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NUREG-0719

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Final Environmental Statement
related to the operation of Virgil C. Summer Nuclear Station Unit No. 1

Docket No. 50-395

South Carolina Electric and Gas Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

May 1981

8106120057

SUMMARY AND CONCLUSIONS

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

1. The action is administrative.

2. The proposed action is the issuance of an Operating License to the South Carolina Electric and Gas Company (the applicant) for the Virgil C. Summer Nuclear Station Unit 1 (Summer) located in Fairfield County, South Carolina, 42 km (26 miles) northwest of Columbia, South Carolina, and 1.6 km (1 mile) east of the Broad River, near Parr, South Carolina. The South Carolina Public Service Authority owns a one-third interest in this generating unit.

   The facility employs a pressurized-water reactor (PWR) to produce up to 2775 MWt. A steam turbine-generator will use this heat to provide 900 MW (net) of electric power capacity.

   The plant site is adjacent to Monticello Reservoir, a 2750-ha (6800-acre) reservoir created by the applicant as part of a pumped storage hydroelectric station.

3. The information in this statement represents the second assessment of the environmental impact associated with the Summer station pursuant to the guidelines of the National Environmental Policy Act (NEPA) of 1969 and 10 CFR Part 51 of the Commission's Code of Federal Regulations. After receiving an application for construction of this plant, the staff carried out a review of impacts that would occur during the construction and operation of this plant. This evaluation was issued as a Final Environmental Statement in January 1973. As a result of this environmental review, a safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and public hearings, the U.S. Atomic Energy Commission (now U.S. Nuclear Regulatory Commission) issued a permit in March 1973 for the construction of the Summer station. As of March 24, 1981, the plant was approximately 98% complete, with a proposed fuel-loading date of August 1981. The applicant has applied for a license to operate the nuclear unit. The required safety and environmental reports to support this application were submitted in December 1976. The staff has reviewed the activities associated with the proposed operation of this plant; the potential impacts, both beneficial and adverse, are summarized as follows:

   a. The increased generating capacity will support the increased load demand of the combined systems and will result in increased system and regional reliability. The increased electric energy production at the Summer station will result in production cost savings in 1981 as consumption of coal or oil at existing fossil-fueled units is reduced (Sect. 7).

   b. Conversion of 1057 ha (2616 acres) of farmland and forestland for the plant and its transmission lines has been necessary. The area impacted is only about 0.1% of the combined forest and agricultural land use in the counties involved (Sects. 4.2 and 8.2.1).

   c. Plant operation and employment is not expected to create a significant local social impact. The potential exists for increased economic development and associated population growth resulting from advantageous county tax income paid by South Carolina Electric and Gas Company to Fairfield County. Increased recreational benefits will accrue from a 120-ha (300-acre) subimpoundment and eventually possibly from all of Monticello Reservoir (Sects. 4.2 and 4.6).

   d. The impacts on terrestrial biota from plant operation and transmission corridor maintenance clearing will be acceptable.

   e. The thermal and chemical effluents from the station will comply with the requirements of the National Pollutant Discharge Elimination System (NPDES) permit and are not expected to significantly affect potential future recreational use of Monticello Reservoir or downstream water resources of the Broad River (Sects. 4.3 and 4.4).

f. The adverse impacts on aquatic biota of Monticello Reservoir that will occur from impingement on intake screens, entrainment through the cooling system, and imposition of the thermal effluent on portions of Monticello Reservoir near the discharge canal are not expected to be critical to the biological population of the reservoir. Significant effects of the nuclear station operation are not expected to extend to Parr Reservoir or the downstream rivers (Sect. 4.4.2).

g. No measurable radiological impact on man or biota is expected to result from routine operation (Sect. 4.5). The environmental risk from radiation exposure is very low.

4. The following Federal, State, and local agencies were asked to comment on this Environmental Statement:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
South Carolina Department of Health and Environmental Control
South Carolina Water Resource Commission
South Carolina Public Service Commission
South Carolina Wildlife and Marine Resources Department
Fairfield County Administrator, Winnsboro, South Carolina

5. This Final Environmental Statement was made available to the public, to the Environmental Protection Agency, and to other specified agencies in May 1981.

The following organizations submitted comments on the Draft Environmental Statement, which was published in June 1979:

Department of the Army, Corps of Engineers
Department of the Interior
Environmental Protection Agency
South Carolina Department of Health and Environmental Control
South Carolina Electric and Gas Company

The following organizations submitted comments on the supplement to the Draft Environmental Statement, which was published in November 1980:

Advisory Committee on Reactor Safeguards
Council on Environmental Quality
Department of Commerce
Department of the Interior
Environmental Protection Agency
South Carolina Electric and Gas Company
Washington Public Power Supply System

6. On the basis of the analysis and evaluation set forth in this statement and after weighing the environmental, economic, technical, and other benefits against environmental and economic costs, the action called for under NEPA and 10 CFR Part 51 is the issuance of an operating license for the Virgil C. Summer Nuclear Station Unit 1 subject to the following conditions for the protection of the environment:

a. License Conditions

Before engaging in operational activities that may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than evaluated in this Environmental Statement, the licensee shall provide written notification of such activities to the Director, Office of Nuclear Reactor Regulation, and receive written approval from that office before proceeding with such activities.

b. Significant Environmental Technical Specification Requirements

(1) The applicant will carry out the environmental (meteorological, radiological, and ecological) monitoring programs outlined in this Statement as modified and approved by the staff and implemented in the Environmental Protection Plan and the Radiological Effluent Technical Specifications incorporated in the operating license for the Virgil C. Summer Nuclear Station, Unit 1. Monitoring of the aquatic environment will be as specified in the NDPES permit issued by the South Carolina Department of Health and Environmental Control (SCDHEC).

(2) The applicant shall notify the Director, Office of Nuclear Reactor Regulation, of all cases in which the discharge limits included in the NPDES permit, are exceeded or if an application has been submitted to the permitting authority requesting revision of the limits.

(3) If, during the operating life of the plant, environmental effects or evidence of irreversible environmental damage are detected, the applicant shall provide the staff with an analysis of the problem and a proposed course of action to alleviate the problem.

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FOREWORD

This Final Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, in accordance with the Commission's regulation, 10 CFR Part 51, which implements the requirements of the National Environmental Policy Act (NEPA) of 1969.

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

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

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

(i) the environmental impact of the proposed action;

(ii) any adverse environmental effects that 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 that would be involved in the proposed action should it be implemented.

An Environmental Report accompanies each application for a construction permit or a full-power operating license. A notice of availability of the report is issued. Any comments by interested persons on the report are considered by the staff. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the Environmental Report, to seek new information from the applicant that might be needed for an adequate assessment, and to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Sect. 102(2)(C) of the NEPA and 10 CFR Part 51.

This evaluation leads to the publication of a Draft Environmental Statement, prepared by the Office of Nuclear Reactor Regulation, which is then circulated to Federal, state, and local government agencies for comment. A summary notice is published in the Federal Register of the availability of the applicant's Environmental Report and the Draft Environmental Statement. Interested persons are also invited to comment on the proposed action and the draft statement.

After receipt and consideration of comments on the draft statement, the staff prepares a Final Environmental Statement, which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final cost-benefit analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether - after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered - the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values. This Final Environmental Statement and the Safety Evaluation Report prepared by the staff are submitted to the Atomic Safety and Licensing Board (ASLB) for its consideration at public hearings held in connection with all construction permit applications and with operating license applications as ordered.

This environmental review deals with the impact of operation of the Virgil C. Summer Nuclear Station Unit 1. Assessments that are found in this Statement supplement those described in the Final Environmental Statement-Construction Permit (FES-CP) that was issued in January 1973 in support of issuance of a construction permit for the unit. The information to be found in the various sections of this Statement updates the FES-CP in four ways: (1) by identifying differences between environmental effects of operation (including those that would enhance as well as degrade the environment) currently projected and the impacts that were described in the preconstruction review; (2) by reporting the results of studies that had not been completed at the time of issuance of the FES-CP and that were under mandate from the NRC staff to be completed before initiation of the operational review; (3) by evaluating the applicant's preoperational monitoring program and factoring the results of this program into the design of a postoperational surveillance program and into the development of environmental technical specifications; and (4) by identifying studies being performed by the applicant that will yield additional information relevant to the environmental impacts of operating the Summer station.

Single copies of this Statement may be obtained by writing the:

Director Division of Technical Information
and Document Control
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. William F. Kane is the NRC Project Manager for this project. Mr. Kane may be contacted at the following address or at (301) 492-8969.

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

LIST OF CONTRIBUTORS

Name	Organization	Responsibility
Norman E. Hinkle	Oak Ridge National Laboratory	Team leader: Need for power, cost benefit
Allen M. Solomon	Oak Ridge National Laboratory	Terrestrial ecology
Ralph E. Greene	Oak Ridge National Laboratory	Chemical and sanitary wastes
Paul Kanciruk	Oak Ridge National Laboratory	Aquatic ecology
Alan J. Witten	Oak Ridge National Laboratory	Thermal hydrodynamics
Martin Schweitzer	Oak Ridge National Laboratory	Socioeconomics
Sarbes Acharya	U.S. Nuclear Regulatory Commission	Radiology
Francis Akstulewicz	U.S. Nuclear Regulatory Commission	Design features
Edward Branagan	U.S. Nuclear Regulatory Commission	Health effects
Richard Codell	U.S. Nuclear Regulatory Commission	Hydrology
James Fairobent	U.S. Nuclear Regulatory Commission	Meteorology
Sidney Feld	U.S. Nuclear Regulatory Commission	Need for the station
Gerald Gears	U.S. Nuclear Regulatory Commission	Terrestrial ecology
Reginald Gotchy	U.S. Nuclear Regulatory Commission	Health effects
Wayne Houston	U.S. Nuclear Regulatory Commission	Environmental impact of postulated accidents
Michael Kaltman	U.S. Nuclear Regulatory Commission	Risk consideration
Earl Markee	U.S. Nuclear Regulatory Commission	Meteorology
Michael Masnik	U.S. Nuclear Regulatory Commission	Aquatic ecology
Darrel Nash	U.S. Nuclear Regulatory Commission	Risk considerations
Hans Shierling	U.S. Nuclear Regulatory Commission	Accident experience and observed impacts
Leonard Soffer	U.S. Nuclear Regulatory Commission	Site features

1. INTRODUCTION

1.1 HISTORY

On June 30, 1971, the South Carolina Electric and Gas Company (SCE&G), the applicant, filed an application with the U.S. Atomic Energy Commission (AEC) [now U.S. Nuclear Regulatory Commission (NRC)] for a permit to construct the Virgil C. Summer Nuclear Station Unit 1, a pressurized-water reactor (PWR) with a thermal rating of 2775 MW and an electrical rating of 900 MW.

The conclusions reached in the staff's environmental review for construction were issued as a Final Environmental Statement-Construction Permit (FES-CP) in January 1973. Following reviews by the staff and the Advisory Committee on Reactor Safeguards, public hearings were held before an Atomic Safety and Licensing Board (ASLB) concerning safety and environmental matters on January 29 and 30, 1973. Construction Permit No. CPPR-94 was issued accordingly on March 21, 1973.

Amendment No. 2 to the construction permit (December 3, 1974) authorizes SCE&G to transfer one-third ownership of the Summer station to South Carolina Public Service Authority (SCPSA) and designates the latter as a coapplicant. However, SCE&G retains sole responsibility for technical direction of all phases of the project throughout the station's useful life.

In December 1976, SCE&G submitted an application, including a Final Safety Analysis Report (FSAR) and an Operating License-Environmental Report (OL-ER), requesting the issuance of an Operating License for the Summer station. These documents were docketed on February 24, 1977, and the operational safety and environmental reviews were initiated at that time.

As of March 24, 1981, construction of the Summer station was approximately 98% complete, and the applicant expects that the facility will be ready for fuel loading in August 1981.

The Summer station is part of a larger power generation complex that includes the Fairfield pumped storage facility. The environmental assessment of the pumped storage facility was the responsibility of the Federal Power Commission (Final Environmental Statement, Parr Hydroelectric Project, Federal Power Commission, Washington, D.C., March 1974).

1.2 PERMITS AND LICENSES

The applicant has summarized its contacts and coordination activities with the public and governmental agencies in Chap. 12 of the OL-ER. In compliance with regulatory requirements, SCE&G has obtained the following permits:

1. construction permit for a nuclear facility from the AEC (now NRC);
2. building permit from Fairfield County, South Carolina; and
3. National Pollutant Discharge Elimination System (NPDES) permit from the South Carolina Department of Health and Environmental Control (Appendix C).

2. THE SITE

2.1 INTRODUCTION

The staff revisited the site and reviewed documentation submitted by the applicant to determine if any significant changes at the Summer site had occurred that would alter the staff's evaluation presented in the FES-CP issued in January 1973. Changes in the socioeconomic structure of the community during the subsequent five-year construction period and additional understanding of the ecological baseline gained from preoperational monitoring studies are addressed in the following sections.

2.2 REGIONAL DEMOGRAPHY AND LAND USE

The Virgil C. Summer Nuclear Station is located in the southeastern corner of rural Fairfield County, South Carolina. The plant property covers approximately 890 ha (2200 acres) (OL-ER, p. 2.1-2) exclusive of the Monticello Reservoir associated with the project and the Fairfield pumped storage facility. The closest incorporated community is Peak, 6 km (4 miles) south of the site in neighboring Newberry County, with a 1975 population of 75. Other incorporated communities within 16 km (10 miles) of the facility are Pomaria, Chapin, and Little Mountain, each with 400 residents or less. Within 32 km (20 miles) of the site are a number of other cities and towns; the two largest are Newberry, the county seat of Newberry County, with 8998 residents, and Winnsboro, the county seat of Fairfield County, with a population of 3257.[1] In addition to the above, there are also a number of small, unincorporated communities (OL-ER, p. 2.1-8). The area within an 80-km (50-mile) radius of the site is shown in Fig. 2.1. Columbia, the State capital, is 42 km (26 miles) southeast of the site and with 111,616 residents[1] is the only city within the 80-km (50-mile) area with a population exceeding 35,000 (OL-ER, p. 2.1-31).

The region in which the Summer site is located is known as the Central Midlands and consists of Fairfield, Newberry, Lexington, and Richland counties. Although located in Fairfield County, the proposed plant is in close proximity to the other three counties. Like Fairfield, Newberry County is primarily rural. The counties of Lexington and Richland, on the other hand, are much more urbanized and make up the Columbia Standard Metropolitan Statistical Area (SMSA). Employee residence statistics compiled by the applicant's principal contractor during the peak construction period show that approximately 70% of all workers living within 80 km (50 miles) of the site made their homes in the four-county Central Midlands region.[2] The above figures indicate that plant-induced impacts have centered in the Central Midlands, and it is the opinion of the staff that this situation will continue. The following discussion of population, land use, and economics will therefore focus on Fairfield, Newberry, Lexington, and Richland counties.

2.2.1 Population changes

As of 1970, only eight people were living in the exclusionary zone within 1.6 km (1 mile) of the Summer site. Within 16 km (10 miles) of the proposed plant 6370 persons resided, an overall density of 20.3 persons per square mile. Figure 2.2, which gives population figures by annular rings for the area within 80 km (50 miles) of the site through the year 2010, shows that the density within 16 km (10 miles) of the site is expected to remain fairly low in the years ahead; the high projection for 2010 calls for an average density of only 27.2 persons per square mile. Population between the 32- to 48-km (20- to 30-mile) rings was the highest in the area in 1970 and will remain so through 2010 because of the presence of the Columbia SMSA. The growth rate in this ring is also expected to be the greatest in the years to come although population increases in the rest of the area should be substantial. The average density in the 80-km (50-mile) circle was 90.0 persons per square mile in 1970 and will be somewhere between 126.9 and 151.8 persons per square mile in 2010.

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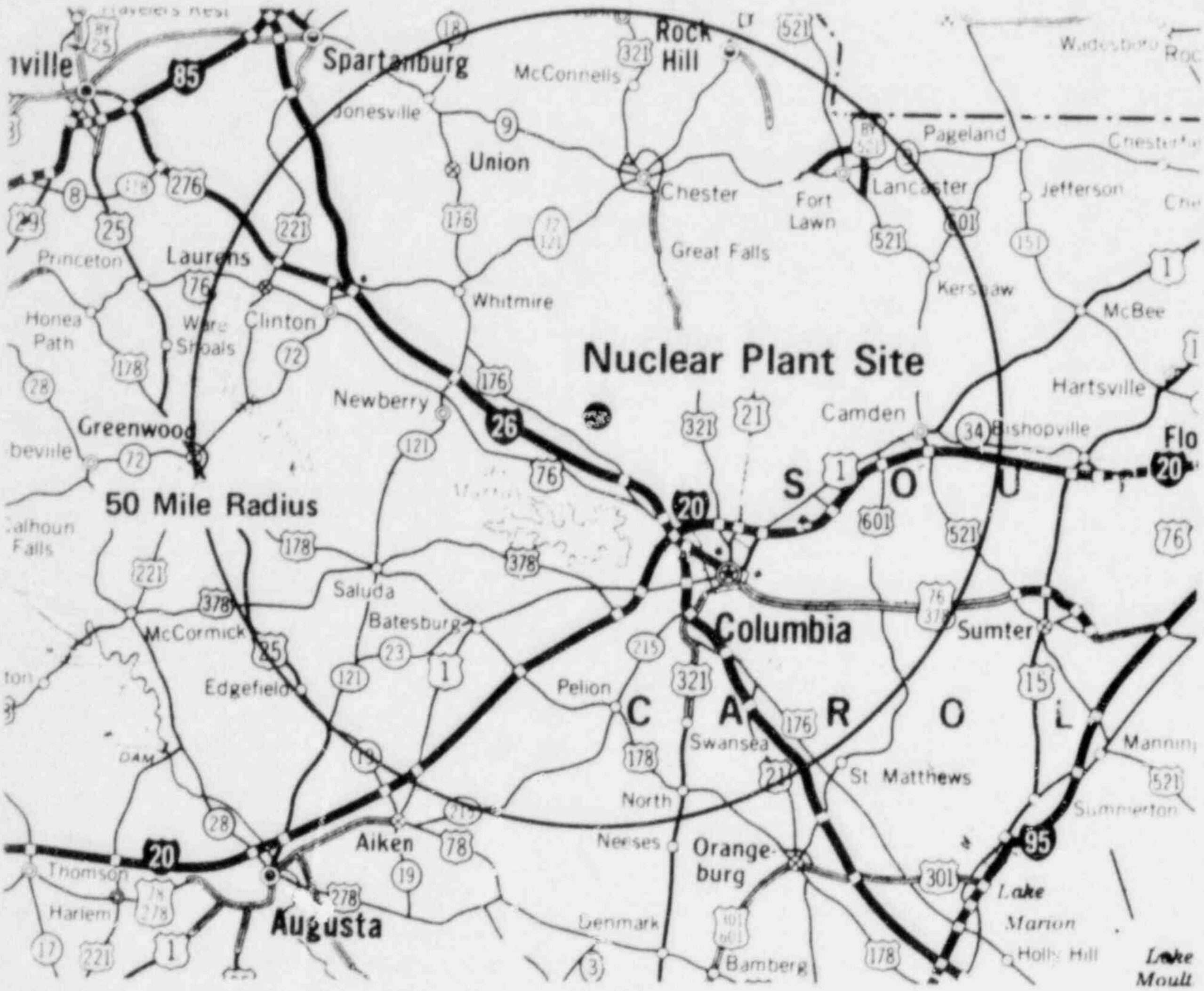


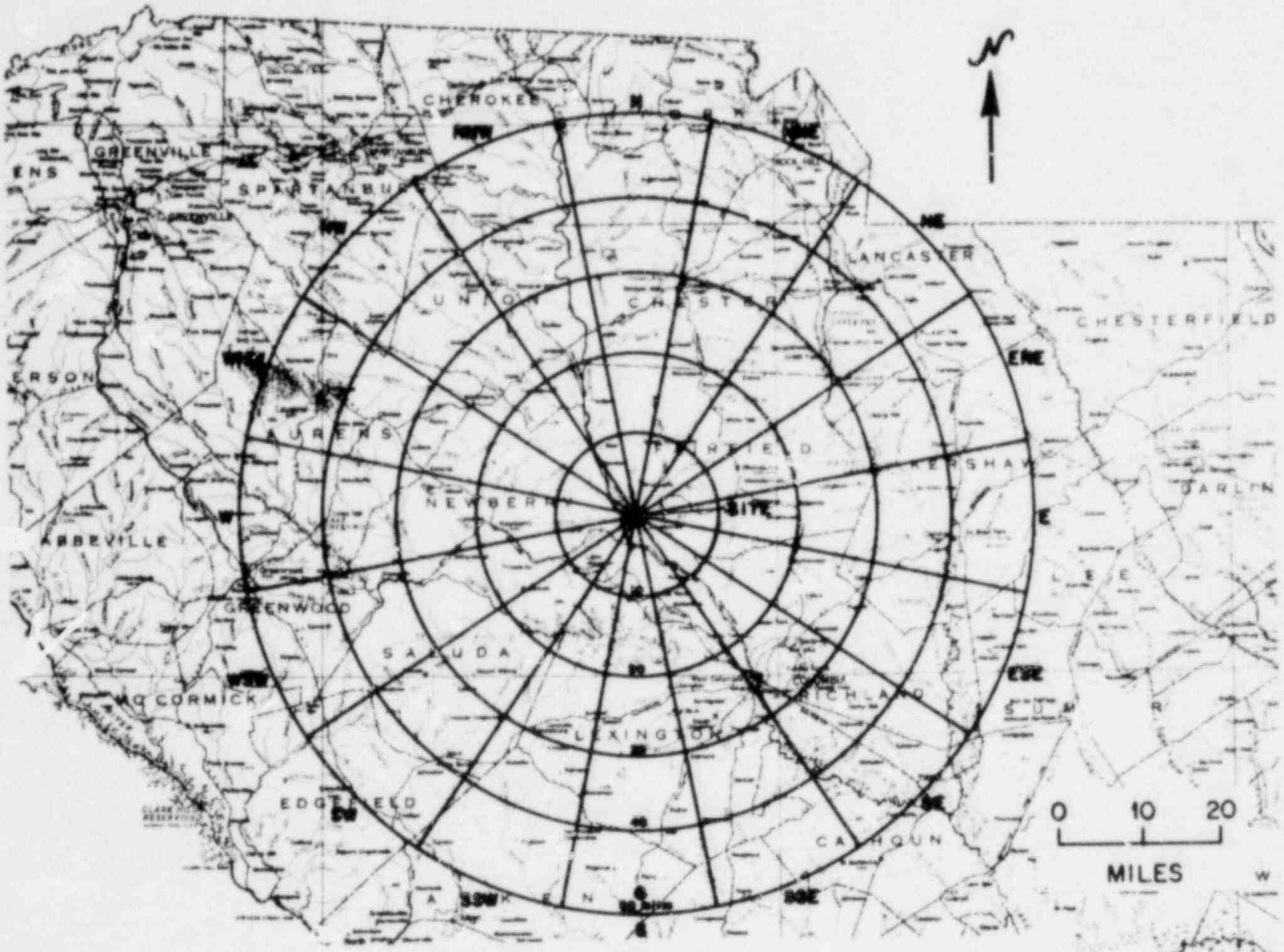
Fig. 2.1. Area within 80 km (50 miles) of the site.

The above population figures were developed by the Bureau of Economic Analysis (BEA) in late 1975 and differ somewhat from the 2010 projections presented in the FES-CP (FES-CP, p. II-7). Overall, the high projections given above are very close to the earlier figures; the low projections are, though, substantially less than those previously proposed. The older figures were based on the assumption of substantial future economic growth and consequent in-migration, whereas the newer figures reflect the possibility of slower growth. The following paragraphs give population figures for the area surrounding the plant site by county and, where appropriate, by municipality.

2.2.1.1 Fairfield County

Between 1970, before construction began on Virgil C. Summer Nuclear Station, and 1976, when peak construction was reached, the population of Fairfield County increased by 0.5%, from 19,999 to 20,100 (Table 2.1), and the composition changed slightly (Table 2.2). Between now and 1985, population growth will be fairly slow, but the last 15 years of this century are expected to bring a dramatic upswing. The projected population for Fairfield County in the year 2000 is 35,000 residents, an increase of [illegible].1% from 1985 and 74.1% from 1976.

In 1970, the city of Winnsboro, the county seat, had 3411 residents. By July 1975 that figure had fallen to 3257, a decline of 4.5%.



POPULATION BY ANNULAR RING

		0-10 MI	10-20 MI	20-30 MI	30-40 MI	40-50 MI	10-50 MI	0-50 MI TOTAL
1970		8,370	48,733	297,771	131,272	221,536	699,312	706,682

	PROJECTION	0-10 MI	10-20 MI	20-30 MI	30-40 MI	40-50 MI	10-50 MI	0-50 MI TOTAL
1979 PROJECTED	LOW	6,527	52,138	332,062	141,796	236,082	762,078	768,805
	HIGH	6,899	54,969	349,388	149,428	248,951	802,714	809,613

	PROJECTION	0-10 MI	10-20 MI	20-30 MI	30-40 MI	40-50 MI	10-50 MI	0-50 MI TOTAL
2010 PROJECTED	LOW	7,058	63,291	464,811	175,894	285,479	989,475	996,531
	HIGH	8,552	75,949	553,614	210,954	343,286	1,183,803	1,182,356

Fig. 2.2. Population within 80 km (50 miles) of the site, 1970, 1979, 2010.

Table 2.1. Population for Central Midlands region, 1970–2000

County	1970	1976	1980	1985	1990	1995	2000
Richland	233,868	252,600	266,000	292,700	322,000	370,000	416,000
Lexington	89,012	120,600	140,000	161,000	181,000	220,000	255,000
Newberry	29,273	31,200	32,200	33,800	38,250	42,750	47,500
Fairfield	19,999	20,100	20,700	21,750	25,500	29,500	35,000

Source: Central Midlands Regional Planning Council, *Population Projections for the Central Midlands Region*, Columbia, S.C., June 1977.

Table 2.2. Racial composition of Central Midlands region, 1970 and 1976

	Population by county (percentage of total)							
	Fairfield		Newberry		Lexington		Richland	
	1970	1976	1970	1976	1970	1976	1970	1976
White	40.6	38.1	66.9	66.9	87.6	92.2	68.0	64.0
Minorities	59.4	61.9	33.1	33.1	12.4	7.8	32.0	36.0

Source: U.S. Bureau of the Census and South Carolina Department of Labor, Division of Research and Statistical Services, *South Carolina Statistical Abstract, 1977,* Columbia, S.C.

2.2.1.2 Newberry County

The population of Newberry County increased by 6.6% between 1970 and 1976 (Table 2.1). Between now and the year 2000, total county population is expected to increase by another 52.2%, from 31,200 to 47,500.

Between 1970 and 1975 the population of Newberry, the county seat, declined by 2.4%, from 9218 to 8998.

2.2.1.3 Richland County

Between 1970 and 1976 the number of residents in Richland County rose by 8%, from 233,868 to 252,600 (Table 2.1). Between now and the turn of the century, Richland County is expected to grow at a rate midway between those expected for Fairfield and Newberry Counties. The projected population for the year 2000 is 416,000, 64.7% greater than the 1976 figure.

Like Winnsboro and Newberry, the city of Columbia also lost some residents in the years between 1970 and 1975. During that time, population in the capital city dropped by 1.7%, from 113,542 to 111,616.

2.2.1.4 Lexington County

Of all the counties in the Central Midlands region, Lexington County has experienced by far the fastest growth. From 1970 to 1976, its population grew from 89,012 to 120,600, a jump of 35.5% (Table 2.1). Between now and the year 2000, Lexington County's rapid growth is expected to continue and should surpass projected increases for the rest of the region. By the turn of the century, a population of 255,000 is expected, 111.4% greater than that in 1976.

2.2.2 Changes in land use

Land use in the vicinity of the site was described in the FES-CP. The only major changes in land use that have occurred since the FES-CP was issued in 1973 have resulted from construction of the Summer station and the adjacent Fairfield pumped storage facility. Before construction began, the nuclear plant site was totally forested. Its 356 ha (880 acres) consisted of 243 ha (600 acres) of coniferous forest, dominated by pines; 73 ha (180 acres) of deciduous forest; and 40 ha (100 acres) of mixed coniferous-deciduous forest (OL-ER, Table 4.1-1). The 356 ha cleared now support bare ground, occasional herbaceous weed communities, and the plant structures. During plant operation, 263 ha (650 acres) will remain cleared (OL-ER, Table 4.1-2), but 93 ha (230 acres) will be allowed to revert to natural vegetation. The nuclear unit and associated facilities will use about 81 ha (200 acres) of the cleared area (FES-CP, p. II-8).

Although the impacts on the land area affected by the pumped storage project are not a direct result of the nuclear plant licensing action, the staff presents the following summary of associated land use changes because of the recognized interrelationship of the two projects.

The 2750-ha (6800-acre) Monticello Reservoir previously consisted of 1267 ha (3130 acres) of coniferous forest, 441 ha (1090 acres) of deciduous forest, 631 ha (1560 acres) of mixed coniferous-deciduous forest, and 413 ha (1020 acres) of pasture and cropland. The enlargement of Parr Reservoir inundated 20 ha (50 acres) of coniferous forest, 870 ha (2150 acres) of deciduous hardwood forest, 81 ha (200 acres) of mixed coniferous-deciduous forest, and 40 ha (100 acres) of pasture and cropland (OL-ER; Appendix 2A, p. 5.3-13).

Transmission corridor construction resulted in destruction of 634 ha (1567 acres) of forest and also crossed 161 ha (399 acres) of pasture and cropland and 14 ha (34 acres) of water (OL-ER, Table 4.2-1 as corrected by the staff).

The area within an 8-km (5-mile) radius of the site includes parts of Fairfield and Newberry counties. Current land use in the 8-km radius, exclusive of the areas disturbed for construction, is dominated by lumber and pulpwood production (OL-ER, Fig. 2.1-25). Over 78% of the land is in second-growth forest; pasture and cropland cover about 12.8% of the area. Cropland is more frequent west of the plant site in Newberry County. Residential land uses control 1% of the land area and occur primarily along South Carolina Highway 215 from Jenkinsville to Monticello. Industrial and commercial land uses (including the plant site) involve less than 1% of the area; 3% of the area within 8 km of the plant site is cleared land (OL-ER, Table 4.1-1). The nuclear plant site and the previously forested portion of the transmission corridors constitute 2.5% of this land area. Most of Monticello and Parr reservoirs also lie within the 8-km radius, constituting almost all of the surface waters and covering 4.2% of the area (OL-ER, Table 2.1-6). The land area used for the reservoirs is not, however, a direct result of the nuclear station.

With one exception, no recognized Federal, State, or local public recreation areas existed within 8 km of the site before construction began (OL-ER; p. 2.1-12, Table 2.1-3). The exception is the Carlisle Game Management Area, which covers 60,000 ha (148,000 acres) of private and public land. It includes the nuclear plant site and approximately one-third of the Sumter National Forest lands, which occur 8 km north-northwest of the plant site. An index of the relatively good hunting potential of the game management area is provided by 1976 hunter-kill data on deer. Hunters in the management area bagged one deer per 41 ha (101 acres) (OL-ER, Sect. 2.1.4.1.3.4), whereas hunters in Newberry and Fairfield counties, which both overlap the management area, only bagged about one deer per 149 and 270 ha (369 and 667 acres) respectively.

Future land use projections for the 8-km area (OL-ER, Fig. 2.1-29) indicate that the growth rate is expected to be slow in this area, with minor residential development occurring along South Carolina 215. More rapid and widespread growth is expected in eastern Newberry County, where Interstate 26 has precipitated moderate urban and residential expansion, and in eastern Fairfield County after Interstate 77 is completed there. These potential growth areas are beyond the 8-km radius. A discussion of land use, land use regulations, and ownership for each of the counties in the Central Midlands region follows.

2.2.2.1 Fairfield County

In 1972-1973, almost 91% of the land in Fairfield County was used for forestry, and another 7% was used for agriculture. Less than 1% was residential; a negligible amount was used for manufacturing, transportation, and trade (Table 2.3). According to projections made by the Central Midlands Regional Planning Council, increased residential and industrial development will occur between now and the year 2000, necessitating more land for these purposes. Forestry should, however, continue to command a significant amount of the county's acreage.[3]

As shown in Table 2.4, the only land use regulation currently in effect in Fairfield County is a sediment-control ordinance. The county seat of Winnsboro, on the other hand, has no such ordinance but does have housing and construction codes, subdivision regulations, and zoning and mobile-home-park ordinances.

Over 95% of the land in Fairfield County is privately owned. Of the publicly owned land, 2.8% is controlled by the Federal government, 1.4% by the State, and less than 0.2% by municipalities, special districts, and the county combined (Table 2.5). Nearly all the Federal land is in the Sumter National Forest, whereas most State land is taken up by highway rights-of-way.

Table 2.3. Land use in the Central Midlands region, 1972–1973

	Land use by county (percentage of total[a])			
	Lexington	Richland	Newberry	Fairfield
Residential	4.8	6.9	1.6	0.9
Manufacturing	0.3	0.9	0.1	0.0
Transportation	0.3	0.3	0.0	0.0
Trade and services	0.2	0.4	0.0	0.0
Recreation	6.0	2.2	0.1	0.0
Agriculture	22.2	18.3	25.0	7.0
Forestry	65.9	57.5	71.0	90.8
Mining	0.2	1.6	0.0	0.1
Undeveloped	0.0	0.0	2.2	1.1

[a] Totals may not equal 100% because of rounding or missing data.

Source: ER, p. 2.1-38.

Table 2.4. Land use regulations in the Central Midlands region, August 1978

Government unit	Construction codes	Housing code	Subdivision regulations	Zoning ordinances	Mobile-home-park ordinances	Sediment control ordinance	Storm drainage ordinance
Fairfield County	No	No	No	No	No	Yes	No
Winnsboro	Yes	Yes	Yes	Yes	Yes[a]	No	No
Newberry County	No	No	Yes	No	No	No	No
Newberry	Yes	Yes	Yes	Yes	Yes[a]	No	No
Richland County	Yes	No	Yes	No	Yes	No	Yes
Columbia	Yes	Yes	Yes	Yes	Yes[a]	No	Yes
Lexington County	Yes	No	Yes	Yes[b]	Yes[a,b]	Yes	Yes

[a] Contained in the zoning ordinance.

[b] Only in the Seven Oak area of unincorporated Lexington County.

Source: Central Midlands Regional Planning Council, *Regional Codes and Ordinances Study*, Columbia, S.C., 1973 [updated in August 1978].

Table 2.5. Land ownership in the Central Midlands region, 1976–1977

County	Ownership (percentage of total)					
	Federal	State	Municipal	County	Special district	Private
Fairfield	2.8	1.4	0.07	0.02	0.1	95.61
Newberry	13.6	1.8	0.01	0.02	0.1	84.47
Lexington		2.7	0.1	0.4	0.6	96.2
Richland	11.6	4.9	0.2	0.2	0.3	82.8

Sources:

State Land Resources Conservation Commission, *S.C. Public Land Ownership Inventory: State and Federal Owned Lands, 1977*, Columbia, S.C.

State Land Resources Conservation Commission, *S.C. County and Municipal Public Land Ownership Inventory, 1976*, Columbia, S.C.

State Land Resources Conservation Commission, *S.C. Special Purpose Districts Public Land Ownership Inventory, 1977*, Columbia, S.C.

2.2.2.2 Newberry County

As seen in Table 2.3, 71% of Newberry County's land was used for forestry and 25% for agriculture in the years 1972 and 1973. Another 1.6% was residential, and only 0.1% was devoted to manufacturing. Long-range plans include increased residential and industrial uses; however, large portions will remain forested or in agriculture.[3]

The only land use control enacted to date by Newberry County has been a set of subdivision regulations; the town of Newberry has these plus construction and housing codes, a zoning ordinance, and a mobile-home-park ordinance (Table 2.4).

The Federal government owns 13.6% of the land in Newberry County, most of this inside the Sumter National Forest. Another 1.8% is State owned, and 0.13% belongs to municipalities, special districts, and the county itself. The remaining 84.47% is in private hands (Table 2.5).

2.2.2.3 Richland County

Table 2.3 shows 57.5% of Richland County in forestry and 18.3% in agriculture. About 6.9% of the land area is residential, and another 0.9% is devoted to manufacturing; both of these figures are higher than those for anywhere else in the Central Midlands region. In addition, more land is used for mining and trade here than in the other Central Midlands counties. Plans formulated by the Central Midlands Regional Planning Council call for increasing residential and industrial uses while protecting prime agricultural land and forestry areas.[3]

As seen in Table 2.4, Richland County has more types of land use controls than do the two counties previously described. Construction codes, subdivision regulations, and mobile-home-park and storm drainage ordinances are all in effect here. The city of Columbia has the above plus a housing code and zoning ordinance.

There is more publicly owned land in Richland County than in the other Central Midlands counties. Of the total, 11.6% is Federally owned, most of that in the Army's Fort Jackson, and another 0.7% belongs to municipalities, special districts, and the county. The State owns an additional 14.9%; about half of the State land is in highway rights-of-way, and the other half is split between parks, forests, properties for correctional and mental health facilities, and other lesser uses. The remaining 82.8% of Richland County is privately owned (Table 2.5).

2.2.2.4 Lexington County

In 1972-1973, 65.9% of Lexington County was used for forestry and 22.2% for agriculture. Of the remaining 11.9%, 6.0% was in recreational use, 4.8% was residential, and lesser amounts were used for manufacturing, transportation, trade, and mining (Table 2.3). The amount of land devoted to recreation is much larger than in the three counties discussed above, and the residential area here is nearly double that in Newberry and Fairfield counties combined. Future projections include a continuation of the urbanization that has occurred here over the last two decades, with both residential and industrial uses expected to increase; however, substantial portions of Lexington County should remain in forestry and agriculture.[3]

Lexington County also has numerous land use controls. The entire county has construction codes, subdivision regulations, and sediment control and storm drainage ordinances, and part of the county also has zoning and mobile-home-park ordinances (Table 2.4).

Less land is publicly owned in Lexington County than in the rest of the Central Midlands. There is no Federally owned land here. The State owns 2.7% of the county land, mostly in highway rights-of-way, and another 1.1% is controlled by special districts, municipalities, and the county itself. The remaining 96.2% is privately owned.

2.2.3 Changes in the local economy

2.2.3.1 Fairfield County

Between 1973, the year construction began on the Virgil C. Summer Nuclear Station, and 1978, Fairfield County's unemployment rate has fluctuated.[4] From 4.9% in 1973 it climbed to 7.3% in

1977 and then came back down to 5.0% for the first five months of 1978. This is above the 1978 Statewide unemployment rate of 4.4% but is closer to it than was the case in 1973 when the State figure was a low 3.6%.

As shown in Table 2.6, nonagricultural wage and salary employment in the county rose from 4690 persons in 1972 to 7480 in 1977. Most of this increase was due to a jump in construction activity directly attributable to the Summer station. At the same time, the number of manufacturing jobs in the county fell slightly whereas the government, services, finance, and trade sectors all experienced moderate gains. Though the number of jobs in transportation and public utilities more than doubled, their total still made up a minor share of the total. Of total county employment, 35.0% was in construction, 29.9% in manufacturing, 15.5% in government, and 8.4% in wholesale and retail trade.

Table 2.6. Nonagricultural wage and salary employment for the Central Midlands region, 1972 and 1977

	Average number employed annually[a]							
	Fairfield County		Newberry County		Lexington County		Richland County	
	1972	1977[b]	1972	1977[b]	1972	1977[b]	1972	1977[b]
Manufacturing	2,580	2,240	4,820	5,220	10,000	10,700	12,700	13,400
Food and kindred products					400	300	1,200	1,100
Textile mill products and apparel			2,800	2,950	900	2,200	1,600	1,400
Lumber and wood products	400	330	540	1,290	300	300	500	200
Printing and publishing					400	500	1,000	1,200
Stone, clay, and glass products	120	50			400	300	800	700
Fabricated metal products					700	800	1,300	1,600
Machinery, except electrical						1,200		1,300
Other manufacturing	2,060	1,860	1,480	980	6,900	5,100	6,300	5,900
Construction	80	2,620	290	330	2,100	2,900	7,400	5,000
Transportation and public utilities	140	350	230	250	1,600	2,600	6,200	5,800
Wholesale and retail trade	600	630	1,350	1,790	4,400	7,000	22,000	26,500
Finance, insurance, and real estate	80	90	200	200	500	900	7,400	11,100
Services	200	290	900	910	2,400	3,600	15,300	19,700
Government	960	1,160	1,230	1,530	4,000	5,600	32,900	44,200
Other nonmanufacturing	50	90	10	10	200	400	300	300
Total	4,690	7,480	9,030	10,230	25,200	33,700	104,200	125,900

[a] Employment by establishment or place-of-work basis. Because of rounding, totals may not be exact.

[b] Preliminary.

Source: South Carolina Employment Security Manpower Research and Analysis, *South Carolina Manpower in Industry*, Columbia, S.C., June 1978.

Between 1970 and 1976, average per capita income in Fairfield County increased by 91.1%, from \$2209 to \$4221 (Table 2.7). Of the 46 counties in South Carolina, Fairfield was ranked 36th in 1975,[5] but incomes were closer at that time to the State average than they were in 1970. During the same time period, retail activity in Fairfield County more than doubled; sales rose from \$15,064,000 to \$31,787,000 (Table 2.7).

2.2.3.2 Newberry County

Between 1973 and 1978, the unemployment rate in Newberry County went from 3.1 to 4.5%, which, though a marked increase, was considerably less than the peak of 6.1% reached in 1975.[4]

Total nonagricultural employment increased from 9030 in 1972 to 10,230 in 1977, and most of the major economic sectors experienced moderate gains. In both years, manufacturing accounted for slightly over 50% of all jobs in the county. Wholesale and retail trade provided 17.5% of the total in 1977, government contributed another 15%, and services accounted for an additional 8.9% of all jobs (Table 2.6).

Table 2.7. Per capita personal income and retail sales for South Carolina and the Central Midlands region 1970–1976

Region	Per capita income			Total retail sales		
	1970	1976	1978[a]	1970 ($10^3)	1976 ($10^3)	Percent change from 1970 to 1976
Fairfield	2,209	3,789	4,221	15,064	31,787	111.0
Lexington	3,409	4,783	5,118	40,629	63,166	55.5
Newberry	3,127	4,634	5,013	109,322	273,377	150.1
Richland	3,444	5,446	5,969	418,878	863,636	106.2
South Carolina	2,990	4,650	5,147			

[a] Estimates derived from average annual growth rate data by South Carolina Department of Labor, Division of Research and Statistical Services.

Sources: U.S. Department of Commerce, Bureau of Economic Analysis, and South Carolina Department of Labor, Division of Research and Statistical Services, *Per Capita Personal Income in South Carolina Counties, 1970–1976*, South Carolina State Development Board, Columbia, S.C., Oct. 28, 1977.

Per capita income in Newberry County rose 60.3% between 1970 and 1976, from $3127 to $5013, but this did not equal the Statewide increase of 72.1% in those same years (Table 2.7). Resident incomes ranked 12th in the State in 1975[5] and were almost identical to the State average; this reflects a loss since 1970 when they were slightly greater than the average.

Between 1970 and 1976, retail activity increased less in Newberry than in any of the other Central Midlands counties. Sales here rose 55.5%, from $40,629,000 to $63,166,000 (Table 2.7).

2.2.3.3 Richland County

Between 1973 and 1978, Richland County's unemployment rate went from 3.2%, slightly below the Statewide average, to 4.7%, slightly above it.[4]

The number of nonagricultural jobs in Richland County grew from 104,200 in 1972 to 125,900 in 1977; the current figure represents over seven times the number of jobs in Fairfield and Newberry counties combined (Table 2.7). Government, finance, service, and trade employment increased markedly while manufacturing increased slightly. Construction and transportation and public utilities declined during these years. The major employers in 1977 were government, accounting for 35.1% of the total number of jobs; wholesale and retail trade with 21.0%; services with 15.6%; manufacturing with 10.6%; and finance, insurance, and real estate with 8.8%. As a proportion of total employment, the government and service sectors here are significantly larger than those in rural Fairfield and Newberry counties, whereas the manufacturing sector is substantially smaller.

Per capita income in Richland County rose from $3444 in 1970 to $5969 in 1976; this is a gain of 73.3%, which is slightly higher than the Statewide increase of 72.1% (Table 2.7). In both 1970 and 1976, income in Richland County exceeded the Statewide average, and in 1975 it ranked second out of the 46 counties in the State.[5] In this same time period, retail sales increased by over 100%, from $418,878,000 in 1970 to $863,636,000 in 1976 (Table 2.7).

2.2.3.4 Lexington County

Between 1973 and 1976, unemployment in Lexington County rose from 3.2 to 6.4% and then declined to 3.5% for the first five months of 1978.[4] This latest figure is substantially below the Statewide rate of 4.4%.

The number of nonagricultural jobs in Lexington County rose from 25,200 in 1972 to 33,700 in 1977 (Table 2.6). Nonagricultural employment for the Columbia SMSA, consisting of Lexington and Richland counties, totaled 159,600, or 90% of all such jobs in the Central Midlands region. Within Lexington County itself there was a substantial increase in the number of jobs in all major sectors except for manufacturing, which grew only slightly. The latest figures show that manufacturing accounts for 31.8% of all employment, wholesale and retail trade for 20.8%, government for 16.6%, services for 10.7%, construction for 8.6%, and transportation and public utilities for 7.7%.

From 1970 to 1976, per capita income in Lexington County rose by 50%, from \$3409 to \$5118 (Table 2.7). This growth rate is less than that experienced by South Carolina as a whole, and the incomes of county residents have dropped slightly below the Statewide average. Still, incomes here were ranked 8th in the State in 1975.[5]

Between 1970 and 1976, retail activity in Lexington County increased more than in any of the other Central Midlands counties. Sales went from \$109,320,000 to \$273,377,000, a jump of just over 150% (Table 2.7).

2.3 WATER RESOURCES

The impacts of the Summer station on the hydrology of the site region will generally be few, especially when compared to those effects projected for the operation of the Fairfield pumped storage facility, as reported in the Final Environmental Statement by the Federal Power Commission (now the Federal Energy Regulatory Commission) for the Parr Hydroelectric Project.[6] Environmental impacts forecast at the construction permit stage and reported by the staff in the FES-CP remain essentially unchanged. The hydrologic engineering summaries presented in subsequent sections reflect the conclusions reached in the FES-CP with minor revisions and updating based on the OL-ER and the FSAR.

2.3.1 Hydrologic engineering description

The site is located approximately 1.6 km (1 mile) east of the Broad River and 4.8 km (3 miles) north-northeast of Parr Dam. The site is situated on a hilltop at an elevation of 133 m (435 ft) above mean sea level, or about 55 m (180 ft) above the Broad River floodplain.

The region surrounding the site is characterized by a network of small tributaries and a few substantial rivers draining the rolling, low-profile terrain into the Broad River. Available data indicate that the runoff is about 0.4 m (17 in.) annually.

2.3.1.1 Broad River and Parr Reservoir

The Broad River, the principal hydrologic feature in the vicinity, drains an extensive river basin above the site of about 11,800 km^2 (4550 sq. miles). The river basin lies between two southeast-northwest trending ridges stretching from Columbia, South Carolina, to the headwaters about 161 km (100 miles) northeast in North Carolina. The average annual runoff is about 5.1×10^9 m^3 (4.1×10^6 acre-ft). Many streams and creeks carry runoff and groundwater drainage into this water course; the important rivers draining into the Broad River basin include the Enoree, the Tyger, and the Pacolet. Near Columbia the Broad River joins the Saluda to form the Congaree River. Because it is very turbid, generally shallow, and has many rapids, the Broad River is not attractive for recreational use; there is also no commercial navigation. At Columbia, approximately 45 km (28 miles) downstream from the site, the water is a source of municipal and industrial supply.

In the vicinity of the Summer station, the Broad River is about 610 m (2000 ft) wide and quite shallow, ranging from 1 m or less to about 5 m deep. Many islands appear during normal flow. The shallow depth in this region is the result of silting behind the Parr Dam. The river flow in the vicinity of Parr Dam averages 173 m^3/sec (6100 cfs), with a wide range between floods and low water. It is essentially unregulated except during operations of the river hydroelectric projects, such as at Parr and Neal Shoals, which modify river flow. The record flood flow and low flow at the Richtex Station [11.3 km (7 miles) downstream from Parr Dam and about 18 km (11 miles) from the Summer station] were 6460 m^3/sec (228,000 cfs) on October 3, 1929, and 3 m^3/sec (105 cfs) respectively. The lowest recorded daily average flow was 4.2 m^3/sec (149 cfs). Low-flow frequencies for different durations of flow are shown in Fig. 2.3. The daily cycle of operation of the Fairfield Pumped Storage Hydrostation will transfer about 4?7 m^3/sec (29,000 acre-ft/day) of water between Monticello Reservoir and Parr Reservoir and back. The daytime drawdown will last about 8 hr and the nighttime pump-up about 10 hr, leaving a 6-hr daily slack time. This operation mode will be in effect Monday through Saturday; the station will operate at about half capacity on Sunday. The water level in Parr Reservoir has been raised 2.7 m (9 ft) by increasing the dam height at the Parr hydrostation. The operating drawdown of the pool will be about 3.0 m (10 ft).

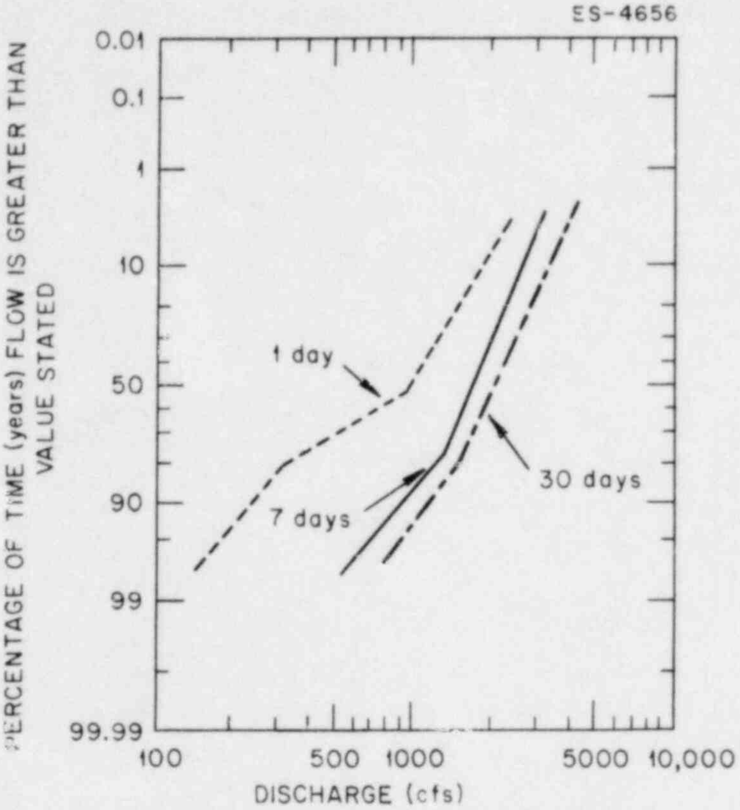


Fig. 2.3. Low-flow frequency and duration, Broad River at Richtex, South Carolina, 1931-1967. Note: Discharge is given as the average for the indicated time intervals. Source: FES-CP, Fig. 8.

The applicant has entered into an agreement (February 1973) with the South Carolina Wildlife and Marine Resources Department to maintain a minimum instantaneous flow release of 28 m^3/sec (1000 cfs) at Parr powerhouse during striped bass spawning (March, April, and May).[7] Minimum daily average release would be the natural inflow of the Broad River into Parr Reservoir. During other periods of the year, the minimum release would be 4.3 m^3/sec (150 cfs), with a minimum daily average of 23 m^3/sec (800 cfs).

2.3.1.2 Monticello Reservoir

Monticello Reservoir has been formed in the Frees Creek valley and receives water from Parr Reservoir through the Fairfield pumped storage facility. The impoundment has a surface area of about 2.8 x 10^7 m^2 (6800 acres) and extends north of the Summer site for about 11 km (7 miles). The average depth is 17 m (57 ft), and in the deepest parts the impoundment is about 30 m (100 ft). During planned operations, the normal drawdown in the impoundment will be about 1.4 m (4.5 ft), representing about 3.6 x 10^7 m^3 (29,000 acre-ft). The design elevation of the impoundment, 130 m (425 ft) above mean sea level, will be reached each day by pumping water back from Parr Reservoir. The impoundment, without the nuclear station, is expected to have an average surface evaporation rate of 0.93 m^3/sec (33 cfs). After initial filling, only the evaporation losses and seepage to groundwater will have to be made up from the Broad River. Seepage is expected to reenter the Broad River as groundwater. Figure 2.4 shows the flow and volume relationships between Monticello Reservoir, the Summer station, and the environs. As can be seen from this illustration, Monticello Reservoir is larger than Parr Reservoir, and the daily circulation through the Summer station is a small fraction of the Monticello Reservoir volume.

2.3.1.3 Other reservoirs

Columbia Dam is approximately 45 km (28 miles) downstream from the site on the Broad River. It is a small reservoir with a surface area of only about 1.1 x 10^6 m^2 (265 acres).

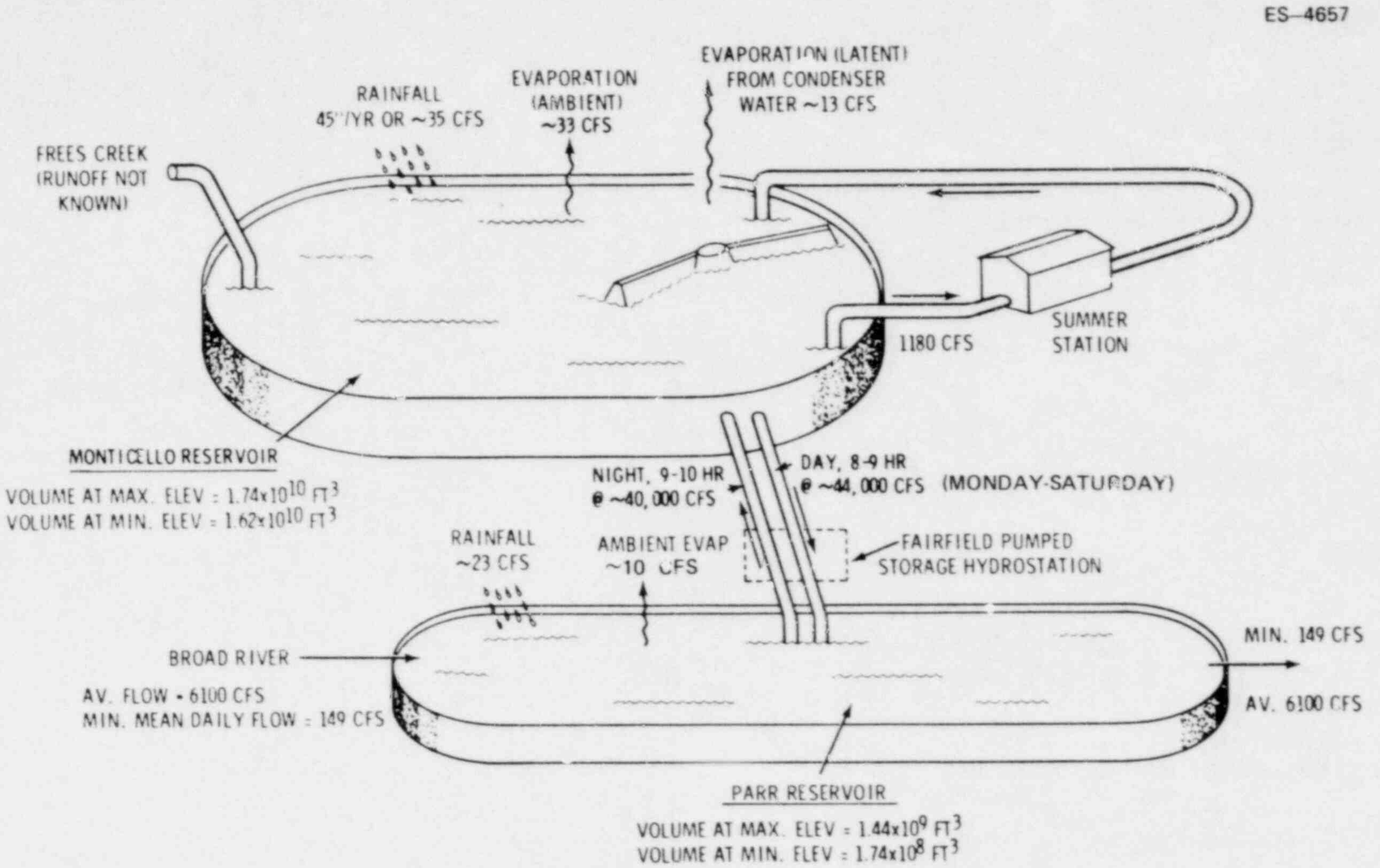


Fig. 2.4. Flow and volume relationships of Monticello and Parr reservoirs. Source: FES-CP, Fig. 9.

