Draft Detailed Statement of Enviro. Considerations
Arkansas 1 + 2
10/1/71

NOTICE

Arkansas Nuclear One, Units 1 and 2, Docket Nos. 50-313 and 50-368

This draft copy has undergone a review by the Review Committee of ORNL. Their comments, because of lack of time, have not been included in this draft.

We will rewrite all sections to some extent. The following sections will be rewritten extensively, and in several instances our rewrite will include further information that we have requested (copies of all questions have been sent to the AEC) from Arkansas Power and Light Company and have not received answers. The sections are:

III-D	Radioactive Waste Systems
V-C	Biological Impact
V-D	Radiological
X	Cost-Benefit Analysis of Proposed Action
Appendix A	

No sections are included on transportation and transmission lines. These will be added in the next draft along with a word glossary.

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

ROUGH DRAFT

8004220 814

D

CONTENTS

ROUGH DRAFT

SUMMARY

(x) Draft ( ) Final Detailed Environmental Statement

U. S. Atomic Energy Commission, Division of Radiological and Environmental Protection.

1. This action is (x) administrative ( ) legislative.

2. This Statement is submitted in relation to the proposed issuance of a (x) operating license (Unit 1), (x) construction permit (Unit 2) to the Arkansas Power and Light Company for the (x) construction (x) operation of the Arkansas Nuclear One, located in the State of Arkansas, county of Pope, near the city of Russellville.

ROUGH DRAFT

3. Summary

The Arkansas Power and Light Company plans to operate two pressurized water reactors located on a peninsula that extends into the Dardanelle Reservoir. The overall plant is known as Arkansas Nuclear One. The site is considered acceptable for two nuclear reactors if they are equipped with adequate safeguards to minimize their impact on the environment. Unit 1 is under construction, and an application has been filed for construction of Unit 2. Both units are pressurized water reactors, but they are dissimilar in mode of operation and in some of the auxiliary equipment that is provided for environmental protection.

Unit I has a once-through cooling system for dissipation of waste heat and discharges water into an embayment of the Dardanelle Reservoir at a temperature 15°F above ambient. Even though 30-day holdup radioactivity decay tanks are available in the gaseous waste system, Unit I will be operated without gaseous holdup until a predetermined activity level dictates a need for additional holdup time. Evaporators are not provided for treatment of the liquid radwaste from Unit I prior to release.

We believe that operation of the gaseous waste treatment system of Unit I should be changed to allow radioactive gases at all activities to decay to their lowest practicable level. In the same context, decay time should be increased by the installation of additional storage tanks. Consideration should be given to the installation of evaporators in the liquid waste systems of Unit I or of a cross connection to the evaporator in the liquid waste system of Unit 2. This should enable the plant to meet the criteria for the lowest practicable liquid effluent radioactivity level.

Unit 2 will use a closed cycle natural draft cooling tower for dissipation of waste heat to the atmosphere. The primary gaseous radioactive waste system will be equipped and operated with radioactivity decay tanks for a 30-day holdup time. Evaporators will be provided in Unit 2 as part of the liquid radioactive waste treatment system.

The routine discharge of radioactive effluents from the two units as now designed will result in an estimated population dose from immersion in air of 1.4 man-rem within 50 miles radius in year 2012. With the assumptions used in our calculations, the corresponding population dose from ingestion of fish is 31 man-rems.

Chemicals not normal to the Dardanelle Reservoir are discharged at concentrations known not to be harmful. Chemicals of the type normal to the reservoir are added during operation and eventually enter the reservoir at fractions of their original concentrations.

We believe that there will be a thermal impact on the waters of the embayment from operation of Unit I but that this impact will be relatively small when considered in relation to the entire reservoir and that it is reversible. We are concerned about the design of the intake canal and intake structure (for both units) with water velocities of 1.5 feet per second and 2.0 feet per second, respectively. Adequate monitoring will be required to ensure that excessive fish kills do not result.

The applicant, with the possible exception of meeting criteria for lowest practicable levels for Unit '. is taking appropriate steps to protect the environment. If the need for additional protection steps are demonstrated, we believe that acceptable engineering methods are now available. The applicant has several alternatives to choose from in selecting additional protective measures. Some of these protective measures are described in Section V, "Environmental Impacts of Plant Operation."

ROUGH DRAFT

FOREWORD

This draft detailed statement on environmental considerations associated with the continuing construction of Arkansas Nuclear One, Unit I (AEC Docket No. 50-313) and the proposed construction of Arkansas Nuclear One, Unit 2 (AEC Docket No. 50-368) by the Arkansas Power and Light Company (the appl cant) has been prepared by the Division of Radiological and Environmental Protection (the staff) of the U. S. Atomic Energy Commission (AEC) in accordance with the Commission regulation 10 CFR Part 50, Addendum D, implementing the requirements of the National Environmental Policy Act of 1969 (NEPA).

NEPA requires that all agencies of the Federal Government report on major federal actions significantly affecting the quality of the environment. These agencies are required to prepare a detailed statement which includes evaluation of specific items set forth in Section 102(2)(c) of NEPA.

i. The environmental impact of the proposed action,

ii. Any adverse environmental effects which cannot be avoided should the proposal be implemented,

iii. Alternatives to the proposed action,

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

v. Any irreversible and irretrievable commitments of resources which could be involved in the proposed action should it be implemented.

This statement was prepared to address the above five points. It is based primarily on information available in the Arkansas Power and Light Environmental Report for Construction Permit Stage - Unit 2, dated 1970; Environmental Report for Operating License Stage - Unit 1, dated June 8, 1971; the Final Safety Analysis Report (FSAR) on Unit 1; and the Preliminary Safety Analysis Report (PSAR) on Unit 2. All are part of the applicant's application to the Commission for construction and operation of the two facilities, Unit 1 and Unit 2. Copies of these documents are available in the AEC Public Document Room, 1717 H Street, N.W., Washington, D.C. 20006, or in the Arkansas River Valley Regional Library in Dardanelle, Arkansas 72834. Additional sources of information are indicated in the references (   ).

Valuable insight into this assessment of environmental impacts was gained from a visit to the Arkansas Nuclear One site and surrounding areas on July 6-7, 1971, by several Staff members.

The safety of the plant as related to fission product releases from postulated reactor accidents is evaluated separately by the AEC, Division of Reactor Licensing; i.e., a thorough analysis of the engineered safety features and a review of the Staff evaluation by the Advisory Committee on Reactor Safeguards and in public hearings. Such a review includes consideration of all radiation safety aspects. Once construction has begun, a continuing review of construction and equipment fabrication is maintained by on site inspections and a quality assurance control program. Prior to issuance of an operating license, the Staff again reviews the station as designed and constructed. The environmental effects as a result of postulated accidents are discussed in Section . The radiological impacts from routine releases are discussed in Part D of Section V.

The applicant must comply with all requirements of Section 21(b) of the Federal Water Pollution Control Act under the terms stipulated in AEC-issued permits and licenses. The construction permit will contain the condition that:

> "The applicant shall observe such standards and requirements for the protection of the environment as are validly imposed pursuant to authority established under Federal and State law and as are determined by the Commission to be applicable to the facility covered by this construction permit (or operating license)."

A public hearing on the granting of a construction permit for Arkansas Nuclear One, Unit 2, will be held, and notice of this hearing will be published in the Federal Register. A public hearing on the granting of the construction permit for Unit 1 was held September 10, 1968, and a provisional construction permit was granted on December 6, 1968.

I. INTRODUCTION

The Arkansas Power and Light Company proposes to construct a nuclear power plant, Arkansas Nuclear One, Unit 2, a 950-megawatt (electrical) pressurized water reactor, immediately adjacent to Arkansas Nuclear One, Unit 1, an 880-megawatt (electrical) pressurized water reactor, which is now under construction. The site location is in Pope County, Arkansas, about 6 miles northwest from the city of Russellville and 2 miles southeast of the town of London. The plant site is on a peninsula extending in a southerly direction into the main stream of the Dardanelle Reservoir on the Arkansas River at river mile 207. The area around the plant site is a valley surrounded by gently rolling terrain that previously had limited pasture use.

A provisional construction permit for Unit 1 (Docket No. 50-313) was granted by the AEC December 6, 1968. The application for the construction permit for Unit 2 was made September 10, 1970, and given AEC Docket No. 50-368.

A. The Need for Power

The Arkansas Power and Light Company is a subsidiary of the Middle South Utilities Corporation, an operating power pool which supplies the electricity needs of most of Arkansas, eastern portions of Louisiana and western Mississippi. This system, in turn, is a member of the larger Southwest Power Pool, a coordinating and planning group for bulk power supply systems in the south central portion of the United States. The proposed operation of Arkansas Nuclear One Unit I facility would add the electrical generation capability of 850 MWe (megawatts of electricity) to these systems by 1973, and the construction of Unit 2 at the same site would lead to further increase this capability by 950 MWe (megawatts electrical) by about 1976.

In evaluating the need for this capability, we believe, that the 1970 National Power Survey of the Federal Power Commission[1] (FTC), prepared with the assistance of several regional advisory committees, constitutes broad-based source material to aid our judgments. This material also reflects various economic indicator forecasts from a number of other

---

[1] Part 3, 1970 National Power Survey of the Federal Power Commission, U. S. Government Printing Office, Washington, D. C.

federal agencies. The projections of electricity needs prepared under these auspices indicate that during the next two decades, a growth rate slightly higher than the national average should occur for the south central region as a whole, and that the area served by the Middle South system is in conformity with this regional trend. On the basis of these projections, the 1973 peak load in the area supplied by the Middle South system is expected to be about 10,000 MW(e) which should further increase to slightly over 11,000 MW(e) by 1976. As illustrative of their impact on system generation capability, if the units are built and operated as proposed, the net system reserve margin should be just under 2000 MW(e), or about 18%, by 1976. Area studies have generally indicated that 15 to 20% reserve margins are needed for reliability considerations, depending on unit sizes in relation to system sizes and interconnections, forced outage rates, and requirements for synchronous operation. If Unit 2, or its equivalent, were not available to meet the projected 1976 peak load, the reserve margin for the Middle South system would drop below 10%, infringing on the minimum reserve margin needed to assure a reliable service in the event of equipment outage. Consideration of the Southwest Power Pool load-supply situation indicates that similar reserve margins will be available, although the margins are not as severely influenced by these units because of the larger scale of the system. Reliance on these larger interconnections for firm power purchase would, however, make the area unduly dependent on long distance bulk power transfer.

Although the precise retirement dates of the units currently owned and operated by the member companies of the Middle South system must remain within their managerial options, on the basis of the current ages of their major units and an "average" plant service life of 30 to 35 years, no large units [≥ 100 MW(e) or larger] are expected to be retired from the system until after 1980. Thus the early operating years of the Arkansas Nuclear One plant units will be used primarily to meet load growth requirements. Retirement of several small units (projected to amount to a total capability of 174 MW(e) from the Middle South system is expected in the 1970s, and this is likely to be followed by retirement of some 2600 MW(e) in the decade of the 1980s, which will include both small and large units.

On the basis of the Federal Power Commission (FPC) projections for 1975 of the average consumption of electricity by major customers groups according to (1) residential users, including farms, (2) commercial and light industrial users, and (3) large industrial users, it is possible to obtain some additional perspective concerning the magnitude of the supply service to be provided by the Arkansas Nuclear One facilities. While we recognize that average customer usage gives no information about the distribution of consumption within customer groups, the averages are sufficiently consistent among supply areas of the south central region to warrant estimation of fictitious "average customers" serviced by the plants. This will be based on a projected average annual usage by residential customers of 9350 kilowatt hours by 1975, an average annual usage of 51,800 kW hours by commercial customers, and sales of 33%, 19%, and 44% to the residential, commercial, and industrial sectors, respectively. For illustration, we will further assume an average capacity factor of 60% for plant operation (accounting for refueling shutdowns, maintenance, and other operating losses). In consequence, Arkansas Nuclear One Unit I would be capable of serving 157,000 of these average residential customers in a power supply area where the total population is projected to be 5.6 million by 1975. Similarly, 61,100 average commercial users could be served, and for each kilowatt hour supplied to residential customers, about 1.4 kilowatt hour could be supplied to large industrial users. The service from Unit 2 could, of course, be somewhat larger, in the ratio of the capacities of the two units.

We believe that, barring a drastic change in the trends of customer demands for electricity, the need is sufficiently demonstrated for these generation facilities.

B. Site Selection

The applicant has chosen the Russellville site as being near a load center and indicates that installation of a power plant will improve system reliability within the service areas of the Arkansas Power and Light Company and the Middle South Utilities Corporation. His investigation into the numerous techniques of power generation resulted in the choice of a nuclear-fueled system as a base-load plant. His discussions of the site and nuclear selection are included in Section VII, Alternatives to Proposed Action.

The AEC recognizes that environmental compatibility was not a prime concern in the selection of this site. This is understandable in view of (1) the relatively recent national expressions of environmental concern and (2) the inadequacy of the guidelines then available for assessing environmental compatibility. Truly adequate guidelines are, in fact, only now being developed (e.g., by the National Academy of Engineering's Committee on Power Plant Siting). The present assessment must, therefore, represent an after-the-fact analysis which can provide positive information useful for minimizing the adverse effects and determining whether potentially serious effects exist.

C. Applications and Approvals

The applications and permits granted for Unit 1 include:

(1) Arkansas Public Service Commission

9-15-67 - Application for Certificate of convenience and necessity to construct, maintain, and operate.

9-29-67 - Public hearing.

10-2-67 - Certificate granted. (   )

(2) Arkansas Pollution Control Commission

11-6-67 - Application for thermal and chemical discharge permit.

6-12-69 - Public hearing.

7-24-69 - Permit granted. (   )

(3) Arkansas State Department of Health

9-25-69 - Approval received for permanent sewage waste facility. Will carry out off-site radiological monitoring.

(4) U. S. Army Corps of Engineers

9-26-67 - Application for permit to operate circulating water facility.

1-28-70 - Permit granted. ( )

11-27-67 - Application for restrictive easement on Dardanelle Reservoir.

4-4-68 - Easement granted. ( )

1971 - Application for permit to discharge heat and chemicals into navigable waters, Executive Order 11574.

(5) U. S. Atomic Energy Commission

11-29-67 - Application for construction permit.

9-10-68 - Public hearing.

12-6-68 - Provisional construction permit granted. ( )

(6) The Arkansas Planning Commission, The West Central Arkansas Planning and Development District, and the Ozark Regional Development Commission have been contacted and indicate that the plant is compatible with regional development plans.

(7) Land use plans are coordinated with the following agencies:

Arkansas State Parks, Recreation, and Travel Commission

Arkansas State Highway Commission

Arkansas Polytechnic College

Arkansas State Planning Commission

Arkansas Game and Fish Commission

Department of Anthropology, University of Arkansas

Arkansas State Historic Preservation Program

Arkansas Archeological Survey

National Park Service

Arkansas Public Service Commission

U. S. Coast Guard

Federal Aviation Administration

Town of London

City of Russellville

The complete record of the applications and permits granted for Unit 2 is not available; however, the applicant's intent to apply has been noted as follows:

(1) Arkansas Pollution Control Commission

Application will be made to use the sewage waste system approved for Unit 1.

(2) Arkansas State Department of Health

Application will by made to use the sewage waste system approved for Unit 1.

(3) Arkansas Public Service Commission

Application will be made to construct Unit 2.

(4) U. S. Army Corps of Engineers

Application will be made for a permit to discharge heat and chemicals into navigable waters

(5) U. S. Atomic Energy Commission

9-10-70 - Application for construction permit.

II. THE SITE

A. General

Arkansas Nuclear One is being built in Pope County, Arkansas. The plant site is situated on a peninsula on the left bank of the Dardanelle Reservoir (Fig. II-1) in a valley approximately 350 feet above sea level and is surrounded by rolling terrain. The peninsula is at navigation mile 207 of the Arkansas River.

