The annual release of radioactivity of liquid wastes for normal operation was calculated to be less than 5 curies per year. However, to compensate for equipment downtime and expected operational occurrences, the values in Table III-2 have been normalized to 5 curies per year for each unit.

b. Gaseous Wastes

During reactor operation, small amounts of radioactive fission products leak from the fuel rods into the reactor cooling water. Radioactive krypton and xenon gases are released from small leaks of

Table III-2

Annual Release of Radioactive Material
in Liquid Effluent from Zion 1 and 2

Nuclide	Ci/Year/Unit
Rb-86	0.0022
-88	0.045
Sr-89	0.0010
-90	0.000032
-91	0.00032
Y-90	0.000053
-91m	0.00021
-91	0.024
-93	0.000070
Zr-95	0.00016
-97	0.000016
Nb-95	0.000082
-97m	0.000027
-97	0.000032
Mo-99	0.90
Tc-99m	0.77
Ru-103	0.00012
-106	0.000032
Rh-103m	0.00012
-105	0.000036
-106	0.000032
Te-125m	0.00010
-127m	0.00077
-127	0.0011
-129m	0.0077
-129	0.0051
-131m	0.0031
-131	0.00051
-132	0.049
I-130	0.0012
-131	0.81
-132	0.074
-133	0.37
-135	0.069
Cs-134	0.83
-136	0.32
-137	0.61

Table III-2 (cont'd)

Nuclide	Ci/Year/Unit
Ba-137m	0.054
-140	0.0011
La-140	0.00079
Ce-141	0.00018
-143	0.000053
-144	0.00010
Pr-143	0.00014
-144	0.00010
Nd-147	0.000061
Cr-51	0.0028
Mn-54	0.0011
Fe-55	0.0028
-59	0.0011
Co-58	0.028
-60	0.0028
Np-239	0.00095
Total	~5 Ci/yr/unit
H ³	1,000 Ci/yr/unit

primary reactor coolant. Part of the radioactive iodine volatilizes and part remains in the liquid. Tritium is released as water vapor or hydrogen gas. Nonvolatile materials can become airborne as particulate matter which can be removed by high-efficiency particulate-air (HEPA) filters. The sources of the principal radioactive gaseous releases, measures taken to control these releases, and estimates of the amounts of activities discharged to the environment are discussed in the following paragraphs. Figure III-9 is a schematic drawing of these systems.

The primary sources of gaseous waste will originate from the degassing of the reactor coolant discharged to the Chemical and Volume Control System; from the displacement of nitrogen cover gas as liquids accumulate in various tanks; from miscellaneous tank vents; and from evaporator vents. During normal operation these gases will be collected and compressed into storage tanks where they will be held for 45 days. The radioactivity level is thereby reduced considerably, as the long lived ^{85}Kr becomes the major constituent.

Additional potential sources of radioactive gases which are not concentrated enough to permit collection and storage originate from (1) the containment building purges, (2) reactor coolant leaks in the auxiliary building and (3) the condenser air ejector exhaust when primary to secondary leakage coincident with fuel cladding defects exists.

In the Zion design, the blowdown heat exchanger is vented to the turbine condenser. The turbine condenser air inleakage and radioactive gases from primary to secondary leakage are discharged to the plant vent without treatment.

In this analysis the staff assumed that the containment building requires purging four times a year and that, prior to purging, both 8,000 cfm recirculating air filter and charcoal adsorbers are operated for 16 hours. The operation of the recirculation system reduces the airborne iodine to 4% of its initial value. The containment is then ventilated directly to the exhaust stack through HEPA filters.

Air from the refueling area, the spent fuel area, the drumming station, and potentially contaminated areas of the auxiliary building are vented to the plant stack through HEPA filters and charcoal adsorbers. The calculated releases of radioactivity from these systems are shown in Table III-3.

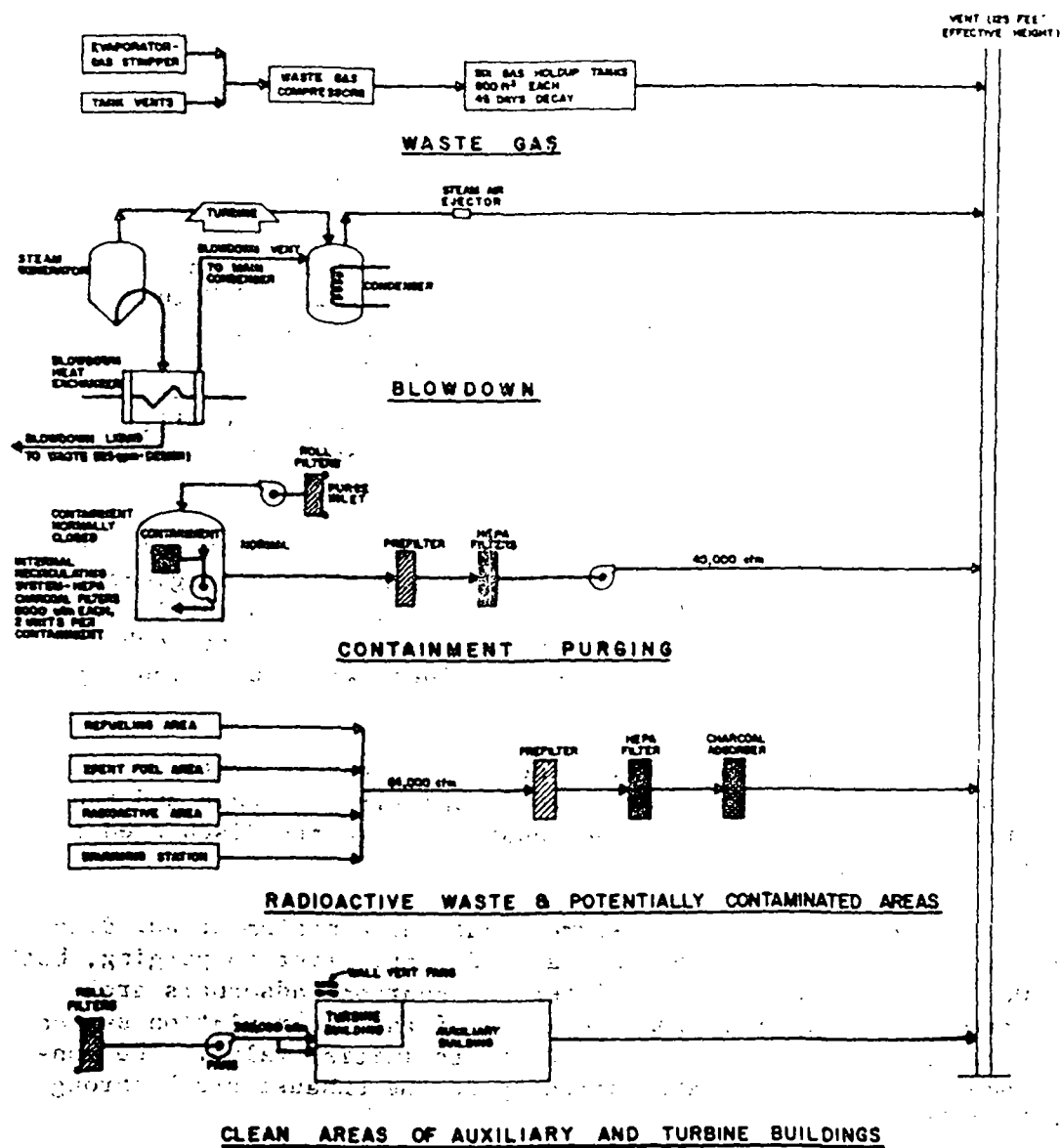


Fig. III-9 GASEOUS EFFLUENTS FROM ZION STATION UNITS 1 & 2

Table III-3

Calculated Annual Release of Radioactive Material
in Gaseous Effluents from Zion 1 and 2
Curies per Year per Unit

<u>Nuclide</u>	<u>Containment Purge</u>	<u>Waste Gas System</u>	<u>Primary Auxiliary Building</u>	<u>Air Ejector</u>	<u>Total Per Unit</u>
Kr-83m			1	1	2
Kr-85m			6	6	12
Kr-85	5	880	3	3	890
Kr-87			3	3	6
Kr-88			10	10	20
Xe-131m	1	45	4	4	54
Xe-133m			10	10	20
Xe-133	120	190	740	740	1800
Xe-135m					
Xe-135			17	17	34
Xe-137					
Xe-138			2	2	4
I-131	0.01		0.06	0.13	0.20
I-133	0.001		0.08	0.06	0.14

c. Solid Radwaste

Solid radwaste is classified as either wet or dry waste. The evaporator concentrates, which are in the form of a slurry, are mixed with vermiculite and cement in fifty-five gallon drums prior to shipment offsite. Dry waste consists of spent air filters, paper, rags, clothing, tools, equipment, and solid laboratory waste. This waste will be collected in containers located in various parts of the building and taken to the drum area where they will be baled and put into fifty-five gallon drums for shipment offsite. All solid waste will be packaged and shipped to a licensed burial ground in accordance with AEC and Department of Transportation regulations. The applicant expects to transport about 1800 drums of solid waste offsite each year.

3. Chemical and Sanitary Wastes

There is a third type of effluent, containing the following sources of chemical and sanitary wastes:

1. Plant service water effluent
2. Make-up demineralizer regeneration effluent
3. Discharge from heating boiler blowdown effluent
4. Sanitary sewage effluent.

These effluent systems constitute the nonradioactive liquid waste systems of the Station. The quantities of chemicals used and discharged are shown in Table III-4.

The plant service water system is the only chlorinated system of this group. In this system, concentrated sodium hypochlorite is added to the plant service water system in three 15-minute doses per day. When added on this schedule, the 8000 lbs/yr of NaOCl shown in Table III-4 would produce 88,000 gpm (for the 2 units) of a solution containing 0.66 ppm of that chemical, or a (molecular) chlorine equivalent of 0.63 ppm. Depending on the concentrations of reducing chemicals that constitute the "chlorine demand" and the ammonia concentration in the supply water, a fraction of the hypochlorite is reduced to the chloride ion or converted to chloramines. This fraction cannot be stated with certainty, due to the variability of the concentrations of the dilute chemicals in question, but perhaps 0.4-0.5 ppm of "free chlorine"* and about 0.1 ppm chlorine equivalent in the form of chloramines will be present in the service water at its point of discharge to the circulating water.

*The concentration of molecular chlorine that would have the same chemical oxidizing capacity as the chlorine actually present in the form of hypochlorous acid (HOCl) and the hypochlorite ion (OCl⁻). The actual chlorine content of HOCl plus OCl⁻ is 1/2 that of an equivalent solution of chlorine because of the higher oxidation state in the acid or ion.

TABLE III-4,* ESTIMATED CHEMICAL USAGE ZION UNITS 1 & 2

Name	lb./yr. used	Releases		Comments
		lbs./yr	PPM Conc.	
Chlorides	None	None	0.006 ¹	See sodium hypochlorite.
Boric acid	1000	None	None	Losses are buried off site.
Sodium Hypo-chlorite	8000	8000	0.032 ²	
Lithium Hydroxide	93	None	None	Removed and retained by demineralizer
Hydrazine	30,000 ³	None	None	Break down to make hydrogen, nitrogen and ammonia and released to the stack.
Morpholine	5,220 ³	None	None	
Sodium Hydroxide	84,000	None	None	See sodium sulphate.
Sulfuric acid	90,000	None	None	See sodium sulphate.
Sodium Sulphate	None	132,000	.023	Products of regenerate neutralization.
Resins - CVCS	15,700	None	None	Resin filters in effluent discharges.
Demineralizer				
Alum	9,840	9,840	.0015	
Detergents	2,000	1,459	.002	
Organic Solids	900	None	None	Kept in liquid radwaste.

TABLE III-4. ESTIMATED CHEMICAL USAGE ZION UNITS 1 AND 2 (Continued)

<u>Name</u>	<u>lb./yr. used</u>	<u>Releases</u>		<u>Comments</u>
		<u>lbs./yr.</u>	<u>PPM Conc.</u>	
Phosphates	500	None	None	Removed and retained by the demineralizer.
Boron	630	630 ⁴	.003 ⁴	Boron and phosphate will be released from the plant during intermittent periods
Phosphates	1,500	1,500 ⁴	.006 ⁴	corresponding to primary-to-secondary steam generator leakage.

* This table was taken from Table D-1.1 of Supplement IV of the applicant's Environmental Report. Modification has been in the chlorides, sodium hypochlorite, sodium sulfate, boron, and phosphate concentrations to show the actual concentrations expected during periods of addition of chemicals, rather than the average for the entire year.

¹ The chloride produced by reduction of some hypochlorite, an unknown additional small amount will be produced before discharge. The concentration is as estimated for periods of addition of sodium hypochlorite.

² The sum of the free and combined chlorine residual. An unknown amount will be transformed to chloride ion before discharge. The concentrations are those calculated for periods of addition of sodium hypochlorite.

³ Largely in primary and secondary systems.

⁴ The applicant's figures were reduced by a factor of 2 to reflect the staff's estimate of the actual releases and concentrations (see Section XII.E).

During the addition of the chlorinated service water the circulating water streams at the point of mixing (1.5 million gpm) will thus contain about 0.023-.029 ppm of free chlorine, plus chloramines with a chlorine equivalent concentration of about 0.006 ppm. There will also be additional chloride ion from the reduced hypochlorite added to the service water (see last paragraph) to the extent of about 0.006 ppm.

The free and combined (chloramines) chlorine will partly be reduced by the chlorine demand of the unchlorinated circulating water-- in fact it might all be reduced to chloride ion-- before discharge to the lake. In any case, the level in the effluent stream will be below the 0.05 mg/l maximum residual chlorine recommended for receiving waters for chlorine additions not exceeding 2 hours per day by the staff of EPA's National Water Quality Laboratory at Duluth Minnesota for the protection of freshwater aquatic life.⁷

The demineralizer system for make-up water to the plant is periodically regenerated with acid and caustic solutions. These regenerative flows are then combined in a neutralizing tank from which they are released into the cooling water discharge systems. An estimated 132,000 lbs per year of dissolved solids (mostly sodium sulfate, with minor amounts of calcium sulfate and magnesium sulfate), having an average concentration of 0.020 ppm when diluted with the cooling water flow, are thus discharged directly into the lake. The discharge will occur over about an 83 hr period every 4 days. This rate of discharge is calculated to increase the average sulfate concentration in Lake Michigan (173 trillion cubic feet)¹ by 1×10^{-5} ppm/yr, a negligible amount.

Hydrazine and morpholine will be added to the secondary water system as corrosion inhibitors, as indicated in Table III-4. The hydrazine will be added at only a very slight excess over that required to react with oxygen in the system. The small amount present in the blowdown from the secondary system should react immediately with oxygen in the circulating water to produce non-toxic products. The morpholine is more stable (its lifetime in natural waters is not known to the staff), and a small quantity will be released at times when the secondary system is blown down to the lake (i.e., when there is no primary-to-secondary leakage). The quantity is not accurately known, but the normal blowdown schedule will be 1/2 hour per day at 75 gpm for each steam generator (~3.5 million lb/hr steam output); i.e., 0.02% of the daily flow will be blown down. The morpholine not released in the blowdown will be collected in the condensate

deminsralizer. On this basis, less than 0.02% of the morpholine added (Table III-4), or less than 1 lb/year will be released to the lake.

Periodic blowdown of the auxiliary heating boiler will be required during startup of the reactors and in winter when neither reactor or only one reactor is running. This discharge will also be routed into the lake via the cooling water discharge. For pH control and corrosion inhibition, trisodium phosphate, morpholine and sodium sulfite are to be added to the boiler water. The total quantities are much smaller than those shown for other uses in Table III-4. With total blowdown averaging one inventory per week, the average concentration of these three chemicals in the cooling water discharge would increase as follows: trisodium phosphate 4×10^{-6} ppm, morpholine 3×10^{-7} ppm, and sodium sulfite 2×10^{-6} ppm. The sodium sulfite will be oxidized quickly (to sulfate) in the lake.

During periods of primary to secondary steam generator leakage, boron will be processed out of the secondary side after being neutralized by treatment with trisodium phosphate. The processing will occur in the steam generator blowdown portion of the liquid radwaste system. As a result, boron and phosphate will be released from the plant during intermittent periods corresponding to such leaks. For design purposes, the leaks were estimated to occur at an average rate of 1 gpm for a total of two weeks per year. As discussed in Section XII.B, the average rate experienced at other plants is about 0.5 gpm, and the quantities of the two chemicals in Table III-4 were calculated on that basis. The applicant has not provided details of housekeeping policy regarding the control of other miscellaneous circulating water discharges (e.g., petrochemicals, cleaning materials, etc.) from floor drains.

4. Other Wastes

The remainder of the plant nonradioactive wastes (i.e., trash, shop and laboratory wastes, water intake debris, etc.) are expected to be processed using normal industrial techniques for solid waste disposal by a commercial scavenger service.

REFERENCES FOR SECTION III

1. Asbury, J. G., Effects of Thermal Discharges on the Mass/Energy Balance of Lake Michigan - AEL/ES-1. Argonne National Laboratory, Center for Environmental Studies, Argonne, Ill., July 1970.
2. Zion/ER, p. 2.3.2-1, May 1971.
3. Zion/ER, Supplement II, Appendix B, Dec. 1971.
4. Zion/ER, Supplement II, Table 5.2, Dec. 1971.
5. Letter: Staff, National Water Quality Laboratory, Duluth, Minnesota, to Mr. Francis T. Mayo, Regional Administrator of EPA Region V. Subject: Water Quality Criteria Recommendation for Residual Chlorine in Receiving Waters for the Protection of Freshwater Aquatic Life, December 20, 1971.
6. Zion/ER, Supplement II, Appendix C, December 1971.

IV. ENVIRONMENTAL IMPACT OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF PLANS AND SCHEDULES

A construction permit for the Station was issued December 26, 1968. Construction has proceeded in accordance with applicable Federal, State, and local regulations. Necessary approvals, certifications, and licenses have been obtained in accordance with those requirements. (A record of these actions is contained in Section I.B.)

It is estimated that Unit 1 should be ready for fuel loading by early 1973, and Unit 2 by late 1973. The applicant has not presented details of the final construction cleanup or landscaping, but it is reasonable to assume that construction activities will be essentially completed by late 1973.

B. IMPACTS ON LAND, WATER, AND HUMAN RESOURCES

Prior to construction, the applicant sought advice and successfully preserved the more valuable indigenous plants on the construction site by transplanting them to areas which were not to be disturbed by construction.

Construction of the Station required the elimination of several previously dedicated streets and roads in the immediate area of the site. These facilities, however, were used primarily to provide access to the private summer cottages and beaches which received little use from the general public.

The applicant constructed a breakwater at the north end of the site which extended 2000 ft out into the lake at an angle of approximately 60° from the shoreline. This breakwater was constructed to provide harbor shelter during construction and is scheduled to be removed upon completion of construction. Severe but relatively localized erosion has occurred to that portion of the beach immediately south of the site at Illinois Beach State Park, while accretion of the beach has occurred north of the breakwater. The applicant has erected a sheet-steel-piling bulkhead along the lakefront and has placed large concrete blocks along the shoreline to retard further erosion.

The applicant concludes that the breakwater may have contributed to the beach erosion and anticipates that the beach and shoreline

will reestablish itself along natural lines after the breakwater is removed. In addition, the applicant states: "However, Commonwealth Edison will provide whatever assistance may be needed for restoration of eroded areas" and is committed to perform such corrective actions.

The construction of the intake and discharge structures involved a large amount of dredging and disturbances of the lake bottom and shoreline. The piping between the intake and discharge structures and the crib house (16 and 14 ft in diameter) is buried below the surface of the lake bottom. Only the intake structure (2600 ft from shore) and the two discharge structures (760 ft from shore) protrude above the lake bottom.

The applicant added large quantities of sand following backfilling and expects the lake bottom to restore itself essentially to the condition which existed prior to installation of the intake and discharge systems.

The applicant attempted to minimize the impact of transmission line construction by utilizing existing right-of-way and existing towers whenever possible, and by installing aesthetically designed steel poles for over 60 of the 89 circuit miles being constructed. On the new right-of-way through a wooded area, specific trees and brush were retained for maximum screening. No swath cutting was permitted.

The transmission lines will cause no major change in land use, and construction of the lines will involve no irretrievable commitment of material resources. The installation of the transmission lines does not appear to make significant changes in the environment. The staff concludes that the transmission lines have been and are being constructed in accordance with "Environmental Criteria for Electric Transmission Systems," U.S. Department of Interior (February 1970).

The period of peak environmental impact due to construction is undoubtedly past. Informal discussions with local officials suggest that the impact of construction of the Station was absorbed by the community without undue inconvenience or problems and that, on balance, the Station is a welcome addition to the community.

IV-3

REFERENCE FOR SECTION IV

1. Zion/ER, pg. 2.3.8-5. May 1971.

V. ENVIRONMENTAL IMPACT OF PLANT OPERATION

A. LAND USE

The environmental impact of operation of the Station on land use will result in large measure from the contrast with the use of the land adjacent to and in the general vicinity of the plant site. As described in Section II.C, the land occupied by the site was previously sparsely occupied by privately owned cottages and was used mainly for recreational purposes. The surrounding areas have a similar character. If the plans for extending the state park north of the site materialize, the Station will be essentially an "island" in the park. In this regard, primary impact of the Station probably will result from its presence rather than its operation; the removal of the 250-acre power station site from the proposed future recreational use at this location will not in itself produce a significant impact on use of the surrounding land.

Reference was made by the applicant's consultant to other sites considered during the site selection process.⁵² No information has been submitted to the staff, however, which discusses these alternate sites or the relative advantages and disadvantages of the sites considered. It appears that discussions and consultations between the applicant and the Northeastern Illinois Planning Commission, the major multi-county planning agency in the area, were held only after the site had been selected by the applicant and construction had begun (Appendix H), although ownership of the major portion of the site (1955) predated the selection (1967)⁵² by approximately 12 years.

It is the conclusion of the staff that site selection was made primarily to realize the economies of once-through cooling. The site also is close to where the power is needed (northeast section of applicant's system). In addition, the site is close to the applicant's fossil-fueled station at Waukegan, and transmission line costs were decreased by utilizing existing rights-of-way.

The construction of the plant did not require any significant changes in grade. After construction and landscaping have been completed,

the natural drainage and functional activity of the land should be very much as it was before (except, of course, for the land actually occupied by structures). The operation of the Station should not significantly change these aspects of the land use. Since access to the site by the general public will be prohibited, the operation of the Station will essentially remove that area of land from direct public use. This land was privately owned previously, and it can be assumed that use by the general public was relatively restricted (but less so than is now the case with a single owner and perimeter fencing). Construction of the proposed Lake Shore Expressway between the site and the industrial and residential areas to the west would have an additional isolating effect.

The operation of the plant should have a minimal effect on the meteorology of the area. The discharge of waste heat to the lake provides an effective temporary holding and transfer mechanism for moving this heat to the atmosphere with minimum impact on the meteorology.

The Station is located in a region which supports extensive industrial activity from Milwaukee, Wisconsin to Gary, Indiana.

The transportation requirements to support operation of this Station will be relatively insignificant for this industrial region of the country.

No visitor center has been established at the site, but the applicant has announced plans to provide such a facility when construction is completed.⁵³

No historical or archeological sites, or fossil deposits of any significant value have been found in the area, nor is there any indication that such exist either on or around the site.

B. WATER USE

1. Source

The primary source of water for the Station is Lake Michigan. The principle use of the water is for condenser cooling. Approximately 1,530,000 gpm will be drawn from the lake, circulated through the plant and returned (minus minor consumption and subsequent evaporative loss) to the lake at a temperature approximately 20°F higher than the ambient receiving temperature.

Domestic water will be supplied from the municipal water systems of the City of Zion. This use (to serve the needs of about 150 people) will be insignificant in an overall assessment of water use in the Station.

2. Condenser Water Circulation and Thermal Discharge

The major impact on the aquatic environment involves the relatively large volume of cooling water passing through the plant, and the thermal loading of this water. With both units operating at full power, approximately 15 billion Btu per hour will be discharged to the lake from diffusers located 760 feet offshore. The temperature increase in the cooling water as it passes through the condenser with both units at full power will result in a maximum ΔT of 20°F above ambient lake temperature. The flow rate will be about 1,530,000 gpm (3400 cfs). Estimated dimensions of surface plume excess isotherms are given in Section III.D. By way of comparison, the flow through the cooling system at full power essentially equals that of the diversion of Lake Michigan water by metropolitan Chicago (3200 cfs) or the average input of the Grand River into Lake Michigan. The heat input of the Station is equaled or surpassed by the Grand River during the summer months. Natural changes in temperature of more than 20°F within a day have been recorded in summer in nearshore waters of the lake, due to changes between a well stratified lake and one with upwelling of deep, colder waters or vice versa.

3. Chemical Discharges (see Section III.D.3)

The Station will employ mechanical cleaning of condensers. Consequently, the condenser water is not chlorinated for control of algae. Sanitary wastes are discharged to the North Shore Sanitary District, and there is therefore no direct impact on the lake or general environment.

The plant service water is treated with sodium hypochlorite and contains a residual chlorine concentration of about 1/2 ppm when discharged into the cooling water. Concentration after dilution in the cooling water at a flow rate of 1.5 million gpm is less than 0.032 ppm during the three 15-minute treatment periods per day.

Boiler water treatment chemicals (phosphates, morpholine, and hydrazine) will be discharged as a result of blowdown of the auxiliary boiler (used only when steam is not available from the main turbine). As with the other liquid wastes, this waste will be discharged into (and diluted by) the condenser cooling water. The concentrations are low (see Section III.D.3).

At times of primary to secondary leakage, estimated at not more than two weeks per year, boron and phosphates will be added to the condensate coolant discharge.

The Station will also produce other wastes such as water intake debris, auxiliary boiler combustion products, industrial trash, and paper. Neither these, nor other miscellaneous chemical wastes (e.g., petrochemicals, cleaning materials) from floor drains are described in the applicant's documentation.

C. BIOLOGICAL IMPACT

1. Terrestrial Ecosystems

As described in Section III.D, the operation of the Zion Station will produce controlled releases of heat, chemical wastes, and radioactive wastes. Of these, the release of radwaste has the greatest potential for producing a biological impact upon the terrestrial ecosystem. The environments in which these releases would operate are principally beach, dune, marsh and prairie. They have been described in Section II. F.

a. Radiation Dose to Species Other Than Man

The radwaste of primary importance to the terrestrial ecosystem consists of radioactive isotopes in gaseous emissions which are selectively incorporated into living tissues of animals via food and drinking water. However, the gaseous and liquid radwaste control systems at Zion Station are designed to contain temporarily these effluents within the plant and thus to permit radioactive decay before release.

As described in Section III, D.2 and V.C.3, the release of any radwaste is to be monitored and controlled at or below existing permissible levels. The estimated radiation doses to the biological population other than man are only a small fraction of the natural gamma radiation background level in the vicinity of the Zion Station (<1.0%). Under normal operation, the radioactivity discharged to the air is far less than the permissible levels.² Consequently, the radioactive gaseous effluents should not be expected to affect the terrestrial plants and animals in the Zion area.³ The radiation exposures predicted at the site boundary would be too low to affect the growth and seed production of even the most sensitive plant species, such as the conifers - particularly the white pine - even

under conditions of environmental stress such as desiccation.^{4,5} The staff does not, similarly, envision any changes in the diversity of the plant species in the duneslands near the Station, for little change has been noted in experimental situations with doses less than 50 to 100 rads per day.⁶ The projected doses are also much lower than those known to stimulate increases in insect populations such as bark lice which feed on dead organic matter,⁶ and the invertebrates and vertebrates likely to be within the domain of the Station are generally insensitive to levels of irradiation below several hundred rads.⁶ Consequently, the staff does not expect to be able to discern Station effects on the biota at levels of radiation predicted from the operation of the Station.

2. Aquatic Ecosystem

The major aquatic environments consist of Lake Michigan and small drainage streams which empty irregularly into the lake (see Section II.F). The major environmental impacts on the aquatic ecosystem are produced by mechanical and thermal effects resulting from the flow and heating of condenser cooling water as it passes through the Station and is discharged into the lake. Some impact is also possible from the discharge of chemicals and radwaste from plant operations into the cooling water.

a. Intake and Forebay Effects

The design of the intake structure and system, and the seasonal modes of operating the system, are described in Section III.D.1.

All aquatic life present in the lake water drawn into the intake (1,530,000 gpm maximum flow) will be drawn with the flow through submerged pipes at high velocity into the Station forebay. Larger organisms, principally adult and juvenile fishes, subsequently will become entrapped in the forebay and/or killed by impingement on the bar racks or travelling screens.

Organisms small enough to pass through the 3/8" travelling screen meshes will pass through the main condensers or the service water system and thus will be subjected to thermal stress, mechanical damage, pressure changes, and intermittent exposure to various chemicals. Effects of condenser passage are discussed in Section V.C.2.b.

From approximately mid-March to mid-November each year (according to the applicant), depending on weather and accessibility for maintenance, the applicant proposes to surround the Station intake with 1" x 1"

diagonal mesh nets (Appendix H), with strands coated to prevent gill-netting. At the location of the nets, the flow velocity toward the intake will be approximately 0.3 ft/sec (disregarding ambient currents). The staff expects that these nets will preclude the possibility of intake entrainment of adults of the larger fish species (e.g., alewives, yellow perch, salmonids) which exhibit relative local abundances during non-winter months, except when the nets are damaged or removed for maintenance. The mesh size of the proposed nets, however, is not small enough to prevent entry of certain adults (e.g., smelt, shiners), most juveniles or any fry, and their subsequent potential entrainment by the high (2.47 ft/sec maximum, "non-winter" mode) velocity of the Station intake flow. For juvenile and (small) adult fishes which find underwater structures attractive (e.g., as "cover"), it is noted that the nets and the intake represent the only significant, accessible "cover" described in the vicinity.

On the basis of life history information known for Lake Michigan fishes⁵⁷ the staff expects that the 2600-ft offshore location of the Station intake will significantly reduce the non-winter entrainment of fry and juveniles of most species, in comparison with that which would occur if the intake were located nearer shore. However, the applicant thus far has submitted only preliminary field data on fishes in Zion waters.⁵⁹ These data include one year's worth of monthly, single (12-15 ft) depth, single mesh-size, three-hour, gill net sets, plus summer shore seining, stomach analyses, etc. No winter sampling data and, no diurnal comparison studies have yet been formally submitted by the applicant. Consequently, the staff does not have sufficient information to reasonably attempt quantitative estimates of fish entrainment at the intake. The applicant's preliminary data is consonant with expectations that alewives, bloater, yellow perch, smelt, and other forage species exhibit relative abundance in Zion Station inshore waters at various (April to October, varying with species) times of the year, as well as that several species of salmon and trout are found in the area.

Although strong wave action, frequently high turbidity, and substrate characteristics would seem to support contentions that near-shore waters at Zion do not favor successful spawning by most species of fishes, the applicant's consultant⁵⁹ has reported that stomach analyses of bloater, perch, and smelt taken in Zion waters show fish eggs (probably mostly of alewife and smelt) to be a primary food source. Fish eggs also were found in stomach analyses of alewives taken locally.

During winter operation (approximately mid-November to mid-March), the proposed nets surrounding the intake will be removed. Also during this time, intermittent return of warm water to the intake, when necessary for heating purposes, will increase the maximum intake flow velocity to

approximately 3.7 ft/sec. In addition, although most of the returned warm water will enter the intake, the staff expects that a certain amount may be lost and produce some local warming. The staff is not able with reasonable confidence to obtain estimates of the area of such warming, or of the area of density underflow ("sinking plume") from the Station's main thermal discharges, but it is obvious that fish in the vicinity would be attracted to such warmer water, since local ambient water temperatures will be below the thermal preferences of most species.^{8,10}

Although most fish species which exhibit inshore abundances return to the deeper waters of the lake by November, spending the winter in the warmest (densest) ambient water, the staff is of the opinion that attraction and entrainment of appreciable numbers of fish may occur during winter operation. In the absence of data on winter fish sampling by the applicant's consultant, it is not possible to quantify this.

Regarding intake entrainment of fish during both winter and non-winter operation, the staff is of the opinion that only impingement data obtained during actual station operation would provide adequate bases for quantitative assessment. There is a paucity of such data for flow velocities as high as that of the Zion Station. On the basis of fish-entrainment versus intake flow velocity data obtained during actual operation of the Indian Point 1 plant, velocities in excess of 0.5-1.0 ft/sec. (the range of maximum swimming speeds of many young fish⁷) are judged undesirable. In the case of the Zion Station, results of laboratory measurements of fish swimming speeds previously have been employed in estimating intake entrainment problems, and the applicant's consultant has been actively engaged in making such measurements. Although these data are of some use, the staff questions any statements which attempt to apply the results of such laboratory determinations of fish swimming speeds to field situations and assessment of intake entrainment. In the first place, standard laboratory apparatus and procedures commonly used to make such determinations were specifically designed originally for physiological studies of active fish metabolism, not field behavior. In the second place, factors such as temperature and the lengths of time of swimming speed tests, the age, condition, and recent environmental history of the fish tested, and other factors, all have great influence on the results and meaning of such measurements. Failure to note carefully the rigorously defined conditions under which such measurements were made in each case introduces ambiguities which can make interspecific comparisons and field behavior applications invalid.

In addition, it should be obvious that the speed at which a fish can swim bears limited necessary resemblance to the speed at which (or direction

in which) it will swim under varieties of combined field conditions (e.g., near the intake).

The well-known "rheotactic" behavior of many fishes (in which a fish maintains or controls its position in a current, compensating by swimming upstream) is known to depend primarily on the fish's visual cues and occasional mechanical contacts with fixed objects, (e.g., the bottom),^{55,56} rather than on lateral line receptors.

During the night and the frequent times of high turbidity in Zion waters, when visual cues are effectively absent or reduced, the staff anticipates the possibility of increased relative rates of fish entrainment at the intake. This will be influenced importantly of course, by diurnal and seasonal variations in local fish densities due to inshore migrations, the condition and effectiveness of the intake exclusion nets, and other factors.

The staff does not imply the possibility that fish impingement at the Station will produce significant adverse effects on lake-wide fish populations. The concern expressed by the staff, however, is that the possibilities of exceeding fish-entrainment expectations at the Station at certain times largely are open-ended, and entrainment selectivity might not be adequately manageable without design changes.

The applicant has not divulged any plans for alternatives to the present intake design should excessive numbers of fish be impinged on the bar racks and traveling screens. The staff will require the applicant to perform intensive traveling-screen and forebay monitoring for entrained fish (adults, juveniles, fry, larvae, and eggs), especially during the first year of Station operation. Further, the applicant will be required to develop and submit for review contingent intake modifications designed to reduce fish entrainment; and be prepared to make such modifications, within a reasonably-specified time period, if postoperational monitoring indicates such is warranted. Forebay diversion modifications are not recommended by the staff, since forebay-entrapped fish mechanically returned to the lake expectedly would be severely stressed, injured, and/or subject to disease or predation, and therefore probably moribund.

b. Condenser-Passage Effects

Organisms small enough to pass through the 3/8" travelling screen meshes subsequently will pass through the Station condensers and service water system. These organisms include phytoplankton, zooplankton (adults, larvae, and eggs), fish eggs, larvae, and certain fry, as well as benthic animals such as Pontoporeia and Mysis, which exhibit vertical migrations.

These organisms will be subjected to (1) thermal shock, (2) mechanical shock and pressure changes, and (3) intermittent exposures to several chemicals. Although the applicant estimates that condenser passage will be brief (a few minutes, out to the 5°F excess isotherm in the plume), it is expected that a significant fraction of such organisms will be killed. The quantity and character of such kill will be highly variable, due to seasonal differences in planktonic species (and life cycle stage) composition and abundance, as well as to seasonal variations in ambient (acclimation) temperatures. The condenser - pass kill also will be difficult to measure and assess, even during actual Station operation, due to "patchiness" of the plankton.

The condenser - pass kill will be skewed. The mechanical-damage component of the kill will be selectively lethal to more of the larger zooplankters, such as Daphnia and Diaptomus, as well as the normally-benthic crustaceans, and the thermal shock component will, of course, select against the more stenothermal (temperature-sensitive) forms. Percent mortality to fish eggs and larvae may be high at certain times although available (limited) evidence does not suggest that an important number of fish eggs and larvae will be present in the entrained plankton.

There is a paucity of applicable data concerning the effect of condenser passage on plankton, and the existing data pertain only to operation of plants which employ discharge canals in which the total exposure period or organisms to heated water is longer than will occur at Zion Station. Furthermore, the relevant data are limited to only a few months of the year.

A review of laboratory and field studies which describe the abilities of juvenile or mature aquatic invertebrates (planktonic and benthic organisms) and vertebrates to adapt to temperature stresses, shows that a sudden rise of 20°F exceeds their tolerances and high mortality ensues¹² depending on period of exposure. Limited experience at electric generating stations on the lake at Waukegan,¹³ Michigan City,¹³ Port Sheldon,¹⁴ Muskegon,¹⁴ and Bailly¹⁵ suggests that during brief condenser passage, such effects are less severe. A 14-20°F increment would be expected to kill 15-30% of the plankton in late summer, when lake water temperatures are already high, although most studies on which such an estimate is based do not allow for recovery of immobilized zooplankters. Operation of the Station during nonsummer seasons could be expected to have less deleterious effects, in terms of total quantity killed, and this could be the reason that the applicant's consultant projects a average plankton kill of about 8% per annum (Appendix N). Zooplankton survival was 88-93% at discharge temperatures of 91.4°F at Turkey Point,¹⁶ and opossum shrimp (Neomysis) mortality was

not significant at the Pacific Gas Electric Company (Pittsburgh) when the discharged water temperature was greater than 85°F.¹⁷ Patrick¹⁸ suggests that algae are little damaged if the temperature does not exceed 93°F, and that the diatoms are more sensitive than the greens and blue-greens which have temperature, growth, and photosynthetic optima of 90 to 95°F. Thermal damage to lake algae as a consequence of condenser passage should primarily involve the diatoms during the later summer months, when ambient lake temperatures can be as high as 78°F (average minimum in the area is about 63°F - see Appendix D).

On the other hand, the brief daily periods when chlorine is being discharged may produce almost total planktonic mortality.¹⁹ Shorter term chlorine exposures (~5 min) have killed 75-90% of entrained estuarine zooplankton.²⁰ The temperatures to which these organisms have been acclimated in the lake before condenser passage transit, as well as the time for transit, must be considered in any projection of the "kill", and this is especially true for fish. There is little operating experience of value for this problem at Zion. Thus, fry of Chinook salmon passed through a condenser at a 16°F differential, and fry of striped bass exposed to temperature increases of 25°F for 10 minutes at the Contra Costa Power Plant on the San Joaquin River (California) showed a 95-100% survival, but the base water temperatures were not reported.²¹ Field studies at the Connecticut Yankee Nuclear Power Station (CYNPS)²² showed that with the condenser cooling water heated to 12.5° above ambient river temperatures and with a 93 second passage through the plant, the survival rate of perch and alewife larvae was 34.5%. This experience cannot be extended reliably to the Zion Station since the cooling water transit time at Zion Station is somewhat longer and the temperature rise will be higher (20°F). The CYNPS experiment, however, also demonstrated that a significant fraction of the mortality was produced by mechanical damage in the condenser tubes, pumps, and piping.

Even if condenser-passage were to be lethal to most planktonic organisms, there are other factors to consider. First, because only a small fraction of the lake water and its plankton passes through the Station, the numbers of the organisms which will be affected will have little impact on lake populations. Many of the species have a short generation time (a few hours to a few weeks). Second, it is doubtful that inshore waters at Zion are important spawning waters for any fish species other than, perhaps, alewives and smelt. Moreover, the important species of fish have demersal (bottom or attached) eggs, which can become planktonic (and entrainable) only transiently.

Condenser-passage effects at the Zion Station are not expected to have an important impact on Lake Michigan populations, although a detailed monitoring plan is in order. The program is summarized in Table V-3 (and Appendix W) and its adequacy is discussed in Section V.C.3.

c. Discharge Effects

The discharge of heated water into the lake is certain to have effects on the viability, reproduction, food-web relationships, and growth of aquatic animals, as well as the photosynthetic capability of algae.^{8,9,12,17,23,25} The heated water is discharged at an initial velocity of 9.5 feet/second into a mixing zone which extends offshore from the diffusers. The diffusers are located 760 feet offshore, and their discharges are directed at 45° angles from the shoreline. The extent of the mixing zone will vary somewhat with wind and current velocities, especially at the lower excess isotherms, but the kinetic plume model submitted by the applicant^{1,25} predicts that temperatures in excess of 5°F above ambient lake temperature would exist at 1070 feet from the discharge point along the center line of the plume. This model assumes that the initial temperature of the discharged water is 20°F above that of the ambient receiving water.

Within the mixing zone, and especially close to the diffuser ports, organisms swept into the plume, as well as those which have survived condenser passage, will be subjected to thermal stress and turbulence. Regarding direct lethality, it is expected that whether acclimated to low or high ambient water temperatures, almost all plankton and fish will be able to survive brief exposures of this type, since residence times in the higher excess isotherms will be short (measured in minutes),¹ due to rapid dilution with lake water.

Lethal temperature limits of fish depend on duration of exposure, previous thermal history, physiological state, and other factors; temperature optima for each species of fish vary seasonally and depend on the criteria considered (e.g., specific growth rate, food conversion efficiency, reproductive success, etc.).^{8,9,12,25}

Local damage probably will occur to alewives which spawn in June and July, when waters in the vicinity can reach 79°F.²³ Optimum survival of alewife eggs has been reported as 30% at 63°F, and many alewives migrating inshore already are stressed.

It is not expected that the heated discharge will have an important effect on commercial or sport fish populations in the lake. Adult whitefish are deep-water fish which migrate from deeper to shallower

waters for spawning in the fall, but this species has been distributed primarily in the more northern parts of the lake. Cisco and lake trout inhabit deeper waters most of the year (see Table II-5) and require 45-50°F waters for spawning. Such are abundantly available away from the Zica site. Several other salmonid populations are maintained in the lake primarily by hatchery propagation and planting (essentially, a "put and take" basis).

The thermal plume may produce some local adverse effect on smelt (common near the Station), when they move inshore for spring spawning. Active sport fishing during smelt runs occurs in April and May.¹⁰ Juvenile perch, and possibly some whitefish and cisco, will school in appreciable numbers in inshore waters off Zica. These would be subject to discharge effects. This hazard is reduced by the offshore placement of the diffusers, but juveniles swept into the plume would be stressed.

Under most conditions, the heated plume will not affect the benthos (outside of the immediate vicinity of the diffuser), except for periods during the winter months, when a sinking plume may occur. This will occur when the cooling water taken near the bottom (about 32°F) will be discharged at about 32°F into the mixing zone, where it will tend to float until its temperature is lowered to the point (39°F) where water is densest and tends to sink. The sinking plume effect should occur at some as yet unknown distance from the discharge structure. Ice making should not be so extensive as to expose the beaches to severe erosive wave action.

It is more difficult to evaluate, without actual operating experience (i.e., there are no other high velocity discharges in operation on Lake Michigan), the concern that fish attracted to warmer waters around the discharge structures during fall, winter, and spring months will show less feeding vigor and ability to escape predation, as well as greater susceptibility to parasitic (e.g., fungal) diseases. Warm water outfalls at power plants do attract many fish during the winter, and Nail¹² has reported intensive feeding by bluegills, bass, and salmonids on zooplankton in discharge canals.

The high (9.5 ft/sec) initial discharge velocity from the diffuser expectedly will prevent important numbers of fish from spending much time (i.e., fully acclimating to) the warmest and most turbulent parts of the plume. At the 5° and 10°F excess isotherms, for example, the applicant has estimated that discharge velocities will be approximately 2.4 and 4.8 ft/sec, respectively (see Section XII.9.4). These velocities have been compared (Appendix N), for example, with the 1-ft/sec laboratory measured maximum sustained swimming speeds of 50°F acclimated adult yellow perch and juvenile lake trout.

The staff is not of the opinion that all fish will be totally excluded from higher excess loathers in which predicted flow velocities exceed maximum sustained swimming speeds. Criticism of statements which attempt to apply laboratory swimming speed measurements to field behavior were listed in Section V.C.2.a. Most of these apply to discharges, as well as to intake, considerations. In addition, juvenile and adult salmonids have been observed by Argonne National Laboratory research personnel on several occasions to swim "upstream" through a discharge pipe (approximately 14 ft in diameter) which feeds the discharge canal of the Point Beach Nuclear Station. Flow velocity in this pipe was estimated at approximately 6 ft/sec. The fish reportedly appeared unable, however, to maintain station in a second pipe (approximately 12 ft diameter), "upstream" of the first, in which flow velocity was estimated to be approximately 8 ft/sec.

On these bases, it therefore appears likely that some fish will be able to enter and spend minimum amounts of time during cooler months in "attractive" pipe areas above the 10°F excess loathers. This should be placed in perspective, however, by recognizing that the applicant's predicted pipe area within this loather is less than 3 acres (see Section III.D.1a). Consequently, the number of fish so affected (regarding physiology, reproduction, cytology, gas-bubble disease, and cold-shock kills) will not be significant in terms of lake populations (see Section III.E. for additional considerations).

Fish attracted to the diffuser area may be exposed to water that is superheated with gases which might cause the development of gas-bubble disease. This does not appear to be an important problem, however, at the Zion Station (see Section III.D.4). There is greater danger, that the fish subjected to the winter water temperatures around and in the pipe could suffer a cold temperature shock if the heated discharges were interrupted suddenly during winter months for fuel loading or emergency procedures, especially if such occurred during cold water spellings. This effect would be quite noticeable during the colder months, but would be minimized if sections of the reactor were to be shut gradually with controlled steam flow to the condensers so that the fish could have time to find comparable temperatures in the adjacent ponds. Effects to know about the rapidly flow which fish are likely to occur if their tolerances were exceeded. The staff considers that the applicant's shutdown (and start-up) schedule, which calls for a temperature change no greater than 10°F/hour, will help to protect juvenile or adult fish inhabiting waters within 1000 ft of the discharges.

Operating experience at electrical power generating stations with discharges shows that the theoretical oxygen deficit predicted for heated waters is not realized. The submerged discharges at Zion would mitigate the chance of oxygen deficit, due also to entrainment of well-oxygenated lake waters in the discharge flow.

Kinetic plume modeling studies under the influence of simulated lake currents and meteorological conditions indicate that the Zion plume is not expected to interact with the heated water discharge from the Hankegen fossil fuel power generating station.²⁵

Because of the short plume residence time of the phytoplankton entrained with the discharged water, as well as the dilution effect, no major changes in phytoplankton abundance or species composition are expected as a result of Station operation. During the late summer, combined effects of condenser passage and plume residence probably will reduce diatom proportions and permit less desirable species to increase somewhat in local surface waters, especially when ambient currents act to increase plume residence times. Such an effect, however, is expected to be local and reversible. In fact, it also may be difficult even to measure, due to "patchiness" in the plankton and entrainment of other plankton with the discharge flow. It should be noted in addition that in Zion inshore waters, maximum phytoplankton densities are not at the surface (where the plume will be), but rather 5-15 feet below the surface.³⁰ Patrick¹⁸ found that when the temperature of laboratory cultures of phytoplankton was gradually raised from 68°F to 103°F diatoms disappeared and green and blue-green algae became dominant. When the temperature was lowered, diatoms reappeared, indicating that a large enough number survived to re-establish the population when the temperature became favorable. Although diatoms subjected to condenser passage and discharge entrainment at the Station will experience temperature increase more rapid than those administered by Patrick, it is expected that compensatory diatom reproduction will occur at Zion as the organisms drift out toward the lower isotherms. The times normally required for this are probably too short to stimulate much green and blue-green reproduction. On the other hand, no direct field data exists to support or contradict these expectations about high velocity discharge effects on phytoplankton (i.e., there are no high velocity discharges on the lake), so careful postoperational monitoring and reassessment will be required. Such also holds true for several questions about sublethal (e.g., epidemiological, physiological) effects on fish, benthos, and plankton.

Some estuarine zooplankters that survive condenser passage have shown a growth lag which reflects the reduction of their phytoplankton food supplies.³¹ The rapid mixing of phytoplankton-rich lake waters with the entrained zooplankters, however, should minimize this effect. The benthic fauna in the area of the Station discharge is not rich, due presumably to wave scouring of sediments, but the species are widely

distributed in the lake. The area does contain certain oligochaetes (e.g., *Limnodrilus hoffmeisteri*) which are potential indicators of environmental quality,^{33,34} and efforts should be made to use this group, as well as others, as environmental indicators. Certain benthic organisms can tolerate a wide range of temperatures,³¹ and the staff does not expect that there will be any widespread change in the benthic fauna from the scouring action of the discharge when the Station goes on-line. The warm water plume will float above the colder lake water and not subject many benthic organisms to warm water, except possibly in winter. During the winter months when the plume tends to sink, the plume temperatures will differ from the bottom temperatures by a few degrees. Biological effects of such density underflow can not be assessed until some measurement or prediction of the extent of this phenomenon becomes available.

Because of the high velocity discharge, there should be some increased turbidity in Zion waters due to bottom scouring and entrainment of sediments in the plume. Predominantly silty bottom sediments are found at 50-100' depths offshore of the discharge structure,³⁵ but silt also is contained in littoral drift. Although the sands brought into the area by littoral drift will be stirred up, they should settle out very rapidly without disrupting bathing activity in the State Park to the south. On the other hand, an unknown amount of smaller sediment particles will also be entrained in and transported by the discharge. The frequently high natural turbidity in Zion waters tends to reduce the apparent importance of this, but the discharge will impose a directed concentration of transported sediment. The staff is of the opinion that the monitoring program should include efforts to assess the transport rates, particle size distribution, distances, and biotic effects (due to increased turbidity and bottom deposition) of such sediment transport.

Liquid Effluents As described in Section III.2.2, liquid effluents are collected and contained within the Station to permit decay prior to controlled release into the condenser cooling water, which is discharged into Lake Michigan. The combined effects of radon decay, storage for decay, and dilution with the condenser cooling water results in negligible release of radon to the lake. Tritium is expected to be the primary isotope to be released (it cannot be separated from water).

The lake near the Station, but they will be diluted during and after discharge, and the residual will be further reduced by the chlorine demand of the lake water. The chlorine will be reduced less quickly and may persist for days. Several considerations suggest that the

Bioaccumulation factors for fish and aquatic invertebrates and plant species have been compiled in Table V-1. The average total (beta and gamma) dose rates to these organisms at the discharge point is calculated to be as follows:

<u>Organism</u>	<u>At the Discharge</u> <u>(rad/yr)</u>
Fish	6.78
Invertebrates	5.964
Plants	2.089

Doses at other points in the lake will be lower than these because of dilution of the effluents by the lake water. There is little evidence at present to suggest that these doses from tritium and the other isotopes to be released into the lake (and deposited in lake sediments) will be injurious to either developing fish eggs or to the planktonic and benthic communities.^{36, 37} Chronic exposure data are scanty, but experience gained with chlorac salmon in Columbia River studies suggests that a dose of 0.5 RAD/day from fertilization until feeding commenced (total of 33-40 RADs) did not result in a decline of returning adults or diminished egg production.³⁸ Higher dose rates did not affect the survival of hatchlings or the number of asexual larvae (genetic effects). No problem should derive from internal emitters (radiostrontium and radocesium) concentrated by fish living and feeding in the cooling water. The total quantities excepting tritium will be of the order of 10 Ci/year.

e. Chemical Impact

As described in Section III.D.3, the chemical wastes of probable biological concern include chlorine, sulfate, phosphate, morpholine, and hydrazine. As a result of the Smith's use of mechanical consumer cleaning (MURRAY), the only chlorine in the effluent originates from plant service water chlorination treatment and is intermittently discharged with the condenser cooling water at a concentration of less than 0.033 ppm. These discharges are scheduled to occur three times a day for a period of 15 minutes each.

The limitations of the fraction plate model make it difficult to estimate the absorption and subsequent residence time and their concentrations in the lake near the fraction, but they will be diluted during and after discharge, and the residual will be further reduced by the chlorine demand of the lake water. The chloramines will be reduced less quickly and may persist for days. Several considerations suggest that the

TABLE V-1

BIOACCUMULATION FACTORS¹ FOR RADIOISOTOPES IN FRESH WATER SPECIES

Radioisotope	Fish	Invertebrates	Plants
Cr-51	200	2000	4000
Mn-54	25	40000	10000
Fe-55	300	3200	5000
Co-53	500	1500	1000
Co-60	500	1500	1000
Sr-89	40	700	500
Sr-90	40	700	500
Rb-95	30000	100	1000
Hg-99	100	100	100
Tc-99m	1	25	100
Ru-103	100	2000	2000
Ru-106	100	2000	2000
I-129	1	25	100
I-131	1	25	100
I-133	1	25	100
I-135	1	25	100
Ta-132	400 ²	150 ²	100 ²
Cs-134	1000	1000	200
Cs-136	1000	1000	200
Cs-137	1000	1000	200
Ba-140	10	200	500
Co-141	100	1000	10000
Co-144	100	1000	10000
Heavy elements	100	100	100
All other	100	100	100
H-3	1	1	1

¹Chapman, W. H., Fisher, H. L., and H. N. Pratt, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms" ERM-30364.