There are two small impoundments within Monticello Reservoir. The first is a small recreational impoundment in the northern portion that is physically isolated and not subject to water level changes from operation of the pumped storage facility. The second is the service water pond, which is protected by Seismic Category I dams and is part of the ultimate heat sink system for the plant.

2.3.1.4 Groundwater

Groundwater in the region occurs in two types of formations: (1) jointed and fractured crystalline bedrock and (2) the lower zones in the residual soil overburden. Recharge to these formations is by infiltration of precipitation falling in the upland areas. Some of the water infiltrating the surface soils evaporates, transpires from plants, or reemerges at the surface at short distances downslope from the point of infiltration. A small portion of the water percolates to perched water zones in the lower soils and into the water table in the underlying jointed bedrock.

In general, the groundwater table follows the land surface but with more subdued relief. Groundwater discharges as visible seeps and springs and/or percolates through the ground into creeks and streams. Some groundwater is discharged via wells, but the amount pumped is very small because the formations are generally not permeable enough to sustain well yields greater than 30 to 61 m^3/day (5 to 10 gpm). Construction and operation of the Summer station should not affect local use of groundwater.

The overburden soils release water slowly to the lower, more permeable units. As a result of the storage effect, yields of wells and flows of springs remain fairly constant and are sustained during periods of deficient precipitation.

The quality of groundwater that occurs within 61 m (200 ft) of the surface in the region is satisfactory for most industrial and domestic purposes. The water is low in dissolved solids, but high iron concentrations are commonly reported.

Following the recent impoundment of Monticello Reservoir, groundwater elevations may be expected to gradually rise. This is discussed further in Sect. 4.3.

2.3.2 Water use

2.3.2.1 Groundwater use

There are approximately 100 wells within 32 km (20 miles) of the site. Groundwater in the region is principally used for individual households and livestock. Wells in the region range from 19 to 111 m (62 to 365 ft) deep but are commonly less than 61 m (200 ft) deep, yielding 61 m^3/day (10 gpm) and less. Future groundwater development in the region is limited by the relatively low yield of the groundwater systems. The nearest well to the site is approximately 1.6 km (1 mile) to the east. The nearest public water supply is the well field at Jenkinsville, about 4 km (2.5 miles) southeast of the site. No groundwater will be used in the operation of the Summer station.

2.3.2.2 Surface-water use

Downstream of the site, surface water is withdrawn by a number of municipalities and industries. The largest user and the nearest population center on the Broad River is the city of Columbia, approximately 45 km, measured along the river (28 river miles), from the site. Columbia uses an average of 1.2×10^5 m^3/day (28.8×10^6 gpd), and nearly all municipal water is obtained from the Broad River. Table 2.8 gives approximate surface-water consumptive use from the Broad River downstream from the site.

Surface water is not used for irrigation at the present time, and there is no evidence that this practice will begin in the near future.

Table 2.8. Significant downstream surface-water users

Location and water user	Average daily use for drinking water (Mgd)	Population or number of employees	Source of supply
Fairfield County			
SCE&G, Parr Dam	0.030		Broad River
Richland County			
City of Columbia	27.0	228,456	Broad River, Saluda River
Lexington County			
City of West Columbia	2.8	19,690	Saluda River
Calhoun County			
Carolina Eastman Co.	0.036	800	Congaree River
Berkeley County			
Georgia Pacific	0.[illegible]		Lake Moultrie
Santee Wool Combing Co.	0.366		Santee River
City of Charleston	1.5		Black River Reservoir
Verona Div. Baychem Corp.	NS[a]		Black River Reservoir
The DuPont Co.	NS		Cooper River
SCE&G, Williams Station	0.003	65	Cooper River
Amoco (future plant)	NS		Black River Reservoir
Georgetown County			
Unknown user	NS		North Santee River

[a] NS – Average daily use not specified for new, future, and unknown users.

Source: OL-ER, Table 3.3.1.

2.4 METEOROLOGY

2.4.1 Regional climatology

The climate of the Summer site can be described as temperate and is characterized by long, warm summers and cool winters. Cold air moving southward into the area is modified by crossing the Appalachian Mountains. The summer circulation pattern is dominated by the semipermanent Bermuda high, which brings warm, moist air up from the Gulf of Mexico. The mean number of days annually with temperatures of 32°C (90°F) or higher is about 60; the mean number of days annually with temperatures of 0°C (32°F) or lower is also about 60.

2.4.2 Local meteorology

Data from the Climatic Atlas,[8] data for Columbia[9] located about 42 km (26 miles) southeast of the Summer site and available onsite information[10,11] were used to assess the local meteorological characteristics of the site.

Mean monthly temperatures in the vicinity of the site may be expected to range from about 7°C (45°F) in January to about 27°C (81°F) in July. Record maximum and minimum temperatures at Columbia are 42°C (107°F) and -19°C (-2°F) respectively.

Annual average precipitation at Columbia is about 1170 mm (46 in.) and is well distributed throughout the year. The maximum monthly average of about 140 mm (6 in.) at Columbia occurs in both July and August. The minimum monthly average at Columbia, about 60 mm (2 in.), occurs in November. The maximum 24-hr rainfall reported at Columbia is about 195 mm (7.66 in.), recorded in August 1949. Annual average snowfall is between 25 and 50 mm (1 to 2 in.), although 399 mm (15.7 in.) of snow fell at Columbia in a 24-hr period in February 1973.

At Columbia, heavy fog [visibility 400 m (1300 ft) or less] occurs on about 30 days annually, averaging 3 days each month from September through January.

The applicant has provided three years (January 1975 through December 1977) of meteorological data representative of site conditions.[11] The wind rose for the 10.5-m (34.4-ft) level for this three-year period is shown in Fig. 2.5. Winds from the southwest and south-southwest are most frequent (9.6 and 9.3% respectively), with winds from the east-southeast and east being less frequent (3.8 and 4.0% respectively). Calm conditions were recorded less than 0.1% of the time at the 10.5-m level.

2.4.3 Severe weather

The Summer site may be affected by thunderstorms, tornadoes, tropical storms, and hurricanes.

Thunderstorms can be expected to occur on about 55 days per year; 60% of these days should occur in June, July, and August.[9] The applicant estimates that lightning (usually accompanying thunderstorms) will strike the reactor building about once every two years. Severe thunderstorms can be accompanied by high winds and hail; there were 22 reports of winds of 25 m/sec (50 knots) or more and 14 reports of hail 20 mm (three-quarters of an inch) or more in diameter during the period 1955 through 1967 in the one-degree latitude-longitude square containing the site.[12] The "fastest mile" wind speed reported at Columbia was 27 m/sec (60 mph).

Information indicates that 49 tornadoes were reported in the period 1953 through 1974 in a 10,000-sq -mile area containing the site, a mean annual frequency of 2.2.[13] The computed recurrence interval for a tornado at the plant site is about 1590 years.[14]

In the period 1871 through 1977, about 45 tropical depressions, storms, and hurricanes passed within 80 km (50 miles) of the site.[15,16]

In the period 1936 through 1970, there were about 84 atmospheric stagnation cases, totalling about 340 days, reported in the site area.[17] About eight cases lasted seven days or more. The maximum monthly frequency occurs in October.

2.4.4 Long-term (routine) dispersion estimates

The applicant provided onsite meteorological data in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability for the period January 1975 through December 1977. Wind speed and direction were measured at the 10.5-m level, and atmospheric stability was defined by the vertical temperature gradient measured between 10- and 61-m (33- and 200-ft) levels. Data recovery for the period January 1975 through December 1977 was 96%.

Estimates of annual average atmospheric dispersion conditions were made for the Summer site using the three years of meteorological data as input to the atmospheric dispersion model presented in NUREG-0324.[18] This model is based on the "Constant Mean Wind Direction" model described in Regulatory Guide 1.111.[19] All releases were considered as ground level, and adjustments were made for mixing within the building cavity. An estimate of the increase in relative concentration (χ/Q) and relative deposition (D/Q) because of spatial and temporal variations in airflow, not considered in the straight-line model, was included as presented in NUREG-0324.

The calculation also included consideration of intermittent releases during more adverse atmospheric conditions than indicated by an annual average calculation by using the methodology described in NUREG-0324 that considers the total duration of release. Radioactive decay of effluents and depletion of the effluent plume were considered as described in Regulatory Guide 1.111.

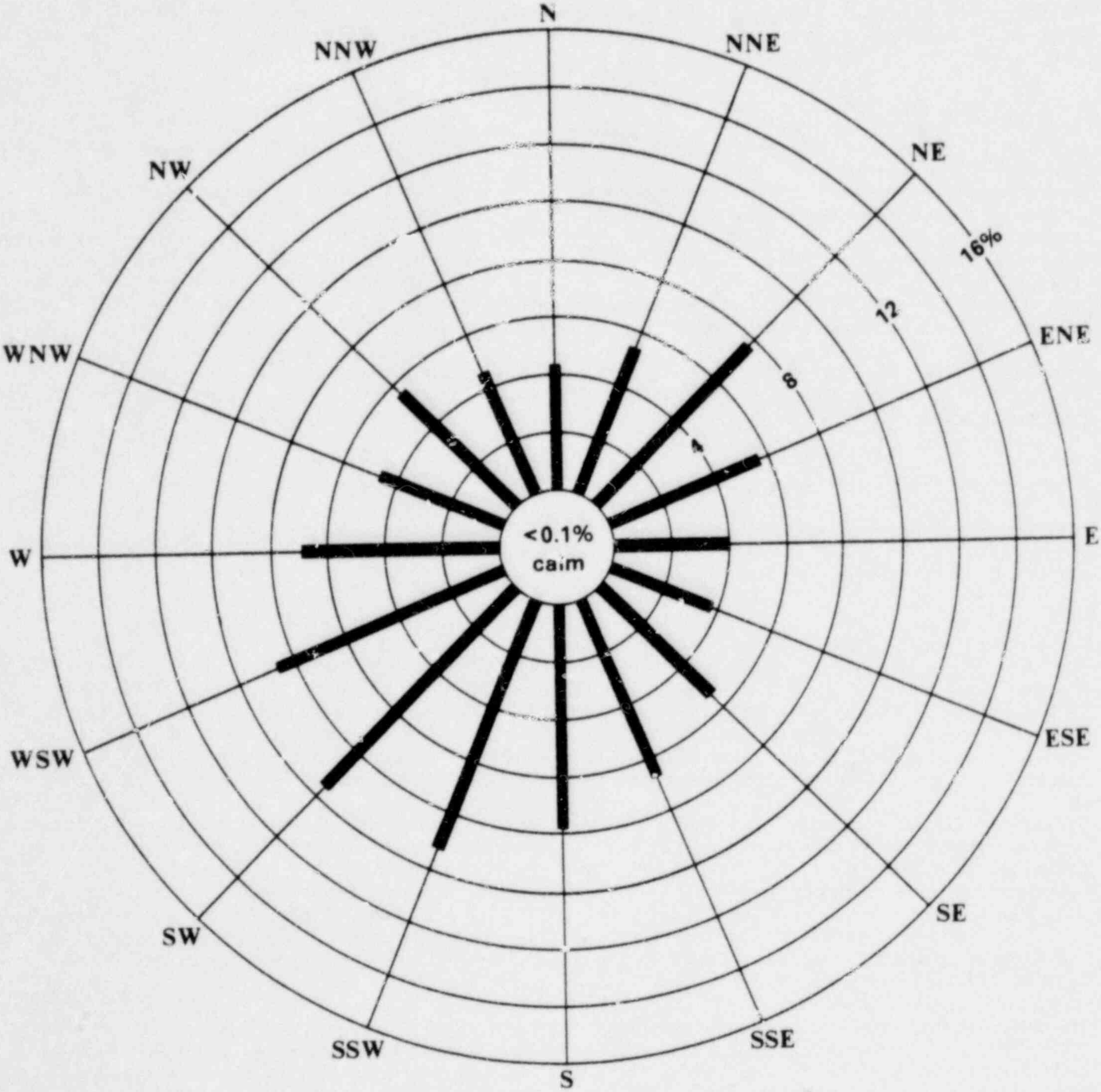


Fig. 2.5 - Wind Rose at 10.5 meter level - January 1975 through December 1977

2.5 SITE ECOLOGY

2.5.1 Terrestrial ecology

Ecological features of the plant site and vicinity were described in the FES-CP. Major changes in the terrestrial ecological features of the area since construction began have resulted primarily from land clearance for construction of the nuclear plant [356 ha (880 acres)], the filling of Monticello Reservoir [2750 ha (6800 acres)], increasing the capacity of Parr Reservoir [1012 ha (2500 acres)], and transmission line construction [572 ha (1410 acres) excluding 168 ha (415 acres) of unforested area that underwent no clearing before construction].

2.5.1.1 Plants

The vegetation associations removed by construction can be subdivided into four major community types (OL-ER, p. 2.2-1). A coniferous community on the well-drained upland sites was dominated by loblolly pine (*Pinus taeda*) and longleaf pine (*P. palustris*). Lowlands were covered on well-drained sites by deciduous species, including yellow poplar (*Liriodendron tulipifera*), oak species (*Quercus sp.*), and sycamore (*Platanus occidentalis*) and on poorly drained sites by willow (*Salix sp.*), blackgum (*Nyssa sylvatica*), water oak (*Quercus nigra*), and red maple (*Acer rubrum*). Mixed coniferous and deciduous communities, composed primarily of the aforementioned species, occurred on slopes where pine was logged allowing deciduous understory species to reach the forest canopy. A prairie-like community occurred on lands used as open pasture and on abandoned farmlands. The community was dominated by grass species in spring (bluestems, *Andropogon virginicus* and *A. gerardi*; three-awn, *Aristida* sp.) and by members of the sunflower or aster family (goldenrod, *Solidago* sp; fleabane, *Erigeron* sp; etc.) in late summer.

The flora observed at the Summer site consisted of 108 identified species, 99 genera, and 51 families (OL-ER, Appendix 2A, Tables 3.4.1 and 5.3.1). The staff finds that none of the species encountered in the site area are listed or proposed for Federal status as endangered or threatened.[20]

To date, the only plant species listed as endangered that occur in South Carolina include *Trillium persistens* and *Sagittaria fasciculata* (on the coastal plain).[20]

Economically important tree species include loblolly pine, several oak species, sweetgum (*Liquidambar styraciflua*), hickory species (*Carya* sp.), and red cedar (*Juniperus virginiana*). Second growth loblolly pine is the principal commercial species in the study area. As determined primarily from loblolly production, Newberry County was first and Fairfield County second among South Carolina counties in pulpwood production during 1975.[21] Annual loblolly pine production in the site area is about 575 bd ft/ha (OL-ER, p. 4.1-2).

2.5.1.2 Animals

In wildlife surveys conducted before and after issuance of the FES-CP, terrestrial vertebrate species observed on the nuclear plant site totaled 170, including 127 birds (OL-ER, Appendix 2A, Table 5.6.1, and Appendix 2B, Table 5.6.2a), 20 mammals (OL-ER, Appendix 2A, Sect. 5.7.3; FES-CP, Appendix A, Table 5.5.1), and 18 reptiles and 5 amphibians (OL-ER, Appendix 2A, Table 5.5.1).

Little new information on important species was gleaned from extensive sampling subsequent to issuance of the FES-CP, although there were minor differences in observations of vertebrate species of recreational importance (white-tail deer, turkey, bobwhite quail, mourning dove, and wood duck). An additional eleven transient species of ducks (black, pintail, ring-necked, bufflehead, baldpate, gadwall, and ruddy ducks; American widgeon, blue-winged teal; hooded and common mergansers) were observed either wintering in the area or migrating through it (OL-ER, Appendix 2A, Table 5.6.4, and Appendix 2B, Table 5.2.6a). No additional game mammals were seen, although the oppossum, a furbearer, was observed. Also, the red fox (*Vulpes fulva*) and the bobcat (*Lynx rufus*) were mentioned as likely residents of the area (OL-ER, p. 2.2-9).

Several endangered or threatened species[22] were observed or generally occur in the region, but all are known to be transients rather than residents. The red-cockaded woodpecker was observed in the region in 1971 (OL-ER, Appendix 2A, p. 5.6-30). The southern bald eagle, which normally nests along the Atlantic coast, was observed at Parr Reservoir in early August 1973 (OL-ER, Appendix 2A, p. 5.6-30). Suitable nesting habitat for Bachman's warbler (heavily timbered swamp, low brush, briers, or cane less than 1 m above the ground) occurs sporadically along the Broad River, but the warbler has never been seen there (OL-ER, Appendix 2A, pp. 5.6-30 and 5.6-31). The eastern indigo snake is restricted to coastal plain areas and lives primarily in sandhill communities where it frequents streams and swamps.[23]

Among endangered mammals, only the mountain lion (Felis concolor) was reported* in the project vicinity (OL-ER, Appendix 2A, p. 5.7-10). The citation did not specify date or location; the staff believes it is very unlikely that the mountain lion (if correctly identified) could be part of a reproducing population.

2.5.2 Aquatic ecology

The Summer station is located on the shore of the newly formed Monticello Reservoir. It will utilize the reservoir as a water source for its once-through cooling system. Monticello Reservoir has only recently been filled (spring 1978), and baseline data on water quality are sparse and are nonexistent for aquatic biota. A baseline preoperational aquatic survey of Monticello is currently being conducted by the applicant and will provide data useful in more accurately predicting operational impacts. The generalized analysis of projected aquatic impacts from station operation (Sect. 4.4) is based on data presented here, which the applicant collected for the preimpoundment Parr Reservoir Broad River area, and a postulated aquatic ecosystem for the newly formed Monticello Reservoir.

2.5.2.1 Surface-water description

Parr Reservoir was created by the 1914 damming of the Broad River to provide a pool for the original Parr hydroelectric facility. It was a relatively small and shallow (generally <6 m in depth) turbid main channel reservoir characterized by fairly low productivity. Monticello Reservoir was formed by the damming of Frees Creek, a very small tributary of the Broad River that flowed into Parr Reservoir about 2 km (1.2 miles) upstream from the existing Parr Dam. It was designed to serve both as the cooling lake for the Summer nuclear station and as the upper pool for the Fairfield pumped storage facility (with an enlarged Parr Reservoir serving as the lower pool). Water flow from Frees Creek into the newly created Monticello Reservoir was negligible, and use of the Fairfield pump/turbines was necessary to initially fill Monticello with water from Parr Reservoir and will be needed to maintain the average level in Monticello.

The amount of water that will be removed and returned to Parr daily (Sect. 2.3.1) represents approximately 88% of Parr's total capacity (1.1 day turnover rate) and will produce 3-m (10-ft) water fluctuations in Parr, exposing and recovering about 1030 ha (over 2550 acres) of littoral zone with each cycle. This daily "tide" will affect about a 16-km (10-mile) stretch of shoreline in Parr Reservoir. There will be an accompanying smaller water fluctuation of about 1.4 m (4.5 ft) in the much larger Monticello Reservoir, exposing about 64 km (40 miles) of shoreline. The daily water exchange through Fairfield represents about 7% of the total water volume in Monticello (14 day turnover rate).

Baseline water quality and aquatic biota data presented in the following sections are a summary of the efforts made by the applicant to characterize this region before the enlarging of Parr Reservoir or the construction of Monticello Reservoir. In addition, since the filling of Monticello Reservoir, the Fairfield pumped storage facility has been intermittently operational at reduced capacity, and its effects on the enlarged Parr Reservoir are not reflected in the following data.

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*Reported to the applicant by W. Schrader, a local private citizen.

2.5.2.2 Water quality

Seven transects with a total of 15 collecting points were designated by the applicant in the 1971 to 1974 baseline study (OL-ER, p. 3.1-1). These transects and stations were located above, below, and within Parr Reservoir and in Frees Creek (OL-ER, Appendix 2A, Map of Project Area).

Water temperatures were recorded at six stations from June 1971 to May 1973. Surface temperatures varied between 31.5°C (88.7°F) and 7.0°C (44.6°F) and bottom temperatures between 28.5°C (83.3°F) and 7.5°C (45.5°F).

Transparency in the Broad River was poor regardless of location or date of sampling and was restricted primarily by silt and clay. Secchi disk readings varied between 0.1 m (0.3 ft) and 0.7 m (2.3 ft) and averaged 0.35 m (1.2 ft). Sediment samples taken in the Parr Reservoir indicated that silt and clay predominated although some stations had a substrate consisting of a mixture of coarse, medium, and fine sand.

Some water quality values for the Parr Reservoir are given in Tables 2.9 and 2.10. Dissolved oxygen values were near saturation for both surface and bottom samples in the shallow Parr Reservoir. The pH was approximately neutral. Dissolved and suspended solids averaged 119.5 mg/liter and 295.2 mg/liter, respectively, and the water was soft, with total hardness averaging 17.8 mg/liter. Preliminary data from preoperational monitoring[24] indicate that dissolved oxygen concentrations in Monticello are high (even at depth); flushing action of the adjacent pumped storage facility is probably the cause of these concentrations.

2.5.2.3 Biota

A total of 260 phytoplankton species were collected from Parr Reservoir during the baseline study. The major groupings were Chlorophyta, 48 species; Chrysophyta, 199; Cyanophyta, 6; Euglenophyta, 5; and Pyrrhophyta, 2 (OL-ER, Appendix 2C, p. 2.3-1). Seasonal fluctuations of species composition were observed; greatest diversity usually occurred in March. Densities were low, varying from 134 to 1163 per liter (averaging 497 per liter). Taxa of the Chlamydomonadaceae (unidentified) were the most abundant algae, and Melosira distans and Nitzschia palea the next most abundant. Net phytoplankton biomass ranged from 0.3 to 22.8 mg per 100 liters (ash-free dry weight), with means of 2.1, 10.2, and 5.5 mg per 100 liters for the months of November, February, and May 1972 to 1973 respectively (OL-ER, Appendix 2A, Sect. 3.3.4.3). Assimilation values for carbon-14 were moderate, about 18 mg C m^{-3} hr^{-1} (OL-ER, Appendix 2C, Sect. 2.3.3.1.2).

Thirty-four zooplankton species were collected in the most recent phase of the baseline study for Parr Reservoir: Protozoa, 6 species; Porifera, 20; Copepoda, 2; and Cladocera, 3 (OL-ER, Appendix 2C, Sect. 2.3.3.2.1). Rotifers are usually the most abundant zooplankter[25] and comprised up to 73% of some Broad River samples. No one species was clearly dominant, and mean densities were usually less than 50 per liter. The copepod and cladoceran densities were low. In general, the relatively low densities of phytoplankton and zooplankton in Parr Reservoir indicate that a restricted productive capacity existed in this river system, probably because of the high turbidity and lotic conditions.

Eighteen species of vascular hydrophytes were identified in this study (OL-ER, Appendix 2A, Sect. 3.4.1). The predominant emergent species was cattail (Typha latifolia), which occurred in dense colonies along portions of the shoreline. Submergent species were generally not abundant, but were most prevalent in areas of reduced water flow.

Ekman dredge samples of the benthic community were taken to characterize this important habitat (OL-ER, Appendix 2A, Sect. 3.5.2). Sixty-six insect taxa were collected; Diptera and Ephemeroptera species dominated. Numerically, the dominate species were chironomid larvae, the phantom midge (Chaoborus punctipennis), and the burrowing mayfly (Hexagenia limbata). Densitites of insects ranged from 0 to 3763 per square meter, with the greatest densities occurring in June and November. The turbidity, current, substrate, and silt deposition in Parr Reservoir probably limited both insect diversity and density.

Table 2.9. Water quality data for Frees Creek and Broad River

Data in mg/liter except as noted

Determination	Station[a]											
	B–				D+				A–			
	Minimum	Maximum	Mean	Number of data points	Minimum	Maximum	Mean	Number of data points	Minimum	Maximum	Mean	Number of data points
Total dissolved solids	32	33	32.5	2	7	580	107.5	20	8	865	142.2	20
Total suspended solids	74	79	76.5	2	12	1110	275.9	20	16	1170	275.4	20
Total solids	106	112	109	2	49	1310	385	20	48	1750	417.6	20
Specific conductance, μmhos/cm	53	103	81	20	27	100	58.5	318	33	116	63	218
Total alkalinity	31	44	37	2	13	29	21	20	13	26	20	20
Calcium hardness	18	20	19	2	4	18	12.4	20	10	16	13	20
Magnesium hardness	2	10	6	2	2	6	2.7	20	2	6	2.6	20
Total hardness	20	30	25	2	12	20	15.5	20	14	20	15.6	20
Chlorides (Cl)	4.89	5.89	5.39	2	1.89	6.89	4.56	20	1.39	5.89	4.34	20
Sulfates (SO_4)	1.3	2.0	1.6	2	2.0	5.5	3.6	20	2.0	5.3	3.5	20
Nitrates (NO_3)	0.51	0.51	0.51	2	0.33	0.89	0.70	20	0.33	0.89	0.67	20
pH	6.7	7.4	7.2	20	6.4	7.6	7.0	315	6.3	8.0	7.2	207
Air temperature, °C	0.6	23.1	12.8	20		33	17.6	318	0.0	29.7	16	218
Water temperature, °C	6.6	21.5	12.7	20	3.3	29.7	16.0	318	3.3	28.1	14.9	218
Dissolved oxygen	5.8	10.4	8.2	20	3.8	13.2	7.7	318	5.0	14.8	8.3	218
Secchi disc, m	0.25	0.41	0.33	2	0.03	0.51	0.28	20	0.03	0.46	0.23	20
Color	75	125	100	2	40	750	122	20	40	750	143	20
Chemical oxygen demand	9.7	11.0	10.4	2	0	47	15.12	15	0	65.60	19.61	16
Soluble SiO_2	30.0	30.5	30.2	2	12	23	18.6	20	12	22.5	18.0	20
Sediment	20	140	[illegible]	20	40	4780	450	318	60	6340	623	218

[a] Station B– located about 1.5 km (0.9 mile) upstream in Frees Creek, D+ located on upstream side of Parr Dam, and A– about 14 km (8.7 miles) above Parr Dam.

Source: OL-ER, Appendix 2B, Tables 3.2.9a and 3.2.10a.

Table. 2.10. Trace metal analyses of surface waters of the Broad River study area (April 24, 1974)

Data in mg/liter except as noted

Determination	Station[a]		
	B–	D+	A–
Sodium (Na)	8.3	6.2	3.6
Magnesium (Mg)	2.7	1.5	1.7
Aluminum (Al)	1.9	2.9	1.8
Arsenic (As)	0.01	<0.01	0.01
Cadmium (Cd)	<0.01	<0.01	<0.01
Chromium (Cr), total	<0.03	<0.03	<0.03
Fluoride (F)	0.19	0.18	0.10
Iron (Fe), total	2.7	1.2	0.95
Lead (Pb)	<0.05	<0.05	<0.05
Manganese (Mn)	0.82	0.06	0.05
Mercury (Hg), μg/liter	<0.2	<0.2	<0.2
Nickel (Ni)	<0.02	<0.02	<0.02
Tin (Sn)	<2.0	<2.0	<2.0
Zinc (Zn)	<0.02	<0.02	<0.02
Selenium (Se)	<0.01	<0.01	<0.01
Vanadium (V)	<0.01	<0.01	<0.01
Beryllium (Be)	<0.02	<0.02	<0.02
Boron (B)	<0.1	<0.1	<0.1
Cobalt (Co)	<0.02	<0.02	<0.02
Molybdenum (Mo)	<0.3	<0.3	<0.3
Silver (Ag)	<0.02	<0.02	<0.02
Strontium (Sr)	0.6	0.3	<0.2
Copper (Cu)	0.036	0.008	0.008

[a] Station B– located about 1.5 km (0.9 mile) upstream in Frees Creek, D+ located on upstream side of Parr Dam, and A– about 14 km (8.7 miles) above Parr Dam.

Source: OL-ER, Appendix 2B, Table 3.2.12a.

Oligochaetes and molluscs were also important components of the benthic fauna. The Oligochaeta *Branchiuran sowerbyi* was a dominant form as were the pelecypods *Corbicula malinensis* (Asiatic clam) and *Sphaerium* sp. Biomass studies indicated values of 1.2 to 6.6 gm/m^2 (ash-free dry weight) for lentic-like areas (mostly chironomids and oligochaetes) and 22.4 to 164.1 gm/m^2 for lotic-like areas (mostly *Corbicula manilensis*).

Bluegill (*Lepomis macrochirus*) was the most abundant fish species collected in Parr Reservoir. Gizzard shad (*Dorosoma cepedianum*), mosquito fish (*Gambusia affinis*), white crappie (*Pomoxis annularis*), redear sunfish (*Lepomis microlophus*), and largemouth bass (*Micropterus salmoides*) were found in decreasing abundance. Table 2.11 lists the species collected, along with standing crop estimates.

2.5.2.4 Summary of baseline data for Broad River/Parr Reservoir area

The Broad River in the study area was characterized (before alteration) by a high silt load, high dissolved oxygen and suspended solids levels, and low buffering capacity. Parr Reservoir, a narrow, shallow, channelized run-of-the-river reservoir, had a relatively high flow rate and a low storage ratio (less than 1 day turnover rate). As a result, the main portion of the reservoir had lotic rather than lentic characteristics.

Phytoplankton production was greatest in the more lentic zones, whereas benthic macroinvertebrate biomass was greatest in the lotic areas near the dam. Diatoms were numerically the dominant species of phytoplankton. Densities of phytoplankton were always low, and population levels fluctuated greatly throughout the study period. Turbidity and lotic conditions appeared to be the primary factor limiting autotrophic production. As a consequence, phytoplankton

Table 2.11. Species composition, relative abundance, and average standing crop estimates for fish collected from the Broad River study area

Common name	Scientific name	Standing crop[a] (Kg/ha)	Percentage by number
Bluegill	*Lepomis macrochirus*	25.4	37.8
Gizzard shad	*Dorosoma cepedianum*	51.3	15.4
Mosquito fish	*Gambusia affinis*		7.3
White crappie	*Pomoxis annularis*	2.18	6.4
Redear sunfish	*Lepomis microlophus*	5.0	5.5
Black crappie	*Pomoxis nigromaculatus*	8.4[b]	5.1
Longnose gar	*Lepisosteus osseus*		4.1
Largemouth bass	*Micropterus salmoides*	14.9	2.7
Warmouth	*Lepomis gulosus*	2.2	2.3
Quillback carpsucker	*Carpiodes cyprinus*		2.1
Channel catfish	*Ictalurus punctatus*	5.8[b]	1.8
Shorthead redhorse	*Moxostoma macrolepidotum*		1.5
Whitefin shiner	*Notropis niveus*		1.0
Redbreast sunfish	*Lepomis auritus*		0.9
Carp	*Cyprinus carpio*		0.8
Sandbar shiner	*Notropis scepticus*		0.8
Brown bullhead	*Ictalurus nebulosus*		0.6
White catfish	*Ictalurus catus*	25.7[b]	0.5
River carpsucker	*Carpiodes carpio*		0.5
Snail bullhead	*Ictalurus brunneus*		0.4
Tessellated darter	*Etheostoma olmstedi*		0.4
Golden redhorse	*Moxostoma erythrurum*		0.3
Highfin carpsucker	*Carpiodes velifer*		0.3
Silvery minnow	*Hybognathus nuchalis*		0.3
Spottail shiner	*Notropis hudsonius*		0.3
Yellow bullhead	*Ictalurus natalis*		0.2
Pumpkinseed	*Lepomis gibbosus*		0.1
Black bullhead	*Ictalurus melas*		0.1
Silver redhorse	*Moxostoma anisurum*		0.1
Striped jumprock	*Moxostoma rupiscartes*		0.1
Spotted gar	*Lepisosteus oculatus*		0.1
Swamp darter	*Etheostoma fusiforme*		0.1
Golden shiner	*Notemigonus chrysoleucas*		0.1
Margined madtom	*Noturus insignis*		0.1
Hybrid sunfish	*Lepomis* sp.		0.1
	Species identified subsequent to sampling		
White bass	*Morone chrysops*		
Johnny darter	*Etheostoma nigrum*		
American eel	*Anguilla rostrata*		
Green sunfish	*Lepomis cyanellus*		
Spotted sucker	*Minytrema melanops*		
Satinfin shiner	*Notropis analostanus*		
Yellow perch	*Perca flavescens*		
Longear sunfish	*Lepomis megalotis*		
Smallfin redhorse	*Moxostoma robustum*		
Chub	*Hybopsis* sp.		
Pallid shiner	*Notropis amnis*		
Creek chubsucker	*Erimyzon oblongus*		
Tadpole madtom	*Noturus gyrinus*		
Speckled madtom	*Noturus leptacanthus*		
Threadfin shad	*Dorosoma petenense*		

Table 2.11. (continued)

Common name	Scientific name	Standing crop[a] (Kg/ha)	Percentage by number
Common shiner	*Notropis cornutus*		
Smallmouth buffalo	*Ictiobus bubalus*		
Spotted sunfish	*Lepomis punctatus*		
Black redhorse	*Moxostoma duquesnei*		
Suckermouth minnow	*Phenacobius mirabilis*		
White sucker	*Catostomus commersoni*		
Flat bullhead	*Ictalurus platycephalus*		

[a] Values averaged for two sample locations. See standing crop data in OL-ER, Appendix 2C, Tables 2.59 and 2.5.10.

[b] Data for one collection site.

appeared to contribute only marginally to the productivity of the Broad River. Allochthonous organic material apparently provided a large portion of the energy requirements for the river biota.

The composition of zooplankton of the study area was numerically dominated by rotifers. The community of benthic macroinvertebrates was characterized by relatively low diversity but, in some portions of the reservoir, high biomass. The Asiatic clam (Corbicula malinensis) was found in high densities in the reservoir. The burrowing mayfly (Hexagenia limbata) occurred throughout the system and contributed significantly to the benthic invertebrate biomass.

Submergent vascular hydrophytes were scarce and found mainly in protected areas near the dam. Although their abundance was usually low, emergent hydrophytes, which predominated, were found throughout the reservoir. The paucity of submergent forms in the protected arms of the reservoir probably resulted from the high turbidity and fluctuating water levels.

The fishes of the study area were represented by more than 55 species, dominated numerically by the bluegill sunfish, an important sport and forage species. Gizzard shad, a nonsport species but important primary consumer and forage species, ranked second. Standing crop data suggest that gizzard shad, bluegill sunfish, white catfish, and largemouth bass were the dominant species by biomass.

2.5.2.5 Predicted limnology of Monticello Reservoir

Because the water and biota now found in Monticello originated in Parr Reservoir and Frees Creek, baseline data gathered for that system will in some ways be applicable in predicting the aquatic habitat and ecology of Monticello. However, there are important differences between the physical environments of Monticello and Parr reservoirs, and these must be taken into consideration when postulating the aquatic ecology for Monticello.

Physical description

Monticello Reservoir differs physically from the old Parr Reservoir primarily in five respects:

1. Monticello is larger - about 100 times the volume of prealtered Parr Reservoir.

2. Monticello has a lentic environment (except as modified by the pumped storage facility), whereas old Parr had lotic regions influenced by Broad River flow.

3. Monticello is deeper, averaging 17.5 m (57 ft) in depth with a maximum of about 34 m (110 ft); old Parr Reservoir was quite shallow, averaging less than 4 m (13 ft).

4. Monticello is subject to stratification because of its morphometry, but old Parr rarely exhibited signs of classical thermal stratification because of shallowness and lotic conditions.

5. Monticello will be influenced by daily water level fluctuations of 1.4 m (4.5 ft) induced by Fairfield pumped storage operation.

Water quality

Water quality in Monticello will be influenced by pumped storage operation and the transfer of 3.57×10^7 m^3 (29,000 acre-ft) of water daily between Monticello and Parr. Preliminary thermal mapping by the applicant (June and July 1978) indicated that thermal and dissolved oxygen stratification and increased clarity (compared to Parr Reservoir levels) were in evidence in Monticello even when measured near the Fairfield intake structure. However, the Fairfield pumped storage facility had not been fully operational before these measurements were taken. Pumped storage operation will most likely disturb limnetic stratification, increase turbidity, and increase dissolved oxygen levels of the deeper water levels in Monticello near the intake/discharge structure. Vertical and horizontal circulation within Monticello will probably be enhanced by pumped storage operation.

Preliminary water quality data for Monticello indicate a fairly good aquatic environment. Surface dissolved oxygen values averaged near 8.9 mg/liter, or about 100% saturation, at the measured temperatures. Dissolved oxygen values decreased with depth, averaging 4.4 mg/liter at an average temperature of 14.2°C (57.6°F) and an average depth of 22 m (66.2 ft). These are, however, preliminary data for this newly formed system and will change as it ages and Fairfield becomes fully operational.

Aquatic flora and fauna

The recent impoundment of Monticello, the substantial but undefined influence of the Fairfield pumped storage facility, and the absence of an adequate biological data base for Monticello limit the ability to qualitatively and quantitatively predict the fauna and flora that will develop in this aquatic environment. It is assumed that Monticello will undergo a postimpoundment development cycle ("aging") of from three to ten years, and after maturity its biota will be similar to other lakes and impoundments in this general area (as modified, however, by pumped storage and nuclear plant operation).

Biotic colonization of Monticello has been initiated and will be influenced in its early stages mainly by input from Parr Reservoir through the Fairfield pumped storage facility. Species transported from Parr or that were in Frees Creek before inundation and are adapted to a shallow, flowing habitat will be quickly eliminated or eventually displaced (succession) by those adapted to a more lentic environment.

Leaching of nutrients from the newly inundated soils and vegetation along with more lentic conditions, relatively reduced turbidity, and enhanced nutrient mixing through pumped storage operation should stimulate phytoplankton and zooplankton community diversity and allow achievement of densities above the low values reported in the baseline survey for Parr (Sect. 2.5.2.3). Copepod and cladoceran species will become more abundant, often the case for lentic conditions.[24] Probably fewer insect, mollusc, and fish species will utilize the benthic environment because of the morphology and possible development of an oxygen deficient hypolimnion; although depending on the sediment types and extent of deoxygenation, the midge/oligochate/ mollusc communities may attain relatively high densities. The fish species listed in Table 2.11 for Parr Reservoir will be introduced to Monticello either as egg, larval, juvenile, or adult forms. In addition, a State-sponsored stocking program for the fishing impoundment in upper Monticello will introduce forage and game species (bluegill, largemouth bass) into this environment.

Establishment of these species will be in proportion to their abilities to adapt to this lentic environment as perturbed and modified by pumped storage operation. Pumped storage operation will modify the biotic environment in Monticello primarily in two ways: by induced water fluctuations and mixing in Monticello and by direct turbine-related fatalities caused by passage of organisms through the Fairfield system. The standing crop of littoral benthic hydrophytes can be expected to be relatively low because of the daily 1.5-m (4.5-ft) water fluctuations, resulting in reduced primary productivity and reduced juvenile fish habitat in Monticello. Species that use the shoreline during reproduction (nest-building species and those that disperse their eggs alongshore), in particular, may be adversely influenced by water level fluctuations in Monticello.[26-28] The extent of possible interference with the reproductive activities of nest-building centrarchids (bluegill, largemouth bass, other sunfish, etc.) and/or egg-dispersing clupeids, both important prey species, is uncertain. Rapid water level fluctuations during the spawning season can induce mortality in both groups through egg desiccation. There is some evidence, however, that centrarchids are able to adjust to periodic water level fluctuations by building their nests below minimum pool elevation,[26,28] but in such situations they are adversely affected by water velocities.[26] If shoreline water velocities in areas of Monticello exceed about 0.2 m/sec during pumped storage operation, then centrarchid reproduction may be further hindered.

Pumped storage operation (enhanced mixing and input of highly turbid Broad River water) will keep the turbidity level in Monticello above that which would otherwise occur. The higher turbidity will reduce phytoplanktonic and littoral-rooted vascular hydrophyte productivity. The productivity of the latter will also be reduced by daily 1.4-m (4.5-ft) water level fluctuations. This reduction in primary productivity is difficult to predict, but may be significant. Organic input to this system may rely heavily on allochthonous material received either directly from the surrounding shoreline or indirectly from Parr Reservoir through the pumped storage facility.

Passage of fish and other organisms through the Fairfield pumped storage pump/turbines will induce mortalities and probably affect standing crops of fish in Monticello. Fish screens are not present, and approach velocities during generation vary from about 150 cm/sec (5 fps) in front of the trash racks to over 600 cm/sec (20 fps) approaching the four 8.4-m-diam (26-ft) intakes. One-pass mortalities for pumped storage passage range between 33 and 75%, averaging about 60%.[29] Specific mortalities for this facility and their effect on standing crops are difficult to predict because they depend on the mechanical design of the pumped storage facility, the species composition, size class, distribution of fish, and the strata from which the station draws off water. For example, upper strata withdrawal for the Jocassee Hydrostation entrains more young-of-the-year fish than does deep water withdrawal.[27] At Fairfield, water will be withdrawn from both the surface and deeper strata during generation. Fish passing safely through Fairfield into Parr will most likely be drawn back through the pump/turbines Preliminary biological and water quality data received by the staff from the applicant[24,30] since publication of the DES indicate that Monticello Reservoir is undergoing biological colonization. Benthic macroinvertebrates were dominated by Diptera, with others (including Corbicula, the Asiatic clam) becoming established. Centrarchids (8 species) dominate the fish population, with bluegills the most abundant. The creek chubsucker was the second most abundant species. Gizzard shad had become established but were not abundant. Icthyoplankton samples indicate that reproducing populations of crappie, gizzard shad, and sunfish exist in Monticello. Vascular hydrophytes are sparse and are confined to the littoral zone.

These preliminary data describe an evolving system. Alterations may be expected as the system ages prior to commencement of operation of the Summer Station.

The staff expects that a species composition typical of reservoirs in this general area will eventually evolve in Monticello Reservoir, although primary productivity and standing crops of fish species may be reduced by the predictable but unquantifiable perturbations induced by pumped storage operation.

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3. THE STATION

3.1 INTRODUCTION

Since the issuance of the FES-CP, there have been a few relatively minor changes in the design parameters of the Virgil C. Summer Nuclear Station. In the following sections, the staff presents updated evaluations of plant systems operations. Particular emphasis is given to radioactive waste treatment systems, chemical waste treatment systems, and waste heat dissipation. Major system changes are noted where applicable.

3.2 DESIGN AND OTHER SIGNIFICANT CHANGES

3.2.1 Water supply

All water necessary for plant operation will be supplied from Monticello Reservoir. Table 3.1 gives anticipated flow rates of all plant water supply systems for maximum power operations, minimum power operations, and temporary shutdown. The only consumptive use of Monticello Reservoir water will be from the increased evaporation (above ambient) due to the thermal loads imposed by the plant. The incremental increase is estimated to be about 0.37 m^3/sec (13 cfs). The ultimate sources of makeup water to the reservoir will be the Broad River, runoff from several small tributaries of Monticello Reservoir, and direct rainfall into the reservoir.

Table 3.1. Flow rates (gpm)

Item	Maximum power operation	Minimum anticipated power operation	Temporary shutdown
Circulating water, total	534,000	400,000	400,000
Main condensers	480,000	366,000	366,000
Other cooling services	54,000	34,000	34,000
Service water, total	12,000	12,000	12,000
Component cooling heat exchangers	9,000	9,000	9,000
Other cooling services	3,000	3,000	3,000
Steam generator	250.0	30.0	30.0
Sanitary wastes	15.6	8.0	8.0
Miscellaneous nonnuclear drains	66.0	10.5	10.5
Water-treatment sludges	20.0	2.1	2.1
Ion exchange regenerant	11.1	2.1	2.1
Reactor grade water	0.14	0.14	0.14
Nuclear plant drains	0.93	0.93	0.93
Laundry and hot showers	0.31	0.31	0.31
Potable water usage	15.6	15.6	15.6

Source: FSAR, Table 3.3-2.

The average annual flow of the Broad River is 173 m^3/sec (6100 cfs). The large storage volumes provided by Parr and Monticello reservoirs would be able to maintain the minimum flow requirement of 4.2 m^3/sec (149 cfs) discharge over Parr Dam for an extended period of drought and still provide the nominal 0.37 m^3/sec of makeup water for the operation of the plant. The staff therefore concludes that there is adequate water supply for plant operation.

3.2.2 External appearance

The applicant has decided to let the exposed surfaces of the concrete reactor-containment building and other concrete structures weather naturally rather than applying any surface coating. The steel-framed structures are enclosed with metal siding of bluish color. Where feasible, the metal siding has been subdivided with vertical panels of translucent material, which permit diffused natural light to enter the buildings and add a visually pleasing change to the expanse of metal siding.

In their site visit, the staff found that the Summer station is not usually noticeable except from the open fields adjacent to Monticello Reservoir and from the State highway crossing the reservoir. This highway crosses at the 121-ha (300-acre) public recreation area near the extreme end of the reservoir, about 8.9 km (5.5 miles) away from the plant site.

3.2.3 Reactor and steam-electric system

The nuclear steam supply system (NSSS) for the Summer station is a three-loop PWR designed and furnished by Westinghouse Electric Corporation and has a core thermal power level of 2775 MW. The turbine-generator was supplied by General Electric Company and has a nominal power output of 900 MWe.

Subsequent to the construction permit proceedings, the reactor fuel element design for the Summer station has been slightly altered (FES-CP and OL-ER). This design change neither alters the maximum reactor thermal power level nor results in any change in the environmental impact.

There have been no other changes in the design of the reactor and steam-electric system that would result in a significant difference in the impact of the station on the environment. Therefore, Sect. III.C. of the FES-CP is still valid (Appendix H).

3.2.4 Heat dissipation system

The heat dissipation system at the Summer station consists of two subsystems: the circulating water system and the service water system. Makeup water for both of these systems is obtained from Monticello Reservoir.

3.2.4.1 Circulating water system

The circulating water system is designed to remove 6.67 × 10^9 Btu/hr of heat from the main and auxiliary condensers as well as the turbine auxiliaries. Cooling water is withdrawn from Monticello Reservoir at a rate of 2030 m^3/min (534,000 gpm), passed through the system, and ultimately returned to Monticello Reservoir. The intake structure, located along the south shoreline of the reservoir, has three pump bays, each with two entrances. Each entrance is 4 m (13 ft) wide and 7.8 m (25.5 ft) high, extending from the bottom of the pump house [elevation 119 m (390.0 ft)] to the bottom of a skimmer wall [elevation 126.5 m (415.5 ft)]. Each entrance has two sets of trash racks, conventional vertical traveling screens, and additional trash bars downstream of the screens. The applicant estimated the velocities within the intake structure for specific reservoir levels with all pumps operating. These velocities should be as follows:

	Emergency drawdown [elevation 127 m (418 ft)]	Normal low level [elevation 128 m (420.5 ft)]	Normal high level [elevation 129.5 m (425 ft)]
Approach velocity measured midway between traveling screen and trash rack, m/sec (fps)	0.17 (0.55)	0.16 (0.51)	0.13 (0.44)

	Emergency drawdown [elevation 127 m (418 ft)]	Normal low level [elevation 128 m (420.5 ft)]	Normal high level [elevation 129.5 m (425 ft)]
Velocity through the screen, m/sec (fps), when screens are			
100% clean	0.38 (1.24)	0.34 (1.13)	0.30 (1.00)
75% clean	0.50 (1.65)	0.46 (1.51)	0.40 (1.32)
50% clean	0.76 (2.48)	0.69 (2.27)	0.60 (1.98)

Further design details of the intake structure are shown in Fig. 3.1.

The heated water is returned to Monticello Reservoir via a discharge canal. The circulating water is delivered through a 12-ft-diam concrete pipe, which has an invert elevation of 123 m (403.5 ft), to a semienclosed basin created by the dam for the service water pond. The outlet for this basin is a canal that discharges the water to a sidearm of the reservoir. This canal is trapezoidal, with an invert elevation of 123 m (404 ft); the canal bottom is 25 m (75 ft) wide and the side slopes are 3:1. A jetty, 792.5-m (2600-ft) long, was built to inhibit recirculation of the heated water. A plan view of the power plant, its intake structure, and discharge canal is shown in Fig. 3.2.

3.2.4.2 Thermal analysis

A thermal analysis was performed for the applicant by Alden Research Laboratory.[1] A complete discussion of this analysis is given in Sect. V.B of the FES-CP.

The staff reviewed the applicant's thermal analysis and finds the results to be too conservative. Because the excess temperatures measured in the Alden physical model do not include any correction for the effect of the model scaling on the surface heat transfer, the results incorrectly indicate that the thermal effluent for the Summer station would violate the NPDES permit condition for excess temperature at the intake to the Fairfield pumped storage facility. After applying an appropriate correction (discussion of which follows), the staff finds that operation of the Summer station will be in compliance with the NPDES permit limitations.

The relevant section of the NPDES permit (Appendix C) reads:

> A monthly average surface temperature as high as 32.2°C (90°F) may be discharged from Monticello Reservoir; however, this surface temperature shall not be greater than 1.66°C (3.0°F) above ambient temperature on a monthly averaged basis. Surface temperatures shall be considered only during the generating mode of the Fairfield Pump Storage Facility.

Figure 3.3 shows plots of surface temperature, as predicted by the Alden physical model, at the intake to the Fairfield pumped storage facility averaged over the generating mode as a function of time under various ambient conditions. As this figure indicates, during extended periods of low ambient temperatures and Broad River flows of less than the average flow of 170 m^3/sec (6000 cfs), the ΔT limitation of the NPDES permit would be exceeded.

The staff has undertaken to correct this result using a more realistic surface heat transfer. The FES-CP stated that the surface heat transfer coefficient used in the Alden study was too low by a factor of 1.4. To correct this deficiency, the incorrect surface heat transfer coefficient must first be removed from the Alden results. This is accomplished through the formula

$$\Delta T' = \Delta T_0 \exp(ht/\rho C_p \delta) \ , \qquad (1)$$

where $\Delta T'$ is the excess temperature without surface heat transfer, ΔT_0 is the excess temperature predicted by the physical model, h is the surface heat transfer coefficient, t is time, ρ is the density of water, C_p is the heat capacity of water, and δ is the depth of the heated layer. Using the corrected surface heat transfer coefficient gives

$$\Delta T = \Delta T' \exp(-1.4ht/\rho C_p \delta) \ , \qquad (2)$$

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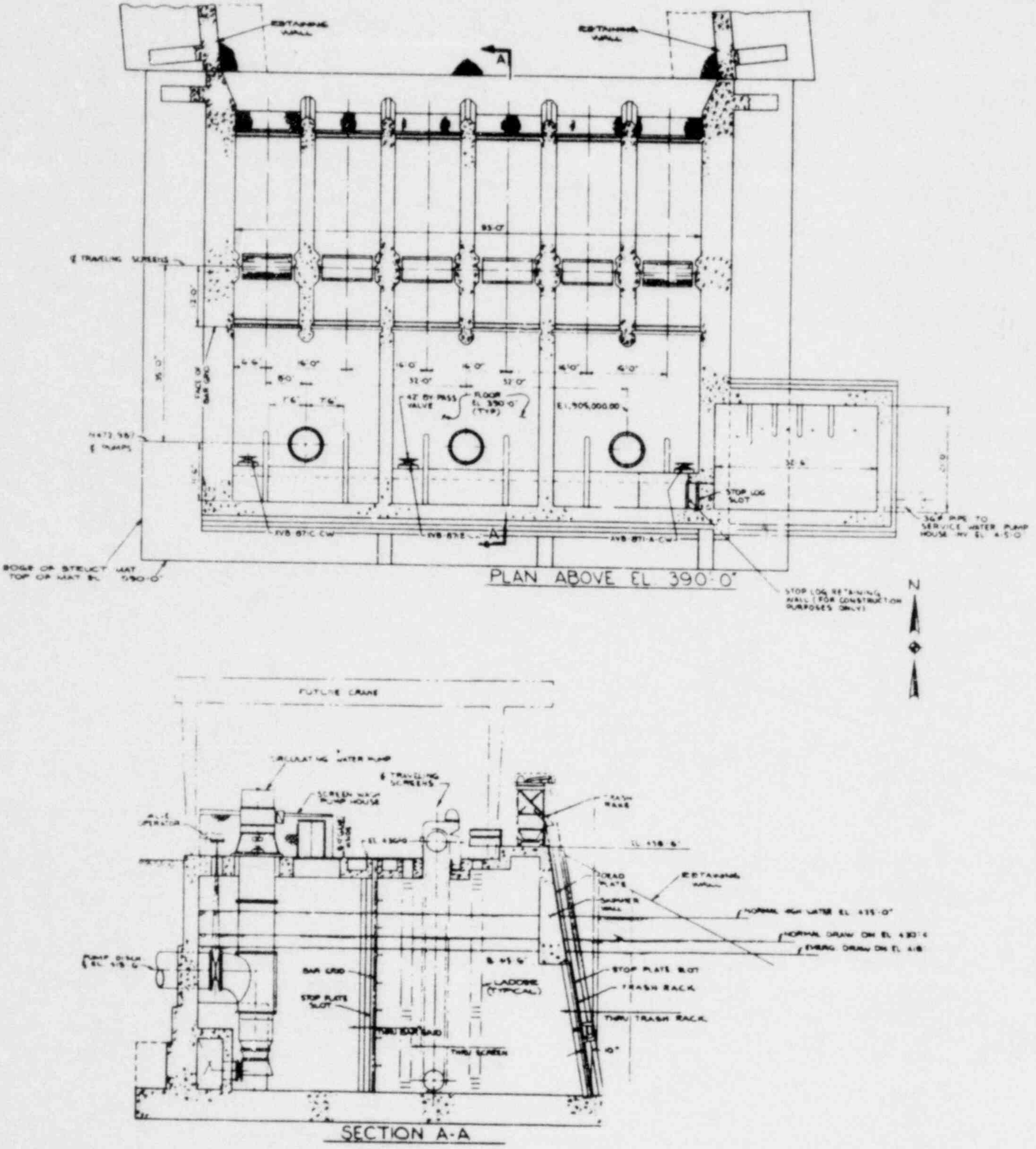

PLAN ABOVE EL 390'-0"

SECTION A-A

Fig. 3.1. Design details of the intake structure. Source: OL-ER, Fig. 3.4-3a.

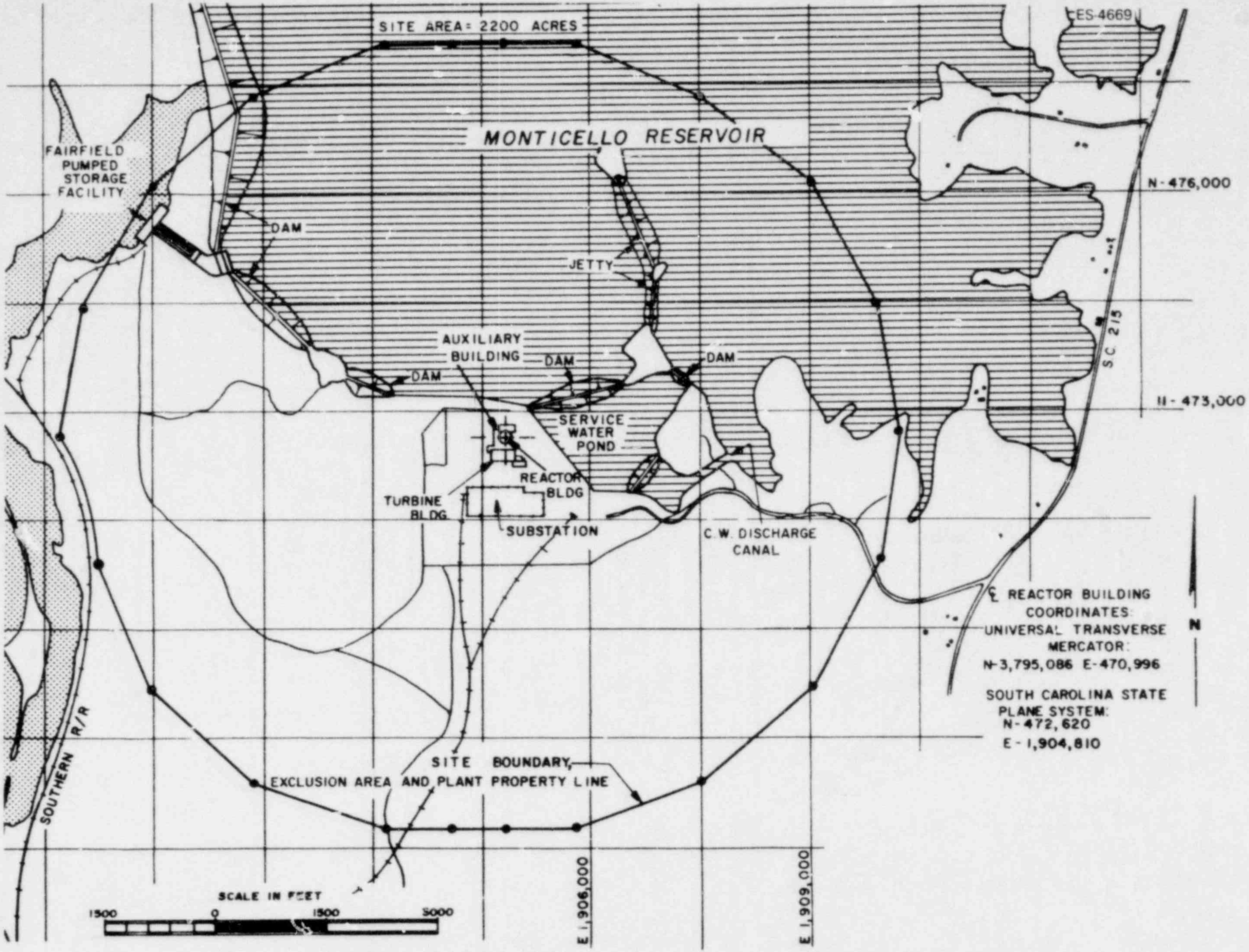

Fig. 3.2. Site area map for the Summer station. Source: OL-ER, Fig. 3.4-1.