The applicant considered six other sites on the Arkansas River and seven sites on the White River. These other sites were not rejected by the applicant for any specific reason, but rather the Russellville site was selected as being the best for the following reasons:

a. Foundations are built on solid bedrock relatively near ground elevation

b. Ample cooling is provided by the Dardanelle Reservoir

c. Only a short railroad spur from a nearby line is required to serve the facility

d. The site is near existing 500 KV and 161 KV transmission lines

e. Major components may be delivered to the site by barge

f. The site is within two miles of an Interstate Highway

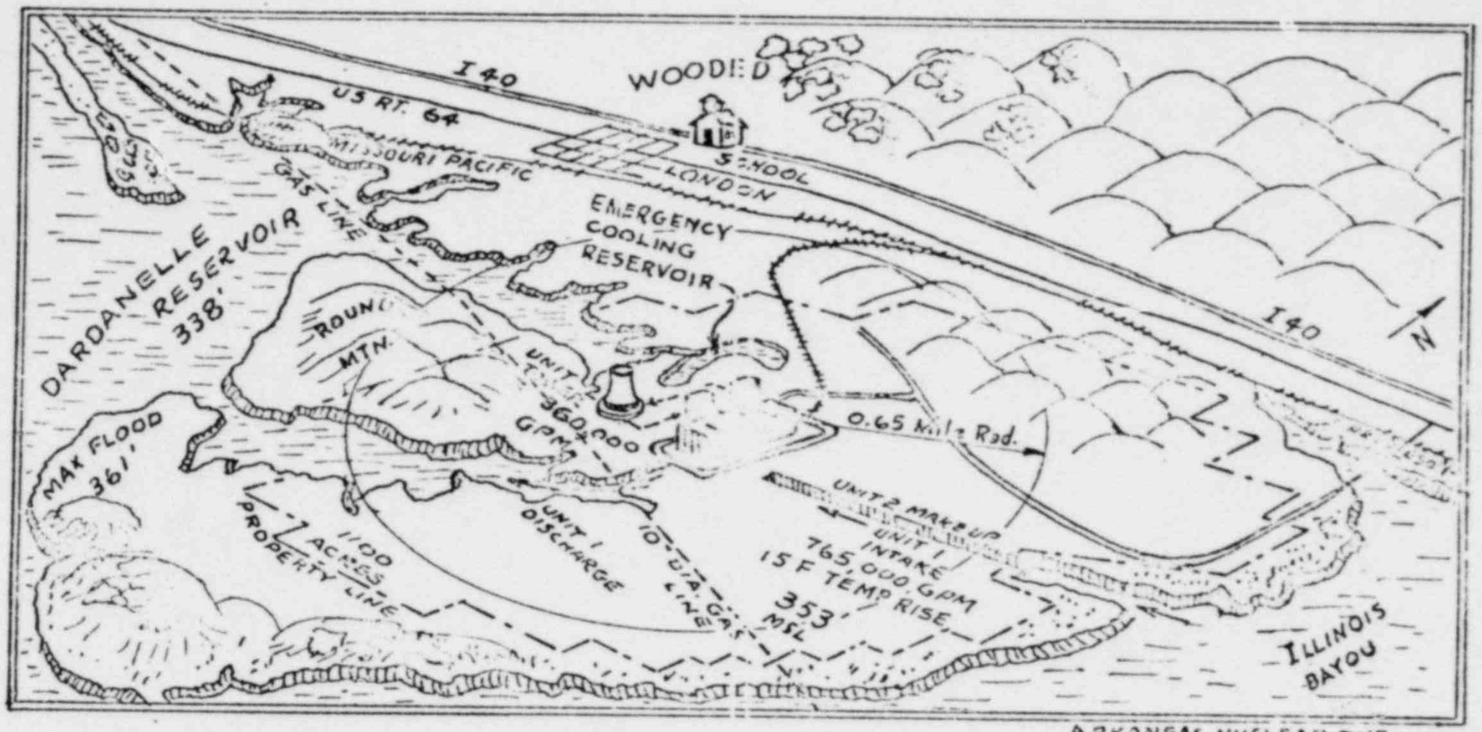
g. Because of the Arkansas River Lock and Dam network, the danger of floods is remote

h. The local community was receptive to the project

i. A good labor market was present in the area

B. Location of Plant

The plant site embraces 1100 acres, but only about 90 acres will be occupied by facilities directly associated with the generating station. An emergency cooling reservoir, holding 84 acre-feet, and a cooling tower are located in close proximity to the two units. Water for the plant is obtained through an intake canal that extends due west from Illinois Bayou. Liquid discharges from the plant are through a discharge canal into an 80-acre embayment and then into the Dardanelle Reservoir. Figure II-2 is a simplified perspective of the immediate plant site and the principle features that interconnect with the environment. The Corps of Engineers, Department of the Army, has granted easements ( ) in three embayments totalling 220 acres to the Arkansas Power and Light Company for the establishment, operation, and use of an exclusion area in the Dardanelle Reservoir area.

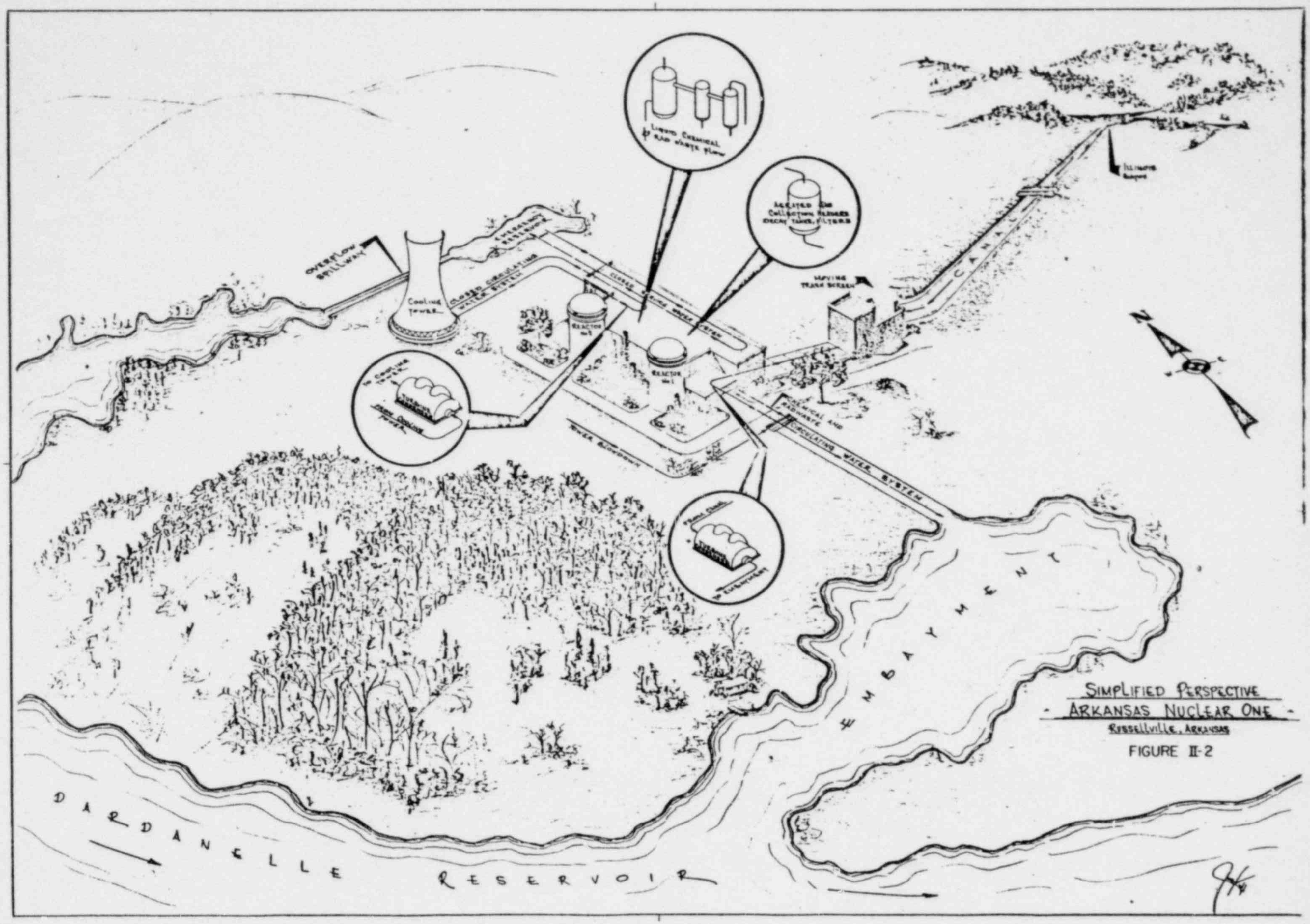


ARKANSAS NUCLEAR ONE
UNITS 1 & 2
FIG. II-1

~~ORNL-DWG 71-8859~~

II-1.

Fig. 1. Site of Arkansas Nuclear One, Units 1 and 2



SIMPLIFIED PERSPECTIVE
- ARKANSAS NUCLEAR ONE -
RUSSELLVILLE, ARKANSAS
FIGURE II-2

As stated in the document,

> "The easement herein granted shall include the rights to prohibit human habitation and to exclude all persons from the said area, during such periods of time that the grantee feels that conditions of the nuclear generating unit would present a hazard to the health and safety of the public...."

This statement has established that environmental effects during normal operation are small, and these are discussed in Section V, Environmental Impacts of Plant Operation. The existence of the above easement was necessary for the effective structuring and implementation of emergency planning.

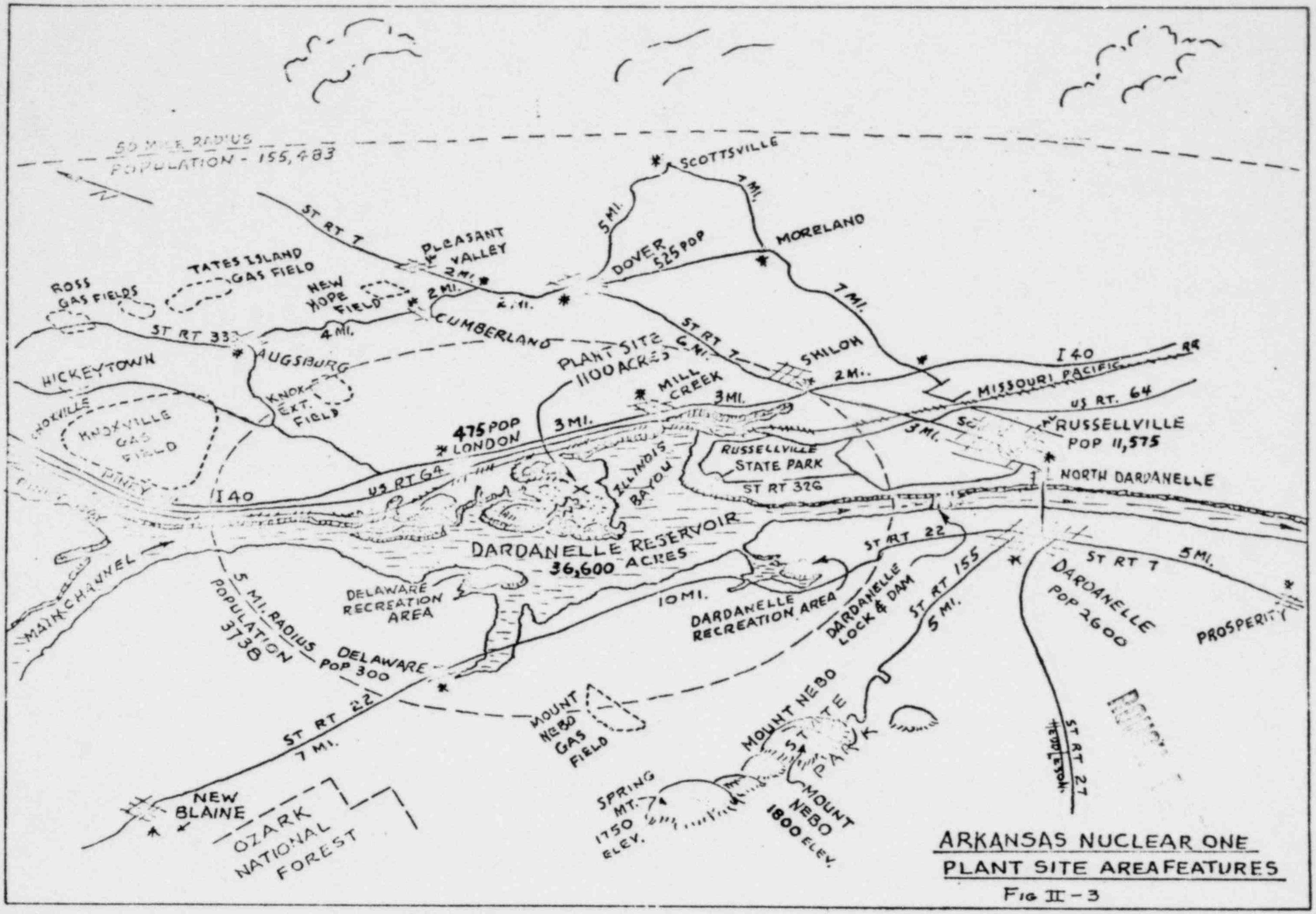
C. Regional Demography and Land Use

The Dardanelle Reservoir of the U. S. Army Corps of Engineers' Arkansas River Navigation Project is operated for navigation and power in coordination with a series of other locks, dams, and storage reservoirs comprising the lower Arkanses River system. Supplemental to this basic purpose is the recreational aspects provided by this large body of water for the population of west central Arkansas. There are 16 developed parks, some operated as State parks, which provide a variety of accomodations for the public. Future development of additional park areas is dependent upon public need, and current national trends indicate that this need will continually increase. Therefore, the general vicinity of the Dardanelle Reservoir should be viewed as an expanding recreational asset.

Mount Nebo State Park, located southwest of the plant site, offers a spectular view of the Arkansas River Valley from the top of the 1800-foot mesa (Fig. II-3).

The population distribution within 100 miles of the plant site is discussed in great detail, subdivision by sectioning, etc., in the applicant's Environmental Report for Unit I, Section I.c.4 - Land Use.

The largest city within 100 miles is Little Rock, Arkansas (1970 metropolitan population 315,375), located 57 miles southeast of the site, and the nearest population center is Hot Springs, Arkansas (35,319), located 55 miles south of the site. Russellville (11,575) is 6 miles southeast, while London (475) is approximately 2 miles northwest of the site. In 1970 the estimated population within 5 miles was 3738 and within 50 miles, 155,483.



ARKANSAS NUCLEAR ONE
PLANT SITE AREA FEATURES

Fig II - 3

ORNL-DWG 71-8860

Fig. 2. View of the Arkansas River Valley from the Top of 1800-ft Mesa, Mount Nebo State Park.

Because of the recreational features of the reservoir, the applicant has estimated the transient population within 5 miles of the site based on the peak holiday population. (   )

In our assessment of radiological impact, we considered two special population groups, namely, the young and the sick or elderly. Three schools are within 5 miles of the site. London Elementary School (100 children) is 2 miles away; Dwight Mission (about 250), 5 miles; and Arkansas Polytechnic College (2500), 5 miles. There are also three medical facilities 5 miles from the site. The Russellville Hospital (105 beds) and two nursing homes (35 beds each) are within several blocks of each other.

Some local industrial activity associated with mineral deposits is found in the area. Stone quarries are found at Midway, Altus, and the Dardanelle damsite; there are sand and gravel deposits near Scranton and the Arkansas River at Dardanelle; and natural gas is produced in a number of locations shown on Fig. 2. Coal, of coking quality in most cases, is found in strip mines north of Russellville and near Clarksville and New Spadra and in pit mines near Paris.

The predominant crops in the area are soy beans, cotton, and milo, with the major farming emphasis on raising livestock for the market. Peaches are the only food crop raised primarily for human consumption. Pastured and cultivated land, as well as the distribution of dairy cattle, are described in detail in the applicant's Report on Unit I, Figs. I-9 and I-10. ( ) The closest dairy herd is that maintained by Arkansas Polytechnic College, approximately 5 miles from the site.

D. Historic Significance

The Arkansas State Historical Preservation Program members have stated that the site itself has no historical significance and that none of the historic sites listed in the National Register of Historic Places will be affected by the project.

An archaeological survey of the plant site was made in October 1969 by a representative of the Arkansas Archaeological Survey. He concluded that the construction of this plant would not disturb the archaeological resources of the area and recommended that further survey, testing, or excavation would be unnecessary. ( ) It was agreed that if further construction work produced information on any archaeological resource of which the Arkansas Archaeological Survey was not presently aware, the Arkansas Power and Light Company should notify the Survey.

E. Environmental Features

1. Ecology

The area surrounding the Arkansas Nuclear One Plant is particularly rich in waterfowl. Holla Bend National Wildlife Refuge, 10 miles south of the station, is a concentration point from which ducks and other waterfowl spread out to nearby bays during the winter months. During the winter and early spring the bald eagle and golden eagle are present in the area. About 30 species of aquatic birds (surface feeders, divers, and waders) can be found in waters around the plant site.

About 20 species of fish are commonly found in the bays and open waters of Lake Dardanelle, and fishermen frequent the area throughout the year.

Oak-hickory forest, along with various mixtures of shortleaf pine and other species, are the dominant vegetation types of the area. Richer forest types with more numerous kinds of trees occur on less-exposed sites or sites which undergo periodic flooding. Over 70 species of trees have been identified in recreational areas around Lake Dardanelle.

An environmental study by the University of Arkansas at Little Rock has been in progress since 1969. The university, in cooperation with the Arkansas Game and Fish Commission and several other agencies, has issued reports on the composition and relative numbers of aquatic organisms and on the chemical and thermal characteristics of the Dardanelle Reservoir. These reports are reviewed and discussed at an annual meeting of all the participants. This study will continue until the Arkansas Nuclear Station begins operation (1973) and will continue for a period of five years after the start of operation.

2. Surface Water Hydrology

The Dardanelle Reservoir is one of 17 reservoirs being built along the Arkansas River to provide navigation from the Mississippi up to Tulsa, Oklahoma. Four of the largest reservoirs, including the Dardanelle, also provide some hydroelectric power. All of the reservoirs, including the seven reservoirs upstream from the head of navigation at Tulsa, provide valuable flood control and are used to increase the low flow of the river system in times of drought.

The Dardanelle Reservoir, one of the largest in the system, is some 50 miles long, is over 50 feet deep at its lower end, and covers 36,600 acres. It is located 259 miles upstream from the mouth of the Arkansas River. The minimum navigation pool elevation is 336 feet, and the top of the normal pool is at elevation 338 feet, so that only 2 feet variation is allowed for normal flood control and power generation.

3. Geology

The geology of the plant site is simple. The site is immediately underlain by 13 to 24 feet of heavy clay or silty clay, which rests on hard shale and sandstone of the McAlester formation. These rocks are horizontal at this locality. The nearest faults are 2 1/2 to 5 miles away and have not been active since the Cretaceous period.