²ORNL - Private Communication

quantities of chlorine released by the Zion Station into the lake will not hazard the biota. The Environmental Protection Agency³⁹ states that intermittent discharge levels of 0.1 ppm, not to exceed 30 minutes per day, "should not result in significant kills of aquatic organisms or adversely affect the aquatic ecology." That agency states, further, that continuous discharges of 0.01 ppm residual chlorine "would probably not protect trout reproduction, some food organisms, and could be partially lethal to sensitive life stages of sensitive fish species" - a condition which will obviously not be present at Zion Station where the releases will be further diluted after discharge, and total only 45 minutes per day. In addition, photochemical reactions will convert some residual chlorine to non-toxic substances during the daylight hours.

In view of the preceding considerations, results of continuous flow laboratory studies on chlorine toxicity, involving continuous exposures of organisms for various lengths of time, make it unlikely that there will be a major adverse biological effect at the Station due to residual chlorine concentrations in the lake. The 7-day TL-50 (toxic level for 50% of the population) residual chlorine concentration (mostly monochloramines) was 0.08 ppm for rainbow trout.⁴⁰ In field studies where fish were restrained in live boxes at the outfall in receiving streams at Michigan wastewater treatment plants for 4 days, the TL-50 residual chlorine concentration for rainbow trout was variously reported to be 0.1 to 0.023 ppm.^{41,42} Adult fathead minnows were killed at total chloramine concentrations of 0.005 and 0.134 ppm, but the lowest concentration unaffected the numbers of offspring produced was 0.016 ppm.⁴³ A safe level of chloramines in streams for rainbow trout is reportedly about 0.04 ppm (to ensure a median period of survival of 1 year).⁴⁷

At Zion Station, it is possible that fish at the discharge and intake (during winter only) might show avoidance to the intermittent chlorine discharges. Sprague and Brury⁴² found that trout could detect and avoid residual chlorine concentrations estimated to be 0.001 ppm. The staff does not know if all species have this sensitivity, but the avoidance reaction might be a potentially significant consideration in the estimate of damage, since there may be winter chloramine spikes at the discharge due to the recirculation of the chlorinated hot water to the intake structure for deicing. Although the staff doubts that this will result in a large danger of fish kill in Zion waters, it recognizes that during the winter months, if fish are attracted and acclimated to the warm waters at the points of discharge, they could thus be forced into colder waters in which they might not acclimate safely. This problem is not considered major, however.

The staff is of the opinion that the Station's use of mechanical condenser cleaning is commendable. It is recommended that the applicant attempt to perform service system chlorination at the same time mechanical cleaning of the main condensers is occurring. Thus, the freed condenser slime would expectedly interact with residual chlorine to further reduce the level at discharge.

Phosphate and morpholine are added to the steam generator water as corrosion inhibitors. Hydrazine is added as a reducing agent to remove oxygen. These substances will be in low concentrations in the steam generator blowdown and will be diluted 40,000 times by the circulating water (Section III.B.3). Hydrazine will be oxidized by the time the water is discharged into the lake. The staff has not been able to determine the effluent concentration, fate, or (consequently) biotic effects, if any, of the morpholine discharges. (See Section III.B.3). It is expected that there will be no important biological impact due to discharges of these substances (also see Section III.E.). The discharges of sodium sulfate, which occur when the demineralizer system is periodically regenerated for plant makeup water, will be discharged with the condenser cooling water at a 0.023 ppm sulfate increase (ambient concentrations average 20 ppm). Present state water quality regulations limit the daily discharge to 24 ppm.⁵

3. Biological Monitoring Program

The early physical and biological preoperational studies conducted by the applicant's consultants are summarized in Table V-2. More recent, supplementary information about such studies has been presented by the applicant in Appendix B. The applicant's proposed postoperational monitoring program, in part representing a modified continuation of preoperational studies, is summarized in Table V-3.

Lack of operating experience with, and biological monitoring of, large power stations similar to Egan Station (e.g. with high velocity discharges) on Lake Michigan imposes requirements for careful pre- and post-operational study. The preoperational studies at the Egan Station have represented attempts to obtain baseline field and collateral laboratory data for later assessment of impacts of Station operation on Lake Michigan biota. There remain a number of biological questions, identified throughout this Statement, about which the staff has felt that quantitative estimates of impact will not yet be possible on the basis of data generated. It should be understood that these questions are all related to severity of local impact and do not imply possibilities of important adverse effects from this Station on lake-wide populations, but the staff will require that reports of all preoperational studies not yet submitted by the

EX-107 0-3

RECEIVED
FEBRUARY 1968
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

TABLE V-2

OPERATIONAL ENVIRONMENTAL SURVEYS CONDUCTED AT THE ZION NUCLEAR POWER STATION^(E)

PHYSICAL

CHEMICAL AND PHYSICAL

Water Currents

Water Temperatures

Water Quality

Turbidity

Weather

Bathymetry

BIOLOGICAL

Phytoplankton

Zooplankton

Benthos

Year

J

F

M

A

M

J

J

A

S

O

N

D

7/63-6/64

1969

1971 (D)

1969

1970

1971 (D)

1969

1971 (D)

1971

1969

1971 (D)

1969 (A)

1970

1971 (D)

1969

1971 (D)

1969

1971 (D)

Literature survey only

(vertical temperature profiles)

Fe, Cs, Mg, Mn, Na, NH₃, PO₄,
Cl, SO₄, D.O., pH, O₂, SiCu, Mn, Hg, Ca, Mg, Fe, K, NO₃,
PO₄, O₂, pH, CO₂, SiSecchi disk at proposed intake
and discharge structures

35, 126, and 250 ft towers

Taxonomic and species diversity
studiesTaxonomic and species diversity
studies

TABLE V-2 (Continued)

PREOPERATIONAL ENVIRONMENTAL SURVEYS CONDUCTED AT THE ZION NUCLEAR POWER STATION

Survey	Year	J	F	M	A	M	J	J	A	S	O	N	D	
Macrophytes														NONE
Periphyton	1969								x					Artificial substrates
	1970 (B)					x	x	x	x	x	x			
Fish	1970 (C)													
	1971					x	x	x	x		x	x	x	Trawling, gill-netting and seining
Bacteria	1969								x		x		x	Coliform
	1971						x	x	x	x	x	x	x	

(A) Gulo, J. E. and M. O. Lambie, Inshore Water Quality Evaluation, Project II, IBT No. WW8955, Part B, Phytoplankton, May 1970-March 1971.

(B) Delinck, H. J., M. O. Lambie, and J. L. Czerwinski, Field Studies on Periphyton, Project V, IBT No. W8958, April 1970-March 1971.

(C) Johnson, D. H. and B. T. Muench, Field Sampling Program, Project VII, IBT No. W8960, Part C-Fish Study, March 1970 to October 1970.

(D) Han, H. T. Interim Report to Commonwealth Edison Co., Field Study Program of Lake Michigan in the vicinity of the Waukegan and Zion Generating Stations, April-December 1971, IBT No. W9860, Project X, April 27, 1972.

(E) Supplementary information has been provided by the applicant (see Appendix N).

TABLE V-3

POSTOPERATIONAL ENVIRONMENTAL MONITORING PROGRAM FOR THE EGM NUCLEAR POWER STATION (a) (b)

<u>Survey</u>	<u>Study Plan</u>	<u>Frequency</u>	<u>Corrective Measures</u>
PHYSICAL PARAMETERS			
Water Temperature	To monitor the size of the thermal plume	Unspecified	---
Water Quality	---	Monthly	---
Water Turbidity	---	Monthly	---
Sediments	---	Monthly (with benthos)	---
Other	Analysis of plume isotherms for O ₂ and N ₂	Unspecified	---
BIOLOGICAL PARAMETERS			
Artificial substrates	Artificial substrates for biomass, taxonomy, and species diversity indices.	Monthly (5 stations)	---
Primary productivity	(a) Primary productivity, density, species diversity indices.	Monthly (6 stations)	---
Condenser passage mortality	(b) Condenser passage mortality	Monthly (2 stations)	---
Taxonomy and species diversity indices	(a) Taxonomy and species diversity indices	Monthly (12 stations)	---
Condenser passage mortality	(b) Condenser passage mortality.	Monthly (2 stations)	---
Taxonomy with emphasis on indicator species such as <u>Pontoporeia affinis</u> , <u>Stylocypris harringtoni</u> , <u>Prionospio sp.</u> , <u>Sabellaria striatulum</u> and <u>Valvata</u>	(a) Taxonomy with emphasis on indicator species such as <u>Pontoporeia affinis</u> , <u>Stylocypris harringtoni</u> , <u>Prionospio sp.</u> , <u>Sabellaria striatulum</u> and <u>Valvata</u>	Monthly (24 stations)	---
Species diversity indices.	(b) Species diversity indices.	Fortnightly (32 stations)	---
Fish	(1) Number and species of fish entrained in the Station forebay and collected on travelling screens. <u>Screens:</u>	Weekly for 1 yr for 1-24 hr period/wk. or as often as 7X/wk	Screening the intake Structure
	<u>Forebay:</u>		
	(2) Seasonal changes in species abundance, length-weight relationships, food habits, and occupancy of the thermal plume isotherms.	Trawls 4X/mo.; gill nets 2X/mo.; Seines 2X/mo.	---

TABLE V-3 (Continued)

POSTOPERATIONAL ENVIRONMENTAL MONITORING PROGRAM FOR THE ZION NUCLEAR POWER STATION^{(a) (b)}

<u>Study</u>	<u>Study Plan</u>	<u>Frequency</u>	<u>Corrective Measures</u>
Fish			
<u>FIELD</u>	(3) Determination of potential spawning ground in the Zion area (fish eggs and larvae in samples, and gonad maturity).	Trawls 4X/mo.; gill nets 2X/mo.; Seines 2X/mo.	--
<u>LABORATORY</u>	(1) Sustained swimming speeds of different species.	Unspecified	--
	(2) Conditions promoting gas-bubble disease (see physical parameters for oxygen and nitrogen determinations in the thermal plume).	Unspecified	--

(a) Zion Nuclear Power Station Environmental Report, Supplement No. IV, April 13, 1972.

(b) Study Plan for Determination of Thermal Effect in Southwestern Lake Michigan, Waukegan and Zion Stations/ Prepared for Commonwealth Edison by Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois, Sept. 13, 1971.

(c) Non-Radiological Technical Specifications, Zion Station, AEC Dets. 50-295 and 50-304, August 1, 1972.

applicant to provide and attendant technical specification of the preoperational monitoring program.

The staff is of the opinion that the study programs of the applicant should be modified, with consideration of, but not limitation to, the following points:

- (1) Inshore water currents near the Station should be monitored sufficiently to enable analysis of their effects on thermal plane characteristics. Monitoring locations and depths at Lion have not been described in detail by the applicant's consultant.
- (2) Some shortcomings of reliance upon results of laboratory studies (e.g. see sections V.C.2.a & c) to predict and assess field effects should be recognized, and appropriate modifications made. The concern here is related to expenditures of effort by the applicant's consultant, some of which might more profitably be spent in other studies. Although it is apparent that the applicant's consultant has become increasingly aware through experience of problems inherent in its laboratory studies, additional modifications will be recommended by the staff.
- (3) Sediment entrainment and transport by the high velocity discharge, and its effects on local biota (e.g., due to increased turbidity or bottom deposition) should be monitored and assessed adequately. Frequencies and locations of sediment core samples and percent particle size analyses should be increased, or other methods devised.
- (4) Daily and periodic diurnal monitoring of fish caught on the traveling screens, as well as drift net and dip net sampling of forebay biota (plankton, benthos, fish eggs and larvae) will be required during the first year of operation, and less frequently thereafter (unless unacceptable entrainment necessitates intake modifications).
- (5) Chemical water quality measurements as proposed appear to be more than are necessary or directly relevant.
- (6) The staff does not wish to encourage extensive reliance by the applicant's consultants on diversity indices, especially with regard to plankton, since seasonal variations, influences other than Station operation, patchy plankton distribution, and discharge entrainment of plankton bring great variability to the data and reduce the usefulness of such indices.

- (7) Frequencies, locations, depths and methods of field sampling need reassessment for adequacy and redundancy. For example, some phytoplankton sampling at depths greater than 1 meter should be performed, since maximum densities usually are found below that depth (2-5 meters); some sampling for benthos in depths greater than 40 feet would be advisable, since extents of density underflow and sediment transport have not yet been predicted.
- (8) Descriptions of postoperational monitoring required in the Station's technical specifications should either include specific cross references to formally-submitted study plans, or also provide complete descriptions of sampling and monitoring procedures, schedules, and locations.

The staff takes favorable note that the applicant has established control points in areas outside the influence of the thermal plume - both south of the site at the outlet of Dead River and four miles north of the site. Although the Dead River Station is questionable as a control, due to Waukegan Station operation, it seems to represent at least as good a south control area as any other.

No plans other than radiological for monitoring the terrestrial environments have been provided by the applicant. The radiological monitoring program is adequate, and no other requirement is felt to be necessary.

4. Conclusions

The principal terrestrial impacts of the Station are expected to consist of aesthetics and exclusion. Former privately-owned dunes land will now be converted to industrial use. The applicant is committed to correcting any beach erosion once construction has been completed and the breakwater is removed. The changes due to construction have removed shoreline from the recreational resource pool, but these have not apparently produced important problems regarding use of nearby areas as a wild life sanctuary or recreational resource.

Condenser cooling water entrainment of planktonic organisms and fish, and waste heat discharge into Lake Michigan will produce the major sources of potential impact on the aquatic ecosystem. An unknown but

NO. 100-100000

... ..

seasonally variable number of adult and juvenile fish (plus eggs and larvae) will undoubtedly be trapped in the Station forebay and/or killed, either on the bar racks or traveling screens or during condenser passage. If the fish kill proves excessive, the applicant will be required to install previously approved measures to minimize this effect by modifying the intake structure. This problem may be potentially acute during the cooler months due to the attraction of fish to the warm water circulated through the intake structure for heating. This water will periodically contain trace amounts of toxic chloramines from plant service water discharges, but such are not considered to constitute a problem.

During winter, a small number of fish may be killed by thermal (cold) shock during infrequent periods of reactor shutdown. The reactor shutdown schedules provide for a gradual controlled steam dump to the condensers. In most months, heated plume water will rise and spread, due to its lower density. Fish may be attracted to the heated plume in cooler months. These will attempt to follow a temperature gradient and select their preferred environmental conditions. Benthic organisms in the immediate area of the discharge are not numerous and ought not to be importantly affected by sinking plumes during the winter months; the sinking plume phenomenon should occur at some distance from the discharge structure, and consequently, the plume and bottom temperatures will only differ by a few degrees.

The wave action, turbidity, nature of the bottom sediments, and lack of tributaries emptying into the lake near Zion argue against the presence of important spawning grounds for most fishes. Moreover, most schooling of young fish is expected to occur in water shallower than the depths at which the intake and discharge structures are buried. Because the intake and discharge pipes are buried beneath the lake bottom, interference of the thermal discharge with fish schooling and migrations will be reduced.

Increased turbidity in Zion waters may occur due to operation of the high velocity discharges. Most entrained sediments will be sands which will settle out rapidly, but possible effects on biota of discharge entrainment and transport of smaller sediment particles should be investigated.

D. RADIOLOGICAL IMPACT ON MAN

1. Introduction

The routine operation of the Station will result in the release of radioactive nuclides to the atmosphere and to Lake Michigan. These releases will be in accordance with the Commission's regulation, as

set forth in 10 CFR 20 and 10 CFR 50. Such release results in low level exposure of people, plants, and animals. These exposures may be external, internal, or both. The modes of external exposure considered are: (a) exposure to gaseous effluent, and (b) immersion in a body of contaminated water. The modes of internal exposure considered are: (a) inhalation, and (b) ingestion. The potential exposures involved are classified as "low level".⁶⁷ The pathways for radiation exposure due to radionuclides that originate in the radioactive effluents released by the Station are presented schematically in Fig. V-1. The staff has calculated the potential radiation dose to residents within a 50 mile radius of the Station, from the releases listed in Section III, Table III-2 and Table III-3 using conservative assumptions relative to dilution, biological accumulation in food chains and use factors for people.

2. Radioactive Material Released to the Atmosphere

The gaseous radwaste effluent will be dispersed by diffusion and atmospheric mixing. The estimated doses from exposure to the gaseous cloud are based on the releases of Table III-3 and the annual average meteorology applied to the site.

The maximum air immersion exposure rate is postulated for a permanently occupied point on the site boundary north of the site at an annual average χ/Q of 3.8×10^{-6} sec/m³. At this point the total body air-immersion dose is 1.43 mrem/yr. Inhalation of air containing radioactive iodine would result in a dose of 0.24 mrem/yr to a child's thyroid. The nearest dairy farm cow is located about four miles north of the Station at Kenosha Road Farm where the annual average χ/Q is 4.1×10^{-6} sec/m³. The additional dose from iodine to the thyroid of a child via the milk chain, assuming an intake of 1 liter of milk per day produced by cows grazing at this site for one half of the year, is 2.6 mrem/yr. Monitoring of this potential source will be conducted, and remedial measures will be taken should the potential dose exceed 5 mrem/yr to the child's thyroid.

The air immersion dose for an individual exposed for the entire year at the Illinois Beach State Park which is located south of the site, where the annual average χ/Q is 1.1×10^{-6} sec/m³ is 0.39 mrem/yr (or an annual average dose rate of 4.4×10^{-5} mrem/hr.). The dose to individuals at various locations as a result of exposure to the gaseous effluent is included in Table V-4.

3. Radioactive Materials Released to Receiving Waters

The liquid effluent from the Station are discharged via the Unit 1 and Unit 2 condenser discharge which has a combine diluting flow of 2.2×10^8 gallons per day. The expected annual average release is

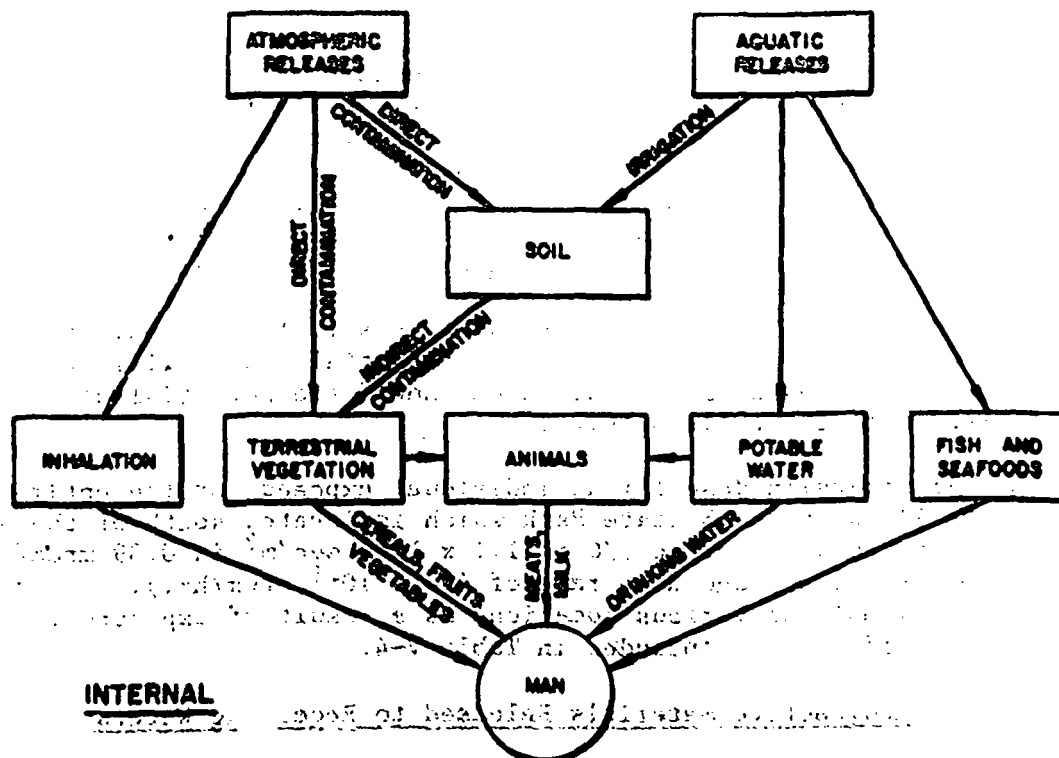
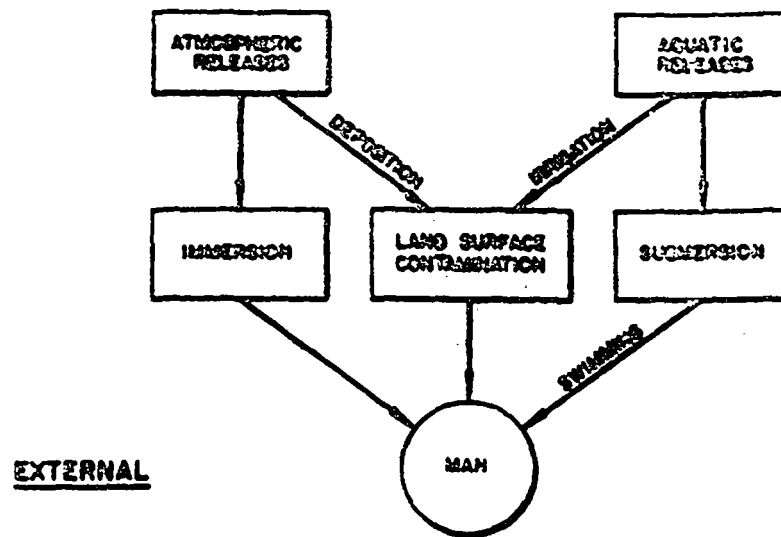


Fig. V-1. — Pathways for radiation exposure of man.

TABLE 2-4

ANNUAL AVERAGE DOSES TO INDIVIDUALS EXPOSED TO LIQUID AND GASEOUS EFFLUENTS FROM THE PLANT

<u>Location</u>	<u>Pathway</u>	<u>Total Body (ppm/yr)</u>	<u>Thyroid (ppm/yr)</u>	<u>G.I. Tract (ppm/yr)</u>	<u>Bone (ppm/yr)</u>
Site Boundary	Cloud	1.43	0.24	--	--
nearest cow (4 mile W)	ingestion of milk	--	2.6	--	--
near Zion Station dis- charge into lake	ingestion of fish ²	0.934	0.020	0.096	1.213
near Wenkagan Station	ingestion of fish ²	0.161	--	0.016	0.197
Illinois Beach State Park (recreation dose)	shoreline silts	0.201 ³			
	swimming	0.5×10^{-3} ⁴			
	boating	0.25×10^{-3} ⁵			

one liter/day milk intake - cows on open pasture 1/2 of year

² based on 50 gm/day intake of fish for sport fishermen

³ based on 500 hr/yr of shore line activity

* based on 100 hrs/yr of swimming where the annual average dilution is 1:5

⁸ based on 100 hrs/yr of boating where the annual average dilution is 1:5

1. poliavoc
 vnuo) ual
 (alim 1)
 nagaubn
 (alim 2. 1)
 ogeim 3. 8)
 (alim 2. 8)
 ual 3. 8)
 (alim 2. 8)
 3. 8)
 (alim 2. 1)
 nagaubn 3. 8)
 (alim 2. 8)
 3. 8)
 (alim 2. 8)
 3. 8)
 (alim 2. 8)
 3. 8)
 (alim 2. 8)
 3. 8)
 (alim 2. 8)

TABLE V-5

ANNUAL AVERAGE DOSE TO INDIVIDUALS EXPOSED TO LIQUID EFFLUENTS FROM THE STATION

<u>Location</u>	<u>Pathway</u>	<u>Calculated Dilution Factors</u>	<u>(Dose in mrem/yr)</u>				<u>Population¹</u>
			<u>Total Body</u>	<u>Bone</u>	<u>Thyroid</u>	<u>G.I.</u>	
Lake County (1 mile)	ingestion of water	1:5	0.020	0.0093	0.11	9.8×10^{-4}	1.25×10^4
Haukegan (3.5 miles)	ingestion of water	1:6	0.015	0.0071	0.087	7.6×10^{-4}	5×10^4
W. Chicago (8.25 miles)	ingestion of water	1:9	0.010	0.0049	0.060	5.4×10^{-4}	1.75×10^4
Great Lake (9.5 miles)	ingestion of water	1:10	0.0093	0.0046	0.055	5.0×10^{-4}	1.1×10^5
Lake Forest (14.5 miles)	ingestion of water	1:13	0.0071	0.0035	0.043	3.9×10^{-4}	4×10^4
Ft. Sheridan (15.7 miles)	ingestion of water	1:14	0.0071	0.0033	0.040	3.7×10^{-4}	1.8×10^3
Highwood (17 miles)	ingestion of water	1:15	0.0065	0.0032	0.038	3.5×10^{-4}	3.5×10^3
Highland Park (18.25 miles)	ingestion of water	1:15	0.0065	0.0031	0.036	3.3×10^{-4}	3.65×10^4
Northbrook (20.5 miles)	ingestion of water	1:16	0.0060	0.0028	0.033	3.1×10^{-4}	1.5×10^4
Glencoe (21 miles)	ingestion of water	1:17	0.0055	0.0027	0.033	3.0×10^{-4}	7×10^3
Winnetka (23.5 miles)	ingestion of water	1:18	0.0053	0.0025	0.030	2.8×10^{-4}	1.8×10^4

¹ Population derived by dividing total pumpage by the average index of 200 gal/person/day.

TABLE V-5 (Continued)

ANNUAL AVERAGE DOSE TO INDIVIDUALS EXPOSED TO LIQUID EFFLUENTS FROM THE STATION

<u>Location</u>	<u>Pathway</u>	<u>Calculated Dilution Factors</u>	<u>Total Body</u>	<u>Bone</u>	<u>Liver</u>	<u>G.I.</u>	<u>Population¹</u>
Kenilworth (24.7 miles)	ingestion of water	1:19	0.0051	0.0024	0.029	2.7×10^{-4}	2.3×10^3
Wilmette (25.75 miles)	ingestion of water	1:20	0.0050	0.0023	0.028	2.6×10^{-4}	3.4×10^4
Evanston (28.5 miles)	ingestion of water	1:21	0.0046	0.0022	0.027	2.4×10^{-4}	1.1×10^5
Central (38.25 miles)	ingestion of water	1:30	0.0036	0.0017	0.020	1.9×10^{-4}	3.2×10^6
S. Chicago (48.7 miles)	ingestion of water	1:33	0.0029	0.0014	0.016	1.5×10^{-4}	1.9×10^6
Kenosha (9.7 miles)	ingestion of water	1:10	0.0093	0.0045	0.054	5.0×10^{-4}	7.1×10^4
Racine (19.4 miles)	ingestion of water	1:16	0.0060	0.0016	0.035	3.2×10^{-4}	1.1×10^5
S. Milwaukee (32.5 miles)	ingestion of water	1:24	0.0041	0.0020	0.023	2.1×10^{-4}	2.2×10^4
Curahy (35.5 miles)	ingestion of water	1:25	0.0038	0.0018	0.021	2.0×10^{-4}	1.57×10^4
Milwaukee (43 miles)	ingestion of water	1:30	0.0033	0.0015	0.018	1.7×10^{-4}	8.1×10^5
Clendale (48.5 miles)	ingestion of water	1:33	0.0029	0.0014	0.017	1.5×10^{-4}	3.2×10^4

¹ Population derived by dividing total pumpage by the average index of 200 gal/person/yr.

The closest intake of Lake Michigan water for drinking purposes (Table V-5) is at the Lake County Public Water District Plant which is 1.1 mile north of the site where the average dilution is approximately 1:5. The total body dose associated with the intake of 1.2 liters of water per person per day by the consumer is 0.0194 mrem/yr. The dose to individuals at various locations as a result of exposure to the liquid effluent is included in Table V-5. Other uses of water from the Lake County Public Water District Intake, such as bathing and humidification of household air, is estimated to result in an additional total body dose 8.9×10^{-4} mrem/yr. The total body dose and doses to other organs of individuals receiving their water from various water intakes within fifty miles of the Station is also shown in Table V-5. The lake dilution factor is based on the steady state diffusion model of A. Okubo.⁴⁸ This model determined the radionuclide concentration at various intakes. A diffusion velocity of 1 cm/sec and an effective mixing depth of 200 cm has been assumed.

If an individual sportfisherman would consume 50 grams of fish per day caught near the Station discharge, his total body dose would be 0.96 mrem/yr (Table V-4). If the same individual caught his fish at the Waukegan Station discharge, where there is an annual average dilution of 1:6, he would receive a total body dose of 0.16 mrem/yr.

The total body dose received by individuals swimming for 100 hr/yr at Illinois Beach State Park, where the average dilution is approximately 1:5, was calculated to be 0.5×10^{-3} mrem/yr. The total body dose to an individual boating in the same vicinity would be 0.25×10^{-3} mrem/yr. Beach activities at Illinois Beach State Park were calculated to result in a whole body dose of 0.201 mrem/yr.

4. Population Doses from All Sources (Table V-6)

The annual integrated population dose for the 6.6×10^6 persons consuming water from Lake Michigan water supplies within 50 miles of the Station was calculated to be 22.9 man-rem/yr. The population served by a given water supply system drawing water from Lake Michigan was determined by dividing the daily intake in gallons by 200 gal/day/person (the average daily usage per individual). It should be noted that this population is greater than the population residing within 50 miles of the Station since the intakes also supply water to persons outside the 50 mile radius.

[illegible]

The total body dose due to the consumption of fish commercially caught in Lake Michigan is calculated to be 2.8 man-rem/yr. This calculation was based on the following assumptions: (1) that 1/3 of the entire commercial catch on the western side of the lake of 1.5×10^{10} grams/yr for 1971⁴⁹ was eatable and was totally consumed by the population within 50 miles of the Zion Station, (2) that the entire catch was caught in water containing the Station cooling water discharge at an annual average dilution factor of 1:100.

The integrated total body dose to the population living within 50 miles of the Station from the immersion in the radioactive gaseous effluents was calculated to be 4.6 man-rem/yr (see Table V-7).

5. Evaluation of Radiological Impact (Tables V-6 and V-7)

The total annual population dose received from all radiological pathways by the approximately 6,339,000 population (1970) who live within the 50 mile radius of the Station was calculated to be about 30 man-rem based on routine operation of the Zion Station. For comparison, a dose of about 0.135 rem/yr/person from naturally occurring radioactive materials results in an annual total population dose of about 855,000 man-rem.

Thus, routine operation of the Zion Station is expected to contribute only 0.005% of the natural background dose. It is not, therefore, postulated to be a significant radiological impact to the population in the surrounding environment. In fact, this dose is much smaller than normal variations in the background dose and could not be distinguished from them.

6. Radiological Environmental Monitoring

The applicant's radiological monitoring program has been planned to serve two objectives: to determine background concentrations of radioactive materials in the Zion environment prior to plant startup (pre-operational studies), and subsequently to determine the radiological effects of plant operations on the environment (operational studies). This latter phase will essentially be a continuation of the pre-operational phase. Only the salient features are presented here.

The sampling locations, types, and frequencies and the analyses were established in consideration of the potential amounts and modes of radionuclide releases, population density and distribution, food and water sources, activities (e.g., agriculture, recreation, industry, etc.) in the region, and natural biological and physical features of the region (Figure V-2).

Air monitoring will include sampling particulates, iodine and precipitation, and measurements of external exposure at appropriate onsite and offsite locations. The water monitoring program includes sampling aquatic biota, sediments, and lakewater, with particular emphasis on the algae, periphyton, and edible finfish that are in the food chain to man. In addition, potable surface and groundwaters are to be sampled, including appropriate municipal water supplies. The land radiological monitoring program will include sampling and analyzing milk, leafy vegetation, fruits, vegetables, grasses, including cattle feed and hay, and soils.

Air filters, precipitation, surface, ground and lakewater samples will be analyzed for gross beta radioactivity and if indicated by gross beta analysis, for appropriate individual radionuclides. Periodic tritium analyses will be performed on appropriate water samples. Charcoal filters will be analyzed weekly for I-131. All other samples will be analyzed for appropriate individual radionuclides.

It is felt that the applicant's proposed program is adequate to determine any radiological effects on the environment from the operation of the Zion Plant. Details of the program are given in the Final Safety Analysis Report and will be defined in the Technical Specifications.

TABLE V-6

ESTIMATED ANNUAL MAN REM DOSE

<u>Pathway</u>	<u>Estimated Dose (man-rem/yr)</u>
Cloud	4.6
Ingestion of Water	22.9
Ingestion of Fish	2.8

3

TABLE V-7

CUMULATIVE POPULATION, ANNUAL MAN-REM DOSE AND AVERAGE ANNUAL
DOSE FROM GASEOUS EFFLUENT IN SELECTED CIRCULAR AREAS
AROUND THE ZION STATION

<u>Cumulative Radius (Miles)</u>	<u>Cumulative Population (1970)</u>	<u>Cumulative Dose (man-rem)</u>	<u>Average Dose (mrem)</u>
1	753	0.16	0.21
2	6,890	0.34	0.049
3	18,790	0.50	0.026
4	33,570	0.60	0.017
5	46,550	0.68	0.014
10	207,500	1.3	0.0062
20	540,100	1.8	0.0033
30	1,234,000	2.3	0.0018
40	3,713,000	3.6	0.0010
50	6,339,000	4.6	0.0010

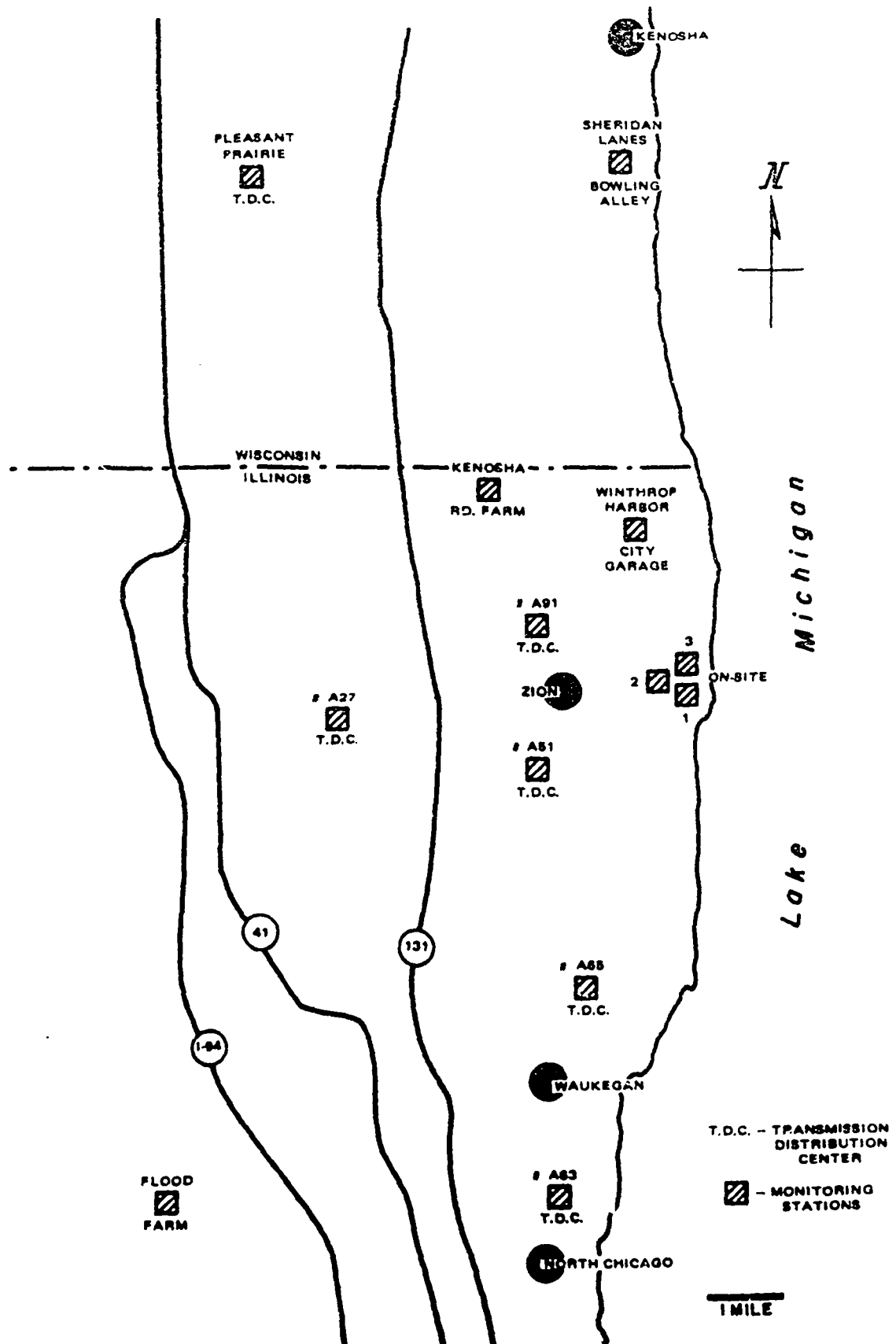


Fig. V-2 Location of Radwaste Monitoring Stations

E. TRANSPORTATION OF NUCLEAR FUEL AND SOLID RADIOACTIVE WASTE

The nuclear fuel for the Zion reactors is slightly enriched uranium in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. Each year in normal operation, about 1/3 of the fuel elements in each of the 2 units is replaced.

The applicant has indicated that cold fuel for the reactor will be transported by truck from the Westinghouse fabrication plant to the power plant site. The applicant has not indicated where the irradiated fuel or solid wastes will be shipped, but he did indicate irradiated fuel will be transported by truck or rail and solid wastes by truck. We have assumed a distance of 900 miles for shipping the irradiated fuel and 500 miles for shipping the solid radioactive wastes.

1. Transport of Cold Fuel

The applicant has indicated that cold fuel will be shipped in AEC-DOT approved containers which hold two fuel elements per container. About 6 truckloads of 8 containers each will be required each year.

2. Transport of Irradiated Fuel

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

Although the specific cask design has not been identified, the applicant states that the irradiated fuel elements will be shipped in approved casks designed for transport by either truck or rail. The cask will weigh perhaps 30 tons for truck or 100 tons for rail. To transport the irradiated fuel, the applicant estimates 22 truckload shipments per year with 3 fuel elements per cask and 1 cask per truckload; or 7 rail carload shipments per year with 9 fuel elements per cask and 1 cask per carload. The staff estimates an average of 40 truckloads or 10 rail carloads from both units each year. An equal number of shipments will be required to return the empty casks.

3. Transport of Solid Radioactive Wastes

Spent resins, waste evaporator bottoms and some process liquids will be dewatered and concentrated and, with other solid wastes, loaded into containers for shipment and disposal. The applicant indicates the normal schedule will generate about 1800 drums of waste per year. The staff estimates 40 truckloads of wastes each year. This may be shipped to a licensed disposal site for disposal. The staff estimates a shipping distance of about 500 miles.

4. Principles of Safety in Transport

The transportation of radioactive material is regulated by the Department of Transportation and the Atomic Energy Commission. The regulations provide protection of the public and transport workers from radiation. This protection is achieved by a combination of standards and requirements applicable to packaging, limitations on the contents of packages and radiation levels from packages, and procedures to limit the exposure of persons under normal and accident conditions.

Primary reliance for safety in transport of radioactive material is placed on the packaging. The packaging must meet regulatory standards⁵⁰ established according to the type and form of material for containment, shielding, nuclear criticality safety, and heat dissipation. The standards provide that the packaging shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear criticality safety, and provide adequate heat dissipation under normal conditions of transport and under specified accident damage test conditions. The contents of packages not designed to withstand accidents are limited, thereby limiting the risk from releases which could occur in an accident. The contents of the package also must be limited so that the standards for external radiation levels, temperature, pressure, and containment are met.

Procedures applicable to the shipment of packages of radioactive material require that the package be labelled with a unique radioactive materials label. In transport the carrier is required to exercise control over radioactive material packages including loading and storage in areas separated from persons and limitations on aggregations of packages to limit the exposure of persons under normal conditions. The procedures carriers must follow in case of accident include segregation of damaged and leaking packages from people and notification of the shipper and the Department of

Transportation. Radiological assistance teams are available through an inter-Governmental program to provide equipment and trained personnel, if necessary, in such emergencies.

Within the regulatory standards, radioactive materials are required to be safely transported in routine commerce using conventional transportation equipment with no special restrictions on speed of vehicle, routing, or ambient transport conditions. According to the Department of Transportation (DOT), the record of safety in the transportation of radioactive materials exceeds that for any other type of hazardous commodity. DOT estimates approximately 800,000 packages of radioactive materials are currently being shipped in the United States each year. Thus far, based on the best available information, there have been no known deaths or serious injuries to the public or to transport workers due to radiation from a radioactive material shipment.

Controls over routing in transport have not been considered a factor in establishing safety standards. Emphasis was placed on package standards and quality assurance procedures apart from any routing restrictions. Although the regulations require all carriers of hazardous materials to avoid congested areas⁵¹ wherever practical to do so, in general, carriers choose the most direct and fastest route. Routing restrictions which require use of secondary highways or other than the most direct route may increase the overall environmental impact of transportation as a result of increased accident frequency or severity. Any attempt to specify routing would involve continued analysis of routes in view of the changing local conditions as well as changing of sources of material and delivery points.

F. RADIOLOGICAL IMPACT - TRANSPORTATION EXPOSURES DURING NORMAL (NO ACCIDENT) CONDITIONS

1. Cold Fuel

Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the 6 shipments, with two drivers for each vehicle, the total dose would be about 0.01 man-rem* per year. The radiation level associated with

* Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 10^5 persons along the shipping route).

each truckload of cold fuel will be less than 0.1 mrem/hr at 6 feet from the truck. A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of about 0.005 mrem per shipment. The dose to other persons along the shipping route would be extremely small.

2. Irradiated Fuel

Based on actual radiation levels associated with shipments of irradiated fuel elements, we estimate the radiation level at 3 feet from the truck or rail car will be about 25 mrem/hr. The individual truck driver would be unlikely to receive more than about 30 millirem in the 900-mile shipment. For the 40 shipments by truck during the year with 2 drivers on each vehicle, the annual cumulative dose would be about 2.4 man-rem.

Train brakemen might spend a few minutes in the vicinity of the car for an average exposure of about 0.5 millirem per shipment. With 10 different brakemen involved along the route, the cumulative dose for 10 shipments during the year is estimated to be about 0.05 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck or rail car, might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 40 shipments by truck would be about 0.5 man-rem and for the 10 shipments by rail, about 0.1 man-rem. Approximately 270,000 persons who reside along the 900-mile route over which the irradiated fuel is transported might receive an annual dose of about 0.9 man-rem if transported by truck, and 0.2 man-rem if transported by rail. The regulatory radiation level limit of 10 mrem/hr at a distance of 6 feet from the vehicle was used to calculate the integrated dose to persons in an area between 100 feet and 1/2 mile on both sides of the shipping route. It was assumed that the shipment would travel 200 miles per day and the population density would average 330 persons per square mile along the route.

The amount of heat released to the air from each cask will vary from about 30,000 Btu's/hr for truck casks to about 250,000 Btu's/hr for rail casks. For comparison, 35,000 Btu's/hr is about equal to the heat released from an air conditioner in an average sized home. Although the temperature of the air which contacts the loaded cask may be increased a few degrees, because the amount of heat is small and is being released over the entire transportation route, no appreciable thermal effects on the environment will result.

3. Solid Radioactive Wastes

The applicant estimates that about 40 truckloads of solid radioactive wastes will be shipped to a disposal site. Under normal conditions, the individual truck driver might receive as much as 15 mrem per shipment. If the same driver were to drive 25 truckloads in a year, he could receive an estimated dose of about 400 mrem during the year. The cumulative dose to all drivers for the year, assuming 2 drivers per vehicle, might be about 1.2 man-rem.

A member of the general public who spends 3 minutes at an average distance of 3 feet from the truck might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the cumulative annual dose for 40 shipments by truck would be about 0.5 man-rem. Approximately 150,000 persons who reside along the 500-mile route over which the solid radioactive waste is transported might receive a cumulative annual dose of about 0.5 man-rem. These doses were calculated for persons in an area between 100 feet and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10 mrem/hr at 6 feet from the vehicle, and the shipment traveling 200 miles per day.

REFERENCES FOR SECTION V

2. Zion/ER, p. 1, May 1971.
3. Sparrow, A. H., and Evans, H. J., Brookhaven Symp. Biol. 14, p. 76 (1961).
4. Sparrow, A. H., Schwemmer, S. S., and Bottino, P. J., "The Effects of External Gamma Radiation from Radioactive Fallout on Plants, with Special Reference to Crop Production," in Survival of Food Crops and Livestock in the Event of Nuclear War, AEC Symp., Sept. 24, 1971, pp. 670-711.
5. Miller, L. N., "Changes in Radiosensitivity of Pine Seedlings Subjected to Water Stress During Chronic Irradiation," Health Physics, 11:1653-1662 (1965).
6. Woodwell, G. M., Radiation and the Patterns of Nature Science 156:461-470 (1967).
7. Hynes, H. B. N., The Ecology of Running Water, University of Toronto Press, 1970.
8. Mount, D. I., "Thermal Requirements for Lake Michigan," National Water Quality Lab., Duluth, Minn., March 1971.
9. Raney, E. C., "Heated Discharge and Fishes in Lake Michigan in the Vicinity of the Donald C. Cook Nuclear Plant," Testimony at a meeting of the Michigan Water Resources Commission, June 24, 1971, Lansing, Michigan.
10. Wells, L., "Seasonal Depth Distribution of Fish in Southeastern Lake Michigan," Fishery Bull. 67, No. 1 (1968).
11. Coutant, C. C. Biological Aspects of Thermal Pollution. 1. Entrainment and discharge canal effects. Rev. Environ. Control 1:341-381, 1970.

12. Coutant, C. C., "Thermal Pollution-Biological Effects," J. Water Poll. Control Federation. 43, p. 1292 (1971).
13. Ayers, J. C., Anderson, R. F., O'Hara, N. W., and Kidd, C. C., Benton Harbor Power Plant Limnological Studies, Part IV, "Cook Plant Preoperational Studies," Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan, March 1970.
14. Krezoski, J. R., Benton Harbor Power Plant Limnological Studies, Part III, "Some Effects of Power Plant Waste Heat Discharge on the Ecology of Lake Michigan." Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan, April 1969.
15. Ayers, J. C., Arnold, D. E., Anderson, R. F., and Soo, H. K., Benton Harbor Power Plant Limnological Studies, Part VII, "Cook Plant Preoperational Studies," Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan, March 1971.
16. Bader, R. G. and Tabb, D. C., "An Ecological Study of South Biscayne Bay in the Vicinity of Turkey Point," University of Miami, 1970.
17. Thermal Effects and U. S. Nuclear Power Stations, Div. of Reactor Development and Technology, AEC, Wash-1169 (Jan. 1971).
18. Patrick, R., "Some Effects of Temperature on Freshwater Algae," in Biological Aspects of Thermal Pollution (eds. R. A. Krenkel and F. L. Parker), Vanderbilt University Press (1969), pp. 161-185.
19. Morgan, R. P. II, and R. G. Stross, Destruction of phytoplankton in the cooling water supply of a steam electric station. Chesapeake Science 10:165-167, 1969.
20. Patrick, R., and R. McLean, Entrainment simulation studies on some estuarine organisms for the Potomac Electric Power Co., Acad. Nat. Sci., Philadelphia (1971).
21. Kerr, J. E., Studies on fish preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Company, Calif. Fish and Game Fish. Bull. 92:1-66, 1953.

22. Marcy, B. C., Jr., "Survival of Young Fish in the Discharge Canal of a Nuclear Power Plant," J. Fish Res. Bd. Canada, 28, p. 1057 (1971).
23. Currie, D. P., Testimony before the Thermal Standards for Lake Michigan Hearings, Jan. 15, 1971.
24. Physical and Ecological Effects of Waste Heat on Lake Michigan, U. S. Dept. of the Interior, Fish and Wildlife Service (Sept. 1970).
25. Zion/ER, Sect. 2.3, May 1971.
26. 1969 Survey of Lake Michigan Shore Water Quality, State of Illinois Sanitary Water Board, Ill. Dept. of Public Health (May 1970).
27. Ayers, J. C., O'Hara, N. W., and Yocum, W. J., Benton Harbor Power Plant Limnological Studies, Part VIII, Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan, June 1971.
28. Neill, W. H., Ecological responses of Lake Monona (Dade County) fishes to heated influent water, Ann. Progress Report, Sept. 1969 to the Wisconsin Utilities Association.
29. Edsall, T. A., and P. J. Colby, Temperature tolerances of young-of-the-year cisco, Coregonus artedii. Trans. Amer. Fish Soc., 99-526 (1970).
30. Preoperational Environmental Monitoring (Thermal) of Lake Michigan near Zion Station, July-December 1969, Report to Commonwealth Edison Company by Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois, IBT W7658 and W8096.
31. Hutchinson, G. E., A Treatise on Limnology, Vol. II, John Wiley and Sons, Inc. New York, 1967.
32. Heinle, D. R., Temperature and zooplankton, Chesapeake Science 10:186-209 (1969).
33. Shrivastava, H. N., Oligochaetes as Indicators of Pollution, Water and Sewage Works, Scranton Gillette Publ. (Jan. 1962).
34. Wurtz, C. B., The effects of heated discharges on freshwater benthos, in Biological Aspects of Thermal Pollution (eds. P. A. Krenkel and F. L. Parker) Vanderbilt University Press, 1960.

35. Ayers, J. C., "The Surficial Bottom Sediments of Lake Michigan," in Studies of the Environment and Eutrophication of Lake Michigan, Special Report No. 30, Great Lakes Research Division, Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan, 1967, pp. 247-253.
36. Auerbach, S. I., "Ecological Considerations in Siting Nuclear Power Plants. The Long-Term Biotic Effects Problem," Nuclear Safety, 12 p. 25 (1971).
37. Woodhead, D. S., "The Biological Effects of Radioactive Waste," Proc. Roy. Soc. London, Ser. B. 177, P. 423 (1971).
38. Templeton, W. L., Nakatani, R. E., and Held, E. E., "Radiation Effects," in Radioactivity in the Marine Environment, National Acad. Sciences, Washington (1971), p. 223.
39. "Water Quality Criteria Recommendations for Residual Chlorine in Receiving Waters for the Protection of Aquatic Life. Letter to Mr. Francis T. Mayo from Dr. W. A. Brungs, Environmental Protection Agency, National Water Quality Laboratory, Duluth, Minnesota, dated December 20, 1971.
40. Merchens, J. C., Studies on the toxicity of chlorine and chloramines to the rainbow trout, Waterland Waste Trt. J. (Great Britain), 7:150-151 (1958).
41. Basch, R., Newton, M., and Fetterolf, C., In situ investigations of the toxicity; of chlorinated municipal wastewater treatment plant effluents to rainbow trout (*Salmo gairdneri*). Michigan Bureau of Water Management, Department of Natural Resources, Lansing, Michigan. Paper presented at the American Chemical Society on Bioassay Techniques and Environmental Chemistry, Sept. 1971.
42. Sprague, J. B., and Drury, D. E., Avoidance reactions of salmonid fish to representative pollutants, Adv. Water Poll. Res. - Proc. 4th Int. Conf., Prague, 1969, Pergamon Press, 1969, pp 169-179.
43. Arthur, J. W., and Eaton, J. G., Chloramine toxicity to the amphipod *Gammarus pseudolimnacus* and the fathead minnow (*Pimephales promelas*). J. Fish. Res. Bd. Canada 28:1841 - 1845 (1971).
44. Letter to Dr. J. Marshall, Argonne National Laboratory, from T. A. Edsell, Bur. of Sport Fisheries and Wildlife, Ann Arbor, Michigan (Oct. 1, 1971).