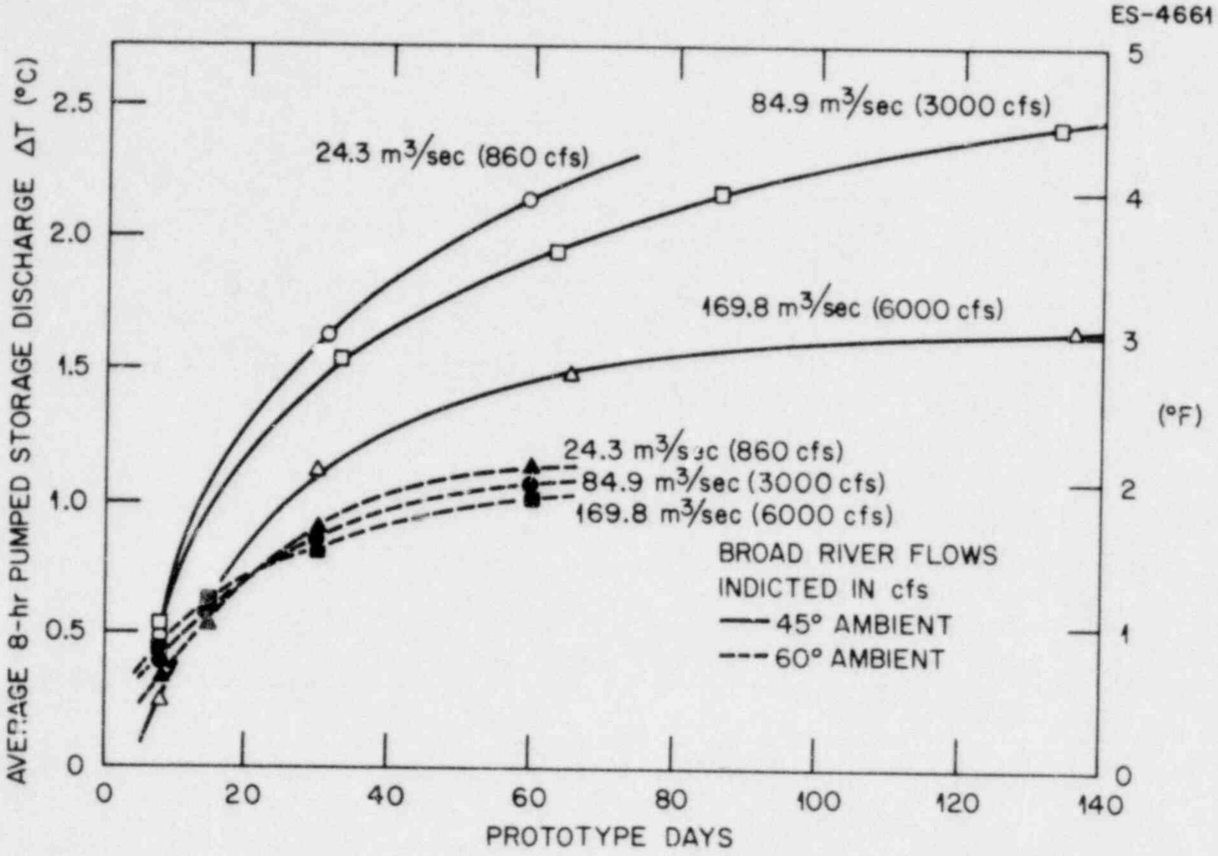

Fig. 3.3. Average temperature rise vs time at Fairfield Pumped Storage Hydrostation intake for operation of the Summer station. Source: Alden Research Laboratories, *Progress Report 2, Parr Hydroelectric Project*, Worcester Polytechnic Institute, Holden, Mass., June 1973, Fig. 57.

where ΔT is the corrected excess temperature. Combining Eqs. (1) and (2) gives the correction factor to the Alden results as

$$\Delta T = \Delta T_0 \exp(-0.4ht/\rho C_p\delta) \ . \qquad (3)$$

To apply this correction, the travel time from the discharge to a position x in Monticello Reservoir must be estimated. This is simply the ratio of the distance to the discharge velocity, or

$$t = x/u \ . \qquad (4)$$

To estimate the velocity, u, this discharge is assumed to be a two-dimensional laminar jet, a conservative assumption. If this theory is used, it can be shown that (ref. 2)

$$u = dx^{-1/3} \ , \qquad (5)$$

where d is a constant that depends on discharge conditions. Combining Eqs. (3), (4), and (5) gives the final form for the correction factor as

$$\Delta T = \Delta T_0 \exp(-0.4hx^{4/3}/d\rho C_p\delta) \ . \qquad (6)$$

The staff used this formula to correct the excess temperatures given in Fig. 3.3. In applying this formula, the following values were used:

h = 120 Btu/(ft^2·day·°F) ,
x = 18,000 ft ,
d = 86,400(ft)$^{4/3}$/day ,
ρ = 62.4 lb/ft^3 ,
C_p = 1 Btu/(lb·°F) ,
δ = 15 ft .

The corrected excess temperatures at the intake to the Fairfield facility averaged over the generating mode are given in Fig. 3.4. As can be seen, these calculations result in a 25% reduction in the excess temperatures given by the applicant. Figure 3.4 indicates excess temperatures greater than 1.7°C (3.0°F) during persistent periods of low flow and low ambient temperatures. Because of the conservatism in the staff's analysis and the low probability of these conditions occurring at the Summer site, the staff believes that the State thermal standards will be satisfied.

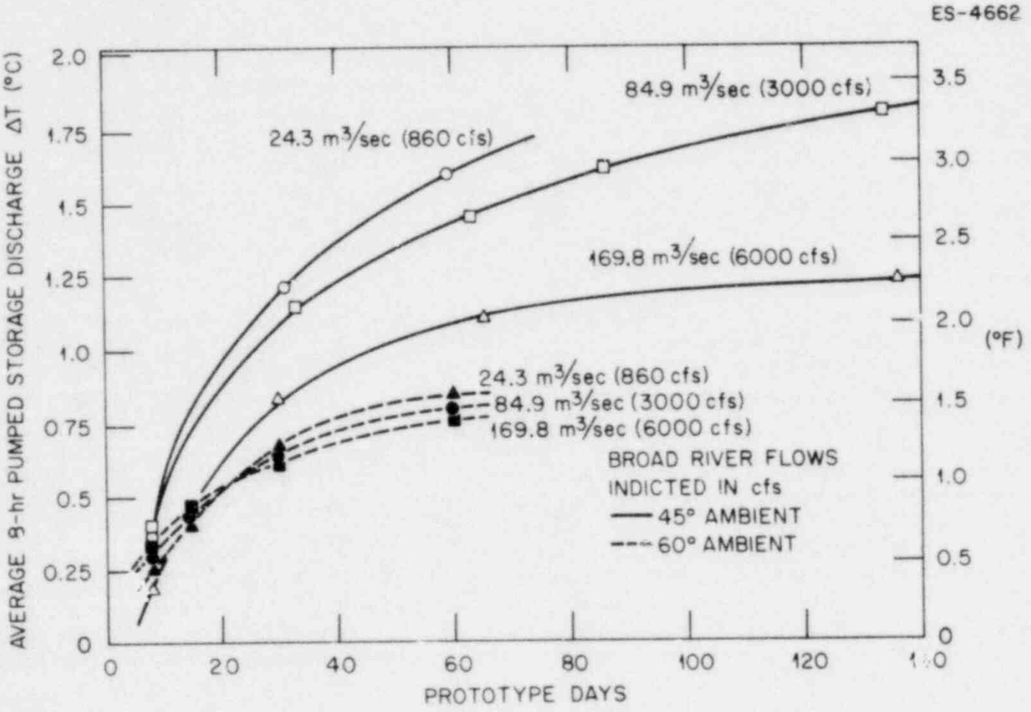

Fig .3.4. Corrected average temperature rise vs time at Fairfield Pumped Storage Hydrostation intake for operation of the Summer station. Source: Modified from Alden Research Laboratories, *Progress Report 2, Parr Hydroelectric Project*, Worcester Polytechnic Institute, Holden, Mass., June 1973, Fig. 57.

An additional concern is the effect of reservoir stabilization on the behavior of the discharge structure. The plant's discharge system is designed to induce stratification in order to maximize surface heat transfer and thereby minimize the temperature rise at the intake to the Fairfield pumped storage facility. This stratification is a necessary condition for meeting State thermal standards. The staff analyzed the thermal behavior of the discharge canal and found that, as designed, the desired stratification will be achieved. However, during the evolution of Monticello Reservoir, silting can be expected and could alter the bathymetry of the discharge canal to the point that stratification would no longer occur. Under these circumstances, State standards would probably not be satisfied. Because of this concern, the staff recommends that the applicant periodically survey the bathymetry of the discharge canal and, if necessary, dredge this canal to a level at which the discharge densimetric Froude number would be no more than 0.6, as determined from the ambient surface temperature measured at monitoring station 17 (Fig. 5.1). This value is a conservative value and was selected because at this value a cold water wedge could intrude into the discharge canal and proper stratification would still be assured. Such a procedure is judged as an appropriate precautionary measure to ensure continuous proper performance of the heat dissipation system.

3.2.4.3 Service water system

A detailed description of the Summer station service water system can be found in Sect. III.D.1.c of the FES-CP. The source of the service water supply is also shown in Fig. 3.2. No change has taken place in the design of this system.

3.2.5 Radioactive waste systems

Part 50.34a of Title 10 of the Code of Federal Regulations requires an applicant for a construction permit for a nuclear power reactor to submit a preliminary description of the design of equipment to be installed for controlling levels of radioactive materials in effluents to unrestricted areas. These effluent levels must be kept as low as is reasonably achievable. The term "as low as is reasonably achievable' implies consideration of the state of existing technology. The economics of improvement in relation to benefits to the public health and safety and other societal and socioeconomic considerations and in relation to the utilization of atomic energy in the public interest are equally important in this determination. Appendix I to 10 CFR Part 50 provides numerical guidance on design objectives for light-water-cooled nuclear power reactors in meeting the "as low as is reasonably achievable" requirement.

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

The staff's detailed evaluation of the liquid and gaseous radioactive waste systems and the capability of this system in meeting the requirements of Appendix I are presented in Chap. 11 of the Safety Evaluation Report (SER). The quantities of radioactive material the staff estimates will be released from the plant are also presented in Chap. 11 of the SER and in Sect. 4.5 of this Statement. The calculated doses to individuals and the population that will result from these effluent quantities are included as well.

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

The staff's detailed evaluation of the solid radwaste system and its capability to accommodate the solid wastes expected during normal operation, including anticipated operational occurrences, are presented in Chapter 11 of the SER. The staff estimates that approximately 15,000 ft^3 of "wet" solid wastes containing approximately 860 Ci of activity (mainly Cs-134, CS-137, Co-58, Co-60, and Fe-55) and approximately 10,000 ft^3 of "dry" solid wastes containing less than 5 Ci of activity will be shipped off-site annually from the Summer Nuclear Station to a licensed burial site. The packaging and shipping of all these wastes will be in accordance with the applicable requirements of 10 CFR Parts 20 and 71, and 49 CFR Parts 170-178.

3.2.6 Chemical, sanitary, and other waste treatment

The operation of the Summer station will result in the discharge of treated chemical wastes into the circulating water discharge canal. The several categories of chemical wastes and changes in treatment methods from those indicated in the FES-CP are briefly described below.

3.2.6.1 Startup wastes

The treatment of the startup wastes will be essentially the same as described in the FES-CP except for a few minor changes. All of the startup wastes will be pumped to one of the lagoons normally used for the water treatment wastes (OL-ER, Fig. 3.6-1) rather than to an oxidation pond or to the sanitary system, as described in the FES-CP. During the initial plain-water wash, the lagoon will act as a sedimentation basin for removal of trash and suspended solids. After settling, the plain-water rinse will be decanted to the debris layer, and then 760 m^3 (200,000 gal) of phosphate detergent flush [as opposed to 2300 m^3 (600,000 gal) of phosphate detergent, as specified in the FES-CP] and 2300 m^3 (600,000 gal) of final rinse water will be accumulated in the lagoon and treated on a batch basis. Characteristics of the startup wastes are given in the OL-ER, Table 3.6-3. Treatment, including pH adjustment, phosphate precipitation, and possible oil removal, will continue until analysis shows that the waste is of acceptable quality for discharge to the Monticello Reservoir. After treatment, the supernatant will be decanted and discharged to the reservoir. Acceptability of the treated startup wastes for discharge to Monticello Reservoir will be determined by compliance with the discharge limitations imposed by the NPDES permit (Appendix C). Any significant sludge accumulation will be dewatered and disposed of in a sanitary landfill.

3.2.6.2 Floor drains and oil-contaminated waste

This source of waste includes spills, leakage, and general cleanup from various floor drains and storm drainage from the transformer area and from the fuel oil storage and handling facilities. Average flow of this stream will be 75,706 liters/day (20,000 gpd), with a maximum flow of 359,605 liters/day (95,000 gpd) and a minimum of 56,779 liters/day (15,000 gpd). In a change from the FES-CP, the applicant now plans to separate the oil in a retention basin using a skimmer rather than using an oil separator before introduction of the waste to a retention pond. Recovered waste oil will be sent offsite for disposal. The treated effluent will gravity flow from the retention basin and combine with treated sanitary and other treated industrial wastes before entering the circulating water discharge canal. The applicant estimates that the retention basin effluent will contain 15 mg of oil per liter and have a BOD of 25 mg/liter (OL-ER, p. 3.6-2). In the treatment described in the FES-CP, the final effluent leaving the pond was expected to have a BOD of 37 mg/liter, which is somewhat greater than the currently anticipated discharge level. The FES-CP gave no concentration of oil in the final effluent but indicated the concentration of oil in the effluent from the oil separator was expected to be less than 100 ppm.

3.2.6.3 Ion-exchange regenerant waste

Ion-exchange demineralization will be used to purify feedwater to the steam generators and water used as the primary coolant for the reactor. Staff review indicates some minor but no significant changes between the FES-CP and the OL-ER. The sodium hydroxide and sulfuric acid regenerant wastes will be combined and the pH adjusted between 6 and 9 (formerly 7 ± 1) before being discharged. In the OL-ER, the applicant indicated the rate of discharge of this stream to be 946 liters/min (250 gpm) to the circulating water discharge in quantities ranging from 41,638 to 60,565 liters/day (11,000 to 16,000 gpd). The corresponding discharge time would range from 44 to 64 min/day. Discharge of this stream at the maximum concentration of 11,500 mg/liter of total dissolved solids (OL-ER, Table 3.6-2) and at a rate of 946 liters/ min (250 gpm) into the circulating water discharge of 2,021,366 liters/min (534,000 gpm) will yield a concentration of approximately 5 mg/liter total dissolved solids (primarily sodium and sulfate ions) in the circulating water discharge during the 44 to 64 min/day discharge period. Averaged over a 24-hr period, the maximum average concentration of ion-exchange regenerate waste in the circulating water discharge should be less than 0.25 mg/liter. This concentration will be reduced further when the discharge is diluted with the water of Monticello Reservoir. The concentrations of total dissolved solids from regenerate waste discharged into Monticello Reservoir are small compared with those naturally present (≈50 mg/liter) in the reservoir.[3]

3.2.6.4 Steam-generator blowdown

The steam-generator blowdown system continuously purges the steam generator of impurities, maintaining the secondary water chemistry. The blowdown is essentially demineralized water to which small amounts of chemicals are added to act as oxygen scavengers and to maintain the water quality within specifications. The blowdown can be discharged to either the circulating water discharge or to the nuclear blowdown processing system. Effluent from this latter system will be recycled to the main condenser hot well or to the penstocks of the Fairfield pumped storage facility. Table 3.2 lists the expected characteristics of the steam-generator blowdown.

Table 3.2. Characteristics of steam-generator blowdown based on continuous discharge

Characteristic or constituent	Concentration (mg/liter)[a]		Average discharge (lb/year)
	Maximum[b]	Average	
pH, at 25°C	10.0	8.9	
Free hydroxide ($CaCO_3$)	0.15	0.15	82
Sodium	0.5	0.1	55
Chloride	0.5	0.15	82
Ammonia	0.5	0.25	137
Hydrazine	150	Negligible	Negligible
Silica	5	1.0	548
Iron	1.0	0.5	273
Copper	1.0	0.5	273
Suspended solids	9.0	3.0	
Flow, gpm	250	125	

[a] Units are in milligrams per liter except for pH measurements and flow rates.

[b] Maximum values are based on startup conditions that may occur once per year, discharging approximately three steam-generator volumes equivalent to 0.4 X 10^6 lb/year.

Source: OL-ER, Table 3.6-1.

3.2.6.5 Water treatment plant wastes

Water treatment plant wastes were not discussed in the FES-CP; therefore, a brief description of this treatment follows.

Water for uses other than cooling will be treated in the water treatment area. The raw water will be taken from the Monticello Reservoir and may receive all or part of the following treatment:

1. clarification,
2. sand filtration,
3. carbon absorption, and
4. demineralization (ion exchange).

The backwash from the demineralization facilities will be discharged to the circulating water system. The blowdown from the clarification process and the backwash from the sand filtration and carbon absorption processes will be collected in a sump and transferred to the waste treatment area for treatment. Treatment will consist of sedimentation before combination with the other effluents for release to the circulating water discharge canal.

From past experience with similar types of operation, the applicant expects that the approximate quantities of waste will be:

	liters/day	gpd
Clarifier blowdown	18,927	5,000
Sand-filter backwash	52,995	14,000
Carbon-filter backwash	37,853	10,000

The water treatment plant wastes will be treated to remove suspended solids; by doing so, the BOD in the clarifier sludge will also be removed. The treatment system will use two lagoons operated on a batch basis. These lagoons will have variable-level discharge facilities to allow decantation of the supernatant as the lagoons are filled. Periodically, the lagoons will be retired from service and the sludge allowed to compact. After sufficient compaction has taken place, the sludge will be removed to a landfill site. The suspended solids and BOD levels of the lagoon-treated effluent are expected to have average values of about 24 and 16 mg/liter respectively (OL-ER, pp. 3.6-3 through 3.6-6).

3.2.6.6 Condensate polishing waste

Treatment of condensate polishing waste was not described in the FES-CP. The condensate polishing system will be operated during startup and shutdown and during condenser leakage as required to maintain acceptable water chemistry levels. Up to about one-half of the condensate flow [about 1.7 m^3/sec (60 cfs)] can be processed by the condensate polishing system, which consists of powdered-resin filter/demineralizers. Because condenser inleakage of coolant water will be a relatively small percentage of the total condensate flow, the quantities of impurities to be removed by the system from this source will be correspondingly low. Polishing system wastes normally will be discharged to one of the lagoons used for water treatment wastes. After settling, wastes will be discharged ultimately to the circulating discharge canal and then to Monticello Reservoir.

3.2.6.7 Sewage and sanitary waste

The sanitary system will handle domestic waste from the rest room and cafeteria facilities. Criteria for the design basis for the sanitary system were a plant work force of 225 maximum (including refueling personnel), 380 liters (100 gal) per capita per day, and 91 g (0.2 lb) per capita per day of BOD.

The waste will be collected in a lift station and pumped to the waste treatment area. Treatment will consist of aeration followed by stabilization and chlorination. The effluent from the chlorine contact tank will be combined with the other wastes and discharged to the Monticello Reservoir via the circulating water discharge channel (OL-ER, pp. 3.7-1 and 3.7-2 and Fig. 3.6-1).

The applicant anticipates, considering the assumed loadings, that the final effluent characteristics will be as follows:

	Concentration (mg/liter)
Suspended solids	30
BOD_5	25
Dissolved oxygen	5
Residual chlorine	0.5

These impurity concentrations are consistent with the values stipulated in the applicant's NPDES permit (Appendix C). In addition, it can be shown that the sewage effluent will have little or no influence on the concentration of suspended solids in the circulating water.

3.2.6.8 Storm drainage

The storm drainage system described in the OL-ER is essentially the same as that described in the FES-CP with the exception of the capacity relative to heavy rainfall. The FES-CP states that the storm drainage system is designed to carry the rainfall from a 3-hr rain of 54.4 cm (21.4 in.). The OL-ER states that the storm drainage system is designed for a 17.8 cm/hr (7 in./hr) rainfall intensity; no duration is indicated. Drainage from potentially contaminated areas, such as those containing chemicals and oils, will be conducted to drainage receptors for treatment and eventual disposal.

3.2.6.9 Compliance with regulations

In controlling the discharge of effluents from the station, the applicant will be required to meet all local, State, and Federal regulations as administered by the proper permitting authority. As determined from the above review of expected effluents of the various subsystems, the waste impurities discharged to Monticello Reservoir will be a small fraction of the naturally occurring impurities in the water. Only in the case of suspended solids in the sanitary waste system effluent is there a possible, but relatively unimportant, infraction of the NPDES permit limitations (Sect. 3.2.6.7)

3.2.7 Transmission lines

Modifications made to approved transmission corridors and lines are described below. Additional lines to Blythewood [37 km (23 miles)] and to Newberry [27 km (17 miles)] were constructed by the Central Electric Power Cooperative, Inc., for lease by the South Carolina Public Service Authority (SCPSA). These lines are assessed in a separate FES issued by the U.S. Rural Electrification Administration [USDA-REA-EIS (adm)-76-1-F; April 1976]. The SCPSA transmission lines require about 174 ha (429 acres) of additional land (OL-ER, Table 3.9-2), but about 44% of SCPSA lines from the Summer station parallel South Carolina Electric and Gas (SCE&G) lines.

The transmission lines built by SCE&G from the Summer station include (OL-ER, Fig. 3.9-3) several short lines, which terminate near the station (Summer-Parr No. 1 and No. 2, Summer-Denny Terrace No. 1, Parr-Summer Safeguard, and Fairfield-Summer No. 1 and No. 2 lines), and three longer lines (Summer-Pineland No. 1 and No. 2, Summer-Denny Terrace No. 2, and Summer-Graniteville lines). In general, the lines built are shorter than those originally planned. Except for construction of the additional Summer-Fairfield line [1.6 km (1 mile)], which connects the pumped storage facility to the nuclear station, and termination of the originally proposed Summer-Urquhart line (OL-ER, Fig. 3.9-2) at Graniteville, about 35 km (22 miles) shorter than planned, the final lines differ little from those originally proposed. Construction of the SCE&G transmission lines did not involve removal of any dwellings or other structures, and no designated parks, monuments, historic sites, archaeological sites, or recreation areas were intersected by the lines (OL-ER, Sect. 3.9). The Summer-Fairfield line, built entirely within the station boundary, was not assessed in the FES-CP.

The lines constructed by SCE&G total 193.3 km (120.1 miles), which is 46.5 km (29 miles) shorter than the originally proposed lines (Table 3.3). The as-built corridors, 637.4 ha (1575 acres), occupy about 110 ha (272 acres) less than originally proposed.

Table 3.3. Transmission corridors originally proposed and those actually constructed by SCE&G

Line name	Length				Row width				Land area			
	Proposed[a]		Constructed[b]		Proposed		Constructed		Proposed		Constructed	
	km	miles	km	miles	m	ft	m	ft	ha	acres	ha	acres
Parr-Summer Safeguard (115 kV)	4.8	3.0	4.2	2.6	30.5	100	30.5	100	14.6	36	12.6	31
Summer-Fairfield No. 1 and No. 2 (230 kV)			1.6	1.0			51.8	170			3.1	20
Summer-Denny Terrace No. 1 (230 kV)	5.6	3.5	4.0	2.5	30.5	100	30.5	100	17.0	42	12.1	30
Summer-Parr No. 1 and No. 2 (230 kV)	4.8	3.0	3.7	2.3	73.2	240	73.2	240	35.2	87	26.3	65
Summer-Pineland No. 1 and No. 2 (230 kV)	30.6 14.5	19 9	29.4 8.9	18.25 5.5	73.2 30.5	240 100	73.2 30.5	240 100	230.7 43.7	570 108	214.5 26.7	530 67
Summer-Denny Terrace No. 2 (230 kV)	30.6 12.1	19 7.5	29.4 11.4	18.25 7.1	0[c] 30.5	 100	0[c] 30.5	 100	0[c] 43.7	 108	0[c] 33.6	 83
Summer-Urquhart	107.8	67	93.7	58.2	30.5	100	30.5	100	329	812[d]	285.3	705
Summer-Graniteville (230 kV)	16.1 12.9	10 8	7.1 .4	4.4	21.3 0[f]	70[e]	25.9	85[e]	34.4 0[f]	85[e]	18.2	45[e]
Total	239.8	149	193	120.1					748.3	1848	637.4	1576

[a] CP-ER, Suppl. 1.

[b] OL-ER, Sect. 3.9.

[c] Utilizes right-of-way of Summer-Pineland corridor.

[d] CP-ER indicated 3300 ha (8100 acres); an apparent error.

[e] Parallels existing right-of-way.

[f] Utilizes existing right-of-way between Graniteville and Urquhart.

3.2.8 Nuclear fuel shipment

Fresh fuel elements are expected to be delivered by truck from a manufacturing facility in Columbia, South Carolina. Five shipments per year will be required to deliver the annual refueling load of 52 fuel element assemblies weighing a total of 33,100 kg (73,000 lb; OL-ER, p. 3.8-1).

A similar number of fuel element assemblies will be removed from the reactor each year. Current Federal policy mandates that these spent fuel elements be placed in either onsite or away-from-reactor (AFR) long-term storage facilities until ultimate storage or reprocessing facilities are approved and made available.

For offsite transportation, the spent-fuel elements will be placed in Interstate Commerce Commission approved and NRC licensed casks. The casks will be transported by truck or rail, depending on the location and/or distance of the offsite depot. The nearest projected spent-fuel AFR storage facility is about 130 km (80 miles) away at Barnwell, South Carolina. This facility may eventually be licensed for reprocessing. Judging from the above transportation distance by truck and the types of casks currently in use, the applicant estimates a range of 2320 to 6700 km (1440 to 4160 miles) per vehicle per year (OL-ER, p. 3.8-2).

3.2.9 Solid radioactive waste shipment

The estimated annual quantities of solid radioactive waste material obtained from the solid radioactive waste processing and packaging system (OL-ER, Sect. 3.5.4) are summarized in Table 3.4 (OL-ER, Table 3.5-9). Shipment of this material to licensed storage facilities will conform to requirements of 10 CFR Part 20, 10 CFR Part 50, and 49 CFR Part 171 through 49 CFR Part 179 (OL-ER, p. 3.5-19). The radioactive material is shipped in 50-ft^3 containers, which are shielded with 1.5 in. of lead when necessary.

Table 3.4. Estimated annual quantities of solid radioactive waste from the Summer station

Type of waste	Waste volume		Shipped volume		Activity				Comment
					Maximum		Average		
	m^3	ft^3	m^3	ft^3	Ci/m^3	Ci/ft^3	Ci/m^3	Ci/ft^3	
Evaporator bottoms	110	4,000	150	5,300	18	0.5	0.18	0.005	Shipped volume is based on 3:1 volume ratio of radioactive waste to solidification agent
Chemical lab samples	8.5	300	11	400	1.8	0.05	0.18	0.005	
Spent resins									
Primary	8.5	300	8.5	300	350	10	18	0.5	Waste and shipped volumes are the same because water or liquid waste and solidification agent fill voids between the resin beads
Secondary	13	450	13	450	35	1	0.18	0.005	
Filter cartridges									
Primary	30 cartridges		0.28	10	140	4	3.5	0.1	High-activity cartridges or hardware are placed in a basket located in the center of a 50-ft^3 container. Low-activity cartridges are randomly dropped into the 50-ft^3 containers. In both cases, the void is filled with liquid radioactive waste and solidification agent
Secondary	100 cartridges		1.9	70	14	0.4	0.35	0.01	
Radioactive hardware	2.8	100	2.8	100	12,500	350	180	5	
Miscellaneous compressible waste			55 (after compaction)	2,000	Negligible				Waste is compressed into 55-gal drums by a dry-waste compactor

REFERENCES FOR SECTION 3

1. Alden Research Laboratories. *Progress Report 2, Parr Hydroelectric Project,* Worcester Polytechnic Institute, Holden, Mass., June 1973.

2. Shih-I Pai, *Fluid Dynamics of Jets,* D. Van Nostrand, New York, 1954.

3. R. S. Nugent, NUS Corporation, letters and attachments to H. B. Visscher, Dames & Moore, Atlanta, Ga., Docket No. 50-395, July 5 and July 27, 1978.

4. ENVIRONMENTAL EFFECTS OF STATION OPERATION

4.1 INTRODUCTION

As a result of new laws and regulatory requirements, increased understanding of environmental issues, and new impact assessment methodologies, the staff has reconsidered the operating impacts of the Virgil C. Summer Nuclear Station.

First, the assessments in this statement examine compliance with the requirements of the Federal Water Pollution Control Act Amendments of October 1972 (FWPCA). Second, potential impacts on the aquatic environment have been thoroughly reassessed, primarily because the assessments in the FES-CP did not consider impacts resulting from impingement and entrainment of aquatic biota. In addition, the original assessment did not attempt to estimate the synergistic (or relative) effect of the operation of the Summer station within the context of the aquatic ecosystem established by operation of the Fairfield pumped storage facility.

The radiological impacts on man and other biota have been reassessed considering the final radiological waste system designs and operating characteristics. Impacts on terrestrial ecosystems, particularly along transmission corridors, are discussed in relation to endangered or threatened species. Finally, the relatively minor impacts of operation on land use, air quality, water use, and socioeconomics are also described.

4.2 IMPACTS ON LAND USE

Land use impacts associated with the Summer station were assessed in the FES-CP. Very few changes have occurred to alter the conclusions in that assessment. As discussed in Sect. 2.2.2, by the time plant operations begin the applicant will own or control about 4500 ha (11,000 acres) in the vicinity of the site. Because the majority of this was flooded by the new Monticello Reservoir or by expansion of the neighboring Parr Reservoir, it is lost to its former uses of forestry and agriculture. This acreage, however, also serves the Fairfield pumped storage facility and is much larger than would be needed for the nuclear station alone.

Pulp and lumber production will be excluded from the 896 ha (2217 acres) of original forest land used for permanent site structures and transmission lines. Assuming the productivity for this forest land is equivalent to the annual value cited in Sect. 2.5.1 for loblolly pine of 575 bd ft/ha, the staff estimates that approximately 2×10^7 bd ft of pulpwood and lumber will be lost during the 40-year operating life of the plant. The staff estimate is believed to be conservatively high in that it is unlikely that all of the forest land preempted would maintain productivity as high as the value given for loblolly pine.

Pasture and cropland preempted by the nuclear plant project amounts to 161 ha (399 acres). Most of this land area is on transmission line rights-of-way. Because farming activities can continue during line operation, the use of land for transmission lines does not constitute permanent loss of farmland. In addition, the classification of agricultural land as "prime" and "unique"[1] was initiated after construction of the nuclear station facilities was begun and the site altered. (1973-1976; OL-ER, p. 4.0-1). Because of these factors, the staff does not attribute loss of prime and unique farmland to operation of the nuclear station and transmission lines.

Outside the immediate area of the site, plant-induced impacts on land use should be much less pronounced. Areawide growth projections (Sect. 2.2.2) indicate that residential, commercial, or industrial future growth on lands now preempted for the project will be unlikely. As will be discussed more fully in Sect. 4.6.2, population growth resulting from the in-migration of workers, both for jobs at the plant itself and for service-oriented jobs stimulated by plant operations, is expected to be small compared to existing population in the Central Midlands region. Because of this, the amount of land converted here from agriculture and forestry to residential and commercial uses should also be small. However, this land conversion may be accelerated by the movement of businesses and individuals to Fairfield County as a result of the lower taxes and/or improved public services likely to occur because of the plant's substantial contribution to the local tax base. A further discussion of the projected tax situation will be found in Sect. 4.6.3.

Finally, as recounted in Sect. 4.6.4, recreational land uses in the site area will increase slightly. The staff concludes therefore that operation of the nuclear plant is not expected to significantly affect land use, other than for lumber and pulpwood production, on the project property.

4.3 IMPACTS ON WATER RESOURCES

4.3.1 Hydrologic impacts of construction

Construction of the Summer station resulted in several adverse impacts on the surface water and groundwater of the region; these impacts do, however, differ from the radical hydrologic impacts caused by construction of the Fairfield pumped storage facility. The following construction activities or effects of construction caused the hydrologic impacts at the Summer site:

- soil erosion from cleared or excavated areas;
- sanitary and chemical waste; and
- construction along shoreline or underwater.

The applicant used standard engineering precautions to reduce the impacts of soil erosion. These measures included use of gradual slopes where possible, retaining natural vegetation or replanting ground cover, and the use of settling basins in conjunction with the storm water drainage system. A limited quantity of silt has been deposited in the waterways. Facilities were provided for the disposal of sanitary, chemical, or other liquid wastes. Finally, the hydraulic structures necessary for the operation of the nuclear plant, such as the intake, discharge, and dividing dike, were constructed before the filling of Monticello Reservoir to minimize the impacts normally experienced with construction on shorelines. Because the waters of the Broad River are characteristically laden with sediment, additional solids contribution from plant construction was not significant.

Construction of the Summer station did not interfere with use of the regional water resources.

The Summer plant is located on the shore of Monticello Reservoir, which is an artificial water body built previously for pumped-storage and for plant cooling purposes. The construction of Monticello reservoir predates the Summer plant, and therefore the staff has not considered the effects of the reservoir itself on floodplains of any nearby river. The staff has restricted its analysis to effects of the plant itself to the floodplain issues covered by Executive Order 11988.

The water level in Monticello Reservoir will normally fluctuate over about a 1-m (4-ft) range because of the operation of the pumped-storage turbines. The 100-year floodplain as interpreted from Executive Order 11988 is the area inundated by the 100-year flood in Monticello Reservoir. The applicant has performed an analysis on this event by assuming that Monticello Reservoir is at the maximum pool elevation of 129 m (425.0 ft) Mean Sea Level (MSL) and that the 100-year 24-h point precipitation falls over the entire basin of the reservoir. Without the effects of infiltration, the estimated water level was predicted to be 130 m (426.0 ft) MSL. The staff considers this analysis to be conservative.

The area of the plant site is shown in Fig. 3.2 and in ER Fig. 3.4-1. Structures in the floodplain which are clearly associated with the Summer plant are the intake and discharge structures and the emergency cooling pond dam. The only effect of these structures on the floodplain of Monticello reservoir would be that they displace a volume of water that diminishes the capacity of the reservoir. This volume is insignificant compared to the total volume of the reservoir. Therefore, there should be no measurable effect of flooding in Monticello reservoir or in the Broad River due to the presence of the Summer plant.

4.3.2 Hydrologic impacts of operation

The operation of the Summer station will have only a minor effect on the hydrology (other than temperature and water supply) of the region. As discussed in Sect. 3.3.2, plant operation is expected to cause an additional 0.37 m^3/sec (13 cfs) evaporation from Monticello Reservoir, which is an insignificant quantity. The main hydrologic impact of the site will be from the presence and operation of the Fairfield pumped storage facility. These impacts would be present whether or not the Summer station operated, even though one of the purposes for constructing Monticello Reservoir was for use as the water resource for the once-through cooling system.

The main impacts of Monticello Reservoir on groundwater hydrology were discussed in the Environmental Report for the Parr Hydroelectric Project,[2] which was submitted to the Federal Power Commission (now the Federal Energy Regulatory Commission) and which is partially excerpted here. As described in the report, the impoundment will raise the water table to the impoundment level at the lake border. The water table will slope away steeply and reverse the groundwater flow locally away from the Frees Creek basin. Ultimately, however, this groundwater will return to the Broad River via the Terrible Creek, Mayo Creek, or Little River valleys. The low permeability of soils and bedrock in the site vicinity will limit the amount of groundwater flow from the impoundment.

The impoundment of Monticello Reservoir and operation of the facilities are not expected to have a significant impact on the surrounding springs or wells or on streamflow in the adjacent drainage basin. Wells close by may experience a rise in water level, but the rise is expected to be slight, probably only a few feet. The water quality in Monticello Reservoir is expected to be essentially the same as the current quality in the Broad River. However, should any contaminants enter the impoundment and move into the groundwater system, the filtration and ion-exchange properties of the soil, coupled with the extremely slow movement of the groundwater, make the possibility of contaminating existing wells remote. Water quality and gross beta radioactivity will be determined by water samples collected at selected wells and springs in the path of the slow-moving groundwater. This will be done as part of the general hydrologic monitoring program (Sects. 5.2.3 and 5.3.3).

Except for small areas near the circulating water intake and discharge structures, operation of the Summer station will not interfere with physical use of Monticello Reservoir when, and if, the applicant and regulatory agencies permit public use of the water body.

4.3.3 Thermal

Some water will be lost from Monticello Reservoir because of Summer operation. The thermal discharge will increase reservoir temperature, which, in turn, will cause increased evaporation. The applicant estimates that the average annual rainfall of 114 cm (45 in.) falling into Monticello Reservoir corresponds to an average inflow rate of about 1 m^3/sec (35 cfs). Because the lake area comprises about 70% of the Frees Creek drainage basin, runoff into the reservoir from the remaining catchment area is not considered. Ambient evaporation from the reservoir was estimated by the applicant (OL-ER, Sect. 2.4.1.3.3) at 0.93 m^3/sec (33 cfs); an additional 0.37 m^3/sec (13 cfs) of latent evaporation was estimated for condenser operation. The staff, assuming that all of the 7.1×10^{12} J/hr (6.7×10^9 Btu/hr) of waste heat will be dissipated by evaporation of water from Monticello Reservoir, concludes that the maximum water loss caused by the Summer plant should be about 0.70 to 0.85 m^3/sec (25 to 30 cfs). Because the staff's assumption ignores heat dissipation by natural processes other than evaporation, the staff finds the applicant's estimate of evaporation of 0.37 m^3/sec to be reasonable. The total evaporation of 1.3 m^3/sec (46 cfs) will produce a flow deficit of about 0.3 m^3/sec (11 cfs) less any runoff from the remaining land area of the drainage basin. To maintain the long-term water balance, this flow deficit of 0.3 m^3/sec must be replaced by pumpage through the Fairfield pumped storage facility (OL-ER, p. 2.4-6). Because the loss is only a very small fraction of the pumping rate of the Fairfield facility [1133 m^3/sec (40,000 cfs)], the staff does not consider this loss significant. It will be automatically replaced during the daily pumping mode through an additional 30 sec of operation.

Should the Monticello Reservoir not be replenished for 30 days because of both inoperation of the Fairfield pumped storage facility and lack of rainfall, lowering of the reservoir would occur. Using the combined values of natural evaporation and that imposed by the Summer plant operation [0.93 m^3/sec + 0.37 m^3/sec = 1.3 m^3/sec (33 cfs + 13 cfs = 46 cfs)], the staff calculated that the Monticello Reservoir would decrease by less than 15 cm (0.5 ft) during the 30-day period. This is a relatively inconsequential change occurring as a result of a very unlikely set of events.

The applicant originally had no plans to permit general public use of Monticello Reservoir for recreation or consumption. However, because of the favorable water quality since the initial operation of the pumped storage facility, the applicant now plans to permit public use of the reservoir. The impacts of dissipation of waste heat on Monticello Reservoir were described in the FES-CP, Sect. 5.B. In the current review (Sect. 3.2.4), the staff finds that the original analysis was unrealistically conservative. Thus the reservoir area affected by the therma plume will probably be smaller than previously predicted. The water near the discharge canal may be somewhat warmer than desirable for human contact, particularly in the summer season. The remaining larger portion of the reservoir is not expected to be unduly impacted by the thermal plume. Therefore, thermal discharge should not affect any possible potential recreational uses. Thermal impacts on biota are described in Sect. 4.4.

4.3.4 Industrial chemical wastes and sanitary wastes

The Summer station will discharge some nonradiological chemical and sanitary wastes into the circulating water discharge canal after treatment. Because the concentrations of the waste impurities to be discharged to Monticello Reservoir (Sect. 3.2.6) are small compared to the concentrations of these impurities occurring naturally in this water body, the staff concludes that the release of these wastes will have a negligible impact on man's use of the reservoir water. Mixing and dilution of impurities are further enhanced in Monticello Reservoir by the rapid exchange of water to and from the Parr Reservoir as a result of the pumped storage generating operation. The applicant will also be required to meet all local, State, and Federal regulations relative to the discharge of chemical and treated sanitary waste effluents from the station.

4.3.5 Applicable effluent guidelines and limitations

Pursuant to the requirements established under the FWPCA, the applicant has applied for and received from the South Carolina Department of Health and Environmental Control an NPDES permit (Appendix C). Effluent limitations, monitoring schedules, and reporting requirements for discharge of waste into Monticello Reservoir are described in the permit.

4.3.6 Effects on water users through changes in water quality

The water quality of Monticello Reservoir will not be affected by the discharge of treated nonradiological chemical and sanitary wastes, which will meet NPDES effluent limitations. Furthermore, subsequent dilution will reduce water quality impact to negligible levels. Because this impact will be negligible, the impact on the water quality of the Parr Reservoir and Broad River downstream from Monticello should be even less because of further dilution through upstream drainage into these water bodies.

4.3.7 Effects on groundwater

The Summer station will use no groundwater during operation and should, therefore, have no direct effect on groundwater levels. Should any contaminants, radioactive or nonradioactive, enter the impoundment and move into the groundwater system, the filtration and ion-exchange properties of the soil, coupled with the extremely slow movement of the groundwater, make the possibility of contaminating existing onsite or offsite wells remote (FES-CP, p. V-8). Groundwater flow direction at the plant site is expected to be to the south and west in the direction of the Broad River. There are no domestic or industrial wells downgradient of this predicted flow (OL-ER, p. 2.4-8).

4.4 IMPACTS ON BIOTA

4.4.1 Terrestrial environment

4.4.1.1 The nuclear station

Impacts of Summer station operation will be minimal, probably insignificant. Effects of chemical air pollutants require no consideration because there will be little nonradiological emissions from the station. Also, there are no closed-cycle cooling systems to emit drift salts or cause ice formation on surfaces. Noise from the facility will be minimal except when outdoor loudspeaker systems are used. No endangered or threatened plants or animals are thought to occur near the facility.

4.4.1.2 The transmission lines

The power transmission lines were described in the FES-CP and the OL-ER. As noted in Sect. 3.2.7, the Summer-Blythewood line [230 kV; 37 km (23 miles)] and the Summer-Newberry line [230 kV; 27 km (17 miles)] have been built by Central Electric Power Cooperative, Inc., since publication of the FES-CP for use by the South Carolina Public Service Authority (SCPSA) and were the subject of an EIS issued by the U.S. Rural Electrification Administration in April 1976. The impacts of operation discussed below for the South Carolina Electric and Gas Company (SCE&G) transmission lines will generally apply to those used by SCPSA. Differences will be noted where appropriate.

Operation of the transmission lines will produce minimal impacts on known biological resources. Effects on recreationally important wildlife, such as white-tailed deer, squirrels, rabbits, foxes, raccoons, mourning dove, bobwhite quail, turkey, and woodcock, will be either beneficial or unimportant. Except for the woodcock, these animals benefit from the mosaic of forests and fields created where the transmission line rights-of-way intersect closed forest stands.[3]

Electrostatic effects upon wildlife from overhead power transmission lines are undetectable at the maximum voltage being supplied by SCE&G,[4,5] and the staff therefore expects no impacts to wildlife from this source.

Maintenance procedures will affect animals that take up residence in the rights-of-way. Tall shrubs and trees are removed by SCE&G about every three years using herbicides, which are applied by helicopter, vehicle, or backpack sprayer (OL-ER, p. 5.5-1). It is, however, SCE&G policy to maintain rights-of-way in or near waterways by hand clearing.[6] Mechanical clearing with bush hogs and hand clearing will occur throughout the SCE&G transmission corridors (OL-ER, p. 5.5-1) every five years. The transmission line maintenance procedures used by SCPSA consist of mechanical clearing by bush hog and bog plow supplemented by hand clearing and hand spraying of herbicides on a four-year basis (OL-ER, p. 5.5-2). The mechanical clearing will destroy nests and dens, whereas the spray treatments, particularly from helicopters, will disrupt reproduction in and adjacent to rights-of-way. Herbicides are most effective in the spring when, coincidentally, vertebrates reproduce. In addition, herbicide treatment every third year will destroy berry- and fruit-producing shrubs on which wildlife species grow dependent during nonspray years.

Information on endangered animal species given in Sect. 2.5.1 indicates that such species are not likely to breed in the region of the transmission line rights-of-way. Even if there were such breeding populations in the vicinity of the lines, the staff believes the populations would suffer little or no impact as a result of the presence of the lines or the maintenance of the rights-of-way. Conductor lines are at least 2.74 m (9 ft) from any grounded surface (OL-ER, Figs. 3.9-8 and 3.9-9), and the largest endangered bird species potentially in the area, the bald eagle, has a wingspan of 2.4 m (8 ft) or less.[7] None of the endangered or threatened species breed in open habitats like the rights-of-way; thus, periodic maintenance is unlikely to disrupt reproduction.

Judging from the information given in Sect. 2.5.1.1, the impacts of proposed maintenance procedures on listed endangered or threatened plant species are unlikely, inasmuch as the two identified endangered species do not appear to occur in the region traversed by the transmission lines (see also Sect. 10.4.4).

4.4.2 Aquatic environment

Operation of the Summer nuclear facility will directly affect the aquatic environment in Monticello Reservoir and, because of the substantial daily water transfer from Monticello to Parr via the Fairfield pumped storage facility (Sect. 2.3), will indirectly affect Parr Reservoir and the Broad/Congaree Rivers below Monticello. Possible impacts to the aquatic environment and biota include effects from (1) the physical and chemical characteristics of the discharge of the Summer once-through cooling system and (2) the impingement/entrainment losses associated with the cooling system.

4.4.2.1 Effects of thermal discharge in Monticello Reservoir

The staff assessed the probable extent and magnitude of the thermal plume generated by the once-through cooling discharge from Summer (Sect. 3.2.4). An analysis of the distribution of surface temperatures in Monticello Reservoir, based on the application of the staff's correction to the applicant's thermal modeling data, is given in Table 4.1. When ambient water temperatures are near 6.6°C (44°F), the staff predicts about 9% of the surface area of Monticello will have a 4°C (7.2°F) or greater elevated temperature (ΔT) as a result of Summer operation. Only 7% of the surface area is expected to experience a ΔT of $\geq$4°C when ambient water temperatures are near 15.6°C (60°F).

Table 4.1. Surface area and shoreline affected in Monticello Reservoir by thermal discharge from the Summer station[a]

ΔT		Percentage affected when ambient water temperature is:			
		6.6°C (44°F)[b]		15.6°C (60°F)[c]	
°C	°F	Surface area	Shoreline	Surface area	Shoreline
8	14.4	1	2.5	1	2
6	10.8	4	3.5	2	3
4	7.2	9	8	7	5
2	3.6	63	43	18	18

[a] Values are approximate and are derived from surface isotherm model data contained in an Alden Research Laboratories report for Monticello (Alden Research Laboratories, *Progress Report 2, Parr Hydroelectric Project*, Worcester Polytechnic Institute, Holden, Mass., June 1973) as modified by a staff correction factor (Sect. 3.2.4).

[b] Test No. 66.

[c] Test No. 72.

Phytoplankton

Optimal temperatures for growth and metabolism of phytoplankton vary with species and group. In general, the order of increasingly thermophilic groups is (1) diatoms (Bacillariophyceae), (2) green algae (Chlorophyta), and (3) blue-green algae (Cyanophyceae).[8] Overall increases in temperature below absolute upper thermal tolerance levels in certain areas of Monticello Reservoir may cause a general shift in population structure toward increased abundance of green and blue-green algae.

The possibility of algal blooms in Monticello Reservoir is dependent on temperature, nutrient concentrations (primarily nitrate and phosphate levels), and light penetration.[8]

Preliminary water quality data for Monticello[9] indicate nitrate values average 1.25 mg/liter and ortho-phosphate levels average 0.014 mg/liter.[*] These nutrient values are not limiting for

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[*] Ortho-phosphate values reported as <0.01 mg/liter were averaged into the mean as 0.005 mg/liter.

algal growth (even to "bloom" proportions) but, as has been observed in other impoundments in this general area, reservoir "aging" may reduce these values.[10] Because of the input of turbid waters from Parr Reservoir (Fairfield will introduce about 7% of Monticello's volume daily from Parr), the staff predicts turbidity in Monticello will be fairly high. Secchi disk readings in Parr are in the order of 0.3 m (1 ft) and have been recorded as low as 0.1 m (4 in.; OL-ER, p. 3.2-5). Preliminary Secchi disk values for Monticello, with the Fairfield facility only intermittently operational (at reduced capacity), have been relatively low [mean 1.25 m (4.1 ft)].[9] These readings will probably be further reduced when Fairfield becomes fully operational. Expected limited light penetration may limit phytoplankton densities to below bloom levels.

Phytoplankton mortalities from plume entrainment are expected to be negligible because of the restricted area and the plume temperatures involved ($\approx 2\%$ surface area at a ΔT of $>6°C$, Table 4.1). The design of the discharge canal will further minimize plume mixing. Data for postimpoundment Lake Keowee, South Carolina, after start-up of the Oconee nuclear station (which has nutrient values similar to those predicted for Monticello) indicate that major changes in phytoplankton composition or densities were not evident after start-up.[10]

Zooplankton

Zooplankton densities are closely linked to phytoplankton densities through trophic relationships.[8] The density of zooplankton in Monticello should correlate with phytoplankton densities. Plume entrainment of zooplankton and subsequent mortality should not be significant because of the low ΔT's involved and limited plume mixing. Data for Lake Keowee, South Carolina,[10] indicate that the thermal effluent from the Oconee nuclear station affected neither the observed densities nor the population structure of zooplankton.

Benthic invertebrates

The effects of thermal discharge on benthic invertebrate density are variable; the discharge can cause an increase or a decrease or can effect no change.[11,12] Benthic invertebrate density and/or diversity will probably be adversely affected within the discharge canal, where predicted ΔT's will be $>10°C$ (18°F). However, the discharge canal represents only a small portion of the available bottom habitat in Monticello; thus the staff assesses the impact of the discharge canal on the overall benthic community as acceptable.

The design of the canal will allow the discharge of the thermal plume into Monticello as a heated surface layer. The plume should not subject a significant portion of the remaining benthic environment to a high ΔT. As determined from the applicant's thermal modeling data and the staff's correction for ΔT (Sect. 3.2.4), the thermal plume will primarily be a surface phenomenon [3 m (10 ft) in depth], and the predicted ΔT at the substrate, even near the point of discharge during warmer months, will be only about 1°C (1.8°F), as shown in Fig. 4.1. Thus the staff expects that the thermal discharge will have an insignificant impact on the overall benthic community in Monticello Reservoir.

Fish

Temperature is an important factor in the aquatic environment and has been shown to influence fish distribution, physiology, behavior, reproduction, and species composition. The problems associated with, and the assessment of, thermal pollution are quite complex and have received much attention.[13-15] In addition, indirect mortalities have been associated with temperature extremes; mortalities occur, for example, when low temperatures interfere with swimming abilities and thereby expose populations to impingement or when temperatures alter toxicity levels of pollutants or susceptibility of fish to disease.[16]

The staff calculated the approximate surface areas of Monticello that will be affected by the various ΔT's caused by Summer operation (Table 4.1). The applicant has not thermally modeled Monticello for ambient temperatures greater than 15.6°C (60.1°F). Results have shown that with increasing ambient temperature (6.6°C to 15.6°C) thermally affected areas in Monticello are

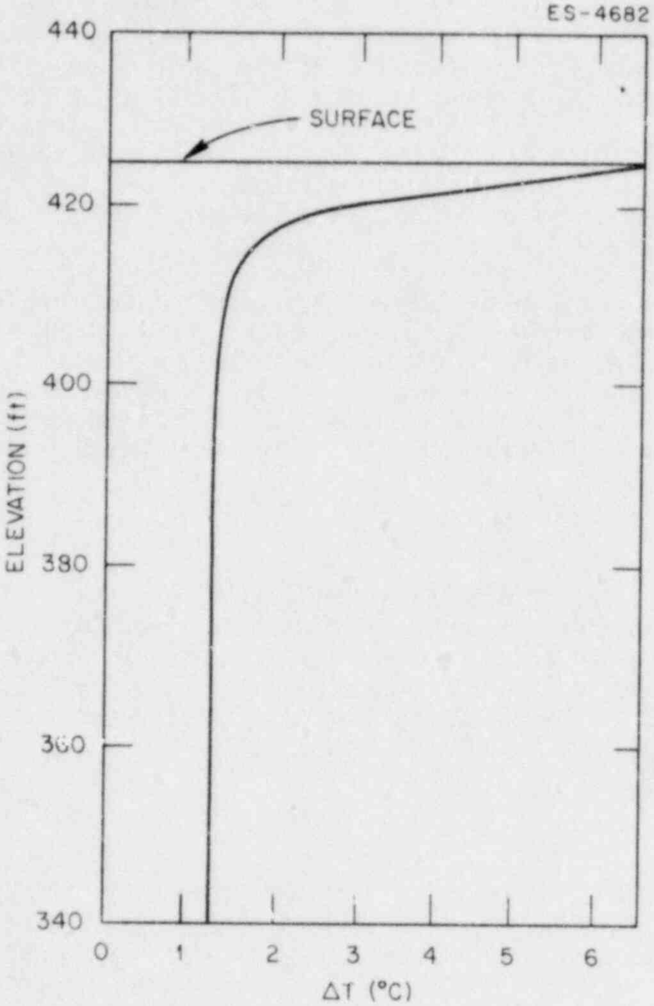

Fig. 4.1. Typical vertical temperature profiles expected in Monticello Reservoir near the Summer station discharge canal. Note that this is the profile for a location at which the ΔT is about 6.5°C; an ambient water temperature of 15.6°C (60.1°F) is assumed. Source: Alden Research Laboratories, *Progress Report 2, Parr Hydroelectric Project*, Worcester Polytechnic Institute, Holden Mass., June 1973, Fig. 55.

reduced in area because of increased rates of natural cooling. However, to directly extrapolate these results to higher ambients than actually modeled would be incorrect. The staff, although recognizing that this is probably a conservative approach, therefore used areas calculated for the 15.6°C test in the following analysis.

The addition of the predicted ΔT's to the highest surface temperatures recorded for Parr during the baseline survey [31.5°C (88.7°F)] yields the following. about 7% of Monticello's water surface will be ≥35.5°C (95.9°F) and 18% will be ≥33.5°C (92.3°F). These temperatures will be experienced only during the warmest parts of the year primarily in the center of the plume as it is discharged into the lake but not along extensive portions of the shoreline. Temperatures will also decrease sharply with depth because the plume is predicted to be a surface phenomenon maximizing heat loss to the atmosphere (Fig. 4.1).

The lethal threshold temperatures for some of the major fish species expected to inhabit Monticello Reservoir are provided in Table 4.2. Expected maximum temperatures in portions of Monticello near the Summer station discharge will approach or exceed some of these reported limits, particularly during high-temperature periods in the summer months.

Table 4.2. Incipient lethal temperatures for selected fish species expected in Monticello Reservoir[a]

Species	Lethal threshold	
	°C	°F
Gizzard shad, *Dorosoma cepedianum* (fingerling)	36	96.8
Mosquito fish, *Gambusia affinis*	37	98.6
Brown bullhead catfish, *Ictalurus nebulosus*	34.8	94.6
Bluegill, *Lepomis macrochirus*	33.8	92.8
Longear sunfish, *Lepomis megalotis* (juvenile, > 12 mm)	36.8	98.2
Largemouth bass, *Micropterus salmoides*	36.4	97.5

[a] Data are for adults unless specified otherwise; an acclimation temperature of 30°C (86°F) is assumed.

Source: Committee on Water Quality, National Academy of Sciences, *Water Quality Criteria*, Environmental Studies Board, Washington, D.C., 1972.

Because of the characteristics of the plume, the high plume temperatures will be concentrated toward the center of Monticello as a shallow [3 m (10 ft)] surface layer. Some fish mortality may occur as a result of the highest plume temperatures.

Deleterious effects of thermal exposure have been shown to be related to both the temperature and duration of exposure.[17] Fish exposed to a varied thermal regime will, though, choose a zone of thermal preference if allowed.[18] The staff calculated the maximum nonlethal durations of exposure at specific levels of thermal stress (assuming a peak ambient reservoir temperature of 31°C) for a few of the more common species that may be found in Monticello (Table 4.3). The NPDES permit (Appendix C) limits the monthly average discharge plume temperature to 32.2°C (90°F). Considering that relatively small surface areas will be raised to these temperatures and only during warmer parts of the year and the limited vertical extent of the plume (Fig. 4.1), the staff feels that there will often be the opportunity for fish to avoid lethal thermal exposures. Therefore, the staff expects that plume mortalities should not be excessive.