The bedrock at the site is actually part of a large syncline, the Scranton syncline, which strikes east and west. The syncline is bordered a few miles to the north by the gentle London anticline and a few miles to the south by the equally gentle Prairie View anticline. Twenty or thirty miles to the south, the gentle structures of the Arkansas Valley give way to the complexly folded structures of the Ouachita Mountains. An equal distance to the north these same rocks form the flat-lying beds which underlie the Boston Mountains.

4. Ground Water

Ground water is not a major source of water in the area except for the farmhouses in this region that get their domestic supplies from wells.

Most of these wells yield only a few gallons a minute; the best of the wells yield only as much as 50 gpm. These small wells derive their water from joint systems in the shale and from the interbedded sandstone, since the clay and silty clay overburden are too nearly impermeable to yield even the modest quantities required for a domestic well. Because the clay overburden provides a seal, the water in the jointed shale and sandstone is confined and is properly artesian water.

There are large variations in the quality of the ground water. For example, at pH values from acid to alkaline, the bicarbonate range is 444 to 5 parts per million (ppm), and total dissolved solids range from 1559 to 34 ppm. The total hardness values are between 4 and 930 ppm. ( )

5. Climate

The climate of the Arkansas River Valley in the region of the site is continental in character. The July daily minimum and maximum temperatures range from 70°F to 94°F and a corresponding range in January is from 30°F to 53°F. The annual precipitation varies from 23 inches to 80 inches with the highest precipitation occurring during spring and early summer. Only minor snowfalls occur in this area. Thunderstorms do occur on approximately 55 days of the year. Eleven tornadoes were observed in Pope County between 1916 to 1950.

III. THE PLANT

A. External Appearance

The plant buildings are of modern industrial architectural design. Variations in geometrical shape and colors that harmonize with the surroundings have been used in an attempt to provide an attractive structure. No exposed machinery will be visible from outside the plant. Figure 2 is an artist's drawing of the completed plant, showing the location and function of various components. Very little noise due to plant operation will be audible outside the buildings.

The immediate plant site, 90 of the applicant's 1100 acres, which is now involved in construction suffers the same damage attendant on most large construction projects. The site will be landscaped upon completion of the project. The remainder of the site has not been disturbed to any great extent and will be left in its present undeveloped state with some modification to selected areas designated for public use and recreation.

The reactors are housed in cylindrical structures, and the attached buildings containing the control room and generating facilities are conventional in shape. The switchyard is east of these facilities.

The natural draft cooling tower for Unit 2 will be approximately 450 feet nigh and will be the most conspicuous structure at the site. The plume from the tower may rise up to 1000 feet. The tower and the plume will be clearly visible from most of the area within 10 miles of the site.

A vi of the tower and its plume will be obtained from Sunset Lookout Point in Mount Nebo State Park, approximately 7 miles south of the site and at an 1800-foot elevation. Unit I, which is now approximately 50% complete, can be clearly seen from this vantage point. The tower will also be visible to motorists from many points on I-40, which runs east and west and is located north of the site. The reactor building for Unit I as it nears completion at the 220-foot elevation is now visible from state highway 326 as the highway parallels the eastern bank of the Illinois Bayou from Russeliville to Russellville State Park along the shores of the Dardanelle Reservoir. The 450-foot-high cooling tower will also be a clear landmark from highway 326.

B. Reactor and Steam-Electric System

Arkansas Nuclear One consists of two units. These units are referred to as Unit I and Unit 2. The steam supply for Unit I is a pressurized water reactor. The net electrical output of the plant is 850 megawatts from 2568 megawatts of heat generated in the reactor. The steam supply system is being furnished by Babcock and Wilcox. Babcock and Wilcox and the Bechtel Corporation are responsible for the design, construction, and start-up of Unit I.

The steam supply for Unit 2 is also a pressurized water reactor with an electrical output of 950 megawatts from a thermal power of 2760 megawatts. Combustion Engineering is the system designer, and Bechtel Corporation provides architectural engineering. Upon completion, the Arkansas Power and Light Company will be responsible for the operation of both units.

C. Heat Dissipation Systems

The two reactor units will use different methods for transferring waste heat from the turbine condensers to the environment:

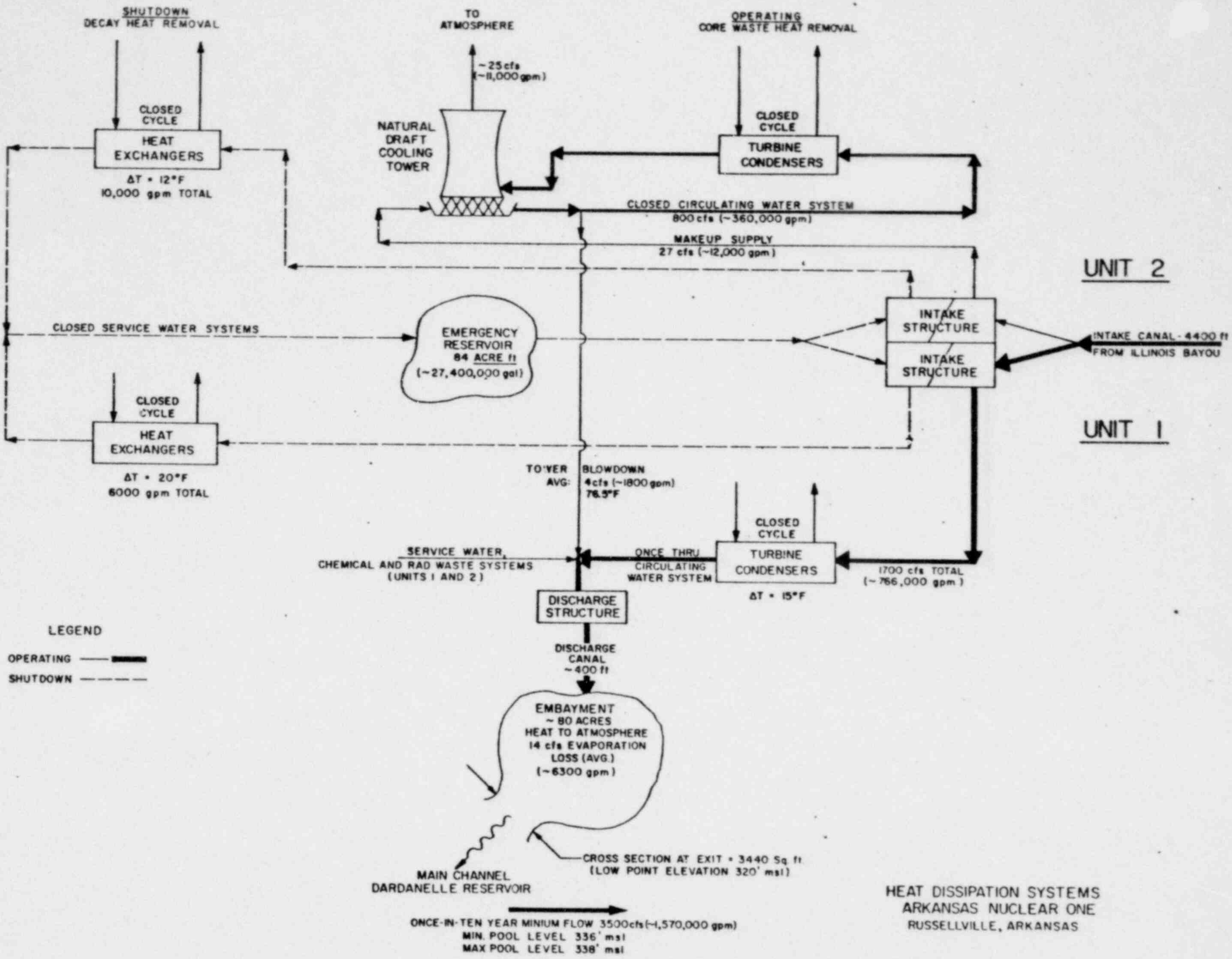
1. The Unit I turbine condensers will be cooled by a once-through circulating water system which will transfer waste heat into the Dardanelle Reservoir and from there eventually into the atmosphere.

2. Unit 2 requires a different system for transferring waste heat to the environment because of the thermal load imposed on the reservoir by Unit I. Turbine condensers will be cooled by a closed-cycle circulating

water system which will transfer approximately 99% of the waste heat to the air flowing through a natural draft cooling tower. The remaining 1% of the waste heat will be discharged directly into the embayment by the water from the tower blowdown.

During reactor shutdowns the dacay heat from the reactor cores of Units 1 and 2 will be removed by a closed-cycle service water system which will transfer the heat to an "emergency cooling reservoir" maintained under the applicant's control. A flow diagram of these systems is shown schematically in Fig. III-1. Additional cooling water systems are provided for the nuclear and non-nuclear auxiliary components, but their thermal contributions to the Dardanelle Reservoir are considered negligible.

Water for the Arkansas Nuclear One Plant will be taken directly from the Illinois Bayou of the Dardanelle Reservoir and then passed through a plant intake structure located at the end of a 4400-foot canal. This canal is approximately 85 feet wide at the bottom, with its banks appropriately sloped to minimize erosion. The sloped sides of the canal will be further protected by riprap or other suitable material. The velocity of water flowing in the canal will be 1.5 feet per second at the minimum pool level of 336 feet above mean sea level and 1.2 feet per second at the



HEAT DISSIPATION SYSTEMS
ARKANSAS NUCLEAR ONE
RUSSELLVILLE, ARKANSAS

FIGURE III-1

power pool level of 338 feet above mean sea level. The intake structure contains the pumps for supplying the station water and the pumps for the fire protection system.

The plant intake structure for Unit 2 will be provided by a continuation in length of Unit I's intake structure but of much shorter length because of the different requirements of the two circulating water systems. The pumps are protected from damage by bar racks and traveling screens to keep out floating debris and fish above fingerling size. The bar racks, with 3-inch maximum opening, are provided for protection of the traveling screens. The screens are the vertical traveling type with a screening medium consisting of 9 foot wide baskets carried on two strands of 24-inch pitch steel roller chain at a speed of approximately 10 feet per minute. The screen mesh is No. 12 galvanized steel with 3/8-inch square openings. Trash grinders are installed to grind up any debris collected on the screens. Under normal station operation, the water velocity through the screens will vary from 2.0 feet per second at maximum pool level (338 feet above mean sea level) to 2.18 feet per second at low pool level (336 feet). Fingerlings that pass the screen will pass on through the station's water systems. Travel time for the water is approximately 12 minutes from the intake structure to the discharge embayment. Major concrete work on the class I intake structure for Unit I is complete and the traveling screens are installed, but installation of the pumps and overhead service crane remains to be completed.

The volume of water required for cooling the Unit I turbine condensers will be 1700 cubic feet per second (about 766,000 gallons per minute), and the temperature of the water on passage through the condensers will be raised a maximum of 15°F. The residence time of the cooling water in the turbine condenser for Unit I will be approximately 6 seconds at average velocity. This water will be discharged through a 520-foot canal to an embayment of the Dardanelle Reservoir upstream from Illinois Bayou (Fig. II-2). This embayment which is approximately 80 acres in size, effectively serves as a temporary holdup cooling basin. The temperature of the water in the embayment will have a range from 15°F above reservoir ambient at the discharge structure to 6°F above reservoir ambient at entrance to the reservoir. The heated water will then pass through an outlet that has a cross section of approximately 3440 square feet and will enter the main channel of the Dardanelle Reservoir. Upon exit from the embayment, the normal flow of water will be released at about a 45° angle to the normal flow of the Dardanelle Reservoir.

Plans have been made to construct a closed-circulation water cooling system with a natural draft cooling tower for Unit 2 which will dissipate 99% of the waste heat from the turbine condensers to the atmosphere. The other 1% of the heat load will be discharged to the embayment in the tower blowdown water. The makeup water to compensate for system losses through evaporation, drift, and blowdown is 27 cubic feet per second (about 12,000 gallons per minute) average. The tower blowdown will discharge to the plant discharge structure. This small heat load will impose essentially no additional thermal load on the waters of the embayment of the Dardanelle Reservoir over what will already have been contributed by the operation of Unit 1.

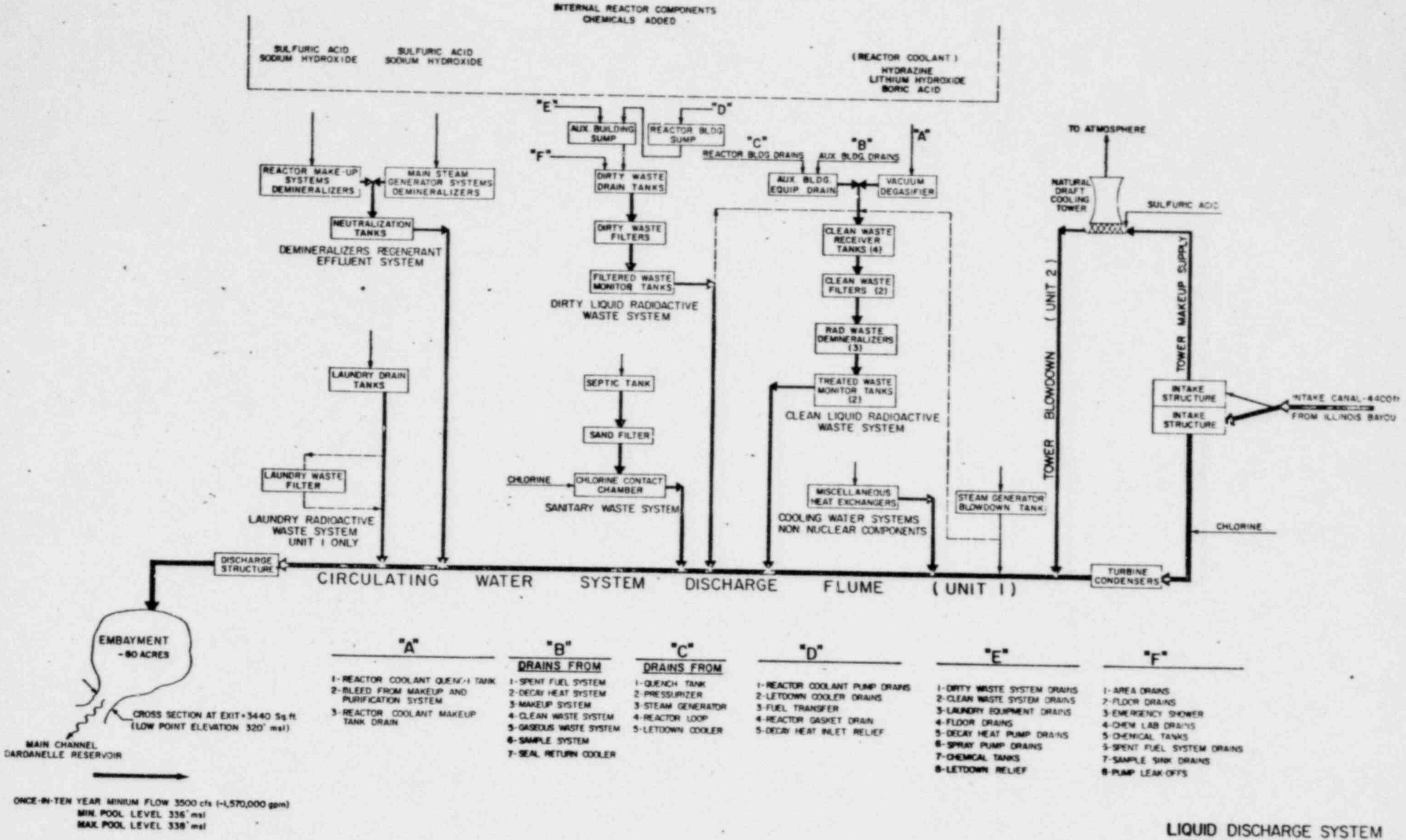
During periods of shutdown, when the decay heat removal systems are in operation, both units will be disconnected thermally from the Dardanelle Reservoir (note the dotted lines in Fig. III-1). The decay heat removal systems will be cooled by service water system pumps located in the Unit 1 and Unit 2 intake structures. These pumps will normally take water from the emergency reservoir shown in Fig. II-2. This reservoir (approximately 84 acre-feet, about 27 million gallons) will be constructed and maintained by the applicant on his property. In the event of an emergency, the service water pumps can take water from the intake canal, but the hea exchangers in the system are not designed to operate for extended periods on Dardanelle Reservoir quality water because of its high mineral content. The water in the emergency reservoir will be maintained by rainfall and will have a relatively low mineral content. To handle any overflows, the reservoir is equipped with a spillway connected to a small embayment north of Round Mountain.

Since submitting his Environmental Report - Construction Permit Stage for Unit 2, the applicant has decided to use the natural draft cooling tower for dissipation of waste heat from the turbine condensers to the atmosphere. This tower is now out for bidding, and the exact operational specifications are not available at this time. A flow diagram of this system is shown schematically in Fig. III-I.

D. Radioactive Wastes

I. Liquid Waste

The sources of liquid radwaste are identified on Fig. II-2. "Clean" liquid radwaste (chemically clean) will come from the reactor coolant system bleeds and drains, the reactor auxiliary system reliefs and drains, and the radwaste system reliefs and drains. These sources will have the highest



LIQUID DISCHARGE SYSTEM
ARKANSAS NUCLEAR ONE
RUSSELLVILLE ARKANSAS
FIGURE III-2

concentration of radionuclides, the major source being the result of boron dilution. The boron management system is essentially a closed-cycle system where the letdown flow from the reactor will be passed through purifiers and back to the reactor via the boric acid makeup tank. A fraction of this flow will be diverted to a flash tank where the pressure is reduced; it will be sent to a holdup tank where it will be stored for an average of 20 days. That which is not recirculated will be filtered and sent through two demineralizers prior to discharge into the condenser cooling water being returned to the embayment. This waste stream will be continuously monitored and can be sent back to the holdup tanks if the level of radioactivity is too high.