45. Floral Survey by Dr. Elizabeth Lunn and Prof. Emeritus, Lake Forest College, Lake Forest, Ill. (1971).
46. Faunal Survey by Mr. R. D. Gustafson, Naturalist at Illinois Beach State Park.
47. "Permissible Dose for Internal Radiation (1959)," Health Physics, 3, (June 1960).
48. Okubo, A., "Review of Theoretical Models of Turbulent Diffusions in the Sea," TID-17342 (1966).
49. Unpublished data from the John Van Oosten Great Lakes Fishery Research Library, U. S. Dept. Interior, Bureau of Sport Fisheries and Wildlife, Great Lakes Fishery Laboratory, Ann Arbor, Michigan, Personal communication to Argonne National Laboratory, Environmental Statement Project, June 1972.
50. 10 CFR Part 71; 49 CFR Parts 173 and 178.
51. 49 CFR Section 397.1(d).
52. Zion/ER, Supplement II, p. 4.1.
53. Letter, Commonwealth Edison Company to D. R. Muller, US Atomic Energy Commission, September 28, 1972.
54. Water Pollution Regulations of Illinois. State of Illinois Environmental Protection Agency, Springfield, Illinois (adopted March 7, 1972).
55. Fraenkel, G. S., and Gunn, D. L., The Orientation of Animals, Dover, New York, pp. 250-253, 1961.
56. Lowenstein, O., The Sense Organs: The Acoustico-lateralis System. In: The Physiology of Fishes (M. E. Brown, ed.), Vol. II. Academic Press, New York, 1957.
57. Final Environmental Statement Related to Operation of the Palisades Nuclear Generating Plant, U. S. Atomic Energy Commission, Washington, D. C. (June, 1972).
58. S. Spigarelli, Argonne National Laboratory. Personal communication.
59. Johnson, D. H., and Muench, B. I., Field Sampling Program, Project VII, Industrial Bio-Test No. W8960. Part C - Fish Study (March 1970 to October 1970).

VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

A high degree of protection against the occurrence of postulated accidents in the Zion Nuclear Power 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. These aspects will be considered in the Commission's Safety Evaluation of the Station. 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, in spite of the fact that they are extremely unlikely; and engineered safety features are installed to mitigate the consequences of these postulated events.

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 were 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. The computed doses that would be received by the population and environment from actual accidents would be significantly less than those which will be presented in the Safety Evaluation.

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

The applicant's report has been evaluated, using the standard accident assumptions and guidance issued as a proposed amendment to Appendix D of 10 CFR Part 50 by the Commission on December 1, 1971. Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious were identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a low occurrence rate, 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 VI-1. The examples selected are reasonably homogeneous in terms of probability within each class. Certain assumptions made by the applicant do not exactly agree with those in the proposed Annex to Appendix D, but the use of alternative assumptions does not significantly affect overall environmental risk.

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 VI-2. Estimates of the integrated exposure that might be delivered to the population within 50 miles of the site are also presented in Table VI-2. The man-rem estimate was based on the population around the site for the year 2000.

To rigorously establish a realistic annual risk, the calculated doses in Table VI-2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operation; 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 are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table VI-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 basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is 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 the required 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.

TABLE VI-1

CLASSIFICATION OF POSTULATED ACCIDENTS
AND OCCURRENCES

<u>Class</u>	<u>AEC Description</u>	<u>Applicant's Example(s)</u>
1.0	Trivial Incidents	Not considered
2.0	Small releases outside containment	Chemical and Volume Control System leak
3.0	Radwaste system failure	Malfunction or inadvertent discharge of gas decay tank
4.0	Fission products to primary system (BWR)	Not considered
5.0	Fission products to primary and secondary systems (PWR)	Fuel defects with steam generator tube leakage
6.0	Refueling accident	Refueling accident inside containment
7.0	Spent fuel handling accident	Fuel handling accident outside containment
8.0	Accident initiation events considered in design basis evaluation in the SAR	Loss-of-Coolant, Steamline Break, Steam Generator Tube Rupture, Rod Ejection, Waste, Gas Tank Rupture, Volume Control Tank Rupture
9.0	Hypothetical sequence of failures more severe than Class 8	Not considered

TABLE VI-2

SUMMARY OF RADIOLOGICAL CONSEQUENCES
OF POSTULATED ACCIDENTS

<u>Class</u>	<u>Event</u>	<u>Estimated fraction of 10 CFR Part 20 limit at site boundary^{1/}</u>	<u>Estimated dose to population in 50 mile radius, man-rem</u>
1.0	Trivial Incidents	<u>2/</u>	<u>2/</u>
2.0	Small releases outside containment	<u>2/</u>	<u>2/</u>
3.0	Radwaste system failure		
3.1	Equipment leakage or malfunction	0.15	27
3.2	Release of waste gas storage tank contents	0.60	110
3.3	Release of liquid waste storage contents	0.017	2.9
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	<u>2/</u>	<u>2/</u>
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	0.004	0.61
5.3	Steam generator tube rupture	0.20	35
6.0	Refueling accidents		
6.1	Fuel bundle drop	0.032	5.6
6.2	Heavy object drop onto fuel in core	0.55	96

TABLE VI-2 (cont'd)

<u>Class</u>	<u>Event</u>	<u>Estimated Fraction of 10 CFR Part 20 limit at site boundary^{1/}</u>	<u>Estimated dose to population in 50 mile radius, man-rem</u>
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop into fuel storage pool	0.02	3.5
7.2	Heavy object drop onto fuel rack	0.08	14
7.3	Fuel cask drop	N.A.	N.A.
8.0	Accident initiation events con- sidered in design bases evaluation in the SAR		
8.1	Loss-of-Coolant Accidents		
	Small Break	0.32	110
	Large Break	3.1	3300
8.1a	Break in instrument line from primary system that penetrates the containment	N.A.	N.A.
8.2a	Rod ejection accident (PWR)	0.31	330
8.2b	Rod drop accident (BWR)	N.A.	N.A.
8.3a	Steamline breaks (PWR's outside containment)		
	Small Break	0.001	0.19
	Large Break	0.002	0.35
8.3b	Steamline breaks (BWR)	N.A.	N.A.

^{1/} Represents the calculated fraction of a whole body dose of 500 millirem, or the equivalent dose to an organ.

^{2/} 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 liquid or gaseous releases).

Table VI-2 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposure of an assumed individual at the site boundary to concentrations of radioactive materials within or comparable to the Maximum Permissible Concentrations (MPC) of Table II of 10 CFR Part 20. The table also shows that the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than that from naturally occurring radioactivity, which corresponds to approximately 1,370,000 man-rem per year based on a natural background of 135 mrem/year. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents are exceedingly small.

B. TRANSPORTATION ACCIDENTS

EXPOSURES RESULTING FROM POSTULATED ACCIDENTS

Based on recent accident statistics,¹ a shipment of fuel or waste may be expected to be involved in an accident about once in a total of 750,000 shipment-miles. The staff has estimated that only about 1 in 10 of those accidents which involve Type A packages or 1 in 100 of those involving Type B packages might result in any leakage of radioactive material. In case of an accident, procedures which carriers are required² to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and the Department of Transportation. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

1. Cold Fuel

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

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

The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote. If criticality were to occur in transport, persons within a radius of about 100 feet from the accident might receive a serious exposure but beyond that distance, no detectable radiation effects would be likely. Persons within a few feet of the accident could receive fatal or near-fatal exposures unless shielded by intervening material. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds and normally would not recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 feet. There would be very little dispersion of radioactive material.

2. Irradiated Fuel

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

(a) Leakage of contaminated coolant resulting from improper closing of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 40-year life of the plant.

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

(b) Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an

extremely severe accident such that the cask containment is breached and the cladding of the fuel assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

In such an accident, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 feet or so of the accident might receive doses as high as a few hundred millirem. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards³ of the Environmental Protection Agency.

3. Solid Radioactive Wastes

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the plant. If a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant. Other solid radioactive wastes will be shipped in Type B packages. The probability of release from a Type B package, in even a very severe accident, is sufficiently small that, considering the solid form of the waste and the very remote probability that a shipment of such waste would be involved in a very severe accident, the likelihood of significant exposure would be extremely small.

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

C. SEVERITY OF POSTULATED TRANSPORTATION ACCIDENTS

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and

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

D. 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. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

REFERENCES FOR SECTION VI

1. Federal Highway Administration, "1969 Accidents of Large Motor Carriers of Property," December 1970; Federal Railroad Administration Accident Bulletin No. 138, "Summary and Analysis of Accidents on Railroads in the U.S.," 1969; U.S. Coast Guard, "Statistical Summary of Casualties to Commercial Vessels," December 1970.
2. 49 CFR Sections 171.15, 174.566, 177.361.
3. Federal Radiation Council Report No. 7, "Background Material for the Development of Radiation Protection Standards; Protective Action Guides for Strontium 89, Strontium 90, and Cesium 137," May 1965.

VII. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

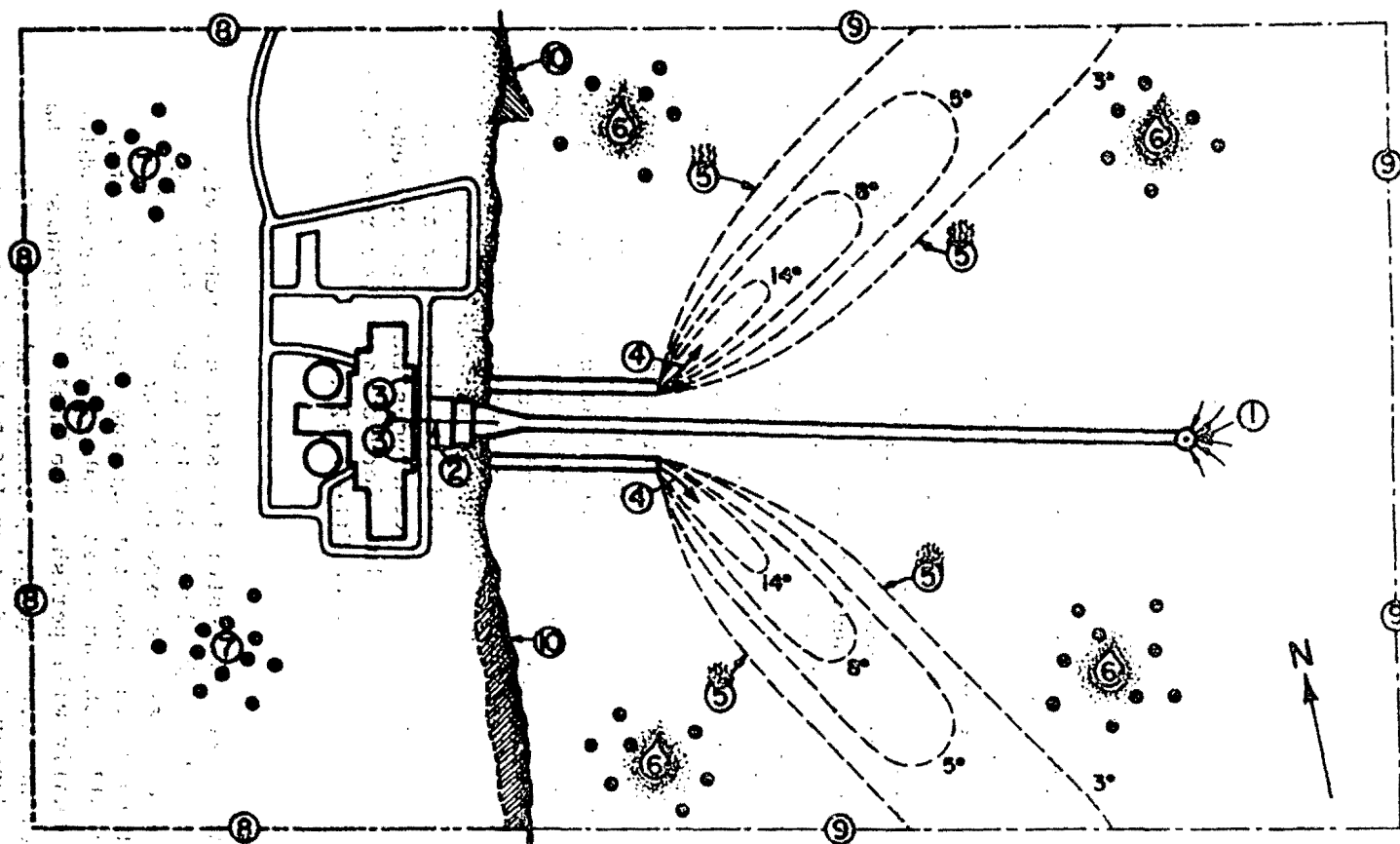
The actual or potential adverse effects due to the construction and operation of the Zion Nuclear Power Station as proposed are graphically illustrated in Fig. VII-1. They are summarized below by discussing each effect as numerically identified in the figure.

Effect #1 - Intake Effect

The intake structure, which is located 2600 feet offshore, will withdraw approximately 1,530,000 gpm of water from the lake for condenser cooling. Normal water flow velocities into the intake structure will be approximately 2.47 ft/sec (3.77 ft/sec maximum during winter). All organisms present in this entrained water will, of course, also be entrained with the flow. These include phytoplankton, zooplankton, vertically-migrating benthic crustaceans (e.g., *Mysis*, *Pontoporeia*), and eggs and larvae of certain fishes. In addition, seasonally variable numbers of juvenile and adult fishes will be entrained. Quantitative estimates of fish entrainment will depend importantly on trends in population densities and migratory patterns and cannot yet be made with reasonable confidence in large part due to the limited relevant data thus far supplied by the applicant. The flow velocity at this intake, however, is undesirably high. Larger fishes would be excluded (by the 1" x 1" mesh nets) from entrainment during most months, but there is no exclusion or entrainment-reduction measure presently proposed for smaller fishes (including juveniles of larger species) at any time, nor for any fishes during the winter (when highest intake velocities and deicing recirculation of warm water, attractive to local fishes, will occur). The position (2600 feet offshore) and mid-depth location of the Zion intake expectedly will result in less biotic entrainment than would probably occur at many nearby alternatives. However, the staff concludes that the presently proposed intake design and operation plans form a basis for reasonable concern regarding fish entrainment (see Effect #2).

Effect #2 - Forebay Effect

Water withdrawn from the lake will enter the station forebay via submerged pipes. Due to the high flow velocity in the pipes, any aquatic life entering the intake is expected to reach the forebay, and not be able to return to the lake through the pipes. The staff is of the opinion that all fish, and most fish eggs and larvae which reach the forebay eventually will perish. The smaller organisms that pass through the traveling screen (e.g., plankton and eggs) will be carried through the condenser (see Section III.D.1 for a description



CODE:

① INTAKE EFFECTS	⑥ CHEMICAL AND RADWASTE (LIQUID and SOLID) DISCHARGE EFFECTS
② FOREBAY EFFECTS	⑦ GASEOUS RADWASTE EFFECTS
③ CONDENSER EFFECTS	⑧ SHORE LINE EXCLUSION AREA EFFECTS
④ DISCHARGE EFFECTS	⑨ LAKE EXCLUSION AREA EFFECTS
⑤ HEAT DISCHARGE EFFECTS	⑩ SHORE LINE EROSION AND ACCRETION EFFECTS

Fig. VII-1. Probable Adverse Effects

of the system). Larger organisms (fishes) will be trapped on the screen and removed as trash. Fish too large to pass through the bar rack may survive in the forebay for an extended period of time, but will not be able to return to the lake without assistance. Even if returned to the lake, such fish would expectedly be severely stressed, injured, and/or subject to disease or predation, and therefore probably moribund.

Effect #3 - Condenser Effects

Aquatic life withdrawn from the forebay into the condenser cooling water and service water flows will be subjected to seasonally variable rates of mortality and sub-lethal stress, due to rapid heating and pressure changes, and to mechanical damage. Passage of organisms through the condensers and out to the 5°F excess isotherm will take place within a few minutes, but the staff estimates that zooplankton kills of more than 30% may occur at times (although the annual average probably will be lower). Most fish eggs, larvae, and fry will perish during condenser passage. Kills will be skewed, with higher mortality in the larger zooplankters and other organisms (some of which are important food sources for fishes), as well as in the more temperature-sensitive species. Mortality will be higher (possibly total) in the service water flow, especially during chlorination. Some recovery of immobilized zooplankters will occur after condenser passage.

Effect #4 - Discharge Effect

Large amounts of warmed condenser cooling water will be discharged from the Station and will contain small concentrations of chemicals and radionuclides. The warmed water will be discharged through high-velocity (9.5 ft/sec max.) diffuser jets and mixed with the lake water in the vicinity of the discharge structure (located approximately 1760 feet from shore). Subsurface transport of sediment entrained at the sides and bottom of the discharge plume will occur, but there presently are no adequate bases for quantitatively estimating the rates, particle size distribution, distances, or biotic effects (due to increased turbidity and bottom deposition) of such sediment transport. The effects of heat, chemicals, and radionuclides contained in the discharge water are discussed below.

Effect #5 - Heat Discharge Effects

Very large quantities of heat (15 to 10⁹ Btu/hr) will be transferred to the lake waters via the condenser cooling water discharge plume. The lake waters will serve as a temporary repository for this heat, which

will eventually be transferred to the atmosphere. This heat transfer, however, is not expected to have an overall effect on lake temperature.

Planktonic and transiently planktonic (e.g., benthos, fish eggs) organisms entrained in the mixing water are not expected to remain within the higher excess isotherms long enough under most conditions to result in significant adverse effects due directly to temperature. Local shifts in zooplankton and phytoplankton species composition in the plume may be expected to favor the more temperature-tolerant forms at certain times (depending mainly on seasonal population differences, ambient water temperatures, and currents), but these will be difficult to measure or assess, due to natural "patchiness" of the plankton and to the entrainment of other plankton with the discharged water.

The most obvious effect of the thermal discharge will be the attraction of fishes to the area, especially during the cooler months, when ambient temperatures are below the thermal preferences of local fishes. Some fish (especially salmonids) will be able to enter the higher excess isotherm areas, including those in which flow velocity exceeds their maximum sustained swimming speeds, but the staff is of the opinion that the limited areas (e.g., less than 3 acres at 10°F) within these isotherms will preclude the possibility that important fractions of the lake's fish populations will be significantly affected (regarding growth, reproduction, gas bubble disease, cold-shock kills during rapid shutdowns, etc.). Fish kills in the plume, produced by cold water upwellings or plant shutdowns, also may occur, but these probably also would be minor, due to the limited numbers of fish able to spend significant time in (and acclimate to) the higher plume temperatures. In addition, the offshore positioning of the discharge expectedly will reduce (although not eliminate) interference with schooling and migration of juvenile and adult fish in the area.

In the absence of confident predictions about the extent of the sinking plume in winter, it is not possible to estimate the extent of effect of density underflow on benthos. Other, indirect effects (e.g., predation or epidemiological kinetics) of temperature on plankton and fish in the plume also are not assessable with available data.

Effect #6 - Chemical and Liquid Radwaste Discharge Effects

Chemicals and liquid radwaste will be discharged in low concentrations to the lake. The use of the mechanical condenser cleaning system (AMERTAP) should reduce the need for chemical additions (especially chlorine) in the discharge to levels which are not expected to cause

significant damage to the aquatic ecosystem. The radwaste discharge system is monitored and controlled to assure that the liquid waste discharge to the lake will be as low as practicable.

Effect #7 - Gaseous Radwaste Effects

Small quantities of gaseous radwaste will be released to the environment. The Station will use a monitored and controlled gaseous radwaste release system to assure that the gaseous wastes discharged to the atmosphere will be as low as practicable.

Effect #8 - Shoreline Exclusion Area Effect

The siting of the Station on the shoreline and the need to maintain control of access to the Station and its facilities will restrict the access across the Station land and along the shoreline. This effect, though relatively unimportant now, could become inconvenient to the public if the State of Illinois expands the Illinois Beach State Park as is presently planned. Siting the Station in the only remaining natural dunes area in Illinois will be considered aesthetically and conceptually undesirable by many of the public.

Effect #9 - Lake Exclusion Area Effect

Although the applicant has not specified any restrictions on beach use, it is probable that the applicant will restrict access to the shoreline (beach) which is a part of the site.

Effect #10 - Shoreline Erosion and Accretion Effects

The construction of a breakwater during construction on the northern shoreline of the site is believed to have caused accretion of the shoreline in the area just north of the breakwater and erosion of the shoreline to the south of the breakwater (including the extreme northern shoreline of the Illinois Beach State Park). This effect, however, is anticipated to be temporary. Shoreline conditions are expected to return to normal when the breakwater is removed during the final stages of construction. If natural restoration does not occur, the applicant is committed to repair the damage which has resulted. In winter, some offshore melting of the shore ice barrier will be produced by the thermal discharge, but available evidence does not suggest that such will result in important winter increases in local beach erosion.

VIII. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The Station site, as previously noted, is on a low sand dune on the lakeshore. The land had previously been occupied by scattered, near-lake cottages and homes. Present State of Illinois plans contemplate the withdrawal of the entire marsh land and dune land area from private use (except for the Station and a small industrial area just west of the Station) and conversion of the land to conservation and public recreational uses. Thus the present plan to use the site for a power Station is projected to be the only industrial land use planned on the lakeshore in this general area.

No operational aspects of the proposed Station have been identified to have important long-term detrimental effect on either the terrestrial or aquatic activities in the area. The short-term use, as proposed, does not encompass any elements or conditions which would restrict the long-term productivity or use of the area after the projected 40-year operating life of the plant with the possible exception being the long-term need of less than 10 acres of dunes occupied by the reactor containment structure (see Section XII.K. for additional consideration).

No specific plan for the decommissioning of the 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, Carolina 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 cap 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

VIII-2

and encase in concrete all radioactive portions which remain above ground. The Hallam decommissioning operation was of this type. (3) Remove the fuel, all superstructure, the reactor vessel and all contaminated equipment and facilities, and finally fill all cavities with clean rubble topped with earth to grade level. This last procedure is being applied in decommissioning the Elk River Reactor. 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.

The applicant estimates the cost of permanently shutting down one of the Zion units is \$10,000,000 and both units is \$15,000,000 (FSAR Amendment 20). The Applicant also estimates that the annual cost of maintaining one shutdown unit in a safe condition is \$350,000 per year, and the cost of maintaining an additional shutdown unit at the same facility is negligible.

Analysis of dismantling cost experience to date indicates that an amount equal to 10-15% of the original construction cost (perhaps \$40 million to \$60 million) would be required to restore the site to its original condition. In cost-benefit considerations, future decommissioning costs should be discounted to obtain their present worth. At a discount rate of 8.75% for 30 years of operation, costs would be divided by 10 to determine their present worth. It is, therefore, concluded that including decommissioning costs would not alter any of the conclusions of the cost-benefit analysis to this Statement.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

At the time of the preparation of this statement, construction of the Zion Nuclear Power Station was over 80% complete. Therefore, a large portion of the labor and materials of construction for the plant have been committed (over \$400,000,000). All the labor and any nonsalvageable materials thus far committed (i.e., concrete, reactor structure and buildings, etc) must be considered as irreversibly committed. No irreversible or irretrievable commitments of air, land, or water resources are evident.

Construction and operation of the Station will temporarily (30-40 years) remove from use for any other purpose the land within the fenced enclosure, including the Station's lake front. After about 40 years of operation the only important, irreversible commitments of resources will be: 1) the nuclear fuel consumed, about 80 metric tons of uranium-235; 2) some structures and equipment which are, in essence, irretrievable due to practical aspects of reclamation and/or radioactive decontamination; and 3) that small amount of land required for the safe disposal of item 2).

At the end of the operating life of the Station, it will be decommissioned. Decommissioning involves removing and reclaiming fuel, decontamination or removal of equipment and waste materials, and sealing of the reactor structure. There is available experience on procedures for dismantling a reactor facility. If necessary, the entire Station site could be restored to its original condition by removing all equipment and razing the buildings. The value of the land thus made available for other uses probably would not justify the added expense. The degree of dismantlement will be determined by the intended future use of the site, which will involve a balance of health and safety considerations, salvage values and environmental effects.

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

X. THE NEED FOR POWER

The Station has a rated output of 2200 million watts electrical (MWe). This Station, along with several other newly built or proposed nuclear facilities, is scheduled to become a major part of the future Commonwealth Edison electrical generating system. The applicant states that these nuclear stations will provide economical, cleanly produced large power capacity while minimizing detrimental effects on the environment.

The applicant's system, through its own generating capacity and diversity interchange and firm purchase agreements, supplies the electrical energy for approximately 7.8 million people in the northern part of Illinois (including the greater Chicago area).

Like most major power generating systems in the nation, this system is presently involved in a rapid, base capacity expansion program. Table X-1 shows the proposed additions and retirements to the applicant's generating system for the years 1972-1980. This table shows the addition of Zion Unit 1 in 1972, and Zion Unit 2 in 1973. It now appears most probable that both startup dates will be delayed.

The actual peak load for 1971 was 10,943 MWe. Table X-2 shows the 1971-1980 anticipated capacity, load, and reserve margins for the applicant's system, including the output from the nuclear units at Quad-Cities, Zion and the proposed LaSalle County Station. The bracketed information in Table X-2 is the staff's assessment of the situation if the Zion Station units were not used.

The reserve margins for the years 1971-1974 with the Zion Units included are approximately equal to the 14% reserve the applicant desires.¹ However, without Zion Station in service the 1974 reserve is projected to be only 4.5%. When reserve margins fall below reasonable levels, there is inadequate capacity to meet peak loads, and brownouts could result.

The applicant is an active participant in several regional power agreements and regularly purchases or sells power through firm purchase agreements and diversity interchanges. Present increases in power demands are such that within 2 years of startup of a new power station (which takes 4 to 5 years to construct) all the power produced by the new station is required within the owner's system just to meet the peak demands of the system. A review of the actual peak loads (system is summer peaking) for the years 1966-1970 and the anticipated peak loads for the years 1971-1976² indicate the demand could increase

Estimated peak load for 1976 is 12,000 MWe.

Table X-1. Commonwealth Edison Planned Addition and Retirement Program 1972-1980*

<u>Planned Generator Additions</u>			
<u>Year</u>	<u>Station</u>	<u>Type</u>	<u>Net Winter Capability MW</u>
1972	Quad Cities 1	Nuclear	809
1972	Quad Cities 2	Nuclear	809
1972	Zion 1	Nuclear	1100
1972	Powerton 5	Fossil	840
1973	Zion 2	Nuclear	1100
1976	Powerton 6	Fossil	840
1976	Various	Peaking	400
1977	Station M 1 and 2	Fossil	1000
1977	LaSalle County 1	Nuclear	1078
1977	Various	Peaking	300
1978	Station M 3	Fossil	500
1978	LaSalle County 2	Nuclear	1078
1978	Various	Peaking	400
1979	Station A 1	Nuclear	1100
1979	Station M 4	Fossil	500
1980	Station A 2	Nuclear	1100
1980	Station B 1	Nuclear	1100
<u>Planned Unit Retirements**</u>			
1972	Waukegan 1, 2 and 3	Fossil	101
1974	Powerton 1 and 2	Fossil	126
1975	Powerton 3	Fossil	119
1976	Powerton 4	Fossil	119
1976	Calumet 7	Fossil	121
1976	Waukegan 5	Fossil	129
1977	Dixon 4 and 5	Fossil	119
1977	Crawford 6	Fossil	94
1978	State Line 1	Fossil	206
1979	State Line 2	Fossil	150
1980	Sabrooke 1, 2, 3, 4	Fossil	152
1980	Ridgeland 2	Fossil	169

*System Planning Department Memo, CECO, 12/23/71.

**Retirements are planned in October of the year indicated.

Table X-2. Anticipated Capacity, Load and Reserve Margins
Through 1980*

	<u>Capacity (MWe)</u>		
	<u>Thermal Generation</u>	<u>Net Purchases (Sales)</u>	<u>Total Dependable Capacity</u>
1971	12,161	700	12,861
1972	15,152 (14,052)	(130)	15,022 (13,922)
1973	16,140 (13,940)	140	16,280 (14,080)
1974	16,190 (13,990)	914	17,104 (14,904)
1975	16,070 (13,870)	1,224	17,294 (15,094)
1976	17,118 (14,918)	1,284	18,402 (16,202)
1977	18,053 (15,853)	1,234	19,287 (17,087)
1978	17,940 (15,740)	594	18,534 (16,334)
1979	18,804 (16,604)	624	19,428 (17,228)
1980	19,724 (17,524)	624	20,348 (18,148)

Estimated Annual Load Growth (MWe) and Reserves

<u>Year</u>	<u>Peak Load</u>	<u>Incr. Over Previous Year</u>	<u>Capacity</u>	<u>Reserves</u>	<u>Z</u>
1971	11,110	1,083	12,861	1,751	13.6
1972	12,190	1,080	15,022 (13,922)	2,832 (1,732)	18.8 (12.4)
1973	13,180	990	16,280 (14,080)	3,100 (900)	19.0 (6.4)
1974	14,230	1,050	17,104 (14,904)	2,874 (674)	16.8 (4.5)
1975	15,340	1,110	17,294 (15,094)	1,954 (-246)	11.3 (-1.6)

Table X-2 (Continued)

1976	16,540	1,200	18,402	1,862	10.1
			(16,202)	(-338)	(-2.1)
1977	17,760	1,220	19,287	1,527	7.9
			(17,087)	(-673)	(-3.9)
1978	19,060	1,300	18,534	-526	-2.8
			(16,334)	(-2,726)	(-16.7)
1979	20,410	1,350	19,428	-982	-5.0
			(17,228)	(-3,182)	(-18.5)
1980	21,820	1,410	20,348	-1,472	-7.2
			(18,148)	(-3,672)	(-20.2)

Note:

All Bracketed Information is AEC Staff Evaluation of Condition if neither Zion Unit is added to the Applicant's System.

*LaSalle County Station Preliminary Safety Analysis, Amendment 3.
Commonwealth Edison Co., 1971.

from 7300 MW in 1966 (actual) to 16,540 MW (estimated) in 1976. This represents an increase of 127% in a 10-year period or approximately 8.5% per year. If power demand continues to increase at this rate, it would be necessary to double the present generating capacity of the entire system by the early 1980's to meet the projected demand. Even if the demand increases at a slower rate, the output of the Zion Station would still be essential to the applicant's system.

As an example of the reserves that might be available from adjacent utilities, two recent letters from the Federal Power Commission (FPC) are summarized here. In a March 3, 1972, letter from T. A. Phillips to Lester Rogers relative to the Point Beach Nuclear Plant, the FPC indicated that the summer 1972 reserves for the Wisconsin - Upper Michigan System (WUMS) would be 1187 MW, assuming Point Beach Units 1 and 2 are operating. With only Point Beach Unit 1 operating, the WUMS reserve margin is 690 MW. Referring back to Table X-2, it can be seen that without Zion Station operating, the applicant's reserve margin is only 1732 MW in 1972 and 900 MW in 1973 (12.4% and 6.4% respectively). In the March 22, 1972, letter from Mr. Phillips to Mr. Rogers relative to the Quad Cities Nuclear Power Station, the FPC indicated that the summer of 1972 reserves in the Mid-America Interpool Network (MAIN), would be 2505 MWe (8.9%) without Quad Cities and Zion in operation, but with Point Beach Units 1 and 2 (each at 497 MWe) in operation. FPC's Bureau of Power also indicated that the MAIN pool criterion of 14% reserves may be low. Again, the power pool does not appear to have sufficient reserves to meet the applicant's needs.

The Station, which is in the northern part of the applicant's service territory, is planned to produce approximately 13% of the total system capacity by 1975. This represents enough generating capacity to supply 75% of the needs of the northern area of the applicant's system. The combination of the Zion Station and the Waukegan Station (fossil-fueled) approximately 4 miles south of the Zion Station, is expected to provide sufficient generating capacity for the northern area of the applicant's system and to eliminate the need for massive power transmission into the area for the immediate future.

It is the conclusion of the staff that the generating capacity of this Station is needed by the applicant in order to meet the public demand for power and assure adequate system reliability via sufficient reserve margins. It is also concluded that the presence of this

generating capacity in the northern area of the applicant's service territory would effectively balance the demand and generating capacity in the area. This proposed action appears to be both economically sound due to the elimination of massive transmission requirements with its attendant losses, and environmentally justified by virtue of fulfilling the need for additional generating capacity in the area which receives the benefits of the proposed action.

The Federal Power Commission in its review of the draft of this Statement states that "the staff of the Bureau of Power concludes that the electric power output represented by Zion Units Nos. 1 and 2 is necessary to meet the applicant's projected load and to provide its reserve margin capacity in accordance with its stated criteria."
(Appendix G)

REFERENCES FOR SECTION X

1. Zion/ER, Supplement I, November 1971.
2. Zion/ER, page 2.1-35, May 1971.

**XI. ALTERNATIVES TO PROPOSED ACTION AND COST-BENEFIT ANALYSIS
OF THEIR ENVIRONMENTAL EFFECTS**

A. SUMMARY OF ALTERNATIVES

The alternatives considered here can be divided into two classes. First to be discussed are alternatives to the Station itself, the full acceptance of which would require abandonment of the Station. These include the purchase of power equivalent to that expected from the Station; extensive use of older fossil-fueled plants scheduled for retirement; construction of a nuclear plant at another site; construction of a fossil-fuel plant either at another site or at the Zion site. Next to be discussed are modifications to the Station design as proposed by the applicant. These modifications might reduce the environmental impact of Station operation.

The specific alternatives which will be considered here are:

- (a) Abandoning the Zion Station, and obtaining equivalent power both from the applicant's existing equipment, and by power purchases from other systems while another plant at a new site is being planned and constructed.
- (b) Converting Zion to a fossil-fueled plant.
- (c) Using cooling towers to dissipate waste heat to the atmosphere rather than directly to the lake.
- (d) Using a cooling pond or a spray cooling system, rather than discharging waste heat directly to the lake.
- (e) Alternative means of cleaning the condensers.

Considerations regarding alternative design or operation of components of the proposed cooling system are presented elsewhere in the Statement and are not discussed in this section.

1. Abandoning the Zion Station

Although environmental factors were not significantly considered in the selection of the Zion site, its location is, in general, compatible with the proposed design. If the Station site were not used, another plant would eventually have to be built on another site to meet projected power needs, duplicating environmental effects of site preparation that have already occurred.

Since the availability of purchased power from other systems is very limited, part of the projected load growth, until a new plant was completed, would have to be provided by additional power production from the applicant's existing plants, which are primarily fossil-fueled. Extensive use would have to be made of older plants, which are inefficient and have little in the way of emission control equipment. Consequently, discharges of fly ash, sulfur dioxide and nitrogen oxides to the atmosphere would be considerably increased. Table XI-1 gives the applicant's projected figures in millions of pounds of sulfur dioxide and particulates which would result, year by year, from a delay in the operation of Zion Station.¹ Furnace ash at a rate of an additional 750,000 tons/yr would be added to the region's solid waste disposal problem.

In terms of costs, the use of older less efficient fossil units and purchased power rather than a new nuclear unit would result in a penalty of about \$70 million per year of delay of Zion Station.² This cost would ultimately be borne by the industrial, commercial and residential customers of the applicant's system.

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

Over \$400 million in construction costs have already been expended. Little of this cost would be salvaged under this alternative. Nearly all of the environmental impact associated with construction of the Station has already taken place and would necessarily be repeated if an equivalent plant were built at another site.

TABLE XI-1

Estimated Increase in Annual Emissions From Fossil-Fueled Stations
To Meet Anticipated Loads If Zion Station Is Delayed¹

	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>
Zion Delay	<u>Sulfur Dioxide, million lb</u>				
1 year	80	270	300	90	70
2 years	80	340	580	350	190
3 years	80	340	640	640	470

TABLE XI-1 Cont'd

	<u>Particulates, million lb</u>				
1 year	4	12	16	3	2
2 years	4	16	30	14	5
3 years	4	16	33	24	12

2. Alternative Fuels

Fossil fuel plants have some environmental advantages over current nuclear plants. The thermal efficiency of fossil fuel plants approaches 40 percent compared to 33 percent for nuclear plants. In addition, about 15 percent of the waste heat is released through the stack with other combustion products. Thus, the heat release to the condenser-cooling water is only about 60 percent of that for a nuclear plant.

The emission of radioactivity to the environment, while small compared to natural background levels, is much less for oil-burning plants. Radioactive emissions from coal-burning plants vary with the source of the coal; in some cases the level of emissions compares with nuclear plants.

On the other hand, the combustion of coal or oil produces objectionable by-products, particularly dust, sulfur dioxide and nitrogen oxides which pollute the air. Natural gas, much better in this respect, is not available as power-station fuel in this region. Because of the growing national shortage of natural gas, this situation is expected to persist. Other environmental disadvantages associated with the use of coal or oil are the very large amounts of fuel which must be transported and stored. For a normal 80 day supply, a pile of coal about 100 feet high and 15 acres in area would be needed. Oil storage tanks would similarly require considerable area.

The Zion Station was designed and constructed for the use of nuclear fuel, and a change to fossil fuel could not now be made without major changes in equipment. This would involve first, substantial new construction and, second, the loss of some of the capital cost which has already been incurred for the nuclear plant. The capital cost of the present construction is estimated to be \$424 million upon completion, and the Station is presently nearing the completion point.

While it is technically possible to convert the nearly completed nuclear station to a fossil-fueled station, the modification would require about five years to complete. During this time the delay costs and lack of adequate reserves discussed in the preceding subsection would apply.

Scrapping the nuclear equipment and substituting fossil equipment would result in the estimated additional capital cost of between \$447 million and \$497 million, depending on the plant design details.

The staff judges that the probable overall environmental impact expected from the operation of either fossil-fuel alternative would exceed that of the nuclear station now under construction. The probable impaired service to customers during the delay period and the large economic penalty to the applicant are considered unwarranted.

3. Alternative Heat Dissipation Systems³⁻¹⁰

As indicated in Section V above, assuming implementation of suggestions made by the staff in this Statement, adverse impact on aquatic biota expected from operation of the Zion Station's once-through cooling system is not considered sufficient to warrant requiring the expense and/or delay which would result from backfitting with alternative cooling systems (most of which would produce adverse impacts of their own). Nonetheless, the staff has given consideration to alternatives which would, if adopted, eliminate or sharply reduce whatever potential exists for such an impact. The alternatives considered are cooling towers, cooling ponds, and spray cooling.

a. Cooling Towers

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

In a wet cooling tower, all of the heat rejection takes place by direct contact of the cooling water with the air. Most of the heat is dissipated by evaporating a portion of the circulating water, while the remaining heat is lost as sensible heat transfer to the air.

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

(1) Dry Cooling Towers

The heat rejection performance of the tower and the thermodynamic performance of the turbine are the two most significant interdependent factors in the operation of a dry-type condensing system. The return temperature of a dry tower can, at best, approach the "dry-bulb" air temperature which is always equal to or higher than the "wet-bulb" temperature (the lowest temperature to which water can be cooled by evaporation into the surrounding environment). Thus in hot weather, the water returning to the condenser is hotter than it would be if any other method of cooling were used. This in turn results in an increased turbine exhaust pressure. Exhaust pressures as great as 10" Hg can occur in hot weather and 5" Hg is the limit of exhaust pressure recommended by turbine manufacturers. It is estimated that turbines designed to operate at high exhaust pressures will not be commercially available before 1976.³

The advantages of dry cooling towers are:

1. Elimination of fogging, mist and icing.
2. Eliminates water problems such as: availability, evaporative loss, blowdown, heat rejection to lakes, rivers, and ponds.
3. Less land area required than for spray ponds, spray canals or quiescent cooling ponds.

The disadvantages are:

1. Capital costs are substantially greater than other methods.
2. High maintenance costs.
3. Large volumes of air must be circulated.
4. Decreased plant output at high dry-bulb temperatures.
5. Larger land area required than wet towers.
6. Susceptible to damaging winds and tornadoes.

Extensive experience does not now exist for dry towers appropriate to large generating stations like Zion Station. The largest dry tower, built in the Union of South Africa, serves a fossil plant of 200 MWe capacity.

(2) Wet Mechanical-Draft Towers

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

The advantages of mechanical-draft wet towers are:

1. Positive control over air supply.
2. Close control of return cold water temperature.
3. Generally low pumping head.
4. Ambient relative humidity has a minimal effect on tower performance.
5. Lower capital cost than a natural-draft tower.
6. Lower tower height than with natural-draft towers.
7. Requires less land area than ponds, spray cooling and dry towers.

The disadvantages are:

1. Subject to mechanical failure.
2. Subject to recirculation of the humid exhaust air.
3. Operation and maintenance costs are higher than natural-draft towers and quiescent cooling ponds.
4. May cause localized icing and fogging.

5. Requires blowdown to prevent salt buildup.
6. May cause deposition of salts on surrounding land from drift.
7. Causes reduction in plant efficiency.
8. Susceptible to damaging winds and tornadoes.

(3) Wet Natural-Draft Towers

This type of tower, also called a hyperbolic tower because of its shape, is generally from 250-550 feet in diameter at the base and 200-300 feet tall. In such a tower air moves upward as a result of the chimney effect (natural draft) created by the difference in density between the warm moist air inside the tower and the colder, denser air outside.

The advantages of wet natural-draft towers are:

1. Eliminates mechanical or electrical components of fans.
2. Lower maintenance costs than mechanical-draft towers.
3. Requires less land area than other towers, ponds and spray cooling systems.
4. Will rarely if ever cause surface fogging and icing in level terrain areas.

The disadvantages are:

1. Great tower height necessary to produce draft results in massive structures.
2. Precise control of outlet water temperature is more difficult than with mechanical draft towers.
3. May cause deposition of salts on surrounding land from drift.
4. Causes reduction in plant efficiency.
5. Can generate large airborne vapor plume which may occasionally extend for 10-20 miles in the windward direction.
6. Requires blowdown to prevent salt buildup.

7. Susceptible to damaging winds and tornadoes.

b. Cooling Pond

A cooling pond is a body of water through which the warmed condenser water is pumped to allow cooling prior to recirculation through the condenser. The heat is dissipated by surface evaporation, radiation and conduction. Large amounts of surface area, 1.5-3 acres per MWe, are required to cool the water before it returns to the condenser.

The advantages of cooling ponds are:

1. Lower operating cost than cooling towers.
2. Requires little maintenance.
3. Virtually free of mechanical and electrical devices.
4. May provide recreational benefits.
5. Not susceptible to damaging winds.

The disadvantages are:

1. Require large land areas (1.5 to 3 acres per MWe).
2. May cause adverse effects to underground water resources unless isolated by natural or artificial impermeable lake bed.
3. Will cause localized fogging and icing.
4. Requires blowdown to prevent concentration of dissolved solids.

c. Spray Cooling

(1) Spray Pond

Spray ponds operate on the same principle as cooling ponds except that surface evaporation is enhanced by spraying the warm water into the air over the pond. The performance of the spray pond is a function of the design of the spray nozzles and their placement.

Advantages of spray ponds are:

1. Requires much less land area than a cooling pond.

2. Lower pumping costs than for cooling towers.
3. Requires less maintenance than mechanical towers.
4. Not susceptible to damaging winds or tornadoes.

The disadvantages are:

1. Larger potential for mechanical and electrical failure than a cooling pond.
2. May cause interference with underground water resources.
3. Will cause localized fogging and icing.
4. Costs more than cooling pond.
5. Requires blowdown to prevent concentration of dissolved salts.

(2) Spray Canal

A spray canal is an elongated pond often several miles in length and 100 to 200 feet wide. The method of cooling is identical to a spray pond. Although less land area is required for a spray canal than for a spray pond, the land must be flat. The advantages and disadvantages are the same as for the spray pond. The canal should meander over a large region to minimize recirculation effects.

Table XI-2 compares the capital cost for various cooling methods as determined by several authors. The capital cost includes the price of the condenser, its associated pumps and piping, the heat rejection unit and its accessories. The figures do not include the cost of backfitting or loss of capability, which can exceed the cost of the system itself.

The values in the table were adjusted by the staff to reflect the costs for a 2200 MWe nuclear unit. Some of the papers quoted were written two or more years ago, and no cost escalation factor was applied to the figures. Thus the costs quoted are probably lower than they would actually be at this date. Dry cooling tower costs were not included since present-day turbine technology would prohibit their use for the Zion Station. The purpose of this table is to present a relative price comparison of the various alternative methods of cooling and not to present data for use in estimating the costs due to the imposition of an alternative at the Zion Station.

TABLE XI-2. Cost of Cooling Systems for a 2200 MWe Nuclear Plant.
The Figures Represent Millions of Dollars.

Cooling System	Tichenor ⁴	Dynatech ⁶	Woodson ³	Jensen ¹⁰
Once-Through	16.3	11.5	17.0	6.6-11.0
Cooling Pond	24.5	16.5	26.4	13.8-20.7
Spray Pond	27.3	17.8		
Natural-Draft Wet	39.2	25.3	38.5	20.7-29.9
Mechanical-Draft Wet	28.2	20.7	25.8	18.4-25.3

4. Environmental Impacts of Alternate Cooling Systems

a. Dry Cooling Towers

This method of cooling is perhaps the best from an environmental standpoint. Dry cooling towers have been used in Europe but have not gained widespread acceptance in the United States for large installations. The principal fabricators of large-capacity dry cooling towers are located in Europe. Because the higher turbine backpressure could result in a decrease of more than 10 % in electrical output, the use of dry towers could greatly increase the capital cost of the Station.

b. Wet Natural-Draft Cooling Towers

Five 350-ft. or three 500-ft. natural-draft cooling towers would be required to dissipate 15×10^9 Btu per hour of heat.¹¹ About 75% of the cooling is accomplished by evaporating 18,000 gallons of water per minute.

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

All of the evaporative cooling systems have a higher potential for creating extended vapor plumes and/or surface fogging and icing than does the once-through cooling proposed.¹² Operational experience both in the United States and in Europe has shown that natural-draft cooling towers have the lowest adverse meteorological impact of all evaporative cooling systems.^{12,13,14,15}

Because of their large size and the large quantities of water vapor discharged, concern has been expressed about the possibilities of weather modification such as fogging, precipitation, increased humidity and icing which might be produced by the towers. Since the total operating experience in this country is still relatively small, techniques for predictions of weather modifications are still in the formative state. Natural-draft cooling towers have been used for at least two decades in Europe, particularly in England. Dwyer¹⁶ has made a survey of European operating experience and has found little evidence of adverse weather modifications attributable to natural-draft cooling towers. Experience in the United States to date has not revealed any significant weather modification problems.^{12,13,16,17,18,19}

Due to the plume's momentum and buoyancy, the visible plume will usually rise well above the tower before leveling off and moving downwind. Under certain weather conditions, dispersion and large-scale eddies will move the base of the visible plume downwards. Adiabatic warming of the

descending air and mixing with the unsaturated air are usually sufficient to evaporate plumes from natural-draft towers before they reach the ground, at least in flat areas such as Zion.^{12,13,14,15,16,17,18}

Lake breezes are common at the site, especially in spring and early summer when Lake Michigan is cold compared with the land areas. A deep surface inversion (up to 300 feet) forms over the cool lake. Under lake breeze conditions, the effluent from the cooling tower will probably be caught in this very stable air layer and travel downwind for many miles with little mixing and evaporation. The base of this plume would be 350 to 600 feet above ground level as the plume moves inland. As this layer of stable air moves across the land, surface heating due to solar radiation would create a layer of turbulence and mixing that would grow thicker and eventually penetrate to the height of the cooling tower plume. The plume would then tend to evaporate rapidly as it descends due both to mixing with drier ambient air and adiabatic compression; however, isolated sections of the visible plume could occasionally be brought to the ground. In any event, visibilities in these evaporating puffs should be fairly good. However, since there are no cooling towers presently operating near the shore of a large lake, no observations exist upon which exact forecasts of the frequency of this type of surface fog can be made.

There has been only one reported instance of the plume from a natural-draft cooling tower returning to the ground.¹⁶

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

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

The applicant has developed a numerical model to predict the dimensions of the visible plume generated by cooling towers.²² This model predicts 3 to 40 hours of surface fog per year as a result of the plant with 300-foot towers. The distance of maximum frequency extends to about 12 miles downwind. For the shorter (350-ft.) units, the values are 15 to 75 hours at 9.3 miles.

even like visible plume-spread has not been observed, and it is not possible to predict the frequency of this type of surface fog.

The staff considers the above estimates of surface fogging to be conservative, since experience at operational cooling towers shows that the plumes rarely if ever reach the surface.^{14,15,16,17,18,19,21}

Some indication of the impact of the cooling towers near the Station is given by the observations of plume length and frequency at the Keystone (Pennsylvania) Plant. Bierman, *et al.*¹⁹ report results of a study at Keystone based on observations of the cooling tower plumes for a six-month period, February through July 1969. During this study, which included 144 individual observations, photographs of the towers were taken daily to explore the general characteristics of the plumes. The results showed that 81% of the time the plume evaporated to invisibility in the atmosphere; most of the remaining time it was absorbed in the overcast. The breakdown of the observations in the cases where it evaporated to invisibility (81%) was as follows:

- a) Plume length less than five tower heights (<1625 ft.) — 87%;
- b) Plume length five to fifteen tower heights — 10%;
- c) Plume length greater than fifteen tower heights (>1 mile) — 3%.

Only two of the three winter months, when long plume formation is most likely, were included in the survey.

The atmospheric conditions tending to produce cooling tower plumes are the same as those favoring the formation of natural fog and clouds. In general, however, because of their height, the towers release heat and vapor above the surface inversion which contributes to fog, while the plumes tend to rise above fog. Consequently, the most probable effect at the Station from the cooling towers is some enhancement of natural fog, particularly during the winter months when humidity conditions are nearest saturation.

A much more frequent atmospheric impact of wet natural-draft tower operation will be the formation of extended plumes aloft. Plumes longer than 10 miles have been observed.^{12,16,17,19} Operating experience with natural-draft cooling towers indicates no measurable enhancement of precipitation attributable to the operation of the towers. A study by IIT Research Institute²¹ showed a negative correlation between rainfall measured at a number of measuring stations within 20 miles of the Keystone Plant after the start of tower operation. Increases in humidity at upper altitude levels beyond the visible

plumes have been measured with aircraft. Unfortunately, the state-of-the-art in cloud physics prohibits exact statements regarding rainfall potentials due to cooling tower plumes.¹⁰

c. Hot Mechanical-Draft Towers

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

The applicant's consultant has estimated the frequency of surface fog around the Station from operation of seven mechanical-draft towers, 60 ft. high, 90 ft. wide and 400 ft. long, to be 630 hours per year, and that this would occur on 100 to 150 days per year.²² The maximum frequency at any one place in the region from 1.5 to 2.5 miles north of the site would be 90 hours/year. Most of these extended plumes would occur during the cooler months. Typical visibilities in tower fog would be 200-600 feet.

The staff considers these estimates to be somewhat high due to the conservative nature of the assumptions used. Nevertheless, mechanical-draft cooling tower systems are the poorest choice for the site from the standpoint of fogging and icing.

d. Cooling Pond

Operational experience with the Dresden Nuclear Power Station (Illinois) cooling pond during the winter indicates that such ponds do create significant amounts of steam fog during cold weather (air temperature less than 10°F) over the pond itself and over the land immediately adjacent to the pond. However, the fog is sufficiently thin and infrequent (1000 feet from the pond that it should pose no hazard to traffic at this distance).

A cooling pond for waste heat dissipation at Egan would require a pond greater than 3000 acres in surface area. Such a pond probably could not be located adjacent to the site, without disruption of the proposed port expansion plans and Lake Front Improvements plans. An area several

miles west of the site was investigated by the applicant as a possible location for such a pond. The proposed site would displace a number of residences and farms. Finding right-of-ways for the required piping could prove difficult. Because of the elevation differential, open canals are not considered feasible. Therefore, a substantial amount of pumping power would be required.

e. Spray Cooling

Land area requirements could be minimized in the case of spray cooling by using spray canals. To increase thermal efficiency of a spray canal system the canal should be long and winding. A spray canal 12,000 to 14,000 feet long, 170 to 230 feet wide, has been proposed by the applicant for the Quad Cities Nuclear Station (1612 ESB).²⁰ The spray nozzles will be placed in four rows in the canal. The land area required is approximately 460 acres.

The visible plume created by the spray canal would contain drift water droplets in addition to drops from condensed vapor. These drift particles will tend to be larger than those produced by evaporation and would increase considerably the wetting and icing potential. Spray canals have a high potential for creating surface fogging.

In contrast with cooling towers and ponds, there has been little operating experience with large spray cooling systems, especially in winter, the season of largest impact potential. A small spray system has been operated for two winters in conjunction with a New Hampshire fossil-fueled electric generating plant. No serious meteorological problems were experienced. Canal-produced fogs, in contrast to several fogs in that area, are thin and do not reduce visibilities over nearby highways to less than 100 feet. Since no significant environmental problems were observed during the past winter, the New Hampshire utility is now expanding the spray canal to dissipate the entire heat load from the fossil-fuel plant.

The applicant started operation of a spray canal system, used to supplement the cooling of a 1275 acre cooling lake, at Dresden Station in August 1971. The Dresden canal has about one-fourth the heat dissipation capacity that would be required at Zion Station and is presently the largest operating spray canal system known to the staff. Experience at Dresden during the summer months did not indicate any environmental problems due to fog from the spray canal.