Table 4.3. Maximum nonlethal exposure times in relation to exposure temperatures[a]

Plume temperature		Percentage of surface area affected[b]	Maximum nonlethal exposure times (min)			
°C	°F		Largemouth bass	Bluegill	Longear sunfish	Gizzard shad
33	91.4	13	>9000	549	>1000	∞
35	95	5	368	27	150	>1000
37	98.6	1	14	1.2	15	25
39	102.2	0.5	0.5	<0.5	1.5	0.5

[a] Exposure times were calculated from data in *Water Quality Criteria* (Committee on Water Quality, National Academy of Sciences, *Water Quality Criteria*, Environmental Studies Board, Washington, D.C., 1972) based on log(time) = $a + b(t + 2)$ and incorporate a 2°C "margin of safety." Maximum exposure times depend on many factors, such as physiological condition, acclimation temperature, etc., and are not absolutes.

[b] Ambient temperature is assumed at 31°C; see Table 4.1.

Fluctuating temperatures can adversely affect spawning of some freshwater fish.[19] The temperature of shoreline areas affected by the plume will fluctuate with changes in plant output, meteorological conditions, etc. The magnitude of these fluctuations is uncertain, but because of the expected small shoreline area involved (Table 4.1) and the probable limitation of littoral zone reproduction as a result of fluctuating water levels (pumped storage operation), the magnitude of this impact is assessed by the staff as acceptable.

A sudden decrease in canal temperature could occur as a result of plant shutdown. During winter months this thermal stress could directly or indirectly induce mortality ("cold shock") of fish inhabiting the discharge plume that have acclimated to the elevated temperatures (especially threadfin shad). These cold shock mortalities will be dependent on unscheduled and infrequent winter shutdowns. If the average percentage of forced outage time is assumed to be 11%[20] and the period of concern for cold shock mortalities to be December through February (90 days), the number of forced outage days will be about ten. If the average outage lasts 6.25 days,[20] then an average of 1.6 cold shock events per season can be expected. However, the actual magnitude of cold shock mortalities and the effect on the fish populations in Monticello Reservoir are difficult to predict because the densities, distribution, and species composition of fish that will be in Monticello (or in the discharge canal) are unknown.

Gas bubble disease in fish results from exposure to water that is supersaturated with dissolved gasses. Symptoms in fish include exophthalmia ("popeye"), hemorrhaging, cutaneous blisters, and occlusion of gill filaments. Death often results from severe cases.[21]

Water can become supersaturated primarily in the following two ways: by passing through a plunging discharge (for example, a hydroelectric facility discharge) or by rapid heating of water at or near the saturation level. The delta-t of 14°C (25°F) through the cooling system of the Virgil Summer power plant is large enough to induce gas supersaturation, particularly during the winter months when the water may naturally be close to saturation. In this case, there is a possibility of gas bubble disease for those fish in Monticello that may congregate in or near the discharge canal. Compensating factors include the presence of the plant-induced thermal plume as a surface phenomenon (Fig. 4.1) and the availability of a deep water refuge near the discharge canal into which affected fish may retreat.

Visual inspection of fish captured during the monitoring program should identify the presence of gas bubble disease in the fish population in Monticello. Mitigating measures, such as use of deep, nonsaturated water withdrawal for the cooling system, can be adopted if necessary.

4.4.2.2 Effects of thermal discharge on the biota of the Broad/Congaree River System

As shown in Fig. 3.4, discharge ΔT's will be highest during the winter months because of lower rates of natural (evaporative) cooling. With low Broad River flow and an ambient temperature of 7.2°C (45°F), the predicted ΔT for the discharge into Parr will be <1.1°C (2.0°F). At the same temperature and with average water flow [170 m^3/sec (6000 cfs)], the predicted ΔT will be about 0.75°C (1.4°F). When water flow is average and the ambient temperature is 15.6°C (60.1°F), the predicted ΔT will be about 0.5°C (0.9°F). These differential temperatures represent surface measurements at the Fairfield intake in Monticello compared to ambient temperatures recorded near the upper end of the reservoir. There may be a substantial decrease in water temperature with depth near the Fairfield intake. Temperature declines (with depth) of >10°C (18°F) have been recorded in the forebay of the Smith Mountain (Virginia) Reservoir pumped storage facility.[22] Even a moderate 3 to 4°C decline of temperature with depth in Monticello near the Fairfield intake would substantially reduce the ΔT of the discharge to Parr. These small ΔT's are not expected to adversely affect biota in Parr Reservoir, which, because of drastic fluctuations in water level and volume, is expected to be a marginal aquatic habitat at best.

Landlocked striped bass (*Morone saxatilis*) spawn in the Congaree River (an extension of the Broad below the Summer plant). The closest reported spawning area is at river mile 53, about 58 km (36 miles) downstream from Parr Reservoir.[23] Predicted thermal discharge temperatures into Parr under the ambient water temperature conditions expected during the spring striped bass spawning season [≈15.6°C (60°F)] indicate that expected surface ΔT's at the Monticello intake to Fairfield will be ≤0.5°C (0.9°F; Fig. 3.4). This ΔT will be reduced through dilution with cooler underlying water in Monticello, with dilution flows from the Saluda River (about 30% flow addition at its confluence with the Broad River), and by natural cooling as the warmed water flows downstream from the Parr Dam. It is the staff's opinion that the negligible ΔT (if any) experienced in the Congaree River will have no effect on the spawning of striped bass.

4.4.2.3 Operational effects on dissolved oxygen

The cooling water passing through the condenser of the nuclear plant will experience a 13.9°C (25°F) rise in temperature. The solubility of oxygen in water decreases with increasing temperature, and there will probably be some decrease in the dissolved oxygen (DO) content of the discharge water. Under theoretical conditions, water at saturation might lose approximately 30% of its DO content at this ΔT.[24] However, if the incoming water were not at saturation and/or underwent supersaturation when heated at the condensers (a common phenomenon), it would lose less of its DO content.

Although difficult to quantify, the staff believes that there will be little, if any, effect on the DO of Monticello Reservoir from operation of the Summer station for the following reasons: (1) the plant will withdraw only a small portion of the water in Monticello (approximately 0.5% on a daily basis, equivalent to about a 175 day turnover rate), (2) the discharged water will be released as a surface flow, which will maximize oxygen readsorption from the atmosphere, (3) the discharged water will be prevented from directly reentering the Summer intake structure (allowing time for reaeration), and (4) the Fairfield pumped storage system will remove and return approximately 7% of Monticello's volume (14 times the daily volume passing through the Summer station) on a daily basis. The round trip passage through the Fairfield tailraces and the movement in shallow Parr Reservoir should foster reaeration of this water mass and will probably compensate for the amount of DO removed by Summer operation.

4.4.2.4 Cooling system impingement/entrainment

Impingement

The Summer plant utilizes a shoreline cooling water intake. Inflowing water passes through a trash rack and a conventional mesh [9.5 mm (0.375 in.)] screen before circulating through the plant. Fish that are too large to pass through the screen and that cannot actively avoid it will be impinged on the screen and often killed. Such mortalities can be substantial[25] but depend on a number of factors such as species composition, size frequency, density and behavioral characteristics of indigenous fish, intake location and design, and approach velocities, among many others.[26,27] Monticello Reservoir is a newly created impoundment and descriptive biological data are not available. The only data available for the Summer plant are the intake design, location, and calculated approach velocities.

The designed average approach velocity is about 0.15 m/sec (0.5 fps; Sect. 3.2.4). An approach velocity of 0.15 m/sec is recommended as a reasonable goal and should assist in achieving, but will not guarantee, low impingement mortalities.[26,27] The approach velocities at Summer will generally be within these guidelines and will be substantially lower than many other operating plants in the Southeast (Table 4.4). Impingement mortalities vary with plant siting and do not necessarily correlate closely with intake velocities. For example, at the Kingston (Tennessee) Steam Plant approach velocities averaged 0.13 m/sec (0.42 fps) and about 405,000 threadfin shad were impinged during a five-month monitoring program. During the same period, only about 14,000 threadfin shad were impinged at nearby Bull Run (Tennessee) Steam Plant even though the approach velocities were considerably higher, 0.37 m/sec (1.22 fps).[20] The staff cannot make an accurate assessment of the impingement mortalities expected to result from Summer station operation because of the absence of necessary information. Data from the preoperational and operational monitoring program are necessary for a more accurate assessment of the effect of impingement losses on the aquatic ecology of Monticello as it develops. The applicant has also developed monitoring studies (Appendix F) to satisfy the requirements of the NPDES permit in regard to paragraphs 316(a) and 316(b) of FWPCA, which require use of the best available technology to minimize the environmental impact of cooling water intake structures. The results of these monitoring studies can be used to determine mitigating measures should they become necessary. Appropriate mitigating measures could include various intake screening devices, fish barriers, and relocation of the water intake.

Entrainment

Organisms in the water column smaller than the traveling screen mesh size [9.5 mm (0.137 in.)] that cannot avoid the cooling intake will be entrained into the cooling water system. Because of rapid temperature rise [13.9°C (25°F)] and mechanical stress, passage through the cooling system can induce mortalities. A mechanical system of condenser cleaning will be employed

Table 4.4. Intake velocities for operating power plants in the southeastern United States

Plant (state)	Power (MWe)	Maximum approach velocity	
		cm/sec	fps
Dan River (North Carolina)	284	14	0.46
Cliffside (North Carolina)	770	24	0.79
Hatch (Georgia)	786	26	0.85
Robinson (South Carolina)	375	6, 64	0.02, 2.10[a]
Lee (South Carolina)	323	88	2.89
Ghent (Kentucky)	511	25	0.82
Handley (Texas)	523	31	1.02
Greene County (Alabama)	568	33	1.08
Riverbend (North Carolina)	730	35	1.15
Buck (North Carolina)	519	82	2.69
Allen (North Carolina)	1140	19	0.62
Gaston (Alabama)	1061	19	0.62
Green River (Kentucky)	263	28	0.92
Gorgas (Alabama)	1546	31	1.02
Cane Run (Kentucky)	1017	46	1.51
Oconee (South Carolina)	2658	51	1.67
Wateree (South Carolina)	772	15	0.49
Marshall (North Carolina)	2025	21	0.69
Browns Ferry (Alabama)	3456	27	0.89
Eagle Mountain (Texas)	706	46	1.51
Mill Creek (Kentucky)	330	47	1.54
Tradinghouse (Texas)	1380	56, 82	1.84, 2.69[a]
Arkansas (Arkansas)	820	90	2.95[b]
Mean		40	1.31

[a] Two units.

[b] Intake canal velocity.

Source: J. Loar, J. Griffith, and K. Deva Kumar, "An Analysis of Factors Influencing the Impingement of Threadfin Shad at Power Plants in the Southeastern United States," in *Fourth National Workshop on Entrainment and Impingement*, L. Jensen, Ed., 1978.

(biocides will not be used to control condenser fouling; FES-CP, p. III-34, and OL-ER, p. 3.4-3) that should reduce potential entrainment mortalities. The daily volume passing through Summer is so small in comparison with the total volume of Monticello (≈0.5%) that the entrainment of organisms with rapid turnover times and high fecundity (phytoplankton, zooplankton) is expected to have a negligible impact on their population in the reservoir. Moreover, any such organisms killed in passage will be released in the plume, and their biomass will enter the food chain as detrital material.

Organisms on which entrainment can potentially have a significant impact, however, are the planktonic larval forms of fish species, that is, ichthyoplankton. The loss of ichthyoplankton from entrainment at the Summer station will depend on their distribution in Monticello, their densities near the intake structure, their growth rates and behavioral characteristics, and the entrainment mortality rate. Because of the absence of such data concerning the newly formed reservoir, the staff calculated potential ichthyoplankton stock losses for various periods of exposure to entrainment at the Summer station determined from a range of entrainment mortalities and the assumption of uniform ichthyoplankton densities throughout Monticello (Fig. 4.2). Goodyear's lake/reservoir model[28] was used to predict entrainment loss.

A species whose ichthyoplankton/juvenile stages are vulnerable to entrainment for a period of 60 days, for example, would suffer about a 24% loss of its entrainable population under the assumption of one-pass mortality of 0.8 and a uniform distribution of entrainable stages in Monticello (Fig. 4.2). However, ichthyoplankton entrainment mortality relies greatly on ichthyoplankton distribution within Monticello, for which there is no data. If the density of entrainable stages were three times as high in the intake area as in Monticello as a whole

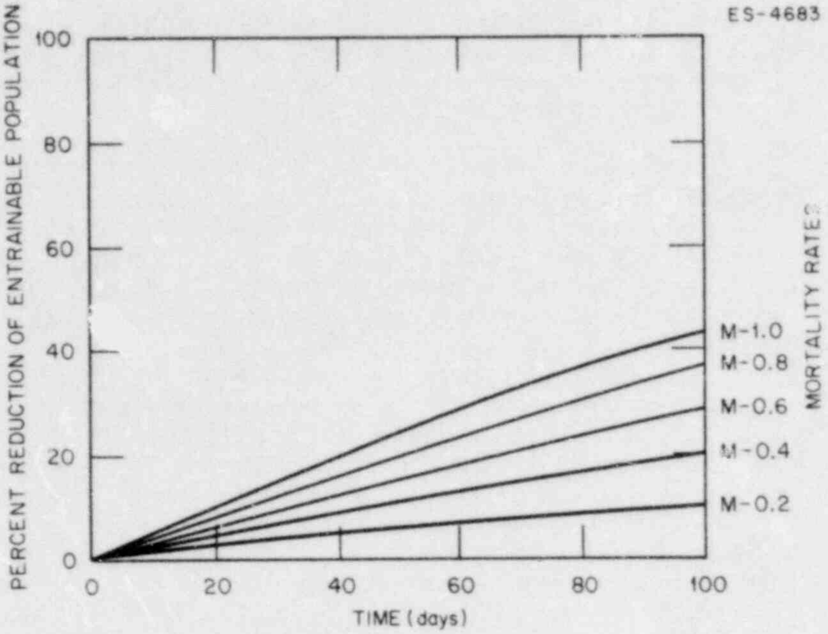

Fig. 4.2. Potential reduction of entrainable ichthyoplankton population from Summer station operation. The time scale refers to the duration of the fish life cycle (as ichthyoplankton) when the fish is susceptible to entrainment mortality. Uniform ichthyoplankton density is assumed for Monticello. Calculations are based on methodology reported in C. P. Goodyear, *Mathematical Methods to Evaluate Entrainment of Aquatic Organisms by Power Plants*, Publication No. FWS-OBS-76/20.3, U.S. Fish and Wildlife Service, September 1977.

(including hypolimnion) and the one-pass mortality were 1.0, the percent reduction of entrainable stock would increase to about 65%. However, if the density in the intake area were one-third the average for Monticello and the one-pass mortality were 0.5, then the percent reduction would be only about 6%. The magnitude of the impact on any individual species will vary and is dependent on distribution within the environment (in turn depending on the lake morphometry and the habitat development in Monticello), growth rates (as they influence the length of entrainment susceptibility), and ambient temperatures (which affect both growth rates and the absolute temperature achieved in the cooling cycle), among other factors. An assessment of absolute impacts based solely on pumping rates is not possible.

At this time, the potential entrainment losses from Summer operation cannot be quantified because of the absence of necessary data. Estimated reductions in entrainable populations of ichthyoplankton can vary greatly with alterations in underlying assumptions. Therefore, the impact of entrainment losses from Summer operation on the aquatic biota of Monticello, as it will evolve and be influenced by pumped storage operation, cannot be predicted at this time. The applicant is required by the NPDES permit to perform a 316(b) demonstration study (Appendix F). The results of this study will quantify these impacts and aid in determining any necessary mitigating measures.

Preliminary preoperational biological monitoring data[29,30] indicate ichthyoplankton densities in the cooling water intake area to be lower by approximately 50% as compared to areas in the upper portion of Monticello. If such distributions are maintained as Monticello ages, then the ichthyoplankton losses may be in the lower portion of the range calculated above. Should entrainment losses be unacceptably high, relocation of the water intake should be considered.

4.4.2.5 Impacts of chemical discharges

The description of the chemical discharges expected during operation of the Summer nuclear facility is given in Sect. 3.2.6. The values for wastes generated by startup, ion-exchange regenerate wastes, blowdown, and sanitary and general plant wastes measured at the discharge are generally low, and the staff does not anticipate any adverse effects from these chemical discharges. Chlorine will not be used as a biocide to prevent fouling of the condenser tubes (FES-CP, p. III-34, and OL-ER, p. 3.4-3), and chlorine used in the treatment of sanitary wastes will yield a total residual chlorine quantity of 0.5 mg/liter before dilution and a negligible 2.4×10^{-8} mg/liter after dilution with the cooling water.

4.4.2.6 Summary of potential aquatic impacts

The staff is limited in accurately assessing all possible aquatic impacts that will result from Summer station operation because Monticello Reservoir is a newly formed and developing environment that will be influenced to an unknown extent by pumped storage operation. Biological data for this reservoir are currently not available.

The staff predicts that Summer operation will have no adverse effect on temperature or oxygen content downstream from Parr Reservoir and, specifically, will not interfere with striped bass spawning in the Congaree River. Possible impacts of the thermal discharge on the aquatic ecology in Monticello should not be significant because of the small surface area involved and the release of the plume as a surface phenomenon. Dissolved oxygen depletion in Monticello is not predicted to be consequential. Losses from impingement and entrainment are impossible to quantify. However, the staff feels that Monticello will most likely be a marginal aquatic habitat because of the adverse influence of the Fairfield pumped storage facility and that impingement and entrainment losses at Fairfield will greatly exceed losses from Summer operation. In addition, impingement losses will be monitored, and if necessary, corrective actions can be taken after startup (Sect. 5.3.5). The applicant is required to undertake 316(a) and 316(b) demonstration studies to quantify thermal and entrainment/impingement impacts on Monticello Reservoir (Appendix F). Such data will aid in determining mitigating measures to be implemented should they be necessary.

4.5 RADIOLOGICAL IMPACTS

4.5.1 Exposure pathways

The environmental pathways considered in preparing this section are shown in Fig. 4.3. The pathways evaluated were direct radiation from the plant and pathways associated with the gaseous and liquid effluents. For gaseous effluents, the following pathways were evaluated:

- immersion in the gaseous plume;
- inhalation of iodines and particulates;
- ingestion of iodines and particulates through the milk cow, goat, meat animal, and vegetation pathway; and
- radiation from iodines and particulates deposited on the ground.

For liquid effluents, the following pathways were evaluated:

- drinking water,
- ingestion of fish and invertebrates, and
- shoreline activities and boating and swimming in water containing radioactive effluents.

Only those pathways associated with gaseous effluents reported to exist at a single location were combined in calculating the total exposure to a maximally exposed individual. Pathways associated with liquid effluents were combined without regard to location but were assumed to be associated with a different maximally exposed individual than the one considered for gaseous effluent pathways.

The models and considerations for environmental pathways used in estimating radiation doses resulting from plant operations to individuals near the plant and to the population within an 80-km (50-mile) radius of the plant are discussed in detail in Regulatory Guide 1.109. Use of these models and additional assumptions about environmental pathways leading to exposure to populations outside the 80-km radius are described in Appendix B of this Statement.

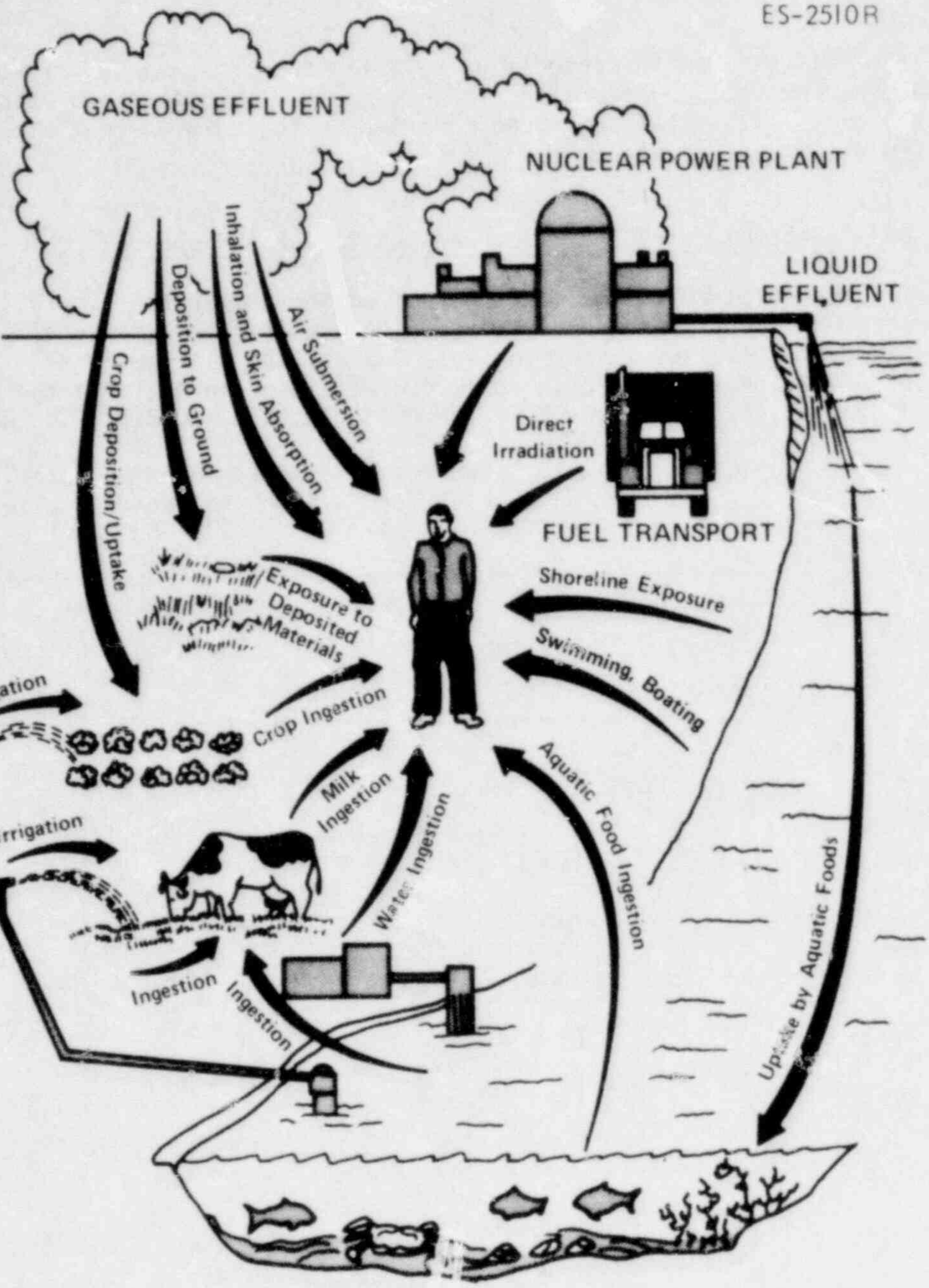

Fig. 4.3. Exposure pathways to man.

4.5.2 Dose commitments

The quantities of radioactive material released annually from the plant were estimated using the description of the radioactive waste systems given in the applicant's Environmental Report and the calculational model and parameters described in NUREG-0017.[31] The applicant's site and environmental data provided in the Environmental Report and in subsequent answers to NRC staff questions were used extensively in the dose calculations. Using these quantities of radioactive materials released and exposure pathway information, the dose commitments to individuals and the population were estimated. Population doses were based on the projected population distribution of the year 2000.

The dose commitments in this Statement represent the total dose received over a period of 50 years following one year's intake of radioactivity under the conditions existing 15 years after the station is started. For the younger age groups, changes in organ mass with age after the initial intake of radioactivity are accounted for in a stepwise manner.

In the analysis of all effluent radionuclides released from the plant, tritium, carbon-14, radiocesium, and radiocobalt inhaled with air and ingested with food and water were found to account for essentially all total-body dose commitments to individuals and the population within 80 km (50 miles) of the plant.

4.5.2.1 Dose commitments from radioactive releases to the atmosphere

Radioactive effluents released to the atmosphere from the Summer facility will result in small radiation doses to individuals and populations. The NRC staff estimates of the expected gaseous and particulate releases listed in Table 4.5 and the site meteorological considerations discussed in Sect. 2.4 and summarized in Table 4.6 were used to estimate radiation doses to individuals and populations. The results of the calculations are discussed below.

Table 4.5. Calculated releases of radioactive material in gaseous effluents from the Summer station (Ci/year)

Nuclide	Waste gas decay tanks	Reactor building	Auxiliary building	Turbine building	Air ejector exhaust	Total
Kr-83m	a	1	a	a	a	1
Kr-85m	a	11	2	a	1	14
Kr-85	203	5	a	a	a	210
Kr-87	a	2	1	a	a	3
Kr-88	a	14	4	a	3	21
Kr-89	a	a	a	a	a	a
Xe-131m	3	10	a	a	a	13
Xe-133m	a	43	2	a	1	46
Xe-133	a	2500	110	a	70	2700
Xe-135m	a	a	a	a	a	a
Xe-135	a	55	7	a	4	66
Xe-137	a	a	a	a	a	a
Xe-138	a	a	1	a	a	1
Total Noble Gases						3100
I-131	a	4.2E-2[b]	1.4E-2	1.2E-3	8.4E-3	6.6E-2
I-133	a	3.3E-2	2E-2	1.4E-3	1.2E-2	6.6E-2
Tritium						800
C-14	7	1	a	a	a	8
Ar-41	a	25	a	a	a	25
Mn-54	4.5E-5	2.1E-4	1.8E-4	c	c	4.4E-4
Fe-59	1.5E-5	7.3E-5	6E-5	c	c	1.5E-4
Co-58	1.5E-4	7.3E-4	6E-4	c	c	1.5E-3
Co-60	7E-5	3.3E-4	2.7E-4	c	c	6.7E-4
Sr-89	3.3E-6	1.7E-5	1.3E-5	c	c	3.3E-5
Sr-90	6E-7	2.9E-6	2.4E-6	c	c	5.9E-6
Cs-134	4.5E-5	2.1E-4	1.8E-4	c	c	4.4E-4
Cs-137	7.5E-5	3.7E-4	3E-4	c	c	7.5E-4

[a] Less than 1 Ci/year for noble gases and carbon-14, less than 10^{-4} Ci/year for iodine.

[b] Read as 4.2×10^{-2}.

[c] Less than 1% of total for this nuclide.

Table 4.6. Summary of atmospheric dispersion factors and values for maximum site boundary and receptor locations near the Summer station

Location	Source[a]	χ/Q (sec/m³)	Relative deposition (m⁻²)
Nearest[b] site land boundary (1.0 mile NNE)	A B	4.4E-6[c] 9.1E-6	1.8E-8 3.7E-8
Nearest[b] garden/residence (1.2 miles E)	A B	2.6E-6 6.7E-6	8.2E-9 2.1E-8

[a] Source A is the reactor building, auxiliary building, turbine building, and air ejector exhaust; release is continuous. Source B is the waste gas decay tank; there are 15 purges per year, 8 hr each purge.

[b] "Nearest" refers to that type of location where the highest radiation dose is expected to occur from all appropriate pathways.

[c] Read as 4.4 × 10^{-6}.

Radiation dose commitments to individuals

Individual receptor locations and pathway locations considered for the maximum individual are listed in Table 4.7. The maximum individual is assumed to consume well above average quantities of the foods considered (see Table E-5 in Regulatory Guide 1.109). The estimated dose commitments to the maximum individual from radioiodine and particulate releases at the selected offsite location and the maximum annual beta and gamma air dose and the maximum total-body and skin dose to an individual at the selected site boundary location are presented in Table 4.8. These calculated doses are compared with the design objective values of 10 CFR Part 50, Appendix I, and of RM-50-2, contained in the Annex to Appendix I, in Tables 4.9 and 4.10 respectively.

Radiation dose commitments to populations

Annual radiation dose commitments from airborne radioactive releases from the Summer nuclear station are estimated for two populations in the year 2000: (1) the population within 80 km (50 miles) of the station (Table 4.9) and (2) the entire U.S. population (Table 4.11). Dose commitments beyond 80 km (50 miles) are based of the assumptions discussed in Appendix B. For perspective, annual background radiation doses are given for the population within 80 km (50 miles) of the site (Table 4.9) and for the entire U.S. population (Table 4.11). The total body population dose to the population with 80 km (50 miles) of the site from airborne radioactive releases from the Summer nuclear station (i.e., about 1.8 person-rem) is a small fraction (less than 0.002 percent) of the corresponding population dose from natural background radiation (i.e., about 105,000 person-rem). The total body population dose to the entire U.S. population from airborne radioactive releases from the Summer Nuclear Station (i.e., about 28 person-rem) is an even smaller fraction about 0.0001 percent) of the corresponding U.S. population dose from natural background radiation (i.e., about 27 million person-rem).

Table 4.7 Receptor and pathway locations considered for selecting maximum individual dose commitments

	Sector	Distance (miles)
Site boundary[a]	NNE	1.0
Residence[b]	ESE	1.1
Garden/residence	E	1.2
Milk cow	NNE	4.5
Meat animal	SE	2.2
Special receptor or pathway[c]	WNW	0.4

[a] Beta and gamma air doses and total-body and skin doses from noble gases are determined at site boundaries.

[b] Dose pathways, including inhalation of atmospheric radioactivity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences.

[c] A special receptor or pathway would be a worker at the Fairfield pumped storage facility likely to be exposed via the same pathways as an individual at the nearest residence[b] for a fraction of the year.

Table 4.8. Annual dose commitments to maximum individual near the Summer station

Dose are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Rev. 1, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors, July 1977. All doses except gamma and beta air doses, which are in millirad per year, are in millirems per year

Doses from noble gases in gaseous effluents

Location	Pathway	Total body	Skin	Gamma air dose	Beta air dose
Nearest[a] site boundary (1.0 mile NNE)	Direct radiation from plume	0.14	0.42	0.23	0.57

Doses from iodine and particulates in gaseous effluents

Location	Pathway	Total body	Thyroid	Liver	Lung	GI tract
Nearest[b] garden/residence (1.2 miles E)	Ground deposit	0.01	0.01	0.01	0.01	0.01
	Inhalation	0.07	0.17	0.07	0.07	0.07
	Vegetation (to a child)	0.34	0.57	0.35	0.34	0.34

Doses from liquid effluents

Location	Pathway	Total body	Thyroid	Liver	Bone
Nearest[b] drinking water intake (city of Columbia)	Water ingestion	0.01	0.01	0.01	<0.01
Nearest sport location (Parr-Monticello reservoir system)	Fish ingestion	0.04	<0.01	0.05	0.03

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[a]Nearest" refers to that site boundary location where the highest doses from gaseous effluents are estimated to occur.

[b]"Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways is estimated to occur.

Table 4.9 Calculated dose commitments to a maximum individual and population within 80 km from Summer station operation

All doses to the individual are in millirems per year except as noted

	Individual doses	
	Appendix I dose design objective[a]	Calculated doses
Liquid effluents		
Dose to total body from all pathways	3	0.05
Dose to any organ from all pathways	10	0.06
Noble gas effluents (at site boundary)		
Gamma dose in air, millirads per year	10	0.23
Beta dose in air, millirads per year	20	0.57
Dose to total body of an individual	5	0.14
Dose to skin of an individual	15	0.42
Radioiodine and particulates[b]		
Dose to any organ from all pathways	15	0.75

Annual population doses (person-rem)

	Total body	Thyroid
Natural background radiation[c]	105,000	
Liquid effluents	1.0	1.0
Noble gas effluents	0.40	0.40
Radioiodines and particulates	1.4	3.0

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[a] Appendix I design objectives from Sects. II.A, II.B, II.C, and II.D of Appendix I to 10 CFR Part 50, consider doses to maximum individual and population per reactor unit. Fed. Reg: 40 19442 (May 5, 1975).

[b] Carbon-14 and tritium have been added to the category.

[c] U.S. Environmental Protection Agency, Natural Radiation Exposure in the United States, Report ORP-SID-72-1, June 1972; calculated using the average South Carolina State background dose of 97 millirems per year and year 2000 projected population of 1.08 x 10^6.

Table 4.10 Calculated dose commitments to a maximum individual from Summer station operation

All doses to the individual are in millirems per year per site except as noted

	RM-50-2 dose design objective[a]	Calculated doses
Liquid effluents		
Dose to total body from all pathways	5	0.05
Dose to any organ from all pathways	5	0.06
Non-tritium releases	5 Ci/yr/unit	0.26
Noble gas effluents (at site boundary)		
Gamma dose in air, millirads per year	10	0.23
Beta dose in air, millirads per year	20	0.57
Dose to total body of an individual	5	0.14
Dose to skin of an individual	15	0.42
Radioiodine and particulates[b]		
Dose to any organ from all pathways	15	0.75
I-131 releases	1 Ci/yr/unit	0.07

[a] Guides on design objectives proposed by the NRC staff on Feb. 20, 1974 consider doses to individuals from all units on site. From U.S. Atomic Energy Commission, "Concluding Statement of Position of the Regulatory Staff," Docket No. RM-2, Washington, D.C., Feb. 20, 1974, pp. 25-30 published as Annex to Appendix I to 10 CFR Part 50.

[b] Carbon-14 and tritium were added to this category.

Table 4.11 Annual total-body population dose commitments in the year 2000

Category	U.S. population dose commitment (person-rem per year)
Natural background radiation[a]	27,000,000
Summer station operation	
Plant workers	1300[b]
General public	
Radioiodine and particulates	27
Liquid effluents	1.1
Noble gas effluents	0.8
Transportation of fuel and waste	7

[a] Calculated using the average U.S. background dose (102 millirems per year) in U.S. Environmental Protection Agency, Natural Radiation Exposure in the United States, Report ORP-SID-72-1, June 1972, and year 2000 projected U.S. population from the U.S. Dept. of Commerce, Bureau of the Census, Population Estimates and Projections, Series II, Series P-25, No. 541, February 1975.

[b] The average reactor annual dose is 410 person-rem.[68,69] Particular plants have experienced average lifetime annual doses as high as 1300 person-rem. For purposes of conservatism the staff has used the higher value in this assessment.

4.5.2.2 Dose commitments from radioactive liquid releases to the hydrosphere

Radioactive effluents released to the hydrosphere from the Summer station during normal operation will result in small radiation doses to individuals and populations. The NRC staff estimates of the expected liquid releases listed in Table 4.12 and the site hydrological considerations discussed in Sect. 2.3 of this Statement and summarized in Table 4.13 were used to estimate radiation dose commitments to individuals and populations. The results of the calculations are discussed below.

Radiation dose commitments to individuals

The estimated dose commitments to the maximum individual from liquid releases at selected offsite locations are listed in Tables 4.8, 4.9, and 4.10. The maximum individual is assumed to consume well above average quantities of the foods considered and spend more time at the shoreline than the average person (see Table E-5 in Regulatory Guide 1.109).

Radiation dose commitments to populations

Annual radiation dose commitment from liquid radioactive releases from the Summer nuclear station are estimated for two populations in the year 2000: (1) the population within 80 km (50 miles) of the station (Table 4.9) and (2) the entire U.S. population (Table 4.11). Dose commitments beyond 80 km (50 miles) are based on the assumptions discussed in Appendix B. For perspective, annual background radiation doses are given for the population within 80 km (50 miles) of the site (Table 4.9) and for the entire U.S population (Table 4.11). The total body population dose to the population within 80 km (50 miles) of the site from liquid radioactive releases from the Summer Nuclear Station (i.e., about 1 person-rem) is a small fraction (less than 0.001 percent) of the corresponding population dose from natural background radiation (i.e., about 105,000 person-rem). The total body population dose to the entire U.S. population from liquid radioactive releases from the Summer nuclear station (i.e., about 1.1 person-rem) is an even smaller fraction (less than 0.00001 percent) of the corresponding U.S. population dose from natural background radiation (i.e., about 27 million person-rem).

Table 4.12 Calculated releases of radioactive materials in liquid effluents from the Summer station

Nuclide	Ci/year	Nuclide	Ci/year
Corrosion and Acivation		Te-129m	9E.5
Produce		Te-129	6.5
Cr-51	1.1E-4[a]	I-130	1.9E-4
Mn-54	1E-3	Te-131m	5E-5
Fe-55	1.1E-4	I-131	1E-1
Co-58	5E-3	I-132	3.8E-3
Fe-59	6E-5	Te-132	9.4E-4
Co-60	8.8E-3	I-133	5.7E-2
Zr-95	1.4E-3	I-134	1E-5
Nb-95	2E-3	Cs-134	[illegible]
Np-239	4E-5	I-135	8.3E-3
		Cs-136	2.7E-3
Fission products		Cs-137	3E-2
Br-83	4E-5	Ba-137m	5.7E-3
Rb-86	2E-5	Ba-140	1E-5
Sr-89	2E-5	La-140	1E-5
Mo-99	2.8E-3	Ce-144	5.2E-3
Tc-99m	3E-3	All others	4E-5
		Total except Tritium	0.26
Ru-103	1.4E-4		
Ru-106	2.4E-3		
Ag-110m	4.4E-4	Tritium	360
Te-127m	2E-5		
Te-127	2E-5		

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[a] Read as 1.1×10^{-4}.

Table 4.13 Summary of hydrologic transport and dispersion for liquid releases from the Summer station[a]

	Transit time (hr)	Dilution factor
Nearest drinking water intake (city of Columbia)	33	1
Nearest sport fishing location (Parr-Monticello reservoir system)[b]	0.0	1
Nearest shoreline (Parr-monticello reservoir system)[b]	0.0	1

[a] See Regulatory Guide 1.113, Estimating Aquatic Disperson of Effluents from Accidental and Routine Releases for the Purpose of Implementing Appendix I, April 1977.

[b] An almost uniform concentration would be established throughout this water body and its shoreline.

4.5.2.3 Direct radiation

Radiation from the facility

Radiation fields are produced in nuclear plant environs as a result of radioactivity contained within the reactor and its associated components. Doses from sources within the plant result primarily from nitrogen 16, a radionuclide produced in the reactor core. Because the primary coolant of a PWR is contained in a heavily shielded area of the plant, dose rates in the vicinity of PWRs are generally undetectable (less than 5 millirem per year). Low-level radioactivity storage containers outside the plant are estimated to contribute less than 0.01 millirem per year at the site boundary.

Occupational radiation exposure

The dose to nuclear plant workers varies from reactor to reactor and can be projected for environmental impact purposes by using the experience to date with modern pressurized water reactors (PWRs). Most of the dose to nuclear plant workers is due to external exposure to radiation from radioactive materials outside the body rather than internal exposure from inhaled or ingested radioactive materials. Recently licensed 1000 MWe PWRs are designed and operated in a manner consistent with the new (post-1975) regulatory requirements and guidance. These new requirements and guidance place increased emphasis on maintaining occupational exposure at nuclear power plants as low as is reasonably achievable (ALARA), and are outlined in 10 CFR Part 20, Standard Review Plan Chapter 12, and Regulatory Guide 8.8.[65,66,67] The applicant's proposed implementation of these requirements and guidelines are reviewed by the NRC staff at the construction permit licensing stage, the operating license licensing stage, and during actual operation. Approval of the proposed implementation of these requirements and guidelines is granted only after the review indicates that an ALARA program can actually be implemented. As a result of our review of the Summer safety analysis report, the staff has determined that the applicant is committed to design features and operating practices that will assure that individual occupational radiation doses can be maintained within the limits of 10 CFR Part 20 and that individual and population doses will be as low as is reasonably achievable.[70]

Based on actual operating experience, it has been observed that occupational dose has varied considerably from plant to plant, and from year to year. Average individual and collective dose information is available from over 190 reactor-years of operation between 1974 and 1979. These data indicate that the average reactor annual dose at PWRs has been about 410 person-rems, with particular plants experiencing an average annual dose as high as 1300 person-rems.[68,69] These dose averages are based on widely varying yearly doses at PWRs. For example, annual collective doses for PWRs have ranged from 18 to 5262 person-rems per reactor.[68] The average annual dose per nuclear plant worker has been about 0.8 rem.[68]

The wide range of annual doses (18 to 5262 person-rems) experienced by U.S. PWRs is dependent on a number of factors such as the amount of required routine and special maintenance, and the degree of reactor operations and inplant surveillance. Since these factors can vary in an unpredictable manner, it is impossible to determine in advance a specific year-to-year or average annual occupational radiation dose for a particular plant over its operating lifetime. The need for high doses can occur, even at plants with radiation protection programs that have been developed to assure that occupational radiation doses will be kept at levels that are ALARA. Consequently, the NRC staff's occupational dose estimates for environmental impact purposes for the Summer nuclear station are based on the conservative assumption that the Summer plant may have a higher than average level of special maintenance work. Based on the Staff's review of the occupational dose data for over 190 PWR reactor operating years, the NRC staff projects that the occupational doses at Summer could average as much as 1300 person-rems/yr when averaged over the life-of-the plant.[70] However, actual year to year doses at Summer may differ greatly from this average depending on actual plant operating conditions.

Transportation of radioactive material

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive waste from the reactor to burial grounds is within the scope of the NRC report entitled, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants."[33] The estimated population dose commitments associated with transportation of fuels and wastes are listed in Tables 4.11 and 4.14.

Table 4.14. Environmental impact of transportation of fuel and waste to and from a light-water-cooled nuclear power reactor

	Normal conditions of transport		
Heat (per irradiated fuel cask in transit)			260 MJ/hr
Weight (governed by Federal or State restrictions)			33,000 kg per truck; 90 MT per cask per rail car
Traffic density			
Truck			Less than one per day
Rail			Less than three per month
	Exposure to population		
Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals[a] (millirems per reactor year)	Cumulative dose to exposed population (man-rems per reactor year)[b]
Transportation worker	200	0.01 to 300	4
General public			
Onlookers	1,100	0.003 to 1.3	
Along route	600,000	0.001 to 0.06	3
	Accidents in transport		
Radiological effects		Small[c]	
Common (nonradiological) causes		1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year	

[a] The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5000 millirems per year for individuals as a result of occupational exposure and should be limited to 500 millirems per year for individuals in the general population. The dose to individuals from average natural background radiation is about 102 millirems per year.

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

[c] Although the environmental risk of radiological effects stemming from transportation accidents cannot currently be numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Source: Data supporting this table are given in the Commission's *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*, Report WASH-1238, December 1972, and Suppl. I, Report NUREG-75/038, April 1975.

4.5.3 Radiological impact on man

The actual radiological impact associated with the operation of the proposed Summer station will depend, in part, on the manner in which the radioactive waste treatment system is operated. As concluded from the NRC staff's evaluation of the potential performance of the radioactive waste system, the proposed system is capable of meeting the dose design objectives of 10 CFR Part 50, Appendix I, and those of RM-50-2 contained in the Annex to Appendix I. The applicant chose to show compliance with the design objectives of RM-50-2 as an optional method of demonstrating compliance with the cost-benefit section of Appendix I, Sect. II.D. Tables 4.9 and 4.10 compare the calculated maximum individual doses to the design objective doses. However, because the facility's operation will be governed by operating license technical specifications and because the technical specifications will be based on the design objective doses of 10 CFR Part 50, Appendix I, shown in Table 4.9, the actual radiological impact of plant operation may result in doses close to the design objective doses. Even if this situation exists, the individual doses will still be very small compared to natural background doses (~100 millirems per year) or the dose limits specified in 10 CFR Part 20. As a result, the staff concludes that there will be no measurable radiological impact on man from routine operation of the plant.

The licensee is also subject to EPA's 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." This specifies that the annual dose equivalent should not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and radiation from these operations.

4.5.4 Radiological impacts to biota other than man

Depending on the pathway and radiation source, terrestrial and aquatic biota will receive doses approximately the same or somewhat higher than those man will receive. Although guidelines have not been established for acceptable limits for radiation exposure to species other than man, it is generally agreed that the limits established for humans are also conservative for other species. Experience has shown that it is the maintenance of population stability that is crucial to the survival of a species, and species in most ecosystems suffer rather high mortality rates from natural causes. Although the existence of extremely radiosensitive biota is possible and although increased radiosensitivity in organisms may result from environmental interactions with other stresses (e.g., heat, biocides, etc.), no biota have yet been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding the Summer station. Futhermore, at all the nuclear plants for which an analysis of radiation exposure to biota other than man has been made, there have been no cases of exposures that can be considered significant in terms of harm to the species or that approach the exposure limits to members of the public permitted by 10 CFR Part 20.[34] Because the BEIR Report[35] concluded that the evidence to date indicates that no other living organisms are very much more radiosensitive than man, no measurable radiological impact on populations of biota is expected as a result of the routine operation of this plant.

4.5.5 Risks due to radiation exposure from normal operations

The individual doses associated with exposures will be controlled such that the limits set forth in 10 CFR Part 20 for exposure of workers and the general public are not exceeded. In addition, the licensee's operating license will contain Technical Specifications to maintain radioactive effluents to values as low as reasonable achievable (ALARA) in order that the dose design objectives of 10 CFR Part 50 Appendix I, can be met for the general public. The limits in 10 CFR Part 20 and the annual dose design objectives in 10 CFR Part 50 Appendix I are intended to assure that the risk to any exposed individual is extremely small. The risk estimates are derived from the recommendations of the National Academy of Sciences Biological Effects of Ionizing Radiation Committee (BEIR I) and GESMO.[71,72] The following estimates of the risks to workers and the general public are based on conservative assumptions (i.e., the estimates are probably higher than the actual number). The following risk estimators were used to estimate potential health effects: about 140 potential deaths from cancer per million person-rem and about 260 potential cases of all forms of genetic disorders per million person-rem. The cancer fatality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. This would produce risk values up to about four times greater than those used in this report. The NRC staff regards this as a reasonable upper limit to the range of our uncertainty. The lower limit of the range would be zero. The range of uncertainty in the genetic risk estimates extends a factor of about 6 above and about 4 below the preceeding value of about 260 potential cases of all forms of genetic disorders per million person-rems. The BEIR III Report estimates that the number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers.[75]

It should be noted that the preceeding values for risk estimators are consistent with the recommendations of a number of recognized radiation protection organizations, such as the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurement (NCRP), the National Academy of Sciences BEIR III Report, and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).[73-76]

4.5.5.1 Occupational exposure

This section contains estimates of the risk of occupational radiation exposure for three categories: (1) the non-radiological and radiological occupational risk experienced by the average power plant worker; (2) the risk of potential fatal radiation-induced cancers in the exposed workforce population; and (3) the risk of potential radiation-induced genetic disorders in all future generations of the exposed workforce population.

Risk to workers

The average annual dose per nuclear plant worker at operating LWRs (about 0.8 rem) has been well within the limits of 10 CFR Part 20. However, for comparative purposes, the NRC staff has estimated the risk experienced by nuclear power plant workers. The nuclear plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The occupational risk associated with the industry-wide average radiation dose is about 11 potential premature deaths/10^5 persons per year of exposure at 0.8 rem/yr due to cancer.* The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers.[75] The nonradiation job-related mortality incidence of nuclear plant workers is expected to be no greater than the job-related mortality incidence for similar types of work. The average nonradiation job-related risk for 7 U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths/10^5 person-years.[77] Adding the nonradiation job-related risk to the potential radiation-related risk the comparable risk to a nuclear power plant worker receiving the average annual dose would be about 23 premature deaths per 10^5 person-years.

The risks of various occupations, including nuclear plant workers, are shown in Table 4.14a. In terms of job-related fatalities, the occupational risks to a nuclear power plant worker (i.e., about 23 premature deaths/10^5 person-years) is higher than the average private sector risk (i.e., 10 premature deaths/10^5 person-years). However, the risk to nuclear plant workers is lower than the risk for a number of other groups. It should be pointed out that the potential mortality incidence rates due to radiation exposure that account for about half of the fatalities for the nuclear power plant workers that are listed in Table 4.14a are conservative estimates (i.e., the actual risk may be much less than the estimate), whereas the mortality incidences for other groups are based on known instances of actual job-related fatalities.

Based on the above comparisons, the staff concludes that the occupational risk to nuclear plant workers from operation of the Summer nuclear station is comparable to the risks associated with other occupations.

Risk to workforce population

The risk of potential fatal cancers in the exposed workforce population, and the risk of potential genetic disorders in all future generations of the exposed workforce population is estimated as follows. Multiplying the annual plant worker population dose (i.e., 1300 person-rem) by the risk estimators, the NRC staff estimates that 0.2 cancer deaths may occur in the exposed population and 0.3 genetic disorders may occur in all future generations of the exposed population. The value of 0.2 cancer deaths means that the probability of one cancer death over the lifetime of the entire workforce due to one year of operation at the Summer nuclear station is about 2 chances in 10. The number of potential non-fatal cancers would be about 1.5 to 2 times the number of potential fatal cancers. The value of 0.3 genetic disorders means that the probability of 1 genetic disorder in all future generations due to exposure to radiation during one year of operations at the Summer nuclear station is about 3 chances in 10. These health impacts will not be measurable when spread over the lifetime of the entire work force.

4.5.5.2 Exposure of the general public

The doses associated with exposure of the general public from radioactive effluents from normal operations at the Summer nuclear station will be controlled so as not to exceed the limits set forth in 10 CFR Part 20. In addition, the licensee's operating license will contain Technical Specifications to maintain radioactive effluents to values as low as reasonably achievable according to the

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*Exposure to individual workers will vary from the average; however, exposure to individual workers will be limited so as not to exceed the limits in 10 CFR Part 20 for occupational exposure.

Table 4.14a Incidence of job-related fatalities

Occupational group	Mortality incidence rates (premature deaths/10^5 person-years)
Underground metal miners[a]	1275
Uranium miners[a]	422
Smelter workers[a]	194
Mining[c]	61
Agriculture, forestry, and fisheries[c]	35
Contract construction[c]	33
Transportation and public utilities	24
Nuclear plant worker[b]	23
Manufacturing[c]	7
Wholesale and retail trade[c]	6
Finance, insurance, and real estate[c]	3
Services[c]	3
Total private sector[c]	10

[a] "The President's Report on Occupational Safety and Health," May 1972.[78]

[b] The fatality incidence rate for nuclear plant workers is based on an annual exposure of 0.8 rem to the average worker, and the nonradiation-related fatalities for 7 large U.S. electrical utilities over the period 1970-1979.[77] About half of the estimated mortality incidence rate for nuclear plant workers is potential, rather than actual, premature deaths that might be caused by radiation exposure.

[c] "Occupational Injuries and Illness in the United States by Industry, 1975," Bureau of Labor Statistics, Bulletin 1981, 1978.[79]

annual dose design objectives in 10 CFR Part 50 Appendix I. The following estimates of the risks to the general public are based on conservative assumptions. For example, the BEIR III Committee has stated:

> "It is by no means clear whether dose rates of gamma or x radiation of about 100 mrads/yr are in any way detrimental to exposed people; any somatic effects would be masked by environmental or other factors that produce the same types of health effects as does ionizing radiation. It is unlikely that carcinogenic effects of low-LET radiation administered at this does rate will be demonstrated in the foreseeable future.[75]

The estimated annual doses associated with exposure of the general population to radioactive effluents from normal operations of the Summer nuclear station are far below the dose rate of 100 mrads/yr referred to by the Beir III Committee.

Risk to individuals

Multiplying the risk estimators in the preceding section by the 10 CFR 50 Appendix I annual dose design objectives, the risk of potential premature death from cancer to the maximum individual from exposure to radioactive effluents from one year of reactor operations is less than one chance in a million (i.e., about 7×10^{-7} for exposure to gaseous effluents and about 4×10^{-7} for exposure to liquid effluents) over the average lifetime.* The risk of potential premature death from cancer to the average individual within 50 miles of the reactor from exposure to radioactive effluents from the reactor is less than 1 percent of the risk fo the maximum individual. The risk of potential non-fatal cancers is approximately 1.5 to 2 times the risk of death from potential fatal cancers.

For comparative purposes, the NRC staff has estimates the risk of potential premature death from cancer to the general public from exposure to other sources of radiation in the United States (see Table 4.14b). These risks have been estimated using the same conservative assumptions that were used in estimating risks to workers and the general public from exposure to radiation from nuclear power plants. The risk to the maximum individual from exposure to gaseous or liquid radioactive effluents from one year of reactor operations is much less than the risk from exposure to any of the major sources of radiation (e.g., smoking, medical exposure and natural background radiation) and within the same range as the risk from exposure to many of the other common sources of radiation (e.g., airline travel, natural gas heating, and television viewing). Since the risk from exposure to gaseous or liquid radioactive effluents from nuclear power plants is so low compared with many other types of risk (radiation-related or otherwise), and since the radiation-related risks are based on conservative assumptions, the NRC staff considers the risk to real individuals from exposure to radioactive effluents from normal operations at the Summer nuclear station to be insignificant.

Risk to U.S. population

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation of the Summer nuclear station (i.e., about 36 person-rem), by the preceding risk estimators, the NRC staff estimates that there may occur 0.005 cancer deaths in the exposed population, and 0.01 genetic disorders in all future generation of the exposed population. The number of potential non-fatal cancers would be approximately 1.5 to 2 times the number of potential cancer deaths. The probability of one cancer death over the lifetimes of the U.S. general public due to exposure to radioactive effluents and transportation of fuel and waste from normal annual operation to the Summer nuclear station is less than 1 chance in 100. The probability of one genetic disorder in future generations of the U.S. general public due to exposure to radioactive effluents and transportation fuel and waste from normal annual operation of the Summer nuclear station is about 1 chance in 100. For comparative purposes, the NRC staff has estimated the risk of poential premature death from cancer to the general public from exposure to natural background radiation. Multiplying the U.S. population dose from one year's exposure to background radiation by the preceding risk estimators, the NRC staff estimates that there may occur about 3600 cancer deaths in the exposed population and about 7000 genetic disorders in the future generations of the U.S. population due to exposure to background radiation. The risks to the general population from exposure to radioactive effluents and transportation of fuel and wastes from each year of operation of the Summer nuclear station are a very small fraction (less than 0.0002 percent) of the risks to the U.S. population from each year of exposure to natural background radiation.

Another way to put the risk to the general public from exposure to radioactive effluents and transportation of fuel and waste from the annual operation of the Summer nuclear station in perspective

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

Table 4.14b Approximate ranking of risks from various sources of radiation exposure in the United States

Source of exposure	Exposed group	Part of body exposed	Average annual dose,[a] mrem	Approximate risk,[b] chance of premature death in a million
Natural radioactivity in tobacco	Smokers	Bronchial epithelium	8000[c]	180
Medical diagnosis by radiopharmaceuticals	Patients	Bone marrow	300	40
Medical diagnosis by X-rays	Adult patients	Bone marrow	103	14
Natural background radiation	Total population	Whole body	~80	11
Many types of radioluminous clocks	Users	Whole body	~8	1.1
Building materials	Population in brick and masonary building	Whole body	7	0.9
Commercial nuclear power plants				
Gaseous effluents (Appendix I objective)	Maximum individual	Total body	5	0.7
Liquid effluents (Appendix I objective)	Maximum individual	Total body	3	0.4
Atmospheric weapons tests	Total population	Whole body	~4	0.5
Unvented heaters using natural gas	Users	Bronchial epithelium	22	0.5
Airline travel	Passengers	Whole body	3	0.4
Dental diagnosis	Adult patients	Bone marrow	3	0.4

Table 4.14b (continued)

Source of exposure	Exposed group	Part of body exposed	Average annual dose,[a] mrem	Approximate risk,[b] chance of premature death in a million
Many types of luminous wristwatches	Users	Gonadal dose equivalent	3	0.4
Natural gas cooking ranges	Users	bronchial epithelium	~7	0.2
Television receivers	Viewing population	Gonads	~0.8	0.1
Commercial nuclear power plants				
Liquid and gaseous effluents	Population within 50 miles	Total body	~0.003	0.0004

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[a] Average annual doses for all sources except commercial nuclear power plants were taken from either BEIR III[75] or NCRP.[80] The average annual dose to the maximum individual from effluents from commercial nuclear power plants is the 10 CFR 50 Appendix I total-body dose design objectives. While other body organs may receive slightly higher doses (e.g., the thyroid dose is limited to 15 mrem/yr from radioiodines and particulates), the risk from the dose to other body organs will not significantly affect the approximate ranking. The average annual dose to the average individual within 50 miles of a commercial nuclear power plant is derived from Table 4.9.

[b] Risk was calculated by multiplying the average annual dose (in rem) by risk estimates of 135, and 22.2 potential cancer deaths per million person-rem for total body and lung exposures, respectively. The total body risk estimator was used to approximate the risk from the dose to the bone marrow from medical exposure. The risk of potential non-fatal cancers would be about 1.5 to 2 times the risk of potential cancer fatalities.

[c] Hypothetical maximum at highly localized points.

is to compare the preceding risks (i.e., 0.005 potential cancer deaths and 0.01 potential genetic disorders) with the risk to the year 2000 population using the current incidents of actual cancer fatalities and actual genetic disorders.

Multiplying the estimated U.S. population for the year 2000 (i.e., ~ 260 million persons) by the current incidence of actual cancer fatalities (i.e., ~20%) and the current incidence of actual genetic diseases (i.e., ~ 6%), then about 52 million cancer deaths and about 16 million genetic abnormalities are expected.[71,81] The risk to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of the Summer nuclear station are very small fractions (less than 1 part in a billion) of the estimated incidence of cancer fatalities and genetic abnormalities in the year 2000 population.

On the basis of the preceding comparisons (i.e., comparing the risk from exposure to radioactive effluents and transportation of fuel and waste from the annual operation of the Summer nuclear station with the risk from exposure to other sources of radiation, and the risk from the estimated incidence of cancer fatalities and genetic abnormalities in the year 2000 population), the NRC staff concludes that the risk to the public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operation of the Summer nuclear station will not be significant.