Other sources of liquid radwaste are floor and area drains, auxiliary building sump discharges, reactor building sump drain, and low-level radioactivity liquid from auxiliary building drains. This "chemically dirty" liquid radwaste will be processed separately from the clean liquid radwaste. Normally it will be filtered to remove particulates and then discharged to the embayment via the condenser cooling water discharge. Normally, the quantity of radionuclides in this water will be low, but should it be too high for discharge directly to the embayment, means are provided for transferring this waste to the clean waste holdup tanks.

Laundry wastes will contain only trace quantities of radionuclides and will be sent directly to the condenser cooling water discharge. Highly contaminated materials will not be laundered but will be discarded with the solid radwaste.

An estimate of the amount of the significant radionuclides that will be discharged to the Dardanelle Reservoir from Arkansas Nuclear One, Units 1 and 2, is given in Table III-1. These values were derived from data in the applicant's FSAR for Unit 1 and PSAR for Unit 2. The activity levels were computed by the applicant assuming operation at design power generation for two operating cycles (about two years) with no defective fuel, followed by a third operating cycle with 1% defective fuel. The inventory of fission products that had accumulated in the defective fuel over the first two operating cycles was assumed to get into the water at a rate based on experimentally determined usage rate coefficients. The purification system was assumed to remove 99% of all radionuclides except that krypton, xenon, cesium, molybdenum, and yttrium would not be removed at all and tellurium was assumed to plate out on the system surfaces. Computer calculations were made by taking into account the following sequence. The radionuclides formed by burnup in the fuel will be released into the coolant and then

Table III-1. Maximum Diluted Liquid Radwaste Released to the Embayment. (Total from Units 1 and 2)

Isotopa	Half-Life	Concentration [(a)] (µCi/cc)	Total Release (µCi/sec)
^{3}H	12.3 years	2.0×10^{-6}	100
^{89}Sr	54 days	2.2×10^{-12}	1.0×10^{-4}
^{90}Sr	28 years	1.4×10^{-13}	7.0×10^{-6}
^{90}Y	64 hours	2.3×10^{-9}	0.12
^{91}Y	58 days	2.2×10^{-7}	11 → ?
^{99}Mo	67 hours	6.2×10^{-8}	3.1
^{131}I	8 days	1.4×10^{-9}	0.07
^{134}Cs	2.3 days	1.4×10^{-8}	0.7
^{136}Cs	13 days	6.5×10^{-10}	0.03
^{137}Cs	30 years	8.4×10^{-8}	4.2
^{140}Ba	12.8 days	2.5×10^{-12}	1.3×10^{-4}

[(a)] From applicant's PSAR for Unit 2 and FSAR for Unit 1.

Note: Radionuclides not listed here have an insignificant impact compared to those listed in Table I.

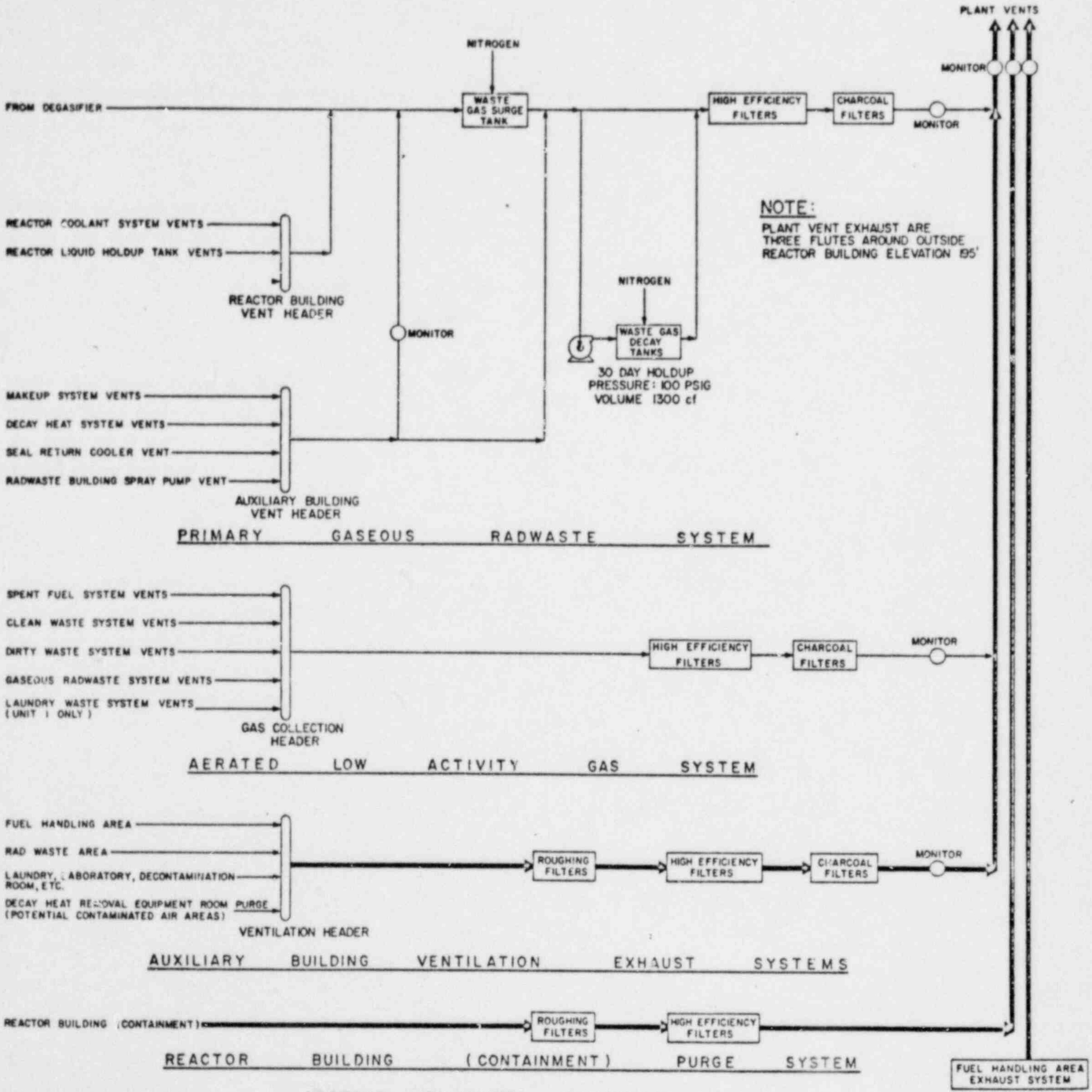
8Y 10^{-8} √3.yrs ?

2 x 10^{-9} = 2 r

removed from the coolant by the purification system. With this mode of operation, a maximum in concentration of radionuclides will be experienced at some time after the fuel elements are assumed to leak, depending on the half-life of the isotope. For calculating the concentration in the liquid radwaste, a steady release was assumed at the maximum release value for each isotope.

2. Gaseous Waste

Gaseous radwaste will originate primarily at the flash tanks (the vacuum degasifier) where the reactor coolant letdown streams will be depressurized, prior to adjusting the boron concentration. There will be numerous sources of smaller quantities of radioactive gas, as shown in Fig. III-3 for Unit I. There will be similar sources of gaseous radwaste at Unit 2. Briefly, at each reactor, radioactive gases will be discharged to the environment through three vents, which are equally spaced around the containment building and which extend to elevation 195 feet above building grade. When the containment is purged, the purge air, at a rate of 40,000 cubic feet per minute, corresponding to a velocity of 3200 feet per minute, will be discharged through one of these vents. Gases from the radwaste system are carried by ventilation air through a second vent at a rate of 56,000 cfm (3500 fpm). The third vent carries air from



NOTE:
PLANT VENT EXHAUST ARE THREE FLUTES AROUND OUTSIDE REACTOR BUILDING ELEVATION 195'

GASEOUS EXHAUST SYSTEMS
(FROM FSAR-UNIT I)
(POTENTIAL RADIOACTIVE SOURCES)
ARKANSAS NUCLEAR ONE
RUSSELLVILLE, ARKANSAS

FIGURE III-3

the fuel handling area at a rate of 40,000 cfm (3200 fpm). In addition to the radwaste system, the aerated low-activity gas system discharges into the radwaste vent.

At Unit I, gases from the radwaste system will normally be filtered and then discharged directly to the radwaste vent, as long as a monitor indicates the level of radioactivity to be below a preset, but unspecified, value. The filter removes particles of size greater than 0.3 micron with an efficiency of 99.95%; it contains charcoal to remove iodine. Should the monitor indicate the radiation level to be too high, the gaseous radwastes will be bypassed to the gas decay system, which consists of four tanks, of 325 cubic feet volume each, that can be pressured to 100 pounds per square inch and provide up to 30 days holdup. Unit 2 will be similar to Unit I except that gaseous radwastes will be routinely routed to decay tanks and the gases monitored before rejection to the vent system; however, the decay tanks can be bypassed to permit direct discharge of radioactive gases to the building vent system. Gases from the aerated low-activity system are filtered through similar combination filters prior to release to the environment; containment purge gases are filtered also.

Maximum amounts of radioactivity to be discharged from Arkansas Nuclear One, Units I and 2, as tabulated by the Arkansas Power and Light Company, are summarized in Table III-2. These acounts should be considered in the context of operating experience at existing pressurized water reactors. Discharges of radioactivity from nine PWR's during the period 1959-1970 have been presented in references I-3, from which we have listed in Table III-3 values for five of these reactors for the period 1965-1970. The actual releases represent only a very small fraction of maximum permissible releases. For example, the 600 curies from Indian Point Unit I in 1969 represents only 0.01% of the permissible release of 5,360,000 curies listed in reference 2. The maximum expected releases of radioactive gases at the Arkansas Nuclear One site are therefore significantly greater (by a factor exceeding 10) than have been experienced by other utilities using pressurized water reactors.

There is considerable uncertainty about the value of 23,000 curies of ^{85}Kr per year from Unit I (Table III-2). In particular, comparison with similar calculations for other reactors suggests that 2300 curies of ^{85}Kr per year is a more reasonable estimate. If this is so, then only the amount of ^{133}Xe to be released appears to be excessive. This could be reduced greatly by increasing the decay tank storage capacity by 5 which would provide an additional 15 days of decay time. This, in turn, would reduce the ^{133}Xe releases from 22,400 to about 3100 curies per year from the two units; it would also reduce the ^{131m}Xe releases from 1455 to about 610 curies per year. Increasing the decay-tank capacity would not, however, affect the quantity of ^{85}Kr in the discharge by a significant amount.

Other radioactive gases in the radwaste system are ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, ^{138}Xe; the half-lives of these are, respectively, 4.4 hours, 76 minutes, 2.8 hours, 2.3 days, 9.2 hours, 16 minutes, and 17 minutes. These are so short compared to a holdup time of 30 days as to make their concentrations negligible.

Table III-2. Maximum Quantities of Radioactive Gases to be Released to the Atmosphere from Units 1 and 2, Arkansas Nuclear One

Isotope	Half-Life	Releases from Building Vents (curies/yr) Unit 1[a]	Unit 2[b]	Total
$^{85}\mathrm{Kr}$	10.76 year	23,000	2,880	25,880
$^{131m}\mathrm{Xe}$	12 d	835	620	1,455
$^{133}\mathrm{Xe}$	5.27 d	10,900	11,500	22,400
$^{131}\mathrm{I}$				
Total				49,735

[a] Data from Table 3-4 of Environmental Report on Unit 1.

[b] Data from Table 11.1-4 of PSAR on Unit 2.

Table III-3. Total Annual Discharges of Noble and Activation Gases from Five Pressurized Water Reactors (Curies)[a]

	Rated Power (MW_e)[d]	1965[b]	1966[b]	1967[b]	1968[b]	1969[c]	1970[d]
Shippingport		0.032	0.030	0.002	0.001		
Yankee	185	1.7	2.4	2.3	0.68 (1.00)	4	17.2
San Onofre	450			4.02	4.83 (0.48)	260	1,610
Conn. Yankee	600			0.021	3.74 (0.82)	190	700
Indian Point I	265	33.1	34.6	23.4	59.7 (0.93)	600	1,750

[a] Below some of the discharge values is an approximate on-stream efficiency which we define as power generated (MW_e) divided by the rated power and then divided by 6500 hours as an expected operating time during the 8760 hours in a year. This 6500 hours corresponds only to 74.2% on-line time.

[b] Data from ref. 1.

[c] Data from ref. 2.

[d] Data from ref. 3.

1. J. E. Logsdon and R. I. Chissler, Radioactive Waste Discharges to the Environment from Nuclear Power Facilities, U. S. Department of Health, Education, and Welfare, Public Health Service, March 1970 (BRH/DER 70-2, PB 190717).

2. Hearings before Joint Committee on Atomic Energy, Congress of the United States, Ninety-First Congress, Second Session on Environmental Effects of Producing Electric Power, January 27, 28, 29, 30; February 24, 25, and 26, 1970. Part 2 (Vol. II).

3. B. Kahn, B. Shleien, and C. Weaver, Environmental Experience with Radioactive Effluents from Operating Nuclear Power Plants, Environmental Protection Agency, U. S. Public Health Service, Department of Health, Education, and Welfare, A/CONF. -49/P-087, in Vol. 2 of United States Papers for the Fourth United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, September 1971.

3. Solid Waste

The sources of solid waste are dewatered, spent ion exchange resins, solidified waste from the concentrator bottoms, filter and strainer elements, and contaminated refuse such as rags, paper, and protective clothing.

The low-level refuse will be collected in drums and compressed by a hydraulic bailer. The spent resins may be stored for decay before sluicing to a drumming station. All of the solid waste will be stored in appropriate shielded containers in a shielded, ventilated storage area to await eventual disposal. These wastes will then be shipped off site in accordance with Department of Transportation regulations, ( ) for ultimate disposal at an AEC-licensed disposal site.

E. Chemical and Sanitary Waste Systems

The sources and flow of the chemical waste are shown in Fig. III-2. The chemical wastes from both reactors will reach the embayment in the condenser cooling water from Unit I. Since Unit I will be cooled directly by reservoir water, the flow will be large (1700 cubic feet per second) and will afford a dilution of about 400 for the chemical and radioactive wastes before they are discharged. The average and maximum concentrations of chemicals that may be discharged are listed in Table III-4 along with

Table III-4. Chemical Discharge to the Cooling Water

Chemical	Average Added Concentration[a] (mg/liter)	Maximum Added Concentration[b] (mg/liter)	Natural Concentration in Dardanelle Reservoir (mg/liter) Min.	Max.
1. Boric acid	2.5×10^{-3}	6×10^{-2}		
Boron	4×10^{-4}	1×10^{-2}		
2. Lithium hydroxide	2×10^{-5}	3.5×10^{-3}		
3. Hydrazine	1×10^{-4}	1.5×10^{-2}		
4. Na^+	3.5×10^{-4}	8.5×10^{-2}	20	237
5. Ca^{++}	6×10^{-6}	9×10^{-4}	22	103
6. Mg^{++}	6×10^{-7}	9×10^{-5}	2.4	21
7. Cl^-	3.5×10^{-6}	5×10^{-4}	28	405
8. Chlorine	---	---	---	---
9. $SO_4^=$	2.4×10^{-2}	4×10^{-1}	20	139
10. Fe^{+++}	2.5×10^{-6}	4×10^{-4}	0	.3
11. SiO_2	6×10^{-6}	2×10^{-3}	6.9	37
12. Alkalinity (as HCO_3)	3×10^{-5}	5×10^{-3}	60	236
13. Cu^{++}	2×10^{-7}	6×10^{-5}		
14. NH_4^+	8×10^{-5}	2.5×10^{-2}		
15. Na_2SO_3	2×10^{-4}	6×10^{-2}		

[a] Based on cooling water flow of 1.3×10^{12} liters/yr.

[b] Assumes 2 regenerations of condensate demineralizers, 1 regeneration of makeup demineralizer, and startup conditions for discharge of boric acid in 24-hour period for one reactor.

an analysis of the Dardanelle Reservoir. These values were taken from data given by the applicant in his FSAR for Unit I and PSAR for Unit 2.

I. Condenser Cooling-Tower Output

The condensers in Unit I do not have a recirculating cooling system, but are cooled by a once-through flow of water from the Dardanelle Reservoir. Chlorine will be used to control aquatic growth, but the chlorimation will be carried out in such a way that only half of the water will be chlorinated, and the natural chlorine demand in the other half is expected to reduce the chlorine concentration to less than detectable limits in the discharge canal.

Minerals that occur naturally in the river will be concentrated by a factor of 3 to 10 in the blowdown water from Unit 2. This water will be diluted when it mixes with the condenser cooling water from Unit I so that the mineral content in the water returning to the embayment will be increased by less than 1%. When Unit I is shut down, its condenser cooling water will be maintained at a flow rate which will provide sufficient radwaste dilution.

Sulfuric acid and chlorine will be added to the closed circulating water system of Unit 2 to reduce corrosion and scale formation. The amount of sulfuric acid will depend on the concentration of minerals in the makeup water. The maximum amount has been estimated to be 9.4 pounds per minute (13,500 pounds per day), which will be added to an average blowdown flow of 1800 gallons per minute (4 cubic feet per second). All the acid will have reacted with the minerals in the makeup water before the blowdown is returned to the embayment. The object is to have a pH of near 7 in the tower cooling water so that the blowdown water will contain no free acid.