Based upon experience at Dresden and New Hampshire, the staff concludes that some light fog (visibilities better than 100 feet) can be expected

up to 1000 feet from the canal near dam on cold winter mornings (temperature less than 10°F). It is expected that the fog would be less dense and less persistent than those which would occur from wet mechanical-draft cooling towers, due to the larger area of heat and moisture transfer. It is also concluded that within 600 feet of the spray canal, deposits of one-fourth to one-half inch of light rime ice can be expected on fences, poles and vegetation.

Another alternative at the Station is the use of a 300 acre area in Lake Michigan for a spray pond. This would, however, impose a cur-face restriction (an area of exclusion for public boating), but might be a preferred solution to reducing land in the proposed State park or locating the alternate cooling system further away from the Station.

f. Summary

It is the conclusion of the staff that imposition of any of the aforementioned cooling alternatives would be very expensive at this point in time (including the cost of backfitting), and that on the basis of available evidence, such imposition would not be warranted by the postulated environmental impacts of the present system. Further, the staff concludes that alternate system designs and modifications can and should be incorporated into the present system to lessen or eliminate any unacceptable environmental impacts which are found to exist after operation commences.

The staff also concludes that the potential adverse effects of any of the more economic alternative cooling systems would create impacts to the area that would be significant to the present and planned activities of the area.

5. Alternative Condenser Defouling

Chemical waste discharges at the Station will be minimized by using the proposed mechanical cleaning (ASHKAP system) technique, as opposed to a chemical condenser defouling system. Chlorination of the plant service water will, however, result in minor releases of chlorine to the lake. The free chlorine could be further reduced by introducing the plant service water discharge into the cooling water flow simultaneously with mechanical cleaning of one of the condenser sections. Thus, any residual chlorine would react with the freed condenser slime, and little free chlorine would reach the lake.

equipment and the cost of the same is not considered as a significant factor in the selection of the alternative cooling system.

The staff concludes that significant adverse effect due to chemical discharges is not expected (see also Section XII.K.). Results, however, will be very much dependent upon management control to insure that inadvertent chemical additions do not take place.

B. COST-BENEFIT ANALYSIS

This section reviews the beneficial and detrimental effects of the Station being built and its alternatives as a basis for a cost-benefit comparison.

1. Economic Benefits of the Station

- a) Each of the Station's two nuclear reactors is designed to provide approximately 1100 MW of electrical capacity. The estimated output of electrical energy by both units together is 14 billion kilowatt hours per year.
- b) Operation of the Station will create approximately 200 jobs and will result in an annual payroll of about \$2,000,000. Construction of the Station required a peak work force of approximately 1800 persons and generated a total payroll estimated at \$115,000,000.
- c) The annual tax revenues resulting from the operation of the Station is estimated to be about \$5,200,000/year.

2. Environmental Benefits

- a) A possible environmental benefit is the increase in sport fishing near the condenser cooling water discharge structures. In view of the fact that the area immediately south of the Station is already used for public recreation and that the area to the north is proposed for use as a public recreational area in the future, it is possible that such could be of benefit and interest to the public.
- b) The operation of the Zion Station should allow the applicant to continue the program of planned retirement of several obsolete and environmentally undesirable fossil fueled stations.

3. Economic Costs

- a) Construction of the Station is estimated to require the investment of about \$423,000,000 in materials and labor.

4. Environmental Costs

- a) Construction of the Station has resulted in the diversion of approximately 250 acres of lakefront land and a 6 mile long parcel of inland area for the siting of the Station and transmission line right-of-ways, respectively.
- b) Small concentrations of chemicals will be released to the receiving waters of Lake Michigan. No significant adverse aquatic impacts are expected as a result of these releases (see also Section XII.K.). Large quantities of heated water will also be released to Lake Michigan. The combined areas of both reactor plumes enclosed by the isotherm which is 3°F above ambient temperature is calculated by the applicant to be about 28 acres. It is not expected that thermal discharges into Lake Michigan from the proposed once-through cooling system will produce significant damage other than local to the aquatic ecosystem (see also Section XII.K.). Small amounts of liquid radwaste will be released into Lake Michigan. The integrated radiation dose due to the ingestion of Lake Michigan water via the public water supply systems within 50 miles of the Station is calculated to be 22.9 man-rem/year, distributed among the approximately 6.6×10^6 persons supplied by these systems.
- c) Radionuclides released to the atmosphere from the gaseous radwaste system would result in a calculated integrated radiation dose of 4.6 man-rem/year, distributed among the approximately 6.3×10^6 persons who reside within 50 miles of the Station.
- d) Due to the vast quantity of water being withdrawn, used and then returned to Lake Michigan, and the entrance velocity at the intake structure, it is possible that an unacceptably large quantity of fish will become entrapped in the Station's forebay and that modification of the intake structure will be required.

A summary by the applicant of economic and environmental aspects of alternatives is given in Table XI-3. The applicant's information supporting Table XI-3 is contained in the Zion/ER, Supplement II, December 1971. The staff is of the opinion (see Section V.C.) that the applicant underestimates the aquatic biological impact stated in Table XI-3.

Table XI- 3 SUMMARY OF REGIONAL ENVIRONMENTAL CONDITIONS, COSTS, AND OTHER CONSIDERATIONS

Conditions and Characteristics	Present Zion Environment	I Present Design - Nuclear Power Plant, Off-Shore Discharge	II Addition of Wet Mechanical Draft Cooling Towers to Present Design	III Addition of Natural Draft Cooling Towers to Present Design	IV Addition of Wet Mechanical Draft Cooling Towers and Upgrade Radiant Heat Control Systems	V Convert Zion into a Pressurized Plant
Capital Investment to date		Unit 1 \$230,000,000 Unit 2 100,000,000 \$330,000,000	\$423,040,000	\$423,040,000	\$423,040,000	\$423,040,000 less savings
Incremental Capital Investment From Current Plant			\$117,000,000	\$124,000,000	At least \$125,000,000 for cooling towers and maximum internal recycle of all piping liquid. Additional costs for 10-15% retention.	\$447,000,000 or \$407,000,000 plus \$120,000,000 for replacement power during conversion.
Water Quality and Quantity	Total surface area - 22,400 sq mi (1.43 x 10 ⁷ acres). Volume of water - 1,400 cu mi (2.57 x 10 ¹⁴ cu ft). Surface area - 10-100 ft depth - good water quality except ammonia nitrogen and total phosphorus. Surface currents are variable, most values within range of 0.20 to 0.30 ft. Average monthly water temperature at Waukegan ramp from 34 F in winter to 63 F in August.	Station cooling water intake - 1,530,000 gpm - 3.41 x 10 ³ cu ft. (AT - 20 F at full flow) Maximum heat rejection 10 x 10 ³ Btu/hr. Less than 8 minutes at temperatures exceeding 4 F above ambient. Area within 5 F ocean temperature contour is about 9.1 acres. Bulk phase extends about 1,300 ft.	Consumptive loss of water from Lake Michigan, 66 cfs (1% of diversion of 3,300 cfs permitted to State of Illinois). Only minor changes in some chemical properties of cooling water in a relatively small area near Zion site.	Consumptive loss of water from Lake Michigan, 66 cfs (1% of diversion of 3,300 cfs permitted to State of Illinois). No other changes anticipated from present environment.	Consumptive loss of water from Lake Michigan, 66 cfs (1% of diversion of 3,300 cfs permitted to State of Illinois). No other changes anticipated from present environment.	If present diffuser system is used, same as I. If cooling systems are implemented, same as II-IV.
Atmosphere (Physical and Chemical)	Air quality - pollutant levels below national primary ambient standard for SO ₂ and slightly above for particulates.	No change from present environment expected in either quality or meteorology.	Increase in fog, up to about 100 hr/yr. Cooling tower plumes visible up to 10 miles. No change from present environment in terms of air quality.	Increase in fog, up to about 100 hr/yr. Cooling tower plumes visible for up to 10 miles. No change from present environment in terms of air quality.	Increase in fog, up to about 100 hr/yr. Cooling tower plumes visible for up to 10 miles. No change from present environment in terms of air quality.	140-million lb SO ₂ emitted per year. 20-million lb particulates emitted per year. Meteorology same as nuclear power options. Same as nuclear power options.
Soil and Land Use	Soils - Most abundant are silty and yellow sand; Spots of red, brown, yellow sand, brown, black; Commercial (more than 8 mi offshore); Marine, yellow sand, black. Climate - Climate is majority of precipitation. Precipitation is 40-50 in. Precipitation is 40-50 in. Precipitation is 40-50 in.	Soils - Expected to avoid high ocean temperature regions. Precipitation - Effects of enrichment. Soils and Precipitation - No effect on existing soils of 10-acre area around discharge.	No change from present environment is expected.	No change from present environment is expected.	No change from present environment is expected.	Same as nuclear power options.
Vegetation	Relatively flat site covered mostly by scrub and with patches of pine and oak in the western portion.	Adverse effects are negligible.	Significant adverse impact.	Overpower adjacent natural landscape.	Significant adverse impact.	Construction of a stack for elevated discharge of combustion products would detract from landscape.
Recreation (Land Utilization)	1,851 acre Waukegan Beach State Park to south: 1,100,000 visitors annually from 1960 to 1968. City park north of Zion and plans for state-park development as part of national shore & recreation plan.	No change from present environment.	Recreation potential of park may be detracted due to fog, clouds, odors, and noise from cooling units there itself.	Detracts from recreation potential of adjacent state park.	Recreation potential of park may be detracted due to fog, clouds, and noise from local cooling units.	

Table XI-3 (continued)

VI Cost of Operation of 2000	VII Apportionment - Provide for Additional Generating Capacity	VIII Addition of Dry Mechanical Draft Cooling Towers	IX Addition of Spray Cooling Pond Water Plant	X Addition of Cooling Lake	XI Addition of Spray Cooling in Lake Michigan
\$423,040,000	\$423,040,000 less change	\$423,040,000	\$423,040,000	\$423,040,000	\$423,040,000
		\$423,040,000			
State is present conditions for operation of units that to which cost added of delay.	No inputs of water heat to lake. State is present conditions.	Detailed environmental evalua- tion was not made. Alternative was rejected on the basis of cost.	Detailed economic and environ- mental evaluation was not made. Land is not available on or near present site for spray cond.	Detailed economic and environ- mental evaluation was not made. A 2,000-acre cooling pond would be required and only land poten- tially available is located south west of site. Foundation and tanks would be disturbed, right- of-way for cooling water intake and return pipes are not available, and loss of capability to station is probably greater than other expensive cooling alternatives.	Detailed economic and environ- mental evaluation was not made. Total disturbance of 200 acres of Lake Michigan to power generation would be required. Alternative was rejected on the basis of due to physical location area.
State is present conditions in this area.					
State is present conditions.					
State is present conditions in this area.					
State is present conditions.	State is present conditions.				

A summary of the economic costs involved in the implementation of the alternatives is presented below. These costs are the best estimates provided by Commonwealth Edison for capital investments, for capital investment equivalents for loss of capability, and for added operating costs.

Alternative I. Present Nuclear Power Plant Design With Submerged, Offshore, High-Velocity Jet Discharge System and Minimal-Emission Radioactive-Waste-Control System

Unit 1	\$230,860,000
Unit 2	<u>192,780,000</u>
	\$423,640,000

Alternative II. Addition of Wet Mechanical-Draft Cooling Towers to Present Plant (three cylindrical, wet, mechanical-draft towers, 390-ft. diameter by 250 ft. high)

Wet Mechanical-Draft Cooling-Tower Installation	\$72,000,000
Loss of Capability and Operating and Maintenance Cost	<u>45,000,000</u>
	\$117,000,000 +
Base cost of	\$423,000,000

Alternative III. Addition of Wet Natural-Draft Cooling Towers to Present Plant (ten wet natural-draft towers, 300-ft. diameter by 250 ft. high)

Natural-Draft Cooling-Tower Installation	\$ 79,000,000
Loss of Capability and Operating and Maintenance Cost	<u>45,000,000</u>
	\$124,000,000 +
Base cost of	\$423,540,000

Alternative IV. Addition of Wet Mechanical-Draft Cooling Towers and Ultimate Radioactive-Waste Treatment System

No estimates are available for the cost of this alternative since there is no power plant experience with conceptual designs for elimination of Kr⁸⁵ release. At least \$117,000,000 would be

required to install and operate wet mechanical-draft cooling towers, and \$3,900,000 would be needed for maximum internal recycle of all plant liquid. There would be added costs for the Kr⁸⁵-removal system. These costs would be above the base cost of \$423,640,000.

Alternative V. Conversion of Zion to a Fossil-Fuel-Fired Plant

Capital Costs of Installing Two
1100-Mw Saturated Steam Boilers \$447,000,000 +
Base cost \$423,640,000
less salvage

Capital Costs of Installing Four
Topping Turbines of 200-Mw Each
and Two 1500-Mw Superheated Steam
Boilers \$497,000,000 +
Base cost \$423,640,000
less salvage

Purchase of Replacement Power for
5 Years \$350,000,000

Alternative VI. Delay in Operation of Zion Units

Under this alternative it was assumed that the Zion nuclear power station was delayed in its operation by 1, 2, and 3 years. The projected annual kilowatt-hours might be filled with existing capacity and firm purchases, but there is no guarantee that peak loads can be met or required maintenance done. The additional costs for fossil fuels for 1-, 2-, and 3-year delay are estimated to be almost \$3,000,000, \$15,000,000, and \$39,000,000 respectively. If requirements, including peak load requirements, are met by purchased power, the added cost is estimated to be \$70,000,000 annually.

Alternative VII. Abandon the Zion Nuclear Power Station

The costs of this alternative are at least equal to the construction costs of the Station and the excess costs resulting from the short-run unavailability of capacity and higher energy costs thereafter, less any recoverable values from the plant and equipment.

Alternative VIII. Addition of Dry Mechanical-Draft Cooling Towers
(twenty dry mechanical draft towers, 78 ft. high,
150 ft. wide, and 1200 ft. long)

Dry Mechanical-Draft Cooling- Tower Installation	\$343,000,000
Loss of Capability and Operating and Maintenance Cost	<u>103,000,000</u>
	\$446,000,000 +
Base Cost	\$423,640,000

Alternative IX. Addition of a Spray Pond Near Plant

This alternative was disregarded because of lack of available land. Total costs were not estimated.

Alternative X. Addition of a Cooling Lake at Zion

This alternative was rejected following investigation of a potential location for a 3000-acre cooling pond several miles west of the Zion site. Residences and farms would be displaced, rights-of-way for pipes for inflow and return of cooling water were obstacles, and loss of capability of the Station would be greater than that with other evaporative alternatives. Total costs were not estimated.

Alternative XI. Present Nuclear Power Plant With Spray Cooling in Lake Michigan

This alternative requires total dedication of 300 acres of Lake Michigan to power purposes. It was rejected since other alternatives do not pose such a restriction on the use of Lake Michigan. Total costs were not estimated.

C. SUMMARY OF COST-BENEFITS

Table XI-4 summarizes the economic and environmental costs and benefits of the Zion Station. From a review of this information and a comparison with the alternatives discussed above, the staff concludes that, subject to verification by the operational monitoring program recommended herein, the anticipated costs of proceeding with the Zion Station as proposed by the applicant are outweighed by the benefits

both to the general public and to the 7.8 million Commonwealth Edison customers, and that none of the alternatives present a more favorable balance of benefits and costs.

...and from all other sources...
 ...the Commonwealth Edison Company...
 ...the general public...
 ...the 7.8 million Commonwealth Edison customers...
 ...the balance of benefits and costs...

TABLE XI-4

COST-BENEFIT SUMMARY

Economic Benefits

Power Generated	14×10^9 kW hrs/yr
Peak Energy Available	2.2×10^6 kW
Employment Provided	~ 200 Jobs
Annual Payroll	~ $\$2.6 \times 10^6$ /yr
Tax Revenue Produced	~ $\$5.2 \times 10^6$ /yr

Environmental Benefits

Improved Area Sport Fishing
Replacement of Environmentally
Undesirable Generating Units

Economic Costs

Capital Investment in Materials and Labor	$\$423 \times 10^6$

Environmental Costs

Land Use for Site and Transmission Right-of-Way	250 acres of lake front property plus 6 miles of inland right-of-way

Water Pollution

Cooling Water Flow	1.53×10^6 gpm
Heat Release to Lake	36×10^{10} Btu/day
Area Within the 5°F Isotherm	11.4 acres (approximate)
Chemicals Release	Small

Air Pollution

Negligible

**Radiological Impact of Routine
Operation**

Air dose to population	4.6 man-rem/yr
Water dose to population via drinking water	22.9 man-rem/yr

TABLE II-4 (continued)

Maximum air exposure dose to individual	1.43 mrem/yr (~1% of natural background)
Radiological impact of accidents during operation or transportation	Potential exposure of population postulated to be small fraction of natural background.
Biological Impact	
Aquatic Impact	Some locally adverse net impact on aquatic life resulting from discharge of cooling water, but not of major importance to lake populations. Possibly significant entrainment of fish in intake structure.
Terrestrial Impact	250-acre lakefront industrialization.

REFERENCES FOR SECTION XI

1. Zion/ER, Supplement II, p. 4.23, December 1971.
2. Zion/ER, Supplement II, p. 6.10, December 1971.
3. Rossie, J. P., E. A. Cecil and R. D. Young, "Cost Comparison of Dry-Type and Conventional Cooling Systems for Representative Nuclear Generating Plants," R. W. Beck and Assoc. YID-26007, March 1972.
4. Feasibility of Alternative Means of Cooling for Thermal Power Plants Near Lake Michigan. Federal Water Quality Administration, U. S. Department of the Interior. Vol. 1, Proceedings of Conference on Pollution of Lake Michigan and Its Tributary Basin. September-October 1970, pp. 164-204.
5. Rossie, J. P. and E. A. Cecil, Research on Dry-Type Cooling Towers for Thermal Electric Generation, Part I, EPA Water Quality Office Report, 16130 EES, November 1970.
6. A Survey of Alternate Methods for Cooling Condenser Discharge Water. Large-Scale Heat Rejection Equipment. Dynatech R/D Company for Water Quality Office EPA. July 1969.
7. Oleson, K. A. and R. R. Boyle, "How to Cool Steam-Electric Power Plants," Chem. Eng. Progress 67, 70-76, July 1971.
8. Woodson, Riley D., "Cooling Towers," Sci. American, 224, 70-78, May 1971.
9. Rossie, J. P., "Dry-Type Cooling Systems," Chem. Eng. Progress, 67, 58-63, July 1971.
10. Jameson, R. M. and G. G. Adkins, "Waste Heat Disposal in Power Plants," Chem. Eng. Progress, 67, 64-68, May 1971.
11. Cleve, H. H., W. J. Westro and J. Y. Parce, "Economics and Operating Experience with Air-Cooled Condensers." Proc. Amer. Power Congress, 33, 511-523, 1971.
12. Carson, J. E., "The Atmospheric Effects of Thermal Discharges into a Large Lake," J. Air. Poll. Cont. Assoc., 22, 523-528, July 1972.

13. Carson, J. E., "The Atmospheric Effects of Thermal Discharges into a Large Lake," J. Air. Poll. Cont. Assoc., 22, 523-528, July 1972.

13. Dacker, F. W., "Probabilities of Cooling System Fogging," AIChE Symposia, Houston, Texas, March 1971.
14. Dacker, F. W., "Report on Cooling Towers and Weather," Federal Water Pollution Control Administration, Oregon State University, February 1969.
15. Zeller, R. W., H. E. Simison, E. J. Weatherbee, H. Patterson, G. Hansen and P. Hildebrandt, Report on Trip to Seven Thermal Power Plants Prepared for Pollution Control Council, Pacific Northwest Area, 1969.
16. Hoeler, C. L., "Wet Cooling Tower Plume Behavior," AIChE Cooling Tower Symposia, Houston, Texas, March 2, 1971.
17. Colbaugh, W. C., J. P. Blackwell, and J. N. Leavitt, Interim Report on Investigation of Cooling Tower Plume Behavior, AIChE Cooling Tower Symposia, Houston, Texas, March 1971.
18. Huff, F. A., R. C. Beebe, D. M. A. Jones, G. M. Morgan and R. E. Semonin, Effect of Cooling Tower Effluents on Atmospheric Conditions in Northeastern Illinois, Illinois State Water Survey, Urbana, Cir. 100, 1971.
19. Bierman, G. F., et al., Characteristics, Classifications and Incidence of Plumes from Large Natural Draft Cooling Towers, Amer. Power Conference, 1971.
20. Lyons, W. A. and H. S. Cole, "Fumigation and Plume Trapping: Aspects of Mesoscale Dispersion on the Shore of Lake Michigan in Summer During Periods of Stable Onshore Flow." Conf. on Air Pollution Meteorology, Raleigh, N. C., April 5-9, 1971.
21. Aynsley, E., Cooling Tower Effects: Studies Abound, Electrical World, 42-43 (May 11, 1970).
22. McVehil, G. E., Evaluation of Cooling Tower Effects at Zion Nuclear Generating Station. Final Report, Sierra Res. Corp., Boulder, Col., October 1970.
23. Letter from Commonwealth Edison Co., to Mr. D. R. Muller, Docket Nos. 50-295 and 50-304, dated September 28, 1972.
24. Quad Cities/ER, Supplement 5, April 24, 1972.

XII. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to Appendix D of 10 CFR Part 50, the Draft Detailed Statement was transmitted, with a request for comment, to: Department of Transportation; Department of Commerce; Department of Health, Education and Welfare; Department of the Army, Corps of Engineers; Federal Power Commission; Department of Interior; Department of Agriculture; Department of Housing and Urban Development; Environmental Protection Agency; the Advisory Council on Historic Preservation; the Governor of the State of Illinois; the Northeastern Illinois Planning Commission; the Illinois Pollution Control Board; the Mayor of the City of Zion, the Commonwealth Edison Co.; and the Metropolitan Sanitary District of Greater Chicago. In addition, the AEC requested comments on the Draft Environmental Statement from interested persons by a notice published in the Federal Register on June 30, 1972 (37 F.R. 12932).

Comments in response to the requests referred to in the preceding paragraphs were received from: the Illinois Environmental Protection Agency; Department of the Army, Corps of Engineers; Federal Power Commission; Northeastern Illinois Planning Commission; Environmental Protection Agency; the Advisory Council on Historic Preservation; the Department of Agriculture; the Department of Transportation; the Department of Commerce; The Commonwealth Edison Co.; the Metropolitan Sanitary District of Greater Chicago; two members of the De Paul University Faculty; and the U.S. Department of Interior. These comments are included in Appendices E through Q, inclusive.

Our consideration of comments received is reflected in part by revised text in other sections of this Statement and in part by the following discussions:

- A. Radiological Effects (EPA, Appendix I, pp. 3, 5, 6, 19, and 20; Department of Commerce, Appendix M, pp. 1-3; CECO, Appendix N, pp. 2, 3, 4, and 13; Metropolitan Sanitary District, Appendix O, pp. 3, 4, and 6; Department of Interior, Appendix Q, p. 7).

1. General

A comment stated that while it appears the Station will have the capability to maintain discharges of radioactive wastes to levels which are as low as practicable, the applicant should follow operating procedures which will result in this attainment. The Commission's Regulation 10 CFR 50.36a requires that the equipment installed in the

radioactive waste treatment systems be maintained and used to control the releases of radioactive effluents as defined by the approved technical specification. Detailed records of the waste system operation along with a semiannual reporting of the operation to the AEC are required. Throughout the operating life of the units modification of the operating procedures and equipment utilization will be required where necessary to accommodate changing conditions of the reactor and the radioactive waste management systems.

2. Estimated Releases

A comment was made that the Final Statement should contain liquid radionuclide discharge estimates categorized by source. The annual releases of radioactivity in the liquid waste were calculated to be 0.97, 0.07 and 0.03 Ci/yr/unit for the steam generator blowdown, chemical, and equipment and floor drain wastes, respectively. The total release, 1.2 Ci/yr/unit was normalized to 5 Ci/yr/unit as presented in Table III-2 to compensate for equipment downtime and expected operational occurrences.

A comment noted that the calculated release of krypton-85 is significantly less than that reported for similar reactors and requested supporting information. The difference resulted from the use of a lower plant use factor. Our review indicates that this lower factor is not justified. Therefore, both the liquid and gaseous releases were recalculated and Table III-3 revised. The normalized liquid source term as previously reported does not change since it is considerably less than the normalized 5 Ci/yr/unit.

A comment was received that recommended applying the provisions of Safety Guide 21 to the Station. The applicant will follow the provisions of Safety Guide 21 for effluent monitoring. The releases referred to were taken into consideration in calculating the amounts of effluents given in Tables III-2 and III-3.

3. Environmental Radiological Monitoring Program

A comment recommended that full details of the program be included in the Statement for reviewers who might not have access to the FSAR. We do not agree that full details should be given in the Statement. Section V.D.6, Radiological Environmental Monitoring, has been revised to provide more specific information.

4

4. Radionuclide Buildup

A comment recommended that an estimate be made of the radionuclide buildup in Lake Michigan from other nuclear reactors planned for the Lake Michigan area. The combined effects of multiple units on the same site are considered, as in this case with Zion Station Units 1 and 2. The combined effects of two or more plants sharing a common boundary or boundaries would be considered, as would be the effects from nuclear reactors sufficiently close to each other to provide a significant interaction. Such is not the case with Zion Station. The closest power station, Waukegan Station, is a fossil-fueled station.

5. Effects of Drinking Water Dose on Health of Population

A comment was made that an estimate should be given in the Statement on the number of cases of cancer that would result from the 22.9 mrem per year predicted to result from persons drinking water that would be affected by the liquid effluents from the Station. It is the staff's position that the present state of knowledge does not permit an accurate quantification of possible cancer cases from these very low levels of radiation exposure, as is evidenced by the disagreement among "experts" in this field. For further information see National Council on Radiation Protection publication No. 39, Federal Radiation Council Report No. 1 (1960), International Commission on Radiological Protection No. 8, and the Public Hearings on Appendix I.

6. Technical Specifications for Liquid Effluents

A comment noted that the liquid effluent radiation exposure is based upon 10 CFR 50, while the technical specifications for Zion Station acknowledge only 10 CFR 20 limits. The technical specifications for the Station will be consistent with 10 CFR 50, requiring the radioactive releases to be as low as practicable. The technical specifications provide boundaries of operation, whereas the Environmental Statement considers expected releases over the 40-year life of the Station.

7. Elimination of Controlled Releases

One comment proposed that the intentional discharge of radioactive waste to the lake (Section III D.2) be eliminated. The primary system, while sealed, releases radioactive effluents during normal operation. These effluents are collected, treated and recycled, or discharged to the environment. The assumed 10% blowdown to the lake discharge tank

is condensate from the boron recycle evaporator. This provides control of the tritium inventory as well as allowance for operational occurrences. The liquid effluents are monitored to assure they meet as low as practicable levels before release to the environment. The staff finds this acceptable.

8. Capacity of Liquid Waste Disposal System

A comment noted that because the system tankage provides an average holdup of one day, an analysis of liquids discharged during equipment outage should be provided. The staff calculations make allowance for operational occurrences and equipment outage. While the tank capacity is greater than needed for one day holdup, processing on a daily basis provides capacity for holdup in the event of operational occurrences. In addition, there are two parallel interconnected systems which provide excess processing capacity.

9. Direct Radiation Exposure from Storage Tanks

A comment requested that an estimate be made of the population radiation dose to visitors to the Illinois Beach State Park from the outdoor water storage tanks. It is estimated that the radionuclide concentration in the two primary coolant storage tanks will be 10^{-6} $\mu\text{Ci/cc}$. Each tank has a capacity of 200,000 gallons. Assuming the average park visitor is 1500 meters from the tanks for an average duration of 4 hours, the dose to the approximate 1.2 million visitors per year is calculated to be 4×10^{-5} man-rem.

B. Transportation and Reactor Accidents (EPA, Appendix I, pp. 7-8; Department of Commerce, Appendix H, p. 3; Metropolitan Sanitary District, Appendix O, pp. 4 and 8; Department of Interior, Appendix Q, p. 7).

A comment was made with regard to the meteorological assumptions used in computing the consequences of postulated accidents. The meteorological conditions assumed in the analysis approximate the dispersion conditions which would prevail at least 50% of the time.

A comment was made that a plant operator might deliberately discharge radioactivity during an accident basing the action on the 10 CFR Part 100 siting guidelines. 10 CFR Part 100 does not present limits of doses which are allowable during accidents. As stated in Section 100.11a(1):

"The whole body dose of 25 rem referred to above corresponds numerically to the once in a lifetime accidental or emergency dose for radiation workers which, according to NCRP recommendations may be disregarded in the determination of their radiation exposure status (see NBS Handbook 69 dated June 5, 1959). However, neither its use nor that of the 300 rem value for thyroid exposure as set forth in these site criteria guides are intended to imply that these numbers constitute acceptable limits for emergency doses to the public under accident conditions. Rather, this 25 rem whole body value and the 300 rem thyroid value have been set forth in these guides as reference values, which can be used in the evaluation of reactor sites with respect to potential reactor accidents of exceedingly low probability of occurrence, and low risk of public exposure to radiation."

A comment was made that dikes should be provided to prevent liquid spills from entering Lake Michigan and that automatic shutoff of discharge from the diked area should be provided. Automatic shutoff valves are provided for the low-level liquid waste discharge from the facility. Any discharge is by pumping from sump tanks and not by gravity flow. There is no need during plant operation to transport high-level wastes outside facility structures. Low-level activity in outside storage tanks would not cause an environmental problem if discharged. The postulated accidents listed in Section VI, including failure of tanks within the facility, would not result in any direct liquid discharge from the facility.

A comment was made that a discussion of the bases for probability numbers should be presented. The consequences of the plant accidents considered are not weighted by probability, but assume each accident to occur. As indicated in Section VI, the environmental risk is small even assuming the occurrence of the accidents listed. As stated in Section VI, to rigorously quantify an environmental risk, the specified numerical consequences would have to be multiplied by numerical values for probabilities. However, because of the absence of significant radiological accidents in the nuclear power industry to date and because of the extensive precautions taken in the design, construction, and operation to assure a low probability of accidents in the future, definitive estimates of accident occurrence probabilities are not available. One of the principal features of the safety review process for nuclear power facilities is that if an accident mechanism is identified which could lead to significant radiological consequences, measures are required to be implemented to reduce the probability of a significant release of radioactivity. These measures can include safety features to reduce both the probability of the initiating event

and the resulting radiological consequences given the event. Because the measures taken are evaluated in a conservative manner in the safety review the subsequent environmental risk, when realistically evaluated, is extremely small. Qualitative estimates of probabilities of the various events are given in Section VI.

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

A comment requested information on the conformance of the Zion Station emergency core cooling system to the AEC interim acceptance criteria. Emergency core cooling system (ECCS) effectiveness is the general subject matter of a pending AEC rulemaking proceeding, Docket No. RM-50-1, in which extensive public hearings are being held for the purpose of aiding the Atomic Energy Commission in its determination as to whether its interim acceptance criteria for emergency core cooling systems for light-water cooled nuclear power reactors (36 F.R. 12247, as amended, 36 F.R. 24082) should be retained in present form or adopted in some other form. The record of the proceeding demonstrates that controversy exists concerning the adequacy of the present criteria. The participants in the rulemaking proceeding include representatives of the general public, nuclear steam supply system vendors, electrical utilities, certain interested States, and the AEC Regulatory Staff.

Pending completion of this rulemaking proceeding, the interim acceptance criteria are applicable to the Zion Station ECCS. In this connection, the Commission has directed that the conduct of the rulemaking proceeding "will not affect the orderly resolution, under the Commission's existing regulations, of the matter of emergency core cooling, in hearings on applications for light-water cooled power reactors pending before atomic safety and licensing boards." (37 F.R. 238).

The Zion Station ECCS has been evaluated by the staff and found to be in accord with the Commission's Interim Acceptance Criteria for Emergency Core Cooling Systems. A more detailed discussion of this

matter is contained in section 6.3.3 of the Safety Evaluation of the Zion Nuclear Power Station Units 1 and 2, issued October 6, 1972, by the U. S. Atomic Energy Commission, Directorate of Licensing.

One comment expressed concern that large numbers of fish entering the intake system could result in the loss of cooling water to the condensers. The staff evaluation indicates that the bar racks and traveling screens are adequate to remove all the fish that can be expected to enter the system. Also, each reactor has the capability for rapid shutdown in the unlikely event that all six traveling screen modules (per unit) malfunction at the same time.

C. Thermal Effects (EPA, Appendix I, pp. 3, 9-12; NIPC, Appendix H, p. 4; Department of Agriculture, Appendix K, p. 4; Department of Commerce, Appendix M, pp. 1 and 2; CECO, Appendix N, pp. 4 to 18; Metropolitan Sanitary District, Appendix O, p. 6; De Paul University, Appendix P, pp. 2 and 3; Department of Interior, Appendix Q, pp. 3, 6, and 8).

1. Criteria

There are two sets of thermal criteria which can be applied to the thermal effects of the Station on Lake Michigan. These are: The State of Illinois, Environmental Protection Agency, Water Pollution Regulations of Illinois (adopted March 7, 1972); and the thermal criteria recommended by the Lake Michigan Enforcement Conference (LMEC, recommended March 23, 1971). It should be noted, however, that the thermal criteria of the LMEC were not imposed (they were Federal recommendations that were finally accepted only by the State of Indiana), whereas the State of Illinois criteria are regulations of the State which are imposed and supersede the previous regulations covering thermal discharge in Lake Michigan. In essence, the Illinois Pollution Control Board has specifically exempted the Zion Station from the 1/2 billion BTU/hr discharge limit. However, the Board does require proof that no unacceptable ecological damage is occurring. Such proof must be presented within 5 years of the commencement of full power operations.

It is indeed possible that under full power operation the Zion discharge may exceed the thermal criteria recommended by the LMEC. A detailed monitoring program will be required to define under what conditions the plume does exceed 3°F at 1000 feet, and what biological effects occur thereby. If unacceptable biological damage is found to be due to the thermal discharge (whether or not the discharge meets LMEC recommendations), the staff recommends modification of the existing discharge system. The staff also recommends that the near-field and mid-range plume temperature be monitored at 1000 feet and 100 feet from the discharge point. The model developed for the near-field and mid-range plume is based on the assumption that the plume is well-mixed and that the temperature is uniform throughout the plume. The model is based on the assumption that the plume is well-mixed and that the temperature is uniform throughout the plume. The model is based on the assumption that the plume is well-mixed and that the temperature is uniform throughout the plume.

The staff is of the opinion that detrimental effects of thermal discharge by Zion Station would be local and reversible upon removal of the discharge.

2. Applicant's Analysis

The applicant has stated that the system, as designed, will meet all the required temperature limits and isotherm restrictions of both the IMEC and the State of Illinois regulations. The staff feels that this statement is debatable within the framework of the present state of knowledge of large thermal discharge phenomena.

The model used in the applicant's analysis (Pritchard Model) is relatively unsophisticated and cannot be expected to provide the specifics of plume behavior in a large lake. No model in existence today can do that because the plume is dynamic and variable, and responds rather rapidly to shifts in the wind direction. Time dependent models would be required to predict this type of behavior and no such models are now available. The difficulties in including all relevant parameters in a rigorous modeling of the Station's plume (such parameters include the range of observed current velocities and direction, upwelling conditions, the presence of a thermal bar, and recirculation of warm water dictated by icing conditions) all lead to the conclusion that the only true picture of plume behavior must ultimately be obtained by measurement.

Pritchard's model has the advantage of being one of the very few that can be used to predict the complete plume-temperature field; that is, from the point of discharge to near-ambient conditions. The model is relatively unverified with quality lake field data, and the operation of the Zion discharge, with adequate monitoring, would provide some badly needed data for testing of this and other models. It has yet to be shown that a significant environmental impact will occur even if the model is incorrect, although certain estimates of biological effects have been based in this Statement on assumptions that the model is nearly correct, especially at the higher excess isotherms.

We concur that a hydraulic model with larger dimensions would have been desirable. The test results show a significant influence of the scale model boundaries on the plume configuration. The currents scaled in the "enlarged" model were about 0.2 fps, and thus are somewhat more representative of the average currents cited by the EPA (Appendix I, p. 10).

It is unrealistic, however, to expect a single hydraulic model to adequately represent both the near-field and the far-field (where the lower temperature isotherms exist). The model becomes too large if the far-field is built to the same scale as the near-field and scaling laws limit how much the near-field dimensions can be reduced. Modeling the

far-field by itself is difficult because of problems in controlling ambient turbulence, surface cooling rates, wind effects, and initial and boundary conditions. While an improved model may allow a better representation of the near-field distribution of temperature and velocity, it will not add much to our knowledge of the environmental impact. A more beneficial use of the experimental resources would be to apply the money and effort to implement a good field monitoring program.

It is true that Pritchard's model implicitly assumes zero ambient current. A critical review of this model by Policastro and Tokar¹ indicates that Pritchard has concluded from experimental evidence in the laboratory that for an ambient current velocity less than about 10% of the initial jet velocity, his model yields satisfactory predictions for centerline temperatures and isotherm areas. Pritchard recommends using a model by Carter² for cases where the ambient velocity is greater than about 10% of the discharge velocity.

While the maximum observed ambient current is within the range where one might consider using Carter's model, the majority of current velocity values are in a range where Pritchard's model should apply.

The position of the isotherms will obviously be altered by the ambient current. Its trajectory will be altered, and in general, the plume will be longer and thinner. The adverse effects of a shore-parallel current are reduced if the discharge structure is located offshore and if the discharge pipes are buried below the bottom of the lake, thus allowing a free flow of the ambient current inshore of the discharge to provide ambient entrainment water to the near-shore side of the plume. This is the situation at Zion Station.

3. Thermal Bar

It is a misconception that the thermal bar separates the main lake mass from the near-shore water. The thermal bar mechanism is transient in nature and has been observed moving offshore, toward the center of the lake, at velocities from 0.1 to 0.5 miles/day in the Zion area. While the thermal bar mechanism inhibits horizontal mixing near the surface of the lake, good vertical mixing has been observed in the region of the convergence. Stratification of the lake does not separate the near-shore water from the main lake. While it may inhibit mixing with the deeper lake water, ambient currents are continually moving large quantities of water into the area.

- D. Biological Effects (EPA, Appendix I, pp. 4, 13-15; Metropolitan Sanitary District, Appendix O, pp. 5, 6, 7, and 8; De Paul University, Appendix P, pp. 2, 3, 4, 5, and 6; Department of Interior, Appendix Q, pp. 2, 3, 4, and 5).

1. General

The staff agrees with the applicant's contention (Appendix N) that describing the lake with arbitrary designations such as an Inshore zone (0-100' depth contour), and a Beachwater zone (0-30' depth contour) as the U.S. Fish and Wildlife Service has done,³ may lead to conceptual problems among biologists, if such depths were interpreted to signify an abrupt change in biota, sediment type or water temperature. But while Beachwater and Inshore Zones are designations which may be less intrinsically meaningful than terms such as "littoral zone" or "littoral shelf", they do have convenience and descriptive value. The applicant's consultant has used them for this purpose.¹⁹

2. Intake Effects

Although the present intake design does not appear to preclude possibilities of unacceptable local fish entrainment, the staff still believes that entrainment effects on the biota at the Station intake and discharge are not likely to constitute an important or irreversible impact on lake populations (see also Section V.C.2a).

Near-shore waters near the Station do not appear to be important spawning grounds for fishes other than alewives, smelt, and (possibly) carp. Wave action, frequent high turbidity, and substrate unsuitability are presumed to be influential in this regard. No sampling data for fish eggs and larvae have yet been submitted formally by the applicant, however, and the staff will require such documentation, as well as subsequent monitoring.

The applicant has recently indicated plans to equip the intake structure with fine nets (1" x 1" diagonal mesh) positioned around the intake at a distance (Appendix N) where the intake velocity is approximately 0.3 ft/sec. These nets, which will be in place during the nonwinter months when they can be maintained (on a weekly basis), should exclude, for example, adult alewives, perch, and salmonids. The netting is coated with a colored plastic to make it more visible. The applicant feels that this should lessen the chance that even small fish would be gill-netted and die on the net. The system probably will not be effective with larval and juvenile fish which are small enough to pass through the nets. The effectiveness of this system, however, will have to be measured under operating conditions.

It should be noted also that maintenance problems preclude use of these nets in the colder months of the year when the lake is iced-over. The winter recirculation mode, as noted in this Statement, provides for the discharge of warm water to deice the intake if the forebay drawdown is 1 foot below normal. Danger of entrainment of local fish attracted to the warm discharge in winter (including commercially valuable salmonids) exists. Although these fish when adult have high burst speeds, and sustained swimming speeds (at 64°F) which are equal to or in excess of the water intake velocity of 3.7 ft/sec,⁷ this does not constitute a guarantee that such fish will not be entrained (see Section V.C.2.a). There is no way at present to judge whether there will be a substantial number of fish entrained in the intake flow during winter, and whether the quantity entrained will be in excess of that incurred during the months the nets are in place. It is also certain that the species and age classes of fish affected in summer and winter will be quite different. This is a problem that requires careful postoperational monitoring. The applicant is committed to just such a program,⁸ in which the numbers, lengths, and species of all fish recovered from the traveling screens will be recorded once a week for a 24 hr period, and the staff will require more frequent monitoring than this during initial operation. Fish eggs and larvae in the forebay are to be monitored from plankton and dip net collections. The intake design must be modified if the fish kill prove excessive, and the applicant will be required to submit for staff approval intake design modifications and installment schedules.

The data relating to plankton mortality under operating conditions is not directly applicable to the Station. Some data has been derived from controlled "bagging" experiments and comparative measurements in intake and discharge canals, but neither of these features exist at Zion. Therefore, the severity of the intake effects at the Zion Station cannot be estimated until operations begin. Such data will, however, be obtainable as an adjunct to the fish egg monitoring study.

3. Condenser Passage and Discharge Effects

On the basis of unpublished Industrial Bio-test studies, the applicant contends that zooplankton entrained at the Haukegan Station suffered an average annual immobility after condenser passage of only 2.1% due to heat and 6.0% due to mechanical damage with a ΔT of 22.5°F (Appendix H). However, it is difficult to interpret average values without reports of the ranges. The applicant's consultant obtained data for the reduction (~30%) in photosynthetic capacity (chlorophyll a concentrations and radiocarbon uptake) of phytoplankton subjected to entrainment, similar to the data obtained by a group from the Great Lakes Research Center.^{9,10,11} The staff does not believe that the mortality rate due to condenser passage and discharge effects will disrupt lake food chains, however.

4. Gas Bubble Disease Probability

In field tests conducted by the applicant's consultant (results not yet submitted formally), gill nets were placed over the mouth of the Waukegan discharge canal for 24 hour periods in January to April 1972. No fish with signs of gas bubble disease were trapped in the nets, but one fish in the canal ($\Delta T = 8^\circ F$ above ambient - normal ΔT at Waukegan is $12-20^\circ F$) did show the effects of oxygen supersaturation at the 132% level. The average supersaturation in the Waukegan Station discharge is about 120%. While the measured range of oxygen levels at Zion is 95-116%, it is expected that the turbulence at the point of discharge will probably produce initial values of about 130% in winter due to the interaction of dilution factors in the plume and the discharge velocity. The best projections of oxygen saturation levels under winter operating conditions when fish are expected to congregate in the warmer water of the discharge and suffer the longest exposures are:

<u>% Saturation</u>	<u>Area Affected (acres)</u>	<u>Discharge Velocity (ft/sec)</u>	<u>Exposure Time (min)</u>
130	-	8.8	0.1
120	0.8	6.0	0.9
110	4.0	2.9	3.3
105	20.0	1.2	20.0

For the growing salmon and perch maintained under laboratory conditions by the applicant's consultant these data suggest that operating conditions at Zion will not cause mortality due to gas bubble disease. It is unlikely that fish will be capable of holding station for important periods of time in the most turbulent parts of the plume where the saturation level is in excess of 120%, levels at which laboratory studies project a mortality rate of 40-50% if the fish remain on-station 24 hours. Adult fish in waters where the discharge velocity is 1-2 feet per second (at which point the saturation level of the water is projected to be 105-110 percent), would experience even after extended exposure times no measurable damage. Even if some fish were swept into the discharge flow, their residence time in areas of supersaturation greater than 110% would be shorter than 3 minutes (neglecting upstream swimming). Although the staff does not expect that the incidence of gas bubble disease will be of any consequence at Zion, it nevertheless recommends

pursuance of this phase of the preoperational monitoring program through the first few years the Station is on-line or for a long enough period to show that this potential problem is, in fact, nonexistent.

5. Undesirable Algal Growths

With insufficient knowledge of the pattern of nearshore water currents in the vicinity of the Station and how they relate to various meteorological conditions, there is no certainty that the Station's warm winter discharge will never recirculate or form a puddle (under certain conditions of wind and current) which could facilitate the growth of undesirable algae. There are no known eddy currents in Zion waters of the type that are believed to operate on the eastern shore of Lake Michigan at Benton Harbor, so that the conditions which could promote puddling and algal growths must include an onshore wind from the east and an increase in the nutrient supply. Algal growths or blooms occur sporadically in the lake following nutrient-rich cold water upwellings and where there is farm runoff or other nutrient sources (rivers). Winds from the east with a 32-36 hour duration are present about 15% of the time at Zion, so that puddling of warmer water at lower excess isotherms could occur - but only for times which are marginally within (greater than 24 hours) the period required to stimulate preferentially blue-green growth. Cladophora problems would not be expected, however, due to the lack of suitable offshore substrates for their growth. Therefore, the staff recommends that the applicant's lake current-meteorology and water quality studies plans be implemented vigorously to increase the ability to predict when Station operations could augment the danger of algal blooms.

6. Discharge Effects during the Winter Recirculation Mode

The winter recirculation mode requires the pumping of warm condenser discharge water back to the intake structure to prevent the buildup of damaging ice in the forebay and around the intake structure. The maximum amount of warm water that can be returned to the intake is 750,000 gpm or 50% of the entire intake volume. If recycling occurred at this maximum, it is possible that some fraction of the discharge would escape around the intake structure and establish a temperature gradient which might attract fish swimming close enough to detect the increased temperature. These fish could then fall victim to intake entrainment. There are at present no estimates of the temperature gradient that might occur around the intake if maximum recycling occurred. The detailed operating procedures have not as yet been formulated for this operation. In general, it would be unusual if conditions become so severe that maximum recirculation for deicing was required. Present estimates suggest that only a small fraction of the total pumpage will

normally be required. There is no way to know at present how much of the recycled warm water will be swept away from the intake, or if there will, in fact, be any discharge of heat from the intake into the lake proper. The applicant will most likely maintain a minimal flow of heated water to the intake during January through March, but the staff has no basis for predicting the quantity of the flow and its discharge velocity. This is a problem, therefore, that also requires monitoring.

- E. Chemical and Sanitary Wastes (EPA, Appendix I, pp. 16-17; CECO, Appendix N, p. 13; Metropolitan Sanitary District, Appendix O, pp. 5, 6, and 7; Department of Interior, Appendix Q, p. 4).

The staff continues to believe that the release of 155,555 lb/yr of chemicals into Lake Michigan does not in itself constitute a significant environmental impact problem on the following basis. With a volume of 173 trillion cubic feet, the water in the lake would have its dissolved solids content increased by 1.4×10^{-5} ppm per year by the Zion effluent. In a hundred years (EPA-quoted retention time), the dissolved solids content would increase by 0.0014 ppm, a 0.0008% change in the present TDS level of 175 ppm near the plant. For the long time required to cause a significant increase in lake water dissolved solids a substantial fraction of mixing in the lake can perhaps be assumed.

More significant changes in dissolved solids content are apparently being caused by other sources. According to Beeton's summary¹² the dissolved solids content of the open water in the lake increased at the approximately constant rate of 32 ppm per century from about 1880 through the late nineteen sixties. The expected change from the Zion Station seems unimportant in this context.

Alternative on-site treatments to dispose of the makeup water regeneration wastes seem impractical or unjustifiable. About 1450 pounds of neutral solids dissolved in 83,000 gallons of water are produced every four days when the makeup water demineralizers are regenerated. Operating half of the time, one of the largest commercial evaporators (30 gpm) would just be able to concentrate the solution by a factor of about 10. Second stage evaporation to dryness, packaging and shipping would complete the process of removing the salts from the water. These costs and operations do not seem to be justified by the seriousness of the problems caused by discharging the chemicals to the lake.

Another possibility, offering the promise of considerably lower cost than simple evaporation, is reverse osmosis, followed by evaporation. This process decreases by approximately 80% the chemical discharges in the circulating water. Reverse osmosis equipment is in the early stages of commercial development, and reliable units in the size

required have not been demonstrated. Again the use of multiple small units does not seem justified by the magnitude of the problem. A rough estimate of the cost can be obtained by up-rating the \$300,000 reverse osmosis-evaporative concentrator considered for the Fitzpatrick Nuclear Power Plant¹³ by the net power ratio (2200 to 821 MWe). An \$800,000 direct cost and a \$7200 annual operating and maintenance cost are estimated in this fashion. The present value of the operating costs, at 8.75% interest and 30-year life (factor of 10.5058) is \$75,600, making the total present cost about \$877,000.

It is questionable whether passing the effluent to the North Shore Sanitary District offers a superior alternative. At present that sanitary district discharges into Lake Michigan. If the district changes to discharging into the local river system (Des Plaines, Chicago, Illinois Rivers), adding the regeneration wastes to the sanitary district effluent would add the wastes to the burden in the rivers accepting the discharge.

The choice of detergents has not yet been made between Sears Roebuck No-Phosphate Detergent (a sodium silicate-base material) and Arway Model S-A-8, containing 8.7% phosphate, now used at the Dresden Nuclear Power Station.

The 3000 pounds of phosphate and 1260 pounds of borate shown in Table III-4 are conservative estimates of the expected releases resulting from primary-to-secondary steam generator leakage. The design leakage figure was 1 gpm for two weeks per year (20,000 gal/yr). Variable operating experience at other plants, however, indicates the average leakage would be more like 0.5 gal/min during periods of leakage.¹⁴ Following leakage to the secondary system, these chemicals will be discharged as part of the blowdown from the secondary system. All of the secondary blowdown passes through the radwaste demineralizer before discharge and, although the removal of phosphate and borate by the exchange resins is not highly efficient, a significant fraction of these ions can be expected to be retained. No allowance has been made for this retention.

At the conservatively high level estimated by the applicant, the phosphate and boron are calculated to increase the levels in Lake Michigan by 3×10^{-5} and 1×10^{-5} ppm per century, respectively. The basis of the calculations is the same as that used above in calculating an increase in total dissolved solids. The phosphate figure represents about 0.08% and 0.15% of the figures quoted for average concentration of total phosphorus (0.013 ppm) and total phosphate (0.02 ppm) in Lake Michigan.¹²

The calculated boron increase is 0.04% of the boron levels at the average of the two available sample points at Milwaukee and Gary (0.027 ppm).¹⁵

Actual discharge rates of phosphates and borates are thus expected to be lower than those in the Draft Statement Table III-4 by a factor of 2 or more. The environmental impact will be accordingly reduced. The table and text have been revised to indicate that the figures given by the applicant are believed to be conservative by a factor of 2.

F. Alternatives and Cost-Benefit Analysis (EPA, Appendix I, pp. 12, 18; WIPC, Appendix H, p. 4; Metropolitan Sanitary District, Appendix O, p. 8).

The present value of operating and maintenance costs was included in the figures for "Incremental Equivalent Capital Investment from Current Plant" in Table XI-2. In computing these figures, the applicant used an operating period of 30 years and a nominal discount rate of 3% per year. In other environmental statements, the AEC has used an operating period of 30 years and a discount rate of 3.75% per year as an average cost of money to investor-owned utilities through the sale of bonds, preferred stock, and common stock. The relative economics of the various alternatives considered are not significantly affected by this difference or even by the use of a discount rate of 10% per year, as recommended by the EPA.

Taxes to be paid by the applicant when the Zion units are operating were included as a benefit because a substantial part of the tax revenues will be available in the area where the environmental impacts occur. Additional local benefits will result from employment at the plant during operation and from the associated payroll.

The selection of the site for the Zion Nuclear Power Station was based on (a) the need for an additional generating station in the Northern Division of the applicant's service territory, (b) the availability of adequate quantities of cooling water from Lake Michigan without interaction with any intake or discharge of industry or a municipality in the Zion area, (c) suitable geology and climatology, and (d) current use of the land. With regard to the latter, 200 acres of the site was purchased by the applicant in 1953 and the remaining 50 acres in 1967. Before acquisition, the site contained 27 privately-owned dwellings that were originally summer homes and of which 23 were listed as marginal or substandard according to the Zion City building code. Acquisition of the site did not result in significant removal

of land from commercial, industrial, agricultural, or recreational use. There are no national historical sites or monuments in the region. All of these aspects are more important than any financial advantage to the applicant due to prior ownership of land at the site, especially since the cost of land is generally a very small fraction of the total cost of a nuclear station.