4.6 SOCIOECONOMIC IMPACTS

4.6.1 Social impacts of construction labor force

Construction of the Summer station began in April 1973 with approximately 500 workers. A year later, the construction work force numbered over 1000, and by the end of 1975 the figure had climbed to roughly 1500. A rapid increase in construction activity occurred in 1976; slightly over 3000 workers were on the job by November of that year. The size of the work force dropped markedly in January 1977 and remained between 2240 and 2455 the entire year. The number of workers is expected to be fairly constant through 1978 as well, ranging between 2200 and 2400. In 1979, construction activity should decline steadily from 2200 workers at the start of the year to only 1650 at the end. The construction activity will continue to decline throughout 1980 until commercial operation commences.

At the same time that the Summer station was under construction, the applicant was also engaged in building the Fairfield Pumped Storage Hydrostation about 1 mile away. Although an assessment of that project's impacts is beyond the scope of this study, the staff notes that peak construction activity was reached there around the same time the Summer work force was at its highest. By adding the roughly 1500 Fairfield workers employed at that time to the 3000 working at Summer, a peak construction work force of 4500 is obtained for the two projects combined.[36]

In mid-November 1976, when construction was at its peak, approximately 2400 of the 3000 workers on the Summer project were craftsmen employed by the primary contractor, the Daniel Construction Company of Greenville, South Carolina. The remainder were salaried and office workers and tradesmen employed by the various subcontractors engaged in the project.[37] Of the 2400 Daniel Company craftsmen, a survey conducted by the Daniel personnel department shows that over 1900 of them, or nearly 80%, lived within 80 km (50 miles) of the construction site. Table 4.15 shows that nearly 50% of this "local" group lived in Lexington and Richland counties, which together comprise the Columbia Standard Metropolitan Statistical Area (SMSA), and over 70% resided in the Central Midlands region, consisting of the SMSA plus Fairfield and Newberry counties. The rest of the local workers were spread among nine neighboring counties. Of those workers living outside the 80-km (50-mile) radius, many probably lived in the Greenville, South Carolina, and Augusta, Georgia, areas (OL-ER, p. 4.1-9).

In addition to those engaged directly in the construction of the Summer facility, there are workers whose jobs have been created "indirectly" by the project. These people provide the goods and services required in the course of building the facility as well as those demanded by the construction work force. According to the U.S. Department of Housing and Urban Development, between 0.3 and 0.9 indirect jobs are created by each construction job.[38] For the Summer project this represents between 690 and 2070 additional workers for the years 1976 through mid-1978, when the average construction work force was about 2300. Because the plant site is so close to the Columbia SMSA, where there is a highly developed service sector, the number of new indirect jobs necessitated by construction has probably been in the low end of the range.

To assess the social impacts of construction, it is not enough to know how many direct and indirect jobs are created by the project; the number of these jobs filled by in-movers, who require various services and facilities, must also be ascertained. Assuming that those direct employees not counted in the Daniel Company survey had similar residence patterns to those responding and that indirect workers were roughly the same, the result is a construction-period work force located predominantly in the Central Midlands region. As discussed in Sect. 2.2.1, the population of Fairfield County grew by only 100 from 1970 to 1976, so it is obvious that plant-related in-migration was limited there. In Newberry County, the population grew by slightly less than 2000 in those same years, an increase of 6.6%. Only half of this growth was from in-migration,[39] and even if this were entirely plant related, it would still represent a small portion of the base population. The remainder of construction-related personnel in the Central Midlands lived in the Columbia SMSA, where the population is approximately 375,000 and growth in the years 1970 to 1976 was over 50,000.[39] Compared to these figures, plant-induced in-migration would have been relatively small even if all construction-related workers in the SMSA were in-movers, a condition that the staff considers highly unlikely.

Because the number of workers moving into the Central Midlands counties has been small relative to existing population, the staff feels that the accompanying social pressures have also been small. According to the county administrators of rural Fairfield and Newberry counties, plant construction has had minimal effects on the demand for housing and public services there.[40],[41] In Lexington and Richland counties, any increased demand for services caused by construction of the Summer facility is a small part of the total brought about by continuing growth in the region.

Because plant construction has not brought substantial growth to the Central Midlands, any out-migration of construction workers that may occur after completion of the plant is likely to have little impact on the area.

Table 4.15. Peak construction work force[a] living within 80 km (50 miles) of the site

Area	Work force residents	Area	Work force residents	Area	Work force residents
Richland County		Laurens County		Cherokee County	
Columbia	535	Clinton	61	Gaffney	12
Blythewood	17	Laurens	35		
Eastover	13	Joanna	23	Greenwood County	
Hopkins	7		119	Ware Shoals	11
	572	Kershaw County			
Lexington County		Camden	75	Total	1913
West Columbia	105	Lugoff	28		
Lexington	55		103		
Batesburg	35	Union County			
Chapin	33	Union	52		
Cayce	31	Carlisle	18		
Gaston	25	Buffalo	11		
Leesville	24		81		
Irmo	23	York County			
Gilbert	12	Rock Hill	60		
Swansea	12	York	12		
	355	Fort Mill	8		
Newberry County			80		
Newberry	115	Chester County			
Pomaria	43	Chester	43		
Prosperity	30	Lockhart	17		
Whitmore	26	Great Falls	13		
Little Mountain	16	Leeds	5		
Peak	12		78		
Silverstreet	9	Lancaster County			
	251	Lancaster	23		
Fairfield County		Elgin	13		
Jenkinsville	57		36		
Blair	52	Saluda County			
Winnsboro	40	Saluda	36		
Blackstock	17				
Ridgeway	13				
	179				

[a] Craftsmen employed by the Daniel Construction Company as of Nov. 14, 1976.

Source: Written communication from Jim Steely, Personnel Department, Daniel Construction Company, Greenville, South Carolina.

Between 1970 and 1976, retail trade in Fairfield County more than doubled (Sect. 2.2.3) despite the fact that population increased by less than 1%. The staff feels that construction of the Summer station is partly responsible for this trend; money spent by workers in the vicinity of the plant has had the effect of stimulating the local economy. In the rest of the Central Midlands, increases in retail sales have been substantial but the Summer project has played a far lesser role in this regionwide growth.

In the same period, per capita income in the Central Midlands has increased substantially. Well-paying jobs associated with the Summer facility have contributed to this trend, but these jobs comprise such a small portion of total region employment that Summer's influence has probably been relatively minor. On the other hand, in Fairfield County, where population is low and wages have long been the lowest in the region, the creation of a substantial number of new, high-paying construction jobs has had a more pronounced effect, as evidenced by the fact that average income climbed more here than in the other Central Midlands counties (Sect. 2.2.3).

Despite the new jobs created by the Summer project, unemployment has still risen in the Central Midlands region in the five years since construction began (Sect. 2.2.3). Without this activity, however, the increase would have been even greater.

According to the applicant, traffic congestion has been very pronounced in the vicinity of the construction site at the beginning and end of the day shift. This increase in road use has resulted in inconvenience to local residents and in accelerated road wear (OL-ER, Sect. 4.1.4).

Finally, there has been an increase in the incidence of certain crimes in the vicinity of the site during the construction period. Between 1974 and 1977, breaking and entering, larceny, and motor vehicle theft all increased in Fairfield County at a much greater rate than in the state as a whole.[42] The staff believes that the jump in these crimes is partly a result of the increased presence of people and money in the area as a result of plant construction. In all these categories, however, the number of crimes in Fairfield County is still below the State average.

4.6.2 Social impacts of operating labor force

During the operation period, expected to begin around mid-1980, the applicant plans to employ 213 people at the site. Table 4.16 shows that slightly more than one-fourth of these will be involved in maintenance, over one-fourth will be administrative employees including security personnel, almost one-fifth will be involved in technical support, and another one-fifth will be responsible for actual operations.

Table 4.16. Operating personnel for the Summer station

Position	Personnel	Position	Personnel	Position	Personnel
Administration		Maintenance		Technical support	
Plant manager	1	Maintenance supervisor	1	Technical support, engineering supervisor	1
Assistant plant manager	1	Mechanical supervisor	1	Nuclear engineer	1
Administrative supervisor	1	Mechanics	10	Plant engineers	10
Quality control engineers	4	Apprentice mechanics	10	Health Physics supervisor	1
Plant clerk	1	Electrical supervisor	1	Health Physics technicians	12
Assistant clerks	5	Electricians	8	Results engineer	1
Security	40	Apprentice electricians	8	Computer technicians	3
Training	5	Instrument supervisor	1	Clerks	3
	58	Instrument mechanics	10	Chemistry supervisor	1
Operations		Apprentice instrument mechanics	10	Chemistry technicians	8
Operations supervisor	1	Utility foreman	1		41
Shift supervisors	5	Utility men	10	Total operating personnel	213
Control room operators	5	Maintenance engineer	1		
Assistant operators and station attendants	30	Storeroom clerk	1		
	41		73		

Source: Written communication from Mark Whitaker, Nuclear Licensing, SCE&G, September 1978.

According to economic base theory, basic activities such as manufacturing drive the local economy by bringing in money from outside the immediate area, which in turn creates jobs in the nonbasic, service-oriented sector. Data compiled at the Argonne National Laboratory indicate that each new basic job in Fairfield County results in 0.7 nonbasic jobs.[43] Because the production of electricity is considered a basic activity, the 213 operations jobs at the Summer station should create an additional 149 jobs in the nonbasic sector. These jobs are not created immediately but develop over time in response to changes in basic employment. Counting both direct and indirect employment associated with the Summer project, 362 new jobs will be created during the operations period. In Fairfield County, there will be an average of 1.8 nonworking dependents for each worker.[43] Applying this ratio to plant-induced employment, a total population of 1013 is reached (Table 4.17).

As discussed in Sect. 4.6.1, the majority of construction workers on the Summer project lived in the Central Midlands region, and the greatest share of these were in the Columbia SMSA. This clustering of employees in the Central Midlands is expected to continue in the operations period and, in fact, is likely to become even more pronounced as permanent workers choose to limit commuting time by living closer to their place of employment. Within the region, Fairfield and Newberry counties may receive a higher proportion of plant-induced population than in the past because of their closer proximity to the site, although the Columbia SMSA is sure to retain its attractiveness for many.

It is unclear what portion of those operations period workers residing in the Central Midlands will be in-movers. Table 4.18 shows the magnitude of projected plant-induced population relative to existing population levels in the four Central Midlands counties and their major cities. If the entire 1013 people associated with this project were in-movers settling in Richland County, they would represent less than 0.5% of the existing population there. In Lexington County, such an in-migration would increase population by less than 1%. Population increases of 3.2 and 5%, respectively, would be associated with an influx of 1013 new residents in Newberry and Fairfield counties. In the municipality of Newberry, absorbing all plant-induced growth would increase current population by 11.3%, whereas in Winnsboro this number of new residents would mean a jump of 31.1%.

The above figures indicate that even for the smaller counties in the region, absorbing total plant-induced growth would bring only moderate growth. On the local level, impacts could be much more substantial if all operations-period workers were in-movers and all settled in a single municipality. Neither of these conditions should occur, and growth within any single jurisdiction should be moderate compared to existing population levels.

According to the county administrators of rural Fairfield[40] and Newberry counties,[41] operation of the Summer station is not expected to bring sufficient population growth to strain existing public service delivery systems, a judgement with which the staff concurs. In both counties, telephone service and electricity are available throughout, and water is provided through both publicly and privately operated systems in those areas where population is most concentrated.

Table 4.17. Operations-period employment and associated population

Direct employment		Indirect employment		Total plant-induced population
Workers	Nonworking dependents[a]	Workers[b]	Nonworking dependents[a]	
213	383	149	268	1013

[a] Based on number of nonworking dependents per worker in Fairfield County, from Stenehjem and Metzger.

[b] Based on ratio of nonbasic to basic employment in Fairfield County, from Stenehjem and Metzger.

Sources: Written communication from Mark Whitaker, Nuclear Licensing, SCE&G, September 1978 (direct employment); E. J. Stenehjem, and J. E. Metzger, *A Framework for Projecting Employment and Population Changes Accompanying Energy Development*, Argonne National Laboratory, Argonne, Ill., August 1976 (indirect employment and nonworking dependents).

Sewer facilities are more limited; they are provided by those individual municipalities with the highest populations. Both counties also provide public education through their school districts, plus fire protection and recreation facilities.[44] Improvements in many of the systems discussed above are currently planned to handle additional growth anticipated between now and the turn of the century.[43]

In Lexington and Richland counties, the area covered by water and sewer systems is much larger than in the two rural counties just discussed. There are a number of municipal and private water systems serving residents here, although certain rapidly growing portions of Lexington County currently have no service. Sewage treatment is also provided in the most densely populated parts of both counties but is not as widely available as is water service. As in the other Central Midlands counties, public education, recreation, and fire protection are provided, as is telephone and electric service.[44] Public service improvements are planned to handle the growth that is expected to continue in the SMSA,[43] the vast majority of which is due to forces other than the Summer station.

Over the past decade, the construction industry has been active in the Central Midlands region. Although the majority of new residential units erected have been in the Columbia area,[39] Newberry and Fairfield counties each averaged about 100 new units annually between 1970 and 1976, excluding mobile.[40,45] The building industry capability and the supply of available land are such that sufficient units can be made available for the plant-induced population influx in the region.

4.6.3 Economic impacts

The 362 jobs created directly and indirectly by Summer operations represent 0.2% of all nonagricultural wage and salary employment in the Central Midlands (Sect. 2.2.3), from which most of the workers involved will be drawn. Because of the small contribution to total employment, the Summer facility will have little influence on the nature of the regional economic base or the rate of unemployment. Overall, regional income will increase slightly because the wages to be paid at the nuclear plant are substantially higher than the Central Midlands average (OL-ER, Responses to Questions, Sect. 8.0, No. 1).

Table 4.18. Plant-induced population relative to existing population in the Central Midlands region

	Existing population	Plant-induced population as a percentage of existing population[a]
Fairfield County	20,100[b]	5.0
Winnsboro	3,257[c]	31.1
Newberry County	31,200[b]	3.2
Newberry	8,998[c]	11.3
Richland County	252,600[b]	0.4
Columbia	111,616[c]	0.9
Lexington County	120,600[b]	0.8

[a] Plant-induced population is projected to be 1013 during the operations period.

[b] As of 1976.

[c] As of July 1, 1975.

Sources:

Population Projections for the Central Midlands Region, Central Midlands Regional Planning Council, Columbia, S.C., June 1977.

South Carolina Statistical Abstract, 1977 South Carolina Division of Research and Statistical Services, Columbia, S.C.

Written Communication from Mark Whitaker, Nuclear Licensing, SCE&G, September 1978 (direct employment); E. J. Stenehjem and J. E. Metzger, *A Framework for Projecting Employment and Population Changes Accompanying Energy Development*, Argonne National Laboratory, Argonne, Ill., August 1976 (indirect employment and nonworking dependents).

The Summer station will generate substantial tax revenues at several different levels. The Federal government is expected to collect about $10 million annually in corporate income tax (OL-ER, p. 8.1-16). The State of South Carolina will receive around $4 million a year from the State corporate income tax, franchise fee, gross receipts tax, electric power generation tax, and levy in support of the public service commission. In addition to this, the SCPSA will return to the state roughly $200,000 each year in surplus earnings from its one-third share of the power station (OL-ER, p. 8.1-15). Finally, those counties in which the plant, substations, and transmission lines are located will collect property tax on the value of the land and fixed assets involved.

Because Fairfield County houses the station, it will receive by far the largest share of SCE&G's property tax payments. Over 95% of these revenues will accrue to Fairfield County where it will be divided between the county's various funds and the school district. In 1981, the first year taxes are expected to be paid on the plant, Fairfield County will receive $3,220,379, whereas Richland, Aiken, Saluda, Edgefield, and Newberry counties will split another $126,123 between them. Because all manufacturers in South Carolina are exempt from general county government taxes during their first five years of operation, SCE&G's tax payments will jump substantially in 1986 when general county taxes are added to the school taxes the company will have already been paying on the value of the plant. Transmission lines and substations are not considered manufacturing enterprises and therefore will have been taxed fully all along. Fairfield County will get $4,545,261 in 1986, whereas the other counties' share will have fallen to $111,949 because of depreciation of transmission lines and substations.[46]

In 1979, the first year the Fairfield pumped storage facility will be taxed, $1,832,000 will be paid to Fairfield County; in 1984, when the five-year exemption on general county taxes has passed, Fairfield County will receive $2,974,000. In 1986, the amount will be $2,883,000, a slight decline because of plant depreciation.[46] Adding to this the $4,545,261 paid by the Summer facility in 1986, a figure of $7,428,261 is reached, representing the total property tax revenues paid to Fairfield County by SCE&G in this peak year.

As mentioned earlier, the SCPSA is to own one-third of the Summer station. Because it is a State agency, SCPSA is exempt from property taxes, but it will make in-lieu-of-tax payments to those counties where the plant, substation, and transmission lines are located. These payments will be insignificant compared to SCE&G's taxes; the payments are equivalent to the taxes levied on the properties in question before their acquisition by SCPSA. Because of this, the tax revenues received by those counties with SCPSA transmission lines and substations will not change from the preoperations level, and the opportunity for future improvements, and larger revenues, will be lost. Finally, Fairfield County will receive approximately $25,000 annually from the State because of the plant's location here and the surplus revenues it is expected to generate (OL-ER, pp. 8.1-12 and 8.1-13).

The above discussion points out that nearly all the property taxes paid on this project will go to Fairfield County. As Table 4.19 shows, the $4.5 million to be paid on the nuclear station by

Table 4.19. Projected pla .duced revenues relative to current revenues in Fairfield County

Projected property taxes paid by SCE&G ($)					Nuclear station property taxes[a] as a percentage of:		Combined property taxes[a] as a percentage of:	
Nuclear plant[b]		Pumped storage facility		Combined				
1981[c]	1986	1979[c]	1986	1986	1976 property tax revenues[d]	Total 1976 revenues[e]	1976 property tax revenues[d]	Total 1976 revenues[e]
3,220,379	4,545,261	1,832,000	2,883,000	7,428,261	314.6	58.5	514.2	96.1

[a] As of 1986.

[b] Includes taxes on transmission lines and substations within Fairfield County.

[c] All manufacturing facilities in South Carolina are exempt from nonschool property tax for the first five years of operation.

[d] 1976 property tax revenues were $1,444,761.31.

[e] Total 1976 revenues were $7,733,536.53.

Sources:

Written Communication from D. F. Ford, Tax Manager, SCE&G, Sept. 6, 1978.

Audit of Fairfield County, South Carolina, Fiscal Year 1976–77.

SCE&G in 1986 is more than three times the total tax revenues received by that county in 1976 and over one-half the total revenues received from all sources. The 1986 property taxes on the nuclear plant and pumped storage facility combined comes to over five times Fairfield County's 1976 tax revenues and is nearly equal to total revenues from all sources for that year.

Clearly, the property taxes anticipated by Fairfield County as a result of the Summer project are very substantial compared to current revenues. According to the county administrator, the local legislature is considering improving public services and also decreasing taxes. Service improvements would focus on upgrading the existing education system as well as expanding water and sewage facilities. Decreasing the millage would offer tax relief to the residents and businesses of Fairfield County and might also stimulate industrial and residential growth. Both improved services and decreased taxes will probably be offered, but the exact combination is currently uncertain.[40]

As mentioned above, lowering taxes and/or improving public services in Fairfield County may act as a stimulus for individuals and businesses to relocate here. Growth cannot be predicted accurately, but plant-induced tax revenues are likely to provide a push in that direction. With the completion of Interstate 77 in 1982, providing improved access from eastern Fairfield County to Columbia, this area may become even more attractive for residential and commercial uses. At that time, a favorable tax/public service situation could encourage more growth than may have otherwise occurred.

4.6. Recreational impact

Recreational opportunities will be provided in conjunction with the Summer project by the creation of a 120-ha (300-acre) subimpoundment on the northern end of Monticello Reservoir. This area will be distinct from the main body of the reservoir and will be managed by SCE&G as a fishing lake for public access. Swimming and picnic areas will be provided, as will be a boat-launching ramp for nonmotorized craft.[47] Other SCE&G recreation facilities will include a wildlife sanctuary, diked waterfowl habitats, and possibly a camping area. Because of its fluctuating water levels, the utility of the main body of the reservoir for recreation is unclear, but its future use for this purpose is still a possibility (OL-ER, Responses to Questions, Sect. 5.1, Nos. 6 and 7).

Because South Carolina has a large supply of lakes and rivers for water-based recreation, it is unlikely that the SCE&G facilities will draw substantial numbers of visitors from outside the immediate area. The 21,000-ha (52,000-acre) Lake Murray, in Lexington and Newberry counties, is in close proximity to the SCE&G site, as is the sizable Wateree Lake on the eastern border of Fairfield County. Still, the 120-ha (300-acre) fishing lake is expected to be well used by local residents and may become more attractive to those outside the immediate area as other more popular recreation sites become increasingly crowded in the future.[48]

4.6.5 Impact on historic and archaeological sites

The applicant has provided a discussion of the documented historic and archaeological sites within 15 km (9.3 miles) of the Summer station and of the historic sites within 2 km (1.2 miles) of the associated transmission lines (OL-ER, Sect. 2.6 and Appendix 2E). The information was derived from the National Register of Historic Places[49] and from the Central Midlands historic preservation survey.[50] The applicant found that six of the identified historic and archaeological sites within 15 km of the Summer station and one within 2 km of a transmission line were listed in the National Register of Historic Places as of August 8, 1978 (OL-ER, p. 2.6-1 and Fig. 2.6-1). The staff has surveyed the National Register of Historic Places through December 5, 1978, and concurs with the applicant's compilation.

The applicant states that the Summer station can be seen from three of the historic sites: Monticello Methodist Church, Davis-Robinson Plantation, and White Hall African Methodist Episcopal Church. These sites are located near the eastern shoreline of Monticello Reservoir (OL-ER, Fig. 2.6-1). The staff has viewed the Summer station from the highway near these sites and concludes that the station will not adversely affect their historic character or the public's use of these historic facilities.

The applicant had an archaeological survey performed in the area affected by the Summer station and also consulted with the South Carolina Department of Archives and History concerning historic sites. The responsible State officers concluded that construction and operation of the Summer station would not have an adverse affect on archaeological or historic sites listed in, or likely to be eligible for, the National Register of Historic Places (see Appendices D and E). The staff concurs in this assessment.

4.6.6 Summary of socioeconomic impacts

The primary benefits that will result from the operation of the Summer station are the creation of a small but stable number of high-paying jobs for area residents and the substantial increase in Fairfield County's revenues expected as a result of SCE&G's property tax payments. This sudden increase in local revenues will probably influence the county to cut tax rates and/or increase services, actions which could serve as a stimulus to additional residential and commercial growth.

As stated earlier, the population growth expected as a result of the creation of about 200 new jobs at the Summer plant and another 150 new service-oriented jobs in the region will be small compared to existing population levels. Consequently, the existing housing market and service delivery systems should not be strained as a result. If, however, changes in Fairfield County's public services and tax rates bring rapid, unplanned growth there in ensuing years, additional services may be demanded in scattered areas throughout the county, and the existing quality of life may decline because of conflicts between incompatible land uses. These consequences are not, however, inevitable. Through advance planning and such techniques as the enactment of zoning and mobile-home-park ordinances and the selective provision of public services in sectors earmarked for development, the local governments can assure orderly growth and many negative impacts can be averted.

It is the judgment of the staff that prospective socioeconomic benefits of the Summer station outweigh the potential socioeconomic costs, especially because, with the proper local government actions, many of those costs can be avoided.

4.7 THE URANIUM FUEL CYCLE

On March 14, 1977, the Commission presented in the Federal Register (42 FR 13803) an interim rule regarding the environmental considerations of the uranium fuel cycle. The interim rule revises Table S-3 of Paragraph (e) of 10 CFR Part 51.20. In a subsequent announcement on April 14, 1978 (43 FR 15613), the Commission further amended Table S-3 to delete the numerical entry for the estimate of radon releases and to explain that the table does not cover health effects. The effectiveness of the interim rule has been extended several times.

On July 27, 1979, the Commission approved a final rule setting out revised environmental - impact values for the uranium fuel cycle to be used in environmental reports and environmental statements for reactors (44 FR 45362).

The final rule reflects the latest information relative to the reprocessing of spent fuel and to radioactive waste management as discussed in NUREG-0116, Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle,[51] and NUREG-0216,[52] which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the AEC report WASH-1248, Environmental Survey of the Uranium Fuel Cycle.[53]

Specific categories of natural resource use are included in Table S-3 of the final rule and are reproduced here as Table 4.20*. These categories relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in Table S-3 for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

The following assessment of the environmental impacts of the fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 and the staff's analysis of the radiological impact from radon releases. For the sake of consistency, the analysis of fuel cycle impacts has been cast in terms of a model 1000-MWe light-water-cooled reactor (LWR) operating at an annual capacity factor of 80%. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff's analysis and conclusions would not be altered if the analysis were to be based on the net electrical power output of the proposed project.

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*A narrative explanation of Table S-3 was published on March 4, 1981 in the Federal Register (46 FR 15154-15175).

Table 4.20. Summary of environmental considerations for uranium fuel cycle[a]

Normalized to model LWR annual fuel requirement (WASH-1248) or reference reactor year (NUREG-0116)

Natural resource use	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1000-MWe LWR
Land, acres		
Temporarily committed[b]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to 110-MWe coal-fired power plant
Permanently committed	13	
Overburden moved, millions of metric tons	2.8	Equivalent to 95-MWe coal-fired power plant
Water, millions of gallons		
Discharged to air	160	Equals 2% of model 1000-MWe LWR with cooling tower
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	Less than 4% of model 1000-MWe LWR with once-through cooling
Fossil fuel		
Electrical energy, thousands of megawatt hours	323	Less than 5% of model 1000-MWe LWR output
Equivalent coal, thousands of metric tons	118	Equivalent to the consumption of a 45-MWe coal-fired power plant
Natural gas, millions of standard cubic feet	135	Less than 0.3% of model 1000-MWe energy output
Effluents – chemical, metric tons		
Gases (including entrainment)[c]		
SO_x	4,400	
NO_x[d]	1,190	Equivalent to emissions from 45-MWe coal-fired power plant for a year
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases		
F^-	0.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards – below level that has effects on human health
HCl	0.014	
Liquids		
SO_4^{2-}	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3 – 600 cfs NO_3 – 20 cfs Fluoride – 70 cfs
NO_3^-	25.8	
Fluoride	12.9	
Ca^{2+}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	0.4	
Tailings solutions, thousands of metric tons	240	From mills only – no significant effluents to environment
Solids	91,000	Principally from mills – no significant effluents to environment
Effluents – radiological, curies		
Gases (including entrainment)		
Rn-222		Presently under reconsideration by the Commission
Ra-226	0.02	
Th-230	0.02	
Uranium	0.034	
Tritium, thousands	18.1	
C-14	24	
Kr-85, thousands	400	
Ru-106	0.14	Principally from fuel reprocessing plants
I-129	1.3	
I-131	0.83	
Tc-99		Presently under consideration by the Commission
Fission products and transuranics	0.203	
Liquids		
Uranium and daughters	2.1	Principally from milling – included in tailings liquor and returned to ground – no effluents; therefore, no effect on environment
Ra-226	0.0034	From UF_6 production
Th-230	0.0015	
Th-234	0.01	From fuel fabrication plants – concentration 10% of 10 CFR Part 20 for total processing 26 annual fuel requirements for model LWR
Fission and activation products	5.9×10^{-6}	
Solids (buried on site)		
Other than high level (shallow)	11,300	9100 Ci come from low-level reactor wastes and 1500 Ci come from reactor decontamination and decommissioning – buried at land burial facilities. Mills produce 600 Ci – included in tailings returned to ground; about 60 Ci come from conversion and spent-fuel storage. No significant effluent to the environment
TRU and HLW (deep)	1.1×10^7	Buried at Federal repository
Effluents – thermal, billions of British thermal units	4,063	Less than 4% of model 1000-MWe LWR
Transportation, person-rems	2.5	
Exposure of workers and general public		
Occupational exposure, person-rems	22.6	From reprocessing and waste management

[a] In some cases where no entry appears, it is clear from the background documents that the matter was addressed and that, in effect, this table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at al in this table. Table S-3 of WASH-1248 does not include health effects from the effluents described in this table or estimates of releases of Radon-222 from the uranium fuel cycle. These issues which are not addressed at all by this table may be the subject of litigation in individual licensing proceedings. Data supporting this table are given in the *Environmental Survey of the Uranium Fuel Cycle*, WASH-1248, April 1974; the *Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, NUREG-0116 (Suppl. 1 to WASH-1248); and the *Discussion of Comments Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle*, NUREG-0216 (Suppl. 2 to WASH-1248). The contributions from reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no-recyle). The contribution from transportation excludes transportation of coal fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of Sect. 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A – E of Table S-3A of WASH-1248.

[b] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, because the complete temporary impact accrues regardless of whether the plant services 1 reactor for 1 year or 57 reactors for 30 years.

[c] Estimated effluents based on combustion of equivalent coal for power generation.

[d] 1.2% from natural gas use and process.

4.7.1 Land use

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 46 ha (113 acres). Approximately 5 ha (13 acres) per year are permanently committed land, and 41 ha (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel cycle plant, e.g., mill, enrichment plant, or succeeding plants. On abandonment or decommissioning, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 41 ha (100 acres) per year of temporarily committed land, 32 ha (79 acres) are undisturbed and 9 ha (22 acres) are disturbed. Considering common classes of land use in the United States,* fuel cycle land use requirements to support the model 1000-MWe LWR do not represent a significant impact.

4.7.2 Water use

The principal water use requirement for the fuel cycle supporting a model 1000-MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43×10^6 m^3 (11.4×10^9 gal), about 42×10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (e.g., evaporation losses in process cooling) of about 0.6×10^6 m^3 (16×10^7 gal) per year and water discharged to the ground (e.g., mine drainage) of about 0.5×10^6 m^3 per year.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4% of the model 1000-MWe LWR using once-through cooling. The consumptive water use of 0.6×10^6 m^3 per year is about 2% of the model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6% of the model 1000-MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the proposed project.

4.7.3 Fossil fuel consumption

Electrical energy and process heat are required during various phases of the fuel cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5% of the annual electrical power production of the model 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3% of the electrical output from the model plant. The staff finds that the direct and indirect consumptions of electrical energy for fuel cycle operations are small and acceptable relative to the net power production of the proposed project.

4.7.4 Chemical effluents

The quantities of chemical, gaseous, and particulate effluents with fuel cycle processes are given in Table 4.20. The principal species are SO_x, NO_x, and particulates. Judging from data in a Council on Environmental Quality report,[54] the staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with these emissions from the stationary fuel-combustion and transportation sectors in the United States, that is, about 0.02% of the annual national releases for each of these species. The staff believes such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel cycle processes are related to fuel-enrichment, -fabrication, and -reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are

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*A coal-fired power plant of 1000-MWe capacity using strip-mined coal requires the disturbance of about 81 ha (200 acres) per year for fuel alone.

required to reach levels of concentration that are within established standards. Table 4.20 specifies the flow of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel cycle operations will be subject to requirements and limitations set forth in the NPDES permit.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient to have a significant impact on the environment.

4.7.5 Radioactive effluents

Radioactive effluents estimated to be released to the environment from reprocessing and waste management activities and certain other phases of the fuel cycle process are set forth in Table 4.20. Using these data, the staff has calculated the 100-year involuntary environmental dose commitment* to the U.S. population. These calculations estimate that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222) would be approximately 400 person-rems per year of operation of the model 1000-MWe LWR. Based on Table 4.20 values, the additional involuntary total-body dose commitment to the U.S. population from radioactive liquid effluents due to all fuel cycle operations other than reactor operation would be approximately 100 person-rems per year of operation. Thus the estimated involuntary 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is approximately 500 man-rems (whole body) per year of operation of the model 1000-MWe LWR.

At this time Table 4.20 does not address the radiological impacts associated with radon-222 releases. Principal radon releases occur during mining and milling operations and as emissions from mill tailings. The staff has determined that releases from these operations for each year of operation of the model 1000-MWe LWR are as given in Table 4.21.

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*The environmental dose commitment (EDC) is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years. The population dose varies with time, and it is not practical to calculate this dose for every year.

Table 4.21. Radon releases for each year of operation of the model 1000-MWe LWR

Radon source	Quantity released	Source
Mining	4060 Ci	a
Milling and tailings (during active milling)	780 Ci	b
Inactive tailings (prior to stabilization)	350 Ci	b
Stabilized tailings (several hundred years)	1 to 10 Ci/year	b
Stabilized tailings (after several hundred years)	110 Ci/year	b

[a] R. Wilde, U.S. Nuclear Regulatory Commission transcript of direct testimony given *In the Matter of Duke Power Company (Perkins Nuclear Station)*, Docket No. 50-488, Apr. 17, 1978.

[b] P. Magno, U.S. Nuclear Regulatory Commission transcript of direct testimony given *In the Matter of Duke Power Company (Perkins Nuclear Station)*, Docket No. 50-488, Apr. 17, 1978.

The staff has calculated population dose commitments for these sources of radon-222 using the RABGAD computer code described in Appendix A of Chap. IV, Sect. J, of NUREG-0002.[55] The results of these calculations for mining and milling activities prior to tailings stabilization are listed in Table 4.22.

When added to the 500 person-rems total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is approximately 640 person-rems. Over this period of time, this dose is equivalent to 0.00002% of the natural background dose of about 3 billion person-rems to the U.S. population.*

The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining, milling, and active tailings and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. The staff has assumed that after completion of active mining underground mines will be sealed, returning releases of radon-222 to background levels. For purposes of providing an upper-bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open-pit mines, releases from them would be 110 Ci per year per reference reactor year (RRY). However, because the distribution of uranium ore reserves available by conventional mining methods is 66.8% underground and 33.2% open pit,[56] the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these proportions. This means that long-term releases from unreclaimed open-pit mines will be 37 Ci (0.332 x 110) per year per RRY.

Based on the above, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods would be about 3700 Ci and 37,000 Ci per RRY respectively. The total dose commitments for a 100 to 1000-year period would be as follows:

Time span (years)	Releases (Ci)	Population dose commitments (person-rem)		
		Total body	Bone	Lung (bronchial epithelium)
100	3,700	96	2,500	2,000
500	19,000	480	13,000	11,000
1,000	37,000	960	25,000	20,000

The above dose commitments represent a worst-case situation in that no mitigating circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for uranium open-pit mines. If so, long-term releases from such mines should approach background levels.

Table 4.22. Estimated 100-year environmental dose commitment per year of operation of the model 1000-MWe LWR

Radon source	Releases (Ci)	Dosage (man-rems)		
		Total body	Bone	Lung (bronchial epithelium)
Mining	4100	100	2800	2300
Milling and active tailings	1100	29	750	620
Total		140	3600	2900

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* Based on an annual average natural background individual dose commitment of 100 millirems and a stabilized U.S. population of 300 million.

For long-term radon releases from stabilized tailings piles, the staff has assumed that these tailings would emit, per RRY, 1 Ci per year for 100 years, 10 Ci per year for the next 400 years and 100 Ci per year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized tailings piles per RRY would be 100 Ci in 100 years, 4090 Ci in 500 years and 53,800 Ci in 1000 years.[57] The total-body, bone, and bronchial epithelium dose commitments for these periods are as follows:

Time span (years)	Releases (Ci)	Population dose commitments (person-rem)		
		Total body	Bone	Lung (bronchial epithelium)
100	100	2.6	68	56
500	4,090	110	2,800	2,300
1,000	53,800	1,400	37,000	30,000

Using risk estimators of 135, 6.9, and 22.2 cancer deaths per million man-rems for total-body, bone, and lung exposures, respectively, are used, the estimated risk of cancer mortality resulting from mining, milling, and active tailings emissions of radon-222 is about 0.11 cancer fatalities per RRY. When the risk from radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities is estimated over a 1000-year release period per RRY. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon induced cancer fatalities per RRY range as follows: 0.11 to 0.19 fatalities for a 100-year period, 0.19 to 0.57 fatalities for a 500-year period, and 1.2 to 2.0 fatalities for a 1000-year period.

To illustrate: A single-model 1000-MWe LWR operating at an 80% capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1000 years as a result of releases of radon-222.

These doses and predicted health effects have been compared with those expected from natural background emissions of radon-222. Calculated using data from the National Council on Radiation Protection (NCRP)[58] the average radon-222 concentration in air in the contiguous United States is about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 millirems. For a stabilized future U.S. population of 300 million, this represents a total lung dose commitment of 135 million person-rems per year. If the same risk estimator of 22.2 lung cancer fatalities per million person-lung-rems used to predict cancer fatalities for the model 1000-MWe LWR is used, estimated lung cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year, or 300,000 to 3,000,000 lung cancer deaths over periods of 100 and 1000 years respectively.

In addition to the radon-related potential health effects from the fuel cycle, other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures. It is estimated that 0.08 to 0.12 additional cancer deaths may occur per RRY (assuming that no cure or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

The latter exposures can also be compared with those from naturally occurring terrestrial and cosmic-ray sources. These average about 100 millirems. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million person-rems per year, or 3 billion person-rems and 30 billion person-rems for periods of 100 and 1000 years respectively. These dose commitments could produce about 400,000 and 4,000,000 cancer deaths during the same time periods. From the above analysis, the staff concludes that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources.

4.7.6 Radioactive wastes

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) are specified in Table 4.20. For low-level waste disposal at land burial facilities, the Commission notes in Table 4.20 that there will be no significant radioactive releases to the environment. The

Commission notes that high-level and transuranic wastes are to be buried at a Federal Repository and that no release to the environment is associated with such disposal. NUREG-0116,[51] which provides background and context for the high-level and transuranic Table 4.20 values established by the Commission, indicates that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is anticipated from such disposal.

4.7.7 Occupational dose

The annual occupational dose attributable to all phases of the fuel cycle for the model 1000-MWe LWR is about 200 person-rems. The staff concludes that this occupational dose will not have a significant environmental impact.

4.7.8 Transportation

The transportation dose to workers and the public is specified in Table 4.20. This dose is small and not considered significant in comparison to the natural background dose.

4.7.9 Fuel cycle

The staff's analysis of the uranium fuel cycle did not depend on the selected fuel cycle (no recycle or uranium-only recycle), because the data provided in Table 4.20 include maximum recycle option impact for each element of the fuel cycle. Thus the staff's conclusions as to acceptability of the environmental impacts of the fuel cycle are not affected by the specific fuel cycle selected.

4.8 AIR QUALITY IMPACTS

The only significant emission of waste gases will originate from auxiliary boiler operation during startup and shutdown and from emergency diesel engine operation. Both operations will use No. 2 diesel fuel oil with a sulfur content of 0.5% by weight. The emissions from the auxiliary boiler are well below applicable limits. The applicant's estimate of SO_2 emission is 0.54 lb/10^6 Btu; the Federal standard is 0.8 lb/10^6 Btu and the State standard 3.5 lb/10^6 Btu. The Federal standards apply only to units of 250 × 10^6 Btu/hr input or greater; State standards apply to all units (OL-ER, p. 3.7-3). The staff concludes that the quality of the emissions and the limited use of these facilities will result in a negligible impact on air quality.

4.9 DECOMMISSIONING

A license to operate a nuclear power plant is issued for a term not to exceed 40 years, beginning with the issuance of the construction permit.[59] At the end of the specified period, the operator of a nuclear power plant must renew the license for another time period or must dismantle the facility and dispose of its components. Before expiration of the operating license, if technical, economic, or other factors are unfavorable to continued operation of the plant, the operator may elect to apply for license termination and dismantling authority at that time.[60] In addition, at the time of applying for a license to operate a nuclear power plant, the applicant must show that he possesses "or has reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the facility down and maintaining it in a safe condition."[61] These activities, termination of operation and plant dismantling, are generally referred to as "decommissioning."

The applicant is not required by NRC regulations to submit decommissioning plans at the time the construction permit or operating license is obtained; consequently, no definite plan for the decommissioning of the plant has been developed. At the end of the plant's useful lifetime, the applicant will prepare a proposed decommissioning plan for review by the Commission. The plan will comply with NRC rules and regulations then in effect. At this time, Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors,"[62] provides guidance on methods and procedures for the termination of operating licenses for nuclear reactors.

Although no large-scale nuclear power plants have been decommissioned, experience in the decommissioning of reactors is available. As of 1975, 5 licensed nuclear power plants, 4 demonstration nuclear power plants, 6 licensed test reactors, 28 licensed research reactors, and 22 licensed critical facilities had been or were in the process of being decommissioned.[63] The primary methods of decommissioning consist of mothballing, entombment, dismantling, or a combination of these three alternatives. The three primary methods are defined below in terms of the definitions provided in Regulatory Guide 1.86.

1. Mothballing is the process of placing a facility in a nonoperating status. The facility may be left intact except that all reactor fuel, radioactive fluids, and nonfixed radioactive wastes (e.g., ion-exchange resins) must be removed from the site. The existing license is amended to a "possession-only" status and continues in effect until residual radioactivity is removed or is at a level acceptable for unrestricted access. The "possession-only" license is a reactor facility license that permits a licensee to possess the facility but prohibits operation of the facility as a nuclear reactor. Adequate radiation monitoring, environmental surveillance, and security procedures must be maintained to ensure that the health and safety of the public are not endangered.

2. Entombment consists of removing all fuel assemblies, radioactive fluids, and wastes, followed by the sealing of the remaining radioactive material, within a structure integral with the biological shield or by some other method, to prevent unauthorized access into radiation areas. A program of inspection, facility radiation surveys, and environmental sampling is required for a licensee's entombed facility.

3. Dismantling is defined as removal of all fuel, radioactive fluids and waste, and all radioactive structures. Surface contamination levels described in Regulatory Guide 1.86, Table 1, define the recommended radioactivity levels for unrestricted access to be met before termination of the facility license. In addition to surface contamination levels, the acceptability of the presence of materials that have been made radioactive by neutron activation will be evaluated on a case-by-case basis prior to termination of the license. If the facility owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed and disposed of.

The mothballing alternative costs* about $2.45 million initially, plus $167,000 annually for maintenance and surveillance. If a 24-hr manned security force is not required (e.g., a site with continuing operations), the annual cost could be reduced to $88,000. If these costs are translated into unit cost of generating electricity, the 30-year levelized unit cost would be about 0.04 mills/kWhr or, if a manned security force is not required, about 0.03 mills/kWhr.[64]

The entombment alternative costs* about $7.58 million initially, plus $58,000 annually for maintenance and surveillance for the duration of the entombment period.[64] These costs, when translated to a 30-year levelized unit cost basis, amount to about 0.06 mills/kWhr.

The dismantling alternative costs* about $26.3 million, the cost of removing the radioactive structures required by the NRC rules for terminating a possession-only license. An additional $4.8 million would be needed to remove the nonradioactive structures (cooling towers, administrative buildings, etc.) to below grade.[64] There are no annual costs associated with this alternative. When the dismantling costs are translated to a 30-year levelized unit cost basis, this amounts to about 0.18 mills/kWhr.**

Combinations of mothballing and delayed (about 100 years) dismantling have 30-year levelized unit costs that are about the same as the mothballing alternative costs. Likewise, the costs for the entombment-delayed dismantling combinations are about the same as the entombment cost. In both instances, the annual maintenance cost for mothballing and entombment alternatives, when converted to a common basis, is sufficient to cover all the delayed dismantling cost for the mothballing alternative and about 80% for the entombment alternative.

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*Costs are in 1975 dollars.

**Based on a 1200-MWe generating unit beginning operation in 1985, a capacity factor of 60%, an escalation rate of 5%, and a discount rate of 10%.

The above costs are for a one-unit station. The savings associated with multiunit stations are small; thus the unit cost (mills/kWhr) is essentially the same for a single-unit station or multiunit station.

Studies of social and environmental effects of decommissioning large commercial power-generating units have not identified any significant impacts beyond those already known. Each alternative will have radiological impacts associated with the transportation of radioactive material, but these should be no different than those associated with transportation impacts during normal facility operation. Also, studies indicate that occupational radiation doses can be controlled to levels comparable to occupational doses experienced with operating reactors through the use of appropriate work procedures, shielding, and remotely controlled equipment. To date, experience at decommissioned facilities has shown that the occupational exposures are generally less than those associated with the facility when operational.

The applicant may retain the site for power generation purposes indefinitely after the useful life of the station. The degree of dismantlement will normally be determined by an economic and environmental study comparing land and scrap values with the cost of complete demolition and removal of the complex. In any event, the operation will be controlled by rules and regulations in effect at the time to protect the health and safety of the public.

4.10 NOISE

There are no sources of noise resulting from plant operation that impact the offsite environs. The testing of the early notification system to be installed as part of the emergency preparedness plan may result in an occasional noise.

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5. ENVIRONMENTAL MONITORING

5.1 INTRODUCTION

The applicant's environmental monitoring program for the Virgil C. Summer Nuclear Station began in connection with the monitoring for the Fairfield Pumped Storage Hydrostation. The data obtained between 1970 and early 1973 were reviewed, and impact assessments for construction of the nuclear station were presented in the FES-CP. Environmental monitoring has continued during the construction phase in an effort to monitor the effects of construction and to establish a larger resource of baseline information. There have been changes in the monitoring effort to improve the usefulness of the information gathered. The following discussions summarize the applicant's proposed preoperational and operational environmental monitoring programs and staff recommendations for changes where it is believed that additional effort or programs would be beneficial.

5.2 PREOPERATIONAL MONITORING PROGRAMS

5.2.1 Onsite meterological program

The preoperational onsite meteorological measurements program was initiated in June 1973. A 15-month period was necessary to allow for system shakedown and to minimize the susceptability of the system to lightning damage. Thus the current data collection program began in November 1974, with one year of data being completed at the end of 1975.

The 61-m (200-ft) primary meteorological tower is located about 457 m (1500 feet) west of the reactor complex, very near the shore of Monticello Reservoir. Measurements of wind speed and direction are made at the 10.5- and 61-m (34.4- and 200-ft) levels of this tower, and vertical temperature gradient is measured between the 10- and 61-m (33- and 200-ft) levels and between the 10- and 40-m (33- and 131-ft) levels. In addition, dry bulb and dew point temperatures are measured at the 10-m (33-ft) level, and precipitation and solar radiation measurements are made near the tower at the 1.5-m (5-ft) level.

The applicant has presented the accuracies of the meteorological sensors and components in the data reduction system separately but has not compared the accuracies of the complete data collection and reduction system with the system accuracies specified in Regulatory Guide 1.23. The sensors have typical accuracies and thresholds for meteorological measurements at nuclear power plant sites. However, the primary data reduction system consists of pulse rates recorded on magnetic tape cartridges. Other utilities have had difficulty complying with the accuracy specifications of Regulatory Guide 1.23 using similar pulse rate systems. The secondary data reduction system is on strip charts.

Additional meteorological measurements (wind speed and direction and dry bulb temperature) are made atop a 10-m (33 ft) mast located across Monticello Reservoir from the primary meteorological tower. Strip charts are used for data collection. The applicant anticipates operating this tower for one year after initiation of commercial station operation to provide comparative data from which the environmental effects of the heat dissipation system (including atmospheric transport and diffusion across the reservoir) may be estimated. This study of the effects of the heat dissipation system will be provided to the staff before discontinuance of the additional meteorological measurements program.

Complete calibrations of the meterological measurement program are performed at six-month intervals. The system is checked daily for instrument malfunction, and calibration checks are performed every two weeks.

5.2.2 Water quality and aquatic biological monitoring

The applicant's preoperational monitoring program to measure physical, chemical and ecological parameters of surface waters is presented in Appendix F and entitled "Thermal Effects Study Plan and 316 (b) Demonstration Study Plan." This document was prepared by the applicant as required by the NPDES Permit No. SC0030856 issued by the South Carolina Department of Health and Environmental Control (SCDHEC). SCDHEC has approved the applicant's study plans. The NRC staff reviewed the aquatic biological and water quality monitoring programs contained in the document and notified SCDHEC of our recommendations in a letter dated May 15, 1979 (Appendix G). These recommendations were reiterated in the DES-OL of this facility. SCDHEC and South Carolina Electric and Gas Company (SCEGC) responded to the recommendations contained in the DES-OL by letters dated August 24, 1979 and August 17, 1979 respectively (Appendix A). The response precipitated a meeting between SCDHEC, SCEGC, and NRC staff. The meeting resulted in the resolution of all issues. A meeting summary is presented in Appendix H.

5.2.3 Groundwater monitoring

The applicant has established seven groundwater observation wells at locations adjacent to the nuclear unit and at distances up to 600 m (2000 ft) from the unit (OL-ER, Fig. 6.1-2). The preoperational program consists of quarterly measurements of groundwater level. This information will be used to ascertain changes that may occur during the year following the filling of Monticello Reservoir. Two onsite and offsite wells will also be monitored for radioactivity (Sect. 5.2.5).

5.2.4 Terrestrial monitoring

Preoperational monitoring of terrestrial biota at the Summer station can be subdivided into three phases. Initial monitoring prior to commencement of construction (1970-1973; CP-ER, Sect. 6) was evaluated in the FES-CP. Monitoring prior to completion of construction (1973-1976; OL-ER, Appendix 2A-D) was approved in the FES-CP. No significant changes were made in that approved monitoring program. Finally, monitoring prior to full-scale operation of the station was proposed in the OL-ER (Sect. 6.1.4.3). This program, which was initiated in mid-1978, is evaluated below.

5.2.4.1 Nuclear station area

Proposed vegetation monitoring prior to station operation will be based on false-color infrared aerial photography. Infrared photographic information has been collected each spring since 1974 (OL-ER, 6.1-30). Should changes be detected in vegetation, the applicant proposes to assess the changes through consultation with NRC and State agency personnel and through subsequent collection of appropriate field samples. The NRC has no reason to expect changes in vegetation.

Bird populations will be monitored during the winter and summer before commercial operation of the station. Birds were chosen as the primary indicator of faunal impacts because (1) they are sensitive to environmental change; (2) they are active and conspicuous during daylight hours; and (3) they are abundant enough to provide valid data for statistical analyses. Standard survey methods will be employed (OL-ER, Sect. 6.1.4.3.2). The NRC staff considers this an adequate, logical program for the early detection of biotic impacts resulting from station operation.

5.2.4.2 Transmission rights-of-way

No biotic monitoring programs were proposed for transmission corridors. The applicant has a state-approved rights-of-way maintenance program that includes broadcast aerial spraying, except for hand clearing along waterways and near critical habitat. The staff believes these procedures will provide reasonable protection to the environment.

5.2.5 Radiological monitoring

Radiological environmental monitoring programs are established to provide data on measurable levels of radiation and radioactive materials in the site environs. Appendix I to 10 CFR Part 50 requires that the relationship between quantities of radioactive material released in effluents during normal operation, including anticipated operational occurrences, and resultant radioactive doses to individuals from principal pathways of exposure be evaluated. Monitoring programs are conducted to verify the effectiveness of in-plant controls used for reducing the release of radioactive materials and to provide public assurance that undetected radioactivity will not build up in the environment. A surveillance program is established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs.

The preoperational phase of the monitoring program includes measurement of background levels and their variations along the anticipated important pathways in the area surrounding the plant, training of personnel, and evaluation of procedures, equipment, and techniques. This is discussed in greater detail in NRC Regulatory Guide 4.1, Rev. 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and the Radiological Assessment Branch Technical Position, Revision 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program."

The applicant has proposed a preoperational radiological monitoring program to meet the objectives discussed above. The applicant's program is presented in Sect. 6.1.5 of the applicant's OL-ER and is summarized here in Table 5.1. The applicant has initiated parts of the program; the remaining portions will begin either six months or one year prior to operation. The staff concludes that the preoperational monitoring program proposed by the applicant is acceptable.

5.3 OPERATIONAL MONITORING PROGRAMS

5.3.1 Onsite meteorological program

For the operational meteorological monitoring program, the applicant is considering alternatives to the present digital data recording (pulse rates on magnetic tape). Because of the difficulties identified by other utilities with the pulse rate system, a change in the digital data reduction system at the Summer site is encouraged. This change in data reduction systems will be coordinated with, and approved by, the staff. It is also recommended that the applicant determine that the accuracies for the current meteorological data collection system (not just "meteorological instrumentation") conform to the recommendations of Regulatory Guide 1.23.

The operational program will emphasize measurements of wind speed and direction and vertical temperature gradient for estimating atmospheric dispersion conditions. However, precipitation measurements should also be continued to document periods of washout of the effluent plume.

5.3.2 Water quality and aquatic biological monitoring

The applicant's operational monitoring program to measure physical, chemical, and ecological parameters of surface waters is presented in Appendix F and entitled, "Thermal Effects Study Plan and 316(b) Demonstration Study Plan." This document was prepared by the applicant as required by the NPDES Permit No. SC0030856 issued by the South Carolina Department of Health and Environmental Control (SCDHEC). SCDHEC has approved the applicant's study plans. The NRC staff reviewed the aquatic biological and water quality monitoring programs contained in the document and notified SCDHEC of our recommendations in a letter dated May 15, 1979 (Appendix G). These recommendations were reiterated in the DES-OL for this facility. SCDHEC and South Carolina Electric and Gas Company (SCEGC) responded to the recommendations contained in the DES-OL by letters dated August 24, 1979, and August 17, 1979 respectively (Appendix A). The response precipitated a meeting between SCDHEC, SCEGC, and the NRC staff. The meeting resulted in the resolution of all issues. A meeting summary is presented in Appendix H.

5.3.3 Groundwater monitoring

The applicant will continue to monitor onsite groundwater level for a period of one year after the Summer station goes into commercial operation. Radioactivity measurements outlined in Sect. 5.2.5 will be continued for an undetermined period.

5.3.4 Terrestrial monitoring

5.3.4.1 Nuclear station area

The program of terrestrial monitoring described in Sect. 5.2.4 will be continued for one year after initial commercial operation of the nuclear station. Considering that impacts of station operation on terrestrial biota are likely to be immeasureably small, the staff believes this program will be adequate.

5.3.4.2 Transmission rights-of-way

No terrestrial monitoring program was proposed for transmission line rights-of-way. The state-approved maintenance procedures will be continued into the operational phase of this project.

5.3.5 Radiological monitoring

The operational offsite radiological monitoring program is conducted to measure radiation levels and radioactivity in the plant environs. It assists and provides backup support to the effluent monitoring program recommended in NRC Regulatory Guide 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants." The effluent monitoring program is required to evaluate individual and population exposures and verify projected or anticipated radioactivity concentrations.

The applicant plans to continue the proposed preoperational program (Table 5.1) during the operating period. However, refinements may be made in the program to reflect changes in land use or preoperational monitoring experience.

The details of the required monitoring program will be incorporated into the Environmental Technical Specifications for the operating license.