There will be some (water) drift loss to the atmosphere, but with the type of natural draft tower that is to be installed this will be very small. The applicant estimated 0.01 percent of the circulation rate (or 36 gallons per minute). The salt deposition from this amount of water has also been determined by the applicant. It is estimated to be a maximum at 600 meters away from the cooling tower, where the annual deposition would be 158 grams per square meter.

2. Demineralizer Regeneration Solutions

The demineralizers in the steam cycle and the demineralizers for the reactor water makeup will be periodically regenerated. A daily consumption of about 1500 pounds of sulfuric acid and about 1000 pounds of sodium hydroxide is anticipated for both reactors. These chemicals will be fully neutralized when discharged.

Water will be discharged in small amounts (0.02 cubic foot per second) from the steam generator to remove impurities. The acidity will be controlled by the addition of 100 pounds of ammonia and hydrazine per day, and 5 pounds of phosphate is added per day for scale control.

3. Reactor Coolant

Chemicals will be added to the makeup water for the reactor coolant: boric acid will be added for reactivity control; lithium hydroxide will be added for pH control; hydrazine will be added to remove the radiolytic oxygen from the reactor coolant. Some of these chemicals will find their way into the discharge canal via the liquid radwaste discharge, but most of them will be removed with the bulk of the radwaste in the filters and radwaste demineralizers. The applicant's estimate of the amounts of these chemicals that may be discharged is shown in Table III-3.

4. Laundry and Decontamination Solutions

The laundry solutions will be filtered and sent directly to the discharge canal. These solutions will contain detergents and perhaps chlorine, but in very small quantities.

Decontamination solutions will be collected from various drains. The solid waste will be separated by evaporation of the solutions, and the condensate from this process will be discharged to the condenser cooling water canal. The chemicals from this source have been included in Table III-3.

5. Sanitary Waste

The plant will have a sewage treatment system. This system will include a septic tank, a sand filter for clarification, and chlorination equipment. The effluent will be discharged to the Dardanelle Reservoir via the condenser coolant discharge canal.

F. Other Waste Systems

In disposing of trash caught in the intake screens, the applicant indicates that trash grinders are installed to grind up any debris collected. It is planned that the residue will then be discharged back into the intake canal. If the residue results in fines smaller than 3/8 inches, it is very likely that they will be drawn into the plant circulating water system and subsequently discharged into the embayment.

No plans have been formulated at present for non-radioactive waste and trash disposal. A number of alternatives are being studied.

IV. ENVIRONMENTAL IMPACTS OF SITE PREPARATION AND PLANT CONSTRUCTION

A. Summary of Plans and Schedule

The initial work on the site was begun in the summer of 1967 and consisted of core drillings. This work continued into the spring of 1968. Construction work then began, and by mid-1971 Unit 1 was 51% complete. Work on Unit 2 has not yet been started. ( )

B. Impacts on Land, Water, and Human Resources

The applicant owns 1100 acres on the London Peninsula for the plant site. It is estimated that 90 acres of this will be directly affected by the construction of the plant and will be permanently altered. The construction of Unit 1 started in October 1968 and will be completed in 1972. Construction of Unit 2 has not yet begun, but it is planned to complete construction in 1975, subject to construction and licensing delays. Therefore, the affected area of the site will be involved in construction until the mid-1970s. When construction of the plant is completed, the 90 acres occupied by the man-made structures will be landscaped to minimize the aesthetic impact.

During the construction of the plant, large amounts of excavated material must be relocated. Several techniques have been used to "dispose" of this material. A causeway road west of the plant site was raised to an elevation of about 340 feet with rock spoil, and irregularities in the terrain in the immediate vicinity of the plant were filled. Excavated material from the intake and discharge canals was used to fill a small cove off the discharge canal embayment.

C. Controls to Reduce or Limit Impacts

At the 50% construction stage for Unit I, a visit was made to the site to gain familiarity with the site and the surrounding countryside. Construction activities are not visible to the uninterested public except for a small number of families whose residences are located on Bunker Hill on the London Peninsula. For those who desire to observe construction activities, a drive 1.7 miles southward from U. S. Highway 64 down a paved road to the construction entrance of the site will enable them to exercise their "sidewalk superintendent" capabilities. Guards stationed at the entrance keep the public from entering the site proper.

At the time of the visit, the construction road into the property was being watered down to keep the dust caused by traffic to a minimum. Using scrapers, the excavation was under way for part of the facility and the slip that will be required for unloading the pressure vessels from a barge which will be brought into the discharge embayment. A minimum of dust was evident as the scrapers moved from the excavation points to the spoils dumping area.

The discharge canal had been dug and was open to the embayment. At the time of the site visit, the banks had not been covered to minimize the effects of erosion which will be caused by the discharge of station cooling water. The intake canal had been dug except for the entrance from Illinois Bayou. Its banks had not been covered. Spoil from the canals and prior excavations not required to backfilling had been spread in low areas on the applicant's property and on the Corps of Engineers property. Some excavated rock spoil had been used to raise the elevation of the causeway road west of the site. The discharge embayment had been dredged for a channel with a minimum depth of 9 feet. This will make it possible to bring the pressure vessels in on barges. The dredged material had been distributed along a low area on the east bank of the embayment. Precautions had been taken in all areas where spoil was placed to minimize washing of mud back into the embayment.

The applicant has consulted with the Corps of Engineers and the Arkansas Fish and Wildlife Service prior to placement of the canal spoil material.

The noise associated with construction will be of the usual type associated with industrial construction, with large earth-moving machinery probably causing the most objectionable noise. People living on the peninsula will certainly be aware of this, but the noise is not expected to affect many others. The town of London is 2 miles from the site and is separated from it by hills 400 to 500 feet high. This combination of location and surrounding hills should confine the major noise impact to the site.

V. ENVIRONMENTAL IMPACTS OF PLANT OPERATION

A. Land Use

The plant site embraces about 1100 acres, but the plant itself will take up only about 90 acres. Formerly, most of the site consisted of pasture land intermingled with forest. Much of the forested area will remain undisturbed. The open land was previously used for marginal farming. The shoreline of Dardanelle Reservoir associated with the site has not been used for recreational purposes and at present most of the recreational activities are confined to the other side of the Reservoir.

Since 1930, the applicant has been a contributor to the recreational developments. 2000 acres of land have been contributed to the Arkansas Game and Fish Commission for park development adjacent to Lake Catherine. This land was donated during the applicants Lake Hamilton hydroelectric project.

Potential recreational lands not required for operation of the Arkansas Nuclear One plant are now being evaluated. Under the terms of the permit granted by the Corps of Engineers, the applicant is required to develop an area for public fishing and the present plans will allow fishing from the banks of the intake and discharge canals with complete access by boats.

Selective clearing of power line right of ways was employed on the site, and the existing low-growing trees were left as a screen and to assist in erosion control.

Drift loss from the cooling towers will produce a deposit, consisting essentially of river water solids, onto the surrounding land. This deposit will reach a maximum of about 0.5 gram per square meter per day (1600 pounds per acre per year) at a distance of 60ymeters (3/8 mile).

These mineral solids will of course be soluble and will be similar to lime in composition. Leaching by rainfall should remove most of the deposit as fast as it falls. We anticipate no unusual impact from the deposition of drift solids.

B. Water Use

The Arkansas Pollution Control Commission's Permit No. 827 for Cooling Water Discharge and the applicant's hydraulic investigations show that the expected temperature rise of the water in the discharge embayment will exceed the 5°F maximum temperature rise allowed by state standards. Since mixing will not occur, the embayment is considered as an extension of the discharge canal. The hydraulic model investigations indicate allowance for a "mixing zone" in the main channel of the Reservoir at the point of discharge from the embayment. An application has been filed with Corps of Engineers for discharge of the heated water and chemicals to the Dardanelle Reservoir. No action has been taken on this request as of September 1971.

In the month of July, for example, with the Reservoir through-flow at a ten-year minimum of 3500 cubic feet per second, an average temperature isotherm of 6°F above ambient (average measured at 0.2 depth and 0.8 depth in the Reservoir) will extend approximately 100 feet into the Reservoir. ( ) In the month of January, according to the model studies, with a Reservoir through-flow of 4300 cubic feet per second, an average temperature differential of 8°F will exist for approximately the same distance out into the main channel. No thermal block across the main channel should exist under any of the conditions studied. Since the conditions studied were for the minimum expected flow, there should be no thermal block during normal operation of the plant.

Recognizing the limitations of analytical investigations and hydraulic modeling, the Arkansas Pollution Control Commission's Permit No. 827 for cooling water discharge was made conditional. It requires that a condition of pollution within the meaning of the Arkansas Water and Air Pollution Control Act must not be created in the waters of the Dardanelle Reservoir of the Arkansas River by the operation of Unit 1. As an additional condition of Permit No. 827, the applicant is required to study Reservoir conditions, before operations begin and for a period of at least five years thereafter, looking for evidence of adverse effects. If, after the operation of Unit 1 has begun, the conclusions from the model studies are found to be in error, the applicant will be required to take measures to abate the adverse conditions indicated by the monitoring program and to eliminate them within such a time as is established by the Arkansas Pollution Control Commission. Measures that can be taken are outlined in the applicant's letter dated February 11, 1971, to the Arkansas Pollution Control Commission, which is attached to Permit No. 827. These measures include such changes as topping cooling towers or full flow cooling tower(s) (as planned for Unit 2) or the addition of a 30°F rise condenser, a condenser bypass arrangement, or the construction of a "spreader" weir across the discharge embayment.

In the applicant's Environmental Report for Unit 2, ( ) a rather detailed analysis of the expected environmental impact was made for both mechanical and natural draft towers. This analysis has been reviewed by Oak Ridge, Tennessee, staff members of the Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration

(NOAA). They are in agreement with the applicant's conclusions as stated in the Environmental Report for Unit 2.

The environmental effects that were evaluated included interaction of the tower plume with the Dardanelle Reservoir, possibly producing an increase in water temperatures. This could invalidate the expected temperatures for operation of a once-through cooling system for the turbine condensers and the general impact of the plume on the environs, including plume visibility, increased fog, ice, drizzle, and salt deposition.

From the applicant's Environmental Report for Unit 2, it appears that the plume's environmental effects will be limited mainly to reinforcing or enhancing naturally occurring weather phenomena. This enhancement should be most evident in January, a representative month for the winter season. In periods of relatively high humidity in January, the plume is expected to increase the low cloud coverage from 2% to several percent. Local fog frequency will be slightly enhanced during periods of high humidity when natural ground fogs occur. Drizzle resulting from the plume will be confined largely to the site or less than 1/2 mile beyond the boundary. U. S. Highway 64 and I-40 are located generally north of the site and are near the edge of the extreme range estimated for drizzle resulting from the plume. Icing from the plume is expected to be slight, since the ambient temperatures are seldom extreme enough to produce icing.

In the applicant's Environmental Report for Unit 2, he has evaluated the potential effect that "plume surfacing" from Unit 2's cooling tower might have on the Dardanelle Reservoir temperatures expected during operation of Unit 1. He considered the most adverse meteorological conditions and the once-in-ten-year minimum flow conditions for the months of January, July, and October. He concluded that thermal block will not occur and that any rise in temperature of the Reservoir water would be a fraction of 1° Fahrenheit. Again, if the assumptions and conclusions of this analysis are found to be in error during the post-operational monitoring required by Permit No. 827, then the adverse effect of the combined operations of Unit 1 and Unit 2 can be corrected by adhering to the conditional provisions of the permit.

After operation of Unit 1 begins, the temperature of the water in the discharge embayment will rise, primarily because of the waste heat discharged from the turbine condensers of Unit 1. After steady-state operation is reached, the water in the entire embayment will reach a steady state temperature with the air and the bottom sediments. The time required to come to a steady state condition will depend upon the amount of channeling, bottom irregularities, and indentations (coves) along the shores of the embayment. This time will be a few days. It is estimated, from a contour map, ( ) that the average elevation of the bottom of the embayment is approximately 330 feet above mean sea level (the elevation of the low point at the exit into the Dardanelle Reservoir is 320 feet). With this estimate, the volume of water in the embayment will vary from 156 million gallons to 209 million gallons as the reservoir varies from minimum (336 feet) to maximum pool level (338 feet). With a discharge of 763,000 gallons per minute from Unit I's circulating water system and perfect flushing, the water in the embayment would be replaced every 5 hours or less. In reality the warm water will spread out as the top layer of water and gradually raise the temperature at greater depths until equilibrium is established.

The planned time for refueling Unit I is the winter, probably January or February. It is planned to refuel Unit 2 either prior to or after refueling Unit I. Operational plans call for the steam generating system to be cooled to 280°F by using the turbine condensers and bypassing steam to the condensers with the turbine bypass system. The circulating water system will continue to cool the condensers during this period of operation.

At 280°F it is planned to cut in the decay heat removal system to provide the additional cooling required. The heat exchangers in the decay heat removal system will be cooled by the service water system in a closed cooling system which makes use of the emergency reservoir. When the decay heat removal system is operating, the only heated water entering the embayment will be the tower blowdown from Unit 2. This flow is very small, a maximum of 9 cubic feet per second as compared to the 1700-cfs circulating water system of Unit 1, and its effect on the embayment temperature should be negligible. For liquid radwaste discharge during shutdown of Unit 1, as an operating minimum two circulating water system pumps will be required for adequate dilution. This flow, 850 cfs (383,000 gallons per minute), will be discharged at ambient intake water temperature. The cooldown rate of water in the embayment will than depend upon the mode and length of operation of these pumps. Since the water then being discharged into the embayment will be cooler and of greater density, it will flow under the warmer water remaining in the embayment because of the operation of Unit 1. Under such conditions and in winter, the embayment water temperature should drop rapidly.

The possibility of contaminating the ground water supplies in the area as a result of the normal release of radioactive materials from the plant is very remote. The clay and silty clay which overlie the bed rock are nearly impermeable. In addition, the clay would strongly absorb many of the hazardous radioactive materials in the water such as strontium and ruthenium. All the private farm wells are above the ground water gradient from the plant site, so that any contamination of the ground water would affect the Dardanelle Reservoir but not the small wells used for domestic supply.

C. Biological Impact

1. Ecological Studies

Biological, chemical, thermal, and radiological characteristics of the Dardanelle Reservoir are being determined prior to plant operation. Studies begun in 1969 will continue until 1973 (date of initial plant operation) and for a period of five years afterward. The University of Arkansas at Little Rock with the cooperation of the Arkansas Game and Fish Commission and the Arkansas Pollution Control Commisssion are carrying out this program.

Biological data on types and numbers of phytoplankton, zooplankton, benthic organisms, and fish are being gathered. In addition to seasonal changes, these data show large year-to-year variations. Since the Dardanelle Reservoir reached normal pool level only in 1965, the biological impact of the Dardanelle Dam on the Arkansas River probably still influences some bottom sediments and population fluctuations of many aquatic organisms.

2. Terrestrial

Resident wildlife in the vicinity of the Arkansas station is limited to small native mammals and birds. Migratory birds, particularly ducks, frequent nearby bays in the winter.

Construction of the station will diminish habitats in the immediate vicinity because of the clearing of vegetation and alteration of the landscape. However, the surrounding forests may offer alternative habitats for some displaced birds and small animals. In the absence of extensive agricultural areas or industrial installations around the Arkansas plant large forests continue to exist adjoining the site.

3. Aquatic

a) Thermal

The major biological impact will be on aquatic biota subjected to the once-through cooling water from Unit I. The greatest impact will be upon the 80-acre embayment into which this heated water is released. The higher temperatures between the surface and a depth of 6 feet should create no serious ecological problems in the vicinity of the embayment discharge. Model studies ( ) in which temperature data were obtained in accordance with advice from the Arkansas Pollution Control Commission indicated that no thermal blocks (ambient plus 5°F) would extend across the reservoir for critical winter or summer conditions (see V-B, Impact Upon Water Use).

Elevated water temperatures within the 80-acre embayment will exist in gradients ranging from about 10 to 15°F above ambient. This area, which is in effect a cooling pond, will undergo observable changes in ecological structure due to this heating. During summer months temperatures of 95 to 100° near the discharge structure will exceed those which are considered lethal to many species of fish and zooplankton. ( ) Since the embayment is open and no mechanical or natural features exist which might trap the fish, they should avoid these unfavorable temperatures. However, warm-water species, particularly catfish, may be attracted to the heated water from the discharge canal.

Certain population changes among algal groups are to be expected in this embayment. At water temperatures above 90°F (most of the embayment will experience this during the summer), blue-green algal species and some heat-tolerant diatoms will probably increase in numbers while most diatoms and green algal species will decrease. ( )

During the winter months some fish will migrate from the Reservoir into the warmer embayment. However, during February, shutdowns for refueling will cause a drop in embayment water temperatures which may provide a shock for fish that become acclimated to the warmer temperature. The environmental studies should include a provision for observing fish populations closely during this period.