G. Diesel Generators and Starting Boilers (EPA, Appendix I, p. 13).

The Station contains five (5) 4000 kW diesel generators which are used as a source of emergency power in case the power supply from external sources is interrupted. These units are each powered by an approximately 5550 hp diesel engine which burns No. 2 diesel fuel. At an approximate fuel usage rate of 0.37 lb/hp/hr, the five units would consume

$$5 \text{ units} \times \frac{5550 \text{ hp}}{\text{unit}} \times \frac{0.37 \text{ lb}}{\text{hp hr}} \text{ of No. 2 diesel fuel, or}$$

10250 lbs of No. 2 diesel fuel per hr. The exhaust from these units would, of course, add to the air pollution of the area. The diesel units are, however, used for emergency power only and would not normally be run except for short periods of time for system testing purposes. No significant, long term air pollution is anticipated due to the intended use of the five diesel generators.

The Station also contains a large, oil fired boiler which is used to preheat the reactor and steam system prior to reactor startup and to provide steam for space heating purposes whenever both reactors are not running. This unit is fueled with No. 2 oil and consumes approximately 1336 gal/hr of fuel while operating. The unit is capable of producing 187×10^6 Btu/hr. During normal Station operation, however, the unit would not be used for space heating purposes as the steam required for these purposes would be produced by the reactors. It is estimated that the starting boiler would burn less than 100,000 gallons of fuel oil per year total due to its intermittent use. No significant, long term air pollution is anticipated due to the intended use of the starting boiler.

H. High Voltage Transmission Line Effects (EPA, Appendix I, p. 18; DOT, Appendix L, pp. 1; Department of Interior, Appendix Q, pp. 3).

The operation of high voltage lines in close proximity to railroad right-of-ways has been found to produce adverse effects such as interference with the railroad communications and signal systems,

induced high voltages in certain types of freight car bodies, direct faulting to railroad cars and increased journal failure. The new transmission line installed to service the Station runs parallel to the main line of the Chicago and Northwestern Railroad (C&NW) for about 1.2 miles and crosses both the main line and two spur lines of the rail system.

In an effort to reduce if not totally eliminate interference with the communications and signal systems, C&NW relocated and consolidated its signal and communications equipment on the opposite side of the track from the new transmission lines. This work is complete and was done at the expense of the applicant.

Incidents of induced voltages appearing on inadequately grounded railroad car bodies have occurred when these railroad cars stand or pass under high voltage transmission lines. Insufficient experience exists to date, however, to make a valid assessment of the magnitude of the problem. Further research of this problem is presently being discussed between the Edison Electric Institute and the Association of American Railroads.

Induced voltages have also been postulated as a cause of journal failure in some types of railroad cars. This problem might occur when voltages induced in railroad car bodies breakdown the lubricant in the journal bearings between the car body (high potential) and the car wheels (ground). Very little research appears to have been done on this problem. Thus little information exists to date which would allow a valid assessment of the magnitude of the problem.

Direct faulting from transmission lines to railroad equipment standing or passing beneath the transmission lines is also a potential problem. Strict adherence to standards and safety codes should, however, eliminate such problems. The applicant has stated that "all lines are being constructed to meet or exceed all requirements of the Illinois Commerce Commission General Order 160, which is identical to the National Safety Code for construction of transmission lines."¹⁶

The operation of high voltage transmission lines has been postulated to produce large quantities of ozone which could have adverse effects on the biota in the vicinity of such lines. The paper by Scherer *et al.*¹⁷ concludes that "765-kV lines do not contribute any measurable amounts of ozone or other oxidant to the prevailing ambient levels." The paper by M. Frydman *et al.*¹⁸ concludes that "Tests conducted at 20 locations under a variety of meteorological conditions show no ozone formation attributable to high voltage lines." 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.

I. Construction Cleanup and Landscaping (Department of Agriculture, Appendix K, p. 3).

The Station construction is being performed by numerous subcontractors. Each subcontractor is required to clean up his wastes and other unwanted material and equipment of construction prior to leaving the site. This procedure will be followed throughout the course of construction. Upon completion of construction, the applicant will complete the cleanup of the area and will proceed with his landscaping program. Details of this program have not been finalized to date, however, and thus, specific details of this program are not available at this time.

J. Restoration of Project-Induced Beach Erosion (Department of Agriculture, Appendix K, p. 3).

The level of Lake Michigan is presently about 2 feet higher than average. This increased water level has caused and is continuing to cause extensive damage to the shoreline of Lake Michigan in general. The problem and corrective measure for reducing the damage is presently the subject of discussion at a series of meetings being held by the State of Illinois, Department of Conservation; the U. S. Army Corps of Engineers; and several other Federal and State agencies. The applicant is participating in these meetings.

The staff understands that present plans call for the placement of granite blocks along the shoreline to stabilize the shoreline and protect the inshore area and to transport sand from the area of accretion to areas of erosion as soon as the conditions stabilize sufficiently to make such activity worthwhile.

K. Lake Michigan Basin Assessment (NIPC, Appendix H, p. 6; Department of Commerce, Appendix M, p. 2; Department of Agriculture, Appendix K, p. 4; Department of Interior, Appendix Q, p. 7).

Several of the comments received included questions related to the water quality and ecological status of Lake Michigan as a whole system, as well as to cumulative effects of multiple nuclear power station siting on the lake. Although such questions are considered by the staff to be beyond the scope of this Statement, the staff agrees that such questions are of great importance and need to be addressed.

Individually, and cumulatively, as long as their number remains fairly small, nuclear power stations on Lake Michigan appear to the staff to be less damaging to water quality and biota than most other kinds of discharges, including fossil-fueled power stations.

On the other hand, the staff is in total agreement with the position that such arguments can not reasonably be extended to indefinite numbers of nuclear stations, and the time to address such questions is at hand. It is expected that in the near future a comprehensive assessment of environmental conditions of Lake Michigan in relationship to power production will be performed.

L. Location of Principal Changes in this Statement in Response to Comments

<u>Topic Commented Upon</u>	<u>Section Where Topic Is Addressed</u>
Applications and Approvals (Commonwealth Edison Co., page N-4)	I B
Historical Significance (Advisory Council on Historic Preservation, page J-1)	II D
The Need for Power (Federal Power Commission, page G-6)	X

The Commission has received many comments on the Statement of Intent and the Draft Environmental Impact Statement. The Commission has carefully considered all comments and has made changes to the Statement of Intent and the Draft Environmental Impact Statement to reflect the Commission's response to the comments. The Commission has also made changes to the Statement of Intent and the Draft Environmental Impact Statement to reflect the Commission's response to the comments of the Advisory Council on Historic Preservation and the Federal Power Commission.

The Commission has also made changes to the Statement of Intent and the Draft Environmental Impact Statement to reflect the Commission's response to the comments of the Advisory Council on Historic Preservation and the Federal Power Commission. The Commission has also made changes to the Statement of Intent and the Draft Environmental Impact Statement to reflect the Commission's response to the comments of the Advisory Council on Historic Preservation and the Federal Power Commission.

REFERENCES FOR SECTION XII

1. Policastro, A. J., and J. V. Tokar. Heated Effluent Dispersion in Large Lakes: State of the Art of Analytic Modeling-Part 1, ANL/ES-11, Argonne National Laboratory, Argonne, Illinois (Jan. 1972).
2. Carter, H. H., A Preliminary Report on the Characteristics of a Heated Jet Discharge Horizontally into a Transverse Current: Part 1 Constant Depth. Technical Report No. 61, Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Maryland (Nov. 1969).
3. Physical and Ecological Effects of Waste Heat on Lake Michigan. U.S. Department of Interior, Fish and Wildlife Service (Sept. 1970).
7. Hynes, H. B. N., The Ecology of Running Water, University of Toronto Press (1970).
8. Letter: Commonwealth Edison Co. to USAEC dated Aug. 1, 1972. Subject: Nonradiological Technical Specifications - Zion Station, AEC DKTS 50-295 and 50-304.
9. Ayers, J. C., R. F. Anderson, H. W. O'Hara, and C. C. Kidal, Benton Harbor Power Plant Limnological Studies, Part IV, "Cook Plant Preoperational Studies," Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan (March 1970).
10. Krezoski, J. R., Benton Harbor Power Plant Limnological Studies, Part III, "Some Effects of Power Plant Waste Heat Discharge on the Ecology of Lake Michigan," Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan (April 1969).
11. Ayers, J. C., D. E. Arnold, R. F. Anderson, and H. K. Soo, Benton Harbor Power Plant Limnological Studies, Part VII, "Cook Plant Preoperational Studies," Special Report No. 44, Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan (March 1971).
12. Beeton, Alfred M., "Changes in the Environment and Biota of the Great Lakes," in Eutrophication: Causes, Consequences and Correctives, Proc. Symp. Nat. Acad. Sci., Washington, D. C. (1969).

13. Supplement #2, Environmental Report for James A. Fitzpatrick Nuclear Power Plant, AEC Docket No. 50-333 (May 1972).
14. Final Safety Analysis Report, Amendment 17, Answer to Question 4.40. CECO, Chicago, Illinois (Dec. 1971).
15. Kopp, J. F., and Robert C. Kroner, Trace Metals in Waters of the United States, Pub. of Fed. Water Pollution Control Admin., Div. of Pollution Surveillance, 1968.
16. Zion Nuclear Power Station Environmental Report, Supplement I. Commonwealth Edison Co., Chicago, Ill., November 8, 1971.
17. Scherer, H. N. Jr., B. J. Ware, and C. H. Shik, Gaseous Effluents Due to EHV Transmission Line Corona, American Electric Power Service Corp., New York, N. Y.
18. Frydman, M., A. Levy, and S. E. Miller, Oxidant Measurements in the Vicinity of Energized 765 kV Lines, American Electric Power Service Corp., Canton, Ohio and Battelle Memorial Institute, Columbus Laboratories, Columbus, Ohio.
19. Preoperational Environmental Monitoring (Thermal) of Lake Michigan near Zion Station, July-December, 1969. Report to Commonwealth Edison Company by Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois. IBT W7658 and W8096.

APPENDIX A

CHECK LIST OF ANIMALS OBSERVED
AT ILLINOIS BEACH NATURE PRESERVE

Mammalia

Didelphidae

Didelphis virginiana

virginia opossum

Soricidae

Cryptotis parva

least shrew

Blarina brevicauda

short-tailed shrew

Cervidae

Odocoileus virginianus

white-tailed deer

Vespertilionidae

Eptesicus fuscus

big brown bat

Lasiurus borealis

red bat

Myotis lucifugus

little brown bat

Leporidae

Sylvilagus floridanus

Eastern cottontail rabbit

Sciuridae

Tamias striatus

chipmunk

Citellus tridecemlineatus

thirteen-lined ground squirrel

C. sp.

Franklin ground squirrel

Sciurus carolinensis

Eastern gray squirrel

S. niger

Eastern fox squirrel

Cricetidae

Peromyscus maniculatus

deer mouse

P. leucopus

white-footed mouse

Microtus pennsylvanicus

meadow vole

M. ochrogaster

prairie vole

Ondatra zibethica

muskrat

Muridae

Mus musculus

house mouse

Rattus norvegicus

house or Norway rat

Canidae

Vulpes flava

red fox

Procyonidae

Procyon lotor

raccoon

Mustelidae

Mustela vison

mink

M. frenata

long-tailed weasel

Mephitis mephitis

striped skunk

Taxidea sp.

badger (tracks)

Reptilia

Chelydridae

Chelydra serpentina

snapping turtle

Emydidae

Chrysemys picta

painted turtle

Kinosternidae

Kinosternon subrubrum

Eastern mud turtle

Sternotherus odoratus

musk turtle

Emys blandingii

Blanding's turtle

Sauria

None

Serpentes

Colubridae

Storeria dekayi

Dekays or northern brown snake

Elaphe vulpina

fox snake

Lampropeltis dolia triangularis

Eastern milk snake

Natrix sipedon sipedon

Northern water snake

Thamnophis sirtalis

Eastern garter snake

L. s. sirtalis

Chicago garter, Eastern sub-species

L. radix

plains garter snake

Heterodon platyrhinos platyrhinos

Eastern hogonose snake

Opheodrys vernalis

smooth green snake

Amphibia

Ambystomatidae

Ambystoma tigrinum tigrinum

Eastern tiger salamander

Bufonidae

Bufo americanus

American toad

B. woodhousei fowleri

Fowler's toad

Ranidae

Pseudacris nigrita triseriata

western chorus frog

Rana palustris

pickerel frog

R. clamitans

green frog

R. pipiens pipiens

Northern leopard frog

Hylidae

Hyla crucifer
Acris crepitans crepitans

spring peeper
Northern cricket frog

Aves

Podicipedidae (Colymb. ae)

Podilymbus podiceps
Centropelma microcollis

pied-billed grebe
eared grebe

Ardeidae

Ardea herodias
Butoroides virescens
*Nycticorax nycticorax
*Botaurus lentiginosus
Ixobrychus exilis
Casmerodius albus egretta

great blue heron
green heron
black-crowned night heron
American bittern
least bittern
American or common egret

Anatidae

*Anas platyrhynchos
*A. rubripes
A. strepera
A. acuta
A. carolinensis
A. discors
Merica americana
Spatula clypeata
Aix spinosa
Arthya collaris
A. marila
A. affinis
Bucephala albeola
B. clangula americana
Clangula hyemalis
Oxyura jamaicensis
Lophodytes cucullatus
Mergus merganser
M. m. americanus
M. serrator
Branta canadensis
Chen hyperborea
C. caerulescens

mallard
black duck
gadwall
pintail
green-winged teal
blue-winged teal
American widgeon, baldpate
shoveles
wood duck
ring-necked duck
greater scaup
lesser scaup
bufflehead
American or common goldeneye
oldsquaw
ruddy duck
hooded merganser
common merganser
American or common merganser
red-breasted merganser
Canada goose
snow goose
blue-goose

Cathartidae

Cathartes aura

turkey vulture

Accipitridae

Astur atricapillus
*Accipiter striatus
*A. cooperi
Buteo jamaicensis
B. platypterus

goshawk
sharp-shinned hawk
Copper's hawk
red-tailed hawk
broad-winged hawk

* Endangered or declining species

Accipitridae (cont'd.)

B. lagopus
*Circus cyaneus
Aquila canadensis canadensis
*Haliaeetus leucocephalus

rough-legged hawk
marsh hawk
golden eagle
bald eagle

Pandionidae

*Pandion haliaetus

osprey

Falconidae

*Falco peregrinus
F. columbarius
*F. sparverius

peregrine falcon, duck hawk
pigeon hawk
sparrow hawk

Phasianidae

Colinus virginianus
Phasianus colchicus

bobwhite
ring-necked pheasant

Gruidae

*Grus canadensis tabida

sandhill crane

Rallidae

Rallus limicola
Porzana carolina
Gallinula chloropus cachinnans
Fulica americana

Virginia rail
sora rail
common Florida gallinule
American coot

Charadriidae

Charadrius semipalmatus
C. vociferus
Pluvialis dominica
Squatorola squatorola
Arenaria interpres morrinella

semipalmated plover
killdeer
American golden plover
black-bellied plover
ruddy turnstone

Scolopacidae

Philohela minor
Capella delicata
Bartramia longicauda
Actitis macularia
Tringa solitaria
Totanus melanoleucus
I. flaripes
Erolia minutilla
Crocethia alba
Tryngites subruficollis

American woodcock
Wilson's or common snipe
upland plover
spotted sandpiper
solitary sandpiper
greater or winter yellowlegs
lesser yellowlegs
least sandpiper
sanderling
buff-breasted sandpiper

Laridae

*Larus argentatus
*L. delawarensis
L. philadelphia
Sterna hirundo

herring gull
ring-billed gull
Bonaparte's gull
common tern

* Endangered or declining species

Laridae (cont'd.)	
<u>S. antillarum</u>	least tern
<u>Chlidonias nigra</u>	black tern
Columbidae	
<u>Zenaidura macroura</u>	mourning dove
Cuculidae	
<u>Coccyzus americanus</u>	yellow-billed cuckoo
<u>C. erythrophthalmus</u>	black-billed cuckoo
Strigidae	
<u>Asio falmeus</u>	short-eared owl
<u>Bubo virginianus</u>	great horned owl
<u>*Otus asio</u>	screech owl
Caprimulgidae	
<u>Chordeiles minor</u>	common nighthawk
Apodidae	
<u>Chaetura pelagica</u>	chimney swift
Trochilidae	
<u>Archilochus columbris</u>	ruby-throated hummingbird
Alcedinidae	
<u>*Megasceryle alcyon</u>	belted kingfisher
*Picidae	
<u>Colaptes auratus</u>	yellow-shafted flicker
<u>Sphyrapicus varius</u>	yellow-bellied sapsucker
<u>Melanerpes erythrocephalus</u>	red-headed woodpecker
<u>Dendrocoptes villosus</u>	hairy woodpecker
<u>D. pubescens</u>	downy woodpecker
Tyrannidae	
<u>Tyrannus tyrannus</u>	Eastern kingbird
<u>Myiarchus cinerascens</u>	great crested flycatcher
<u>Sayornis phoebe</u>	Eastern phoebe
<u>Empidonax minimus</u>	least flycatcher
Alaudidae	
<u>Eremophila alpestris</u>	horned lark
Hirundinidae	
<u>Hirundo rustica</u>	barn swallow
<u>Progne subis</u>	purple martin
<u>Piranga rubra</u>	bank swallow
<u>Iridoprocne bicolor</u>	tree swallow
Corvidae	
<u>Cyanocitta cristata</u>	blue jay
<u>Corvus brachyrhynchos</u>	common crow

* Endangered or declining species

Paridae	
* <u>Parus atricapillus</u>	black-capped chickadee
* <u>P. bicolor</u>	tufted titmouse
*Sittidae	
<u>Sitta carolinensis</u>	white-breasted nuthatch
<u>S. canadensis</u>	red-breasted nuthatch
Certhidae	
<u>Certhia familiaris</u>	brown creeper
Troglodytidae	
* <u>Troglodytes aedon</u>	house wren
<u>Cistothorus platensis</u>	short-billed marsh wren
Mimidae	
<u>Denatella carolinensis</u>	catbird
<u>Toxostoma rufum</u>	brown thrasher
Turdidae	
* <u>Turdus migratorius</u>	robin
* <u>Sialia sialis</u>	Eastern bluebird
<u>Hylocichla minima</u>	gray-cheeked thrush
<u>H. ustulata</u>	Swainson's or olive-backed thrush
Regulidae	
<u>Regulus calendula</u>	ruby-crowned kinglet
<u>R. satrapa</u>	golden-crowned kinglet
Bombycillidae	
<u>Bombycilla cedrorum</u>	cedar waxwing
Sturnidae	
<u>Sturnus vulgaris</u>	starling
Parulidae	
<u>Minioilta varia</u>	black and white warbler
<u>Seiurus aurocapillus</u>	ovenbird
<u>S. noveboracensis</u>	Northern waterthrush
<u>Setophaga ruticilla</u>	American redstart
* <u>Dendroica aestiva</u>	yellow or golden warbler
<u>D. coronata</u>	myrtle warbler
<u>D. magnolia</u>	magnolia warbler
<u>D. pennsylvanica</u>	chestnut-sided warbler
<u>D. dominica</u>	yellow-throated warbler
<u>D. striata</u>	blackpoll
<u>D. palmarum</u>	palm warbler
<u>Helminthophila versivoxus</u>	worm-eating warbler

*Endangered or declining species

Parulidae (cont'd.)

Wilsonia citrina
Vermivorus peregrina
S. noveboracensis
Vermivora celata

hooded warbler
 Tennessee warbler
 Northern waterthrush
 orange-crowned warbler

Thraupidae

Piranga olivacea
Phenictus ludovicianus
Hesperiphona vespertina

scarlet tanager
 rose-breasted grosbeak
 evening grosbeak

Icteridae

Agelaius phoeniceus
Icterus galbula
Sturnella magna magna
Molothrus ater
Quiscalus quiscula
Dolichonyx orizivorus

red-winged blackbird
 Baltimore oriole
 Eastern meadowlark
 Eastern brown-headed cowbird
 purple or common grackle
 bobolink

Fringillidae

Richmondia cardinalis
Passer domesticus
Spinus pinus
S. tristis
Acanthis flammea
Loxia curvirostra
Carpodacus purpureus
Pipilo erythrophthalmus
Spizella passerina
S. pusilla
Passerella iliaca
Zonotrichia leucophrys
Z. albicollis
Plectrophenax nivalis
Melospiza melodia
M. georgiana
Junco hyemalis
Z. querula

cardinal
 house or English sparrow
 pine siskin
 American goldfinch
 common redpoll
 red crossbill
 purple finch
 rufous-sided towhee
 chipping sparrow
 field sparrow
 fox sparrow
 white-crowned sparrow
 white-throated sparrow
 snow-bunting
 song sparrow
 swamp sparrow
 slate-colored junco
 Harris' sparrow

APPENDIX A

CHECK LIST OF THE FISH OF LAKE MICHIGAN

Petromyzonidae	
<u>Petromyzon marinus</u>	great sea lamprey
Acipenseridae	
<u>Acipens fulvescens</u>	lake sturgeon
Clupeidae	
<u>Alosa pseudoharengus</u>	alewife
<u>Dorosoma cepedianum</u>	gizzard shark
Salmonidae	
<u>Salmo gairdneri</u>	rainbow trout
<u>S. trutta</u>	brown trout
<u>Salvelinus fontinalis</u>	speckled trout
<u>S. namaycush</u>	lake trout
<u>Oncorhynchus kisutch</u>	coho salmon
<u>O. tshawytscha</u>	chinook salmon
Coregonidae	
<u>Coregonus clupeaformis</u>	lake or humpback whitefish
<u>C. hoyi</u>	bloater
<u>C. reishardi</u>	shortnose cisco
<u>C. alpanae</u>	longjaw cisco
<u>C. artedii</u>	lake herring
<u>C. kiyi</u>	kiyi
Osmeridae	
<u>Osmerus mordax</u>	American smelt
Esoecidae	
<u>Esox lucius</u>	Northern or yellow pike
<u>E. masquinongy</u>	muskellunge
<u>Esox sp.</u>	mud pickerel
Umbridae	
<u>Umbra limi</u>	central mudminnow
Cyprinidae	
<u>Cyprinus carpio</u>	common carp
<u>Notropis hudsonicus</u>	spotted shiner
<u>N. atherinoides</u>	emerald shiner
<u>N. communis</u>	common shiner
<u>Rhinichthys cataractae</u>	longnose dace
Catastomidae	
<u>Notostoma erythrum</u>	golden redhorse
<u>Catastomus commersonii</u>	common or white sucker
<u>C. catastomus</u>	longnose sucker
<u>Cariacus cyprinus</u>	quillback

Gadidae

Lota lota

burbot

Gasterosteidae

Pungitius pungitius

ninespine stickleback

Percopsidae

Percopsis omiscomaycus

troutperch

Percidae

Perca flavescens

yellow perch

Percina caprodes

logperch

Etheostoma nigrum

Johnny darter

Stizostedion canadense

sauger

Cottidae

Cottus bairdi

mottled sculpin

C. ricei

spoonhead sculpin

C. cognatus

slimy sculpin

Myoxocephalus quadricornis

fourhorn sculpin

Coregonus bairdi

sculpin

Azeiurduo

Ictalurus melas

black bullhead

I. punctatus

channel catfish

Centrarchidae

Micropterus dolomieu

smallmouth bass

Lepomis macrochirus

bluegill

APPENDIX A

"Resident" Bird Species in the Illinois Dunes State Park¹

Name	Common >3-mo./yr.	Uncommon <3-mo./yr.	Breeds	Endangered
Great Blue Heron	x		x	
Black Crowned Night Heron	x		x	
Yellow-crowned Night Heron		x		
Bald Eagle		x	x	x
Semipalmated Plover		x		
Piping Plover		x	x	
Killdeer	x		x	
American Golden Plover		x		
Black-bellied Plover	x			
Ruddy Turnstone		x		
Common Snipe	x		x	
Whimbrel		x		
Spotted Sandpiper	x		x	
Solitary Sandpiper	x			
Greater Yellowlegs	x			
Lesser Yellowlegs	x		x	
Knot		x		
Pectoral Sandpiper	x			
White-rumped Sandpiper		x		
Baird's Sandpiper		x		
Least Sandpiper	x		x	
Dunlin	x			
Short-billed Dowitcher	x			
Semipalmated Sandpiper	x			
Western Sandpiper		x		
Buff-breasted Sandpiper		x		
Hudsonian Godwit		x		
Sanderling	x			
Red Phalarope		x		
Wilson's Phalarope		x	x	x
Northern Phalarope		x		
Mourning Dove	x		x	
Snowy Owl		x		
Belted Kingfisher	x		x	
Horned Lark	x		x	
Common Crow	x		x	
Long-billed Marsh Wren	x		x	
Short-billed Marsh Wren	x		x	
Catbird	x		x	
Starling	x		x	
Myrtle Warbler	x			

¹Smith, E. T. and W. L. Hebert. 1964. "Birds of the Illinois Dunes State Park." Chicago Natural History Museum Bulletin 100: 1-10.

²George, W. O. 1964. "Variations and endangered birds of Illinois." Illinois Natural History Survey Bulletin 100: 1-10.

³Smith, E. T. and W. L. Hebert. 1964. "Birds of the Illinois Dunes State Park." Chicago Natural History Museum Bulletin 100: 1-10.

TABLE A-3

APPENDIX A (cont'd.)

Name	Common >3-mo./yr.	Uncommon <3-mo./yr.	Breeds	Endangered ²
Black-throated Green Warbler	x			
Palm Warbler	x			
Mourning Warbler	x		x	
Yellowthroat	x		x	
House Sparrow	x		x	
Redwinged Blackbird	x		x	
Brown-headed Cowbird	x		x	
Cardinal	x		x	
Indigo Bunting	x		x	
American Goldfinch	x		x	
Slate-colored Junco	x			
Oregon Junco		x		
White-throated Sparrow	x			
White-crowned Sparrow	x			

Total = 55

18 uncommon

37 common

26 breeding

2 endangered

¹ Smith, E. T. and W. J. Beecher: Chicagoland Birds. Where and When to Find Them. Chicago Natural History Museum Publication, 1963.

² George, W. G., Vanished and endangered birds of Illinois: A new "Black List" and "Red List." The Audubon Bulletin No. 158, June 1971, pp. 2-11.

CHECK LIST OF THE VASCULAR PLANTS OF THE ILLINOIS BEACH STATE PARK (1)

Scientific Name	Common Name	Herbarium Access Code
EQUISETACEAE		
<i>Equisetum arvense</i> L.	Horsetail	1542, 16682
<i>Equisetum hyemale</i> L.	Tall Scouring Rush	650, 1390
var. <i>affine</i> (Engelm.) A. A. Eat.	Smooth Scouring Rush	127, 452
<i>Equisetum hyemale</i> L.		
var. <i>intermedium</i> A. A. Eat.		
SELAGINELLIACEAE		
<i>Selaginella apoda</i> (L.) Spring	Marsh Club Grass	5107
OSMUNDACEAE		
<i>Osmunda regalis</i> L.	Royal Fern	108, 1204
var. <i>spectabilis</i> (Willd.) Gray		
POLYPODIACEAE		
<i>Dryopteris thelypteris</i> (L.) Gray	Marsh Shield Fern	131, 573
var. <i>pubescens</i> (Lamson) Nakai		
<i>Onoclea sensibilis</i> L.	Sensitive Fern	712, 1808
<i>Pteridium aquilinum</i> (L.) Kuhn	Bracken Fern	538
var. <i>latiusculum</i> (Desv.) Underw.		
PINACEAE		
<i>Juniperus communis</i> L.	Common Juniper	145, 613
var. <i>depressa</i> Pursh	Trailing Juniper	99, 633
<i>Juniperus horizontalis</i> Moench	Red Cedar	714, 976
<i>Juniperus virginiana</i> L.	European Larch	1063
var. <i>crebra</i> Fern.	Jack Pine	1660
<i>Larix decidua</i> Mill.	Austrian Pine	1202, 5073
<i>Pinus banksiana</i> Lamb.	Pitch Pine	1649
<i>Pinus nigra</i> Arnold	White Pine	790
<i>Pinus rigida</i> Mill.	Scotch Pine	782, 1061
<i>Pinus strobus</i> L.		
<i>Pinus sylvestris</i> L.		
TYPHACEAE		
<i>Typha angustifolia</i> L.	Narrow-leaved	713
<i>Typha latifolia</i> L.	Cat-tail	1770
SPARGANIACEAE		
<i>Sparganium eurycarpum</i> Engelm.	Common Bur Reed	1660

1
Dr. Elizabeth Lunn, Professor Emeritus, Lake Forest College, Lake Forest, Ill.

ZOSTERACEAE

Potamogeton foliosus Raf. Var. niagarensis (Tuckerm.) Morong	Leafy Pondweed	1396, 4065
Potamogeton gramineus L.	Grass-leaved Pondweed	4094, 5067
Potamogeton illinoensis Morong	Illinois Pondweed	1252, 5057
Potamogeton natans L.	Common Pondweed	5056
Potamogeton nodosus Poir.	Long-leaved Pondweed	5058
Potamogeton pectinatus L.	Comb Pondweed	1327, 5054
Potamogeton pusillus L.	Small Pondweed	1933
Potamogeton zosteriformis Fern.	Flat-stemmed Pondweed	1328, 5059

NAJADACEAE

Najas flexilis (Willd.) Rostk. & Schmidt	Slender Naiad	5060
Najas guadalupensis (Spreng.) Magnus	Southern Naiad	1329, 1932

JUNCAGINACEAE

Triglochin maritima L.	Arrow Grass	111, 728

ALISMATACEAE

Alisma triviale Pursh.	Water Plantain	677, 1251
Sagittaria latifolia Willd.	Arrowhead	630, 1170

HYDROCHARITACEAE

Elodea canadensis Michx.	Waterweed	1253, 1362

GRAMINEAE

Agropyron repens (L.) Beauv.	Quack Grass	1054
Agropyron trachycaulum (Link) Malte	Bearded Wheat Grass	1953
Agropyron trachycaulum (Link) Malte Var. unilaterale (Cassidy) Malte	Bearded Wheat Grass	831
Agrostis alba L.	Red Top	1217
Agrostis hyemalis (Walt.) BSP	Tickle Grass	815
Ammophila breviligulata Fern.	Sand-reed or Marram	1632
Andropogon gerardi Vitm.	Turkey Foot Grass	315
Andropogon scoparius Michx.	Little Bluestem Grass	674
Aristida intermedia Scribn. & Ball	Triple-awned Grass	835
Avena fatua L.	Wild Oats	2028
Avena sativa L.	Oats	823
Bromus inermis Leyss.	Hungarian Brome	671
Bromus japonicus Thunb.	Japanese Brome Grass	1214

GRAMINEAE (Cont'd)

Bromus kalmii Gray

Bromus latiglumis (Shear) Hitchc.

Bromus tectorum L.

Calamagrostis canadensis (Michx.)
Nutt.

Calamagrostis inexpansa Gray
Var. *brevior* (Vasey) Stebbins

Calamovilfa longifolia (Hook) Scribn.
Var. *magna* Scribn. & Marr.

Cenchrus longispinus (Hack.) Fern.

Dactylis glomerata L.

Digitaria ischaemum (Schreb.) Muhl.

Digitaria sanguinalis (L.) Scop.

Echinochloa crusgalli (L.) Beauv.

Echinochloa walteri (Pursh.) Nash

Elymus arenarius L.

Elymus canadensis L.

Elymus virginicus L.

Eragrostis megastachya (Koel.) Link

Eragrostis pectinacea (Michx.) Nees

Festuca elatior L.

Glyceria striata (Lam) Hitchc.

Hierochloa odorata (L.) Beauv.

Hordeum jubatum L.

Koeleria cristata (L.) Pers.

Leersia oryzoides (L.) Sw.

Muhlenbergia frondosa (Poir.) Fern.

Muhlenbergia racemosa (Michx.) BSP

Panicum capillare L.

Panicum dichotomiflorum Michx.

Var. *paniculatum* (Wood) Fern.

Wild Chess 159,
1216

Broad-glumed Bromo 1954
Grass

Downy Bromo 453

Blue Joint 673,

1156

Bog Reed Grass 5069

Sand reedgrass 1894,
331

Sandbur 2029

Orchard Grass 3007a

Crab Grass 2072

Crab Grass 715

Barnyard Grass 641, 643

Salt-marsh Cockspur 733

Sea Lyme-Grass 146,

330

Wild Rye 354, 594

Wild Rye 1952

Stink Grass 1581

Lova Grass 1567,

2073

Meadow Fescue 853,

1636

Fowl Meadow Grass 784,

1768

Sweet Grass, 1689,

Vanilla Grass 3064

Foxtail Barley 163,

796

June Grass 670,

1167

Cut Grass 793,

3026

Common Seta Grass 3001

Upland Wild Timothy 662

Witch Grass 854,

1564

Knee Grass 1579

GRAMINEAE (Cont'd)

<i>Panicum flexile</i> (Gatt.) Scribn.	Wiry Panic Grass	693, 2037
<i>Panicum lanuginosum</i> Ell.	Hairy Panic Grass	2051, 2038
Var. <i>implicatum</i> (Scribn.) Fern.	Mat Panic Grass	1119, 1199
<i>Panicum meridionale</i> Ashe	Scribner's Panic Grass	1118, 1205
<i>Panicum oligosanthos</i> Schultes	Early Panic Grass	4093
Var. <i>scribnerianum</i> (Nash) Fern.	Switch Grass	335, 644
<i>Panicum praecocius</i> Hitchc. & Chase	Reed Canary Grass	1157, 4051
<i>Panicum virgatum</i> L.	Timothy	1114, 1890
<i>Phalaris arundinacea</i> L.	Common Reed	667, 5031
<i>Phleum pratense</i> L.	Canada Blue Grass	668, 1197
<i>Phragmites communis</i> Trin.	Kentucky Blue Grass	832, 1011
Var. <i>berlandieri</i> (Fourn.) Fern.	Yellow Foxtail	1286, 1604
<i>Poa compressa</i> L.	Whorled Foxtail	1934
<i>Poa pratensis</i> L.	Green Foxtail	640, 1935
<i>Setaria glauca</i> (L.) Beauv.	Indian Grass	326
<i>Setaria verticillata</i> (L.) Beauv.	Cord or Slough Grass	316, 596
<i>Setaria viridis</i> (L.) Beauv.	Slender Wedge Grass	1283
<i>Sorghastrum nutans</i> (L.) Nash	Sand Dropseed	666, 797
<i>Spartina pectinata</i> Link.	Prairie Dropseed	818
<i>Sphenopholis intermedia</i> Rydb.	Poverty Grass	2073
<i>Sporobolus cryptandrus</i> (Torr.) Gray	Needle Grass,	1117,
<i>Sporobolus heterolepis</i> Gray	Porcupine Grass	1791
<i>Sporobolus vaginiflorus</i> (Torr.) Wood	Slender Fescue	1196
Var. <i>inaequalis</i> Fern.		
<i>Stipa spartea</i> Trin.		
<i>Vulpia octoflora</i> (Walt.) Rydb.		
Var. <i>tenella</i> (Willd.) Fern.		
CYPERACEAE		
<i>Carex Bebbii</i>		1163a, 3098
<i>Carex Buxbaumii</i> Wahl.		1162
<i>Carex comosa</i> Boott.	Bristly Sedge	844
<i>Carex conoidea</i> Schk.		1002, 1010
<i>Carex crassipes</i> Dew.		5082
<i>Carex davisii</i> Schw. & Torr.		4050
<i>Carex garberi</i> Fern.		3097
<i>Carex granularis</i> Muhl.		3086

CYPERACEAE (Cont'd)

Carex lanuginosa Michx.
Carex laxiflora Lam.
Carex meadii Dew.
Carex muhlenbergii Schk.
Carex pennsylvanica Lam.
Carex scoparia Schk.
Carex stricta Lam.
Carex subereta (Olney) Britt.
Carex viridula Michx.
Eleocharis acicularis (L.) R & S
Eleocharis calva Torr.
Eleocharis compressa Sulliv.
Eleocharis obtusa (Willd.) Schult.
Eleocharis pauciflora (Lightf.)
Link var. *fernaldi* svanson
Eriophorum angustifolium Honckeny
Fimbristylis drummondii Boeckl.
Hemicarpha drummondii Nees
Rhynchospora capillacea Torr.
forma *leviseta* E. J. Hill
Scirpus americanus Pers.
Scirpus atrovirens Willd.
Scirpus cyperinus (L.) Kunth.
Scirpus lineatus Michx.
Scirpus validus Vahl. var. *creber*
Fern.
Scleria triglomerata Michx.

ARACEAE

Acorus calamus L.
Symplocarpus foetidus (L.) Nutt.

LEMNACEAE

Lemna trisulca L.
Lemna minor L.
Wolffia columbiana Karst.

COMELINACEAE

Tradescantia ohiensis Raf.

PONTEDERIACEAE

Pontederia cordata L.

JUNCACEAE

Juncus alpinus Vill.
var. *rariflorus* Hartm.
Juncus balticus Willd.
var. *littoralis* Engelm.
Juncus brachycephalus (Engelm.) Buch.
White Poplar
Gray Poplar
Large-toothed Poplar

Woolly Sedge 1057, 1131
Wood Sedge 3086
1226
Sand Sedge 1056, 1172
Pennsylvania Sedge 927, 972
1163
1008, 1161
1129
115, 838
Needle Spike Rush 1378
1166, 1324
Flat-stemmed Spike Rush 1003, 1165
Blunt Spike Rush 1058
5034
Narrow-Leaved Cotton Grass 114, 1005
Chestnut Sedge 4081
1285
Hair Beak Rush 842, 1330
Chairmaker's Rush 699, 5095
Dark Green Rush 856, 1565
Wool Grass 855, 4080
Red Bulrush 1171, 4063
Great Bulrush 684, 685
Tall Nut Rush 5106
Sweet Flag 1254
Skunk Cabbage 997, 1661

Forked Duckweed 1631, 5074
Small Duckweed 1152
Common Water Meal 1577, 5075
Common Spiderwort 80, 1827

PICKEREL WEED

Richardson's Rush 826, 1289
Lake Shore Rush 759, 1653

Short-headed Rush 2031, 5034
Populus alba L.
Populus canadensis (Mill.) B.S.P.
Populus deltoides Marsh.
Populus jackii Sarg.

JUNCACEAE (cont'd)

Juncus bufonis L.
Juncus canadensis J. Gray
Juncus dudleyi Wieg.
Juncus grisei Oakes & Tuckerm.
Juncus nodosus L.
Juncus tenuis Willd.
Juncus torreyi Cov.
Luzula bulbosa (Wood) Rydb.
Luzula multiflora (Retz.) Lejune

Toad Rush 1397, 1793
Canadian Rush 687, 1927
Dudley's Rush 1130, 1572
Greene's Rush 2022
Joint Rush 829, 1279
Roadside Rush 1198, 2060
Torrey's Rush 1293, 4056
Bulbous Wood Rush 4000
Common Wood Rush 998

LILIACEAE

Alisteria farinosa L.
Allium canadense L.
Allium cernuum Roth
Asparagus officinalis L.
Erythronium albidum Nutt.
Lilium michiganense Parv.
Lilium philadelphicum L.
var. *andinum* (Nutt.) Ker.
Maianthemum canadense Desf.
Polygonatum canaliculatum (Muhl.) Pursh
Saxifraga stellata (L.) Desf.
Smilax acutirrhata (Engelm.) Watson
Smilax lasioneura Hook
Smilax tannoides L. var. *hispida*
(Muhl.) Fern.
Tofieldia glutinosa (Michx.) Pers.
Trillium grandiflorum (Michx.) Salisb.
Trillium recurvatum Beck

Colic Root 174
Wild Garlic 101, 1741
Nodding Wild Onion 306
Asparagus 96, 1845
White Trout Lily 3049
Turk's Cap Lily 1264, 1851
Prairie Lily 169
Wild-lily-of-the-valley 85, 1050
Smooth Solomon's Seal 587, 1051
Starry False Solomon's Seal 1689, 1820
Upright Carrion Flower 474
Common Carrion Flower 583, 1203
Bristly Green Brier 711, 1174
False Asphodel 302, 633
Large-flowered Trillium 3071
Red Trillium 3050

AMARYLLIDACEAE

Hypoxis hirsuta (L.) Coville

Yellow Star Grass 95, 1006

IRIDACEAE

Iris virginica L. var. *shrevei*
(Small) E. Anders
Sisyrinchium albidum L.

Blue Flag 110
Common Blue-eyed Grass 450, 3091

ORCHIDACEAE

Calopogon pulchellus (Salisb.) R. Br.
Habenaria flava (L.) R. Br. var.
herbiola R. Br.
Habenaria psycodes (L.) Spreng.
Spiranthes cernua (L.) Richard
Spiranthes lacera Raf.

Grass Pink 148
Pale Green Orchid 1801
Purple Fringed Orchid 1941
Nodding Ladies' Tresses 380, 2050
Slender Ladies' Tresses 339, 629

SALICACEAE

Populus alba L.
Populus canadensis (Ait.) Sm.
Populus deltoides Marsh
Populus jackii Sarg.

White Poplar 602
Gray Poplar 599, 778
Large-toothed Poplar 141, 900
710

SALICACEAE (cont'd)

Populus nigra L. *italica* Muenchh.
Populus tremuloides Michx.
Salix alba L.
Salix amygdaloides Anderss.
Salix bebbiana Sarg.
Salix discolor Muhl.
Salix glaucophylloides Fern. var.
glaucophylla (Bebb.) Schneid.
Salix humilis Marsh
Salix interior Rowles
Salix rigida Muhl.

Salix serissima (Bailey) Fern.
Salix syrticola Gray

JUGLANDACEAE

Carya cordiformis (Wang.) K. Koch
Juglans nigra L.

CORYLACEAE

Betula papyrifera (Marsh.) Spach.
Betula pumila L.
Betula pumila L. var. *glandulifera* Gray
Betula sandbergii Britt. = *B. papyrifera*
x *B. pumila*
Corylus americana Walt.

FAGACEAE

Quercus alba L.
Quercus bebbiana Schneid. = *Q. alba* x
Q. macrocarpa
Quercus macrocarpa Michx.
Quercus velutina Lam.

MORACEAE

Morus alba L.

URTICACEAE

Laportea canadensis (L.) Gand.
Urtica procera Muhl.

SANTALACEAE

Comandra richardsoniana Fern.

POLYGONACEAE

Polygonum sagittatum (L.) Rostk.
Polygonum amphibium L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.
Polygonum (Columba) L.

Lombardy Poplar 601
Trembling Aspen 97, 899
White Willow 1298
Peach-leaved Willow 1883, 4057
Bebb's or Beaked Willow 3080
Pussy Willow 1287
Sand-dune Willow 692, 3063

Prairie Willow 721, 975
Sandbar Willow 144, 1381
Cordate or Heart-leaved Willow 1560, 1882
Autumn Willow 1379
Sand-dune Willow 720, 4002

Bitternut 5062
Black Walnut 1596, 5071

White Birch 475, 1335
Swamp Birch 746, 1121
Glandular Swamp Birch 399, 704
Sandberg's Birch 791, 1602

Hazelnut 5070

White Oak 1585, 1884
Bebb's Oak 779, 2095
Burr Oak 39, 1352
Black Oak 140, 962

White Mulberry 603, 1594

Wood Nettle 1350, 2064
Tall Nettle 1365, 1589

False Toadflax 98, 3083

Buckwheat 647, 1184
Water Smartweed 788, 1362

Knotweed 1193, 1384
Water Smartweed 788, 1362
Black Knotweed 1748, 1812
Water Smartweed 788, 1362

POLYGONACEAE (cont'd)

Polygonum pennsylvanicum L.
var. *laxvigatum* Fern.
Polygonum persicaria L.
Polygonum punctatum Ell.
Polygonum tenue Michx.
Rumex acetosella L.
Rumex altissimus Wood
Rumex crispus L.
Rumex orbiculatus Gray

Pennsylvania Knotweed 564
Lady's Thumb 543, 789
Smartweed 676, 763
Slender Knotweed 775, 1387
Sheep Sorrel 1123, 1718
Pale Dock 1853, 4056
Curled Dock 1794
Great Water Dock 748, 5016

CHEENOPODIACEAE

Atriplex patula L. var. *hastata*
(L.) Gray
Chenopodium album L.
Chenopodium leptophyllum Nutt.
Corispermum hyssopifolium L.
Cyloloma striplificifolium (Spreng.)
Coulter
Kochia scoparia (L.) Roth.
Salsola kali L. var. *tenuifolia* Tausch.

Orach 1910
Lamb's Quarters 719, 1185
Goosefoot 744, 2044
Bugseed 709, 5017
Winged Pigweed 1218, 552
Summer Cypress 2093
Russian Thistle 1915

AMARANTHACEAE

Achida altissima Riddell var. *subnuda*
(S. Wats.) Fern
Amaranthus albus L.
Amaranthus graecisans L.
Amaranthus powellii S. Wats.
Froelichia floridana (Wutt.) Moq. var.
caespitris (Small) Fern.

Water Hemp 1516, 1519
Tumbleweed 776, 1570
Creeping Amaranth 697
Smooth Pigweed 1558, 1569
Cottonweed 716

NYCTAGINACEAE

Mirabilis nyctaginea (Michx.) Mac M.

Umbrella Wort 717, 1913

AIZOACEAE

Mollugo verticillata L.

Carpetweed 1523, 2070

PORTULACAEAE

Portulaca oleracea L.

Common Purslane 705, 1367

CARYOPHYLLACEAE

Arenaria lateriflora L.
Arenaria stricta Michx.
Cerastium vulgatum L.
Plantago armeria L.
Lychnis alba Mill.
Silene antirrhina L.
Silene acaulis Baumg.
Silene stellata (L.) Ait.
Silene officinalis L.
Stellaria media (L.) Cyrillo

Wood Sandwort 1712
Stiff Sandwort 90
House-ear Chickweed 1191
Deptford Pink 1220
White Campion 132, 625
Sleepy Catchfly 1257, 1733
Glaucous Campion 1729
Starry Campion 1351, 1936
Bouncing Bet (Columbian) 568, 1839
Common Chickweed 1725

CARYOPHYLLACEAE

Caryophyllus demersus L.

St. George's Wort 5051

LYMPHAEACEAE

Luphar variegatum Engelm.
Luphasea tuberosa Paine

Yellow Pond Lily 176, 1262
 Water Lily 1930, 5052

ANUNCULACEAE

Anemone canadensis L.
Anemone cylindrica Gray
Anemone quinquefolia L. var. *interior*
 Fern.

Meadow Anemone 129, 175
 Thimbleweed 324, 1175
 Wood Anemone 3036

Anemone virginiana L.
Quillogia canadensis L.
Altha palustris L.
Lamatis virginiana L.
Anunculus abortivus L.
Anunculus acris L.
Anunculus flabellaris Raf.
Anunculus scleratus L.
Anunculus septentrionalis Poir.
Anunculus trichophyllus Chaix.
Galictium dasycarpum Fisch. & Hall.

Thimbleweed 1767, 4041
 Wild Columbine 116
 Marsh Marigold 1699
 Virgin's Bower 2027
 Small-flowered Buttercup 1663, 2053
 Tall Buttercup 1829
 Yellow Water Crowfoot 1529, 1700
 Cursed Buttercup 1196, 1315
 Swamp Buttercup 965, 1673
 White Water Crowfoot 1250, 1843
 Purple Meadow Rue 1730, 4031

ERBERIDACEAE

Erberia thunbergii DC

Japanese Barberry 1360

APPARIDACEAE

Apparis graveolans Raf.

Clammy Weed 1353

ROSACEAE
Agrostis exaristata Willd.
Amelanchier alnifolia (Mill.) B.S.P.
Amelanchier canadensis Mill.
Crataegus mollis (L.) DC.
Viburnum acerifolium L.
Fragaria virginiana Duchesne
Cornus latifolia L. var. *trichosperma*
 Fern.
Potentilla anserina L.
Potentilla arguta L.
Potentilla arguta Pursh
Potentilla fruticosa L.
Potentilla norvegica L.
Potentilla palustris (L.) Scop.
Potentilla recta L.
Potentilla simplex Michx.
Rosa carolina Marsh.
Rosa pratincola L.
Rosa rugosa L.
Rosa wichuraiana (Rostk.) Schmidt

CRUCIFERAE

Arabis hirsuta (L.) Scop. var.
 adpressipilis (Hopkins) Rollins
Arabis laevigata (Muhl.) Poir
Arabis lyrata L.
Barbarea vulgaris R. Br. var.
 arcuata (Opiz) Fries
Berteroa incana (L.) DC
Brassica kaber (DC) L. C. Wheeler
 var. *pinnatifida* (Stokes) L.C.
 Wheeler
Brassica nigra (L.) Koch.
Cakile edentula (Bigel.) var.
 lacustris Fern.
Capsella bursa-pastoris (L.) Medic.
Carlinia bulbosa (Schreb.) B.S.P.
Diplotaxis muralis (L.) DC
Draba reptans (Lam.) Fern.
Lepidium campestre (L.) R. Br.
Lepidium densiflorum Schrad.
Lepidium virginicum L.
Rorippa islandica (Oeder) Borbas
 var. *vernaldiana* Butters & Abbe
Sisymbrium altissimum L.
Sisymbrium officinale (L.) Scop.

Hairy Rock Cress 1147
Smooth Rock Cress 1702
Sand Cress 86, 929
Winter Cress 955, 1672
Hoary Alyssum 1608, 1728
Crunchweed 1182, 1719
Black Mustard 321
Sea Rocket 172
Shepherd's Purse 2076
Spring Cress 1701, 3073
Wall or Sand Rocket 5099
Creeping Draba 3048
Field Cress 1189, 1211
Small Pepperwort 120, 1150
Common Pepper Grass 792, 1064
Yellow Cress 1212, 1768
Tumbling Mustard 1148, 1739
Hedge Mustard 5282

SAXIFRAGACEAE

Heuchera richardsonii R. Br.
 var. *grayana* Rosend., Butt. & Lck.
Parnassia glauca Gray
Penthorum sedoides L.
Ribes americanum Mill.
Saxifraga pennsylvanica L.

Alum Root 85, 1107
Grass of Parnassus 2086
Ditch Stonecrop 799, 1222
Black Current 1673, 1188
Swamp Saxifrage

ROSACEAE

Agrimonia gryposepala Wallr.
Amelanchier arborea (Michx.) Fern.
Amelanchier humilis Wieg.
Crataegus holmesiana Ashe var.
 villipes Ashe Id. E. Kruschke
Fragaria virginiana Duchesne
Geum laciniatum L. var. *trichocarpum*
 Fern.
Potentilla anserina L.
Potentilla argentea L.
Potentilla arguta Pursh
Potentilla fruticosa L.
Potentilla norvegica L.
Potentilla palustris (L.) Scop.
Potentilla recta L.
Potentilla simplex Michx.
Prunus americana Marsh
Prunus pennsylvanica L.f.
Prunus pensilvanica L.
Prunus serotina Ehrh.

Tall Agrimony 1528, 1880
Service Berry 734
Low Shadblow 954, 1001
Hawthorn 1951, 3068
Strawberry 130, 1684
Rough Arens 1385
Silverweed 82
Silvery Cinquefoil 4083
Prairie Cinquefoil 192, 1209
Shrubby Cinquefoil 555
Rough Cinquefoil 1269, 1769
Marsh Cinquefoil 142, 1817
Sulfur Cinquefoil 107, 1177
Common Cinquefoil 124, 738
Wild Plum 1676, 3058
Pie Cherry 5079
Sour Cherry 610, 1000
Black Cherry 1591, 1682

ROSACEAE (cont'd)

Prunus virginiana L. forma
leucocarpa (S. Wats) Haynie
Prunus virginiana L.
Pyrus ioensis (Wood) Bailey
Pyrus malus L.
Pyrus melanocarpa (Michx.) Willd.
Rosa blanda Ait.
Rosa carolina L.
Rosa palustris Marsh
Rubus allegheniensis Porter
Rubus flagellaris L.
Rubus idaeus L. var. *strigosus*
(Michx.) Maxim.
Rubus occidentalis L.
Spiraea alba DuRoi

LEGUMINOSAE

Amphicarpa bracteata (L.) Fern. var.
comosa (L.) Fern.
Amorpha canescens Pursh.
Apice americana Medic.
Astragalus canadensis L.
Eaptisia leucantha T & G
Lesmodium canadense (L.) DC
Lesmodium illinoense Gray
Lathyrus japonicus Willd. var.
glaber (Ser.) Fern.
Lathyrus palustris L.
Lathyrus venosus Muhl. var.
intonsus Butters & St. John
Lespedeza capitata Michx.
Lupinus perennis L.
Medicago lupulina L.
Medicago sativa L.
Melilotus alba Desr.
Melilotus officinalis (L.) Desr.
Petalostemum candidum (Willd.) Michx.
Petalostemum purpureum (Vent.) Rydb.
Petalostemum purpureum (Vent.) Rydb.
forma *arenarium* Gates
Robinia pseudoacacia L.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium repens L.
Vicia americana Muhl.
Vicia villosa Roth.