Table 5.1 Radiological environmental monitoring program for the Summer station

			Sample locations		
Exposure pathway and/or sample	Criteria for selection of sample number and location	Sampling and collection frequency	Number[a]	Distance and direction from site (miles)	Type and frequency of analysis
		Airborne			
I. Particulates	A. Three indicator samples to be taken at locations (in different sectors) beyond but as close to the exclusion boundary as practicable where the highest offsite sectoral ground-level concentrations are anticipated[b]	Continuous sampler operation with weekly collection	2 5 10	1.1 SW 1.3 SE 2.4 NNE	Gross beta following filter change; monthly composite (by location) for gamma isotopic
	B. One indicator sample to be taken in the sector beyond but as close to the exclusion boundary as practicable corresponding to the residence having the highest anticipated offsite ground-level concentration or dose[b]		6	1.1 ESE	
	C. One indicator sample to be taken at the location of one of the dairies most likely to be affected[b,c]		14[c]	5.2 W	
	D. Two control samples to be taken at locations at least 10 air miles from the site and not in the most prevalent wind directions[b]		17 16	24.7 SE 28.0 W	

Table 5.1 (continued)

			Sample locations		
Exposure pathway and/or sample	Criteria for selection of sample number and location	Sampling and collection frequency	Number[a]	Distance and direction from site (miles)	Type and frequency of analysis
II. Radioiodine	A. Three indicator samples to be taken at two locations as given in I.A	Continuous sampler operation with weekly cannister collection	2 5 10	1.1 SW 1.3 SE 2.4 NNE	Gamma isotopic screening of all five indicators with conjunctive screening of the two controls; if screening is positive, each sample will be subjected to isotopic analysis for iodine
	B. One indicator sample to be taken at the location as given in I.B		6	1.1 ESE	
	C. One indicator sample to be taken at the location given in I.C		14[d]	5.2 W	
	D. Two control samples to be taken at locations similar in nature to those in I.A through I.C		17 16	24.7 SE 28.0 W	
III. Direct	A. Five indicator samples to be taken at the locations as given in I.A through I.D	Monthly exchange[d]; two or more dosimeters at each location	2, 5, 6, 10, 14		Monthly gamma dose[d]
	B. Three additional indicator samples to be taken in sectors different from III.A beyond but as close to the exclusion boundary as practicable		1 4 8	1.3 S 1.2 NW 1.3 ENE	
	C. Control samples to be taken at the locations as given in I.D		16 17	28.0 W 24.7 SE	
	D. One additional control sample to be taken at a location as set forth in I.D		18	16.5 S	
	E. Additional sites		3 7 9 11 12 13 15 19 20	0.8 WSW 1.7 E 2.6 NE 3.6 NNE 4.3 N 2.9 NNW 2.3 SSW 17.9 ESE 22.0 NW	

Table 5.1 (continued)

Exposure pathway and/or sample	Criteria for selection of [illegible]ple number and location	Sampling and collection frequency	Sample locations		Type and frequency of analysis
			Number[a]	Distance and direction from site (miles)	
	F. Accident Evaluation	Quarterly exchange, two or more dosimeters at each location	41	3.7 S	
			42	3.6 SSW	
			43	4.7 SW	
			44	2.3 WSW	
			45	5.4 WSW	
			46	3.7 WNW	
			47	1.0 NW	
			48	2.4 NW	
			49	4.6 NNW	
			50	5.6 N	
			51	5.6 N	
			52	4.3 NNE	
			53	3.6 NE	
			54	2.2 ENE	
			55	3.2 E	
			56	2.0 ESE	
			57	2.7 SE	
			58	2.4 SSE	
			59	2.1 SSE	
			60	5.7 WSW	
		Waterbone			
IV. Surface water	A. One indicator sample to be taken at a location that allows for mixing and dilution in the ultimate receiving river	Time composite samples with collection every month[d] (corresponds to USGS continuous sampling site)	21[e,f]	2.7 SSE	Gamma isotopic with quarterly composite (by location) to be analyzed for tritium[g]
	B. One control sample to be taken at a location on the receiving river, sufficiently far upstream so that no effects of pumped storage operation are anticipated		22[e]	12-15 NNW	
	C. One indicator sample to be taken in the upper reservoir of the pumped storage facility	Monthly grab sampling[g]	23[e]	<1 E	As in V
	D. One indicator sample to be taken in the upper reservoir's nonfluctuating recreational area		24[e]	4.7 N	
V. Groundwater	A. Two indicator samples to be taken within the exclusion boundary and in the direction of potentially affected groundwater supplies	Quarterly grab sampling[g]	26 27	Onsite Onsite	Quarterly gamma isotopic and tritium analyses[g]

Table 5.1 (continued)

			Sample locations		
Exposure pathway and/or sample	Criteria for selection of sample number and location	Sampling and collection frequency	Number[a]	Distance and direction from site (miles)	Type and frequency of analysis
	B. One control sample from an unaffected location		16	28.0 W	
VI. Drinking water	A. One indicator sample from nearby public groundwater supply source	Monthly grab sampling[d]	28	1.3 ESE	Monthly gamma isotopic and gross beta analyses[d] and quarterly tritium analyses[g]
	B. One indicator sample from a location immediately upstream of the nearest downstream municipal water supply	Time composite sample[f] with monthly collection[d]	17	24.7 S	Monthly gamma isotopic and gross beta analyses[d] and quarterly tritium analyses[g]
		Ingestion			
VII. Milk[d]	A. One indicator sample to be taken at the location of one of the dairies most likely to be affected[b,d]	Semimonthly when animals are on pasture,[h] monthly at other times[d]	14[c]	5.2 W	Gamma isotopic and I-131 analysis semimonthly when animals are on pasture,[h] monthly at other times[d]
	B. One control sample to be taken at the location of a dairy 10-20 miles distant and not in the most prevalent wind direction[b]		16	28.0 W	
	C. One indicator grass (forage) sample to be taken at one of the locations beyond but as close to the exclusion boundary as practicable when the highest offsite sectoral ground-level concentrations are anticipated[b]	Monthly when available[d]	6	1.1 ESE	Gamma isotopic
	D One indicator grass (forage) sample to be taken at the location of VIII.A when animals are on pasture		14[c]	5.2 W	

Table 5.1 (continued)

			Sample locations		
Exposure pathway and/or sample	Criteria for selection of sample number and location	Sampling and collection frequency	Number[a]	Distance and direction from site (miles)	Type and frequency of analysis
	E. One control grass (forage) sample to be taken at the location of VIII.B		16	28.0 W	
VIII. Food products	A. One indicator sample to be taken at a nearby garden likely to be affected	Annually at the approximate median harvest time for the area; samples, if available, will include green leafy, fruit, and grain	6	1.1 ESE	Gamma isotopic on edible portion; radioiodine on green, leafy vegetables
	B. One control sample for the same foods taken at a location at least 10 miles distant and not in the most prevalent wind direction		18[e]	16.5 S	
IX. Fish	A. One indicator sample to be taken at a location in the upper reservoir	Semiannual[i] collection of the following species types if available: (1) bass, bream, and crappie, (2) catfish and carp, and (3) forage fish (shad)	23[e]	0.3-0.5	Gamma isotopic on edible portions
	B. One indicator sample to be taken at a location in the lower reservoir		21[e]	1-3	
	C. One indicator sample to be taken at a location in the upper reservoir's nonfluctuating recreational area		24[e]	4-5 N	
	D. One control sample to be taken at a location on the receiving river sufficiently far upstream so that no effects of pumped storage operation are anticipated		22[e]	12-15 NNW	
		Aquatic			
X. Sediment	A. One indicator sample to be taken at a location in the upper reservoir	Semiannual grab sample	23[e]	0.3-0.5	Gamma isotopic[e]
	B. One indicator sample to be taken in the upper reservoir's nonfluctuating recreational area		24[e]	4-5 N	
	C. One indicator sample to be taken on the shoreline of the lower reservoir		21[e]	1-3	

Table 5.1 (continued)

Exposure pathway and/or sample	Criteria for selection of sample number and location	Sampling and collection frequency	Sample locations: Number[a]	Sample locations: Distance and direction from site (miles)	Type and frequency analysis
	D. One control sample to be taken in receiving river sufficiently far upstream such that no effects of pumped storage operation are anticipated		22[e]	12-15	

[a] Location numbers refer to ER, Figs. 6.1-3 and 6.1-4.

[b] Sample site locations are based on the meteorological analysis for the period of record as presented in ER, Chaps. 5 and 6.

[c] Milking animal and garden survey results will be analyzed annually. Should the survey indicate new dairying activity of a significant nature (five or more cows milking) in a quadrant(s) other than W or NW and closer than 5.7 miles, the owners shall be contacted with regard to a contract for supplying sufficient samples. If contractual arrangements can be made, the site(s) will be added for additional milk sampling.

[d] Not to exceed 35 days.

[e] Though generalized areas are noted for simplicity of sample site enumeration, airborne, water, and sediment sampling is done at the same location, whereas biological sampling sites are generalized areas to reasonably assure availability of samples.

[f] Time composite samples are samples collected with equipment capable of collecting an aliqout at time intervals that are short (e.g., hourly) relative to the compositing period.

[g] Not to exceed 100 days.

[h] Not to exceed 18 days.

[i] Not to exceed 200 days.

Note: Deviations from this sampling schedule may occasionally be necessary if sample media are unobtainable because of hazardous conditions, seasonal unavailability, insufficient sample size, malfunctions of automatic sampling or analysis equipment, and other legitimate reasons. If specimens are unobtainable because of sampling equipment malfunctions, every effort shall be made to complete corrective action before the end of the next sampling period. Deviations from sampling-analyses schedule will be described in the annual report.

Source: ER, Table 6.1.15.

6 ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

6.1 PLANT ACCIDENTS

The staff has considered the potential radiological impacts on the environment of possible accidents at the Summer Nuclear Station in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980.[1] The following discussion reflects these considerations and conclusions.

The first section deals with general characteristics of nuclear power plant accidents including a brief summary of safety measures to minimize the probability of their occurrence and to mitigate their consequences if they should occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and impacts on society associated with actions to avoid such health effects are also identified.

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

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

6.1.1 General characteristics of accidents

The term accident, as used in this section, refers to any unintentional event not addressed in Section 4.5 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Such limits are specified in the Commission's regulations in 10 CFR Part 20.

There are several features which combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation comprising the first line of defense are to a very large extent devoted to the prevention of the release of these radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defenses that are designed to mitigate the consequences of failures in the first line. Descriptions of these features for the Summer plant may be found in the applicant's Final Safety Analysis Report,[2] and in the staff's Safety Evaluation Report.[3] The most important mitigative features are described in Section 6.1.3.1 below.

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

6.1.1.1 Fission product characteristics

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the reactor core in the form of fission products. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials are also normally present in the water that circulates in the reactor coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment is dependent not only on mechanical forces that might physically transport them, but also upon their inherent properties, particularly their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids and a few are gaseous in nature. These characteristics have a significant bearing upon the assessment of the environmental radiological impact of accidents.

The gaseous materials include radioactive forms of the chemically inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are very low frequency but credible events (see Section 6.1.2). It is for this reason that the safety analysis of each nuclear power plant incorporates a hypothetical design basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment structure. If further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure is designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process and, in some chemical forms, may be quite volatile. For this reason, they have traditionally been regarded as having a relatively high potential for release from the fuel. The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperatures, however, so that they have a strong tendency to condense (or "plate out") upon cooler surfaces. In addition, most of the iodine compounds are quite soluble in, or chemically reactive with, water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release from containment structures that have large internal surfaces areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may "escape" into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces, e.g., dew, the radioiodines will show a strong tendency to be absorbed by the moisture. Because of radioiodine's distinct radiological hazard, its potential for release to the atmosphere has also been reduced, as a result of special consideration in the safety analysis of postulated accidents, by the use of special filter systems and/or containment spray systems. If released to the environment, the principal radiological hazard associated with the radioiodines is ingestion into the human body and subsequent concentration in the thyroid gland.

Other radioactive material found during the operation of a nuclear power plant have lower volatilities and therefore, by comparison with the noble gases and iodine, a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes quite high. By the same taken, such materials, if they escape by volatilization from the fuel, tend to condense quite rapidly to solid form again when transportated to a lower temperature region and/or dissolve in water when present. The former mechanism can have the result of producing some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surface features by gravitational settling or by precipitation (fallout), where they will become "contamination" hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years (see Table 6.1). Many of them decay through a sequence or chain of decay processes and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes is the reason that they are hazardous materials.

6.1.1.2 Exposure pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive material, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways for the transport of radiation and radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are depicted in Section 4, Figure 4.3. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure 4.3. One of these is the fallout of radioactivity initially carried in the air onto open bodies of water. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This creates the potential for the release of radioactive material into the hydrosphere through contact with ground water. These pathways may lead to external exposure to radiation, and to internal exposures if radioactivity is inhaled, or ingested from contaminated food or water.

Table 6.1

Approximate Radiation Doses from
Design Basis Accidents

		Dose (rem) at 1 Mile	
Infrequent Accidents	Duration of Release	Whole Body	Thyroid
Waste Gas Tank Failure	< 2 hr[1]	0.04	nil
Small-Break LOCA[2]	hrs-days	0.02	< 0.001
Steam General Tube Rupture[3]	< 2 hr	0.04	< 0.001
Fuel Handling Accident	< 2 hr	0.10	< 0.005
Limiting Faults			
Main Steam Line Break	< 2 hr	0.0005	< 0.0001
Control Rod Ejection	hrs-days	0.06	0.1
Large-Break LOCA	hrs-days	0.50	< 1.0

[1] < means "less than."

[2] LOCA - loss of coolant accident; the TMI-2 accident was one kind of a small-break LOCA.

[3] See NUREG-0651[5] for descriptions of three steam generator tube rupture accidents that have occurred in the United States.

It is characteristic of these pathways that, during the transport of radioactive material by wind or by water, the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The result of these natural processes is to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but they also tend to increase the number who may be exposed. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere which vary considerably with time and from place to place. This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time.

6.1.1.3 Health effects

The cause and effects relationships between radiation exposure and adverse health effects are quite complex[4a] but they have been more exhaustively studied than any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rem for a few persons and about 25 rem for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 10 to 20 times larger than the latter dose, also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe, but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in the close proximity of such accidents if measures are not or cannot be taken to provide protection, e.g., by sheltering or evacuation.

Lower levels of exposures may also constitute a health risk but the ability to define a direct cause and effect relationship between any given health effect and a known exposure to radiation is difficult given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necessary to assess such effects on a statistical basis. Such effects include cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. Cancer in the exposed population may begin to develop only after a lapse of 2 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), cancer may begin to develop at birth (no latent period) and end at age 10 (i.e., the plateau period is 10 years). The health consequences model currently being used is based on the 1972 BEIR Report of the National Academy of Sciences (NAS).[5]

Most authorities are in agreement that a reasonable, and probably conservative, estimate of the statistical number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths (although zero is not excluded by the data) per million person-rem. The range comes from the latest NAS BEIR III Report[6] (1980) which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the current NRC health effects models. In addition, approximately 220 genetic changes per million person-rem would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million person-rem currently used by the NRC staff.

6.1.1.4. Health effects avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is a slow one, however, and where the material becomes relatively fixed in its location as an environmental contaminant (e.g., in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential environmental societal impact of severe accidents is the avoidance of the health hazard rather than the health hazard itself, by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential social and economic impacts that this can cause are discussed below.

6.1.2 Accident experience and observed impacts

The evidence of accident frequency and impacts in the past is a useful indicator of future probabilities and impacts. As of mid-1980, there were 69 commercial nuclear power reactor units licensed for operation in the United States at 48 sites with power generating capacities ranging from 50 to 1130 megawatts electric (MWe). (The Summer plant is designed to produce 900 MWe.) The combined experience with these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities.[7] Some of these have resulted in releases of radioactive material to the environment, ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience base is not large enough to permit a reliable quantitative statistical inference. It does, however, suggest that significant environmental impacts due to accidents are very unlikely to occur over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these units, during the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979. In addition to the release of a few million curies of xenon-133, it has been estimated that approximately 15 curies of radioiodine was also released to the environment at TMI-2.[8] This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. No other radioactive fission products were released in measurable quantity.

It has been estimated that the maximum cumulative offsite radiation dose to an individual was less than 100 millirem.[8,9] The total population exposure has been estimated to be in the range from about 1000 to 3000 person-rem. This exposure could produce between none and one additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 person-rem and approximately a half-million cancers are expected to develop in this group over its lifetime,[8,9] primarily from causes other than radiation. Trace quantities (barely above the limits of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were impacted.

Accidents at nuclear power plants have also caused occupational injuries and a few fatalities but none attributed to radiation exposure. Individual worker exposures have ranged up to about 4 rem as a direct consequence of accidents, but the collective worker exposure levels (person-rem) are a small fraction of the exposures experienced during normal routine operations that average about 400 person-rem per reactor year for PWRs.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries.[7] Due to inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at the Enrico Fermi Atomic Power Plant Unit 1. This was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power in four years following the accident. It operated successfully and completed its mission in 1973. This accident did not release any radioactivity to the environment.

A reactor accident in 1957 at Windscale, England, released a significant quantity of radioiodine, approximately 20,000 curies, to the environment. This reactor, which was not operated to generate electricty, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor, the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123m (405-foot) stack. Milk produced in a 200-square-mile area around the facility was impounded for up to 44 days. This kind of accident cannot occur in a water-cooled reactor like Summer, however.

6.1.3 Mitigation of accident consequences

Pursuant to the Atomic Energy Act of 1954, the Nuclear Regulatory Commission has conducted a safety evaluation of the application to operate Summer Nuclear Station.[3] Although this evaluation contains more detailed information on the plant design, the principal design features are presented in the following section.

6.1.3.1 Design features

The Summer Nuclear Station contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESF). The possibilities or probabilities of failure of these systems is incorporated in the assessments discussed in Section 6.1.4.

The steel-lined concrete containment building is a passive mitigating system which is designed to minimize accidental radioactivity releases to the environment. Safety injection systems are incorporated to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage. Cooling fans provide heat removal capability inside the containment following steam release in accidents and help to prevent containment failure due to overpressure. Similarly, the containment spray system is designed to spray cool water into the containment atmosphere. The spray water also contains an additive (sodium hydroxide) which will chemically react with any airborne radioiodine to remove it from the containment atmosphere and prevent its release to the environment.

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

The Summer containment ventilation system also contains high efficiency filters to remove radioactive particulate fission products from the containment atmosphere to minimize their release.

The fuel handling area located in the auxiliary building also has accident mitigating systems. The safety-grade ventilation system contains both charcoal and high efficiency particulate filters. This ventilation system is also designed to keep the area around the spent fuel pool below the prevailing barometric pressure during fuel handling operations so that out-leakage won't occur through building openings. If radioactivity were to be released into the building, it would be drawn through the ventilation system and radioactive iodine and particulate fission products would be removed from the flow stream before exhausting to the outdoor atmosphere.

There are features of the plant that are necessary for its power generation function that can also play a role in mitigating certain accident consequences. For example, the main condenser, although not classified as an ESF, can act to mitigate the consequences of accidents involving leakage from the primary to the secondary side of the steam generators (such as steam generator-tube ruptures). If normal offsite power is maintained, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of radioactivity released to the environment. In this case, the fission product removal capability of the normally operating off-gas treatment system would come into play.

Much more extensive discussions of the safety features and characteristics of the Summer Nuclear Station may be found in the applicant's Final Safety Analysis Report.[2] The staff evaluation of these features are addressed in the Safety Evaluation Report.[3] In addition, the implementation of the lessons learned from the TMI-2 accident, in the form of improvements in design, and procedures and operating training, will significantly reduce the likelihood of a degraded core accident which could result in large releases of fission products to the containment. Specifically, the applicant is expected to follow the guidance on TMI-related matters specified in NUREG-0737. As noted in Section 6.1.4.7, no credit has been taken for these actions and improvements in discussing the radiological risk of accidents.

6.1.3.2 Site features

In the process of considering the suitability of the site of the Summer Nuclear Station, pursuant to NRC's Reactor Site Criteria in 10 CFR Part 100, consideration was given to certain factors that tend to minimize the risk and the potential impact of accidents. First, the site has an exclusion area as provided for in 10 CFR Part 100. The purpose of the exclusion area is twofold, to assure that activities that might be hazardous to the plant cannot be located too close to it, and to exclude residential or transient use of the close-in property that might involve an unnecessarily large number of people. This area comprises approximately 890 ha (2200 acres) of property. The reactor building is so situated that the closest boundary of this area is approximately one mile distant. Thus, this is the minimum distance at which any permanent residents could live. A part of Monticello Reservoir is also within the exclusion area. Under South Carolina law the surface water of this reservoir is in the public domain and there is expected to be some recreational use within the exclusion area. Provisions for the warning and evacuation of such persons have been made in the event of an emergency. There are no public highways or railroads traversing the exclusion area.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by Part 100. This is a circular area of 4.8 km (3 miles) outer radius, also centered on the reactor building. The purpose of this zone is also twofold, to assure that the total number and density of residents are such that there is a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident, and to assure that the nearest population center containing more than about 25,000 persons is outside this zone. Current and projected population densities in the LPZ are substantially lower than current regulatory guidelines which are intended to minimize accident risk. Out to 48 km (30 miles), the population density is not expected to exceed 250 persons per square mile at any time during the operating life of the facility. The nearest population center, Columbia, South Carolina, is approximately 37 km (23 miles) southeast of the site. More complete descriptions of the site, its population and land use characteristics are given in Section 2.

The safety evaluation of the Summer site has also included a review of potential external hazards, i.e., activities offsite that might adversely affect the operation of the plant and cause an accident. This review encompassed nearby industrial, transportation, and military facilities that might create explosive, missile, toxic gas or similar hazards. The risk to the Summer plant from such hazards has been found to be negligibly small. More detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards are given in the staff's Safety Evaluation Report.[3]

6.1.3.3 Emergency preparedness

Emergency preparedness plans including protective action measures for the Summer facility and environs are in an advanced, but not yet fully completed stage. In accordance with the provisions of 10 CFR Section 50.47, effective November 3, 1980, an operating license will not be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plans are provisions for two Emergency Planning Zones (EPZs). A plume exposure pathway EPZ of about 16 km (10 miles) in radius and an ingestion exposure pathway EPZ of about 80 km (50 miles) in radius are required. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC findings will be based upon a review of the Federal Emergency Management Agency (FEMA) findings and determinations as to whether State and local government emergency plans are adequate and capable of being implemented, and on the NRC assessment as to whether the applicant's onsite plans are adequate and capable of being implemented. NRC staff preliminary findings are reported in the staff's Safety Evaluation Report to be supplemented.[3] Although the presence of adequate and tested emergency plans cannot prevent the occurrence of an accident, it is the judgment of the staff that they can and will substantially mitigate the consequences to the public if one should occur.

6.1.4 Accident risk and impact assessment

6.1.4.1 Design basis accidents

As a means of assuring that certain features of the Summer plant meet acceptable design and performance criteria, both the applicant and the staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment and calculations have been performed to estimate the potential radiological consequences to persons offsite. For each postulated initiating event, the potential radiological consequences cover a considerable range of values depending upon the particular course taken by the accident and the conditions, including wind direction and weather, prevalent during the accident.

In the safety analysis and evaluation of the Summer plant, three categories of accidents have been considered. These categories are based upon their probability of occurrence and include (a) incidents of moderate frequency, i.e., events that can reasonably be expected to occur during any year of operation, (b) infrequent accidents, i.e., events that might occur once during the lifetime of the plant, and (c) limiting faults, i.e., accidents not expected to occur but that have the potential for significant releases of radioactivity. The radiological consequences of incidents in the first category, also called anticipated operational occurrences, are discussed in Section 4. Initiating events postulated in the second and third categories for the Summer plants are shown in Table 6.1. These are collectively designated design basis accidents in that specific design and operating features as described in Section 6.1.3.1 are provided to limit their potential radiological consequences. Approximate radiation doses that might be received by a person 1 mile from the plant are also shown in the table, along with a characterization of the time duration of the releases. The results shown in the table reflect the expectation that engineered safety and operating features would function as intended.

An important implication of this expectation is that the releases considered are limited to noble gases and radioiodines and that any other radioactive materials, e.g., in particulate form, are not expected to be released. The results are also quasi-probabilistic in nature in the sense that the meteorological dispersion conditions are taken to be neither the best nor the worst for the site, but rather at an average value determined by actual site measurements. In order to contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 6.1 are sometimes referred to as "realistic" doses.

Calculated population exposures for these events range from a small fraction of a person-rem to about 200 person-rem for the population within 50 miles of the Summer plant. These calculations for both individual and population exposures indicate that the risk of incurring any adverse health effects as a consequence of these events is exceedingly small. By comparison with the estimates of radiological impact for normal operations shown in Chapter 4, we also conclude that radiation exposures from design basis accidents are roughly comparable to the exposures to individuals and the population from normal station operations over the expected lifetime of the plant.

The staff has also carried out calculations to estimate the potential upper bounds for individual exposures from the same initiating accidents in Table 6.1 for the purpose of implementing the provisions of 10 CFR Part 100, "Reactor Site Criteria." For these calculations, much more pessimistic (conservative or worst case) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include much larger amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESFs in a degraded mode,* and very poor meteorological dispersion conditions. The results of these calculations show that, for these events the limiting whole-body exposures are not expected to exceed 4 rem and most would not exceed 1 rem to any individual at the site boundary.[3] They also show that radioiodine releases have the potential for offsite exposures ranging up to about 200 rem to the thyroid. For such an exposure to occur, an individual would have to be located at a point on the site boundary where the radioiodine concentration in the plume has its highest value and inhale at a breathing rate characteristic of a person jogging, for a period of two hours. The health risk to an individual receiving such an exposure is the potential appearance of benign or maligant thyroid nodules in about 7 out of 100 cases, and the development of a fatal thyroid cancer in about 3 out of 1,000 cases.

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

6.1.4.2 Probabilistic assessment of severe accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design basis accidents discussed in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe, both for the plant itself and for the environment. These severe accidents, heretofore frequently called Class 9 accidents, can be distinguished from design basis accidents in two primary respects; they involve substantial physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment.

The assessment methodology employed is that described in the Reactor Safety Study (RSS) which was published in 1975.[10]** The Summer plant is a Westinghouse-designed pressurized water reactor (PWR) very similar to the Surry Unit 1 facility used in the RSS as a prototype for PWRs. This assessment has used as its starting point, therefore, the same set of accident sequences that were found in the RSS to be dominant contributors to risk in the prototype PWR. The same set of nine release categories, designated PWR 1 through 9, have also been used to represent the spectrum of severe accident releases that are hypothesized for the Summer facility. Characteristics of these categories are shown in Table 6.2. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events and those that could be initiated by deliberate acts of sabotage are not included in these event sequences. The radiological consequences of such events would not be different in kind from those which have been treated. Moreover, it is the staff's judgment, based upon design requirements of 10 CFR Part 50, Appendix A, relating to effects of natural phenomena, and safeguards requirements of 10 CFR Part 73, that these events do not contribute significantly to risk.

A calculated probability per reactor-year associated with each release category is also shown in the second column in Table 6.2. These probabilities are the result of a detailed engineering analysis of the prototype PWR in the Reactor Safety Study. There are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in the data base on failure rates of individual plant components that were used to calculate the probabilities.[11] (See Section 6.1.4.7.) Except as indicated in the footnotes in Table 6.2, the staff has no present basis for judging whether the probabilities may be too high or too low. The error band for the probabilities of some of the event sequences could be as much as a factor of 10 but is very unlikely to be as great as a factor of 100. The event sequences in categories PWR 1-7 lead to partial or complete melting of the reactor core while those in the last two categories do not involve melting of the core. In release categories 1 to 3, the event sequences include containment failure by steam explosion, hydrogen burning, or overpressure. Release categories 4 and 5 contain event sequences in which the systems intended to isolate the containment fail to act properly. In release categories 6 and 7, the dominant containment failure mode is by melt-through of the containment base mat.

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*The containment structure, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR Section 100.11(a).

**Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 6.1.4.7.

Table 6.2

Summary of atmospheric release categories representing hypothetical accidents in a PWR

Release Category	Probability (reactor-yr^{-1})	Fraction of Core Inventory Released[a]						
		Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[b]	La[c]
PWR 1	5.1×10^{-8}[d]	0.9	0.7	0.4	0.4	0.05	0.4	3×10^{-3}
PWR 2	7×10^{-6}	0.9	0.7	0.5	0.3	0.06	0.02	4×10^{-3}
PWR 3	2.3×10^{-6}	0.8	0.2	0.2	0.3	0.02	0.03	3×10^{-3}
PWR 4	2.1×10^{-11}	0.6	0.09	0.04	0.03	5×10^{-3}	3×10^{-3}	4×10^{-4}
PWR 5	5×10^{-8}	0.3	0.03	9×10^{-3}	5×10^{-3}	1×10^{-3}	6×10^{-4}	7×10^{-5}
PWR 6	6×10^{-7}	0.3	3×10^{-3}	8×10^{-4}	1×10^{-3}	9×10^{-5}	7×10^{-5}	1×10^{-5}
PWR 7	4×10^{-5}	6×10^{-3}	4×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}
PWR 8	4×10^{-5}	2×10^{-3}	1×10^{-4}	5×10^{-4}	1×10^{-6}	1×10^{-8}	0	0
PWR 9	4×10^{-4}	3×10^{-6}	1×10^{-7}	6×10^{-7}	1×10^{-9}	1×10^{-11}	0	0

(a) Background on the isotope groups and release mechanisms is presented in Appendix VII, WASH-1400 (Ref. 10).

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

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

(d) Current understanding of the phenomenon of containment failure by steam explosion embodied in this release category indicates that this probability should be lower than stated.

NOTE: Please refer to Section 6.1.4.7 for a discussion of uncertainties in risk estimates.

Table 6.3

Activity of Radionuclides in the
Summer Reactor Core at 2775 MWt

Group Radionuclide	Radioactive Inventory in Millions of Curies	Half-Life (days)
A. Noble gases		
Krypton-85	0.49	3,950
Krypton-85m	21	0.183
Krypton-87	41	0.0528
Krypton-88	59	0.117
Xenon-133	150	5.28
Xenon-135	29	0.384
B. Iodines		
Iodine-131	74	8.05
Iodine-132	100	0.0958
Iodine-133	150	0.875
Iodine-134	160	0.0366
Iodine-135	130	0.280
C. Alkali Metals		
Rubidium-86	0.023	18.7
Cesium-134	6.5	750
Cesium-136	2.6	13
Cesium-137	4.1	11,000
D. Tellurium-Antimony		
Tellurium-127	5.1	0.391
Tellurium-127m	0.95	109
Tellurium-129	27	0.048
Tellurium-129m	4.6	34
Tellurium-131m	11	1.25
Tellurium-132	100	3.25
Antimony-127	5.3	3.88
Antimony-129	29	0.179
E. Alkaline Earths		
Strontium-89	82	52.1
Strontium-90	3.2	11,030
Strontium-91	95	0.403
Strontium-140	140	12.8
F. Cobalt and Noble Metals		
Cobalt-58	0.68	71
Cobalt-60	0.25	1,920
Molybdenum-99	140	2.8
Technetium-99m	120	0.25
Ruthenium-103	95	39.5
Ruthenium-105	62	0.185
Ruthenium-106	22	366.0
Rhodium-105	42	1.50

Note: The above grouping of radionuclides corresponds to that in Table 6.1.

Table 6.3 (continued)

Group Radionuclide	Radioactive Inventory in Millions of Curies	Half-Life (days)
G. Rare Earths, Refractory Oxides and Transuranics		
Yttrium-90	3.4	2.67
Yttrium-91	100	59
Zirconium-95	130	65.2
Zirconium-97	130	0.71
Niobium-95	130	35
Lanthanum-140	140	1.67
Cerium-141	130	32.3
Cerium-143	110	1.38
Cerium-144	74	284
Praseodymium-143	110	13.7
Neodymium-147	52	11.1
Neptunium-239	1420	2.35
Plutonium-238	0.049	32,500
Plutonium-239	0.018	8.9×10^6
Plutonium-240	0.018	2.4×10^6
Plutonium-241	2.9	5,350
Americium-241	0.0015	1.5×10^5
Curium-242	0.43	163
Curium-244	0.020	6,630

Note: The above grouping of radionuclides corresponds to that in Table 6.1.

The magnitudes (curies) of radioactivity release for each category are obtained by multiplying the release fractions shown in Table 6.2 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 6.3 for the Summer plant at the core thermal power level of 2775 megawatts.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS[12] adapted to apply to a specific site. The essential elements are shown in schematic form in Figure 6.1. Environmental parameters specific to the site of the Summer facility have been used and include the following:

(1) Meteorological data for the site representing a full year of consecutive hourly measurements and seasonal variations,

(2) Projected population for the year 2000 extending throughout regions of 80 km and 560 km (50 and 350 miles) radius from the site,

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

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

To obtain a probability distribution of consequences the calculations are performed assuming the occurrence of each accident release sequence at each of 91 different "start" times throughout a one-year period. Each calculation utilizes the site specific hourly meteorological data and seasonal information for the time period following each "start" time. The consequence model also contains provisions for incorporating the consequence-reduction benefits of evacuation and other protective actions. Early evacuation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage. The evacuation model used (see Appendix I) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the Summer site are best-estimate values made by the staff and based upon evacuation time estimates prepared by the applicant. Actual evacuation effectiveness could be greater or less than that characterized but would not be expected to be very much less.

The other protective actions include: (a) either complete denial of use (interdiction), or permitting use only at a sufficiently later time after appropriate decontamination of food stuffs such as crops and milk, (b) decontamination of severely contaminated environment (land and property) when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels, and (c) denial of use (interdiction) or severely contaminated land and property for varying periods of time until the contamination levels reduce to such values by radioactive decay and weathering so that land and property can be economically decontaminated as in (b) above. These actions would reduce the radiological exposure that the people from immediate and/or subsequent use of or living in the contaminated environment.

Early evacuation within the plume exposure pathway EPZ and other protective actions as mentioned above are considered as essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for the Summer reactor include the benefits of these protective actions.

There are also uncertainties in the estimates of consequences and the error bounds may be as large as they are for the probabilities. It is the judgment of the staff, however, that it is more likely that the calculated results are overestimates of consequences rather than underestimates.

The results of the calculations using this consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions, and costs associated with property damage by radioactive contamination.

6.1.4.3 Dose and health impacts of atmospheric releases

The results of the calculations of dose effects and health impacts performed for the Summer facility and site are presented in the form of probability distributions in Figures 6.2 through 6.5 and are included in the impact summary Table 6.4. All of the nine release categories shown in Table 6.2 contribute to the results, the consequences from each being weighted by its associated probability.

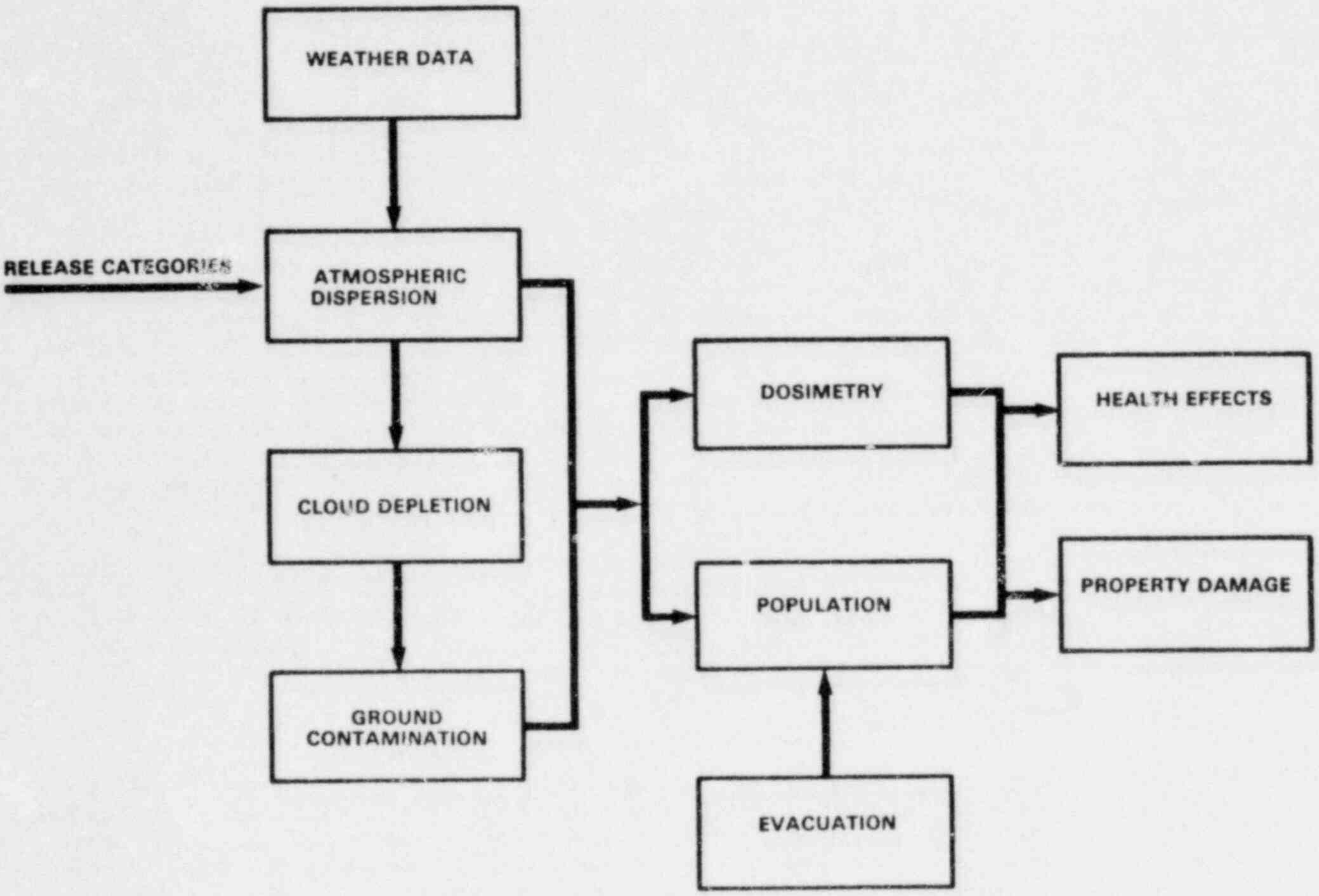

Figure 6.1 Schematic outline of consequence model

Figure 6.2 shows the probability distribution for the number of persons who might receive whole-body doses equal to or greater than 200 rem and 25 rem, respectively, and thyroid doses equal to or greater than 300 rem from early exposure,* all on a per-reactor-year basis. The 200-rem whole-body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body (which has been identified earlier as the lower limit for a clinically observable physiological effect) and 300-rem thyroid figures correspond to the Commission's guideline values for reactor siting in 10 CFR Part 100.

The figure shows in the left-hand portion that there is approximately one change in 100,000 per year (i.e., 10^{-5}) that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves run almost parallel in horizontal lines shows that if one person were to receive such doses, the chances are about the same that several tens to hundreds would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about 1 in 100,000,000 (1×10^{-8}) that 60,000 or more people might receive doses of 200 rem or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 56-km (35-mile) radius of the plant. Virtually all would occur within a 160-km (100-mile) radius.

Figure 6.3 shows the probability distribution for the total population exposure in person-rem, i.e., the probability per reactor-year that the total population exposure will equal or exceed the values given. Most of the population exposure up to 10 million person-rem would occur within 80 km (50 miles), but the more severe release categories (PWR 1-3) would result in exposure to persons beyond the 80-km (50-mile) range as shown.

For perspective, population doses shown in Figure 6.3 may be compared with the annual average dose to the population within 80 km (50 miles) of the Summer site due to natural background radiation of 105,000 person-rem and to the anticipated annual population dose to the general public from normal station operation of 36 person-rem (excluding plant workers) (Section 4, Tables 4.9 and 4.11).

Figure 6.4 shows the probability distributions for acute fatalities, representing radiation injuries that would produce fatalities within about one year after exposure. Virtually all of the acute fatalities would be expected to occur within a 72-km (45-mile) radius and the majority within 24-km a (15-mile) radius. The results of the calculations shown in this figure and in Table 6.4 reflect the effect of evacuation within the 16-km (10-mile) plume exposure pathway EPZ only. For the very low probability accidents having the potential for causing radiation exposures above the threshold for acute fatality at distances beyond 10 miles, it would be realistic to expect that authorities would evacuate persons at all distances at which exposures might occur. Acute fatality consequences would therefore reasonably be expected to be very much less than the numbers shown.

Figure 6.5 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 80 km (50 miles) are shown separately. Further, the fatal, latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

6.1.4.4 Economic and societal impacts

As noted in Section 6.1.1, the various measures for avoidance of adverse health effects including those due to residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for the Summer facility and environs have also been made. Unlike the radiation exposure and health effect impacts discussed above, impacts associated with adverse health effects avoidance are more readily transformed into economic impacts.

The results are shown as the probability distribution for cost of offsite mitigating actions in Figure 6.6 and are included in the impact summary Table 6.4. The factors contributing to these estimated costs include the following:

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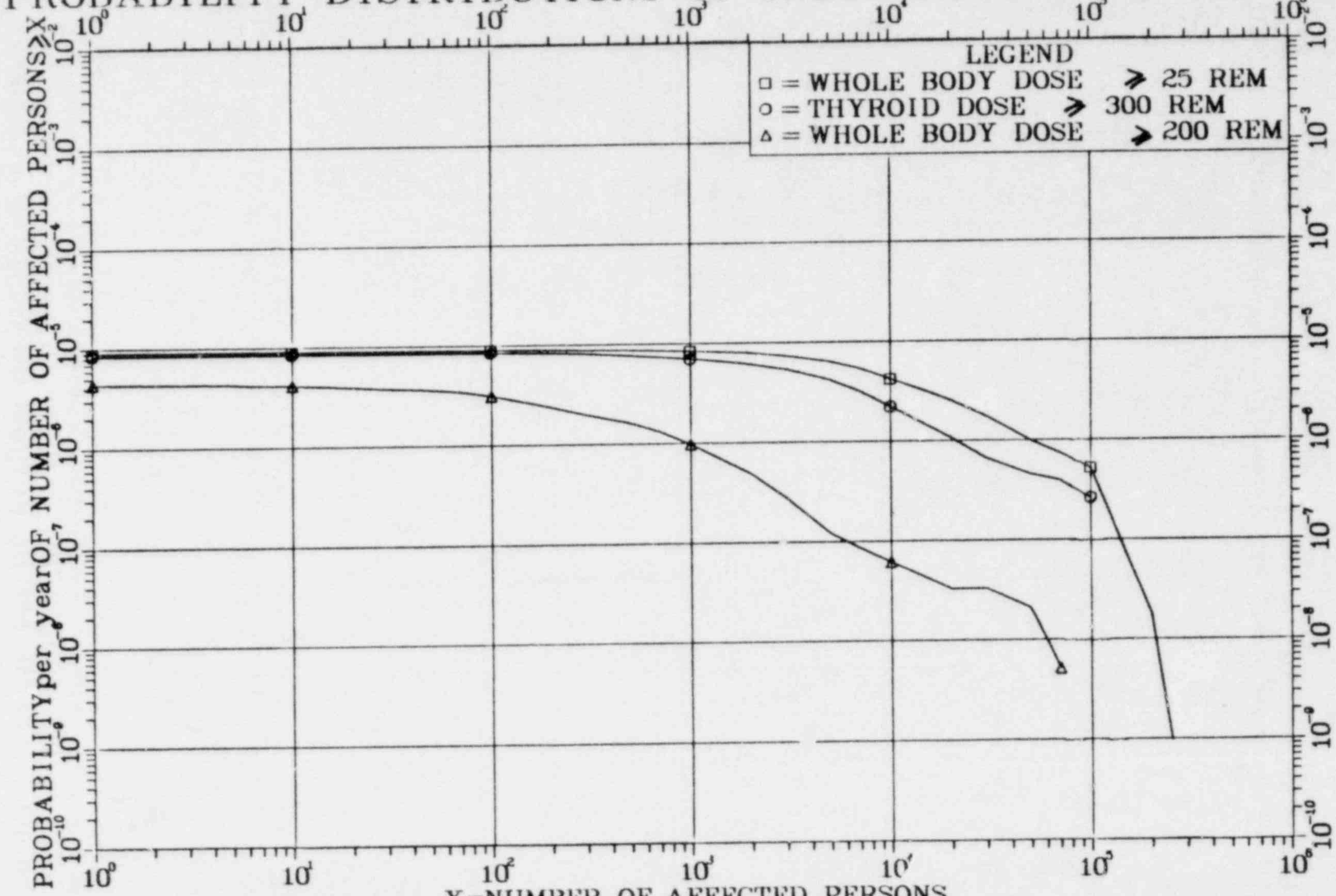
*Early exposure to an individual includes external doses from the radioactive cloud and the contaminated ground, and the dose from interlaly deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposure are excluded.



PROBABILITY DISTRIBUTIONS OF INDIVIDUAL DOSE IMPACTS

Figure 6.2

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

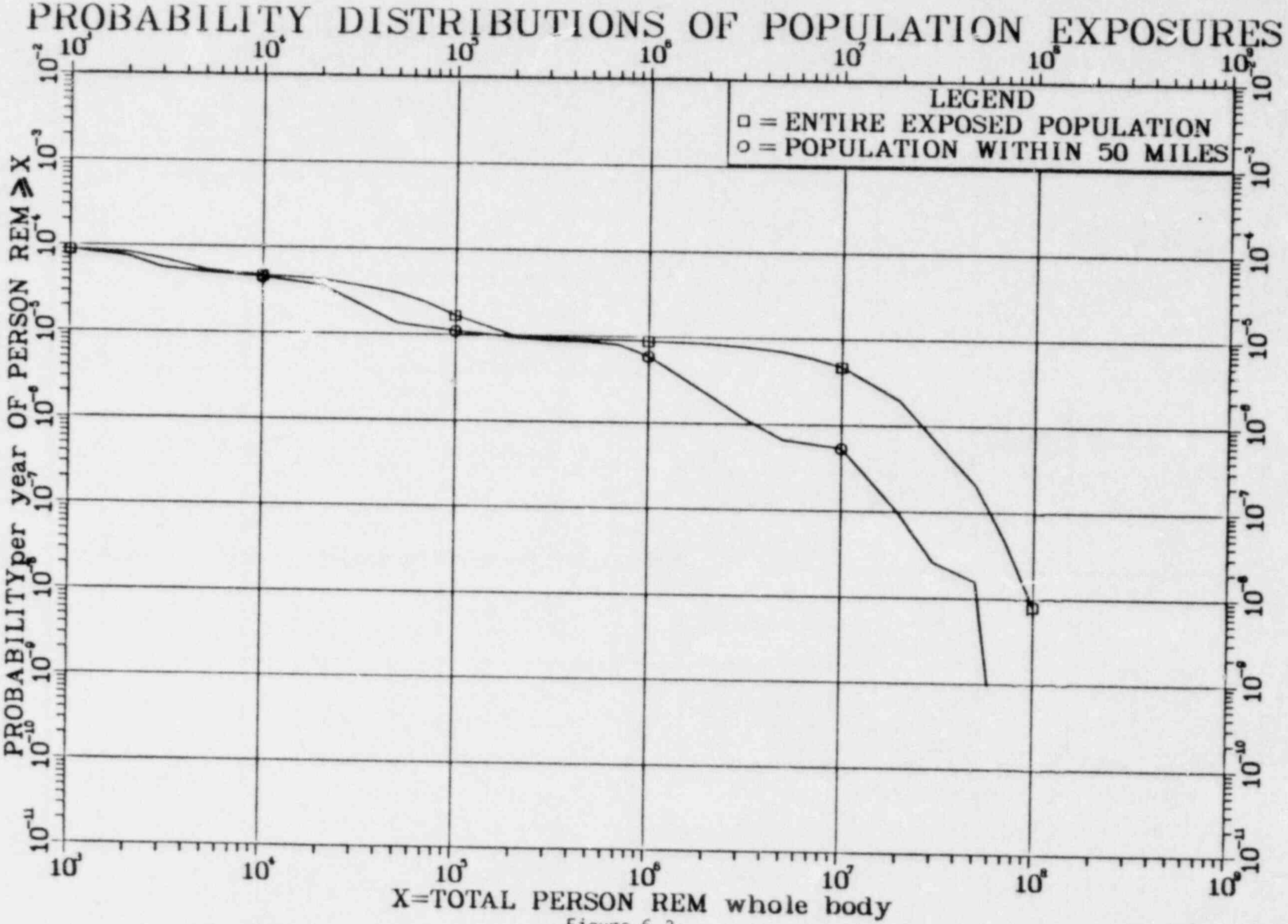


Figure 6.3

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

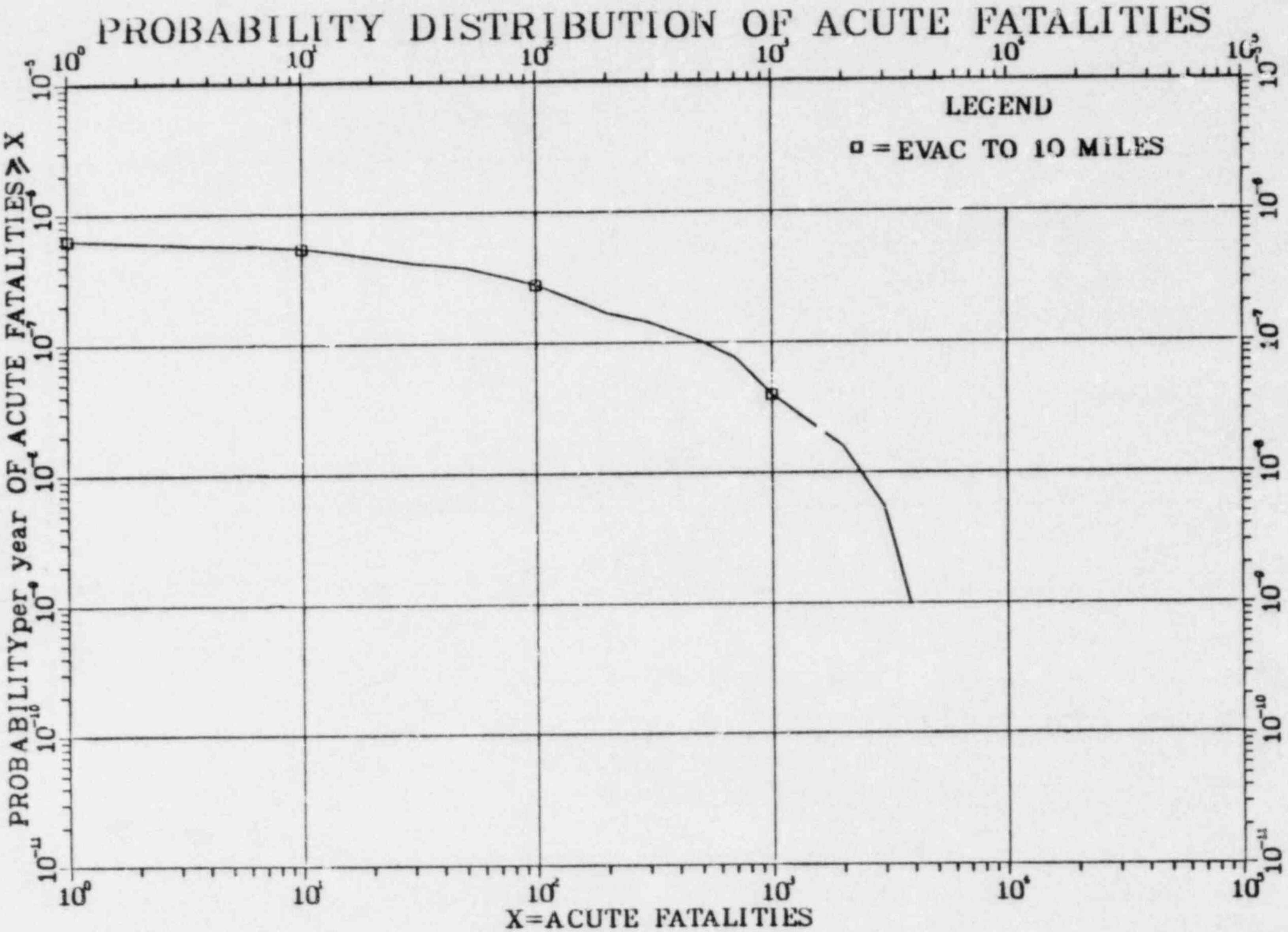


Figure 6.4

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

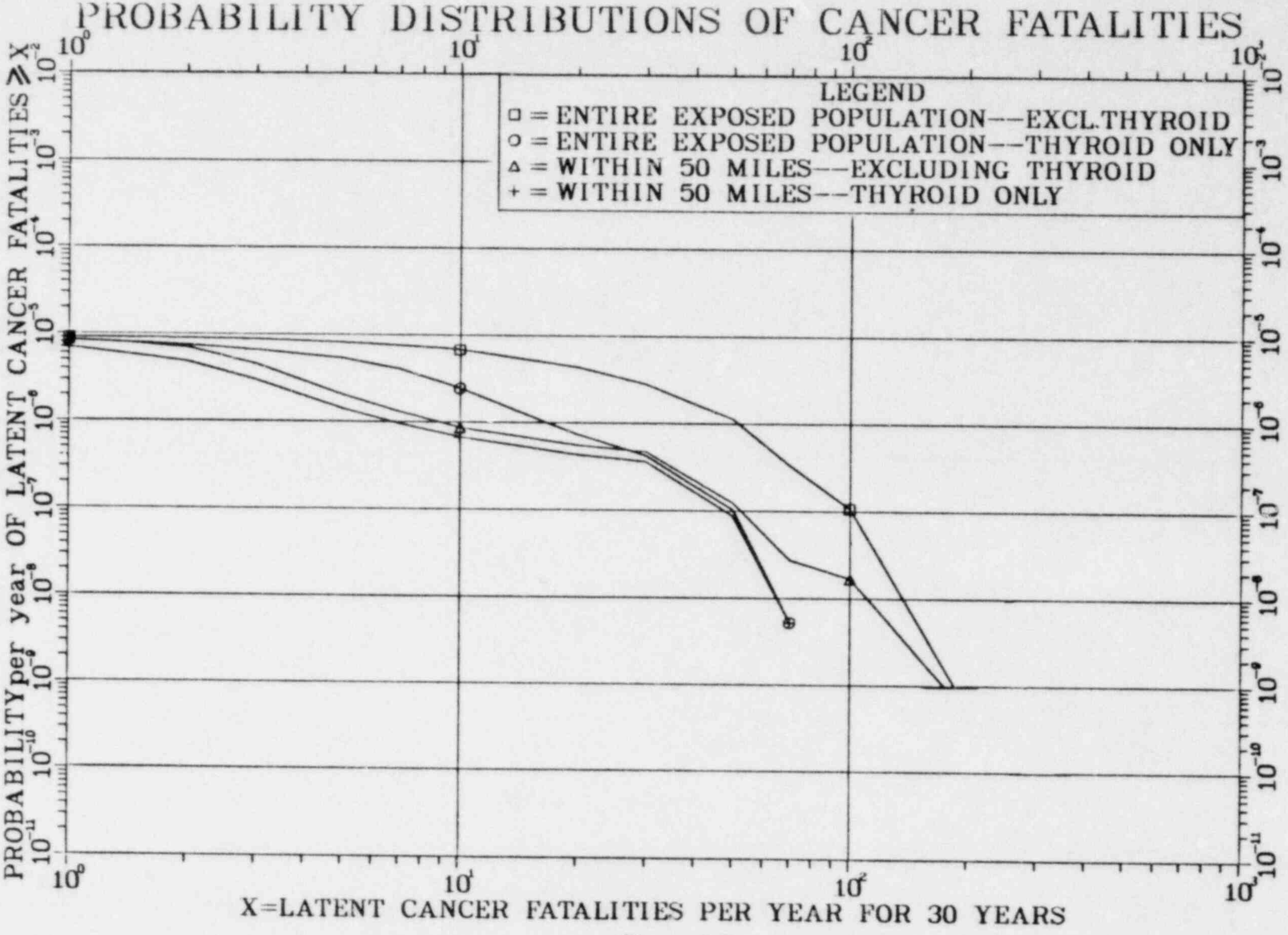


Figure 6.5

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

- Evacuation costs
- Value of crops contaminated and condemned
- Value of milk contaminated and condemned
- Costs of decontamination of property where practical
- Indirect costs due to loss of use of property and incomes derived therefrom.

The last named cost would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 6.6 shows that at the extreme end of the accident spectrum these costs could exceed several billion dollars but that the probability that this would occur is exceedingly small, less than one chance in a million per reactor-year.

Additional economic impacts that can be quantified include costs of decontamination of the facility itself and the costs of replacement power. Probability distributions for these impacts have not been calculated but they are included in the discussion of risk considerations in Section 6.1.4.6.

6.1.4.5 Releases to groundwater

A pathway for public radiation exposure and environmental contamination that could be associated with severe reactor accidents was identified in Section 6.1.1.2. Consideration has been given to the potential environmental impact of this pathway for the Summer plant. The principal contributors to the risk are the core-melt accidents associated with the PWR-1 through 7 release categories. The penetration of the basemat of the containment building can release molten core debris to the strata beneath the plant. Soluble radionuclides in this debris can be leached and transported with groundwater to down-gradient domestic wells used for drinking or to surface water bodies used for drinking water, aquatic food, and recreation. In pressurized water reactors, such as the Summer unit, there is an additional opportunity for groundwater contamination due to the release of contaminated sump water to the ground through a breach in the containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS).[13] The LPGS compared the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for four conventional, generic land-based nuclear plants and a floating nuclear plant, for which the nuclear reactors would be mounted on a barge and moored in a water body. Parameters for the land-based sites were chosen to represent averages for a wide range of real sites and are thus "typical," but represented no real site in particular.

The discussion in this section is an analysis to determine whether or not the Summer site liquid pathway consequences would be unique when compared to land- based sites considered in the LPGS. The method consists of a direct scaling of LPGS population doses based on the relative values of key parameters characterizing the LPGS "small river" site and the Summer site. The parameters which were evaluated included amounts of radioactive materials entering the ground, groundwater travel time, sorption on geological media, surface water transport, drinking water usage, aquatic food consumption, and shoreline usage.

Doses to individuals and populations were calculated in the LPGS without consideration of interdiction methods such as isolating the contaminated groundwater or denying use of the water. In the event of surface water contamination, alternative sources of water for drinking, irrigation, and industrial uses would be expected to be found, if necessary. Commercial and sports fishing, as well as many other water-related activities would be restricted. The consequences would therefore be largely economic or social, rather than radiological. In any event, the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

The Summer site is underlain by a complex series of soil, metamorphic rock, and igneous intrusions. The basemat of the reactor buildings is in a micaceous silty sand formation, approximately 48-64 km (30-40 feet) above the underlying bedrock.

Groundwater at the site occurs in two types of formations:

(1) jointed and fractured crystalline bedrock, and

(2) the lower zones of the soil overburden.

Table 6.4

Summary of Environmental Impacts and Probabilities

Probability of Impact Per Reactor-Year	Persons Exposed over 200 rem	Persons Exposed over 25 rem	Acute Fatalities	Population Exposure Millions of Person-Rem 50 mi/Total	Latent Cancers 50 mi/Total	Cost of Offsite Mitigating Actions Millions of Dollars
10^{-4}	0	0	0	<0.001/<0.001	0/0	<.001
10^{-5}	0	<1	0	<0.25/<0.25	<60/<60	1.3
5×10^{-6}	<1	8,000	0	1/7	140/680	200
10^{-6}	1,000	50,000	<1	3.5/25	470/2000	1,000
10^{-7}	60,000	130,000	500	20/60	3,000/4,500	2,800
10^{-8}	60,000	200,000	2,300	50/90	5,300/5,900	4,000
Related Figure	6.2	6.2	6.4	6.3	6.5	6.6

*Includes cancers of all organs. Thirty times the values shown in Figure 6.5 are shown in this column reflecting the thirty-year period over which cancers might occur. Genetic effects might be approximately twice the number of latent cancers.