Bottom organisms and bacteria are likely to be affected by temperatures over 90°F. If the food supplies become abundant, bacterial multiplication will increase while bottom organisms will decrease in number. ( ) Such changes in the ecology of the embayment are not necessarily detrimental, but the impact of thermal effluents will change both the kinds and numbers of organisms in this body of water.

b) Chemical

Chlorine will be used in Unit I to control aquatic growth, but it will be diluted to less than detectable limits before discharge into the embayment. Sulfuric acid which is added to the closed circulating water will be neutralized before discharge. The sulfate ion concentration in the effluent may be as high as 0.4 milligram per liter, but even this is a negligible amount when we consider that the normal fluctuation in sulfate level is from 20 to 139 milligrams per liter. One toxic substance, boron, will be discharged at a rate of 581 pounds per year, but it is released to the embayment in concentrations of 0.01 milligram per liter and further diluted to concentrations far below the levels that are considered toxic to the most sensitive plants (0.5 to 1.0 milligram per liter). ( ) Copper releases (16.2 pounds per year, 5×10^{-5} milligram per liter) also are well below concentrations known to affect sensitive plants (0.1 milligram per liter). ( ) Other constituents and ions of the discharged cooling water (Na^{+1}, Ca^{+2}, Mg^{+2}, SO_4^{-2}, Fe^{+3}, SiO_2, NH_4^{+1}) will be diluted and released so that water returning to the embayment will be increased in mineral content only by about 1%. While releases of these substances and radionuclides are far below concentrations shown to be toxic to aquatic organisms, uptake by organisms in the heated embayment may be different because of temperature effects. Chemical and radiological analyses of water, sediments, and organisms in the applicant's environmental monitoring program will show whether such interactions occur.

c) Intake Structure

An additional impact will involve the passage of small fish and plankton through the intake structure. Traveling screens (3/8-inch openings) will prevent large fish and debris from entering the cooling system. Small fingerlings will, however, pass through the system. The number of small fish drawn through and the number surviving this passage should be measured under operational conditions.

Of greater concern is the possibility of fish entering the 4400-foot intake canal from Illinois Bayou and being trapped against the intake screens. Velocities of 1.5 feet per second in the canal and 2.0 feet per second through the screens are reported by the applicant. Experience at Indian Point Unit 1 ( ) showed that velocities exceeding 0.8 foot per second were sufficient to prevent fish from escaping intake structures. No estimate is available on the number of fish that may enter the intake canal.

4. Monitoring Program

The applicant's environmental monitoring program, both preoperational and operational, is a cooperative program involving applicant personnel, the University of Arkansas at Little Rock (ULAR), and the Arkansas State Department of Health (Division of Radiological Health). The applicant contracted with UALR to conduct a comprehensive ecological study of the Dardanelle Reservoir to determine reservoir characteristics (thermal, chemical, biological, and radiological) five years prioe to and five years after nuclear plant operation. The Arkansas State Department of Health will carry out the major effort in the off-site radiation monitoring program, coordinating their program with UALR to avoid duplication of effort. The applicant's personnel will conduct the on-site radiation monitoring program with the assistance of the Arkansas State Department of Health and the preoperational phase of the on-site program will begin one year prior to receipt of nuclear fuel. The same program will be continued as an operational monitoring program after the reactor begins.

a) Radiation Monitoring

Airborne radioactivity is monitored at four isotropic locations on-site, at two locations within a 10-mile radius of the station, and at one control location 20 miles from the station. Data collected in the air monitoring network include: (1) radionuclide concentrations in air, vegetation, and soil at all locations; (2) radionuclide concentrations in precipitation at one location on-site and at a control location 20 miles from the station; and (3) integrated gamma doses (direct radiation) at four locations on-site. The sample collection and analysis frequency range from weekly for continuous air sampling filters to semi-annually for vegetation and soil samples.[a] Samples analysis is limited primarily to gross activity and gamma spectral measurements.

Raw milk is collected semi-annually from local herds at eight locations about the station. The type analyses performed on the samples are: (1) specific nuclide analyses for ^{131}I, ^{137}Cs, and ^{140}Ba-La; (2) gamma spectral measurements; and (3) gross beta measurements.

The reservoir is monitored by sampling water, fish, bottom sediments, algae, and plankton at the sampling locations illustrated in Figure . Samples are collected and analyzed semi-annually prior to station operation and quarterly thereafter. Aquatic biota samples are taken at various depths in the reservoir as well as various distances from the discharge embayment. Mussels (which do not naturally occur in these waters) will be planted on a selected radial line 500 feet from the discharge embayment and recovered at six-month intervals for radiological assay. All samples from the reservoir are subjected to gross activity and gamma spectral analysis. In addition, specific radionuclide analyses are made on water samples for ^{3}H, ^{131}I, ^{137}Cs, ^{65}Zn, ^{54}Mn, and ^{140}Ba-La, and on aquatic biota samples for ^{131}I, ^{137}Cs, and ^{65}Zn.

---

[a] Appendix D of applicant's Environmental Report.

Ground water is monitored by collecting samples, quarterly, from one well on the station-site and from two wells within a five-mile radius of the station. Samples are analyzed for gross activity and ^3H.

The use of film badges appears questionable for the measurement of integrated gamma submersion doses because of the sensitivity of film to varying environmental conditions (temperature, humidity, etc.). We recommend the use of thermoluminescence dosimeters for this purpose and additionally that gamma dose measurements be made at the established off-site air monitoring stations.

The sampling program in the Dardanelle Reservoir is adequate for defining radioactive concentrations in the reservoir resulting from liquid waste discharges from the station. The highest concentrations will exist, however, in front of the discharge structure in the discharge embayment. We recommend that a continuous sampling station be installed in front of the discharge structure to provide measured concentrations of the released materials rather than calculated concentrations and that samples from the station be analyzed for all radionuclides which contribute significantly to the projected dose to humans in all exposure pathways from the use of reservoir water.

b) Temperature Monitoring

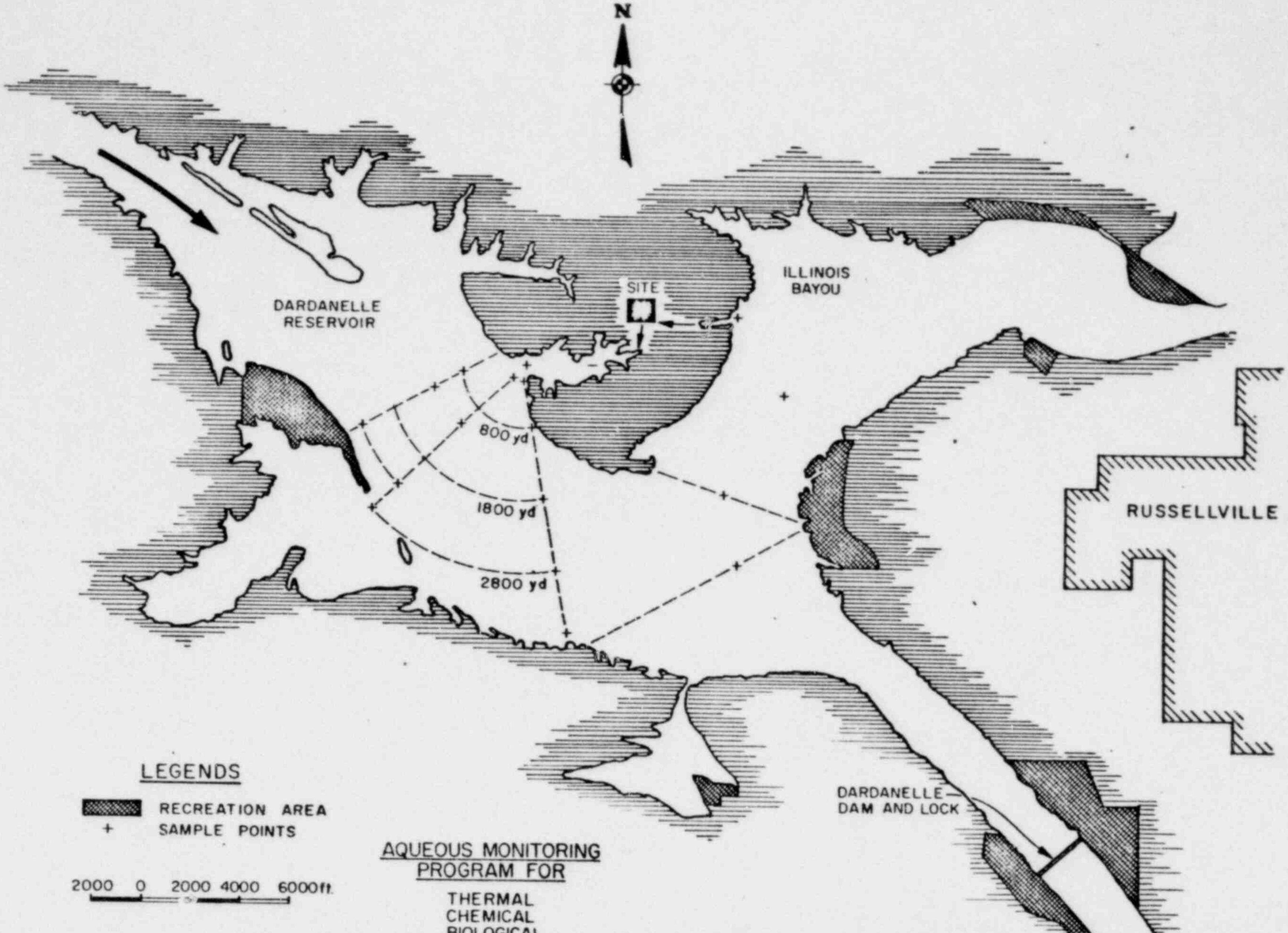
To establish temperature patterns in the reservoir and to determine the extent of the thermal plume after station startup, temperature measurements are made at the locations illustrated in Figure V-1. For the five-year period prior to reactor operation temperature measurements were made at selective points on the grid network during the months of January, April, June, July, August, and October each year. After reactor operations begins, measurements will be made at all points in the network at monthly intervals. At each location readings will be taken at one foot below the surface, two feet below the surface, seven feet below the surface and at five-foot intervals from that point to bottom elevations.

This system of measurements is adequate to define the thermal plume and to provide data for evaluating the thermal impact of reactor operations on the reservoir.

D. Radiological

1. Radioactive Effluents and Exposure Modes

The radionuclide releases to the environment from Units 1 and 2 of Arkansas Nuclear One, under design operation are assumed to be in liquid and gaseous forms. We assumed that few particulates are released in the gaseous effluents of a pressurized water reactor because of filters.



AQUEOUS MONITORING PROGRAM FOR

THERMAL
CHEMICAL
BIOLOGICAL
RADIOLOGICAL

GENERAL LOCATIONS
MONITORING STATIONS
ARKANSAS NUCLEAR ONE
RUSSELLVILLE, ARKANSAS

FIGURE V-1

ROUGH DRAFT

The potential modes and pathways of radiation exposure that are considered here are (1) external exposure by immersion in (a) the gaseous effluent and (b) the waters of the Dardanelle Reservoir while swimming and (2) internal exposure from consumption of (a) drinking water, (b) fish obtained from the Dardanelle Reservoir, and (c) milk obtained from cows whose entire supply of drinking water is the Dardanelle Reservoir.

2. Liquid Effluents

The estimated sum of the radionuclides to be discharged in the liquid radwaste (see Table III-1) is about 600 curies per year, excluding tritium. This is a high value compared to measured radwaste discharges from operating PWR's corrected to the power level of the Arkansas Nuclear One Plant.( ) The primary reason for this high value is the applicant's estimate for the release of ^{91}Y and ^{137}Cs. He should reevaluate his liquid radwaste discharge. If his estimated discharge does not come down to values more in line with those from similar plants, he must seek ways of reducing the discharge to the lowest practicable level.

All the tritium is expected to be discharged as water with the liquid effluent. The maximum concentration is estimated to be 2×10^{-6} microcuries per cubic centimeter. This is well below the present permitted release limit.

Blowdown from the steam generator cycle is discharged without holdup or treatment. Normally, this water will be free of radioactivity. In the case of a leak between the primary reactor coolant water and the steam generator circuit, however, the steam generator water will become contaminated with radionuclides from the primary circuit. The applicant has made provision for monitoring the blowdown tank but has not said how he will treat this water if it becomes contaminated. He should show how he will route this water to the liquid radwaste cleanup system in the event of a primary to secondary leak. He should also be able to vent the radioactive gases from the steam generator blowdown tank to the waste gas holdup tank if necessary.

An analogous situation will exist with the afterheat removal system for use during shutdowns. In case of a leak between the primary and the secondary system, radioactive water will be discharged to the emergency reservoir.

3. Gaseous Effluents

The applicant's estimate of gaseous radwaste release shown in Table III-2 amounts to about 50,000 curies per year. This is much higher than the worst case reported for an operating pressurized water reactor. ( )

The applicant should check his calculations of the gaseous radwaste release. There is a factor of 10 between the estimated ^{85}Kr release reported for Unit 1 in the applicant's Environmental Report and the release projected for Unit 2 in the PSAR. To be conservative, we used the higher value in our evaluation of the radiological impact.

The planned holdup of gases before discharge is 30 days. Unless revised estimates bring the ^{133}Xe release value down, the holdup should be increased to 60 days.

The gaseous exhaust system (see Fig. III-3) shows the normal flow of the primary gaseous radwaste directly to the plant vent with a bypass to the holdup tanks when the level of radioactivity is too high. This gas, especially that from the degasifier, will nearly always be too radioactive to discharge directly to the atmosphere without holdup. The applicant is aware of this, and his calculations are based on 30-day holdup. The normal flow of gas should be to the holdup tanks, with an emergency bypass of the holdup tanks if this is necessary.

4. Estimated Doses and Dose Commitments

A summary of dose and dose commitment estimates for the radionuclide release from both Units 1 and 2 of Arkansas Nuclear One is given in Table V-1. "Dose commitment" is the total dose an individual will accrue within his lifetime as a result of a given radionuclide intake. It is particularly important to consider dose commitment for those radionuclides which selectively deposit in bone, where their effective half-time may be long (years). Throughout these discussions, use of the term "dose" should be understood to include "dose commitment" whenever internal exposure modes are involved. It should be pointed out that our estimates of the internal doses for each radionuclide are based on the dose to its respective "critical" organ, a conservative procedure. The "critical" tissue or organ is defined by the International Commission on Radiological Protection (ICRP) as that tissue which, when irradiated in the case of approximately uniform irradiation of the whole body, constitutes the greatest hazard to the health of the individual or of his descendents. ( ) All our dose estimates were calculated for adults, using dosimetric parameters applicable to "standard man," and the population was assumed to be composed entirely of adults. "Standard man", as defined by radiation protection authorities, is intended to represent a typical or average adult who is exposed occupationally. ( ) Limitation of our calculational effort to the adult population is thought to be reasonable on the basis of our experience which indicates that, in an environmental exposure of a population involving a spectrum of radionuclides, population groups having dose expectations exceeding those of the adults by as much as a factor of 2 would be unusual. No such unusual exposure groups became apparent during the course of our investigations. One should recognize too that within what appears to be a homogeneous population group for a given exposure situation, the doses received by individual members of the group can vary by as much as a factor of 3. The details of the dose estimate calculations and ssumptions can be found in Appendix A. The potential dose was also estimated for several special population groups near the plant site. These dose estimates are given and discussed in Appendix A.

The highest estimate of annual whole body dose due to immersion in the radioactive gaseous effluent at the site boundary is 3.7 millirems. This estimate is the result of a "worst case" calculation where first, the gaseous effluent downwashes to the ground and second, no additional vertical dispersion occurs beyond the site boundary. The second assumption specifically provides conservative dose estimates for all directions from the plant site, regardless of the topography. A more reasonable estimate of the potential annual whole-body dose expected at the site boundary is 1.3 millirems.

The estimates of potential dose from drinking water and eating fish taken from the discharge embayment are 10 and 26 millirems per year, respectively, as given in Table V-I. If the water is taken from the Dardanelle Reservoir below the embayment, the estimates are 0.5 and 1.0 millirem per year respectively. Since the water of Dardanelle Reservoir is not of a quality normally used for drinking, only occasional consumption from the Reservoir is likely to occur, and therefore this estimate is conservative. With respect to a potential dose from the consumption of fish, two reasonable assumptions are: (1) the large seasonal changes in water temperature of the discharge embayment make it unlikely that many fish of any species will spend their entire life there, and (2) it is unlikely that all the fish consumed by any individual will come from the embayment. Therefore, it is concluded that a reasonable estimate of the potential dose commitment by any individual due to ingestion of fish is 1.0 millirem per year (see Appendix A).

The estimates of potential dose from swimming in the Dardanelle Reservoir or from the use of Reservoir water for drinking by dairy cows are smaller than all other estimates of potential dose as shown in Table V-I. The estimate of potential dose from the consumption of food from irrigated crop lands was much less than that found for the water-cow-milk pathway and therefore is omitted.

Table V-1. Summary of Estimated Dose Contributions[a] per Year of Discharge

Exposure Pathway	Maximum Dose (mrem) to Individual at Site Boundary	Maximum Dose (mrem) to Individual from Liquid Effluents	Man-Rems Within 50 Miles in Year 2012	
1. Immersion in air	3.7 (total body)		1.4	(7.1) man-rem
2. Ingestion				
a. Fish		26.	31.	
b. Water		10.	--	
c. Milk		0.30	--	
3. Submersion in Water		<0.1	1.9	

---

[a] Conservative assumptions were used to maximize doses estimated in cases where specific site data were not available.

The dose estimates for our radiological safety assessment were based on source term information provided by the applicant; however, the release rates for some radionuclides (e.g., ^{85}Kr and the cesium and yttrium isotopes) could not be established to our satisfaction on the basis of that information. If the assumed release rates in Tables III-1 and III-2 are correct, then some remedial actions will be required. It could be that additional holdup of the gaseous effluent is desirable. For the liquid effluent, ingestion of fish is the critical exposure pathway and ^{137}Cs, ^{91}Y, and ^{134}Cs are the critical radionuclides. The dose estimates for this exposure pathway (26 millirems maximum to an individual and 31 man-rems to the population) are not excessive, but these values do not seem to be "as low as practicable." Again, it appears quite probable that a reevaluation of the release rates to be expected could reduce this dose estimate considerably. The cesium and yttrium isotopes contribute 95 percent of the dose estimated for exposure via ingestion of fish.