LINACEAE

Linum medium (Planch.) Britt.
var. *texanum* (Planch.) Fern.

OXALIDACEAE

Oxalis europaea Jord.
Oxalis stricta L.
Oxalis violacea L.

White-fruited Choke 795
Cherry
Choke Cherry 607, 969
Wild Crab 1623, 3073
Apple 1742, 3011
Black Chokeberry 760
Early Wild Rose 1733, 1779
Prairie Rose 813, 1763
Swamp Rose 1802
Common Blackberry 1950
Common Dewberry 3095
Red Raspberry 723, 1386

Black Raspberry 1549, 1937
Meadowsweet 1259, 1913

Hog Peanut 757, 1371

Lead Plant 194, 560
Wild Bean or Ground-Nut 651
Milk Vetch 534
Prairie Falae Indigo 143, 1223
Tick Trefoil 361, 4072
Tick Trefoil 762
Beach Pea 5094

Vetchling 1113, 1721
Vetchling 1722

Bush Clover 320, 627
Wild Lupine 91, 473
Black Medick 1192, 1213
Alfalfa 5045
White Sweet Clover 1803
Yellow Sweet Clover 1840
White Prairie Clover 193, 563
Purple Prairie Clover 2030

Black Locust 1634
Alsike Clover 1583
Red Clover 1924
White Clover 117
1110, 1715
118

Small Yellow Vicia 645, 1923

Ball Head Sorrel 1530, 1740
Common Head Sorrel 1543
Violet Head Sorrel 1809

GERANIACEAE

<i>Geranium carolinianum</i> L.	Carolina Cranesbill	1297
<i>Geranium maculatum</i> L.	Wild Geranium	1703

POLYGALACEAE

<i>Polygala polygama</i> Walt.	Purple Milkwort	168, 1764
var. <i>obtusata</i> Chodat		
<i>Polygala sanguinea</i> L.	Field Milkwort	628, 1535
<i>Polygala senega</i> L.	Seneca Snakeroot	1106
<i>Polygala verticillata</i> L.	Whorled Milkwort	2041
var. <i>isocycla</i> Fern.		

EUPHORBIACEAE

<i>Acalypha rhomboides</i> Raf.	Three-seeded Mercury	5064
<i>Euphorbia corollata</i> L.	Flowering Spurge	162, 314
<i>Euphorbia dentata</i> Michx.	Toothed Spurge	2074
<i>Euphorbia glyptosperma</i> Engelm.	Ridge-seeded Spurge	2046
<i>Euphorbia maculata</i> L.	Nodding Spurge	1281, 1529
<i>Euphorbia polygonifolia</i> L.	Seaside Spurge	620, 1925
<i>Euphorbia supina</i> Raf.	Creeping Spurge	731, 2069

ANACARDIACEAE

<i>Rhus glabra</i> L.	Smooth Sumac	553, 1154
<i>Rhus radicans</i> L.	Poison Ivy	1799
<i>Rhus typhina</i> L.	Staghorn Sumac	1704

AQUIFOLIACEAE

<i>Ilex verticillata</i> (L.) Gray	Winterberry	482, 755

CELASTRACEAE

<i>Celastrus scandens</i> L.	Climbing Bittersweet	556

ACEERACEAE

<i>Acer negundo</i> L.	Box Elder	1838
<i>Acer saccharinum</i> L.	Silver Maple	3002

BALSAMINACEAE

<i>Impatiens capensis</i> Moerb.	Spotted Touch-me-not	1543, 2075

RHAMNACEAE

<i>Ceanothus americanus</i> L.	New Jersey Tea	574, 1784
<i>Ceanothus ovatus</i> Desf.	Red-root	60, 479
<i>Rhamnus cathartica</i> L.	Common Buckthorn	1886, 1336
<i>Rhamnus frangula</i> L.	Glossy Buckthorn	1782

VITACEAE

<i>Parthenocissus quinquefolia</i> (L.) Planch	Virginia Creeper	1179
<i>Vitis riparia</i> Michx.	Dune Grape	477, 126
var. <i>syrticola</i> (Fern. & Weig) Fern.		

TILIACEAE

<i>Tilia americana</i> L.	Basswood	579, 1724

MALVACEAE		
Abutilon theophrasti Medic.	Velvet Leaf	551, 1585
GUTTIFERAE		
Hypericum canadense L.	Canadian St. John's Wort	4090
Hypericum Kalmianum L.	Kalm's St. John's Wort	695, 1825
Hypericum majus (Gray) Britt.		2047
Hypericum perforatum L.	Common St. John's Wort	1835, 4059
Hypericum virginicum L.	Marsh St. John's Wort	722, 1597
var. fraseri (Spach) Fern.		
CISTACEAE		
Helianthemum bicknellii Fern.	Rockrose	764, 1785
Helianthemum canadense (L.) Michx.	Common Rockrose	104, 1228
Lachea leggettii Britt. & Holl.	Leggett's Pinweed	694, 824
var. moniliformis (Bickn.) Hodg.		
Lachea stricta Leggett	Bushy Pinweed	857, 1892
Lachea villosa Ell.	Hairy Pinweed	4065
VIOLACEAE		
Viola conspersa Reichenb.	Dog violet	1668
Viola cucullata Ait.	Hooded Violet	1679, 3052
Viola papilionacea Pursh	Common Blue Violet	960, 1670
Viola pedata L.	Bird's Foot Violet	959
var. lineariloba DC		
Viola pedatifida Don	Prairie Violet	4038
Viola pubescens Ait.	Downy Yellow Violet	1671, 3057
Viola sagittata Ait.	Arrow-leaved Violet	956, 1669
Viola sororia Willd.	Hairy Wood Violet	961
CACTACEAE		
Opuntia humifusa Raf.	Prickly Pear	178
LYTHRACEAE		
Lythrum alatum Pursh	Winged Loosestrife	165, 1223
Lythrum salicaria L.	Purple Loosestrife	4089
ONAGRACEAE		
Epilobium angustifolium L.	Fireweed	4099
Epilobium coloratum Biehler	Cinnamon Willow Herb	801, 1526
Epilobium glandulosum Lehm. var. adenocaulon Haussk	Northern Willow Herb	5304
Gaura biennis L.	Biennial Gaura	598
Ludwigia palustris (L.) Ell.	Marsh Purslane	1368, 1888
var. americana (DC) Fern & Griseb		
Ludwigia polycarpa Short & Peter	False Loosestrife	1595
Oenothera biennis L.	Common Evening Primrose	626, 1926
Oenothera rhombipetala Nutt.	Sand Primrose	665, 1262

HALORAGAGIDACEAE

Myriophyllum exalbescens Fern.
Myriophyllum heterophyllum Michx.
Myriophyllum verticillatum L.
 var. *pectinatum* Wallr.
Proserpinaca palustris L.
 var. *crebra* Fern. & Griseb.

Spiked Water Milfoil 5049
 Various-Leaved Milfoil 1245, 1931
 Whorled Water Milfoil 1246
 Mermaid Weed 761, 1244

UMBELLIFERAE

Cryptotaenia canadensis (L.) DC
Daucus carota L.
Eryngium yuccifolium Michx.
Heracleum maximum Bartr.
Osmorhiza longistylis (Torr.) DC
Oxypholis rigidior (L.) Coulter & Rose
Pastinaca sativa L.
Sanicula canadensis L.
Sanicula gregaria L.
Sanicula marilandica L.
Sium suave L.
Taenidia integerrima (L.) Drude
Zizia aurea (L.) Koch.

Honewort 1348, 5094
 Queen Anne's Lace 1864
 Rattlesnake Master 575
 Cow Parsnip 472, 1713
 Smooth Sweet Cicely 1714
 Cowbane 325, 582
 Wild Parsnip 4043
 Canadian Black Snakeroot 1548
 Clustered Black Snakeroot 1347
 Black Snakeroot 1120, 1731
 Water Parsnip 758, 1520
 Yellow Pimpernel 1716
 Golden Alexanders 93, 1707

CORNACEAE

Cornus obliqua Raf.
Cornus racemosa Lam.
Cornus stolonifera Michx.

Silky Dogwood 1193, 1159
 Gray Dogwood 1046, 5042
 Red-osier Dogwood 565, 1271

ERICACEAE

Arctostaphylos uva-ursi (L.) Spreng
 var. *coactilis* Fern. & Macbr.
Gaylussacia baccata (Wang.) K. Koch

Bearberry 428, 957
 Huckleberry 759, 1623

PRIMULACEAE

Dodecatheon meadia L.
Lysimachia ciliata L.
Lysimachia quadriflora Sims.
Lysimachia thyrsoiflora L.

Shooting Star 94, 473
 Fringed Loosestrife 4054
 Marsh Loosestrife 681, 1920
 Tufted Loosestrife 125, 1213

OLEACEAE

Fraxinus pennsylvanica Marsh.
Fraxinus pennsylvanica Marsh.
 var. *subintegerrima* (Vahl.) Fern.

Red Ash 1842, 5302
 Green Ash 737, 3079

GENTIANACEAE

Gentiana andrewsii Griseb.
Gentiana crinita Froel.
Gentiana procera Holm.
Gentiana puberula Michx.
Menyanthes trifoliata L.
 var. *minor* Raf.

Closed Gentian 3000
 Fringed Gentian 36, 427
 Small Fringed Gentian 37, 750
 Downy Gentian 785
 Buckbean 749, 1680

APOCYNACEAE

<i>Apocynum androsaemifolium</i> L.	Spreading Dogbane	724, 1787
<i>Apocynum sibiricum</i> Jacq.	Indian Hemp	196, 591

ASCLEPIADACEAE

<i>Asclepias amplexicaulis</i> Sm.	Sand Milkweed	1760
<i>Asclepias incarnata</i> L.	Swamp Milkweed	307, 1276
<i>Asclepias purpurascens</i> L.	Purple Milkweed	1811
<i>Asclepias syriaca</i> L.	Common Milkweed	1186
<i>Asclepias syriaca</i> L. var. <i>kansana</i> (Vail) Palmer & Stayner	Tuberclad	1302
<i>Asclepias tuberosa</i> L.	Butterfly Weed	170, 1261
<i>Asclepias verticillata</i> L.	Whorled Milkweed	537, 713
<i>Asclepias viridiflora</i> Raf.	Green Milkweed	153, 1200

CONVOLVULACEAE

<i>Convolvulus arvensis</i> L.	Field Bindweed	2097
<i>Convolvulus sepium</i> L.	Hedge Bindweed	123, 777
<i>Cuscuta coryli</i> Engelm.	Hazel Dodder	2067
<i>Cuscuta groenovii</i> Willd.	Common Dodder	1539, 2031

POLEMONIACEAE

<i>Phlox glaberrima</i> L. var. <i>interior</i> Wherry	Marsh Phlox	171, 1003
<i>Phlox pilosa</i> L.	Prairie Phlox	89, 1823

BORAGINACEAE

<i>Lithospermum canescens</i> (Michx.) Lehm.	Hoary Puccoon	121, 1685
<i>Lithospermum croceum</i> Fern.	Hairy Puccoon	105, 1809
<i>Lithospermum incisum</i> Lehm.	Fringed Puccoon	1705, 1382
<i>Myosotis verna</i> Nutt.	White Forget-Me-Not	3093

VERBENACEAE

<i>Verbena bracteata</i> Lag. & Rodr.	Creeping Vervain	4055, 5101
<i>Verbena hastata</i> L.	Blue Vervain	166, 1940
<i>Verbena urticifolia</i> L.	White Vervain	637, 1334

LABIATAE

<i>Glechoma hederacea</i> L.	Ground Ivy	1381, 1677
<i>Lycopus americanus</i> Muhl.	Water Horehound	638, 1345
<i>Lycopus asper</i> Greene	Bungle-weed	342, 1521
<i>Mentha arvensis</i> L. var. <i>villosa</i> (Benth.) S.E. Stewart forma <i>glabrata</i> (Benth.) S.E. Stewart		343, 700, 1395

<i>Monarda fistulosa</i> L.	Wild Bergamot	299, 399
<i>Monarda punctata</i> L. var.	Horsemint	572, 1267
<i>Nepeta cataria</i> L.	Catnip	1187
<i>Prunella vulgaris</i> L. var. <i>lanceolata</i> (Bart.) Fern.	Self-heal	899, 1288

1881
1881
1881

Red-stemmed Plantain

<i>Pycnanthemum virginianum</i> (L.) Durand & Jackson	Mountain Mint	571, 1601
<i>Satureja arkansana</i> (Nutt.) Briq.	Calamint	816, 1906
<i>Scutellaria epilobifolia</i> A. Hamilton	Common Skullcap	1292, 1810
<i>Scutellaria lateriflora</i> L.	Mad-dog Skullcap	621, 1918
<i>Scutellaria parvula</i> Michx. var. lecnardi (Epling) Fern.	Small Skullcap	87, 483
<i>Stachys tenuifolia</i> Willd. var. hispidula (Pursh) Fern.	Hedge Nettle	1272, 4082
<i>Stachys tenuifolia</i> Willd. var. platyphylla Fern.	Hedge Nettle	1846
<i>Toscoreum occidentale</i> Gray	Western Germander	1346, 1562

SCROPHULARIACEAE

<i>Castilleja coccinea</i> (L.) Sprang	Indian Paintbrush	425, 964
<i>Castilleja sessiliflora</i> Pursh.	Downy Indian Paintbrush	3085
<i>Chaenorrhizum minus</i> (L.) Langa	Dwarf Snapdragon	1180, 2026
<i>Chelone glabra</i> L.	Turtlehead	691
<i>Gerardia grandiflora</i> Benth. var. pulchra (Pennell) Fern.	Yellow False Foxglove	327
<i>Gerardia podicularia</i> L. var. ambigua Fern.	Clammy False Foxglove	321, 635
<i>Gerardia purpurea</i> L.	Purple False Foxglove	623, 1605
<i>Gerardia skinneriana</i> Wood	Pale False Foxglove	622
<i>Linaria vulgaris</i> Hill	Butter-and-eggs	1944
<i>Mimulus ringens</i> L.	Monkey Flower	1370
<i>Pedicularis canadensis</i> L.	Wood Betony	963, 1681
<i>Pedicularis lanceolata</i> Michx.	Swamp Betony	787
<i>Penstemon digitalis</i> Nutt.	Foxglove Heart Tongue	1765, 5090
<i>Scrophularia marilandica</i> L.	Carpenter's Square	1340, 1901
<i>Verbascum thapsus</i> L.	Common Mullein	701, 1937
<i>Veronica comosa</i> Richter	Water Speedwell	1369, 1887
<i>Veronicastrum virginicum</i> (L.) Farw.	Culver's Root	1260, 5063

OROBANCHACEAE

<i>Orobanche uniflora</i> L.	One-flowered Cancer Root	3087

LENTIBULARIACEAE

<i>Utricularia cornuta</i> Michx.	Horned Bladderwort	1384, 1907
<i>Utricularia minor</i> L.	Small Bladderwort	5103
<i>Utricularia intermedia</i> Hayne	Flat-leaved Bladderwort	1248, 1794
<i>Utricularia vulgaris</i> L.	Great Bladderwort	1363, 1247

PHYTACEAE

<i>Phytolacca leptostachya</i> L.	Lopseed	1546, 1841

PLANTAGINACEAE

<i>Plantago indica</i> L.	Whorled Plantain	2034
<i>Plantago lanceolata</i> L.	English Plantain	1830
<i>Plantago major</i> L.	Common Plantain	1531, 2042
<i>Plantago rugelii</i> Don.	Red-stalked Plantain	609, 1831

RUBIACEAE

Cephalanthus occidentalis L.
Galium aparine L.
Galium boreale L.
Galium obtusum Bigel.
Galium trifidum L.

Butterbush 2045
Cleavers 1181, 1710
Northern Bedstraw 1110, 1812
Wild Madder 434, 1238
Small Bedstraw 1207

CAPRIFOLIACEAE

DierVilla lonicera Mill.
Lonicera dioica L.
Lonicera morrowi Gray
Lonicera tatarica L.
Viburnum lentago L.
Viburnum opulus L.

Bush Honeysuckle 1318
Red Honeysuckle 603, 1270
Morrow's Honeysuckle 1706
Tartarian Honeysuckle 604
Hannyberry 733, 1047
European Highbush Cranberry 1334

VALERIANACEAE

Valeriana ciliata T. & G.

Valerian 143, 451

CUCURBITACEAE

Echinocystis lobata (Michx.) T. & G.

Wild Cucumber 1343

CAMPANULACEAE

Campanula americana L.
Campanula aparinoides Pursh.
Campanula rapunculoidea L.

Tall Bellflower 1341
Marsh Bellflower 199, 619
European Bellflower 581, 1293

COMPOSITAE

Achillea lanulosa Nutt.
Achillea millefolium L.
Ambrosia artemisiifolia L.
var. *elatior* (L.) Descurtils
Ambrosia trifida L.
Anaphalis margaritacea (L.) Bernh.
& Hook.
Arctium lappa (Mill) Bernh.
Artemisia biennis Willd.
Artemisia canadensis Michx.
Artemisia ludoviciana Nutt.
var. *gnaaphalodes* (Nutt.) Tr. & G.
Aster aureus Lindl.
Aster ericoides L.
Aster junceiformis Rydb.
Aster lateriflorus (L.) Britt.
Aster novae-angliae L.
Aster pilosus Willd.
Aster propertus Peir.
Aster puniceus L. var. *firms* T. & G.
Aster sparganiioides (Nutt.) T. & G.
Aster sparganiioides (Nutt.) T. & G.
Aster sparganiioides (Nutt.) T. & G.
Aster sparganiioides (Nutt.) T. & G.
Aster sparganiioides (Nutt.) T. & G.

Woolly Yarrow 1763
Yarrow 1735, 1752
Common Ragweed 707, 1939
Grass Ragweed 1045
Pearly Everlasting 5027
Common Burdock 605, 1948
Biennial wormwood 2098
Wormwood 611, 1921
Mugwort 2099
Sky-blue Aster 702, 1620, 2081
Heath Aster 30, 731
Rush Aster 1048
Side-flowering Aster 2098
New England Aster 2031
Rusty Aster 102, 123
Willow Aster 2031
Swamp Aster 2031
Stiff Aster 119, 1922
Drummond's Aster 2031
Silky Aster 111

Aster simplex Willd.

Aster umbellatus Mill.

Bidens cernua L.

Bidens coronata (L.) Britt.

var. tenuiloba (Gray) Sheriff.

Bidens frondosa L.

Bidens vulgata Greene

Chrysanthemum leucanthemum L.

var. pinnatifidum Laccq. & Lamotte

Cichorium intybus L.

Cirsium arvense (L.) Scop.

Cirsium discolor (Muhl.) Sprang

Cirsium nuticum Michx.

Cirsium vulgare (Savi) Tenore

Coreopsis lanceolata L.

Coreopsis tripteris L.

Coreopsis lanceolata L.

var. villosa Michx.

Coreopsis palmata Nutt.

rigida annua (L.) Pers.

rigida canadensis L.

rigida philadelphicus L.

rigida pulchellus Michx.

rigida strigosus Muhl.

Eupatorium maculatum L.

Eupatorium perfoliatum L.

Eupatorium purpureum L.

Eupatorium rugosum Roult.

var. tomentellum (Robins) Blake

Galinsoga ciliata (Raf.) Blake

Onopordium obtusifolium L.

Helianthus annuus L.

Helianthus divaricatus L.

Helianthus grosseserratus Martens

Helianthus hirsutus Raf. var.

var. brachyphyllus T. & G.

Helianthus occidentalis Muhl.

Helianthus strumosus L.

Helianthus scaberrimus L.

Helianthus scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

var. scaberrimus (L.) Sweet

Marsh Aster

Panicled Aster

Flat-top Aster

787

2059

2066

Nodding Bur Marigold

Tall Swamp Marigold

725, 774, 1596

19, 322, 678

Common Beggar-ticks;

Sticktight

732, 2062

Tall Beggar's-ticks

Ox-eye Daisy

2068

1735

Chicory

Canada Thistle

Pasture Thistle

Swamp Thistle

Bull or Common Thistle

Sand Coreopsis

Tall Coreopsis

Hairy Sand Coreopsis

708

613, 1847

2035

747, 1533

581, 1574

103, 1049

5318

81, 473

Prairie Coreopsis

Annual Fleabane

Horsemint

Marsh Fleabane

Robins Plantain

Daisy Fleabane

Spotted Joe-Pye-Weed

Boneset

Purple Joe-Pye Weed

White Snakeroot

1255, 1790

793, 1201

690, 1624

1726

1126

1127, 1826

348, 4078

1905

5296

1544

Peruvian Daisy

Old-field Balsam

Sneezeweed

Garden Sunflower

Woodland Sunflower

Sawtooth Sunflower

Rough Sunflower

1541

1605

349a, 772, 1957

1534

585, 1372

30, 347

726

Western Sunflower

Pale-leaved Sunflower

Jerusalem Artichoke

False Sunflower

305, 636

5374

1552, 2079

1553, 1854

Canada Hempseed

Field Hempseed

False Hempseed

Wild Hempseed

323

4003

1151, 1828

1584, 2039

<i>Lactuca scariola</i> L.	Prickly Lettuce	1356
<i>Liatris aspera</i> Michx.	Rough Blazing Star	20, 318, 336
<i>Liatris cylindracea</i> Michx.	Cylindrical Blazing Star	311, 612
<i>Liatris spicata</i> (L.) Willd.	Marsh Blazing Star	310
<i>Matricaria matricarioides</i> (Less.) Porter	Pineapple Weed	1761
<i>Prunanthus alba</i> L.	White Lettuce	2078
<i>Prunanthus racemosa</i> Michx.	Glaucous White Lettuce (Rattlesnake-root)	29, 391
<i>Ratibida pinnata</i> (Vent.) Barnh.	Yellow Cone-flower	567, 1263
<i>Rudbeckia hirta</i> L.	Black-eyed Susan	173, 1274, 1877
<i>Rudbeckia laciniata</i> L.	Wild Golden-glow	1946
<i>Rudbeckia subtomentosa</i> Pursh.	Sweet Black-eyed Susan	577, 662
<i>Senecio pauperculus</i> Michx. var. <i>balsamites</i> (Muhl.) Fern	Balsam Ragwort	401, 1043
<i>Silphium intergrifolium</i> Michx. var. <i>deamii</i> Perry	Rosin Weed	617, 1326
<i>Silphium perfoliatum</i> L.	Cup plant	585
<i>Silphium terebinthinaceum</i> Jacq.	Prairie Dock	1176
<i>Solidago altissima</i> L. S. <i>canadensis</i> L.	Tall Goldenrod	703, 1615
<i>Solidago flexicaulis</i> L.	Broad-leaved Goldenrod	3005
<i>Solidago gigantea</i> Ait. var. <i>laipphylla</i> Fern.	Late Goldenrod	353
<i>Solidago graminifolia</i> (L.) Salisb. var. <i>nuttallii</i> (Green) Fern.	Grass-leaved Goldenrod	350, 5030
<i>Solidago nemoralis</i> Ait.	Old-field Goldenrod	332, 1616, 5029
<i>Solidago ohioensis</i> Riddell	Ohio Goldenrod	349, 679
<i>Solidago riddellii</i> Frank	Riddell's Goldenrod	769
<i>Solidago rigida</i> L.	Stiff Goldenrod	351, 654
<i>Solidago speciosa</i> Nutt.	Showy Goldenrod	768, 812, 1617
<i>Solidago uliginosa</i> Nutt.	Bog Goldenrod	1282, 5014
<i>Sonchus uliginosus</i> Bieb.	Smooth Sow Thistle	1282, 1851, 1949
<i>Taraxacum officinale</i> Weber	Common Dandelion	3051
<i>Tragopogon major</i> Jacq.	Sand Goat's Beard	1734, 4005
<i>Vernonia fasciculata</i> Michx.	Common Ironweed	634, 1343
<i>Xanthium strumarium</i> L.	Cocklebur	1530, 2032

TABLE B-1
Page 1

APPENDIX B

CLIMATIC SUMMARY FOR 1951 - 1960 - WISCONSIN (1)

Mean Area Temperatures (°F)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Racine Co.	23.1	26.8	33.1	47.3	56.6	63.8	72.2	72.0	64.5	53.1	33.1	27.8	48.5
Kenosha	22.9	26.9	32.6	46.6	55.7	65.7	71.3	71.3	63.6	52.6	38.0	27.9	47.9
Milwaukee	21.1	25.0	31.0	45.8	55.2	65.4	70.9	70.7	62.3	51.9	36.6	25.5	46.8
Chicago	27.0	30.0	36.2	50.1	59.9	70.1	75.3	74.8	67.6	54.3	41.3	31.9	51.0
Madison	22.9	27.0	39.0	47.6	57.4	67.8	73.1	71.6	64.3	53.1	38.4	28.8	49.6
Mean Daily Maximum Temperatures (°F)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Racine Co.	30.7	34.3	41.2	57.3	67.5	77.7	83.3	82.1	75.2	62.9	46.3	34.0	57.7
Kenosha	31.3	34.8	40.3	56.4	66.4	76.3	81.2	80.7	74.3	62.4	47.1	36.0	57.3
Milwaukee	28.6	32.0	38.1	54.7	65.1	75.4	80.3	79.8	72.3	60.6	44.3	33.5	55.4
Chicago	32.1	34.1	43.0	59.0	71.1	81.0	85.2	84.0	77.0	64.6	47.0	35.3	59.0
Madison	30.4	34.6	41.2	57.7	68.2	77.6	81.9	81.2	74.8	63.0	46.0	33.3	57.8
Mean Daily Minimum Temperatures (°F)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Racine	15.5	19.3	24.9	37.9	45.6	55.8	61.9	61.8	53.7	43.3	29.9	20.7	39.1
Kenosha	14.5	19.0	24.8	36.9	44.9	55.0	61.4	61.7	52.9	42.7	28.8	19.8	39.5
Milwaukee	13.6	18.0	23.9	36.9	45.2	55.3	61.4	61.6	52.3	42.0	28.7	19.5	39.2
Chicago	18.4	22.2	28.1	41.2	50.6	63.1	65.9	65.2	56.6	48.0	31.8	23.2	42.3
Madison	15.1	19.3	24.9	37.5	46.5	54.7	62.9	62.0	53.7	43.2	29.8	20.7	39.3

(1) Climatic Summary of the United States, U. S. Weather Bureau (1963)

TABLE B-1
Page 2

APPENDIX B

CLIMATIC SUMMARY FOR 1951 - 1960 - PRECIPITATION & SNOW⁽¹⁾

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Total Precipitation (inches rain)													
Boston	2.84	1.71	2.87	3.7	3.9	3.4	4.2	5.6	1.8	2.7	2.4	2.3	34.64
Boston	1.6	1.2	2.1	3.5	3.6	3.6	4.4	3.9	1.8	2.6	2.1	1.7	31.99
Milwaukee	1.7	1.5	2.2	3.1	3.1	3.7	3.8	3.5	1.9	2.6	2.0	1.7	30.76
Chicago (WFO)	1.8	1.9	2.6	3.9	3.3	3.8	4.6	3.6	1.7	3.4	2.1	1.8	34.49
Madison	1.6	1.6	2.7	3.5	3.2	4.1	4.1	3.6	1.7	2.4	2.1	1.8	32.30
Total Snowfall (inches)													
Boston	10.7	7.0	8.2	0.2	T	T	T	0.0	T	T	3.2	8.2	57.5
Chicago	7.3	6.7	6.9	0.6	T	T	0.0	T	T	0.5	4.4	10.4	37.0
Milwaukee	14.2	8.8	10.5	0.7	T	T	T	0.0	T	T	3.8	10.1	47.0

T = Trace amounts.

(1) = Climatic Summary of the United States, U. S. Weather Bureau (1963)

Stratigraphy of Northeastern Illinois⁽¹⁾

PERIOD	STAGE	GROUP OR FORMATION	HYDROLOGIC UNIT	LOG	THICKNESS (Ft.)	DESCRIPTION
Quaternary	Pleistocene		Glacial drift aquifers		0-350+	Unconsolidated glacial deposits - pebbly clay (fill), silt, and gravel. Alluvial silt and sands along streams.
Permian		Carbonate			0-175	Shale; sandstone, fine-grained; limestone; coal; clay.
Mississippian	Hard-rock				0-365	Shale, green and brown, dolomitic; dolomite, silty.
Devonian					0-25	Shale, calcareous; limestone beds, thin.
Ordovician	Silurian	Port Hope	Sheldon		0-455	Dolomite, silty at base, locally cherty.
		Waukegan				
	Onondaga	Onondaga	Onondaga		0-250	Shale, gray or brown; locally dolomite and/or limestone, argillaceous.
		Onondaga				
	Mohawkian	Galesburg	Galesburg		220-300+	Dolomite and/or limestone, cherty. Dolomite, shale partings, speckled. Dolomite and/or limestone, cherty, sandy at base.
		Flatville				
	Chazyan	Glenwood	Glenwood		100-650	Sandstone, fine- and coarse-grained; little dolomite; shale at top. Sandstone, fine- to medium-grained; locally cherty red shale at base.
		St. Peter				
Cambrian	Frisco de Chino	Shelburne	Frisco de Chino		0-340	Dolomite, sandy, cherty (oolitic); sandstone. Sandstone, interbedded with dolomite. Dolomite, white to pink, coarse-grained, cherty (oolitic), sandy at base.
		New Richmond				
		Onondaga				
		Onondaga				
	St. Onogene	Trempealeau	Trempealeau		0-225	Dolomite, white, fine-grained, good quartz, sandy at base.
		Fennoscandia				
		Boston				
	St. Onogene	Galesville	Galesville		165-270	Sandstone, fine- to medium-grained, well sorted, upper part dolomitic.
		St. Onogene				
		St. Onogene				
	St. Onogene	St. Onogene	St. Onogene		225-400	Shale and siltstone, dolomitic, glauconitic; sandstone, dolomitic, glauconitic.
		St. Onogene				
	St. Onogene	St. Onogene	St. Onogene		2000+	Sandstone, coarse-grained, white, red in lower half; lenses of shale and siltstone, red, micaceous.
		St. Onogene				

1. Preliminary Report on Ground-Water Resources of the Chicago Region. Illinois. Cooperative Ground-Water Report 1. Urbana, Illinois. 1959.

APPENDIX D

STATE OF ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
 WATER POLLUTION REGULATIONS OF ILLINOIS ADOPTED
 MARCH 7, 1972

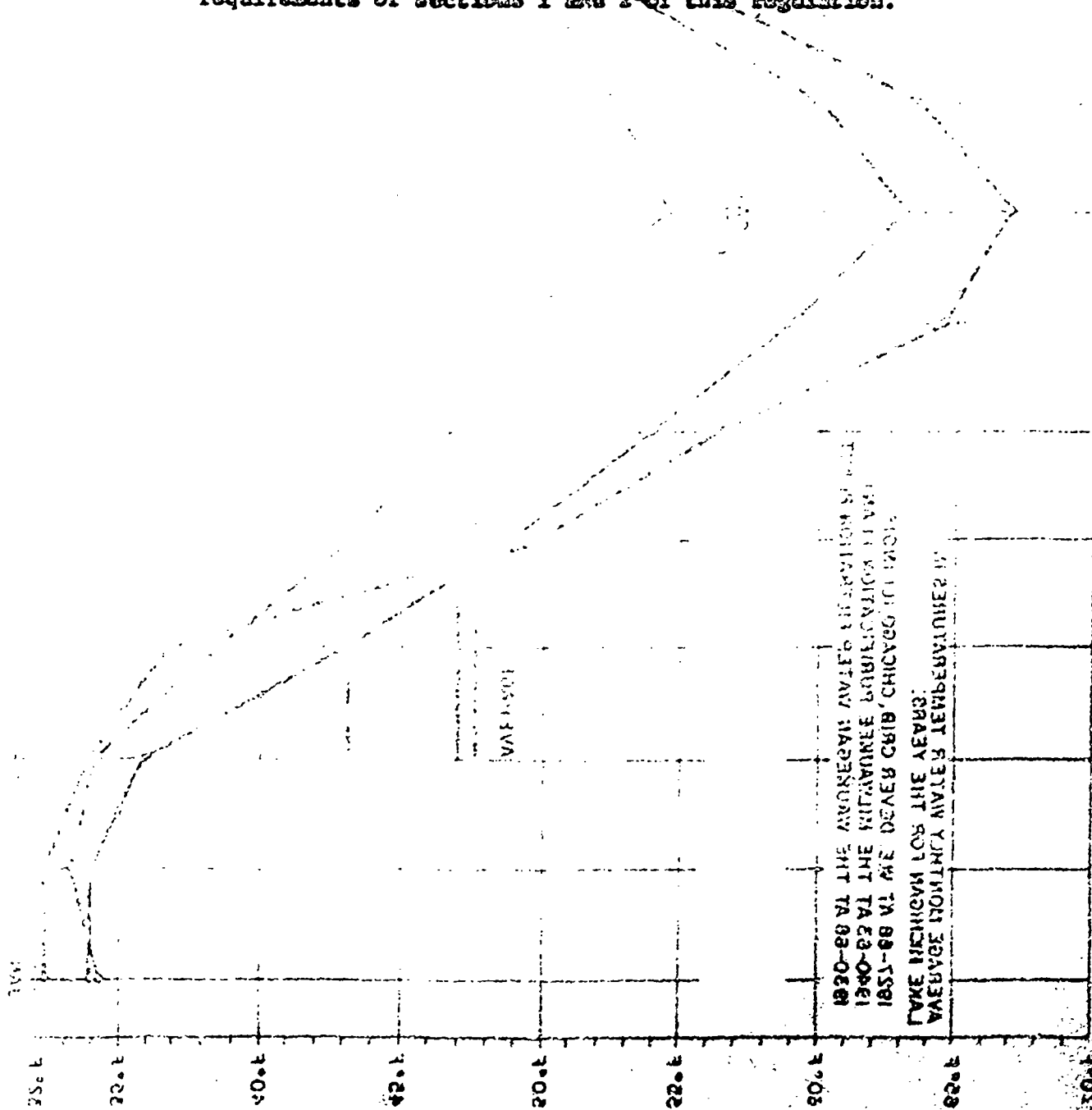
1. (a) All sources of heated effluents in existence as of January 1, 1971, shall meet the following restrictions outside of a mixing zone which shall be no greater than a circle with a radius of 1000 feet or an equal fixed area of simple form:
- (i) There shall be no abnormal temperature changes that may affect aquatic life.
 - (ii) The normal daily and seasonal temperature fluctuations that existed before the addition of heat shall be maintained.
 - (iii) The maximum temperature rise at any time above natural temperatures shall not exceed 3°F. In addition, the water temperature shall not exceed the maximum limits (°F.) indicated in the following table:

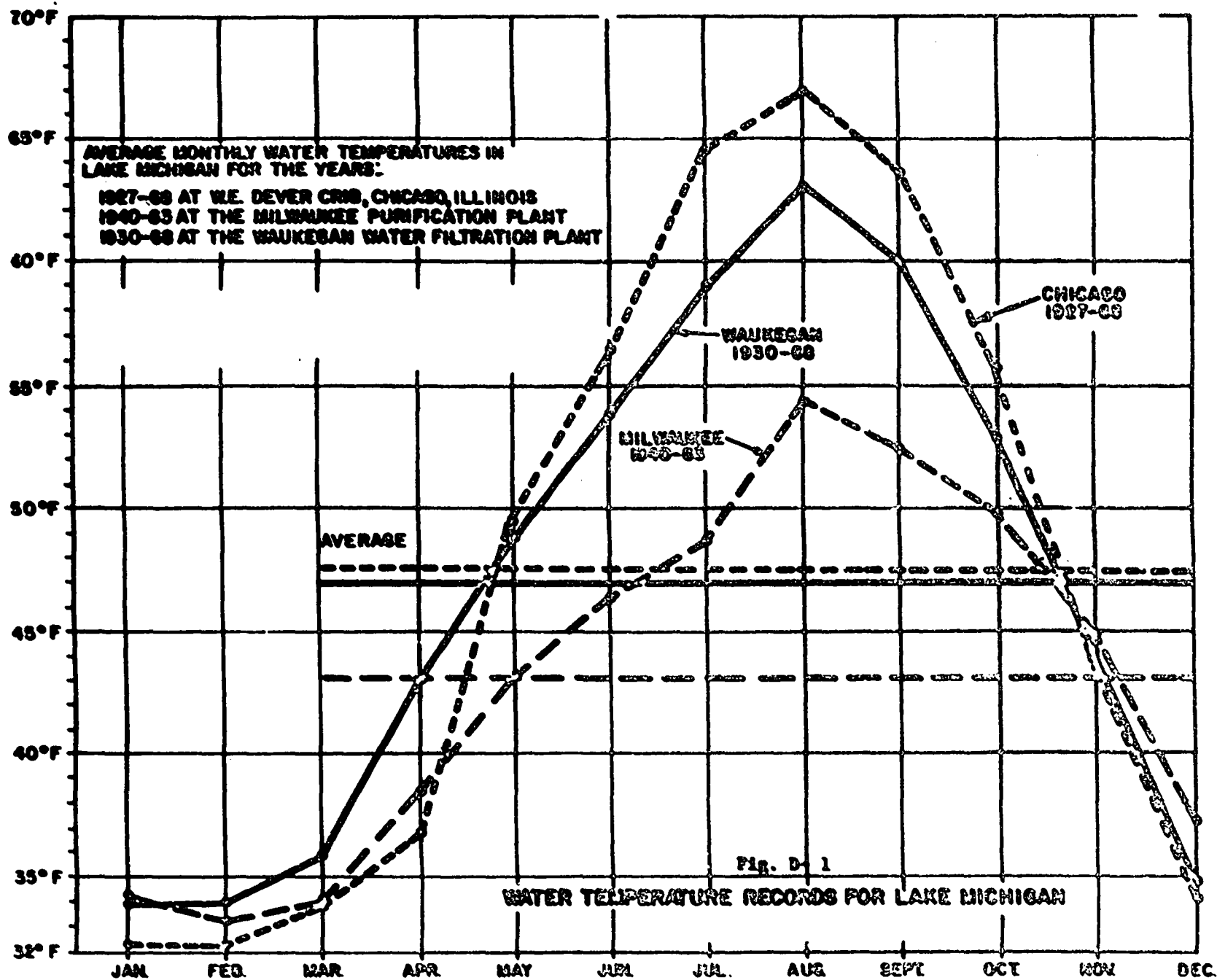
Jan. 45	May 60	Sept. 80
Feb. 45	June 70	Oct. 65
Mar. 45	July 80	Nov. 60
Apr. 55	Aug. 80	Dec. 50

- (b) The owner or operator of a source of heated effluent which discharges 0.5 billion British thermal units per hour (Btu/hr.) or more shall demonstrate in a hearing before this Board not less than 5 nor more than 6 years after the adoption of this regulation, that discharges from that source have not caused and cannot be reasonably expected in the future to cause significant ecological damage to the Lake. If such proof is not made to the satisfaction of the Board, backfitting of alternative cooling devices shall be accomplished within a reasonable time as determined by the Board.
3. (a) No source of heated effluent which was not in operation under construction as of January 1, 1971, shall discharge more than a daily average of 0.1 billion Btu/hr.

- (c) The owner or operator of a source of heated effluent shall maintain such records and conduct such studies of the effluents from such source and of their effects as may be required by the Environmental Protection Agency or in any permit granted under the Environmental Protection Act.
 - (d) Backfitting of alternative cooling facilities will be required if, upon complaint filed in accordance with Board rules, it is found at any time that any heated effluent causes significant ecological damage to the Lake.
2. Any affluent source under construction as of January 1, 1971, but not in operation, shall meet all the requirements of Section 1 of this regulation and in addition shall meet the following restrictions:
- (a) Neither the bottom, the shore, the hypolimnion, nor the thermocline shall be affected by any heated effluent.
 - (b) No heated effluent shall affect spawning ground or fish migration routes.
 - (c) Discharge structures shall be so designed as to maximize short-term mixing and thus to reduce the area significantly raised in temperature.
 - (d) No discharge shall exceed ambient temperature by more than 20°F.
 - (e) Heated effluents from more than one source shall not interact.
 - (f) All reasonable steps shall be taken to reduce the number of organisms drawn into or against the intakes.
 - (g) Cleaning of condensers shall be accomplished by mechanical devices. If chemicals must be used to supplement mechanical devices, the concentration at the point of discharge shall not exceed the 96-hour TLm for fresh water organisms.
3. (a) No source of heated effluent which was not in operation or under construction as of January 1, 1971, shall discharge more than a daily average of 0.1 billion Btu/hr.

- (b) Sources of heated effluents which discharge less than a daily average of 0.1 billion Btu/hr. not in operation or under construction as of January 1, 1971, shall meet all requirements of sections 1 and 2 of this regulation.





ENVIRONMENTAL PROTECTION AGENCY • STATE OF ILLINOIS



William L. Blum, Director • Richard B. Ogilvie, Governor

Appendix 7

July 12, 1972



ENVIRONMENTAL IMPACT STATEMENT—Commonwealth Edison Company
Eisen Nuclear Power Station

U. S. Atomic Energy Commission
Division of Radiological and Environmental Protection
Washington, D. C. 20545

50-237
50-238

Gentlemen:

The Permit Section of the Division of Water Pollution Control has reviewed the Environmental Report prepared by Commonwealth Edison Company and the Draft Environmental Statement prepared by the U. S. Atomic Energy Commission for the Eisen Nuclear Power Station Units 1 and 2, received on July 5, 1972.

Based on our review we believe the reports contain the proper information, and we are in agreement with the conclusions as outlined in the report.

Very truly yours,

DIVISION OF WATER POLLUTION CONTROL

Robert A. Weiss
Robert A. Weiss, P. E.
Manager
Permit Section

cc: Federal Environmental Protection Agency
Commonwealth Edison Company
E. S. Nolle

JHL/lcc



DEPARTMENT OF THE ARMY
CHICAGO DISTRICT, CORPS OF ENGINEERS
812 SOUTH DEARBORN STREET
CHICAGO, ILLINOIS 60604

50-295
50-304

HC97D-BRR

Appendix F

SUBJECT: Draft Environmental Impact
Statement for Zica, Units 1
and 2, June 1972, Dockets
50-295 and 50-304

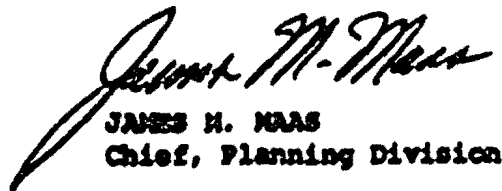
Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

Appropriate review of the subject environmental statement has been
completed by this office. The statement is considered satisfactory.

The opportunity to review this statement is appreciated.

Sincerely yours,


JAMES H. MAAS
Chief, Planning Division

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426
August 1, 1972

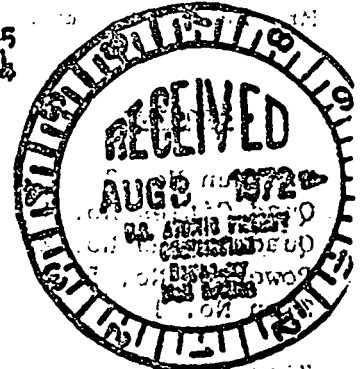
IN REPLY REFER TO:

FWR-ER

Appendix G

50-295
50-304

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20345



Dear Mr. Muller:

This is in response to your letter dated June 28, 1972, requesting comments on the AEC Draft Environmental Statement Related to the Proposed Continuation of Construction Permits CFFR-58 and CFFR-59 and the proposed issuance of an operating license to the Commonwealth Edison Company (CE) for Zion Station Units Nos. 1 and 2.

Pursuant to the National Environmental Policy Act of 1969, and the Guidelines of the President's Council on Environmental Quality dated April 23, 1971, these comments are directed to a review of the need for the facilities as concerns the adequacy and reliability of the affected bulk power systems and matters related thereto.

In preparing these comments, the Federal Power Commission's Bureau of Power staff has considered the AEC Draft Detailed Statement, the Applicant's Environmental Report and Supplement thereto, related reports made in response to the Commission's Statement of Policy on Reliability and Adequacy of Electric Service (Order No. 383-2), and the FPC staff's independent analysis of these documents together with related information from other FPC reports. The staff of the Bureau of Power bases its evaluation of the need for a specific bulk power facility upon long-term considerations as well as the load-supply situation for the critical load period immediately following the availability of the facility. The useful life of such facilities is generally 30 years or longer, and they are required in order that the utility may continue to serve the needs of its customers during the service life of the project.

Need for the Facility

The Commonwealth Edison Company's base-load generation expansion program for the period October 1971 through September 1975 included five nuclear-fueled units and one fossil-fired unit (Powerton No. 5) as outlined below:

Appendix G-2

Mr. Daniel B. Muller

<u>Station</u>	<u>Capability (MW)</u>	<u>In-Service Date</u> ^{2/}
Dresden No. 3	809	See below
Quad Cities No. 1	405 ^{1/}	See below
Quad Cities No. 2	809	See below
Powerton No. 5	840	7/72 ^{2/}
Zion No. 1	1,050	11/72 ^{2/}
	+50	4/73 ^{2/}
Zion No. 2	1,050	Winter 73/74 ^{2/}
	+50	Winter 73/74 ^{2/}

^{1/} Jointly owned unit, Commonwealth Edison Company's share

^{2/} Estimated date

Dresden Unit No. 3 and Quad Cities Units Nos. 1 and 2 are in operation at less than 100 percent rated power in accordance with AEC licenses, but are expected to be in full operation for the 1973 summer peak. The fossil-fired Powerton Unit No. 5 is currently undergoing on-line testing and is expected to be available for commercial operation in July 1972. The Zion Units Nos. 1 and 2 have met delays and the 1,050 megawatts of base-load capacity of Zion Unit No. 2 is not now expected to be available for the Applicant's 1973 summer peak load period as originally scheduled.

The following tabulation shows the electric system loads to be served by the Applicant and the Mid-America Interpool Network (MAIN) of which the Applicant is a member, and the relationship of the electrical output of the Zion units to the available reserve capacities on the summer-peak Applicant's and summer-peak MAIN's systems at the time of the 1973 summer peak load period. The peak load period mentioned is the anticipated initial service period of the Zion units; these units are expected to constitute a proportionate part of the Applicant's total generating capacity for some 30 years. Therefore, the units will be depended upon to supply power to meet future demands over a period of many years beyond the initial service needs discussed in this report.

The Commonwealth Edison Company's base-load generation expansion program for the period October 1971 through September 1975 included five fossil-fired units and one fossil-fired unit (Powerton No. 5) as outlined below:

Mr. Daniel R. Muller

Forecast Summer 1973 Peak Situation

Commonwealth Edison Company

RAH

Conditions With Zion Unit No. 1
(1,100 Megawatts)

Net Total Capability - Megawatts	13,090	35,851
Net Peak Load - Megawatts	13,040 1/	29,943 2/
Reserve Margin - Megawatts	2,050	6,908
Reserve Margin - Percent of Peak Load	15.7	21.4

Conditions Without Zion Unit No. 1
(1,100 Megawatts)

Net Total Capability - Megawatts	13,990	34,751
Net Peak Load - Megawatts	13,040 1/	29,943 2/
Reserve Margin - Megawatts	950	5,208
Reserve Margin - Percent of Peak Load	7.3	17.6

Applicant's Stated Reserve Margin Needs
Based on 14 Percent Criterion - Megawatts 1,826

Reserve Margin Deficiency - Based on Applicant's
Stated 14 Percent Criterion - Megawatts 876

- 1/ Native load reduced by net firm purchases of 140 megawatts
- 2/ Native load reduced by net firm purchases of 476 megawatts and 75 megawatts of interruptible load

The Applicant states that, on the basis of past experience and the results of probability studies, they feel a minimum installed reserve criterion of 14 percent of peak load is necessary to maintain adequate system reliability.

The availability of the Zion Unit No. 1 for the summer of 1973 would provide the Applicant an expected system reserve margin of 2,050 megawatts or 15.7 percent of peak load. However, any delays which result in the unavailability of Zion Unit No. 1 for the 1973 summer peak load period would reduce system reserves to 950 megawatts or 7.3 percent of peak load.

Mr. Daniel A. Muller

or an overall deficiency of 876 megawatts based on the Applicant's minimum reserve criterion of 14 percent of peak load. The Applicant has no other base-load generating units scheduled until the addition of Powerton Unit No. 6 presently scheduled for commercial operation in October 1975.

The adequacy and reliability of the Applicant's system in 1973 is not only dependent on the timely operation of the Zion Units, but also on the continued operation of the other generating units. Recent experience with new large generating units indicates frequent forced outages of these units are probable during their first few years of operation. The two Quad Cities units, Dresden No. 3 and Powerton No. 5, totaling 3,263 megawatts, will all have been in operation less than two years by summer of 1973. Unexpected (forced) outage of any of these four units is not improbable, and would have a serious effect on system reliability if the Zion unit was not in operation.

Including the Zion Unit No. 1, the MAIN region projects a reserve margin of 6,308 megawatts or 21.4 percent of peak load for the summer of 1973. The MAIN region reserve margins include the new large units tabulated below:

<u>Unit</u>	<u>Type</u>	<u>MW</u>	<u>Scheduled Date</u>
Point Beach No. 2	Nuclear	495	November 1972
Kewaunee No. 1	Nuclear	527	March 1973
Coffeen No. 2	Fossil	600	July 1972
Baldwin No. 2	Fossil	603	March 1973
Labadie No. 3	Fossil	580	August 1972
Labadie No. 4	Fossil	580	June 1973
New Madrid No. 1	Fossil	600	July 1972
E. D. Edwards No. 3	Fossil	350	April 1972

In view of possible licensing delays for Kewaunee No. 1 and Point Beach No. 2, as well as the brief time for maturation of all these units between their scheduled dates and the summer peak of 1973, the MAIN reserves appear none too large.

MAIN's prime functions are the furthering of reliability of the member's bulk power systems through coordination of the member's expansion plans and subsequent operation of their generation and transmission facilities and the coordination of those facilities to provide short term emergency relief in the event of contingencies normally

Appendix G-5

Mr. Daniel R. Muller

experienced on interconnected power systems, rather than to provide a substitute for the firm power, base-load requirements of the members. In order to provide adequate reserves for the region, a proportionate reserve must be maintained by each system, based on its own load.

Transmission Facilities

Five 345-kilovolt transmission lines totaling approximately 20.6 miles will integrate the Zion plant into Commonwealth Edison Company's existing transmission system. A sixth transmission line 7.83 miles long will interconnect with the Wisconsin Electric Power Company. In the absence of any stated results of engineering studies upon which this design was predicated, the staff of the Bureau of Power can only comment that this arrangement could be expected to provide for some of the normal contingencies that are experienced in electric power systems operations.

The Applicant states all lines are being constructed to meet or exceed all requirements of the Illinois Commerce Commission General Order 160, which is identical to the National Electrical Safety Code for construction of transmission lines.

Certificates of Convenience and Necessity were obtained from the Illinois Commerce Commission for construction and permits were applied for and approval received for the construction of these lines from the Illinois Department of Highways, Illinois Department of Aeronautics, the Federal Aviation Administration, Illinois Department of Waterways, and the U. S. Corps of Engineers.

Alternates to the Proposed Facilities

The Applicant, in determining the need for additional generation to meet its projected demands, considered a number of alternatives including location, type (base-load and peaking), fuel (nuclear, coal, oil or gas), purchases of power, environmental effects and economics. The final decision rested between a base-load nuclear-fueled plant and a base-load coal-fired or oil-fired plant. Economics and environmental considerations led to the selection of the nuclear-fueled plant over the fossil-fired plant.

The Applicant estimates the economic consequence of a further delay of one year in the construction schedule and commercial operation of Zion Units Nos. 1 and 2, for just the additional fuel cost of providing

Appendix G-6

Mr. Daniel R. Muller

replacement power assuming it is generated on the Edison System, at almost \$39 million. This economic consequence does not include the cost of purchased power, if any is available, or the increase in the total capital cost of the plant (cost escalation and interest charges) due to the delay.

Conclusions

The staff of the Bureau of Power concludes that the electric power output represented by Zion Units Nos. 1 and 2 is necessary to meet the Applicant's projected loads and to provide its reserve margin capacity in accordance with its stated criteria.

Very truly yours,


T. A. Phillips
Chief, Bureau of Power

199.