NOTE: Refer to Section 6.1.4.7 for a discussion of uncertainties in risk estimates.

Estimates of groundwater travel time from the reactor building to the Board River varied over a wide range from 1140 years in the overburden soils to a conservatively estimated 7.4 years in the fractured media. The latter value was used in the comparison for conservatism.

For groundwater travel times of several years, the most important radionuclide contributors to population dose are Sr-90 and Cs-137. Conservative values of the retardation factors, which reflect the effects of sorption on geologic materials similar to the fractured media at the site[14] of 8.6 for Sr-90 and 154 for Cs-137 were used in the present analysis. The transport time from the reactor building to the Broad River is, therefore, conservatively estimated to be about 64 years for Sr-90 and 1140 years for Cs-137. When these times are compared to 5.7 for Sr-90 and 51 years for Cs-137 in the LPGS land-based river case, the relatively larger travel times for the Summer site would allow a smaller portion of the radioactivity to enter the surface water. This reduction is about a factor of 4 for Sr-90 over that predicted in the LPGS case. Virtually all of the Cs-137 will have decayed before reaching the Broad River.

The Broad River would be the receptor for radionuclides mitigating through the ground. No drinking water wells would be directly affected by the contaminated groundwater.

There would be two major municipal water users affected by the contamination of the Broad River and other waterways downstream. The city of Columbia, South Carolina draws most of its drinking water from the Broad River. An estimated 230,000 people would be affected. The City of Charleston, South Carolina presently draws about 10% of its water from Lake Moultrie. By 1990, this portion is expected to increase about 50%. The estimated 1990 population of Charleston affected would be 325,000 people. There are other smaller drinking-water users that would be affected between Columbia and Charleston.

The hypothetical LPGS river site had a drinking water population of 620,000 people distributed at multiple points down the river. Hence, the uninterdicted drinking water population dose for the Summer site was calculated to be about 90% of that for the LPGS river site by comparing the populations, groundwater travel times, and dilutions for the two sites, assuming that the radioactive source terms at the sites would be identical.

Population dose from the consumption of finfish, molluscs, and crustaceans was calculated in a manner similar to the drinking water population dose. The annual harvest which could be affected by contamination downstream from the Summer plant has been estimated to be about 3.5×10^6 Kg. The LPGS small river site, by comparison, used an annual fish harvest of 1.2×10^6 Kg. The uninterdicted population dose from the Summer site was calculated to be about 2 times greater than that of the LPGS site when consumption of the fisheries harvest, dilution, and groundwater travel time were compared.

The Broad River and Monticello Reservoir are not heavily used for swimming or other recreation which would subject people to direct radiation from contaminated water and sediments. There may be heavier usage in waters downstream. The LPGS population dose assessment, however, showed that virtually all of the beach shore, boating, and swimming dose was due to Cs-137. Since virtually no Cs-137 is predicted to escape in the Summer case, the staff concludes that there will be an insignificant contribution to population dose from shoreline usage, boating, and swimming.

The Summer liquid pathway contribution to population dose has, therefore, been demonstrated to be the same order of magnitude as that predicted for the LPGS river site, which represents a "typical" river site. Thus, the Summer site is not unique in its liquid pathway contribution to risk.

There are measures which could be taken to minimize the impact of the liquid pathway. The staff estimated that the minimum groundwater travel time from the Summer site to the Broad River would be 7.4 years, and that the holdup of radioactivity would be much greater, which would allow ample time for engineering measures such as slurry walls and well-point dewatering to isolate the radioactive contaminants at the source.

6.1.4.6 Risk considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Since the ranges of both factors are quite broad, it is also useful to combine them to obtain average measures of environmental risk. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with normal operational releases.

PROBABILITY DISTRIBUTION OF MITIGATION MEASURES COST

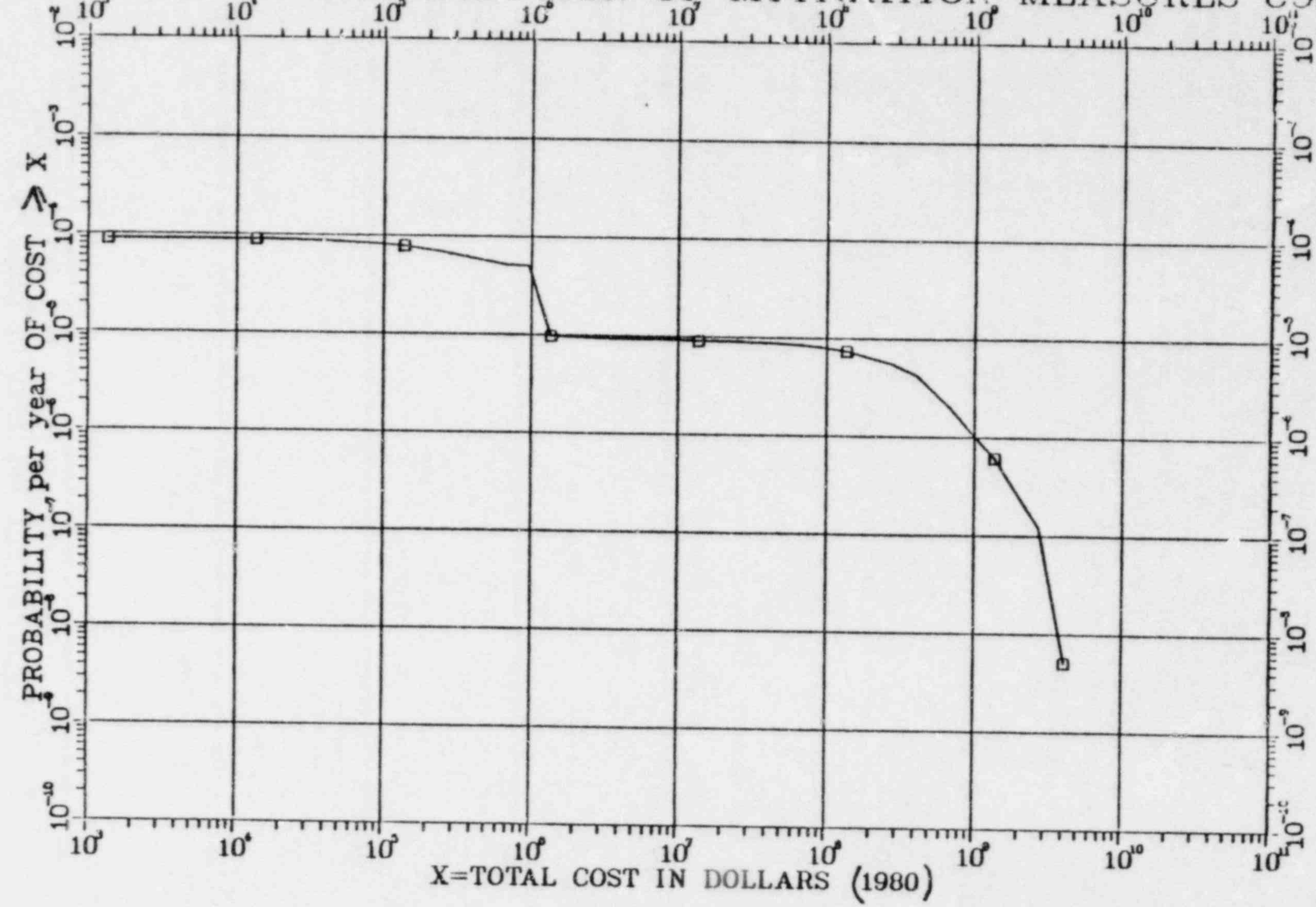


Figure 6.6

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time. Such a quantification of risk does not at all mean that there is universal agreement that peoples' attitudes about risk, or what constitutes an acceptable risk, can or should be governed solely by such a measure. At best, it can be a contributing factor to a risk judgment, but not necessarily a decisive factor.

In Table 6.5 we show average values of risk associated with population dose, acute fatalities, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of distributions. Since the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

The population exposures and latent cancer fatality risks may be compared with those releases for normal operation shown in Section 4, Tables 4.9, 4.11, and Section 4.5.5. The comparison (excluding exposure to the plant personnel) shows that the accident risks are substantially lower than those for normal operation.

There are no acute fatality nor economic risks associated with protective actions and decontamination for normal releases; therefore, these risks are unique for accidents. For perspective and understanding of the meaning of the acute fatality risk of 0.0002 per year, however, we note that to a good approximation the population at risk is that within about 10 miles of the plant, about 9,000 persons in the year 2000. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 2 from motor vehicle accidents, 0.7 from falls, 0.3 from drowning, 0.3 from burns, 0.1 from firearms.[4b]

Figure 6.7 shows the calculated risk expressed as whole-body dose to an individual from early exposure as a function of the distance from the plant within the plume exposure pathway EPZ. The values are on a per-reactor-year basis and all release categories in Table 6.2 contributed to the dose, weighted by their associated probabilities.

Evacuation and other protective actions reduce the risks to an individual of acute and latent cancer fatalities. Figures 6.8 and 6.9, respectively, show curves of constant risks per reactor-year to an individual, living within the plume exposure pathway EPZ of the Summer plant, of acute death and of death from latent cancer, respectively, as functions of distance due to potential accidents in the reactor. Directional variation of these curves reflect the variation in the average fraction of the year the wind would be blowing into each direction from the plant. For comparison, the following risks of fatality per year to an individual living in the U.S. may be noted[4b]; automobile accident 2.2×10^{-4}, falls 7.7×10^{-5}, drowning 3.1×10^{-5}, burning 2.9×10^{-5}, and firearms 1.2×10^{-5}.

Table 6.5

Average Values of Environmental Risks
Due to Accidents per Reactor-Year

Population exposure	
Person-rem within 50 miles	24
Person-rem total	130
Acute Fatalities	0.00017
Latent cancer fatalities	
All organs excluding thyroid	0.007
Thyroid only	0.0024
Cost of protective actions and decontamination	$4,800

Note: Please see Section 6.1.4.7 for discussions of uncertainties in risk estimates.

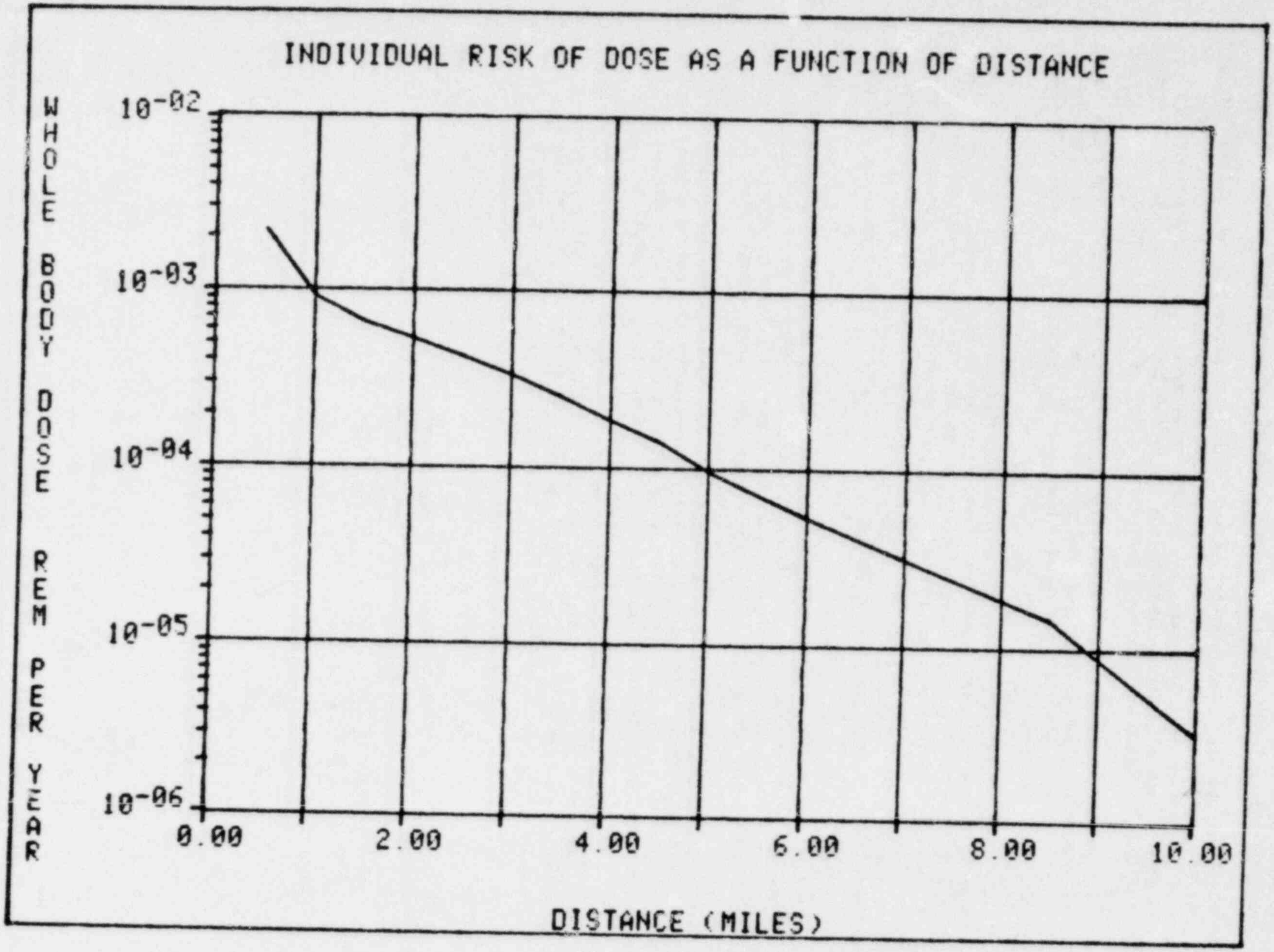
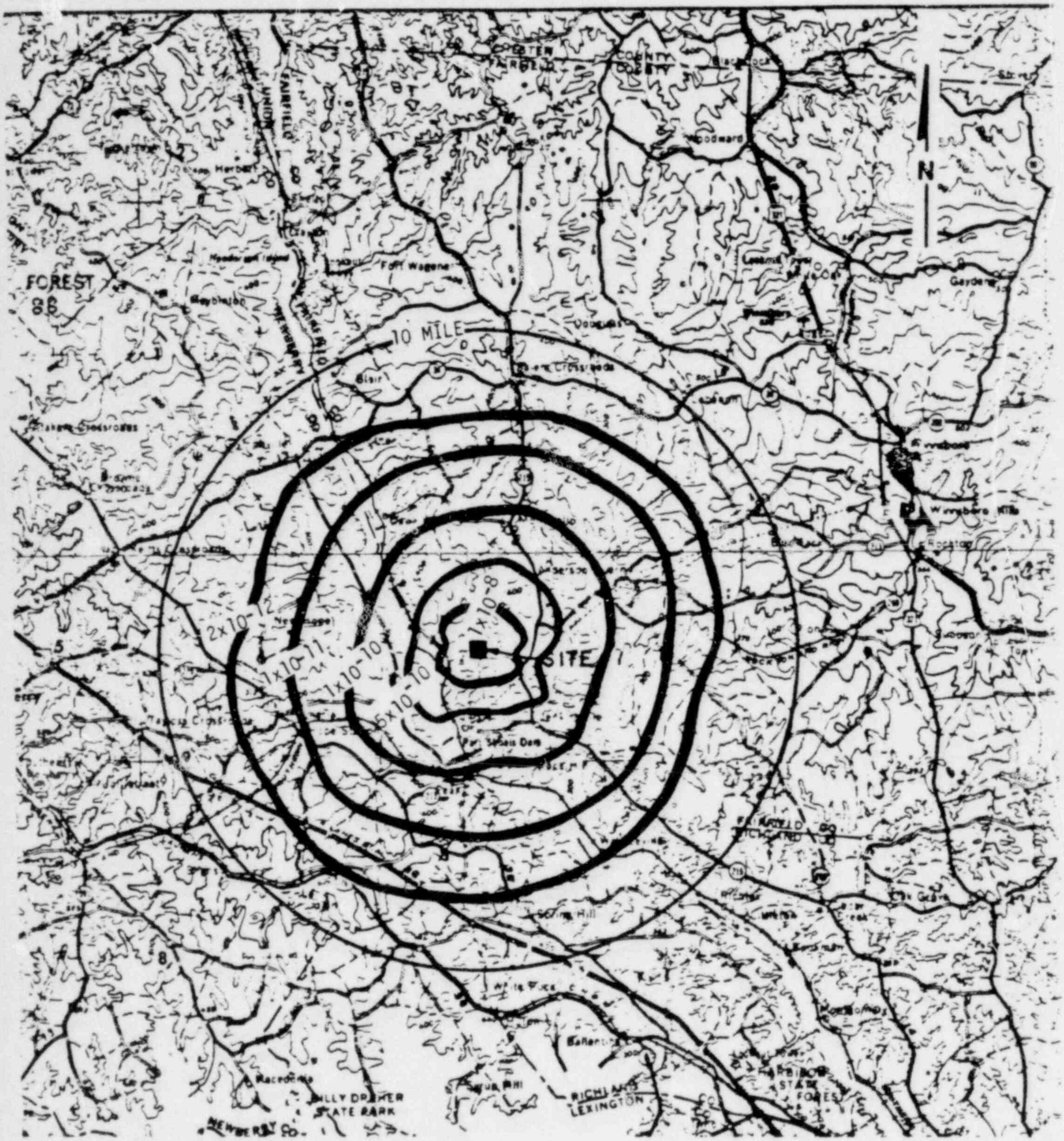


Figure 6.7

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.



ISOPLETHS OF RISK OF ACUTE FATALITY PER REACTOR YEAR TO AN INDIVIDUAL

Figure 6.8

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

ISOPLETHS OF RISK OF LATENT CANCER FATALITY PER REACTOR YEAR TO AN INDIVIDUAL

Figure 6.9

NOTE: Please see Section 6.1.4.7 for discussion of uncertainties in risk estimates.

The economic risk associated with evacuation and other protective actions could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels, coal or oil, for example, would emit substantial quantities of sulphur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental, and ecological damage through the phenomenon of acid rain.[40] This latter effect has not, however, been sufficiently quantified to draw a useful comparison at this time.

There are other economic impacts and risks that can be monetized that are not included in the cost calculations discussed in Section 6.1.4.4. These are accident impacts on the facility itself that result in added costs to the public, i.e., ratepayers, taxpayers, and/or shareholders. These are costs associated with decontamination of the facility itself and costs for replacement power.

No detailed methodology has been developed for estimating the contribution to economic risk associated with cleanup and decontamination of a nuclear power plant that has undergone a serious accident toward either a decommissioning or a resumption of operation. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. It is already clear, however, that such costs can approach or even exceed the original capital cost of such a facility. As an illustration of the possible contribution to the economic risk, if the probability of an accident serious enough to require extensive cleanup and decontamination is taken as the sum of the nine categories in Table 6.2, i.e., about 5 chances in 10,000 per reactor-year, and if the "average" decontamination cost for these nine categories is assumed to be one billion dollars, then the estimated economic risk would be about $500,000 per reactor-year.

The cost of replacement power is significantly affected by the point in the lifetime of the plant at which a loss in electric generating capability might occur. The cost is highest at the beginning of plant operating life decreasing to zero at the end of life. For illustrative purposes, the costs and economic risk have been estimated for a "worst case" situation for the 900-megawatt (electric) Summer plant by postulating a total loss in the first year of a projected 30-year operating life. Replacement power at 57 mils per kWh is assumed over an 8-year period before a new plant of like capacity can be put into service. Using a 60% capacity factor, the annual cost of replacement power would be $180 million per year for the 8-year period. Interest and depreciation charges for the new plant are estimated at $77 million per year in 1980 dollars, representing the differential cost of having to construct a new facility, and extending over the majority of the lifetime of the original facility.

If the probability of sustaining a total loss of the original facility is taken as the probability of occurrence of a core melt accident (approximated by the sum of the probabilities for the categories PWR 1 through 7 in Table 6.2), then the average contribution to economic risk that would result from an early life loss of the Summer plant is about $10,000 per year during the 8-year replacement period and about $3,000 per year for the balance of the 30-year original lifetime.

Additional replacement power costs could be sustained by operators of nuclear power plants other than the one directly involved in an accident if the cause of the accident is of a generic nature and resulted in forced outages of other plants. Estimates of such additional economic impacts would be speculative and have not been made by the staff.

6.1.4.7 Uncertainties

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

In July 1977, the NRC organized an Independent Risk Assessment Review Group to (1) clarify the achievements and limitations of the Reactor Safety Study, (2) assess the peer comments thereon and the responses to the comments, (3) study the current state of such risk assessment methodology, and (4) recommend to the Commission how and whether such methodology can be used in the regulatory and licensing process. The results of this study were issued September 1978.[11] This report, called the Lewis Report, contains several findings and recommendations concerning the RSS. Some of the more significant findings are summarized below.

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

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

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

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

The accident at Three Mile Island occurred in March 1979 at a time when the accumulated experience record was about 400 reactor years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity.[4d] It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents like that one, by a significant number of investigative groups both within NRC and outside of it. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-1 Accident," NUREG-0660, Vol. I, May 1980 collects the various recommendations recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization, and Management. The action plan presents a sequence of actions, some already taken, that will result in a gradually increasing improvement in safety as individual actions are completed. The Summer plant is receiving and will receive the benefit of these actions on the schedule indicated in NUREG-0660. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements.

6.1.5 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the Summer facility. These have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and groundwater pathways. Included in the considerations are postulated design basis accidents and more severe accident sequences that lead to a severely damaged reactor core or core melt.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe but the likelihood of their occurrence is judged to be small. This conclusion is based on (a) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment, (b) the fact that, in order to obtain a license to operate the Summer facility, it must comply with the applicable Commission regulations and requirements, and (c) a probabilistic assessment of the risk based upon the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is roughly comparable to the risk from normal operation although accidents have a potential for acute fatalities and economic costs that cannot arise from normal operations. The risks of acute fatality from potential accidents at the site are small in comparison with risks of acute fatality from other human activities in a comparatively-sized population.

We have concluded that there are no special or unique circumstances about the Summer site and environs that would result in different or substantially greater environmental impacts than those from other presently operating pressurized water nuclear power plants. Therefore, on the basis of this analysis, no special or additional engineered safety features are recommended for the Summer plant.

6.2 TRANSPORTATION ACCIDENTS

The transportation of cold fuel to a reactor, of irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to burial grounds is within the scope of the NRC report entitled, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants."[15] The applicant has facilities available for shipping irradiated fuel by truck. The staff has examined these facilities and feels that they will meet all staff requirements for shipping such wastes. The applicant has stated that solid radioactive wastes will be transported from the reactor to burial grounds by truck (OL-ER, Sect. 3.5.4). The environmental risks of accidents in transportation are summarized in Table 6.6 (normal conditions of transport are summarized in Table 4.14).

Table 6.6

Environmental Risk of Accidents in Transport of Fuel and Waste To and From a Typical Light-Water-Cooled Nuclear Power Reactor[3]

	Environmental risk
Radiological effects	Small[b]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.

[a] Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1, NUREG-75/038, April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 1717 H Street, NW., Washington, D.C., and may be obtained from National Technical Information Service, Springfield, VA 22161. WASH-1238 is available from NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microfiche, $2.25).

[b] Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

REFERENCES FOR SECTION 6

1. Statement of Interim Policy, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1979," 45 FR 40101-40104, June 13, 1980.

2. Final Safety Analysis Report (FSAR) for the Virgil C. Summer Nuclear Station, Docket No. 50-395, South Carolina Electric & Gas Co., February 24, 1977, as amended.

3. Safety Evaluation Report related to the operation of Virgil C. Summer Nuclear Station, Unit No. 1, Docket No. 50-395, NUREG-0717.*

4a. "Energy in Transition 1985 - 2010," Final Report of the Committee on Nuclear and Alternative Energy Systems (CONAES), National Research Council, 1979, Chapter 9, pp 517-534; also C. E. Land, Science 209, 1197, September 12, 1980.

4b. CONAES Report, loc cit, pp 577.

4c. CONAES Report, loc cit, pp 559-560.

4d. CONAES Report, loc cit, p 553.

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

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

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

8. "Three Mile Island - A Report to the Commissioners and the Public," Vol. I, Mitchell Rogovin, Director, Nuclear Regulatory Commission Special Inquiry Group, January 1980, Summary Section 9, NUREG/CR-1250, Vol. 1.*

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

10. "Reactor Safety Study," WASH-1400 (NUREG-75/014), October 1975.**

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

12. "Overview of the Reactor Safety Study Consequences Model," NUREG-0340, October 1977.***

13. "Liquid Pathway Generic Study," NUREG-0440, February 1978.***

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

15. U.S. Atomic Energy Commission, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," Report WASH-1238, Washington, D.C., December 1972, and U.S. Nuclear Regulatory Commission, Office of Standards Development, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1," Report NUREG-75/038, Washington, D.C., April 1975.***

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*Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and/or the National Technical Information Service, Springfield, VA 22161.

**Available free upon written request to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

***Available for purchase from the National Technical Information Service, Springfield, VA 22161.

7. NEED FOR THE STATION

7.1 INTRODUCTION

This section presents an analysis of the need for Unit 1 of the Virgil C. Summer Nuclear Station based on the energy demands of the service area, the potential for production cost savings, and the increased reliability of the applicant's system. Reflected in the analysis are the dramatic changes that have occurred since the Arab oil embargo of 1973 and the downward revision of the applicant's load forecasts that resulted from those changes.

7.2 SERVICE AREA AND REGIONAL RELATIONSHIPS

7.2.1 Service area

The 900-MWe Virgil C. Summer Nuclear Station is owned by South Carolina Electric and Gas Company (SCE&G) and the South Carolina Public Service Authority (SCPSA) in a two to one ratio. Power produced by the plant will be allocated according to the ownership ratio, 600 MW to SCE&G and 300 MW to SCPSA. Construction, licensing, and operation of the power station is the responsibility of SCE&G.

The service area of SCE&G includes 24 of South Carolina's 46 counties in the southern portion of the state and a population of more than 1.2 million. Electricity is provided at retail to more than 336,000 customers (as of the end of 1979) in 127 communities. In addition, three municipalities and six electric co-ops are served. Columbia and Charleston are the two major electrical load centers in the service area.

An entity of the State of South Carolina, SCPSA was created in 1934 to provide flood control, drainage and navigation services, and electric power. Electric service is provided directly at retail to approximately 37,000 residential and commercial customers in 8 communities (mostly in the counties of Berkeley, Horry, and Georgetown), 3 military establishments, and 21 large industrial customers. Wholesale sales are made to 2 communities and to 15 individual electric distributive cooperatives represented by the Central Electric Power Cooperative in 35 counties of the State.

7.2.2 Regional relationships

The SCE&G and SCPSA are members of the Southeastern Electric Reliability Council (SERC) and the Virginia-Carolinas (VACAR) subregion group. Membership in these larger groups provides a means for the member utilities to coordinate their load forecasting and system-generation planning in a way that will maximize reliability at acceptable costs of generation.

The transmission systems of SCE&G and SCPSA are interconnected at several points for emergency and economic exchange purposes. The SCE&G also has interconnections with Georgia Power Company, Duke Power Company, Carolina Power & Light Company, and the Southeastern Power Administration (SEPA); SCPSA has other interconnections with Carolina Power & Light and SEPA. The SEPA interconnections provide both utilities with strengthened ties with Georgia Power Company and Duke Power Company and permit transmission of SEPA-generated electricity over SCE&G and SCPSA lines to power distribution cooperatives in much of South Carolina. The applicant's external interties provide the capability of receiving emergency support from distant members of SERC and VACAR and from utilities in adjacent reliability council regions to the north and west through a weblike transmission interconnection system.

7.3 BENEFITS OF OPERATING THE STATION

7.3.1 Minimization of production costs

In the absence of any overriding environmental or safety considerations, the decision to operate the completed Summer station can be evaluated with respect to the economic merits of such action. The applicant has provided 1982 projected fuel costs for its fossil-fueled generating facilities and for the completed Summer Station. These cost data are summarized in Table 7.1.

Table 7.1 1982 fuel cost in mills/Kwh.

Fuel	Cost (mills/kWhr)
Coal	19.6
Oil	44.2
Nuclear	6.6

Because it is assumed that the station is completed and ready to operate, the investment costs are expected to be borne by the consumer whether the plant operates or not. The economic comparison to be made, therefore, is that of the nuclear fuel costs vs the fuel costs for increased use of the existing fossil-fueled stations in both utility systems. A comparison of the fuel costs presented above reveals that the fuel costs at the nuclear plant will be about one-third to one-sixth of the fuel-related portion of the generating costs at fossil-fueled stations. Assuming a 60% plant capacity factor for its initial operation and 75% replacement by coal and 25% replacement by oil, the staff finds that the following additional (differential) cost of generation would result for the combined owners if operation of the Summer station were delayed for one year:

Plant type	Cost ($\$10^6$)
Coal-fired plants (about 75% of system)	46.1
Oil-fired plants (about 25% of system)	44.5

Therefore, the total additional cost of generation from a one-year delay in operating the Summer station would be about $90 million in 1982.

A production-cost analysis should also include the differential in variable O & M costs between the Summer Station and the units which would provide the replacement energy. However, these cost items are quite small in relation to the fuel cost differential and could not alter the ultimate cost differential to any meaningful degree.

7.3.2 Load growth

Since the issuance of the FES-CP, SCE&G has made extensive downward revisions in its projected load growth for the late 1970s and early 1980s, reflecting the economic- and conservation-related after effects of the Arab oil embargo of 1973 and subsequent increase in costs of all forms of nonrenewable energy resources. The most recent tabulation of load responsibility, shown in Table 7.2, indicates that the current load responsibility for 1980 is about 1800 MWe lower than projected by SCE&G in the early 1970s. The basic system annual load growth is projected to grow at an average annual rate of about 2.5% between 1980 and 1985. This is significantly lower than the observed growth rate between 1970 and 1977.

Table 7.2 Projected load responsibility for SCE&G through 1985

Year	Load responsibility (MWe)	Annual change (%)
1977[a]	2365	
1978[a]	2420	2.3
1979[a,b]	2376	-1.8
1980[a]	2563	7.9
1981[c]	2399	-6.4
1982	2483	3.5
1983	2631	6.0
1984	2760	4.9
1985	2899	5.0

[a] Actual.

[b] Decrease in actual load for 1979 due to expiration of 75 MWe control with Georgia Power Company

[c] Decrease in projected load for 1981 due to expiration of 74 MWe contracts with Carolina Power & Light and Duke Power Companies. Projection for 1981 based on normal weather; whereas 1980 summer temperatures were abnormally high. Source: Letter from T.C. Nichols, Jr. (SCE&G) to H. Denton (NRC), Dec. 31 1980.

The staff believes that the applicant's latest projection of a compound annual growth rate of 2.5 percent is not excessive when compared with the compound annual growth rates of 7% between 1966 and 1978, or 2.7% between 1977 and 1980.

In response to the reduced growth rate of peak load, SCE&G reduced its planned growth of power supply primarily by selling one-third of the capacity of the Summer station to SCPSA and deferring construction of other new facilities. Table 7.3 shows SCE&G installed capacity (current and projected) through 1985. The Summer unit is scheduled for commercial operation in late 1981.

Table 7.3 Existing capacity, additions, and retirements through 1985 for SCE&G

Unit	Capacity (MWe)	Year	Type of use	Type of Fuel
Existing 1977	1644		Base	Coal
	580		Base	No. 6 oil
	94		Peak	No. 6 oil
	290		Peak	No. 2 oil
	206		Peak	Hydro
	38		Base[a]	Hydro
Total	2852			
Fairfield	256	1978	Peak	Hydro-pumped storage
Fairfield	256	1979	Peak	Hydropumped storage
Canadys	8	1980	Base	Coal
Pan	-13	1980	Peak	No. 2 oil
Summer	600	1982	Base	Nuclear

[a] Available capacity dependent on flow of rivers.

Letter from Nichols (SCE&G) to Denton (NRC), December 31, 1980.

The applicant is committed to maintaining a reserve capacity equivalent to the greater of either 20% of the load responsibility or the capacity of the largest unit in the system. These are generally considered by the industry and regulatory groups[1] to be acceptable criteria for establishing reserve capacities. The power system generation reserve capacities with and without the Summer station in operation, determined from the load responsibility and planned system capacity (Tables 7.2 and 7.3), are shown in Table 7.4 for the years 1982 through 1985. By comparing the data in Table 7.4 with the reserve criteria, the staff finds that the Summer station will be needed to maintain minimum reliability conditions by 1985.

Table 7.4 Power system reserves for SCE&G with and without Summer station

Year	Reserves with Summer station		Reserves without Summer station	
	MWe	% of peak load	MWe	% of peak load
1982	1476	59.4	876	35.3
1983	1328	50.5	728	27.7
1984	1199	43.4	599	21.7
1985	1080	36.6	460	15.9

The projected load responsibility for SCPSA through 1985 is shown in Table 7.5. Compound annual load growth for the 1980-1985 period is projected at about 6% by SCPSA for the basic service area. This is below the growth rate of 8.8% per year since the Arab oil embargo and lower than the 12% per year from 1966 to 1973 (OL-ER, Table 1.1-12). An additional load of 360 MW for a new aluminum-smelting plant is added (in segments) to the base-load projections for 1980 and 1981. Considering the consistent growth pattern of load responsibility and the trend toward increased use of electricity by residential consumers, the staff believes that the SCPSA near-term load growth projections are not unreasonable.

Table 7.5 Projected load responsibility for SCPSA through 1985

Year	Load responsibility (MWe)	Annual Change (%)
1977[a]	1161	
1978[a]	1231	6.0
1979[a]	1352	9.8
1980[a]	1508	11.5
1981	1868	23.9
1982	1966	5.2
1983	2084	6.0
1984	2227	6.9
1985	2377	6.7

[a] Actual.

Note - A new aluminum production company began operation in late 1980 and accounts for the large growth rate in 1981 and part of the growth rate in 1980. Source: Letter from Nichols (SCE&G) to Denton (NRR), December 31, 1980.

To meet the projected load responsibility, SCPSA currently plans to operate the generating resources listed in Table 7.6. Determined from this resource planning (including purchases) and the projected load responsibility (Table 7.5), the system reserve capacities with and without the Summer station through 1985 are shown in Table 7.7. By the same 20% reserve criteria, SCPSA will need its share of the Summer unit in 1982.

Table 7.6 Existing capacity, additions, and retirements through 1985 for SCPSA

Unit	Capacity (MWe)	Year	Type of use	Type of fuel
Existing 1980	1152		Base	Coal
	170		Intermediate	Coal
	130		Intermediate (or base)	Hydro
	92		Peaking	No. 6 oil
	177		Peaking	No. 2 oil
Total	1721			
Winyah Unit 4	280	1981	Base	Coal
Summer	300	1982	Base	Nuclear
St. Stephen[a]	84	1983	Intermediate	Hydro
Cross Unit 2	450	1984	Base	Coal

[a] Owned by Corps of Engineers; dispatched by SCPSA.

Source: Letter from Nichols (SCE&G) to Denton (NRC), December 31, 1980.

Table 7.7 Power system reserves for SCE&G with and without Summer station

Includes 155 MWe of purchases

Year	Reserves with Summer station		Reserves without Summer station	
	MWe	% of peak load	MWe	% of peak load
1982	490	24.9	190	9.7
1983	456	21.9	156	7.5
1984	763	34.3	463	20.8
1985	613	25.8	313	13.2

However, if all other VACAR units planned for initial commercial operation in 1980 and 1981 were delayed beyond the summer of 1981, the regional reserve level during the 1981 summer peak-load period would be about 8.5%, which is not adequate.

Considering the recent history of delay in completion of base-load steam-electric generating stations, the staff believes it is prudent for SCE&G to complete the Summer station as scheduled to assure SCE&G and SCPSA system reliability in 1982.

7.3.3 Energy consumption

The projected annual energy requirements and growth rates for both utilities are shown in Table 7.8. A combination of extrapolation techniques, judgment based on experience, and econometric modeling are used by SCE&G to forecast its annual energy requirements. The econometric model (OL-ER, Sect. 1.1.1.2.2) is based on correlations of historic energy consumption with economic activity in the following three sectors defined by the U.S. Bureau of Economic Analysis (BEA):

1. finance, insurance, and real estate;
2. transportation, communication, and public utilities; and
3. professional services.

Table 7.8 Projected annual energy consumption through 1985 in service areas of SCE&G and SCPSA

Year	SCE&G Annual energy (10^9 kWhr)	SCE&G Annual change (%)	SCPSA Annual energy (10^9 kWhr)	SCPSA Annual change (%)
1977[a]	11.14		5.78	
1978[a]	11.62	4.2	6.25	8.1
1979[a,b]	11.25	(3.2)	6.59	5.4
1980[a]	11.79	5.0	7.84	19.0
1981[c]	11.49	(2.5)	10.28	31.1
1982	11.90	3.5	10.70	4.1
1983	12.62	6.1	11.22	4.9
1984	13.24	4.9	11.64	5.5
1985	13.91	5.1	12.50	5.6

[a] Actual consumption figures.

[b] Decrease in SCE&G 1979 energy consumption due to expiration of 75 MWe contract with Georgia Power Company

[c] Decrease in SCE&G 1981 energy consumption due to expiration of 74 MWe contract and abnormally high summer temperatures in 1980

Source: Letter from Nichols (SCE&G) to Denton (NRC), December 21, 1980.

Projections of future electricity consumption are made by applying BEA projections of economic activity in these sectors to the basic model and making adjustments for losses and expected future perturbations.

The projected compound annual growth rate of energy generated by SCE&G is about 3.4% from 1980 through 1985, compared with 7.7% for the period 1966 through 1977.

By combining historical trend extrapolation, forecasts from its wholesale customers (cooperatives and major users; i.e., those who purchase more than 83% of the system's generated energy; OL-ER, Sect. 1.1.1.2.3), new customer needs, and independent evaluation of economic growth in the service area, SCPSA develops its annual energy forecast. The projected compound annual growth rate generated by SCPSA for the system is about 9.8% between 1980 and 1985. However, because of the significant energy consumption of a new aluminum production company in the service area, the annual growth rate for the basic service area is significantly less.

The energy consumption growth rates projected by SCE&G and SCPSA are significantly higher than those determined in recent State-level analysis by Chern et al.[2] However, the staff believes the applicant's projections are reasonable for the next few years judging from the overall effects of the following factors:

1. the price of electricity,
2. the price and availability of natural gas,
3. the number of electric heating and air-conditioning customers, and
4. population and economic growth.

The price of electricity in the service area of the two utilities has been increasing slightly faster than the general inflation rate as reflected by the gross national product price deflator.[3] The increasing real price of electricity is expected to act as a depressant on growth of consumption.

The price of natural gas has also increased rapidly in the last few years. There have also been occasional actual, and/or expected, shortages in supply. These factors have fostered an increase in the number of current and new customers requesting service for electric heating and air conditioning. For example, SCE&G has observed an increase in all-electric heating customers from 16,700 in 1970 to more than 56,000 in 1977 (OL-ER, Table 1.1-14). Electricity was used for heating in about 7% of South

Carolina residential units in 1970,[4] and the staff finds that the current proportion of electrically heated homes exceeds 20%. Natural gas prices are expected to continue to increase more rapidly than the general inflation until its energy cost is equivalent to fuel oil and coal.

There is, determined from the 1969 population and the State projections for 1980 and 1990 (OL-ER, Table 1.1-21), an annual compound growth of population of 4.5% per year. This population growth, which is much greater than for the nation, will induce economic growth and demand for energy, particularly electricity. This population growth rate is also about 50% higher than the value used in the projections prepared by Chern et al.[2]

7.4 CONCLUSION

The staff concludes that timely operation of the nuclear unit will result in production cost savings through the reduction in consumption of the more expensive coal and oil fuel resources. The staff concludes that it is prudent for the utilities to operate the Summer station to ensure the reliability of their systems in 1982 (particularly SCPSA) and to maintain acceptable regional reserve levels in case other units under construction are delayed.

High state-wide population and economic growth in recent years, combined with an increasing proportion of energy use in the form of electricity, will result in a growth rate of electricity demand in South Carolina greater than that observed on the national scale. The staff finds that the Summer station will be useful in meeting the increased demand for electric energy.

REFERENCES FOR SECTION 7

1. 1972 Summer Load Power Supply Situation, Memorandum to the Commission from Chief, Bureau of Power, Federal Power Commission (now Federal Energy Regulatory Commission), Washington, D.C., Apr. 17, 1972.

2. W. S. Chern, R. E. Just, B. D. Holcomb, and H. D. Nguyen, Regional Econometric Model for Forecasting Electricity Demand by Sector and State, NUREG/CR-1295, July 1980, Oak Ridge National Laboratory, Oak Ridge, Tenn.*

3. Survey of Current Business, Bureau of Economic Analysis, U.S. Department of Commerce, 57(12) (December 1977); 58(3) (March 1978).

4. F. A. Heddleson, Fuels Used for Single Family Detached Residential Heating in the United States, Report ORNL/TM-4690, Oak Ridge National Laboratory, Oak Ridge, Tenn., March 1975.

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*Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and/or the National Technical Information Service, Springfield, VA 22161.

8. EVALUATION OF THE PROPOSED ACTION

8.1 INTRODUCTION

The staff has reassessed the physical, social, and economic impacts attributable to the Summer station. Because the plant is currently under construction, many of the predicted and expected adverse impacts of the construction phase are evident. None of these impacts has been significantly greater than predicted in the FES-CP, and none has significantly changed the benefit-cost balance determined during the construction permit stage. Also, no unexpected impacts have occurred that influenced the benefit-cost balance.

Operation of the station has been reassessed, with increased emphasis on impacts of impingement and entrainment on the aquatic biota of Monticello Reservoir. Changes in transmission line routing and new environmental protection laws regarding endangered and threatened species have necessitated new assessment of terrestrial impacts of station construction and operation. Although no impacts of operation are expected to significantly change the benefit-cost balance, ecological and physical monitoring data during operation, as outlined in Sect. 5, are needed for verification. The applicant is required to submit this information in fulfilling the requirements set forth in its NPDES permit (Appendix C). The specific studies required to comply with the NPDES permit are detailed in Appendix F.

8.2 ADVERSE EFFECTS THAT CANNOT BE AVOIDED

8.2.1 On land

In Sects. 2.2 and 4.4, it was stated that plant operations would result in the conversion of some forested and agricultural land for use primarily for the generating station, substations, and transmission lines. This loss of forest and agricultural resources can be considered an adverse impact, although the amount to be taken is a small fraction (0.1%) of the total forest and agricultural resources of the affected counties in this predominantly rural region.

8.2.2 On surface waters

The discharge of treated chemical and sanitary wastes from operation of the Summer station (Sect. 3.2.6) to Monticello Reservoir and subsequently to the Parr Reservoir and Broad River is expected to have no measurable adverse effects on these water bodies.

The discharge of waste heat will result in an acceptable increase in the temperature of Monticello Reservoir (Sect. 4.3.3). The temperature of the water discharged through the Fairfield pumped storage facility will satisfy the limitations imposed by the NPDES permit (Sect. 3.2.4).

8.2.3 On groundwater

Because the discharge of treated chemical and sanitary wastes is expected to have only minimal adverse impact on surface waters, infiltration of water from Monticello Reservoir into the groundwater system will likewise be expected to have minimal adverse effects.

8.2.4 On air

The quantity of nonradioactive gaseous effluents released during operation will be small and insignificant in effect. Because the plant will use once-through cooling and have no cooling towers, the heat dissipation system will cause only minor increases in evaporation and will have no significant impacts on air.

8.2.5 Terrestrial ecology

Terrestrial biotic impacts of Summer station operation are expected to be insignificant and immeasurable.

8.2.6 Aquatic ecology

The unavoidable adverse effects on the regional aquatic ecology because of Summer operation are identifiable but are not easily quantified. Operation of the Summer facility may adversely affect the fish population in Monticello by impingement of adults, entrainment of larvae, and perhaps thermal shock in and near the discharge canal area. The absence of baseline data for the Monticello Reservoir environment and the additional perturbations from nearby Fairfield operation preclude the quantification of these unavoidable impacts. It is the staff's opinion that the adverse environmental effects of Summer operation will not be unduly severe and, in particular, will be small compared to those expected from Fairfield operation.

8.2.7 Radiological

Releases of radioactive materials to the environment for normal operation will occur in small quantities and are not expected to have any measurable effects.

8.3 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

8.3.1 Scope

The National Environmental Policy Act requires the staff to consider specifically the long-term consequences to biological productivity of building and operating the Summer station and of alternative short-term uses of man's environment. In this context, short-term is the period of construction and operation, and long-term is the period beyond the service life of the facility. In the case of nuclear power facilities, there may be strong economic pressures to continue to use the chosen site (or adjacent ones) for power generation for several facility lifetimes. In this event, the long-term effects on productivity will increase but not to a significant level when compared to the regional biological productivity.

8.3.2 Short-term uses and productivity

Electricity generation for which the site is needed, possibly on a short-term basis, is described in Sect. 7. Before construction most of the site and transmission corridors was wooded, and in the short-term, the forest products from these areas will be unavailable to man. Agricultural land in the transmission corridors will for the most part continue in agricultural use. Although the trees will be removed from the transmission corridors, this area can still remain biologically productive through growth of grasses, shrubs, and other vegetation and thus provide habitat and feeding areas for fauna. The staff does not believe there will be any serious impacts on short-term productivity or use of the heavily forested area of the proposed power station.

8.3.3 Long-term productivity

The potential exists that the plant structures will not be dismantled until sometime after operation ceases. In this case the Summer station will directly affect the long-term productivity of the forested environment. About 81 ha (200 acres) will be affected on a long-term basis. However, the remaining portion of the area cleared for plant use will be landscaped or allowed to revert to natural vegetation.

8.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

8.4.1 Scope

Irreversible commitments generally concern changes set in motion by the proposed action that, at some later time, could not be altered to restore the present order of environmental resources. Irretrievable commitments are generally the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization. The detailed discussions of the impacts are in Sect. 4.

8.4.2 Commitments considered

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

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

8.4.3 Biotic resources

8.4.3.1 Terrestrial

About 81 ha (200 acres) of the site have been removed from natural biological productivity and will remain so for the life of the station. However, only that part of the site not recovered when the plant is dismantled, as determined by the eventual decommissioning method, can be considered a permanent loss, and this is expected to be only a small portion of the land now in use. Virtually none of the area affected by the transmission corridors is considered irreversibly lost to biotic productivity.

8.4.3.2 Aquatic

Operation of the Summer station will result in a small increase in the biotic impact caused by the existing pumped storage facility. However, no irreversible impacts should occur.

8.4.4 Materials of construction

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

Some materials are of such value that economics clearly promote recycling. Facility operation will contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed to reclaim and recycle the constituents. Some parts of the facility will become radioactive by neutron activation. Radiation shielding around the reactor and around other components inside the primary neutron shield constitutes the major material in this category, for which it is not feasible to separate the activation products from the base materials. Components that come in contact with reactor coolant or with radioactive wastes will sustain variable degrees of surface contamination, some of which would be removed if recycling is desired. The quantities of materials that could not be decontaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry.

Many materials on the "List of Strategic and Critical Materials"[1] (e.g., aluminum, asbestos, beryllium, cadmium, lead, nickel, platinum, silver, tin, tungstun, and zinc) are used in nuclear facilities. Construction materials are generally expected to remain in use for the full life of the facility, in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend on need.

8.4.5 Uranium fuel and its availability

Department of Energy resource estimates indicate that sufficient uranium resources exist in the United States to fuel all operating reactors, reactors under construction, and reactors being planned for their full 30-year lifetimes at a U_3O_8 cost (1978 dollars) of $30/lb or less. These quantities of uranium can be supplied from the resource categories designated as "reserves" and "probable potential," the two most certain resource categories.[2]

8.4.6 Other replaceable components and consumable materials

Other materials consumed, for practical purposes, are fuel-cladding materials, reactor-control elements, other replaceable reactor core components, chemicals used in processes such as water treatment and ion-exchanger regeneration, ion-exchange resins, and minor quantities of materials used in maintenance and operation.

The consumed resource materials have widespread usage. However, their use in the proposed operation is expected to be reasonable with respect to needs in other industries.

8.4.7 Water and air resources

A maximum of about 0.37 m^3/sec (13 cfs) of water will be lost from the Summer station through evaporation. However, the use of the water can be viewed as an irreversible loss only in the same sense that natural evaporation from water bodies is an irreversible loss. The staff does not believe that such usage will have a long-term effect.

Operation of the Summer station will have little affect on air resources beyond the minimal impact caused by various equipment emissions.

8.4.8 Land resources

The staff's assessment of this impact has essentially not changed since the earlier review, except for a decrease of about 9 ha (22 acres) of transmission line corridors. Land is not necessarily irreversibly and irretrievably committed in the long term because most or all of it could be used for other purposes in the future. On the site, land not committed to buildings, the switchyard, and other facilities will be landscaped or covered with vegetation. Although the applicant will probably continue to use the land for an extended period for electric power production, with adequate effort at some future time the land could be restored for other useful purposes.

8.5 ALTERNATIVES TO THE PROPOSED ACTION

8.5.1 Résumé

During the construction-permit (CP) review stage, the staff analyzed alternative sites, plant designs, and methods of power generation, including the alternative of not adding production capacity. The staff concluded, based on its analysis of these alternatives, as well as on a cost-benefit analysis, that additional capacity was needed, that a nuclear-fueled plant would be an environmentally acceptable means of providing the capacity, and that the Summer Station at a specified site and of a specified design, was acceptable from both economic and environmental perspectives. Since that time, construction of Summer Station has been nearly completed; and many of the economic and environmental costs associated with the construction of the station have already been incurred and must be viewed as "sunk costs" in any prospective assessment.

8.5.2 Alternatives

The staff believes the only reasonable alternative to the proposed action of granting an operating license for Summer Station available for consideration at the operating license stage is denying the license for operation of the facility and thereby not permitting the constructed nuclear facility to be added to the applicant's generating system. Alternatives such as construction at alternative sites, extensive station modification, or construction of facilities utilizing different energy sources would each require additional construction activity with its accompanying economic and environmental costs, whereas operation of the already constructed plant would not create these costs. Therefore, unless the major safety or environmental concerns resulting from operating the plant are revealed that were not evident and considered during the CP review, these alternatives are unreasonable as compared to operating the already constructed plant. No such concerns have been revealed with regard to operation of the Summer Station.

With respect to the proposed action of operating the facility, it was shown in Section 7 that the addition of Summer Station to the SCE&G and SCPSA systems is expected to result in savings in the system production costs of about $90 million per year. Further, operation of this unit will provide diversity of fuel sources, thereby decreasing dependence on oil, and coal, and will contribute to increased system reliability. The environmental impacts of operation are reassessed in Section 4 of this statement. As discussed in Section 9 as a result of this reassessment, the staff has been able to forecast more accurately the effects of operation of Summer Station and has determined that the station will operate with acceptable environmental impacts.

The alternative of not operating the facility will require the utilities to substitute approximately 4.73 billion kWh per year of electrical energy that would have been provided by SCE&G and SCPSA with other sources of energy which have a greater economic cost and have an equal or greater environmental cost. As indicated above, the additional economic cost has been estimated at approximately $90 million per year.

After weighing the above described options, the staff concludes the preferable choice is operation of the Summer Station.

REFERENCES FOR SECTION 8

1. G. A. Lincoln, "List of Strategic and Critical Materials," Fed. Regist. 37(39): 4123 (1972).

2. D. L. Hetland, Potential Uranium Resources, Resources Division, Grand Junction Office, U.S. Department of Energy, October 1978.

9. BENEFIT-COST SUMMARY

9.1 INTRODUCTION

There has been relatively little change in the benefits and costs (excluding effects of inflation) of operation of the Virgil C. Summer Nuclear Station since issuance of the FES-CP in 1973. In the preceding sections of this statement the staff has provided reassessments of the terrestrial, aquatic, social, and radiological impacts, incorporating updated information and improved methods of analysis. The staff has also reappraised the benefits of the additional generating capacity in meeting the power demands in South Carolina and in supplying an economic substitute for the fuel oil used in existing power plants.

The results of these assessments are summarized in the following sections and are displayed in Table 9.1.

9.2 BENEFITS

The primary benefits to be derived from operation of the Summer Station include about 4.73 billion kWh of baseload electrical energy that the station will be able to produce annually (assuming an average 60% capacity factor) and improve reliability of the SCE&G and SCPSA systems brought about by the addition of 900 MWe of generating capacity to the system, as well as the saving of about $90 million in production costs per year. Finally, the operation of the Summer Station will increase the diversity of fuel supply of the SCE&G and SCPSA systems by providing baseload generating capacity using a fuel type other than coal and oil presently used by their systems (Sec. 7).

An important consideration for the local area are the property taxes that will be paid to Fairfield County. The annual payments related to the nuclear station and its transmission lines will be about three times the county property tax revenue in 1976 (before operation) or more than one-half of all county revenues in 1976 (Table 4.20). However, these local economic benefits are not used in the benefit-cost balancing because they are actually transfer payments from those paying for the electricity produced (the price of which is adjusted to recover taxes) to those people residing near the facility.

Operation of the Summer station will also result in a small but stable number of high-paying jobs for area residents.

9.3 ECONOMIC COSTS

If a 5% per year escalation rate and a 10% discount rate are assumed and the 1981 estimates of production costs cited in Sect. 7.3.1 are used in the calculations, the 30-year levelized production costs for the Summer station at 60% plant factor are as follows: fuel costs – $50.3 million per year; operating and maintenance costs – $15.1 million per year. The generation cost related to decommissioning by removal of the facility at the end of a 30-year life is about 0.18 mills/kWhr at 60% plant factor (Sect. 4.9). This is equivalent to about $850,000 per year.

9.4 ENVIRONMENTAL COSTS

The current assessment of environmental costs associated with operation of the Summer station is generally similar to that presented in the FES-CP. The major cost in land use is the lifetime loss of about 2×10^7 bd ft of forest production on 896 ha (2217 acres) of the plant site and transmission line corridors (Sect. 4.2). The thermal and chemical effluents from the station are not expected to have a deleterious impact on the water resources, Monticello and Parr reservoirs, or on man's use of the reservoirs (Sect. 4.3).

Environmental costs related to terrestrial biota consist primarily of periodic destruction of animal habitat (nests, dens, and food) and of proposed threatened or endangered plant species, if proposed corridor maintenance procedures are used (Sect. 4.4.1). In the context of the regional environment, the wildlife losses are not considered significant. If necessary, mitigating measures to avoid destruction of the plant species will be required (Sect. 5.2.4.2).

There will be a small, but insignificant, environmental cost in the fish mortality that will result from the high-temperature plumes to occur in Monticello Reservoir during summer months. Impingement and entrainment losses at the Summer station are, however, expected to be overshadowed by losses from operation of the pumped storage facility. Thermal effluents of the Summer station are not expected to have an adverse effect on biota in Parr Reservoir or the downstream rivers (Sect. 4.4.2).

Radiological effluents during normal plant operation are not expected to cause a measurable adverse impact on human and biotic populations (Sect. 4.5). The environmental risk from accidental radiation exposure is very low (Sect. 6).

9.5 SOCIAL COSTS

If public services are improved and/or tax rates are lowered in Fairfield County as a result of its greatly expanded tax base, rapid, unplanned growth may occur there. This could bring a costly demand for additional public services in scattered areas throughout the county and could degrade the existing quality of life through conflicts between incompatible land uses. These consequences are not inevitable, however, and can be largely averted through adequate advance planning by the county officials.

9.6 ENVIRONMENTAL COSTS OF THE URANIUM FUEL CYCLE AND TRANSPORTATION

The staff evaluated the environmental impacts of the uranium fuel cycle as given in Table 4.20. The staff finds that these fuel cycle impacts are sufficiently small so that, when added to the other environmental impacts predicted for the proposed project, they do not alter the overall benefit-cost balance.

9.7 SUMMARY OF BENEFIT-COST

As the result of this second review of potential environmental, economic, and social impacts, the staff has been able to provide additional insight into the effects of plant operation. No unique and/or significant environmental impact of operation has, however, been identified by the staff in this assessment. Consequently, the staff concludes that the environmental and social costs of plant operation are acceptable, and the total costs (including economic) are outweighed by the benefits of added capacity, energy produced, potential production cost savings, and increased reliability.