1. Environmental Report, Arkansas Nuclear One, Unit I, APL, Appendix C.

2. C. C. Coutant, Biological Aspects of Thermal Pollution.

   I. Entrainment and Discharge Canal Effects. CRC Critical Reviews in Environmental Control, I (3) 1970.

3. Temperature and Aquatic Life, Laboratory Investigations - No. 6. Technical Advisory and Investigations Branch, FWPCA, U. S. Dept. Interior, Cincinnati, Ohio, 1967.

4. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior. FWPCA, April I, 1968.

References

1. International Commission on Radiological Protection, Recommendations of the International Commission on Radiological Protection (Adopted Sept. 17, 1965), ICRP Publ. 9, Pergamon Press, London (1966).

2. International Commission on Radiological Protection, Recommendations of the International Commission on Radiological Protection (Report of Committee 2 on Permissible Dose for Internal Radiation), ICRP Publ. 2, Pergamon Press, London (1959).

VI. ADVERSE EFFECTS WHICH CANNOT BE AVOIDED

A. Effects on Land Use

The construction and operation of a large electrical generating plant such as Arkansas Nuclear One will cause some unavoidable adverse effects. Land for the site is committed to long-term use (that is, for the life of the plant), and some portion of this land will probably be committed for an indeterminate period of time thereafter. Approximately 1000 acres of the site, which are unoccupied by plant buildings and facilities but are needed for an exclusion area, can be used (with permission from the Arkansas Power and Light Company) to develop recreational facilities, timber growth, or other future uses. The remaining 90 acres are committed for an estimated plant life of 40 years. It may be possible at the end of the 40 years to dismantle the entire plant and return the land to other uses, or another unforeseen electrical generating plant may take its place. Since the land, prior to the start of construction of Unit 1, was partly used for pasture, timber growth, and marginal farm operations, the conversion to an electrical generating plant appears in this case to be beneficial to mankind. The construction of Unit 2 at the same site, instead of at a new location, means that no additional land commitments will be required.

B. Effects on Water Reservoirs

1. Effects Related to the Intake Canal and Intake Structure

The excavation of an intake canal 4400 feet long from the Illinois Bayou to the power plant restricts the use of some land during the life of the plant. The intake structure at the end of the canal near the power plant contains traveling screens through which the velocity of the water varies at maximum plant input from 2.0 to 2.18 feet per second as the Reservoir varies from power level (338 feet above mean sea level) to navigational level (336 feet). This velocity is sufficient to trap, and thereby kill, small sizes of some species of fish. ( ) The magnitude of this effect cannot be determined at present, but it will depend on the number, size, and kind of fish leaving the Reservoir and traveling the 4400-foot-long canal. Small fish (less than 3/8 inch in diameter) and lower forms of suspended aquatic life will pass on through the screens and into the plant water systems. This will result in an unavoidable loss of some aquatic life.

2. Effects of Radioactive Effluents

The nuclear generating station will emit small amounts (see Sect. III-D) of radioactivity in gaseous and liquid discharge streams. During the life of the plant the radioactive effluents discharged to the environment will not be large enough to be detrimental to human, terrestrial, or aquatic life. The two units at this location will release radioactivity at concentrations below recommended MPC values (maximum permissable concentrations) and within the expected values to be issued by the Atomic Energy Commission as an amendment to 10 CFR Part 50.

3. Effects of Chemicals

The introduction of chemicals into plant components is required for operation. Most of the chemicals added to the systems will undergo a chemical reaction so that the liquid effluent streams contain only inorganic salts. Table III-4, Section III-D, lists the constituents of these substances. Most of these constituents are now present in the waters of the Dardanelle Reservoir in greater quantity than will be expected from plant operation. Boric acid is required for nuclear control, but its concentration when discharged is not high enough to be harmful to any species living in the receiving waters. Those chemicals normal to the Reservoir waters enter the lake largely by the normal leaching of the drainage area by rainfall. Other chemicals are now added by the discharge effluents from cities and industries upstream. The quantities now coming from cities and industries are expected to decrease in the years ahead by enforcement of better water quality standards. Any suspended chemicals will be flushed downstream by natural conditions, or some will be deposited in the bottom sediment of the lake, where they can enter the life chain. There is no evidence that the chemicals in their present concentrations, or those added during plant operation, will be harmful to the life species using the waters of the lake.

4. Effects of Heated Water

Heated water will be discharged to the embayment and eventually into the Reservoir at lower temperatures. Some damage to life i the embayment is to be expected (see Sect. V-c), but the extent of this damage can only be assessed after the plant is in operation and the results of the post-operational monitoring program are compared to preoperational data. The 80 acres of the discharge embayment amount to 0.2% of the Dardanelle Reservoir acreage and may be considered to be in the same category as the commitment of 90 acres of the land site for building and facilities, with one important exception, namely, that the changing of the ecology in the embayment by warm water will not be irreversible. When the inflow of warm water ceases, the life cycles of the species in the main reservoir will again predominate in the embayment. The warm water flow into the embayment is not expected to affect life cycles in the main reservoir. If post-operational monitoring shows an effect in the main reservoir, then means are available to correct these adverse conditions. ( )

The warm water from Unit I and the tower blowdown of Unit 2 entering the embayment will cause an average evaporation loss of 6300 gallons per minute. This, when added to the drift from the cooling tower and the average natural evaporation of 11,000 gallons per minute from the Dardanelle Reservoir, accounts for 1% of the once-in-ten-year minimum flow. This evaporated water will be returned to the land mass by naturally occurring phenomena. The 1% loss of water will have no effect on the availability of water from the Reservoir for downstream users.

5. Effects of Salt Deposition and Drizzle

Some salt deposition and drizzle are expected from the tower plume (Unit 2) at distances less than 1/2 mile from the site boundary. The maximum salt deposition is estimated to be at 600 meters (1970 feet) from the cooling tower and would amount to 0.4 g/m^2 per day. The salts deposited on the ground are the same as those found in the waters of the Dardanelle Reservoir. If they are not absorbed in the ground after deposition, they will be returned by natural drainage back to the Reservoir.

Drizzle from the tower could occur principally during periods of high relative humidity in the surface air. This high relative humidity is normal for the area during winter months. Low cloud coverage in the vicinity of the plant is expected to increase several percent under some weather conditions. These effects are limited and do not extend to the nearby towns nor do they have long-term significance.

C. Supplementary Effects

There are potential adverse effects to the operation of Arkansas Nuclear One but the effects are not considered to be excessively harmful or detrimental to life. The commitment of an area of less than 90 acres for a long time is more than outweighed by the large number of people who will benefit from the generation of additional electrical energy.

VII. ALTERNATIVES TO THE PROPOSED ACTION

As discussed in Section I of this report, the requirement for power in this region is such that the 1800 megawatts of electrical capacity developed by Arkansas Nuclear Units I and 2 must be provided from some source. Since this installation is part of the Southwest Power Pool, it must be considered in the context of the regional demands for power in the Southwest. Neither hydropower nor geothermal power reservoirs of this magnitude are available to the region; so steam power plants are the only suitable electrical energy source. Various types of fuel can be visualized for steam power plants in this area including gas, fuel oil, and coal as well as fissionable uranium.

The use of gas would be contingent on locating an uncommitted gas reserve suited to the needs of this electrical demand equivalent to 20% of the current total gas consumption in the State of Arkansas.[2] Gas is undoubtedly the cleanest non-nuclear fuel, but its use appears to be possible only by instituting an exploration program of uncertain results to establish a reliable supply. With other pressing demands for gas in

---

[2] Letter from John N. Nassikas, Chairman, Federal Power Commission, to H. L. Price, Director of Regulation, USAEC, Attachment: "Federal Power Commission Comments Relative to the Environmental Statement on the Arkansas Nuclear One Facility, Unit No. 2 of Arkansas Power and Light Company," April 8, 1971.

the United States and an urgent need for clean fuel supplies to satisfy air pollution standards in the metropolitan areas, this appears to be an undesirable use of national gaseous fuel resources even though it has been used for other power plant installations in this region.

Like gas, the use of fuel oil for this power plant would require the establishment of a new source of supply. Effective use of fuel oil depends upon the availability of refinery capacity that will produce the proper fuel characteristics. Thus, a refinery capacity commitment of substantial size would be necessary. Since this in turn would be contingent on expansion of domestic or foreign oil production sources, the prospects for developing a reliable long-term, low-cost fuel supply suited to the 30-year life of a power plant are quite poor.

The coal supplies available to this region with existing transportation and production facilities have a high sulfur content (3 to 5%) and their use could be considered only be acceptance of high release of sulfur dioxide,[2] along with some dispersion of fly ash into the atmosphere. Further, the boiler grate ash disposal would impose a serious solid waste problem that would at best create an undesirable scenic blight on this newly developed recreational area. These effects are certainly detrimental to the use of the recently created recreational areas of the Dardanelle

Reservoir, which are superbly suited to both human habitation and natural wilderness.

From the above, it appears that the currently available domestic nuclear fuel is the most suitable energy source for the expansion of the Southwest power system.

The completion of the Arkansas Nuclear One power Unit I establishes a capital commitment to nuclear power production of such size that it would be very costly to abandon the installation even if there were more attractive methods of power production from an environmental standpoint. Based on current capital costs for nuclear plants, the replacement value of the 850-megawatt Nuclear One Unit I would be equivalent to more than $250 million, which would have to be recompensed by the regional power consumers through higher electrical power rates if some other power supply source were to be substituted to satisfy the Southwest Power needs. Considering the nominal value of land in this region, this would be comparable to asking the area land holders to abandon more than one million acres of local land without compensation. Further, if abandonment were to be considered, then some other power plant site of comparable environmental impact would have to be found for power supply purposes.

The transfer of Arkansas Nuclear One Unit 2 to another site would relieve the thermal load effects on the air and water environment at this site and result in a minor reduction in chemical pollution from water treatment. Since the second power unit would have to be re-sited to satisfy power needs of the Southwest Power Pool, the main effect would be to introduce comparable environmental penalties at a second site. Hence, the addition of Arkansas Nuclear One Unit 2 at the present location seems to be a desirable action.

The available nuclear power systems for electrical power production in the United States currently are based on water-cooled reactor technology. Other types of nuclear systems, including gas-cooled reactors and liquid-metal-cooled breeder systems, are currently under development; but the state of their technology does not warrant their selection for a very near term electrical power demand that must be satisfied by the end of 1975. The two types of water-cooled systems available, boiling-water and pressurized-water reactors, have comparable environmental effects, and either type will result in equivalent environmental impact. Both water-cooled systems, as well as any other fueled source of electrical power, introduce substantial thermal loads on the environment. These loads must be absorbed in the immediate air, water, and land surroundings through indirect heat removal devices such as evaporative water-cooling towers and air-cooled heat exchangers or by direct water-cooled steam condensers that deliver the heat to a surrounding body of water, which in turn dissipates the heat to the atmosphere by natural heat transfer phenomena.

Arkansas Nuclear One Unit I has been provided with direct once-through water-cooled steam condensers. This unit will use essentially all of the available heat capacity of the water reservoir adjoining the Arkansas Nuclear One Unit I and 2 installation and will result in peak water temperatures of about 100°F during summer extremes. At an additional cost of around $10 million, Arkansas Unit I could be fitted with a evaporative cooling tower that would reduce the peak temperatures in the water embayment. This would result in some penalty in thermal efficiency during the warm season and some loss of electrical capacity during the peak demand period. While this would serve to minimize the effect on the aquatic life in the discharge embayment, the existing arrangement would probably have no substantial effect on the aquatic ecological system of the whole Dardanelle Reservoir. The thermal peaks in the embayment are localized, and most fish life would probably shift to other parts of the Dardanelle lake. Some minor effect on growth of algae would probably be observed.

If the effect were later found to be substantial, a cooling tower could be added to the installation without substantial penalty to the power system beyond the additional capital cost effect on the consumer power rates.

The principal effect on aquatic life of concern is the possible destruction of fish life by the impact of high-velocity water at the cooling water intake. A fish screen placed in a position that would prevent fish from being carried into the high-velocity water region would counter the impact effect but would impose operational problems on the power plant cooling system because of screen plugging from water-transported solids. This difficulty might be mitigated by a horizontal traveling screen if one were available. An extension and widening of the intake structure could also reduce the water velocity to acceptable fish mortality limits. A decision concerning the need for these modifications could be deferred until effects on the aquatic life have been observed without serious penalty beyond that incurred by immediate modifications and without irreversible damage to the environment.

Arkansas Nuclear One Unit 2 is being equipped with an evaporative natural draft cooling tower and will dissipate heat to the embayment only through blowdown of the cooling tower basin, creating an inconsequential thermal effect. The use of direct condenser cooling could not be effected without extension of cooling water discharge lines beyond the embayment into the main body of the lake. While this is possible, it would be a costly engineering arrangement and would only transfer the thermal effects into a larger body of water. The use of an evaporative cooling tower in preference to an air-cooled heat exchanger does create some undesirable fog effects and some air-entrained distribution of water treatment chemicals as well as some chemical discharge from the cooling tower blowdown. The fog and entrainment effects do create some environmental nuisances of infrequent occurrence. These might be avoided by the use of air-cooled heat exchangers (dry cooling towers), but such equipment is not presently available from commercial sources. Further, air-cooled heat exchangers would introduce capital costs that are several times those of evaporative cooling towers, reduce the thermal efficiency of the installation, and perhaps increase the noise level in the vicinity because of the forced air cooling system needed to make them effective.

The discharg of radioactive liquid water from the nuclear operation is a matter of major consequence that must be managed properly in order to assure that all necessary safety controls are exercised. All systems require an arrangement for holdup of waste for a specified time to permit radioactive decay of radioactive contaminants in the waste. The alternative methods of handling the discharge of such wastes are either to dilute the wastes with water to a level that may be safely discharged into the cooling water system or to convert the wastes into a solid form for permanent storage. Since the volume of waste generated during the life of the reactor systems is small, either method could be applied effectively, but the solid conversion method is not subject to operational error having environmental significance and is, therefore, most desirable.

The most common arrangement is to collect all solid waste suspended in the liquid system by means of filters and to follow this with an ion exchange system which removes the anion and cation contaminants by deposition i solid form on the ion exchange resins. The effluent water, which is then essentially clean of all harmful isotopic contaminants with the exception of tritium combined as ^3H_2O, can then be discharged directly to the cooling water system. This, of course, adds some tritium to the water system, but the dilution is adequate to eliminate any known harmful effects in the water system. Tritium occurs naturally in all sources of water, and the main effect is to increase its concentration. The principal concern is to make certain that the dilution is such that the water discharged into the environment causes no major change in the isotopic concentration of tritium in the hydrological system.

An alternative method of handling the liquid wastes is to evaporate some or all of the waste to a concentrated form and recover the condensate, which can then be reused as makeup water in the reactor coolant system. The main value is to produce a smaller volume of solid waste, since the solid bulk from the ion exchange resins can be minimized in this scheme. It may, therefore, reduce the storage and handling requirements. The discharge of the tritium could be altered by this approach since the reuse of the reactor coolant might enable it to be concentrated in a volume which could be conveniently converted to solid form by chemical reaction or by hygroscopic absorption into a solid crystalline form. However, the volume of tritium produced continuously by the reactor operation is small enough so that disposal is effected safely by dilution and frequent discharge, while the long-term concentration for conversion into solid form creates solid waste that would have essentially no environmental impact but that would have to be stored in a way that avoids accidental use under uncontrolled conditions.

The Arkansas installation provides for ion exchange and (in the case of Unit 2) for evaporation as methods of concentrating the liquid radioactive waste and converting it into solid form. Maximum flexibility is therefore provided to assure the most effective means for minimizing the difficulties of handling such wastes.

VIII. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The Arkansas Power and Light Company's 1969 Annual Report, quoted here stated that "the race of supply and demand in America was leaving a proper conservation of our national resources behind" in the 1960s. Throughout the 1970s "an Arkansas Power and Light-sponsored 10-year research project on ecology of the Dardanelle Reservoir . . . (will) help is operate the Arkansas Nuclear One Generating Station there without upsetting the many advantages of this fast-growing recreation area."

Our staff evaluation of evidence regarding adverse thermal impacts on the Reservoir is made difficult by the unavoidable fact that this ecosystem is still undergoing readjustment from the impact of the Dardanelle Reservoir dam. Besides, the industrial pollution from upstream is not yet in conformance with state standards. When it does conform, another period of adjustment can be anticipated. For these reasons, in addition to the obvious need for understanding the effects of the generating station itself, the sponsored study will also need careful orientation to avoid confounding these transient impacts on aquatic productivity.

In spite of these difficulties, we find no reason to doubt the Reservoir's capability for sustaining the designed once-through cooling system of Unit 1. Note that the operating approvals are still contingent on continued conformance with thermal standards.