100

199. 100
The staff of the Bureau of Power concludes that the electric power output represented by Zion Units Nos. 1 and 2 is necessary to meet the Applicant's projected loads and to provide its reserve margin capacity in accordance with its stated criteria.

5

400 west madison street • chicago, illinois 60606 • (312) andover 3-1266

NORTHEASTERN ILLINOIS PLANNING COMMISSION

MATTHEW L. ROCKWELL
Executive Director

FRED M. DUMKE
President
ROBERT F. OLSON
Vice President
WALDEMAR A. RAKOW
Secretary
FRANK W. CHEBROW
Treasurer

August 2, 1972

Appendix B

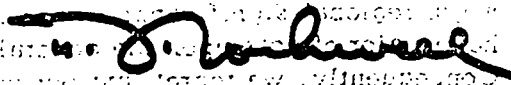
Mr. Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Re: Docket No. 50-295 and 50-304
NIPC # 71-A-50 (Revised)

Dear Mr. Muller:

The staff of the Northeastern Illinois Planning Commission previously reviewed the Environmental Report and Supplemental Environmental Reports submitted by the Commonwealth Edison Company for Zion Station Units 1 and 2. As the information contained in the draft environmental impact statement prepared for the Zion Station remains fundamentally unchanged, I have enclosed a copy of our review statement of March 16, 1972 in lieu of any additional comment.

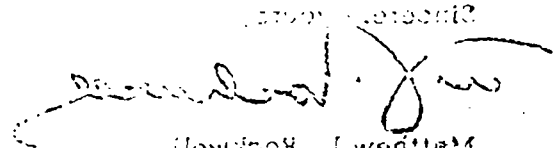
Sincerely,


Matthew L. Rockwell
Executive Director

MLR:jl

Enclosure (1)

cc: Jerry Estes, Director, Lake County Regional Planning Commission


Matthew L. Rockwell
Executive Director

MIR:as
Encl.

cc: Jerry Estes, Director, Lake County Regional Planning Commission
Earle Harrison, NIPC Commissioner
Fred Dumke, NIPC President

4323

The Northeastern Illinois Planning Commission was created by the Illinois General Assembly in 1967, and is authorized to act as the official planning agency for the six northeastern Illinois counties of Cook, DuPage, Kane, Lake, McHenry and Will. It is governed by nineteen appointed Commissioners, a majority of whom are elected officials. The current members of the Commission are listed on the reverse side.

NORTHEASTERN ILLINOIS
PLANNING COMMISSION

MATTHEW L. ROCKWELL
Executive Director

March 16, 1972

Appendix B-2

In letter reply to:
NIPC #71-A-50

Mr. R. C. DeYoung
Assistant Director for Pressurized Water Reactors
Division of Reactor Licensing
United States Atomic Energy Commission
Washington, D. C. 20545

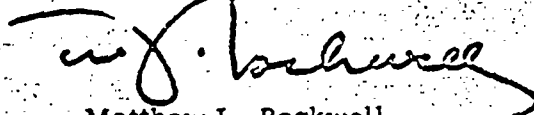
Re: NIPC Project No. 71-A-50, AEC Docket Nos. 50-295 and 50-304,
Environmental Impact Report & Supplemental Reports, Zion Nuclear
Power Station, Units 1 and 2, Lake County, Illinois

Dear Mr. DeYoung:

The staff of the Northeastern Illinois Planning Commission has reviewed the document entitled "Zion Nuclear Power Station Environmental Report" and the report of supplemental information. Our comments on the project are contained in the attached enclosure. You will notice that a principal item of our concern is that power generating stations are facilities of major regional significance whose location, construction and operation have major effects upon the general welfare of the metropolitan area. Consequently, we regret that our comment was invited after the site was selected and construction begun. Involvement of the Regional planning agency would have been most appropriate in the earliest planning stages.

We request that NIPC's review comments along with the appropriate responses be included with the final environmental impact statement. I hope that our comments will still be useful to you.

Sincerely yours,



Matthew L. Rockwell
Executive Director

MLR/sa
Encl.

cc: Jerry Estes, Director Lake Co. Regional Planning Commission
Earle Harrison, NIPC Commissioner
Fred Dumke, NIPC President

bcc: W. Boyd, J. Smedley, P. Peters, W. Luhman (RDM)

The Northeastern Illinois Planning Commission was created by the Illinois General Assembly in 1957. Its purpose is to plan and coordinate the development of the northeastern Illinois counties of Cook, DuPage, Kane, Lake, McHenry and Will. It is composed of representatives of the local government units of the area. The current members of the Commission are listed on the enclosed list.

ATTACHMENT

There are several major areas of regional planning concern which relate to nuclear power generation:

- 1) protection of the environment from harmful effects of thermal discharges.
- 2) protection of biological systems from harmful exposure to radiation.
- 3) the location of power plants in areas of prime esthetic and recreational value.

The Northeastern Illinois Planning Commission is especially concerned with the specific relationships of power plants to the adopted regional functional plans for open space, wastewater and transportation, all of which bear significant relationships to the Zion facility. Because of these interrelationships, the Commission should have been consulted in the early planning phases of this project, including the site selection phase.

The comments offered below are made on the assumption that, whatever environmental consequences may pertain to the choice of the Zion site the only decisions left open are those of engineering. We regret to find ourselves in the position of responding to a project wherein those decisions of most significance to a comprehensive regional planning agency have already been made. Our detailed comments are as follows:

1. The environmental report does not discuss site selection criteria for a nuclear power station or other alternative sites that might have been selected. It is possible that other sites or modifications of the existing one would have been more compatible with the full range of regional goals for Northeastern Illinois with little or no increase in the cost of energy production.
2. The adequacy of existing standards for radiation and thermal discharges is currently being reviewed by various authorities. It is not within the capability of the Northeastern Illinois Planning Commission to evaluate these standards as they relate to the Zion power plant. We are vitally concerned that the highest necessary level of protection be required for all nuclear power plants. The facility at Zion should meet all existing standards and should be modified if necessary to meet revised standards if and when they are adopted by the appropriate regulatory agencies. The production of increased

amounts of electrical energy should occur only to the extent that such production will maintain high environmental standards and not significantly interfere with the functioning of vital ecological systems.

It might be appropriate for our society to consider the full environmental implications of the assumption that power needs will continue to grow at a rapid rate and that the demands must be unquestionably met. More careful consideration may reveal the wisdom of finding ways to conserve electrical energy and thereby reducing or deferring the needs for new power plants.

3. It appears that the Zion plant will not meet the thermal standards adopted by the Illinois Pollution Control Board. The requirement as amended June 9, 1971 requires that the daily average thermal discharge be limited to 0.1 billion BTU/hr. The Zion plant will discharge 15 billion BTU/hr.

4. The cooling pond alternative has not been adequately evaluated. It is difficult to accept the impracticality of this alternative without further justification in view of recent proposals for using this technique at other generating stations. A cooling pond could be used to implement certain objectives of the Regional Open Space Plan for Northeastern Illinois by maintaining a large area of low intensity use in an area inappropriate for intensive development. The feasibility of Commonwealth Edison using its own right of way which extends two miles west of Zion (and then north and south some considerable distance) for the necessary pipelines should be studied, as well as the actual impact resulting from construction of the pond. Similarly, the benefits that might be derived from heat utilization from piped cooling water, such as for ice control on highways, has not been adequately treated in the reports.

5. The Environmental Report does not discuss the relationship of the project to goals and objectives for the Northeastern Illinois area, as presented in plans prepared by local, county and regional planning bodies. A thorough discussion of the relationship between the facility and the regional and local plans for the area should have been included in Section 2.2.2 entitled "Regional Planning and Economic Development." Similarly, Section 2.3.1 on Land Use Capability should have appropriately included data relating to future land use and forecasted population levels for the immediate area and the entire region. It is

these land uses to which the facility must be a neighbor and these future populations which the facility must serve.

There is conflict between the location of the site and the policy adopted by the Commission which states that:

"Future development along the Lake Michigan shorelines... should make provision for the maximum use of these areas for public recreation."

The Zion power plant clearly restricts part of the shoreline of Lake Michigan to private, non-recreational use. The plant blocks the continuous accessibility to the lakefront and separates major existing and proposed open space sites. (These sites are not adequately illustrated in the environmental report.) This conflict could be partly resolved if public access could be provided adjacent to or through the site, thereby connecting public open space on both sides. Such access should preferably be located on the lakeshore side of the site.

The site, prior to construction of the plant, was extremely important from a geological and ecological point of view. The area is widely known for its unique and delicate plant habitats. Much of the nearby area within the Illinois Beach State Park has been dedicated as a nature preserve. Had not the site been previously acquired by Commonwealth Edison, it presumably would have been a part of the current Illinois Beach State Park expansion program.

The esthetic effect of the Zion plant is a very significant one. With the construction of this plant the views both north and south from Illinois Beach State Park are terminated by imposing industrial structures of electrical generating facilities. The effect is most significant because Illinois Beach State Park is the most frequently visited Illinois State Park and more than a million persons visit the park annually seeking an educational or outdoor recreational experience.

6. There is little discussion or illustration of the facility's relationship to the proposed lakefront expressway. Together the expressway and the power plant will have very significant effects upon the accessibility to and the appearance of the lakefront area.

Appendix H-6

7. An item of interstate concern is the total environmental impact of the numerous nuclear generating facilities which have been proposed for construction along the Lake Michigan lakefront. The environmental impact report does not place the Zion plant in a broad context, relating it to other facilities, proposed or existing, in Wisconsin, Illinois, Indiana or Michigan.

Appendix I

ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

50-295
50-304

10 AUG 1972



OFFICE OF THE
ADMINISTRATOR

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 statement for the Zion Nuclear Power Station and we are pleased to provide our comments.

In order to provide adequate protection for the aquatic environment of Lake Michigan, we suggest that the applicant initiate steps appropriate to assure that the Zion station facilities and operation will be in accordance with the Lake Michigan Enforcement Conference recommendations and that no significant adverse effect on water quality or aquatic biota will occur.

With respect to the radiological aspects, we feel that the Zion Nuclear Power station will be equipped properly to ensure discharge levels which are as low as practicable, if good administrative controls over operating procedures are observed.

We will be pleased to discuss our comments with you or members of your staff.

Sincerely,

Sheldon Meyers
Director
Office of Federal Activities

Appendix I-2

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

August 1972

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Zion Nuclear Power Station Units 1 and 2

TABLE OF CONTENTS

	<u>PAGE</u>
INTRODUCTION AND CONCLUSIONS	1
RADIOLOGICAL ASPECTS	3
Radioactive Waste Discharge	3
Transportation and Reactor Accidents	5
NON-RADIOLOGICAL ASPECTS	7
Thermal Effects	7
Biological Effects	11
Chemical and Sanitary Wastes	14
COST-BENEFIT ANALYSIS	16
ADDITIONAL COMMENTS	17

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental impact statement for the Zion Nuclear Power Station, Units 1 and 2, prepared by the U.S. Atomic Energy Commission and issued on June 28, 1972. Following are our major conclusions:

1. From the description of radioactive waste treatment systems presented in the draft statement, it appears that the Zion Nuclear Power Station will be capable of operating with radioactive discharge levels which are as low as practicable. However, the achievement of this objective will be contingent on management procedures for operating the installed equipment. Therefore, we recommend that the applicant develop and use operating procedures which result in the "low as practicable" levels afforded by equipment capability.
2. In order to provide protection for the aquatic environment of Lake Michigan, we suggest that the applicant initiate steps appropriate to assure that the Zion station facilities and operation will be in accordance with the Lake Michigan Enforcement Conference recommendations and that no significant adverse effect on water quality or aquatic biota will occur.
3. Analysis of available information indicates that it may not be possible for the Zion plant using the once-through cooling system to operate at full power

Appendix I-4

and, at all times, comply with the thermal criteria of 1000 ft. - 3°F as specified in the conference report. The final statement should indicate how compliance is to be accomplished.

4. The intake structure, as presently designed, will probably entrain appreciable numbers of fish and other aquatic species. We recommend, therefore, that the structure be modified to lower the intake velocity to 1 ft/sec or less. The final statement should describe these modifications and any other measures necessary to prevent a significant adverse impact on aquatic biota from entrainment.

Radioactive Waste Discharges

The estimates of radioactive liquid waste effluents presented in the draft statement indicate that anticipated discharges will be less than 5 Ci/yr/unit, excluding tritium. This release estimate is based on the use of a steam generator blowdown treatment system consisting of filters and demineralizers to reduce secondary system blowdown activity during conditions where a primary to secondary leak exists. Past draft statements have presented liquid discharge estimates categorized by source, i.e., separate radionuclide listings for radwaste system, steam generator leak, and chemical and volume control system. The draft statement for Zion presents only one listing of radionuclides which, presumably, includes the contributions from each of these sources of liquid waste. We feel the presentation of separate listings by source are important for the purposes of evaluating the capability of each system to reduce the environmental impact. Therefore, we recommend that the final statement for the Zion Nuclear Plant contain radionuclide discharge estimates categorized by source. In addition, the anticipated decontamination factors should be presented for the blowdown demineralizer.

The AEC estimate for ⁸⁵Kr of 533 Ci/yr/unit is significantly less than that previously estimated for other similar reactors, (for example, Surry, Indian Point-2). The AEC, in the final statement, should provide the bases for its estimates of the amounts of radioactive gases to be discharged by Zion, including the assumptions, references, and any

Appendix I-6

other information which would explain the inconsistencies between these estimates and those for other similar facilities.

It would appear, from the description of radioactive waste treatment systems presented in the draft statement, that the Zion Nuclear Plant would have the capability to maintain discharges of radioactive wastes to levels which are as low as practicable. However, the realization of this objective will be highly contingent on the operational procedures followed by the applicant. We recommend that the applicant follow operating procedures which result in the attainment of the "low as practicable" objective.

Transportation and Reactor Accidents

In its review of nuclear power plants, EPA has identified a need for additional information on two types of accidents which could result in radiation exposure to the public: (1) those involving transportation of spent fuel and radioactive wastes and (2) in-plant accidents involving reactor systems.

Many of the factors in accident analysis are common to all nuclear power plants; the environmental risk for each type of accident is therefore amenable to a general analysis. Although the AEC has done considerable work for a number of years on the safety aspects of such accidents, we believe that a thorough analysis of the probabilities of occurrence and the expected consequences of such accidents is necessary. A general study would result in a better understanding of the environmental risks than would a less-detailed examination of the questions on a case-by-case basis. An understanding has been reached with the AEC that they will conduct such analyses, with EPA participation, concurrent with reviews of impact statements for individual facilities and will make the results public in the near future. We believe that any changes in equipment or operating procedures for individual plants, required as a result of these analyses, could be included without appreciably changing the overall plant design. If major redesign of the plants to include engineering changes were expected, or if an immediate public or environmental risk were being taken while these two issues were being resolved, we will, of course, make our concerns known.

Appendix I-8

The statement concludes "...that the environmental risks due to postulated radiological accidents are exceedingly small." The conclusion is based on the standard accident assumptions and guidance issued by the AEC for light-water-cooled reactors as a proposed amendment to Appendix D of 10 CFR Part 50 on December 1, 1971. EPA commented on this proposed amendment in a letter to the Commission of January 13, 1972, indicating that the necessity for a detailed discussion of the technical bases of the assumptions involved in determining the various classes of accidents mentioned above will be adequate to resolve these points and that the AEC will apply the results to all licensed facilities.

Appendix I-9

NONRADIOLOGICAL ASPECTS

Thermal Effects

As indicated in the draft statement, condenser cooling at the Zion Nuclear Station will be accomplished using a once-through system. This system will withdraw cooling water from Lake Michigan through an off-shore intake structure and discharge heated water from each nuclear unit through individual pipes and associated surface jet sections, also located off-shore. Although preoperational model studies conducted by the applicant do not provide definitive predictions, analysis of currently available information indicates that this once-through cooling system may not enable the nuclear station to operate at full capacity without exceeding thermal criteria imposed by the Lake Michigan Enforcement Conference (LMEC: Sect. I part 1) or comply with other recommendations, particularly regarding entrainment (Sect. I, part 2). Since EPA is committed to protecting the aquatic environment of Lake Michigan and supports compliance with LMEC, we suggest that the applicant initiate appropriate steps to assure that the Zion station facilities and operation will be in accordance with the existing conference recommendations and that no significant adverse effect on water quality or aquatic biota will occur. This is particularly important considering the substantial use of near-shore water along the southern end of Lake Michigan.

Appendix I-10

As indicated in the draft statement, the applicant has developed both analytical and physical models to assist in predicting the probable size, shape, and behavior of the plume. Although there is some agreement between the results of these two approaches as to the water areas encompassed by the plume, the general shape differs considerably. The analytical model assumes an elliptical plume shape and zero ambient currents. These assumptions, however, are not realistic considering that average currents of from 0.2 to 0.5 ft/sec exist in the area and currents as high as 1.09 ft/sec have been observed. These currents will distort each plume from the idealized shape, and as a result, the analytical model does not accurately predict recirculation effects or account for merging of the plumes from the two discharges. In addition, although this modelling approach does provide reasonable results with regard to plume areas, the specifics of actual plume behavior are not predicted.

of the area of the plume, the applicant has developed both analytical and physical models to assist in predicting the probable size, shape, and behavior of the plume. Although there is some agreement between the results of these two approaches as to the water areas encompassed by the plume, the general shape differs considerably. The analytical model assumes an elliptical plume shape and zero ambient currents. These assumptions, however, are not realistic considering that average currents of from 0.2 to 0.5 ft/sec exist in the area and currents as high as 1.09 ft/sec have been observed. These currents will distort each plume from the idealized shape, and as a result, the analytical model does not accurately predict recirculation effects or account for merging of the plumes from the two discharges. In addition, although this modelling approach does provide reasonable results with regard to plume areas, the specifics of actual plume behavior are not predicted.

of the area of the plume, the applicant has developed both analytical and physical models to assist in predicting the probable size, shape, and behavior of the plume. Although there is some agreement between the results of these two approaches as to the water areas encompassed by the plume, the general shape differs considerably. The analytical model assumes an elliptical plume shape and zero ambient currents. These assumptions, however, are not realistic considering that average currents of from 0.2 to 0.5 ft/sec exist in the area and currents as high as 1.09 ft/sec have been observed. These currents will distort each plume from the idealized shape, and as a result, the analytical model does not accurately predict recirculation effects or account for merging of the plumes from the two discharges. In addition, although this modelling approach does provide reasonable results with regard to plume areas, the specifics of actual plume behavior are not predicted.

CONFIDENTIAL

The physical model study was conducted utilizing a 0.1 ft/sec current. Although this value is somewhat lower than the observed currents, a more accurate picture of plume behavior and shape is provided. The resulting plume patterns are asymmetrical and quite complex. In our opinion, however, this model could be improved by going to larger dimensions. The relatively small size of the physical model adopted by the applicant prevents observation of the lower temperature isotherms of the discharge plumes. We recommend, therefore, that consideration be given to conducting additional studies, using an improved physical model, prior to full power plant operation.

Despite the uncertainties in the preoperational predictions of the model studies, our analysis of these studies, other data presented on the Zion plant, and information gained from experience with existing plants employing once-through cooling systems lead to the conclusion that it may not be possible for this facility to operate at full capacity at all times and remain within the 1000 ft - 3°F criteria of the enforcement conference. In fact, it is possible that on occasion, the thermal plume may encompass 1500 ft at the 4°F isotherm. The final statement, therefore, should discuss in detail the means by which this plant can be operated in compliance with the recommendations of the LMEC and the Illinois Water Quality Standards.

In our opinion, the possible adverse thermal effects of the Zion plant may be intensified under conditions where the volume of water in Lake Michigan available for mixing with the heated discharge is restricted. This could occur if the near-shore water becomes separated from the main lake mass due to the presence of a thermal bar or if there is any appreciable stratification in the lake. We believe such possi-

Appendix I-12

bilities argue for the applicant initiating additional hydrological studies of Lake Michigan near the plant site. This would permit a more accurate determination of the possible thermal effects of the Zion plant, facilitate decisions regarding the necessity of design changes in the once-through cooling system, and assist in developing operational methods to be employed during the period prior to installation of a closed-cycle system. The final statement should describe the studies to be conducted in detail.

Since the LMEC requires closed-cycle cooling on all facilities exceeding 0.5 billion BTU/hr that have not begun operation as of March 1, 1971, it is important that the final statement consider more fully the alternative closed-cycle systems. For example, the final statement should thoroughly explore the environmental impact of fogging, drift, and blowdown associated with cooling towers. In addition, the environmental costs and benefits of each alternative system should be considered in more detail than that provided in the draft statement. Also, we believe the final statement should include a discussion of other possible alternatives such as conventional mechanical draft towers with more cells or combination wet-dry mechanical draft towers.

and the final statement should also include a discussion of the

in our opinion, the possible adverse thermal effects of the

Zion plant may be intensified under conditions where the volume of water

in Lake Michigan available for mixing with the heated discharge is

restricted. This could occur if the near-shore water bodies adjacent

from the rapid lake turnover due to the presence of a thermal bar in the

is any appreciable amount of water in the lake. We believe such a

Biological Effects

In our opinion, there will be appreciable entrainment of fish and smaller organisms that move or drift into the vicinity of the cooling water intake and, as a consequence, there may be a significant impact on aquatic biota. Although the draft statement indicates that the area is unsuitable for spawning, fishery studies in the vicinity of the Zion plant appear to be inadequate to support this contention. Even if there is a lack of spawning areas near the intake, the 8 to 10 foot depths appropriate for nurseries (mentioned in the draft statement) are found near the discharge structure. It is likely, therefore, that schools of fish will pass near the intake. The final statement should discuss this possibility.

In general, the design and operational characteristics of the intake system, particularly the high intake velocities (e.g., 2.47 feet/sec during summer; 3.7 feet/sec during winter recirculation mode), will result in excessively high capture or entrainment of many aquatic species. In addition, during colder periods of the year when a portion of the discharge water will be diverted to the intake structure to prevent icing, fish will be attracted to the vicinity of the intake by the warmer water. This would increase the likelihood of entrainment. With no barrier to prevent fish and mobile fish food organisms from entering the intake structure, the loss could be extensive.

The draft statement recognizes the relationship between high intake velocities and entrainment rates and concludes that "... the applicant should now design the modifications to the intake structure necessary to reduce the water velocity to about 1 foot per second." We agree with the intent of this recommendation, but believe that the applicant

Appendix I-14

should be between 0.5 and 1 foot per second (preferably the lower value). The final statement should include a description of the redesigned intake system.

It has been well established that planktonic communities can be damaged as a result of entrainment mortalities due to temperature increases and mechanical abrasions during passage through condenser cooling systems. Preoperational studies at the Zion site to date have not been adequate to determine the effect of this mortality on the Lake Michigan population. Also, the monitoring program for the post-operational studies will probably not provide sufficiently reliable data to determine such effects. For example, this program calls for sampling at 9 or 10 stations monthly. In our opinion, in order to obtain reliable population estimates and detect changes, both the number of stations and the frequency of sampling should be substantially increased. The data gained from an expanded monitoring program would permit verification of estimates of plankton mortality as a function of the time of year (e.g., recent studies indicate that high mortality rates occur in November as well as during the summer months indicated in the draft statement) and would increase the accuracy of long-term projections.

The draft statement indicates that examinations of the numbers of fish captured by the traveling screens will be used to determine the need to modify the intake structure. Since the intake system uses a wire screen with a 3/8 inch mesh, larval fish will not be detected. Because larval forms are most likely to be drawn into the intake, we recommend that studies include screenings with fine mesh nets.

to reduce the water velocity to about 1 foot per second. We agree with the intent of this recommendation, but suggest that studies be conducted to determine the effect of this reduction on the intake system.

Appendix I-15

Since the intake water will, in most instances, be saturated with dissolved oxygen, the discharge water will be in a supersaturated state. This will create a region of supersaturated water in the vicinity of the plant site. Supersaturated water at levels as low as 110% have been observed to cause adverse effects in some aquatic species. We recommend, therefore, that the expected levels of supersaturation and the potential effects on fish and other aquatic species be described in the final statement.

The final statement should discuss the temperature increase (ΔT) above ambient conditions at the discharge points that can be expected during the winter recirculation mode. Since this increase will undoubtedly be greater than the 20°F indicated for the summer operational mode, there may be increased mortality of entrained organisms and more significant effects on fish and other mobile species that move through the discharge plume. An estimation of these effects should also be provided in the final statement.

Chemical and Sanitary Wastes

Because Lake Michigan has a retention time for pollutants of approximately 100 years, small amounts of chemicals and other wastes discharged from many sources over a long period of time may result in an appreciable degradation of water quality. This effect, evidenced by the continuous increase in the concentrations of dissolved solids that is observed, may lead to future restrictions on polluted discharges. Thus, considering the contribution to the total pollutant load that will be made by each source, we cannot agree that the release of approximately 155,555 pounds per year of chemicals from the Zion facility will not result in a significant adverse impact. The final statement should consider such long-term effects in the evaluation of the environmental costs of operating the Zion facility.

If dissolved solids are not removed from waste discharges, we believe it would be desirable to develop other means of disposal instead of adding them to the cooling water discharge to Lake Michigan. The draft statement indicates that sanitary wastes are to be discharged to the North Shore Sanitary District which reportedly has long-range plans to eliminate all waste discharges to Lake Michigan. Thus, routing of chemical and industrial waste residues to the District system with any required pretreatment would eliminate the discharge of chemical Zion wastes to the lake. The alternative of a comparable method to eliminate discharges of dissolved chemicals to the lake should be considered in the final statement.

Appendix I-17

Table III-4, page III-26, shows an estimated discharge of 1,455 pounds per year of detergents. The effects of this chemical discharge, however, cannot be evaluated because the chemical composition of the detergents is not provided. The final statement should include this information and consider any alternative means of disposal.

In addition, the estimated discharge of 3,000 pounds of phosphates is detrimental because it is a nutrient and, thus, contributes to eutrophication. The discharge of this quantity of phosphate is inconsistent with the requirement of the Lake Michigan Enforcement Conference that phosphate discharges be significantly reduced. We recommend, therefore, that an appropriate mechanical cleaning system technique for minimizing chemical waste discharges be installed.

Table III-4 shows an estimated discharge of 1,260 pounds per year of boron. Boron concentrations of one milligram per liter (mg/l) are reportedly acceptable in public water supplies. Boron is an essential element to plant growth, but it is toxic to many plants at levels as low as one mg/l. Short-term environmental effects would not be expected from boron discharges at concentrations of 0.0005 mg/l. From the standpoint of long-term buildup, however, any discharge of boron is undesirable. This and other discharges of boron will be retained in the lake for over 100 years and contribute to a cumulative increase in boron concentrations.

COST-BENEFIT ANALYSIS

It was not clear from the presentation in the statement whether the costs and benefits were discounted to present values, and, if so, what discount rate was used. We recommend using a rate of 10 percent.

Although taxes are either financial costs or financial benefits to either the applicant or to local government, from the point of view of the welfare of the nation they are merely transfers.

A financial advantage of the chosen site in competition with alternative sites was prior ownership by the applicant. Again considering the point of view of the welfare of the nation, which is the point of view appropriate for the AEC, this should not have been a consideration in the choice of a site.

ADDITIONAL COMMENTS

During the review we noted in certain instances that the 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 Zion Nuclear Power Station. The cumulative effect, 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:

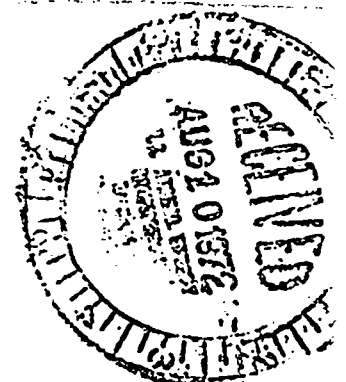
1. We encourage the AEC to apply the provisions of Safety Guide 21 to the requirements for the Zion site. In this manner, meaningful dose estimates can be calculated during operation of the plant. The final statement should also evaluate the amounts of liquid and gaseous radioactivity that could be released undetected and should present estimates of the amount of activity that will be discharged before monitoring alarms are activated and the discharge terminated.
2. A limited number of measurements made at operating pressurized water reactors have indicated that direct external radiation exposure from large outdoor water storage tanks (such as the condensate storage tank) could be a significant contributor to the radiation dose received by people living in areas or frequenting areas close to the plant. Neither the applicant nor the AEC has estimated the potential radiation exposure from this source; such estimates should be included in the final statement. We note that the Illinois Beach State Park is directly south of the Zion site and the closest residence is less than 1 mile west of the site. The

Appendix I-20

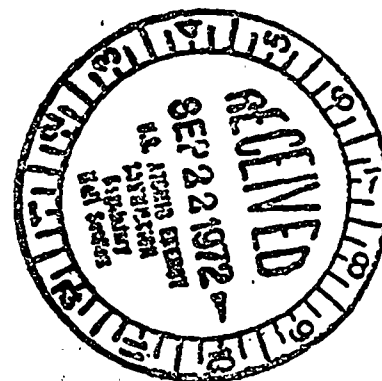
location of tanks which would contribute to the doses at these points should be specified. Although the period of exposure will be short in the case of visitors to the state park, the number of people so exposed will probably be large. Estimates of the population radiation dose (expressed as man-rem/yr) should be made, including the expected number of visitors to the park per year and the average external radiation dose due to direct shine from the plant.

3. The impact of high voltage transmission lines discussed in the draft statement does not mention the production of ozone by the lines. Since little information concerning the production of ozone by high voltage transmission lines is available, EPA is preparing to study this problem. It would also be desirable for the AEC to provide whatever available information the utility companies may have in the final statement.

4. No information about the diesel generators and starting boilers was presented, and therefore, it was impossible to assess the magnitude of the effects they may have. Similar starting boilers at other nuclear facilities have large enough capacity to be classified as an air pollution point source as defined in 42 CFR 51.1. The information needed to complete the assessment of the boilers and generators is the capacity rating, fuel usage rate, and sulfur content of the fuel to be used.



The Council is charged by the Act of October 12, 1966, with advising the President and Congress in the field of Historic Preservation, recommending measures to coordinate governmental and private activities, advising on the dissemination of information, encouraging public interest and participation, recommending the creation of special studies, assisting in the preparation of legislation, and encouraging specialized training and education. The Council also has the responsibility to recommend or request or voluntarily accept individuals that have an effort on cultural property listed in the National Register.



STATE OF ILLINOIS
DEPARTMENT OF CONSERVATION
SPRINGFIELD 62706

RICHARD B. OGILVIE
GOVERNOR

HENRY N. BARKHAUSEN
DIRECTOR

Appendix J-2

September 1, 1972

50-295/304

Mr. Richard Roman
Building 11
Argonne National Laboratory
Argonne, Illinois 60439

Dear Mr. Roman:

This letter will certify that the Illinois Department of Conservation has reviewed the land sections to be affected by the Zion Nuclear Power Station and has determined that no archaeological, architectural, or historical resources are evident within the same.

Thank you for this opportunity of review.

Sincerely,

Henry N. Barkhausen
Director
State Liaison Officer

Mr. Henry N. Barkhausen, Director, Department of Conservation, 101 State Office Building, 400 South Spring Street, Springfield, Illinois 62706

This letter is being sent to you as a courtesy and does not constitute an official action of the Department of Conservation. It is the policy of the Department to review all proposed actions which may affect the State's natural resources. The Department's review is limited to the information provided to it and does not constitute an endorsement or approval of the proposed action. The Department's review is for informational purposes only and does not constitute a guarantee of the accuracy or completeness of the information provided to it.



DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

50-295
50-304

Appendix K



August 18, 1972

Mr. Daniel R. Muller
Director of Licensing
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

We have reviewed the draft environmental impact statement for Commonwealth Edison Company's Zion Nuclear Power Station Units 1 and 2. Comments from the Agricultural Research Service and the Soil Conservation Service, both agencies of this Department, are enclosed.

Forest Service, also an agency of this Department, has not yet completed its review and will communicate directly with you later if they have any comments.

Sincerely,


T. C. BYERLY
Coordinator, Environmental
Quality Activities

Enclosures

1004

4601

Appendix K-2

Agricultural Research Service

Subject: Environmental Report for Zion Units 1 and 2,
AEC Dkts. 50-295 and 50-304, Respectively

The subject environmental report has been reviewed, and we find nothing in the report that would indicate that this action would damage the land and water environment. The benefits derived from the additional energy would far offset any minor damage to the environment that might occur.

103A

4601

Appendix K-3

**SOIL CONSERVATION SERVICE - USDA
COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT PREPARED
BY THE ATOMIC ENERGY COMMISSION FOR THE ZION NUCLEAR POWER
STATION UNITS 1 AND 2 OF THE COMMONWEALTH EDISON COMPANY**

1. As indicated on page iv-1 of this statement, the applicant has not presented the details of final construction cleanup and landscaping. The applicant should be encouraged to complete final grading and landscaping of disturbed areas at the earliest possible date to reduce erosion and sediment damage to surrounding areas.

2. On page iv-2 the statement indicates that Commonwealth Edison will provide assistance in restoration of project induced beach erosion areas south of the site. It would be helpful if the types of assistance to be provided were indicated in the statement.

The Soil Conservation Service, through the Lake County Soil and Water Conservation District, is willing to provide technical assistance in matters concerning soils, control of erosion and sedimentation, and establishment of suitable vegetation.

ADRIAN M. WALSH
Acting Deputy Chief

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Washington, D.C. 20250

Appendix K-4

50-295
50-304

AUG 28 1972

1940



Mr. Daniel Muller
Director of Licensing
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muller:

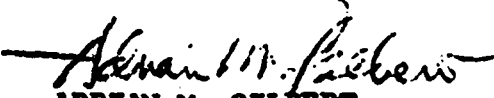
We have reviewed the draft environmental statement for the Zion Station, Units 1 and 2, Commonwealth Edison Company, Illinois.

There appears to be little effect on forest or other terrestrial vegetation due to operation of the Zion Plant, especially in view of the prevailing westerly winds that take the effluents away from land. A nuclear power plant is preferable to a coal or oil-burning plant from the standpoint of sulfur dioxide emissions.

Since many industries are discharging hot water into Lake Michigan, total effect of heating should be considered. Temperature of the lake should be monitored so that corrective measures may be taken before the temperature reaches critical levels for aquatic life. Industries should prepare to use methods of cooling that do not result in discharge of high temperature water into the lake.

We appreciate the opportunity to review this draft environmental statement.

Sincerely,


ADRIAN M. GILBERT
Acting Deputy Chief

4867

1001

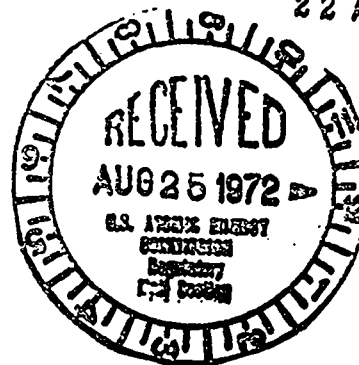


DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS:
U.S. COAST GUARD (GWS/83)
309 SEVENTH STREET SW.
WASHINGTON, D.C. 20503
PHONE: 202/426-2262

Appendix L

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545



22 AUG 1972

50-295
50-304

Dear Mr. Muller:

This is in response to your letter of 28 June 1972 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, concerning the draft environmental impact statement and pertinent papers on Zion Nuclear Power Station, Units 1 and 2, located in Lake County, Illinois.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted and the Federal Railroad Administration noted the following:

"We do not consider that adequate attention has been given to the problem of electrical interference impacts on railroad communications and signal systems. It is noted that at least one transmission line crossing and 1.2 miles of parallel construction will involve railroads. Induced voltages of a high magnitude in addition to the problem of high currents from direct faulting may destroy the integrity of signal and communication facilities. Recent experience has also produced evidence of high induced voltage in certain types of freight car bodies. The consequences of this problem are manifested in the injury of employees (standing train situation) and likely as a cause of journal failure."

The Department of Transportation has no further comments to offer nor do we have any objection to the project. It is recommended that the concern of the Federal Railroad Administration relative to the transmission lines be addressed in the final environmental impact statement.

The opportunity to review and comment on the draft statement and other material for the Zion Nuclear Power Station Project is appreciated.

Sincerely,

[Signature]
R. A. BISHOP
Rear Admiral, U. S. Coast Guard
Chief, Office of Marine Environment
and Systems

4690

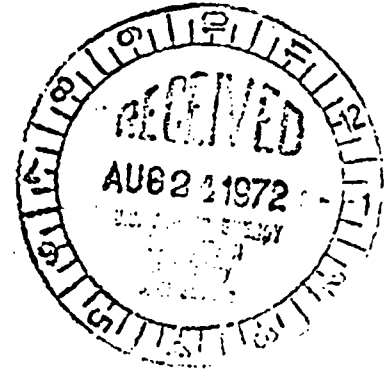


THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

50-295
50-304

Appendix H

August 24, 1972



Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

The draft environmental impact statement for the "Zion Nuclear Power Station Units 1 and 2 - Docket Numbers 50-295 and 50-304," has been received by the Department of Commerce for review and comment.

The Department of Commerce has reviewed the draft environmental statement and has the following comments to offer for your consideration.

The postoperational monitoring program appears to be adequate in regard to determining the effects of thermal, chemical, and physical parameters on the aquatic biota. Further, a memorandum from the Atlantic Estuarine Fisheries Center states their belief that the environmental radiological program described in the final safety analysis report is adequate. However, the statement contains only a summary of the program. It would seem advisable to include full details in the statement since some reviewers may not have access to the FSAR.

On page II-29 it is noted that "Michigan is committed to an extensive program of lamprey control . . .". Although the State of Michigan is of course vitally concerned and plays an important role in the lamprey control program, other agencies such as the Bureau of Sport Fisheries and Wildlife, the former Bureau of Commercial Fisheries, (prior to October 1970), and the Great Lakes Fishery Commission have been and continue to be the primary agencies that administer and carry out this federally-financed program.

4672

In previous comments to AEC Directorate of Licensing dated June 5, 1972, we have estimated a maximum annual average concentration of 5×10^{-6} sec m^{-3} at the nearest site boundary 600 m to the north. This is slightly higher than the value listed on page V-23 of the impact statement. The basis for our calculations was the one year of onsite wind measurements taken at a height of 35 feet and the temperature difference measurements taken between 35 and 125 feet. These data were found in the Final Safety Analysis Report but are not included in the Applicant's Environmental Report.

We are unable to evaluate the consequences of postulated accidents since the specific meteorological assumptions used, the resulting relative concentrations in units of sec m^{-3} , and the expected frequency of occurrence of such concentrations were not listed in reference to the AEC estimates discussed on page VI-2.

An error of identification is that Table E-1 in the Appendix, covering the period 1951-1960, is listed as a 1958 publication. It was correctly identified as a 1963 publication as Item 6, page II-31.

The following typographical-type errors are noted in the draft:

- Page V-14; 8th line following table -- "feed"/ feeding.
- Page V-25; first line, last paragraph -- "In"/ If.
- Page VII-1; line 2, second paragraph -- 1,530 gpm/ 1,530,000 gpm.
- Table A-1; page 4 -- Phasianidae; ring-necked pheasant.
- Table A-2; page 1 -- Clupeidae: Dorosoma.
- Table A-2; page 2 -- Lepomis macrochirus - Bluegill.

We hope these comments will be of assistance to you in the preparation of the final statement.

Sincerely,

Sidney R. Galler

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

cc: Mr. Daniel R. Miller
AEC



OFFICE OF THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

50-295
50-304

Appendix H-4

August 29, 1972



Mr. Bennett Harless
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Ben:

In our comment letter of August 24, 1972, on the
"Zion Nuclear Plant Station Units 1 and 2, Docket
No. 50-295 and 50-304," a typing error showed up.
In accordance with our telephone conversation, this
letter will confirm the following change.

Please change the sentence (page 2 of our comment
letter, first paragraph) from "... it seems the
egg gathering process after spawning could be ...".
Delete "after spawning".

Thank you.

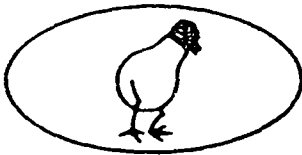
Sincerely,

Morris Robinson
Office of the
Deputy Assistant Secretary
for Environmental Affairs

cc: Mr. Daniel R. Muller
AEC

U.S. DEPT. OF COMMERCE
OFFICE OF THE ASSISTANT SECRETARY
FOR ENVIRONMENTAL AFFAIRS

4772



Commonwealth Edison Company

ONE FIRST NATIONAL PLAZA ★ CHICAGO, ILLINOIS

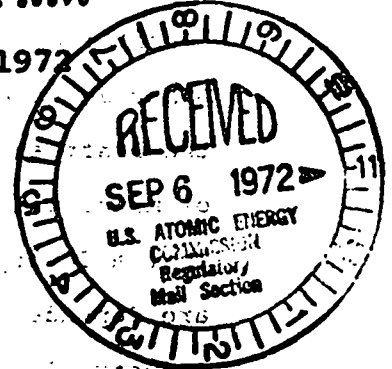
Address Reply to:

POST OFFICE BOX 767 ★ CHICAGO, ILLINOIS 60690

September 5, 1972

Appendix H

Mr. D. R. Muller, Assistant Director
for Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D. C. 20545



Subject: Comments on Zion Station Draft Environmental Statement Dockets 50-295 and 50-304

Dear Mr. Muller:

Attached are three signed originals and 40 copies of Commonwealth Edison Company's comments on the Zion Station Draft Environmental Statement and replies to comment letters submitted to the AEC by other regulatory agencies.

This submittal should not be considered as a complete response to all the comment letters since additional letters have been received as recently as August 22 and 29, 1972. These latter comments are being reviewed currently and additional responses will be submitted where such is deemed appropriate.

Our replies provide additional information where it has become available and where further clarification of previous information seemed advisable.

If we can provide further information, please do not hesitate to call.

Very truly yours,

Byron Lee, Jr.
Assistant to President

SUBSCRIBED and SWORN to
before me this ____ day
of _____, 1972.

Notary Public

Appendix N-2

This memorandum summarizes Commonwealth Edison's comments on the AEC Draft Environmental Statement For Zion Nuclear Power Station Units 1 and 2 (Dockets 50-295 and 50-304) June, 1972 (the "Draft") and Edison's responses to certain comments received from other agencies. The memo proceeds in consecutive page numbers of the Draft and two levels of comments are included; the correction of minor inaccuracies and more detailed comment where we believe that a faulty approach has been used. A portion of the comments are dependent on research conducted for the Company by Bio-Test Industrial Laboratories under the supervision of a board of consultants. Some of this research will not be available for publication until shortly before the ASLB hearing on Zion station because it comprises pre-operational studies only now being completed. Another portion is currently being prepared for publication at the September 1972 Four State Lake Michigan Enforcement Conference. In addition, a systematic revision of the September 1970 Study Plan is nearly ready for publication. All of these documents will be made available to the AEC as they are completed. Additional comments on the Draft, based on these developing materials, will be made to the AEC if the research involved is available by September 15, 1972.

- ii, para. g Item 3(g) of the summary and conclusions to the Draft Environmental Statement indicates that Zion Station will discharge to the environment approximately 10 curies per year of radioactive liquid waste in addition to approximately 2000 curies per year of tritium. As pointed out at page III-20, the staff actually

OF RECORDS AND COMMUNICATIONS
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20545
JUL 11 1972

MOORE BOWEN

#184

Appendix H-3

calculated the releases of liquid wastes, other than tritium, to be less than 5 curies per year per unit. Thus, the Zion system complies with the design objectives of Appendix I to 10 CFR 50 as proposed even with upward "normalization" of calculated releases. However, we believe that the estimates contained on page 7 of Supplement 1 to the Zion Environmental Report more accurately typify the emissions which will be experienced during Station operation. These estimates show a total of less than 1 curie per year from both units. There are a number of reasons why the Commonwealth Edison Company estimates are substantially below 5 curies per year per unit. First, the Draft points out that the numbers actually calculated by the regulatory staff are raised to compensate for equipment down time and abnormal operational occurrences. As shown in section 11 of the Final Safety Analysis Report and the answer to staff questions as to section 11, the equipment in Zion Station is oversized to compensate for down time and abnormal occurrences. In addition, the Draft Statement does not allow credit for the use of the blowdown demineralizer trains to polish other liquid wastes.

The estimated release of 2000 curies per year of tritium is also unduly high. It is possible that such emissions would be experienced in some year of plant operation if the tritium recycle system contemplated by the applicant works as expected, but abnormal water management problems are experienced during some year when concentrations within the plant are near their peak. However, as indicated on page 28 of Supplement 1 to the Environmental Report, tritium emissions will not exceed a level

Appendix E-4

of 700 curies per year averaged over any 5 year period. This number would constitute a more reasonable upper range example in a statement dealing with the whole of plant life. In addition to apparently focusing on peak year emissions, the staff's evaluation is high because it assumes only 90% recycle of the flow through the chemical and volume control system evaporator monitor tanks! III-18 Such may be the experience from time-to-time but the typical results will be far closer to 100% recycle, with a resultant greater retention of tritium.

Page I-4: The Illinois Pollution Control Board has held it does not have jurisdiction to issue an operating permit. The Application filed on October 19, 1971 can be deleted from Section B, Chapter I.

Commonwealth Edison has applied to the Illinois Environmental Protection Agency for a discharge permit for Six Units 1 and 2.

The application was filed on July 11, 1972 in accordance with Rules 906 and 911, Chapter 3, Water Pollution, of the Illinois Pollution Control Board Rules and Regulations. This permit application should be added to Section B, Chapter 1.

Page II-12-14: The fourth paragraph states on page II-12:

"The inshore zone is defined arbitrarily as the volume of water between the shoreline and the 100 foot contour."

The fifth paragraph states:

"The beach water zone is a sub-area of the inshore zone which extends to the 30-foot depth contour."

Both of these definitions are taken from a 1970 publication of the U. S. Fish and Wildlife Service commonly known as the Lake

Michigan Water Management Plan. The plan is a study of the water management problems which may be encountered in some year when concentrations within the plant are near their peak. However, as indicated on page 28 of Supplement 4 to the Environmental Report, tritium emissions will not exceed a level

Michigan White Paper (1). That White Paper was largely discredited during the October 1970 Four State Enforcement Conference, especially insofar as it attempted to create the impression that Lake Michigan was really several physically separate bodies of water.

There are major conceptual problems in using an arbitrarily defined "inshore zone" and "beach water zone". The terms "inshore zone" and "beach zone" have been used to designate distances from the shoreline for large lakes but they are not generally accepted by limnologists and have not been shown to have any general conceptual utility for scientific studies. Many physical, chemical, and biological parameters of the Lake do change gradually from shallow water to deep water but there is nothing particularly significant about the 30 foot depth or the 100 foot depth or a distance of three or ten miles from shore.

Limnologists do use definitions of a littoral shelf and a beach. For instance, Hutchinson (2, p. 178) says:

"Normally the slope of a basin, both above and below water level, will be greater than the equilibrium slope, defined as that slope that is unaltered by shore processes. The result will be that at times of considerable wind, when high waves are formed, these will break against a sloping land, creating a beach, which they will tend to erode. The result of this erosion depends upon the original slope, on the depth of the water, on the nature of the material forming the land, and on the fetch and so the height of the waves.

part of the terrace. It is interesting to note that Hutchinson

cited Lake Michigan as an example of a lake having an extremely wide (100-150 miles) littoral shelf.

(1) Physical and Ecological Effects of Waste Heat on Lake Michigan, by J. C. Rhee, 1970, Michigan Department of Natural Resources, Lansing, Michigan.

(2) Hutchinson, G. E., 1957, "The Littoral Zone of Large Lakes", Journal of the American Water Resources Association, 1: 177-187.

(3) Hutchinson, G. E., 1957, "The Littoral Zone of Large Lakes", Journal of the American Water Resources Association, 1: 177-187.

"As material is removed by cutting, the larger fragments are of course transported a negligible distance and the finest clay may be suspended in the water for a long period; the material usually moved this way is gravel, sand, and silt. The result is a terrace formed both by cutting peripherally and building centrally. The part of the terrace above water will be termed the beach, the part below water will be the littoral shelf. The beach of a lake is dry during quiet weather. When waves break upon it, the swash carries particles upward from the quiet-weather waterline, the smallest particles being carried furthest. A beach may therefore consist of progressively smaller particles as one ascends from the waterline, while the shelf bears progressively smaller particles as one descends towards the deep water. This effect is best seen subsequent to the initial stages of beach formation during which much material is falling from the cliff face.

"The formation of a wave-cut cliff, beach, and sublittoral shelf is possible on any scale. The cliff may be less than a meter high in lakes in regions of very gentle relief, or hundreds of meters high along the coasts of some of the Norwegian fjord lakes. The shelf likewise can be of any width up to about 20 km as in one part of Lake Michigan (Andrews, 1870), but Johnson (1919) estimates that only a part of this width is due to cutting and at least half to building."

Thus, according to Hutchinson, the beach and littoral shelf of a lake are built up as a terrace by wave erosion along the shoreline, the beach being the part of the terrace which is dry during quiet weather and the littoral shelf being the submerged part of the terrace. It is interesting to note that Hutchinson cited Lake Michigan as an example of a lake having an extremely wide littoral shelf. A study of a contour map of Lake Michigan indicates that the wide part of the littoral shelf occurs in the southwest part of the Lake and in this area the edge of the shelf is at a depth of approximately 350 feet. However, Hough (3)

(3) Hough, J.L., Geology of the Great Lakes, University of Illinois Press, Urbana, Illinois (1958).

ascribes the formation of the edge of the terrace not to the erosion of the shoreline of the present lake by wave action but to the existence of Lake Chippewa approximately 6000 years ago. Whatever the original cause, the contours of the bottom of Lake Michigan show that in the area near Zion Station the slope is gradual and relatively uniform and that the only feature which could be interpreted as the edge of a littoral shelf is more than 10 miles from shore and more than 300 feet deep.

The significance of the littoral shelf in limnology is that it provides the physical basis for an area or zone of a lake in which a distinct ecological community may develop.

Reid (4, p. 37) in his discussion of lake shores and shore zones describes the physical development of the beach and littoral shelf in a manner essentially identical to that used by Hutchinson. In his (4, p. 148) discussion of the chemical constituents of lake waters the only distinction he makes is:

In the shallow shore region (the littoral), submerged rooted plants along with phytoplankton contribute oxygen to the lake. In the euphotic zone of the open lake (the limnetic), phytoplankton contributes the autochthonous oxygen."

However, in his discussion of aquatic communities he includes a three page (4, pp. 300-303) description of the littoral zone. His ecological definition of the littoral zone is:

The littoral zone is that portion of a body of water extending from the shoreline lakeward to the limit of occupancy by rooted plants."

- (4) Reid, G.K., Ecology of Inland Waters and Estuaries, Reinhold Publishing Corp., New York (1954).

Limnologists have found it useful to define the littoral shelf in terms of the biological processes which produce a terrace near the shore of a lake and to define the littoral zone in terms of a biological community which is distinct from the community in other parts of the lake. In contrast to this the definition of an "inshore zone" and of a "beach water zone" has no particular conceptual utility and may actually have a confusing rather than clarifying effect because these are not regions of the lake which are either physically or biologically separable from other regions of a lake.

In the case of Lake Michigan the picture is of a remarkably simplified ecological situation. The littoral shelf, if it is present, is extremely wide and extremely deep in comparison with other lakes. Due to the nature of the sediments along the shoreline and the wave action there are very few areas of the Lake which can be accurately described as a littoral zone. Except for areas in which rocks and other hard substrates exist on the shoreline as points of attachment for periphyton, the oxygen produced in the lake is produced by phytoplankton. Because land runoff and waste discharges enter the Lake at the shoreline there is a gradual variation of chemical constituents from the shore outward to the deep water but there are no sharp lines of demarcation in water quality as might occur if a true littoral zone were present. Plankton populations are "patchy" and may vary considerably along the shore as well as from the shore outward. There are no physical or biological barriers to fish

moving either inshore or offshore at different parts of the year, as their behavioral tendencies lead them. In other words, except for the bays connected with Lake Michigan and the very shallow water near the beach where the wave action is often quite violent, Lake Michigan presents very little habitat diversity compared to other lakes.

The definition and use of the "inshore zone" and "beach water zone" for Lake Michigan implies a separateness of these zones from the rest of the Lake which has never been substantiated and also implies a habitat diversity which does not exist. The use of these definitions introduces an element of complexity into the limnology of Lake Michigan which is confusing and obscures some of the concepts (such as the gradient in water quality from shore outward) which are necessary for an understanding of the ecology of the Lake. They should be discarded.

The erroneous basis for the definition by the Fish and Wildlife Service of the terms "inshore zone" and "beach zone" is illustrated by an analysis of the data presented on page II-14, in Table II-1, entitled "Chemical Characteristics Measured in Inshore Waters of Lake Michigan in 1962-63". The data presented in this table are taken from the same Fish and Wildlife Service Report and to a report (5) prepared by Industrial Bio-Test Laboratories for Commonwealth Edison Company. However, the data presented in Table II-1 were not in fact taken from the "inshore zone" as defined on p. II-12.