Table 9.1 Benefit-cost summary

Primary impact and population or resource affected	Magnitude of impact
	Direct benefits
Energy, kWhr	4.73×10^9 (60% plant factor)
Capacity, MWe	900
	Indirect benefits
Taxes paid by SCE&G,$/year	
Local - Fairfield County	
1981	3,220,379[a]
1986	4,545,261
State	4,000,000
Federal	10,000,000
Employment	
Plant operation jobs	213
Community support jobs	149
	Economic cost
Operating cost, 30-year levelized (1980),$/year	
Fuel (60% plant factor)	50,300,000
Operation and maintenance	15,100,000
Decommissioning	850,000
	Environmental cost
Impacts on land use	
Forest (site and transmission rights-of-way)	
Land, ha (acres)	896 (2217)
Pulp and lumber production lost, bd ft	2×10^7 lifetime loss
Pasture and cropland,[b] ha (acres)	161 (399)
Impacts on terrestrial biota	Not significant in region, but possible impacts on endangered or threatened plant species
Impacts on water use	
Consumption, m^3/sec(cfs)	0.37 (13)
Heat discharged to Monticello reservoir, Btu/hr	6.67×10^9
Chemicals and sanitary waste discharged to Monticello reservoir	
People	Negligible
Aquatic biota	Negligible
Water quality	Negligible
Groundwater	
Chemical and sanitary waste	Negligible
Change in groundwater levels	Negligible
Effects on aquatic biota	
Thermal	Small, not significant
Impingement and entrainment	Small compared with losses from operation of pumped storage facility
Impacts on air	
Operation of auxiliary boiler during startup and shutdown and emergency diesel	Negligible
Radiological impact on population	
Normal Operation (year 2000)	
Plant workers	410 person-rem/yr (average); 1300 person-rem/yr
General public	36 person-rem/yr
Accidents	
Within 80 km (50 miles)	24 person-rem/yr
Total	130 person-rem/yr
Transportation	7 person-rem/yr

[a] All manufacturing facilities in South Carolina are exempt from nonschool property taxes for the first five years of operation.

[b] Because this land area is on transmission line rights-of-way, farming activity during line operation.

10. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

10.1 BACKGROUND

Pursuant to 10 CFR 51.25 the Draft Environmental Statement (DES) for operation of the Virgil C. Summer Nuclear Station was transmitted with a request for comments to:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Energy
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Environmental Protection Agency
South Carolina Department of Health and Environmental Control
South Carolina Water Resource Commission
South Carolina Public Service Commission
South Carolina Wildlife and Marine Resources Department
Fairfield County Administrator, Winnsboro, South Carolina

In addition, the NRC requested comments on the DES from interested persons by a notice published in the Federal Register on July 10, 1979 (44 FR 40460). Comments in response to the requests referred to above were received from:

Department of the Army, Corps of Engineers (COE)
South Carolina Electric and Gas Company (SCEG)
William A. Lochstet (WAL)
South Carolina Department of Health and Environmental Control (SCDHEC)
Environmental Protection Agency (EPA)
Department of the Interior (DOI)

Additionally, a supplement to the DES was transmitted with a request for comments to:

Advisory Council on Historic Preservation
Department of Agriculture
Department of the Army, Corps of Engineers
Department of Commerce
Department of Education
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Interior
Deparment of Transportation
Environmental Protection Agency
Federal Emergency Management Agency
Rural Electrification Administration
South Carolina Department of Health and Environmental Control
South Carolina Water Resource Commission
South Carolina Public Service Commission
South Carolina Wildlife and Marine Resources Department
Fairfield County Administrator, Winnsboro, South Carolina

The NRC requested comments on the DES supplement from interested persons by a notice published in the Federal Register on November 14, 1980 (45 FR 75399). Comments were received (within the extended 60-day comment period) from:

Advisory Committee on Reactor Safeguards (ACRS)
Anna Wasserbach (AW)
Council on Environmental Quality (CEQ)
Department of Commerce (DOC)
Federal Energy Regulatory Commission (FERC)

Department of the Interior (DOI)
Environmental Protection Agency (EPA and Mills)
South Carolina Electric and Gas Company (SCEG)
Washington Public Power Supply System (WPPSS)

The staff consideration of comments received and disposition of the issues involved is reflected in part by text revisions in other sections of the Final Environmental Statement (FES) and in part by the following discussion which will reference the comments by use of the abbreviations indicated above. As noted earlier, all comments received are included in Appendix A of this statement. The pages in Appendix A on which copies of the respective comments appear are indicated by each subject title relating to the comment.

10.2 THE SITE

10.2.1 Omission of geology discussion from DES (DOI, A-25)

This environmental statement relates to the operation of the Summer plant and its purpose is to update information relating to plant operation which was presented in the environmental statement issued at the construction permit stage. Site geology as it relates to plant safety is discussed in Section 2.5 of the Safety Evaluation Report (NUREG-0717).

10.3 THE STATION

10.3.1 Sanitary waste water treatment (EPA, A-23)

The applicant notified NRC by letter of October 12, 1979 that "the value given for the concentration of suspended solids (40 mg/l) is incorrect and should read 30 mg/l" and will be corrected with the next amendment to the operating license environmental report for the V. C. Summer Nuclear Station. The text in this statement (Section 3.2.6.7) has been changed to reflect this new information.

10.4 ENVIRONMENTAL EFFECTS OF STATION OPERATION

10.4.1 Health consequences of radon-222 are improperly evaluated (WAL, A-8)

Dr. Lochstet's basic contention is that "the health consequences of radon-222 emissions from the uranium fuel cycle are improperly evaluated" in the Summer Draft Environmental Statement (DES, NUREG-0534). The basis for Dr. Lochstet's contention is that the NRC staff has arbitrarily evaluated the health impacts of radon-222 releases from the wastes generated in the fuel cycle for 1000 years or less, rather than for "the entire toxic life of the wastes." Dr. Lochstet then estimates that radon-222 emissions from the wastes from each annual reactor fuel requirement will cause about 600,000 to 12 million deaths over time periods of more than one billion years.

The major difference between the NRC staff's estimated number of health effects from radon-222 emissions and Dr. Lochstet's estimated values is the issue of the time period over which dose commitments and health effects from long-lived radioactive effluents should be evaluated. Dr. Lochstet has integrated dose commitments and health effects over what amounts to be an infinite time interval, whereas the NRC staff has integrated dose commitments from radon-222 releases over a 100-year period, a 500-year period and a 1000-year period.

The NRC staff has not estimated health effects from radon-222 emissions beyond 1000 years for the following reasons. Predictions over time periods greater than even 100 years are subject to great uncertainites. These uncertainties result from, but are not limited to, political and social considerations, population size and health characterisitcs, and, for time periods on the order of thousands of years, geologic and climatologic effects. In contrast to Dr. Lochstet's conclusion, some authors estimate that the long-term (thousands of years) impacts from the uranium used in reactors will be less than the long-term impacts from an equivalent amount of uranium left undisturbed in the ground. For example, see B. L. Cohen, "Radon: Characteristics, Natural Occurrence, Technological Enhancement and Health Effects," Progress in Nuclear Energy, Vol. 4, 1979, pp 1-24. Consequently, the NRC staff limits its time periods of consideration to 1,000 years or less for decision-making and impact-calculational purposes.

10.4.2 Impacts of plant operation on wetlands (EPA, A-23)

Impacts of station operation upon the Monticello Reservoir and the Broad River are described elsewhere (Sections 2.5.2 and 4.4.2). Impacts of station operation upon other wetlands will encompass, at most, possible effects of transmission corridor maintenance near streams. Because SCE&G maintains rights-of-way near wetlands by hand clearing (Section 4.4.1.2, paragraph 4), the staff expected no detectable impacts.

10.4.3 Suggestion of buffer zone at transmission line stream crossing (EPA, A-23)

The suggestions for transmission line construction (spanning streams, non-disturbance of streamside vegetation) are cogent to the construction of the nuclear station, but the staff did not consider them within the confines of this present statement on operation impacts. EPA comments on the construction of the station were considered in the Virgil C. Summer Nuclear Station Unit 1 FES, January 1973.

10.4.4 Terrestrial survey of transmission lines and site to identify endangered or threatened species (SCEG, A-2, DOI, A-25)

The staff agrees with the comment of D. A. Rayner regarding the two federally listed endangered plant species (letter to M. B. Whitaker, Jr., SCE&G, from D. A. Rayner, South Carolina Heritage Program, October 21, 1980). Since publication of the Summer DES, Isotria medeoloides has been proposed for inclusion on the federal list of Threatened and Endangered Species (45 FR 82484, December 15, 1980). From the staff's information on critical habitat requirements for this species, there appears little probability that the Summer transmission rights-of-way, presently cleared of wooded forest habitat, would contain suitable conditions for this species.

On December 15, 1980, the Fish and Wildlife Service published a notice of review for plant taxa (45 FR 82479). This notice contained lists of plant taxa including Myriophyllum laxum which are being considered for listing as endangered or threatened. The service recommends that these plant taxa should be considered in environmental planning but that publication of proposed and final rules allowing inclusion of these taxa on the federal list has not occurred. Myriophyllum laxum is not known to occur on site or in the vicinity.

The staff has discussed and reviewed the DES requirements (Sections 5.2.4.2 and 5.3.4.2 of the Summer DES) with Dr. Rayner and the applicant. The applicant has provided additional information concerning the use of mowing, hand clearing, and herbicide uses along their transmission rights-of-way (letter to H. R. Denton, Director, Office of Nuclear Reactor Regulation, USNRC, from T. C. Nichols, Jr., Vice President, South Carolina Electric and Gas Company, March 24, 1981). Based upon its review of the current status of plant taxa contained in Section 5.2.4.2 of the DES and discussions with Dr. Rayner and the applicant, the staff, as part of its environmental considerations, has concluded that the added economic costs and greater potential erosion impacts associated with mowing and hand clearing the difficult terrain along the Summer transmission system do not justify restricting the use of herbicides. Therefore, Sections 2.5.1.1, 4.4.1.2, 5.2.4.2, 5.3.4.2, 8.2.5, and the summary and conclusions have been modified to reflect these conclusions.

10.4.5 Fish and wildlife resources (DOI, A-25)

The staff concurs with the DOI's concern that pumped storage operation will be the major impact on the fishery resources in the project vicinity. The recreational impoundment is presently being stocked and managed to maximize the recreational fishery. Additionally, the main body of Monticello is experiencing post-impoundment high productivity and is supporting a large recreational fishery.

New data have been received from the applicant subsequent to the DES and have been incorporated into the FES.

The staff is not overly concerned about phytoplankton and/or zooplankton entrainment at the station due to high reproductive rates of these biotic groups. Icthyoplankton losses are of greater concern. Preliminary data (referenced in the FES, 4.4.2.4) indicate that sampled icthyoplankton densities were lower by 50% in the vicinity of the water intake than other sampled areas of Monticello. These data suggest that entrainment losses will be within the lower portion of the range given in the DES. The need to consider relocating the water intake (should operational impingement or entrainment losses be unacceptably high) has been added to the FES.

10.4.6 Thermal and dissolved oxygen stratification and station operation in Monticello Reservoir (DOI, A-25)

The staff believes that the discussion in this section adequately addresses the thermal stratification issue. Dissolved oxygen stratification will probably not be a problem as pumped storage operation will flush Monticello Reservoir with riverine water approximately every 15 days. Preliminary preoperational data reviewed subsequent to the DES (referenced in the FES, Sect. 2.5.2.2) indicates that dissolved oxygen levels in Monticello are high, even at depth in the summer, probably due to the flushing action of the adjacent pumped-storage facility.

10.4.7 Effects of discharge on phytoplankton (DOI, A-25)

The only sewage discharge into Monticello will be from the nuclear facility. It will be treated as described in Section 3.2.6.7. It is anticipated that the limited sewage source, limited area affected by the thermal plume, and the quick (15 day) flushing rate with a riverine system (the Broad River) induced by pumped-storage operation will reduce the probability of propagation of large concentrations of undesirable phytoplankton.

10.5 ENVIRONMENTAL MONITORING

10.5.1 Rejection of staff recommendation of monthly fish sampling (SCEG, A-2 and SCDHEC, A-20)

Subsequent to the issuance of these comments at the staff's request, a meeting was held between the SCDHEC, the staff (NRC and ORNL), and the applicant on November 15, 1979, in Columbia (Appendix H). At that meeting, the staff stated that its primary concern was that infrequent sampling combined with natural sample variance could confound statistical interpretation of the results. The SCDHEC agreed to meet with the applicant's consultant to discuss the addition of two sampling efforts at two existing stations to better estimate fish standing crops (Appendix H).

10.5.2 Rejection of staff recommendation of weekly impingement monitoring (SCEG, A-2 and SCDHEC, A-20)

The NRC staff met with the applicant and the SCDHEC on November 15, 1979, in Columbia, S.C. A state fisheries biologist indicated that past experience in this region has shown that bi-weekly (twice monthly) impingement sampling would be an adequate monitoring effort (Appendix H). The staff agreed with this conclusion.

10.5.3 Rejection of staff recommendation that impingement monitoring begin before commercial operation (SCDHEC, A-20)

The staff met with the SCDHEC and the applicant subsequent to this comment (Appendix H). At that time an agreement was made that impingement monitoring would commence at the time the station reaches commercial operation (Appendix H).

10.5.4 Preoperational thermal monitoring of Monticello Reservoir (SCEG, A-2 and SCDHEC, A-20)

The staff suggested a standard statistical data analysis method which, based on the staff's experience with similar cases, is consistent with the state's thermal standards. Such a regression analysis is routinely included in the basic programs library provided by computer vendors. A similar analysis was performed during an evaluation of the environmental technical specifications for the Peach Bottom Atomic Power Station.[1] The physical mechanisms controlling the thermal structure of the impoundment for Peach Bottom are quite similar to those for Monticello Reservoir. Monthly-averaged upstream/downstream temperature differences were computed for both a preoperational and operational period. The analysis showed that it is quite difficult, if not impossible, to segregate temperature variations resulting from station operation from those resulting from natural variations. (It is expected that a similar situation exists in Monticello Reservoir.[2]) To deal with this, a monthly station by station quadratic regression analysis was performed on the preoperational thermal monitoring data. The object of this analysis was to determine the coefficients A, B, C in the formula $T = AT_c^2 + BT_c + C$ which is used to predict an ambient temperature T at some monitoring station based on the observed temperature T_c at the control station. The procedure was performed for two separate candidate control stations in order to identify the most suitable control station location. Having developed a statistically significant method for inferring ambient temperature, monthly-averaged excess temperatures at each station were determined.

While this data analysis method was suggested by the staff for Virgil C. Summer Nuclear Station, the practical method suggested by the applicant and approved by SCDHEC is acceptable.

10.5.5 Staff recommendation of alternative method for biomass determination (SCEG, A-2, and SCDHEC, A-20)

The applicant and SCDHEC both concur with the recommendation that phytoplankton biomass determinations be made using pheophyton corrected chlorophyll measurements.

10.5.6 Staff recommendation of monthly ichthyoplankton samples during October, November, December, and January (SCEG, A-2 and SCDHEC, A-20)

The SCDHEC indicates that the NPDES permit will be modified to include monthly ichthyoplankton monitoring during the period October through January.

10.5.7 Staff recommendation for rotenoning neutralization (SCEG, A-2 and SCDHEC, A-20)

The applicant and SCDHEC both indicated that neutralization by the applicant of an appropriate oxidizing agent to avoid unintentional fish mortalities is standard procedure during sampling.

10.5.8 Aquatic hydrophyte monitoring program (DOI, A-25)

A hydrophyte monitoring program is required by the Thermal Effects Study Plan (Appendix F).

10.6. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

10.6.1 Adequate emergency response preparations (EPA, A-61)

The NRC must receive a favorable finding from the Federal Emergency Management Agency (FEMA) regarding the State's emergency response plan prior to issuing an operating license for the plant. The NRC staff is responsible for reviewing and determining the adequacy of the applicant's emergency plans. For a discussion of emergency planning, refer to Section 13.3 of the Safety Evaluation Report for Summer Nuclear Plant (NUREG-0717).

10.6.2 Health effects (WPPSS, A-66, SCEG A-64, and AW A-32)

This section has been modified in the FES to include a discussion of the susceptibility of fetuses (in utero) to the development of latent cancers.

The staff agrees that the health experts still claim they do not know precisely how much low-level radiation is harmless to human health. The key word is "precisely." No one knows now and no one ever will know the impacts of radiation at dose rates on the order of 100 millirem per year or less. The average American receives on the order of 200 millirem per year from natural background radiation, medical, and dental X-rays, consumer products, aircraft flights, technologically enhanced natural radioactivity, and fallout from nuclear weapons testing. Variation in natural background alone are commonly in the range of 20 to 50 millirem per year, and people are exposed to thousands of millirems over their lifetimes from these sources. As a result, it will never be possible to observe the effects of small additional radiation doses (e.g., the average dose to the 50-mile population at TMI was about 1.5 millirem, and normal operation of the Summer plant would contribute much less than 1 millirem per year to nearby populations. As a result, the NRC staff, and other responsible scientists, assume that there is always some risk of cancer and genetic effects regardless of how small the dose may be, even though the latest estimates of the National Academy of Sciences Committee on the Biological Effects of Ionizing Radiation (BEIR III, 1980) concluded the data do not exclude the possibility that the risks at doses on the order of 100 millirem per year or less may be zero.

The NRC, jointly with EPA, has prepared a report on "The Feasibility of Epidemiologic Investigations of the Health Effects of Low-Level Ionizing Radiation" (December 1980) to Congress as required by Public Laws 95-601 and 96-295. The investigations were prepared by the Health Systems Division of Equifax Inc., an independent, private concern specializing in health program monitoring, occupational health studies, and evaluations of health care delivery models. The studies were monitored by the Interagency Scientific Review Group, composed of representatives of the NRC, EPA, and Human and Health Services (formerly HEW). The investigation, which began shortly after the TMI accident, considered the feasibility of a long-term epidemiological study of the general population around TMI and concluded such a study would be an effort in futility for the same reasons presented above.

10.6.3 Accident experience and observed impacts ACRS, A-29)

The paragraph summarizing the Windscale accident was included primarily because it was unique with respect to environmental impact rather than being indicative "of the considerable experience available from the operation of reactors not licensed by the NRC."

10.6.4 Design features (ACRS A-29 and SCEG A-64)

This section has been modified in the FES to incorporate the comment that all such features have some probability of failure.

10.6.5 Accident risk and impact assessment (ACRS A-29)

This section of the FES has been modified to reflect consequence and risk reduction benefits that can reasonably be expected to reflect the implementation of the Commission's requirements for emergency preparedness. An appendix has also been added that describes the evacuation model employed for the calculations. This is believed to be an improved version over that which was used in the Reactor Safety Study. The results of research efforts to improve the consequence model (CRAC Code) are being assimilated and used as they become available.

- Mills A-59; EPA A-61

In the original DES the discussion of impacts of normal operational releases assumes that such releases have essentially unit probability of occurrence. By contrast, accidental releases have less than unit probability of occurrence. The staff believes that the potential magnitude of consequences has not been "glossed over" and that the distinction among probabilities of occurrence, impacts, and risk has been preserved.

- CEQ A-33

The staff believes that the general discussion of the potential impacts of serious accidents in human health and the environment that is given in Sections 6.1.1 and 6.1.2 should be readily understood by the public. The treatment of risk and impact given in Section 6.1.4 is in conformance with the Commission's Statement of Interim Policy in that the probabilities of occurrence of accidents and the probabilities of the consequences of accidents are given approximately equal attention. The staff has attempted to present this discussion in a clear and understandable manner and welcomes specific suggestions as to how it might be made clearer. The staff's response to an EPA comment (see Section 10.6.8 below) is an effort in this direction.

The number of specific accident sequences that is included in the probabilistic treatment is very large. The staff believes that it would not serve either public understanding or the decision process to enlarge the discussion in this statement to include complete descriptions of these sequences. They have been identified and described in the Reactor Safety Study, WASH-1400.

The magnitude of uncertainty in the probabilistic assessments is discussed in the text. The staff believes that the inclusion of error bands on the referenced figures would tend to misrepresent the state of knowledge regarding the magnitude of uncertainty and would serve no useful purpose in these discussions.

10.6.6 Design basis accidents (WPPSS A-66)

It is the staff's judgment that the health effects attributable to a population exposure of 200 person-rem are exceedingly small. The sentence has been revised in the FES, however, to avoid a misunderstanding based upon use of the term "design basis accidents."

10.6.7 Probabilistic assessment of severe accidents (WPPSS A-66)

The consequence model used was structured to account for 100% of the radioactive material released in an accident, even if a small fraction of it could be carried in the atmosphere beyond 50 miles. The relative importance of the environmental parameters beyond 50 miles is clearly shown in the probability distribution Figures 6.3 and 6.5 for population exposures and latent cancer fatalities. Although not stated in the text, the calculations also use the average U.S. population density for all regions beyond 350 miles.

- ACRS A-29

The text in the FES has been modified to include a discussion of natural phenomena and sabotage as potential causes of accidents.

10.6.8 Dose and health impacts of atmospheric releases (EPA A-61 and DOC A-25)

New Figures 6.8 and 6.9 have been added in the FES to provide a representation of the risk to individuals at various distances and directions from the plant site. Wind rise data for 16 compass sectors are incorporated in the consequences calculations.

10.6.9 Economic and societal impacts (WPPSS A-66)

The considerations employed to derive the economic costs in Figure 6.6 are described in the reference provided, "Overview of the Reactor Safety Study Consequence Model," NUREG-0340, October 1977.

10.6.10 Summary of environmental impacts and probabilities (EPA A-61)

Nine tables similar to Table 6.4 could have been displayed to show the impact contributions from each of the nine release categories. The staff judgment, however, is that the summary table, reflecting the sums of the contributions from all of the release categories, is sufficient. Information regarding the relative contributions of the release categories is available in the Reactor Safety Study, WASH-1400.

10.6.11 Releases to Groundwater (ACRS A-29)

The development of better methods for estimating the impact of releases via the liquid pathway is included within the scope of the NRC staff's TMI Action Plan, NUREG-0660, Item III.D.2.3.

- EPA A-61

It is the staff's judgment that if a core melt accident were to occur, interdiction of groundwater pathways would be employed to assure that no groundwater users would be impacted and that no surface water contamination would result. The cost of interdiction, while not explicitly analyzed, is judged to be within the uncertainty associated with the estimate of potential decontamination costs discussed in Section 6.1.4.6.

- EPA A-61; WPPSS A-66

The scope of the staff's assessment of the liquid pathway was limited to a determination as to whether the Summer site represented a unique or special circumstance outside the range of a "typical" river site as analyzed in the Liquid Pathway Generic Study. Since the site was found not to be unique, detailed consequence calculations have not been performed. In the judgment of the staff, such added detail would neither contribute to nor alter the conclusions.

- DOI A-57

The method employed for estimating groundwater travel times is the same as that described in the Liquid Pathway Generic Study, NUREG-0440.

- DOI A-57

The shortest conservatively estimated groundwater travel time of 7.4 years was estimated from groundwater transport from the reactor to one of the small channels flowing into the Broad River. Transport times through the groundwater directly to the Broad River would be at the higher end of the range.

10.6.12 Risk considerations (Mills A-59; EPA A-61)

Standard methods for estimating costs of reactor building cleanup and decontamination and replacement power for the economic risk calculations are under development. Reasonable estimates of costs of plant decontamination and replacement power have been made, however, and are discussed in Section 6.1.4.6. Staff conclusions on the benefit cost balance are reported in Section 9.

- EPA A-61

Estimates of risk reduction benefits of evacuation are more explicitly reflected in the FES. (See also response to comment on Section 6.1.4 above.)

- WPPSS A-66

The Summer station is a single unit and SCE&G presently operates no other nuclear power plant and no application has been received that would indicate an intent to construct additional units. The FES has been modified, however, to reflect the possibility that forced outages of other plants could occur.

- WPPSS A-66

The reference to environmental impacts of alternative energy generating technologies, e.g., acid rain, is judged to be relevant, even though not quantified.

- WPPSS A-66

The reference to individual plant insurance coverage was not for purposes of comparison, but rather to indicate that there is a relationship between the cost and amounts of such coverage and the discussion of the economic risks associated with plant cleanup and decontamination. This matter is more properly treated in the benefit-cost balance, and the reference to insurance has been removed from this section in the FES.

10.6.13 Uncertainties (DOI A-57)

The staff believes that is has given adequate attention to the existence of uncertainties in this treatment of accident impacts.

REFERENCES FOR SECTION 10

1. A Critical Evaluation of the Nonradiological Environmental Technical Specifications, Volume 3: Peach Bottom Atomic Power Station Units 2 and 4. S. M. Adams, et al., ORNL/NUREG/TM-71, April 1977.

2. South Carolina Electric and Gas Company, Summer/Farfield Environmental Monitoring Program Thermal Mapping Study Final Report, August 1978.

Appendix A

COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

SOUTH CAROLINA ELECTRIC & GAS COMPANY
POST OFFICE BOX 764
COLUMBIA, SOUTH CAROLINA 29218

E. H. CREWS, JR.
VICE-PRESIDENT AND GROUP EXECUTIVE
ENGINEERING AND CONSTRUCTION

August 17, 1979

Mr. Don E. Sells, Acting Director
Environmental Project Branch No. 1
Division of Site, Safety & Environmental Analysis
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Virgil C. Summer Nuclear Station
Docket No. 50/395

Dear Mr. Sells:

Pursuant to 10CFR51, South Carolina Electric & Gas Company, acting for itself and as agent for the South Carolina Public Service Authority offers the enclosed comments related to the Draft Environmental Statement for the Virgil C. Summer Nuclear Station dated June 29, 1979.

Very truly yours,

E. H. Crews, Jr.

MBW:EHC:rh

cc: H. T. Babb
G. H. Fischer
W. C. Mescher
W. S. Murphy
W. A. Williams, Jr.
T. B. Conner, Jr.
NPCF/Dixon
File

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COMMENTS - DRAFT ENVIRONMENTAL STATEMENT

Reference:

Page 5-5, Section 5.2.5.1, and
Page G-5, Item I.B.1

The comment included on both of the above referenced pages recommends applicant consider using an alternative method for biomass determination not influenced by suspended solids.

Comment:

Applicant concurs with this recommendation.

Reference:

Page 5-6, Section 5.2.5.3; and
Page G-5, Item I.B.2

The comment included on both of the above referenced pages recommends that the applicant should take ichthyoplankton samples on a monthly basis for the months of October, November, December, and January.

Comment:

The applicant is presently sampling (sampling began for the agencies June, 1978) ichthyoplankton on a weekly basis during each of the months from February through June and bi-weekly during each of the months from July through September. No ichthyoplankton samples are presently being taken during the months of October through January. From the present sampling program, applicant has demonstrated that the current sampling schedule is sufficient for this particular aquatic ecosystem. Results from data collected during the early spring of 1979 showed that larval fish and eggs were first found in samples collected during the first week of April. Sampling was carried out during late February and all of March proceeding April 1979, and no larval fish or eggs were found from those samples. If ichthyoplankton sampling were to be conducted during the period October through January in addition to the present sampling schedule, the results would yield no useful data on spawning characteristics of fish in the study area.

Reference:

Page 5-6, Section 5.2.5.5; and
Page G-5, Item I.B.3

The comments included on both of the above referenced pages recommends that the applicant conduct fish sampling on a monthly basis.

Comment:

The applicant presently is sampling (sampling began for other agencies June, 1978) fish on a quarterly basis. The present sampling schedule has demonstrated its sufficiency to answer the questions related to this particular program. By sampling quarterly, for fish, adequate representative numbers are collected from all the species on a seasonal basis. These fish are in a relatively closed aquatic system as opposed to a continuous flowing stream. It can be demonstrated that all of the species collected and the populations represented will be in this system and that the present sampling scheme, is adequately sampling these populations. Applicant feels that the data collected during the preoperational program will establish the baseline conditions for Monticello Reservoir. In fact, if sampling were to be conducted monthly there is the possibility that impacts could be created to the fish populations as a result of the sampling efforts.

Reference:

Page 5-12, Section 5.3.5.1; and
Page G-5, Item I.B.5

The comments included on both of the above referenced pages recommends that impingement monitoring be conducted on a weekly basis rather than bi-weekly

Comment:

Applicant is of the opinion that bi-weekly sampling for impingement monitoring is adequate for this particular aquatic ecosystem. There are no threatened or endangered species of fish found in this area, nor are there any species of special interest, such as species that should move upstream to spawn. Impacts due to impingement are adequately assessed from samples taken every two weeks.

Reference:

Page 5-6, Section 5.2.5.5; and
Page G-5, Item I.B.6

The comments included on both of the above referenced pages recommends that any riverine rotenoning be neutralized by the application of an appropriate oxidizing agent to avoid unintentional fish mortalities.

Comment:

Following the rotenone operation, Applicant utilizes an appropriate oxidizing agent, potassium permanganate. The collecting permit issued by the South Carolina Department of Wildlife and Marine Resources stipulates that this procedure be followed.

Reference:

Page G-5, Item II.A

The staff believes after reviewing the applicant's monitoring program that the thermal monitoring procedures as proposed may not be adequate to consistantly and reliably determine compliance with state temperature limits."

Comment:

The staff recommends a sophisticated physical mathematical approach for establishing a predictive means of determining compliance with the state temperature limits that is not acceptable.

Applicant is presently performing extensive thermal surveys of the Monticello Reservoir including continuous monitoring of the water temperature at Stations 17 and 12 to develop a history of temperature variations throughout the entire volume of the reservoir prior to operation of the Summer Station. This survey work is being performed anticipating the possibility of odd temperature distributions caused by the operation of the Fairfield Pumped Storage and influence of weather conditions. When the Summer Station begins operation, these tests will enable the Applicant and the State of South Carolina to objectively determine any changes required to the State's temperature monitoring requirements.

Reference:

Page 4-5, Section 4.4.1.2, 3rd Paragraph

"Judging from the information and assumptions given in Section 2.5.1.1, the impacts of proposed maintenance procedures on proposed endangered or threatened plant species (if present) are likely to be significant. Specifically, Draba aprica (proposed as endangered), Helianthus schweinitzii, Rhus michauxii, Isoetes melanospora, Platanthera flava, and Echinacea laevigata (proposed as threatened) occur in open fields as well as forest and therefore could occur in the rights of way.

Page 4-5, Section 4.4.1.2, 4th Paragraph

"However, plant species within the corridors were already virtually destroyed during clearing of the corridors, and maintenance clearing will not have a significant additional impact."

Page 4-5, Section 4.4.1.2, 3rd Paragraph

"Judging from the information and assumptions given in Section 2.5.1.1, the impacts of proposed maintenance procedures on proposed endangered or threatened plant species (if present) are likely to be significant. Specifically, Draba aprica (proposed as endangered), Helianthus schweinitzii, Rhus michauxii, Isoetes melanospora, Platanthera flava, and echinacea laevigata (proposed as threatened) occur in open fields as well as forest and therefore could occur in the rights of way.

Page 5-2, Section 5.2.4.2

"Considering the information in Sections 2.5.1.2 and 4.4.1.2, the staff requires that the applicant submit an in-depth terrestrial survey of the area along the transmission corridors that will be subject to broadcast spraying of herbicides. This survey will determine the presence of the important plant species discussed in Sections 2.5.1.1 and 4.4.1.2."

Page 8-2, Section 8.2.5

"Terrestrial biotic impacts of maintaining the transmission lines associated with the Summer Station are expected to be minimal if broadcast spraying of herbicides is eliminated from the maintenance procedures (Section 4.4.1.2).

Comment:

The applicant contends (1) that the broad assumptions of the staff of existence of proposed endangered or threatened species is unjustified and, (2) that the requirement for the applicant to submit an in-depth terrestrial survey along the routes of the Summer Station transmission corridors is unjustified for the following reasons:

1. Dr. D. A. Rayner, Field Botanist for the South Carolina Wildlife Department Hertiage Trust Program, confirmed the same fact stated in your report in Section 2.5.1.1 that there was only one plant species (Trillium ersistens) on the endangered list when your report was written. Dr. Rayner stated that only one more species (Sagittaria fasciculata) has been added since the writing of your report. Both species are found in the upper areas of the State and are not impacted by Applicants transmission corridors.

2. Dr. Rayner affirmed the fact that the six species listed in Section 4.4.1.2, paragraph four (4), are all proposed; but, are not listed. In regards to these six (6) listed species, the applicant has these comments:

    A. Draba aprica (proposed as endangered) is only found in South Carolina in shallow soils around granite outcrops. The habitat given in Table 2.8 of Section 2.5.1.1 by small is incorrect. This species is found in clearings in Arkansas, Missouri, and Oklahoma. The fact that this species occurs in open clearings and woods in these three states, is not true for South Carolina and cannot be assumed.

    B. Rhus michauxii (proposed as threatened) is not on any federal register list.

    C. Isoetes melanospora (proposed as threatened) according to State authorities, has never been found in South Carolina.

   D. Platanthera flava (proposed as threatened) is so wide spread in South Carolina that it is considered by State authorities as not being rare.

   E. Helianthus schweinitzii and Echinacea laevigata (proposed as threatened) occur only in dry woods in the Uplands and Piedmont, respectively, in South Carolina. The applicant therefore, insists that four of the six species listed in Section 4.4.1.2 can be eliminated from possible concern (A through D above) and that there is only the remotest of changes that the remaining two species (E above) would ever be impacted.

3. According to the latest data output and county overlays from the South Carolina Wildlife and Marine Resources Heritage Trust Program, which identify locations of endangered plant and animal species in South Carolina, none of the listed species have ever been sited or documented as occuring in any areas affected by the transmission rights of way.

4. Applicant's aerial spraying of transmission rights of way is done under the supervision of a registered forester. Both the Supervisor and Pilot are South Carolina State registered applicators. The herbicide application is done by helicopter at close range and miltiple passes with a micro-foil boom which gives an even 0.06 particle size. A consistent large particle size gives a very precise controlled pattern. It has been the Applicant's experience in applying herbicides that the short distance of application and controlled particle size reduces to a minimum any adverse affects of broadcast spraying on plant species outside the rights of way. In 1979 to date, Applicant has had claims on only 2 acres of timber damaged out of 3700 acres sprayed. It is stated in Section 4.4.1.2 that maintenance within the corridors will not have a significant additional impact due to the plant destruction during initial clearing. Applicant ascertains that due to its type of supervised helicopter maintenance, the concern over impact on species outside the specified corridor, which lands are not under the supervision, control or ownership, of the Applicant, are not justified.

Applicant feels that it is clear that the need for a plant species survey outlined in Sections 4.4.1.2 is unwarranted and unjustified, and should be eliminated from the Final Environmental Report, Section 2.5.1.1. Other related sections of the report should be corrected to reflect accurate information.

104 Davey Laboratory
Penn. State University
University Park
Pa., 16802

19 August 1979

Director, Division of Site Safety
and Environmental Analysis
U.S. Nuclear Regulatory Commission
Washington, D.C.
20555

Gentlemen:

Enclosed are my comments on the Draft Environmental Statement for the Virgil C. Summer Nuclear Station, NUREG-0534. Please note that the Information presented is my own and not necessarily the position of The Pennsylvania State University, which affiliation is given for identification purposes only.

My comments consist of one page of main text (beyond this page) and ten pages of appendix, which I would like to have considered in entirety.

Sincerely,

William A. Lochstet

Wm. A. Lochstet

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30308

August 24, 1979

4SA-EIS

Mr. Ronald L. Ballard
Chief, Environmental Projects Branch 1
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Ballard:

We have reviewed the Draft Environmental Impact Statement on the operation of Virgil C. Summer Nuclear Station (Unit #1) in Fairfield County, South Carolina, and offer these comments:

Page 3-11, Section 3.2.6.7, Sewage and Sanitary Waste

Sanitary waste water treatment systems can readily meet the 30 mg/liter monthly average stipulated in the NPDES permit. If necessary, the present system may have to be redesigned to meet this requirement.

Section 4.2, Impacts on Land Use

Appropriate data should be included in the Final Statement describing all wetlands which exist at the plant site and along the transmission lines as well as the impact of the facility on these plant communities. It is indicated that the transmission corridors and the plant site occupy 2,217 acres of original forestland, but there is no indication what portion of these forestlands can be classified as wetlands.

To retain the integrity of streams/wetlands and to maintain water quality we recommend that these sensitive areas be spanned and that a buffer zone of undisturbed vegetation (at least 50 feet wide) be left on the crossing. Tall trees which might interfere with the transmission lines may be removed but other vegetation should be left intact.

Our review of the document indicates that the plant should be capable of operation in accordance with EPA 40 CFR 190, Environmental Radiation Standards for Nuclear Power Operations, and the radionuclide portion of 40 CFR 140, Interim Drinking Water Regulations. However, the reactor accident at the Three Mile Island has focused attention on the need for a thorough re-examination of reactor safety. We believe it is incumbent on the NRC to carefully review its programs and procedures for identifying,

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assessing and acting on potential accident sequences as operating experience with reactors increases.

We are particularly concerned about the States' emergency response preparations. Those States having reactors should be urged to develop adequate emergency response preparations. Those plans that have received NRC concurrence should be updated as necessary. Emergency preparedness at every level of responsibility (including licenses compliance with Reg. Guide. 1.101) is imperative to protect the public health and safety in the event of a severe nuclear power plant accident.

We will have additional comments on the in-stream effects of the plant as soon as the 316A/B Studies are completed. On the basis of our review a rating of LO-2 was assigned, i.e., we have no significant reservations, but some additional information is requested.

If we can be of further assistance, feel free to call on us.

Sincerely yours,

John E. Hagan III

John E. Hagan, III
Chief, EIS Branch

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER-79/633

SEP 18 1979

Mr. Ronald L. Ballard, Chief
Environmental Projects Branch 1
Division of Site Safety and
Environmental Analysis
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Ballard:

The Department of the Interior has reviewed the draft environmental statement for Virgil C. Summer Nuclear Station as requested in your June 29, 1979, letter. We have the following comments.

<u>General</u>

Our comments and concerns are primarily with the fish and wildlife resource discussions and with the nuclear risk analysis discussions.

The statement is generally adequate and addresses potential impacts on terrestrial systems at the project site and in the transmission corridors. However, the assessment of aquatic impacts in the Monticello Reservoir is unsupported by baseline data for the new aquatic system. The Department's Fish and Wildlife Service (FWS) is aware that the majority of impacts on fishery resources in the project vicinity will occur as a result of pumped storage which will create water level fluctuations of as much as 10 feet in Parr Reservoir and 4.5 feet in the Monticello Reservoir. These unstable conditions will either severely limit or preclude the use of the affected area for spawning or nursery habitat. We therefore urge that every effort be made to increase the benefits of the proposed recreational subimpoundment which will not be affected by water level fluctuations.

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The FWS concurs with the NRC staff recommendations regarding modification of the proposed aquatic and terrestrial biological monitoring program. Any new data generated from the monitoring study should be incorporated into the final statement. Although baseline conditions will not be representative of later seral stages in the reservoir, the data collected will enhance predictive capabilities of entrainment, impingement, and thermal impacts. Aquatic impacts from actual station operation will center around entrainment, impingement, and thermal effluent. Location of the cooling water intake will have a direct effect on entrainment and impingement. Also, secondary effects regarding water quality impacts may stem from alteration of circulation in the reservoir. A series of alternative depths for the cooling water intake should be discussed. Advantages to locations below both the hypolimnion and photic zone which includes reduction in phytoplankton entrainment and the use of cooler, less oxygenated water for plant cooling should also be discussed.

Our comment on the environmental statement for the construction-permit stage about the lack of evaluation of a class 9 (core melt) accident was answered by reference to the low probability of such accidents (page H-109, item 13). Since then, NRC's Reactor Safety Study has shown the probability of such accidents to be much higher than had been assumed previously. The review of this study, organized by NRC, was unable to determine whether these probabilities were high or low, but concluded that the error bands were understated (page 6-2, item 1), or that the confidence placed in these probabilities was rather low. How much confidence can then be placed in the conclusion, continued in the present environmental statement, that the probability of class 9 accident is so small that their environmental risk is extremely low (page 6-2, paragraph 1)? We continue to believe that environmental analyses of nuclear reactor sites are not complete without due consideration of the consequences of class 9 accidents.

The section on In-plant Accidents enumerates some of the more significant findings of the Lewis Report (pages 6-2 to 6-3). The three findings that are enumerated exclude the final finding of the Lewis Report.

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N. W.
WASHINGTON, D. C. 20006

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Office of the Secretary
Docketing & Service
Branch
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DOCKET NUMBER
PROD. & UTIL. FAC. 50-395

February 4, 1981

Samuel J. Chilk
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

DOCKET NUMBER
PROPOSED RULE PR 50, 51.
45 FR 40101

Dear Secretary Chilk:

Enclosed for filing in both Proposed Rule Docket PR 50, 51 (45 FR 40101) and Licensing Docket No. 50-395 are the Council's comments on the Draft Supplement to the Draft Environmental Statement for the Virgil C. Summer Nuclear Station, Unit No. 1 (NUREG-0534).

Sincerely,

C Foster Knight
C. FOSTER KNIGHT
Acting General Counsel

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U.S. NUCLEAR REGULATORY COMMISSION

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COMMENTS OF THE
COUNCIL ON ENVIRONMENTAL QUALITY
ON NUREG-0534

The Council on Environmental Quality has reviewed the Draft Supplement to the Draft Environmental Statement related to the operation of the Virgil C. Summer Nuclear Station Unit No. 1 (NUREG-0534) and has the following comments pertaining to the adequacy of that document under the National Environmental Policy Act (NEPA) and the Council's regulations for the implementation of NEPA.

Background

The Council provided earlier guidance to the Nuclear Regulatory Commission on the analysis of serious nuclear accidents in Environmental Impact Statements (EISs) in a letter dated March 20, 1980 (copy attached). In that letter the Council indicated that its review of NRC impact statements on nuclear power plants had revealed them to be "largely perfunctory, remarkably standardized, and uninformative to the public." Additionally, the Council found that the potential impacts of serious nuclear accidents on human health and the environment were presented in a cursory and inadequate manner with little attention to facilitating public understanding. The Council urged the Commission to move quickly to revise its policy on accident analysis in EISs and to implement 40 C.F.R. Sec. 1502.22(b) of the Council's regulations. Specifically, the Council urged the Commission to (a) discuss the full range of potential nuclear reactor accidents, including "worst case" accidents previously categorized as "Class 9" accidents, in EISs and supplemental EISs; (b) include in the analysis the likely range of environmental and other consequences from severe and other accidents; (c) include within these EISs and supplements the best estimates of the likelihood of such events; and (d) broaden the range of variables used in determining accident impacts and expand the discussion in EISs of the impacts of nuclear accidents on human health, the natural environment, and local economies.

On August 14, 1980, in response to the NRC's Interim Policy Statement of June 13, 1980, the Council transmitted a letter to the Commission stating that the general approach of the Commission appeared to conform to the Council's basic outline for the treatment of serious nuclear accidents (copy attached). The Council also indicated it would provide the NRC with comments on the first NEPA analysis issued by the Commission in this connection.

Specific Comments

The Council has not critically reviewed the data or calculations presented in NUREG-0534. Rather, the following comments pertain to the approach and format of the accident analysis presented.

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Policy

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Director, Division of Licensing

Dear Sir:

This is in reference to your supplement to the draft environmental impact statement entitled, "Virgil C. Summer Nuclear Station, Unit No. 1." The enclosed comments from the National Oceanic and Atmospheric Administration are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving ten (10) copies of the final statement.

Sincerely,

Robert T. Miki
Deputy Assistant Secretary for
Regulatory Policy (Acting)

Enclosure Memo from: Mr. Kenneth D. Hadeen
Environmental Data and Information Service
National Oceanic and Atmospheric Administration

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
[illegible]

Center for Environmental Assessment Services

December 15, 1980 OA/D242:DL

TO: PP/EC - Joyce Wood

FROM: OA/D2x1 - Kenneth D. Hadeen

SUBJECT: DEIS 8011.03 - Virgil C. Summer Nuclear Station Unit No. 1
(Docket No. 50-395) Supplement

General Comments: None

Specific Comments: pg. 6-14 par. 6.1.4.3

It appears that wind rose data (frequency distributions) are not considered in determining probability of total population exposure. Why not?

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER-80/1338

JAN 5 1981

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Thank you for your letter of November 10, 1980, transmitting copies of a supplement to the draft environmental statement, operating license stage, for the Virgil C. Summer Nuclear Station, Unit 1, Fairfield County, South Carolina.

Groundwater

For the evaluation of the consequences of core-melt accidents, groundwater travel times to the Broad River are estimated to range from 1,140 years in the overburden soils to 7.4 years in the fractured media; the derivation of these estimates should be given. The site area is drained by a number of small channels leading to deeply encised valleys downstream from the site. These channels, either directly tributary to the Broad River or indirectly via Freese Creek and Mayo Creek, are shown as ephemeral in the site area on the Jenkinsville, South Carolina, 7.5-minute topographic map (U.S. Geological Survey, 1969) but, subsequent to the filling of Monticello Reservoir, sustained flow in some or all of these channels appears likely due to the probable rise in groundwater levels. In the event of a core-melt accident, contaminated groundwater from the site would be likely to first reach surface waters in these small channels west and south of the reactor. It appears that this has been ignored in the estimates of travel times of contaminants to the Broad River. The derivation of these estimates should be made available for review prior to issuance of the final environmental statement.

Uncertainties

This section enumerates "Some of the more significant findings..." from the Lewis Report. However, the three findings summarized on page 6-21 exclude the final finding of that report which is:

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> "There have been instances in which WASH-1400 has been misused as a vehicle to judge the acceptability of reactor risks. In other cases it may have been used prematurely as an estimate of the absolute risk of reactor accidents without full realization of the wide band of uncertainties involved. Such use should be discouraged." (NUREG/CR-0400, page x)

That finding appears particularly pertinent to the discussion heading. The finding of the Lewis Report that there is a wide band of uncertainty in the risk of reactor accidents should be discussed in the final statement.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

James H. Rathlesberger
Special Assistant to
Assistant SECRETARY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 19 1981

Dr. William E. Kreger
Assistant Director for
Radiation Protection (P-302)
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear ~~Dr. Kreger~~ Bill:

In response to your request, I had my staff review the Supplement to the Draft Environmental Statement (DES) for the Virgil C. Summer Nuclear Power Plant. Because this particular DES considers the possible impacts of the occurrence of a class 9 type accident, we were pleased to have this opportunity to comment specifically on this consideration. We have encouraged the inclusion of this class in environmental statements on light-water reactors and view this as a continuing practice. We believe that a discussion of the possible impacts resulting from core melt accidents can provide a more comprehensive evaluation of the overall environmental risk associated with an individual nuclear power plant. Although our detailed comments are being forwarded to our Region IV office for a coordinated EPA response to NRC, there are a couple of thoughts I want to pass on to you.

The original DES presented operational impacts without a discussion of probability of occurrence. In the supplement, the discussion of accident impacts in terms of risk biases the presentation by glossing over the magnitude of the consequences. It is our view that the discussion of probabilities of occurrence, magnitude of consequences, and risk considerations of accidents in environmental statements should be given separate attention.

The other point I want to express is the need to develop standard methodologies for incorporating costs of reactor building clean-up and decontamination and replacement power into the economic risk calculations. These factors are significant and important to the benefit-cost balance.

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Thank you for the opportunity to review this document. Do not hesitate to contact me if I can be of further assistance. I look forward to our continued close working relationship.

Sincererly yours,

Bill

William A. Mills, Ph.D.
Director
Criteria & Standards Division (ANR-460)
Office of Radiation Programs

cc: C. Wakamo, Region IV

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET
ATLANTA, GEORGIA 30365

JAN 12 1981
4SA-EIS

Mr. William Kane, Project Manager
Office of Nuclear Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Kane:

In our previous reviews of environmental documents dealing with Light Water Reactors (LWR) EPA has consistently emphasized the need for a thorough evaluation of the environmental impacts from different LWR accident scenarios to include Class 9 accidents. The discussion of the environmental and societal impacts of a core melt down accident included in the Supplement to the Draft Environmental Impact Statement (DEIS) for the Virgil C. Summer Nuclear Plant Unit No. 1 is a step forward in this respect and as a result, EPA applauds NRC's decision to prepare this Supplement.

The assessment of environmental impacts for severe accidents at the Summer plant uses methodologies originally developed in the Reactor Safety Study (WASH-1460) and the Liquid Pathway Genenu Study (NUREG-0440). Because these two studies will be the cornerstones for similar assessments for other nuclear power plants environmental statements, we would refer NRC to EPA's original technical comments on these studies. These comments can be found in "Reactor Safety Study (WASH-1400): A Review of The Final Report" and my letter to NRC's Voss Moore dated February 8, 1977.

Our specific comments on the Supplemental DEIS on the Summer Plant are included in the attached technical comments.

Sincerely yours,

Rebecca W. Hanmer

Rebecca W. Hanmer
Regional Administrator

Enclosure
Technical comments

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TECHNICAL COMMENTS:

Section 6.1.4.3 and 6.1.4.4

Section 6.1.4.3 and 6.1.4.4 of the Supplement discuss radiation dose and health effects in terms of yearly probability distributions (risk) and are consistent with the discussions in the original DEIS. However, the discussion in the Supplement of the operational impacts of the facility is in terms of consequences. We believe that is desirable to maintain consistency between the original DEIS and the Supplement in this regard and therefore, would suggest impacts in both documents be presented in terms of consequences. We feel this approach will be more meaningful to the general public.

Table 6.1.4.4

This Table should correspond on a one-to-one basis with the release categories (PWR 1-9) in Table 6.1.4-2.

Section 6.1.4.5

In the discussion in this Section it is not clear whether the socio-economic cost of an accident involving groundwater contamination were considered in Sections 6.1.4.4, 6.1.4.6 and Section 9 (of the original DEIS, June 1979). If not, the cost of these impacts and mitigating measures should be included in the overall risk assessment and benefit-cost balance in Table 9.1 of the original DEIS.

Section 6.1.4.6

It is unclear what is the basis of the conclusion that "Estimates of risk reduction by evacuation of the public within the 10-mile emergency planning zone for accidents can be reduced by a factor of ten to twenty..." This statement seems inconsistent and premature considering the following:

1. The emergency preparedness plans and protective action measures for the Summer facility are not yet complete.

2. NRC and Federal Emergency Management Agency's (FEMA) review of State and local government emergency plans have not been accomplished.

3. The NRC's Safety Evaluation Report (SER) which reviews the applicant's on site plan is not yet available.

General Comment

To facilitate the understanding of impacts from the liquid pathway it would be helpful to provide a summary of the environmental consequence and risks

SOUTH CAROLINA ELECTRIC & GAS COMPANY
POST OFFICE BOX 764
COLUMBIA, SOUTH CAROLINA 29218

T. C. NICHOLS, JR.
VICE PRESIDENT AND GROUP EXECUTIVE
NUCLEAR OPERATIONS

December 23, 1980

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

Subject: Virgil C. Summer Nuclear Station
Supplement to Draft Environmental
Statement
Docket No. 50/395

Dear Sir:

South Carolina Electric and Gas Company, acting for itself and as agent for South Carolina Public Service Authority, has reviewed NUREG-0534 Supplement "Draft Environmental Statement related to the operation of Virgil C. Summer Nuclear Station Unit No. 1" and finds that the statement addresses the Commission positions as stated in NRC interim policy statement (45 FR 40101). However, we do offer the following comments for your consideration:

1. The document should further, if not quantitatively address the approximate resultant reduction in effects anticipated with mitigative actions required by a basic emergency plan consistent with NRC regulatory mandate. Of particular interest would be population effects of the worst case accident and the resultant dose benefit of emergency mitigative actions.

2. Section 6.1.1.3 should be expanded to include further discussion of the dose-health relationship with particular note made of the sources of this information.

3. Page 6-7, last paragraph, first line - "auxiliary" should be changed to "fuel handling".

4. Page 6-6, fourth paragraph, eighth line - "sodium" is misspelled.

In our opinion, this supplement appears to fulfill the interest of the Commission's policy statement, and is an acceptable statement of accident impacts.

Very truly yours,

T C Nichols, Jr

T. C. Nichols, Jr.

RBW:TCN:glb

cc: Page 2

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for the Summer Plant and the risk and consequence developed in the Liquid Pathway Generic Study (NUREG-0440).

As the Three Mile Island-2 (TMI-2) accident pointed out, the cost of reactor building decommissioning and replacement power cost are sizable. These costs could significantly change the benefit-cost balance in Section 9 of the original DEIS. Future EIS's or Supplements to EIS's should evaluate these costs and include them in their benefit-cost analysis.

A figure should be included showing dose versus distance from the plant for severe accidents. This would allow the local population to judge individual risks.

Washington Public Power Supply System
A JOINT OPERATING AGENCY

P.O. BOX 968 3000 GEO. WASHINGTON WAY RICHLAND, WASHINGTON 99352 PHONE (509) 372-5000

January 19, 1981

Docket No. 50-395

U.S. Nuclear Regulatory Commission
1717 H. Street N.W.
Washington, D.C. 20555

Attention: Director, Division of Licensing

Gentlemen:

Subject: Comments on Draft Environmental Statement Supplement

Reference: Draft Environmental Statement Related to the
Operation of Virgil C. Summer Nuclear Station
Unit No. 1, NUREG-0534 Supplement, November 1980

Based on our experience with previous NRC Environmental Statements, we suspect that the reference supplement may be prototypical of the environmental analysis the Commission Staff will prepare in other operating license cases. We, therefore, have reviewed the subject report and find that, while it generally complies with the NRC interim policy statement (45 FR 40101), it can be improved in a few areas.

Subsection 6.1.1.3 seems excessively brief, given the body of literature and public interest in radiation exposure health effects. This general discussion should relate pathways and individual organ doses to health effects. The susceptability of different age groups should also be discussed.

The second sentence of the fourth paragraph of Subsection 6.1.4.1 should be deleted. The judgment that the health effects of design basis accidents are "exceedingly small" contributes nothing and invites debate.

In Subsection 6.1.4.2, we can find no explanation for considering environmental parameters out to 500 miles. Such a large exposure area is not required by the NRC policy statement. The projection of population and land use statistics for this area to year 2000 is not a useful exercise when the health-related exposures would virtually all occur within a 50-mile radius (see Subsection 6.1.4.3). Such projections and the attendant assumptions only invite unproductive criticism.

Subsection 6.1.4.4 is weak in that the considerations employed to derive the economic costs in Figure 6.1.4.-6 are not explained. For instance, the reader doesn't know what uses of property or services are assumed to

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cc: V. C. Summer
G. H. Fischer
T. C. Nichols, Jr.
E. H. Crews, Jr.
O. W. Dixon, Jr.
D. A. Nauman
O. S. Bradham
W. A. Williams, Jr.
A. A. Smith
A. R. Koon
R. B. Clary
J. B. Knotts, Jr.
J. L. Skolds
B. A. Bursey
NPCF/Whitaker
File

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON 20426

IN REPLY REFER TO:

December 10, 1930

Mr. A. Schwencer
Chief, Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Comm.
Washington, D. C. 20555

Dear Mr. Schwencer:

I am replying to your request of November 10, 1980 to the Federal Energy Regulatory Commission for comments on the Draft Environmental Impact Statement related to the Operation of the Virgil C. Summer Nuclear Station Unit No. 1. This Draft EIS has been reviewed by appropriate FERC staff components upon whose evaluation this response is based.

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

Thank you for the opportunity to review this statement.

Sincerely,

J M Heinemann
Jack M. Heinemann
Advisor on Environmental Quality

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be foregone and for how long. (In this section, and in others, there is inadequate cross-referencing to other sections of the DES which provide the basis.) Also not considered are the probable costs associated with forced outages of other units of similar design operated by SCE&G or other licensees (ala TMI-1).

Radiological impacts via the groundwater pathway, discussed in Subsection 6.1.4.5, are referenced to the "Liquid Pathway Generic Study" (LPGS) results. The reader doesn't really know what water sources are made unusable or whether the individual doses in Columbia and Charleston, South Carolina, and other communities would exceed 40 CFR Part 141 standards. As presently written, the reader is told that the drinking water of upwards of 550,000 people "would be affected" without being given any basis for assessing the significance of the contamination. It is stated that the population doses for the liquid pathway from Summer are the same order of magnitude as for the LPGS, but it would be more effective to provide the calculated doses.

Reference to the latest environmental crisis--acid rain--at the top of Page 6-20 seems patronizing. On the same page, the economic risks associated with cleanup and decontamination are inappropriately compared with individual plant insurance coverage.

In summary, the DES supplement appears to fulfill the intent of the Commission's policy statement and provides a generally good statement of environmental impacts due to accidents. The length and detail of the discussion in general seems appropriate for the uncertainties and assumptions inherent in the subject matter.

Very truly yours,

G. D. Bouchey
Nuclear Safety Director

shm

cc: J. R. Lewis, BPA

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT. CORPS OF ENGINEERS
P.O. BOX 919
CHARLESTON, SOUTH CAROLINA 29402

SACEN-E

23 July 1979

Mr. Ronald L. Ballard, Chief
Environmental Projects Branch 1
Division of Site Safety and Environmental
  Analysis
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Ballard:

This is in response to your letter dated 29 June 1979, concerning the Draft Environmental Impact Statement for the operation of Virgil C. Summer Nuclear Station, Unit No. 1. We have reviewed the statement and have no comments in connection with environmental considerations. However, Department of the Army permits will be required for some of the proposed work.

Should you have any questions concerning Department of the Army permits, please telephone Mr. A. B. Gould, Jr., at (803) 724-4610.

Sincerely,

William W. Brown
WILLIAM W. BROWN
Colonel, Corps of Engineers
District Engineer

Copy furnished:
HQDA (DAEN-CWP-V)
WASH DC 20314

Division Engineer, South Atlantic
ATTN: SADPD-R

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