Also we emphasize judgments (a) that the need for alternative heat dissipation is not presently indicated from all evidence regarding operation of Unit 1, also (b) that the margin of environmental cooling capacity is nevertheless small enough to require some kind of cooling tower installation, as proposed, for Unit 2. The particular choice of a large hyperbolic tower is essentially acceptable environmentally to avoid risking thermal impact of a magnitude that could not be limited by future procedural changes. As in the large industrial areas of Europe, where such towers are common, there is no way of hiding a tower 450 feet tall. Many of the people in Arkansas have expressed a desire to have an appearance of industrialization in their area in order to attract more commercial developments.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The obvious resource that is irretrievably lost is the uranium fuel that is consumed i the reactor. In addition, the fission products that are separated from the spent fuel will have to be stored, and this will commit a small amount of land at some storage facility.

Only about 90 acres of the site will be used for the power plant. The remainder will be left in its natural state, with some improvement of selected areas. This land was only marginally productive heretofore. After construction of the Arkansas Nuclear One plant, several recreational areas will be developed, and fishing will be allowed on the shoreline of the discharge embayment.

Chemical additions to the Dardanelle Reservoir will be too small to cause harmful changes. However, thermal discharges to the embayment will cause changes in the kinds of fish and other biota found there. If operation of the plant is discontinued at some future date, the biota of the embayment should return to nearly its original state.

The plant site will contain certain support buildings and a large cooling tower which probably would remain there even if at some future date the plant were shut down and the site returned to its original condition. In particular, there is always the possibility that some small areas would remain contaminated after dismantling of the plant. The cost of removing this contamination may be too great for the gain that would be realized. In this case we would be left with a small restricted area.

X. COSTS AND BENEFITS

Arkansas Nuclear 1 Unit 1 is more than 50% complete, and it is anticipated that the construction of Unit 2 will proceed concurrently with the completion of Unit 1. The present 600-man construction force will rise to about 850 at the peak of construction. Up to now, the community has been able to absorb the effect of construction influx without difficulty, and the additional work force should not add an excessive burden to the community facilities. Upon completion of construction and during subsequent operation, the remaining environmental effect will be changes in water temperature over a small portion of the Dardanelle Reservoir and some local fogging and misting from the operation of the Unit 2 cooling tower. The peak of the construction program will tax the facilities of Russellville, causing some inconvenience to residents, but the effect is short lived and does not appear capable of causing undue stress on residential living conditions in the community.

It must be recognized that the whole Southwest region benefits from the recreational resources created by the Federal development of the Dardanelle Reservoir. Preservation of its recreational values is a paramount consideration that cannot be expressed in financial terms.

There are only a limited number of freshwater fishing lakes in this region. As the region grows economically, the recreational values will increase exponentially. Thus, a short-range financial evaluation would be meaningless. The addition of the two power units has largely eliminated the recreational fishing value during the summer months of an 80-acre embayment which is approximately 0.2% of the total recreational fishing area. More than likely, the entire perimeter of the embayment has been made less attractive from a human habitation standpoint. Considering, however, the total land area involved and the more than 100 miles of total lake perimeter, the fractional loss in recreational value is not significant.

The development of the Arkansas River basin provided for some industrial siting as one of the development purposes. The addition of the power plant is consistent with the planned industrial use. It does modify the scenic panorama as seen from the shoreline and by boating enthusiasts from a few vantage points. The architecture of the power plant is pleasing to the eye and fitting to the surroundings. It will do no greater damage to the scenic values than each of the residential property developments, boat docks, and private fishing resorts that already dot the perimeter of the reservoir.

Potentially, there could be some loss in the fish population due to water velocity impact effects at the water intake of Arkansas Nuclear One Unit I. The total effect cannot be established because the fish population of the Dardanelle Reservoir is unknown. Some indication of its magnitude can be seen from considering the fate of 60,000 striped bass fry released to the lake last year. Normal predatory and biological factors will probably prevent more than one-third of this fish population from maturing. Because of the embayment quiescence, it is virtually certain that less than 1% of this remaining fish inventory would reach the water intake of Arkansas Unit I, an/ if all were killed, the loss would only amount to 200 fish. Even if a dozen varieties of such game fish were affected in this way, the loss would hardly warrant an expenditure of several hundred thousand dollars to modify the intake structure, since the total value of the fish killed would not exceed $5,000 per year. The fish loss will have no material effect on the recreational use of the reservoir provided tha the embayment and surrounding lake area are kept clear of dead fish or other debris. No irreversible damage is expected, and the recreational value of the Dardanelle Reservoir should not be harmed.

The metropolitan area of Russellville has had to absorb the community impact caused by the influx of construction workers for Arkansas Nuclear One Unit 1, and a second construction peak will develop for Arkansas Nuclear One Unit 2. While the influx of outside construction forces has taxed the various service facilities of Russellville, the community has not suffered unduly from the construction program. Since no major disturbances have resulted from the construction program thus far and the power plant licensee has diligently worked toward restoring conditions equivalent to or better than the original, the community should not be damaged by the shifting worker population.

The completion of these two power units will enrich the local community as well as provide benefit to the Southwest Power Pool, which supports the economic growth of the region. The two power units will provide very attractive employment for approximately 90 persons engaged in power unit operations and probably will create an equivalent number of service support jobs in the Russellville community. The $600,000 annual economic contribution to the community from these jobs will more than compensate for the additional demand for schools and other community services which permanent residents must support. Further, the two units will add more than $250 million of taxable industrial property to the county tax assessment base with only a very minor effect on the community services. This too should contribute to the economic well-being of the community.

Those in the immediate vicinity of the nuclear power station will be accepting the same type of tisk that accompanies almost any industrial enterprise. Because of the stringent safety requirements specified by the Atomic Energy Commission, the degree of direct risk to each member of the community from the power plant is well below that which each accepts daily in using automobile transportation or other like activities of his living routine. The economic benefits to the community which will be felt as an improvement in educational facilities, higher grade community services, and better job opportunities should be more than ample compensation for this minor additional risk which the community will accept.

APPENDIX A

ESTIMATION OF POTENTIAL DOSES AND DOSE COMMITMENTS

I. Potential Doses from Gaseous Effluents Discharged to the Atmosphere

The radionuclides to be released to the atmosphere, all inert gases, are listed along with th[illegible] estimated release rates in Table III-2, Section III-D. The radiation do[illegible] immersed in a cloud of inert gas radionuclides is treated in accordance with the International Commission on Radiological Protection (ICRP), which says, "In this case, one would expect the radiation from the radioactive cloud to deliver a much higher dose than that from gas held in the lungs or other body organs."[1] Therefore internal exposure to inert gas radionuclides is neglected.

The gaseous effluents are to be released via exhaust ducts on the perimeter of the reactor building at a height of 195 feet above grade. The average concentration of radionuclides as a function of distance from the reactor buildings due to the exhause duct mode of release is not easily estimated because the usual dispersion calculation is made for an exhaust stack assumed to be at least 2-1/2 times the height of other site buildings. The exhaust ducts do not approximate a stack release, and so the downwash caused by the reactor and turbine buildings was assumed to effectively reduce the release height from 195 feet (58 meters) to 82 feet (25 meters). The average release rate is estimated to be 196,000 cubic feet per minute (45 cubic meters per second). The effluent was assumed to have zero exit velocity and thus to produce no momentum plume rise. An inversion lid at 295 feet (90 meters) was assumed for stability categories E and F of the applicant's meteorological data (Ref. 11). The average annual exposure concentration (in units of microcurie-hours per cubic centimeter per year) at ground level was estimated in each of sixteen 22.5° sectors at various distances by using the applicant's site specific meteorological data (Ref. 11) in an atmospheric dispersion model.[2] Radioactive decay was ignored because the half-lives of the isotopes involved are long relative to the average time required for the plume to travel 50 miles and because this leads to a conservative estimate. The exposure concentrations were converted to estimates of whole body dose using the external dose code[13] (EXREM) and other estimates of dose.[4] The resulting annual whole body doses for each direction sector at various distances are shown in Table A-1. The highest estimate of potential whole body dose at the site boundary is 1.3 millirems per year. The population information provided by the applicant in Ref. 1 was used to estimate the potential man-rem dose to the entire population within a 50-mile radius of the plant site from the gaseous effluent. This dose estimate is 1.4 man-rem and is simply the sum of all individual doses in this population.

Since the land topography surrounding Arkansas One is not flat, a "worst case" estimate of dispersion was made by assuming that the gaseous release completely downwashed to effectively become a ground zero release. Further, the vertical dispersion parameter was limited to a maximum value of 66 feet (20 meters) so that dilution of the gaseous release at points more distant than the site boundary (about 1000 meters) occurred only through horizontal dispersion. The results for this "worst case" set of assumptions give an estimated potential whole body dose of 3.7 millirems per year. A complete table of "worst case" potential dose estimates for the whole body can be obtained from Table A-1 by multiplying each value there by a factor of 2.9. These "worst case" estimates of potential dose will be conservative regardless of the topography surrounding the Arkansas Nuclear One site.

2. Potential Doses from Liquid Effluents Discharged to the Dardanelle Reservoir

The estimated radionuclide concentrations in liquid effluents discharged to the Dardanelle Reservoir were taken from the applicant's PSAR for Unit 2 and FSAR for Unit 1. The combined discharge (about 1700 cubic feet per second) from the two units flows into an embayment prior to entering the main body of the Reservoir. If it is assumed that water discharge from the plant will displace the embayment volume every 5 hours (see Section V-B), the effluent will not be diluted significantly until it enters the main body of the Reservoir. Note that among the radionuclides considered the shortest radioactive half-life is 64 hours. When the radionuclides leave the embayment and enter the main body of the Reservoir their concentration will be reduced by a factor of 21 due to the average water flow of 35,620 cubic feet per second through the Reservoir.

a. Dose from Ingestion of Contaminated Fish

The maximum dose to an individual resulting from fish consumption, 26 millirems per year of release, was estimated assuming that his total annual intake of fish (6350 grams per year)[4] came from the discharge embayment and that the radionuclide concentration in the fish was equal to the concentration in the embayment water. It seemed more reasonable, for purposes of the man-rem calculation, to utilize an estimate of man's annual intake of game fish (1365 grams per year)[5] and further to assume that those game fish came from the main body of the Reservoir rather than the embayment. On these assumptions the estimated dose to an individual is 0.26 millirem per year of release. The estimate of total population dose resulting from fish consumption is 31 man-rems for the year 2012 using the added assumption that 50 percent of the game fish caught within 50 miles of the site are from the Dardanelle Reservoir. Radionuclide intakes were converted to estimates of dose with the internal dose code[6] (INREM).

b. Dose Due to Drinking Water from the Dardanelle Reservoir

Another exposure pathway of potential importance is via drinking water. The maximum dose to an individual, 10 millirems per year of release, was estimated on the assumption that all of his daily intake of water (1200 cubic centimeters per day) came from the discharge embayment. If the drinking water comes form the main reservoir, the dose estimate is reduced to 0.5 millirem per year of release. No attempt was made to estimate the population man-rems for this exposure pathway because, as stated by the applicant and verified by the Arkansas Pollution Control Commission, the Arkansas River is not used as a source of public drinking water for people at any point downstream from the release point or or the entire Dardanelle Reservoir.

c. Dose Due to Ingestion of Milk from Cows Drinking Reservoir Water

The dose potential of this exposure pathway was estimated by assuming that a man drinks one liter of milk each day and that the milk is produced by cattle that have the Dardanelle Reservoir as their sole source of drinking water. The maximum dose estimate for an individual via this pathway is 0.30 millirem per year of release. A man-rem calculation was not made for this exposure pathway because the pathway is an unrealistic one for the majority of the total population living within 50 miles of the site.

d. Dose from Swimming in the Dardanelle Reservoir

Swimming in the reservoir was considered as a potential source of external exposure. The maximum dose to an individual (1.7×10^{-2} millirem per year of release) was estimated assuming he swam in the discharge embayment 1% of the year. If the swimmer is placed in the main reservoir, the dose estimate is reduced to 8.2×10^{-4} millirem per year of release. If one makes the further arbitrary assumption and 1% of the total population within 50 miles of the site spend 1% of their time swimming in the reservoir, the estimated total population dose is 1.9 man-rems for the year 2012.

3. Potential Doses to Special Population Groups

Certain population groups near the plant site were chosen for estimates of the possible dose to an individual of these groups. The estimated doses are based solely upon immersion in the gaseous effluent. A student at the London Elementary School, 2 miles from the Arkansas Nuclear One site, could receive 1.0×10^{-2} millirem per year while at school. A student at Arkansas Polytechnic College, 5 miles from the plant site, could receive 7.1×10^{-3} millirem per year if he lives on campus the whole year. A student at the Dwight Mission School in Russellville, 5 miles from the plant site, could receive 1.9×10^{-3} millirem per year while at school. A person in the Russellville Hospital or in one of two nearby nursing homes, all about 5 miles from the plant site, could receive 7.6×10^{-3} millirem per year.

Table A-1. Annual Whole Body Dose (MREM)

Sector	Distance From Release Point (Miles)										
	0.65	1.00	2.00	3.00	4.00	5.00	10.00	20.00	30.00	40.00	50.00
N	1.58E-01	7-66E-02	2.35E-02	1.21E-02	7.58E-03	5.32E-03	1.89E-03	7.40E-04	4.41E-04	3.10E-04	2.33E-04
NNE	3.04E-02	1.49E-02	4.63E-03	2.42E-03	1.54E-03	1.09E-03	4.03E-04	1.63E-04	9.91E-05	7.05E-05	5.44E-05
NE	1.29E-02	6.02E-03	1.74E-03	8.40E-04	5.00E-04	3.34E-04	9.75E-05	3.04E-05	1.56E-05	9.89E-06	6.95E-06
ENE	4.14E-02	1.97E-02	5.90E-03	2.95E-03	1.81E-03	1.25E-03	4.13E-04	1.51E-04	8.62E-05	5.91E-05	4.44E-05
E	1.47E-01	7.44E-02	2.45E-02	1.35E-02	8.93E-03	6.56E-03	2.66E-03	1.17E-03	7.38E-04	5.37E-04	4.21E-04
ESE	1.19E-01	6.53E-02	2.37E-02	1.41E-02	9.91E-03	7.59E-03	3.44E-03	1.62E-03	1.06E-03	7.84E-04	6.22E-04
SE	1.11E-01	6.29E-02	2.37E-02	1.46E-02	1.04E-02	8.07E-03	3.77E-03	1.81E-03	1.19E-03	8.86E-04	7.05E-04
SSE	7.78E-02	4.37E-02	1.63E-02	9.97E-03	7.11E-03	5.50E-03	2.55E-03	1.22E-03	8.02E-04	5.96E-04	4.74E-04
S	8.24E-02	4.46E-02	1.60E-02	9.43E-03	6.58E-03	5.02E-03	2.25E-03	1.05E-03	6.86E-04	5.07E-04	4.02E-04
SSW	1.12E-01	5.71E-02	1.88E-02	1.04E-02	6.90E-03	5.08E-03	2.07E-03	9.12E-04	5.77E-04	4.20E-04	3.30E-04
SW	1.76E-01	9.48E-02	3.36E-02	1.97E-02	1.37E-02	1.04E-02	4.63E-03	2.16E-03	1.40E-03	1.04E-03	8.20E-04
WSW	4.07E-01	2.23E-01	8.11E-02	4.85E-02	3.41E-02	2.61E-02	1.19E-02	5.61E-03	3.66E-03	2.71E-03	2.15E-03
W	1.26E-00	6.83E-01	2.45E-01	1.46E-01	1.02E-01	7.77E-02	3.50E-02	1.65E-02	1.07E-02	7.93E-03	6.29E-03
WNW	4.63E-01	2.43E-01	8.39E-02	4.82E-02	3.30E-02	2.48E-02	1.07E-02	4.91E-03	3.16E-03	2.32E-03	1.84E-03
NW	2.42E-01	1.26E-01	4.30E-02	2.45E-02	1.66E-02	1.24E-02	5.31E-03	2.42E-03	1.55E-03	1.14E-03	8.98E-04
NNW	2.20E-01	1.13E-01	3.80E-02	2.13E-02	1.43E-02	1.06E-02	4.43E-03	1.99E-03	1.26E-03	9.26E-04	7.28E-04

Annual whole-body dose to an individual located at a designated distance and direction from the plant site.

Basis for Dose Estimates: 1000 microcuries per second ^{85}Kr, 100 microcuries per second ^{31m}Xe, 1000 microcuries per second ^{133}X discharged from a release height of 82 feet with an inversion lid of 295 feet using the specific site meteorology data in an atmospheric dispersion model.

References

1. International Commission on Radiological Protection, *Recommendations of the International Commission on Radiological Protection (Report of Committee 2 on Permissible Dose for Internal Radiation)*, ICRP Publ. 2, Pergamon Press, London (1959).

2. F. T. Binford, T. P. Hamrick, and Beth H. Cope, *Some Techniques of Estimating the Results of the Emission of Radioactive Effluent from ORNL Stacks*, ORNL-TM-3187 (Oct. 1, 1970).

3. W. Doyle Turner, *The EXREM II Computer Code for Estimating External Doses to Populations from Construction of a Sea-Level Canal with Nuclear Explosives*, CTC-8 (July 21, 1969).

4. H. J. Dunster and B. F. Warner, *The Disposal of Noble Gas Fission Products from the Reprocessing of Nuclear Fuel*, United Kingdom Atomic Energy Authority, Harwell, Didcot, Berkshire (1970).

5. United States Department of Agriculture, *Agricultural Statistics 1969*, U. S. Govt. Printing Office, Wash., D. C. (1969).

6. W. Doyle Turner, S. V. Kaye, and P. S. Rohwer, *EXREM and INREM Computer Codes for Estimating Radiation Doses to Populations from Construction of a Sea-Level Canal with Nuclear Explosives*, K-1759 (Sept. 16, 1968).