- (5) Preoperational Environmental Monitoring (Thermal) of Lake Michigan near Zion Station/July 1969-December 1969, prepared for Commonwealth Edison Co. by Industrial Bio-Test Laboratories, Inc.

(6) Physical and Chemical Quality Conditions, Water Quality Investigations, Lake Michigan Basin, Great Lakes Region, Federal Water Pollution Control Administration, Chicago, Illinois (1968)

The publication, Physical and Ecological Effects of Waste Heat on Lake Michigan, is a review and does not present any original data. The reference given in that publication as the source of the chemical data is Physical and Chemical Quality Conditions, Water Quality Investigation, Lake Michigan Basin, Great Lakes Region, a report published by the FWPCA in 1968 (6). In the FWPCA report, the "inshore water" samples were samples taken within 10 miles of the shoreline. Within 10 miles of the shoreline of Lake Michigan there are waters considerably more than 100 feet deep and there is no information in the FWPCA report to indicate the depth of water in which the "inshore" samples were collected. It is likely that much of the chemical data presented in the first two columns of Table II-1 were collected from samples taken at water depths considerably greater than 100 feet.

The third column of data in Table II-1 is from the Bio-Test report and is based on chemical analyses of samples of Lake Michigan water obtained near Zion Station in 1969. The samples described in the Bio-Test report were obtained in August, October, and December. In August water samples from chemical analyses were obtained at twelve stations all of which were located at water depths of less than 30 feet. In October water samples for chemical analyses were obtained at twelve stations, eight of which were at water depths of less than 30 feet and four of which were at water depths of 34, 35, 36 and 37 feet, respectively. In December water samples for chemical analyses were

(6) Physical and Chemical Quality Conditions, Water Quality Investigations, Lake Michigan Basin, Great Lakes Region, Federal Water Pollution Control Administration, Chicago, Illinois (1968).

obtained at thirty stations none of which were located at water depths of more than 30 feet. Thus of the fifty-four samples described in the Bio-Test report fifty of them were in the so-called "beach water zone" and the other four were so close to the "beach water zone" that they could not be said to be characteristic of another zone. Indeed, a review of the chemical data from the four stations at water depths greater than thirty feet indicates that the chemical constituents in the water from these samples are essentially the same as from the samples obtained at depths of less than 30 feet.

[The third column of Table II-1 gives the notation N.D. for the following constituents: $\text{NO}_3\text{-N}$, organic-N, SiO_2 , Na, K, dissolved solids, specific conductance, alkalinity, Ca, Mg, and phenols. The notation N.D. is indicated at the bottom of Table II-1 to mean "not detectable at sensitivity of the test." In the Bio-Test report data on the concentrations of $\text{NO}_3\text{-N}$, SiO_2 , Na, dissolved solids, alkalinity, Ca, and Mg in all of the samples taken are presented and the concentrations in all cases were detectable. No data on organic-N, specific conductance, and phenols are presented. N.D. thus means "not determined" rather than "not detectable." Thus, the notations N.D. in the third column of Table II-1 are inaccurate and should be changed if this table is to be included in the final AEC Environmental Statement for Sion Station.]

Page II-13

The first sentence of the last paragraph on page II-13 should read, "Lake Michigan waters have a bicarbonate buffering system with a pH which varies from 7.8 - 8.3 in the Sion area."

The table on this page could include more recent information pertaining to the concentration and ranges of these parameters listed for the Zion area. Data resulting from the Bio-Test analysis of Lake Michigan water collected at the Lake County Public Water Districts intake are shown below. The cribhouse is located approximately 3000 feet from shore and about 1 mile north of the Zion intake structure. There should be little, if any, difference in water quality between the two areas.

Suggested Modifications to Table II-1

<u>Characteristic</u>	<u>Zion Average</u>	<u>Zion Range</u>
DO	2.2	0.2-6.2
NH ₃ -N	0.03	0.01-0.14
NO ₃ -N	0.11	0.06-7.3
Total Phosphorus as PO ₄	0.061	0.004-6.24
SiO ₂	1.0	0.3-1.8
Na	4.9	4.1-6.9
Specific Conductance (micromhos per centimeters)	270	250-307
pH (pH units)	8.0	7.3-8.7
alkalinity	106	90-144
Ca	36	30-55
Cl	0.7	0.5-12.5

Page II-13 The Draft states that the spring thermal bar tends to inhibit mixing between the open lake and the inshore waters. This is in a context which infers that nutrients trapped inside the thermal bar are related to plankton abundance and biological productivity. The bar itself is an area of rapid mixing (Britchard, IPCS, November 7, 1971). The spring thermal bar does not inhibit mixing. In any case the spring plankton pulse comes before the thermal bar forms and there is no physical relationship between the two. The reference in the Draft is to the work of Dr. Stember, a distinguished biologist. It is not generally useful, however, to rely on biologists for statements as to the hydraulic properties or phenomena of a lake.

Appendix B-13

Page III-
para. 2

Steam pressure at the outlet of the steam generator is 720 psia rather than 690 psia. Pipe losses reduce the pressure to 690 psia at the turbine throttle valves.

Page III-
para. 3

The blowdown treatment system will be used to polish the discharge to the lake from the Liquid Waste Disposal System.
(ref: Q 11.12 amend. 16)

Page III-8
and III-9

Water intake pipes are 15 feet in diameter, not 16 feet.

Page III-13

At the bottom of this page there is a reference to the

Alden Test data as indicating that there will be interaction between the two discharges. The phenomenon shown in test 009 by the Alden Research Laboratories was due to reflection from the boundary limits of the model. Recirculation is most unlikely. At 10' above ambient, for example, the water in the plume has a velocity of 4.75 fps, far larger than any current occurring in the lake, and too large to be affected by local currents. The low velocity portion of the discharge occurs long after the plume has passed the intake structure.

Page III-20
para. 3

Allowance was made for equipment downtime in specifying evaporator capacity and blowdown demineralizer capacity. Further

allowance need not be made in estimating the rough estimate of radioactivity in liquid wastes to be withdrawn from the

Page III-16
para. 2

The analysis system releases there will be 1000 rads of the contents from the facility will evaporator condenser and

Page III-20
para. 2

When the unit are operating, the auxiliary boiler will not be in use, so there will be no release of steam from

Page V-78

The last paragraph concerning steam from water around cold water intake during release will remain unchanged. The intake structure, 150 ft high, will prevent release of steam from the intake

suggest that the only species which are found in sufficient numbers to be of concern is the rainbow smelt.

Page V-8

This section considers condenser passage effects. We do not believe that there will be an "important fraction" of entrained organisms that are killed. The first sentence suggests that the "larvae of some benthic crustaceans will be entrained in the cooling water and pass through the condenser. The common benthic crustaceans of Lake Michigan do not have free-floating larvae and thus will not be entrained. The major benthic crustaceans are Pontoporeia affinis and Mysis relicta. Studies at the Waukegan station have found these organisms in only small numbers. Although a few are expected to be entrained at Zion, the numbers are expected to be small.

This section implies that a sudden temperature change of 20°F. would exceed the temperature tolerance of juvenile or mature aquatic invertebrates (planktonic and benthic organisms). There is substantial evidence to suggest that this is not true (e.g., Heinle 1969 and Coker 1934). Further, our own studies, conducted by Industrial Bio-Test have found that zooplankton subjected to entrainment at the Waukegan Station have an average annual immobility after condenser passage of 2.1% due to heat and 6.0% due to mechanical damage with a ΔT of 22.5°F. Also, the evidence from phytoplankton studies indicate that mortality is substantially under 100%. In September 1971, when lake temperatures were at their maximum, there was only a 30% reduction in ¹⁴C uptake for phytoplankton subjected to entrainment. The ¹⁴C determinations were made 72 hours after sample collection. Comparable decreases were found in chlorophyll concentrations.

Page V-9

The Draft reports ambient temperatures in the lake, during the summer, at 78°F. Such temperatures are expected extremely rarely. The average maximum is about 63°F. (Environmental Impact Report, p. 2:15)

Page V-10

The first sentence of the last paragraph states that temperature tolerances are much narrower for fish than for plankton and benthos. This is an oversimplification; a number of fish species are less sensitive to temperature change than invertebrate species such as Nysis relicta. This sentence should be deleted.

Page V-12

In the second sentence on this page, it is suggested that fish attracted to the plume in the winter could develop gas-bubble disease. Commonwealth Edison does not believe that this will be a problem. Studies conducted at the Company's fish laboratory have shown that it takes a sustained level of supersaturation of 110% to kill rainbow trout and 115% to kill yellow perch. Calculation of dilution rates of the plume indicates that a level of 110% will occur at a point where the discharge velocity will equal 3 ft/sec. Fish cannot maintain themselves indefinitely in a water velocity of this magnitude. For example, adult yellow perch have a maximum sustained swim speed of about 1 ft/sec at 10°C. Sampling of species of economic importance at Hudson station discharge canal in the winter has shown that such species did not develop this disease even though the percent saturation averaged 120%. This indicates that such species will avoid areas of supersaturation that a hypothetical animal would be subjected to. The Draft expresses concern that fish attracted to the plume would be subjected to supersaturation of the water.

Page V-12
(line 8)

Appendix E-16

suddenly. When the relationships between the maximum sustained swim speed and discharge is examined, cold shock is not expected to occur at Zion. The discharge velocity at Zion was calculated to be 4.75 ft/sec. at the 10°F. isotherm and 2.38 ft/sec. at the 5°F. isotherm. Preliminary data indicates that the maximum sustained swim speed of immature lake trout (13.6 cm. length) at 57°F. is approximately 1 ft/sec. The maximum sustained swim speed of adult perch at 50°F. is also about 1 ft/sec. Brett found a sustained swim speed for adult sockeye salmon at 13°C. to be about 4 ft/sec. In a review paper on temperature tolerance of fish, Brett (1956) indicated that the lower lethal limit for fry of coho salmon acclimated to 39°F. to be 32.4°F. and for fry acclimated to 50°F. to be 35°F. The lower lethal limit for adults would be lower for any acclimation temperature than that of juvenile or fry of that species. The preliminary evidence from our own studies and from the literature indicates that for most species cold shock will not be a problem.

age V-12
line 24)

The Draft states that there would be a temperature drop of 20°F. to 30°F. and during such a drop fish would be killed. Based on the arguments developed above, we do not believe that fish will acclimate to temperatures 20°F. above ambient.

age V-13
line 9)

The report states that the algae will reestablish their populations as they drift out of the area affected by the warm water. We believe the use of the term reestablish is somewhat misleading here. It is unlikely that the populations will undergo any appreciable changes, certainly not elimination, in the short time they are exposed to the warm water; we do not believe that it is appropriate to speak of their reestablishment.

Page V-16
(Section 3)

This section of the Draft deals with the Company's monitoring program. It reflects, in part, the fact that nearly concluded 1971-72 studies were not available to the AEC. As one means of indicating that the unevenness detected by the AEC staff is not currently occurring, we attach as Exhibit 1 a revision of the Table V-2 (p. V-17) showing current study programs. As a result of earlier studies, these programs reflect changes in methodology designed to increase the confidence levels with which conclusions can be drawn about subtle long term effects. A fuller exposition of changes in methodology will be made as part of a new study plan. In this connection, we question the usefulness of the emphasis which the Draft places (V-22) on short term monitoring. Short term variations in plankton, for example, are unlikely to be indicative of lake quality in view of the large annual or seasonal variations. The series of aquaria suggested in the Draft (V-19, 20) presents a very unnatural environment for plankters. For many of the most important forms from Lake Michigan, it is difficult if not impossible for them to live and reproduce in aquaria at all. Thus, it seems unlikely that a situation could be maintained in the aquaria that would bear much resemblance to what was happening in the natural environment. Further, if such effects as algal blooms are to be detected, the organisms will need to be kept under observation for at least several days, and it is difficult to see how this could be accomplished in a flowing system.

The fish monitoring program at Zion is in part designed to provide and to determine if there are any sub-lethal effects. Coefficients of condition are being calculated on a monthly basis

Appendix B-18

for each sex of each species. Gonads are examined to determine if there is any premature maturation. Age and growth analyses are done on the yellow perch and lake trout. In addition, sampling is being done on Lake Michigan about 15 days/mo. Should a fish kill or plankton bloom be noted, people are present to determine if it was due to station operation. We note that emphasis on short term effects is precisely contrary to the consistent EPA position that one must concentrate on subtle long term effects. See, for example, the testimony of Dr. Donald W. Mount to the Four State Enforcement Conference, March 22, 1971, p. 123.

Page V-16
last para.

No particular purpose would be served by quantitative information on bacteria, since the amount of bacteria will decline very substantially when the North Shore Sanitary District diverts its sewage effluents affluent away from the Lake.

Our field sampling program has been modified and an additional control sector, located 4 miles north of Zion Station, is being sampled on a monthly basis for phytoplankton and zooplankton.

Benthos is being sampled every other month in this sector.

Page XI-2
para. 4(b)

(Cont) : 50 miles of station is 22.2 mm/yr. as stated on p. V-29 of

paragraph 4 and Table XI-3 page XI-14.

the statement will need to be made that the

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

100240 28-013 5 10 11 12 13 14

10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042 1043 1044

SECRET

Calculations of condition are being calculated. A summary basis

J) REIGNANCE FOR THE REIGNANCE OF THE REIGNANCE TABLE V-2

Preoperational Environmental Surveys Conducted at the Zion Nuclear Station

Survey	Year	J	F	M	A	M	J	J	A	S	O	N	D	
Water Currents	1969	X	X	X	X	X	X	X	X	X	X	X	X	Literature Survey
Water Temp.	1969	X	X	X	X	X	X	X	X	X	X	X	X	Vertical Temperature profiles
Water Quality	1969	X	X	X	X	X	X	X	X	X	X	X	X	Fe, Cu, Mg, Mn, Na, NH ₃ , PO ₄ , Cl, SO ₄ , D.O., pH, O ₂ , Si
Water Quality	1970	X	X	X	X	X	X	X	X	X	X	X	X	B, Fe, Cu, Cr, Zn, T.D.S., T.S.S., Mn, Pb, Cd, TOC, pH, hardness, Na, K, Cl, SO ₄ , NO ₂ , NO ₃ , PO ₄ , Si
Water Quality	1971	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1972	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1969	X	X	X	X	X	X	X	X	X	X	X	X	Seeshi disk area of Zion
Water Quality	1970	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1971	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1972	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1969	X	X	X	X	X	X	X	X	X	X	X	X	35, 126 & 250 ft towers
Water Quality	1970	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1971	X	X	X	X	X	X	X	X	X	X	X	X	
Water Quality	1972	X	X	X	X	X	X	X	X	X	X	X	X	

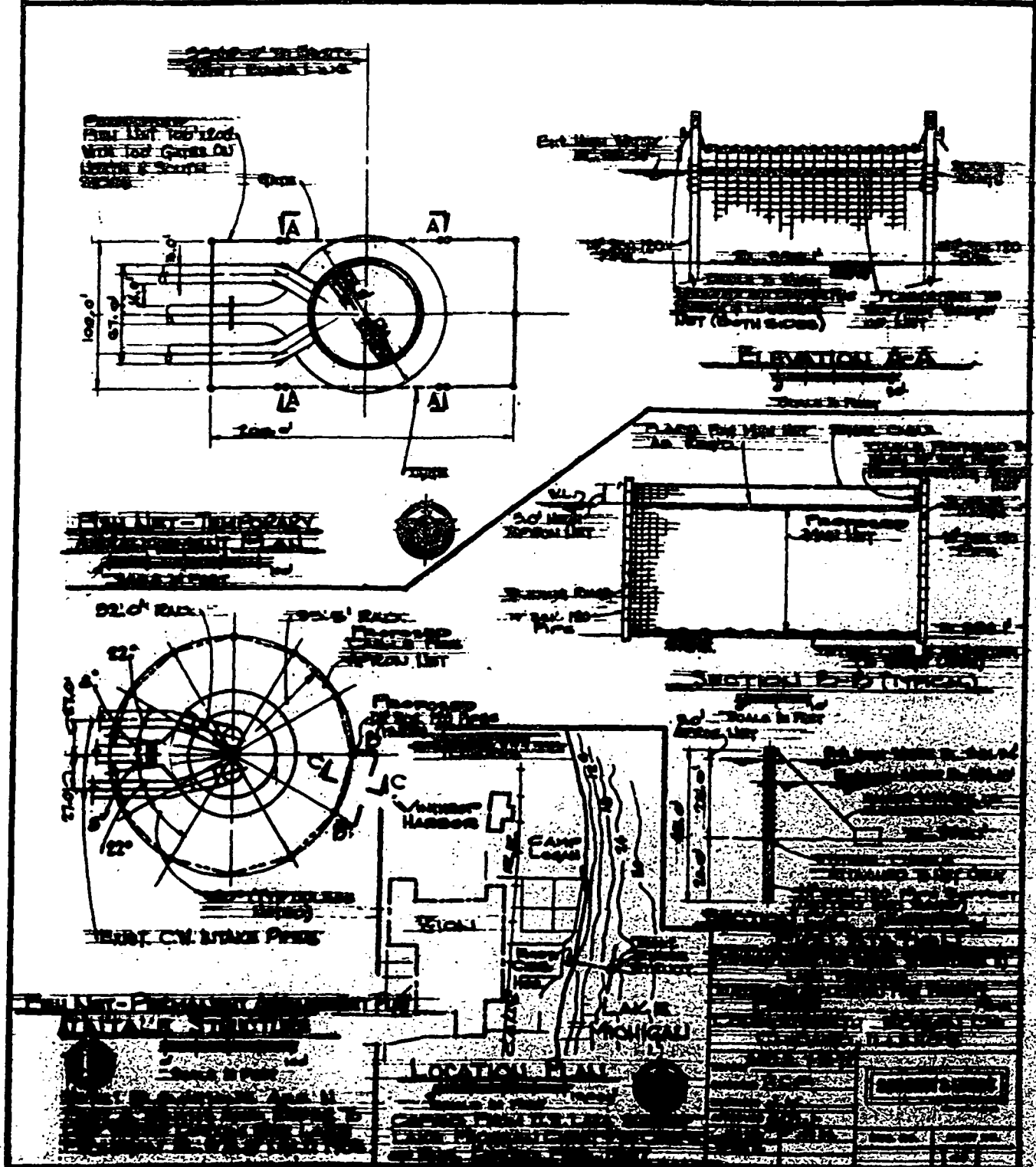
TABLE V-2 (continued)

Appendix B-19

TABLE V-2 (continued)

Survey	year	J	F	M	A	M	J	J	A	S	O	N	D	
Phytoplankton	1969								X		X		X	Taxonomy, species diversity, ¹⁴ C, chlorophyll a, entrainment studies at Waukegan Station
	1970	X	X	X	X	X	X	X	X	X	X	X	X	
	1971	X	X	X	X	X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					
Periphyton	1969								X					Artificial and natural substrates; taxonomy, chlorophyll a, biomass and relative abundance.
	1970					X	X	X	X	X	X	X	X	
	1971					X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					
Zooplankton	1969								X		X		X	Taxonomy, species diversity; entrainment studies at Waukegan Station
	1970					X	X	X	X	X	X	X	X	
	1971				X	X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					
Benthos	1969								X		X		X	Taxonomy
	1970		X	X	X	X	X	X	X	X	X	X	X	
	1971	X	X	X	X	X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					
Macrophyte	1972							X	X					Underwater photography
Fish	1970			X	X	X	X	X	X	X				Trawling, gill nets, seines and shocking.
	1971			X	X	X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					
Bacteria	1969								X		X		X	Coliform
	1970					X	X	X	X	X	X	X	X	
	1971	X	X	X	X	X	X	X	X	X	X	X	X	
	1972	X	X	X	X	X	X	X	X					

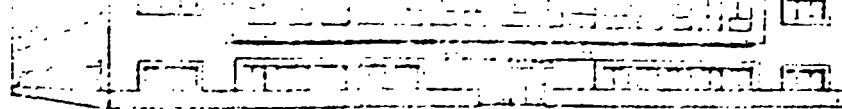
1) References for the studies by Industrial Bio-Test are listed in Literature Cited.





THE
METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO

100 EAST ERIE ST., CHICAGO, ILLINOIS 60611 751.5600



Appendix 0

September 8, 1972

CERTIFIED MAIL

Deputy Director
U. S. Atomic Energy Commission
Reactor Projects, Directorate of Licensing
Washington, D. C. 20545

Dear Sir:

Re: AEC Docket No. 50-295 and 50-304
Related to the Proposed Issuance of the Operating
License to the Zion Nuclear Power Station

Attached are comments by the Metropolitan Sanitary District of Greater Chicago concerning the Draft Environmental Statement by the U. S. Atomic Energy Commission Directorate of Licensing for the Zion Nuclear Power Station, Units 1 and 2 of the Commonwealth Edison Company, Docket Nos. 50-295 and 50-304.

The comments are directed to the issue of whether or not an operating license should be issued to the Commonwealth Edison Company for the start-up and operation of the Zion Nuclear Power Plant.

Based on the attached comments, it is the opinion of the Sanitary District that the required operating license should not be issued.

Very truly yours,


Ben Rosowicz
General Superintendent

THE METROPOLITAN SAITAKY DISTRICT OF GREATER CHICAGO

AEC DOCKET NO. 50-295 and 50-304
Related to the Proposed Issuance of the
Operating License to the Zion Nuclear Power Station

General Superintendent
Ben S. S. S. S.

- 1) As the agency responsible for protecting the water supply of the City of Chicago from pollution from all sources, the Metropolitan Sanitary District notes that by the ABC staff's evaluation (Draft Statement, Table V-5) the whole-body exposure in man-rem per year due to ingestion of liquid effluents from the Zion Station is preponderantly to persons using the Chicago water supply. The exposure due to water consumed from the intakes designated "Central" and "S. Chicago" represents about 75% of the total calculated (Pg. V-29) 22.9 man-rem per year to the 6.6 million people consuming water within 50 miles of the station. Furthermore, ingestion of water is calculated to be the major source of exposure of the populace (Pg. V-30).

The Metropolitan Sanitary District notes that these 22.9 man-rem per year are tabulated with the "costs" in the "Cost-Benefit Summary" (Table XI-3). The Metropolitan Sanitary District believes it to be the responsibility of the ABC to express this cost in units more meaningful to the evaluation of costs and benefits. Presumably, since radiation is conceded to be one of the causes of cancer, leukemia, and genetic damage, a man-rem can be quantified in terms such as the number of resulting cancer cases. The agency with the greatest expertise in this area, including but not limited to the ABC, should give its best estimate of such values.

- 2) It is noted that the man-rem per year exposure of the populace is based on a liquid effluent release rate to Lake Michigan (10 curies per year) set forth as a design objective in the proposed Appendix I of 10 CFR 50.47 in 1967, to under the regulations in force; this limit is not an enforceable one. The Technical Specifications of the Zion Station, not approved only 10 CFR 20.29 designating radioactivity limits on effluents. Under 10 CFR 20.20, releases of radioactive materials could be 10 to 100 times higher than 10 curies per year (exclusive of tritium). This means that the 22.9 to man-rem per year exposure of the populace (Central) would be 10-100 times higher. In the absence of a final version of 10 CFR 20.20, Appendix I of the ABC should state what effluent standard it really desires to Zion and make its cost-benefit summary on these values.

3)

The ABC should state what it really desires to Zion and make its cost-benefit summary on these values.

that these interim standards are themselves the subject of challenge in on-going hearings. Quite apart from that controversy, however, the draft statement makes no mention of any AEC evaluation of the conformance of the Zion ECCS to the interim standards. The relevant curve in the Zion PSAR shows the cladding temperature prediction for a loss-of-coolant accident to have a maximum at/or near the maximum (2300°F) prescribed by the interim standards. The Metropolitan Sanitary District believes that the factor of safety in this situation to be inadequate in view of the potential hazards involved, and that this matter requires an independent and critical evaluation.

- 4) The Draft Environmental Statement contains no indication that, should current ECCS standards be altered, the Zion plant would have to be modified as required to conform to the new standards. The Metropolitan Sanitary District believes that such modification should be a prerequisite for licensing.
- 5) The Metropolitan Sanitary District is concerned that in the event of an unusual occurrence resulting in the release of highly radioactive water from the primary system, as in a loss-of-coolant accident, the Zion plant operator may make voluntary emergency releases of liquid effluents to Lake Michigan, basing the action on the dose limits of 10 CFR 100 (considerably higher than those of 10 CFR 20, which applies to normal operation). The AEC should make a clear statement that the limits of 10 CFR 100 are not to be used as the basis for voluntary releases even under emergency or accident circumstances.

- 6) Due to the radioactive nature of materials used within the plant, the need to transport these materials outside the containment structure, the possibility of large volumes of contaminated water being discharged onto the ground from any of the postulated accidents included on Table VI-I, and the effect on the water supplies of the Great Lakes States of any major accidental discharge, we believe the following design changes should be required:

(a) Dikes should be provided to prevent any liquid accidentally discharged within the plant site from reaching the lake.

(b) All gravity pipes connected directly to the lake should have the design of the pipe and the location of the pipe controlled shut-off valves or valves to prevent accidental discharge to the lake.

Appendix O-5

- 7) We believe there is a mistake in Table II-7, since most of the Coregonus production is attributed to C. reighardi, whereas fishery biologists have known for many years that C. hoyi (bloomer) is the only coregonid in abundance in Lake Michigan.
- 8) Lake Michigan is not the second largest of the Great Lakes in surface area; Lake Huron has a surface area of 23,000 square miles. Furthermore, the surface area of Lake Michigan is 22,400 square miles, not 24,200 square miles. (Page II-12)
- 9) Paragraph 5, Page II-13, states that published phosphorus data are insufficient to demonstrate an overall change. Data presented by the Chicago Water Department to the Four-State Pollution Conference on March 25, 1971 indicates that increasing levels of phosphorus are entering the lake.
- 10) The chemical characteristics of the inshore waters are not too different from those for the entire lake; studies elsewhere have demonstrated a consistent difference between inshore and offshore characteristics throughout the years. It is important to note that inshore values for phosphate and ammonia are higher than offshore, whereas inshore silica values are lower than offshore. The abundance of diatoms is much greater inshore than offshore in response to the nutrients (P&N) and the diatoms take up silica near shore. It is surprising to see in Table II-1 that most things are listed as ND (not detectable) at Zion. This must be a mistake, since almost everything listed as ND would be detectable with standard methods of analysis. Perhaps these things were not measured. Certainly analyses could have been made for nitrate, organic-N, SiO₂, Na₂CO₃, dissolved solids, specific conductance, alkalinity, Ca, and Mg, which have been measured in this area by the Sanitary District. The lake is (not) always termed "oligotrophic" and we have evaluated various physical, chemical, and biological data and concluded that on the basis of these chemical data Lake Michigan would be mesotrophic, but biologically it was mostly oligotrophic. Certainly the inshore waters would be mesotrophic. Lake Michigan is (not) always considered with dissolved oxygen as a consideration. Also, low pH (5.0-5.5) is found in and around many of the harbors. (Page II-13 and Table II-1)

Appendix O-6

- 11) The thermal bar may function to keep nutrient rich waters inshore, but our studies and those of other investigators have demonstrated that nutrient rich waters are associated with inshore waters throughout the year. A thermal effluent could create an artificial thermal bar which could further restrict mixing and dilution of nutrients and heat.

It is true that the Lake Michigan phytoplankton are those characteristic of large and deep lakes, but this statement does not apply to all those species found in the inshore zone listed in Table II-2. For example, Stephanodiscus hantzschii is not characteristic of large deep lakes. It is a species favored by eutrophication that has become a major species in Lake Erie over the years. Only recently has it been identified in abundance near shore in Lake Michigan (Page II-15)

- 12) Paragraph 2, Page III-7, states that "the primary system is a sealed system, fission products are contained in it unless there are leaks". The AEC Staff evaluation assumes 10% blowdown to the lake discharge tank (III-18). This proposed intentional discharge of controllable radioactive waste should be eliminated.
- 13) The plume configuration is in doubt. (Page III-13) Temperatures higher than predicted may be found in the area of the discharge. A strong possibility exists for recirculation of the warm water under certain wind conditions. This combined with thermal bar conditions could result in a puddle of warm nutrient rich water sitting off the plant site.

Thermal stimulation of phytoplankton in a nutrient enriched area could result in abnormally high rates of primary production and cell proliferation. This would tend to increase rates of eutrophication in the southern end of the lake. With circulation restricted, blooms could result creating unfavorable conditions around the site. The State Park, just south of the site could be adversely affected if blooms restricted recreational activity (Page III-13-15).

- 14) The Liquid Waste Disposal System is shared by both units. Since there is no back-up treatment proposed and holding capacity is limited to one day, the Statement should include an analysis of discharge quality during a breakdown of the treatment facilities and during routine maintenance of the treatment system. (Page III-16)

Appendix 0-7

- 15) Table III-4, Page III-26, contains an estimate that the following chemicals will be discharged annually to the lake:

Sodium Hypochlorite	8,000 lbs./yr.
Sodium Sulphate	132,000 lbs./yr.
Alum	9,840 lbs./yr.
Detergents	1,455 lbs./yr.
Boron	1,260 lbs./yr.
Phosphates	3,000 lbs./yr.

The Impact Statement should include an evaluation of alternate systems to eliminate this chemical discharge. The pounds of these chemicals contributed over the estimated 40-year life of the plant, plus similar pounds from the other nuclear plants proposed for Lake Michigan, would increase the rate of eutrophication of the lake resulting in increased cost and operating problems for Chicago Water Plants. The use of dilution to reduce concentrations to meet effluent criteria is not acceptable in most federally approved Effluent Regulations.

- 16) The warm effluent will undoubtedly attract fish during the cooler months of the year. Fish moving into the warmed area will be in close proximity to the intake structure. In the winter when the plant is operating in a deicing mode, warm water at the intake itself will probably draw fish to the area. Due to the intake velocity designed for the plant, fish will still be drawn into the intake. If this occurs, there is no escape route for the fish. Large fish will be caught on the trash bars, while small fish will be trapped by the traveling screens. Aside from the loss of these fish, a possibility exists that large numbers of fish could clog the intake screens causing a loss of cooling water to the plant. This has happened at Indian Point on the Hudson and at other east coast plants. A large school of alewife in the intake forebay could clog the screens very quickly. Consideration should be given to redesigning the intake forebay to provide an exit for trapped fish.

Ch. V, p. 8, states: "Any fish, however, which enters the intake system is expected to perish there. The loss of a school of alewife would be of little consequence compared to the problems which could result from the loss of cooling water to the condensers. We would think that this possibility would be a prime concern of AEC and the power company. The proposed permanent fish net could reduce the probability of the entry of large fish into the intake, provided it is not punctured by ice or debris. There is a possibility that a large school of alewife could clog the intake screens very quickly. Consideration should be given to redesigning the intake forebay to provide an exit for trapped fish."

spawning prematurely in the warmed waters could also result, but these do not appear to be as serious as the intake problem discussed above. (Page V-7)

- 17) "The known interaction between temperature and nutrient concentrations which facilitate processes contributing to eutrophication are unlikely to operate in the waters off Zion, where there is only limited stream access and little agricultural runoff of PO_4 and NO_3 ".

We do not agree that there is sufficient experimental data to back up this statement. We would expect to see an increase in productivity of several fold during the winter and spring, with lesser increases noted in the warmer months. During the period of maximum water temperature, some inhibition of photosynthesis might be expected, although it is difficult to say without more data. (Page V-12)

- 18) Paragraph three, Page VI-2, states "To rigorously establish a realistic annual risk, the calculated doses in Table VI-2 would have to be multiplied by estimated probabilities." Probability of accident estimates should be included in the Impact Statement together with a technical discussion concerning how the probability estimates were computed. The probability of a loss-of-coolant (Type 8) accident is stated to be "very small". In view of the questions concerning the reliability of emergency core cooling systems raised by the AEC Staff and others in AEC public hearings, the method used in preparing the estimate of "very small probability" of a LOCA accident should be detailed.

Recommendations of the Advisory Committee on Reactor Safety, concerning the need to limit initial power production due to lack of experience with pressurized fuel assemblies, should be included in the Statement.

- 19) Estimates for the construction cost of cooling towers are more than three times cost estimates prepared by the Federal Water Quality Administration in 1970. More precise estimates for cooling tower construction should be included in the final statement (Page XI-5).

Appendix 0-3

20) We are in agreement with the AEC Staff findings that:

Residual chlorine in discharge could weaken chronically exposed fish so that they would be unable to hold station against water velocity. (V-7)

A detailed monitoring plan should be developed for Condenser-Passage Effects on organisms. (V-10)

There will be some increased turbidity in Zion waters after start-up. (V-13)

The omission of water current measurement from the Biological Monitoring Program is serious. (V-16)

Knowledge of the benthic, macrophyte and periphyton populations is particularly scanty and little quantitative information is available for bacteria in the Biological Monitoring Program. (V-16)

Additional techniques should be found to provide a continuous monitoring of the changes which might occur due to station operation. (V-19)

The existing field sampling program is unsuited to the problem of short-term monitoring of the health of the aquatic ecosystem in Zion waters. (V-19)

A field program is needed to detect possible deleterious sub-lethal effects of exposure to thermal plumes and the chemical discharges. (V-21)

Intake velocity should be reduced to 1-foot/second or less. (V-21)

Additional control points outside of the influence of the thermal plume should be located north of the discharge point. (V-21)

DePaul UNIVERSITY

DEPARTMENT OF BIOLOGICAL SCIENCES
1036 WEST BELDEN AVENUE
CHICAGO, ILLINOIS 60614
Lincoln 9-6700

Appendix P

September 12, 1972

Deputy Director for Reactor Projects,
Directorate of Licensing,
U. S. Atomic Energy Commission,
Washington, D.C. 20545.

50-295
50-304

Dear Sir:

We have reviewed the Draft Environmental Statement
by the Atomic Energy Commission for the Zion Nuclear
Power Station (Illinois), Units 1 and 2, Docket Nos.
50-295 and 50-304.

Enclosed are our comments for your consideration. We
are pleased to have been given the opportunity to comment
on this document.

Respectfully submitted,
M. A. McWhinnie

M. A. McWhinnie

M. A. McWhinnie, Ph.D.
Professor, Biological Sciences

Thomas J. Murphy

Thomas J. Murphy, Ph.D.
Asst. Professor, Chemistry



MAN/TJM/vo
encl.

Comments by M. A. McWhinnie and T. J. Murphy (De Paul University) on the AEC "Draft Environmental Statement for the Zion Nuclear Power Station". (Issued: June 1972).

In general, we find no real criticism of the evaluation of impact of the thermal and chemical wastes from the Zion Station on the aquatic biota. However, there are a few items we should like to inquire about/draw attention to:

(1) Page II-15, paragraph 2:

The objective of this Statement is to estimate the influence of a thermal increment on the waters (biotic communities) of Lake Michigan in the vicinity of Zion, Ill. However, data on diatom abundance is given for Grand Haven, Michigan, pointing up that some 30-50% of the "particulate mass" is due to diatoms. This is interesting, but why is this used in a discussion of Zion? In the latter case, there is stated a "--- significant concentration of three genera of diatoms ---". Since "major emphasis in pre-operational monitoring has been on the phytoplankton --" (Pre-operational, pg. V-16) it would be advantageous, from all points of view, to be as explicit as possible. One could assume that these data, e.g., percentages of dominant phytoplankton species are, in fact, available for the Zion, Illinois area. We would suggest that they should be presented and become, thereby, a part of the record.

(2) Page III-13, paragraph 2:

While the results from the hydraulic (physical) model may not be directly comparable to those predicted by the

6

kinetic (mathematical) model, the test results from the hydraulic model show that the plume goes much deeper than the kinetic model assumes/predicts. Thus, a larger area of the Lake bottom will be affected by the plume than is assumed when results are based on the kinetic model (as in this Statement). In fact, hydraulic model tests #004 and #009 (report by Alden Research Laboratories) show contact of the 6°F contour of the plume, with the Lake bottom, at distances greater than 800 feet from the outfall. This significant discrepancy in results between the mathematical and physical model is not discussed in the Impact Statement.

(3) Page V-10, paragraph 2:

"--- a detailed monitoring plan should be developed and --- results --- included in --- operating data ---".

The principle here is, of course, true and good. However, one would like to know what the authors of the Statement have/had in mind as they call for, "--- a detailed monitoring plan". It is this point which is central to the question of thermal effects and, one over which much debate has been held (see item (5) below).

(4) Page V-11, paragraph 3, line 10:

"--- heated plume will not affect the generally temperature insensitive benthos ---".

Based upon a number of considerations characterizing thermal discharges of this type, the estimate (prediction?)

that the heated plume, "will not --- generally affect the benthos ---", is (presently, at least) valid. However, one would not want to say, "temperature insensitive" for any biological system or community. It is assumed that this is/ was not meant as a categorical statement but one inadvertently not qualified. The opening statement of this section (Page 10, paragraph 3) supports this assumption. The statement should be re-evaluated, for it is erroneous.

(5) Page V-16. Biological Monitoring Program.

This discussion indicates that the pre-operational baselines now provide a reference for post-operational evaluation/ phenomena/changes/etc. However, it also suggests that these measures may not be sufficiently sensitive, "--- to detect --- sub-lethal effects ---", etc.

Further, "--- microcosms could be sampled --- to detect changes ---".

What changes? What should be measured? There is no clear recommendation (prescription) that would allow a real detection of change, sub-lethal effect(s), etc. Particle counting will not provide answers; dead; dying; "sick"; healthy, diatoms, rotifers, copepods, or etc. "still get a count of one!!"

The authors are correct that species diversity measures will permit an assessment of "long-term changes". They will not permit the establishment of any certitude concerning "short-term changes". Rate changes in community composition

(in open systems; currents/mixing; seasonal thermal variation; etc.) based on species immigration/emigration/substitution/etc. are exceedingly slow. One cannot measure dynamic effects acting upon a population/ecosystem if he waits to have it change and then must infer the cause.

A functional approach alone will allow a measure of the dynamic response of any system to an environmental change.

(6) Page V-16, paragraph 1:

Since phosphate seems to be the limiting nutrient in the Lake, and since small amounts of it permit such large increases in biomass (greater than 50:1 on a dry weight basis), it is the total quantity of phosphate discharged that is important. Should not:

- 1) the 3,000 pounds of phosphate produced when leakage occurs between the primary and secondary coolant (page III-29),
- 2) the phosphate contained in the blowdown of the auxiliary heating boiler (page III-29),
- 3) the phosphate contained in the blowdown of the steam generator (page V-16),
- 4) and the phosphate contained in the 2,000 pounds of detergent discharged (composition unspecified, table III-4)

be summed to give a more accurate indication of the possible local impact of the discharge of phosphates?

It should be noted that the open Lake concentrations of phosphate are generally found to be 0.050 mg/l or lower, in

Appendix P-6

contrast to the "range at Zion" reported in table II-1 (clearly a mistake). Thus, the 0.012 mg/l of phosphate to be discharged two weeks per year will be a 24% increase over the ambient.

If the Impact Statement is to serve as a Guideline in the elucidation of environmental effects resulting from operation of this nuclear plant it appears to lack direction in achieving this goal. The direction must come through the measurement of dynamic phenomena and they should be both defined and critical, if the identification of short-term effects is being sought.



United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

50-295
50-304



SEP 14 1972

ER-72/819

Appendix Q

Dear Mr. Muller:

This is in response to your letter of June 28, 1972, on environmental considerations for Zion Nuclear Power Station, Units 1 and 2, Lake County, Illinois.

General

The Geological Survey has previously reviewed the geology and hydrology of the proposed site with respect to safety aspects of the operation for the Atomic Energy Commission. The Bureau of Sport Fisheries and Wildlife has also previously commented in regard to fish and wildlife resources.

Although pre-operational and post-operational monitoring and other studies will be conducted and corrective measures will be taken based upon future findings, we remain concerned that operating this plant requiring 3410 cfs of water to be raised in temperature by 20° F. will have an adverse long-range effect on fish and other aquatic organisms having great value to sport and commercial fisheries.

Our specific comments are presented according to the format of the statement or according to specific subjects.

Historical Significance

At the time the draft statement was prepared, the plant was about 75% complete; therefore, most of the environmental effects of site development have already been experienced. Apparently, the applicant was negligent by not arranging for an archeological survey of the site prior to initiation of construction. Accordingly, there is no way of knowing what effects construction of the plant had on archeological resources. The draft statement did indicate that the Geology Department of the Field Museum "confirmed that no archeological sites or fossil deposits have been found or are reasonably expected to be found in the area of the site."

5077

Description of the Environment

The environmental statement at several points seems to assume and imply that the sector of Lake Michigan shoreline in which the Zion Plant is located is sterile and unproductive.

This sector of the Lake shore may be less productive of game fish than are some other sectors. However, we disagree with the apparent conclusion that the fisheries of this area are unimportant, either in terms of present or potential production, both commercially and for sport.

The yellow perch, a popular and valuable fish in both the commercial and sport fisheries, has been in a severe population decline for the past several years throughout Lake Michigan. This is shown in Table II-6.

In 1964, the record harvest of 5,835,000 pounds of yellow perch included more than 600,000 lbs. in Illinois, a significant portion of which came from the Zion area of Lake Michigan. This is not an insignificant resource and is one much needed for recreational use in this area.

The studies upon which the environmental statement is based were conducted only during the low cycle of the perch population. The fisheries of Lake Michigan have been adversely and severely affected during the past century by a host of man-caused factors.

Recently the fishery resources have begun to respond to major management efforts and further improvements are predictable. In view of this, and the great need for healthful outdoor, water oriented recreation by the large human population of this region, it is essential that no significant adverse impacts such as those which we believe will result from the Zion Plant be allowed to occur, when they are readily avoidable.

Impacts on Land, Water and Human Resources

We are pleased to notice on page IV-2 that the construction of the transmission lines will be in accordance with "Environmental Criteria for Electric Transmission Systems," published by the Departments of the Interior and Agriculture in February 1970. Nevertheless, it is necessary

Appendix Q-3

that some natural vegetation will be removed from portions of the rights-of-way. We suggest that the final statement discuss the consideration that will be given to revegetating these areas with wildlife food and cover species, and plans for making these areas available for public use for hunting and other recreational uses consistent with the safe operation of the project.

If chemicals are to be used to control vegetation on project lands, the publication entitled "Chemical Vegetation Control Manual for Fish and Wildlife Management Programs" issued in January 1968 as a Resource Publication 48 by the Bureau of Sport Fisheries and Wildlife should be consulted for policy on the use of pesticides and herbicides, and referenced in the final statement.

The statement should describe in more detail the extent and pattern of isotherms that are expected to occur in the mixing zone at various seasons of the year in response to changes in surface and sub-surface currents.

The applicant will be required to develop an affirmative plan of action to remedy detrimental effects on the aquatic ecosystem. It is not clear from this statement on page iii if this means simply that the continuing damage would be stopped or if the damage which took place would be mitigated. We think that means and measures should be planned by the applicant to compensate for any significant project-caused damages to aquatic resources which are identified by the monitoring programs. This should be discussed in the statement.

Land Use

According to page V-1, the removal of the 250-acre power station site from the proposed future recreational use at this location will not in itself produce a significant impact on use of the surrounding land. Contrary to this statement, we think that the proposed 250-acre power station project site will act as a physical barrier to utilization of the existing and proposed recreation area on either side of the station. The impact of this area as a barrier to full recreational use of the proposed beach should be more fully addressed in the final statement. This effect is partially recognized on page VII-4; however, the restrictions which the applicant may place on beach use and the remaining area of the site are not identified.

Appendix Q-4

It appears that the public is essentially excluded from the area. This is contrary to our belief that these lands should be made available for public recreational opportunities to the extent that such use would not interfere with the safe operation of the plant and within the limitations of safety to the general public. The lack of provision for a visitor center is particularly noticeable considering the potential use it would receive in an area surrounded by proposed and existing recreation lands. Also, the close proximity of this proposed nuclear station to the large population of the area would in itself seemingly justify the need for such a facility.

Condenser-Passage Effects

The statement is made on pages V-9 and V-10 that about 0.625% per year of the lake water is passed through the condensers and it is inferred that since this is small the total effects on aquatic organisms would also be insignificant. Since water is not drawn evenly from all parts of the lake but rather drawn from the shallow areas which are the most biologically productive, the percentage of damage to entrained aquatic life would be much greater than 0.625%.

With regard to circulation of water through the plant, we do not think that the figure of 0.625% per year of the total volume of the 1122 cubic miles in the lake is meaningful. The important question is not the percent of the total volume of the lake circulated, but rather the percentage of the water in the Beach water zone (out to 30 feet depth contour) and the Inshore water zone (out to the 100 feet contour and includes the Beach water zone), the most vital areas of the lake for fish life. The significance of these zones has been well defined in a publication of this Department entitled "Physical and Ecological Effects of Waste Heat on Lake Michigan," in connection with the Lake Michigan Enforcement Conference. The report is cited by the environmental statement. The volume circulated annually by the Zion Plant at 3410 cfs/day would be about 6810 AF/day or nearly 2.5 million AF per year. This is about 0.73 cubic miles of water which is over 16% of the total volume of 4.36 cubic miles in the Beach water zone. More importantly, 0.73 cubic miles is 178 percent of the 0.41 cubic miles of water lying within the 30 feet contour of the Chicago-Gary sector.

Appendix Q-5

of Lake Michigan. That sector extends from the Wisconsin-Illinois border to Gary, Indiana. A volume of water equal to that in the Beach Zone of this sector would be circulated through the plant about every 200 days.

The volume of 0.73 cubic miles/year equals about 1.5% of the Lake volume lying in the Inshore Zone (within the 100 foot contour including the Beach Water Zone) and about 12% of the volume in the Inshore Zone between the Wisconsin-Illinois border and Gary, Indiana. The plankton of these huge volumes of water would be subjected to entrainment and probable loss.

We feel that these volumes are significant and can have serious adverse long-term impact on fish and other aquatic resources of Lake Michigan which are dependent on the Beach and Inshore Zones of Southern Lake Michigan.

Intake Effects

We are greatly concerned that the cooling water intake velocity of about 2.5 fps will cause unacceptable entrainment and impingement losses of fish and other important aquatic organisms. Information obtained at several operating powerplants show that when intake velocities exceed one fps, extensive adverse impacts on aquatic life may occur. Generally, we think that 0.5 fps is a maximum design velocity at which the adverse impacts of aquatic life are limited to an acceptable level. The intake velocities of 2.47 ft./sec. at the intakes in summer and that of 3.7 ft./sec. in winter are excessive. The use of warmed discharge water to keep the intake ice free in winter will undoubtedly attract some fish. The loss of many of these seems a near certainty in view of the excessive intake velocities.

The AEC proposed monitoring of this with a suggested solution of a large screen to keep out the fish appears to be quite adequate. Such a screen, capable of keeping out all sizes of fish, would present major problems with ice, etc. These should be discussed adequately in the alternatives section.

Additionally, on page V-7 it is assumed that in summer the young fish would be schooled in water 8 to 10 feet deep. This is not a valid assumption for most if not all species of fish in the lake. Yellow perch larvae are commonly taken in depths of 18 to 30 feet.

Appendix Q-6

These larvae show on and offshore movements and frequently move as a result of wind induced currents.

Thus larval fish may move both off and on shore and laterally along shore and would probably be exposed to entrainment by the high velocities of the intakes not once but many times.

The description of along shore currents on page II-13 leaves little doubt that larval, juvenile or adult fish, or planktonic forms from considerable areas north or south of the Zion site would be exposed to entrainment by the Zion intakes as they move along the lake shore in response to these currents.

Thermal Discharge

A principal area of concern is with the thermal effects of the once-through cooling water discharge into Lake Michigan. According to the statement, thermal plumes have been both hydraulically and mathematically modeled. As pointed out by AEC, the results do not compare; therefore, the evaluation must await actual plant operation and subsequent temperature measurements.

Due to the lack of a clear understanding of the extent of the thermal plume and the corresponding effects on the aquatic environment, as stated on page III-13 and 14, we agree with AEC that a plan of action to remedy detrimental effects on the aquatic ecosystem should be a condition of the operating license. We are also in agreement with AEC that there is insufficient information on currents and flows in Lake Michigan during different periods such as is needed to evaluate the dispersion of liquid radioactive wastes and heated water.

We are also quite concerned with the possibility of the occurrence of thermal shock due to reactor shutdown during the colder months. The factor that fish kill hazards are greatest in winter was recognized by the Lake Michigan Enforcement Conference. This possibility is also recognized in the statement, which states that the effect could be minimized by shutting down only one unit at a time. This would allow some haven in the adjoining plume for aquatic life which becomes accustomed to the higher temperature water. We suggest that operating license stipulations be included in this regard to assure minimal shutdown effects.

Cumulative Impacts

We have a major concern with the rationale that the impacts of individual projects should be evaluated strictly on an incremental basis. We maintain that the cumulative impacts of projects existing and under construction must be considered, especially in enclosed or semi-enclosed water bodies. The interaction of individual project impacts can cause the total or cumulative impacts to be greater than the sum of the individual project impacts evaluated without regard to other developments.

The magnitude of future development of steam-electric plants on Lake Michigan should be considered in the final statement. "Physical and Ecological Effects of Waste Heat on Lake Michigan" cites present and projected power-plant cooling water requirements based largely on the industry's projected generating capacity increases. More recent reviews by the FPC should provide more up-to-date information.

Environmental Impact of Postulated Accidents

This section contains an adequate evaluation of impacts resulting from plant accidents through Class 8 for airborne emissions. However, the environmental effects of releases to water are lacking. Many of these postulated accidents listed in Tables VI-1 and VI-2 could result in releases to Lake Michigan and should be evaluated in detail. We also think that Class 9 accidents resulting in both air and water releases should be described and the impact on human life and the remaining environment discussed as long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects on land and in Lake Michigan which could persist for centuries affecting millions of people in this densely populated area.

Irreversible and Irretrievable Commitments of Resources

This section should include the annual fish and wildlife production that would be lost due to the project construction and operation.

Alternatives

The possibility of conversion of the already virtually completed nuclear power station to firing with fossil fuel is considered. The statement gives an estimate that this would involve a 5-year delay and an additional expenditure of \$447 - \$497 million. Detailed data are not included which permit confirmation of these estimates; however, they seem reasonable. We agree that change over from nuclear to fossil fuel is not an acceptable alternative.

According to the information on page XI-6a, an alternative spray pond would require approximately 300 acres of surface area. The area of the lake surface enclosed by the 3° F. temperature rise is estimated to be about 14 acres for each unit or 28 acres for both units as given on page i. It is recognized that the alternative spray pond would dissipate 100% of the waste heat while the mixing zone of the once-through system would dissipate only part of the total; however, we question this difference in area of a factor of more than 10. We suggest that these two estimates for required area be reviewed and changed if necessary to be in conformity with each other.

Conclusions

The Lake Michigan Enforcement Conference, held in Chicago in March 1971, considered in depth the electric power industry's cooling water requirements. Recommendations of the conferees, later approved by the Administrator of the Environmental Protection Agency, limit the discharge from any new waste heat source exceeding daily average release of 1/2 billion BTu per hour to that amount essential for blowdown in the operation of a closed-cycle cooling facility.

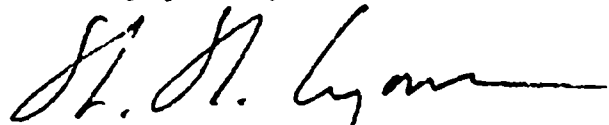
We believe that the thermal standards set by the Lake Michigan Enforcement Conference recommendations are the minimum requirements which should be met in order to provide adequate protection for the aquatic environment of Lake Michigan. It does not appear to this Department that the Zion plant using the once-through cooling system can operate at full load and comply with the thermal criteria of the conference and the requirement that no significant adverse effect on aquatic biota will occur.

Appendix Q-9

Therefore, this Department recommends that the operating license for the Zion Nuclear Power Station contain stipulations requiring that the plant operate within the limitations of the Lake Michigan Enforcement Conference Standards even if it means reducing plant factor or installing a close cycle cooling system.

We hope these comments will be helpful to you in the preparation of the final environmental statement.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "H. H. Lyman". The signature is fluid and cursive, with a long horizontal stroke at the end.

Secretary of the Interior

Mr. Daniel R. Muller
Assistant Director for
Environmental Projects
Directorate of Licensing
Atomic Energy Commission
Washington, D. C. 20545

**WE REGRET THAT SOME OF
THE PAGES IN THE
MICROFICHE COPY OF THIS
REPORT MAY NOT BE UP TO
THE PROPER LEGIBILITY
STANDARDS, EVEN THOUGH
THE BEST POSSIBLE COPY
WAS USED FOR PREPARING
THE MASTER FICHE**