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FINAL

ENVIRONMENTAL IMPACT STATEMENT

Defense Waste Processing Facility
Savannah River Plant
Aiken, S.C.

February 1982

U.S. Department of Energy
Assistant Secretary for Defense Programs
Office of Defense Waste and Byproducts Management
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COVER SHEET

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CONTACT: Additional information concerning this statement can be obtained from: Mr. T. B. Hindman, Director, ATTN: FEIS for DWPF, Waste Management Project Office, Department of Energy, Savannah River Project Office, P.O. Box A, Aiken, S.C. 29801. (803) 725-2566.

For general information on DOE's EIS process contact: Office of the Assistant Secretary for Environmental Protection, Safety and Emergency Preparedness, U.S. Department of Energy, ATTN: Robert J. Stern, Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C. 20585. (202) 252-4600.

ABSTRACT: The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into both the selection of an appropriate strategy for the permanent disposal of the high-level radioactive waste (HLW) currently stored at the Savannah River Plant (SRP) and the subsequent decision to construct and operate a Defense Waste Processing Facility (DWPF) at the SRP site. The SRP is a major U.S. Department of Energy (DOE) installation for the production of nuclear materials for national defense. Approximately 83 x 10^3 m^3 (22 million gal) of HLW currently are stored in tanks at the SRP site. The proposed DWPF would process the liquid HLW generated by SRP operations into a stable form for ultimate disposal. This EIS assesses the effects of the proposed immobilization project on land use, air quality, water quality, ecological systems, health risk, cultural resources, endangered species, wetlands protection, resource depletion, and regional social and economic systems. The radiological and nonradiological risks of transporting the immobilized wastes are assessed. The environmental impacts of disposal alternatives have recently been evaluated in a previous EIS and are therefore only summarized in this EIS.

FOREWORD

The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into both the selection of an appropriate strategy for the permanent disposal of the high-level radioactive wastes currently stored at the Savannah River Plant (SRP) and the subsequent decision to construct and operate a Defense Waste Processing Facility (DWPF) at the SRP site. The proposed DWPF would process the liquid high-level radioactive waste generated by SRP operations into a stable form for ultimate disposal. The SRP is a major U.S. Department of Energy (DOE) installation for the production of nuclear materials for national defense. The high-level waste has been and is continuing to be safely stored in underground tanks. Continuous surveillance and maintenance of the tanks ensure isolation of the waste from the environment. Approximately 83 x 10^3 m^3 (22 million gal) of high-level waste currently are stored in these tanks.

In May 1977, the Energy Research and Development Administration (ERDA) described technical alternatives for processing SRP wastes together with preliminary cost estimates but did not evaluate fully the environmental impacts associated with long-term management of these wastes.[1] A *Final Environmental Impact Statement -- Long-Term Management of Defense High-Level Radioactive Waste (Research and Development Program for Immobilization), Savannah River Plant* (Report DOE/EIS-0023) was issued in November 1979[2] to present the environmental implications of continuing a large research and development (R&D) program directed toward the immobilization of these wastes. The decision of DOE to continue the immobilization R&D program was announced in February 1980.[3]

The R&D on immobilization of the SRP high-level wastes has been in progress since 1973. Conceptual design of immobilization facilities began in 1975. Should the preferred alternative (staged process alternative) be pursued, construction could start in October 1982, which would allow the immobilization facility to begin operation in 1989. Onsite storage of the immobilized waste would be provided, as necessary, until a Federal repository, expected sometime in the 1990's, is available. The current status of the R&D activities concerning immobilization processes development, waste form evaluation, and environmental studies are summarized in Appendix P.

A Notice of Intent[4] to prepare this EIS was published by DOE on March 11, 1980, to present pertinent background information regarding the proposed scope and content of the EIS and to solicit comments and suggestions for consideration in its preparation. As stated in the Notice of Intent, the decisions will be addressed at two levels: (1) a disposal strategy and (2) an immobilization facility. The preferred alternative of waste immobilization for shipment to an offsite mined geologic Federal repository was compared to other disposal strategy alternatives as well as immobilization alternatives. Because the expected environmental impacts of disposing of the SRP high-level waste would be no greater than that for a similar quantity of commercially generated waste and because the disposal of commercially generated waste was analyzed in detail in the *Environmental Impact Statement -- Management of Commercially Generated Waste* (Report DOE/EIS-0046F), the discussions on the disposal strategy will rely upon the analyses and decisions resulting from this report.

In response to the Notice of Intent, 14 individual and private organizations and 10 governmental agencies provided comments to DOE to assist in the preparation of this EIS. An analysis of the issues raised in the comment letters is given as Appendix M of this EIS.

A draft environmental impact statement was made available for public review and comment on October 2, 1981.[5] Four individuals, 1 private organization, and 7 government agencies provided comments; Appendix Q contains these comments and the complete DOE responses to them. All substantive comments were considered in the preparation of this final environmental impact statement.

In this final environmental impact statement, changes from the draft have been indicated by a vertical line in the margin of the page. Minor editorial and typographical corrections are not identified. Changes that are the results of public comments are identified by the specific comment numbers that appear in Appendix Q. A change that is the result of an error (typing error, etc.) in the draft is identified with the letters "TE," and one made to clarify or expand on the draft statement is identified with the letters "TC." For example, if this sentence were added to clarify a point, it would be identified as shown. The responses to the individual comments contained in Appendix Q also provide additional information and clarification. TC

Three reports were used extensively as data sources in the preparation of this EIS. The following table lists these reports, the institutions at which they were prepared, the dates issued, and the abbreviated notation (call-out) used to reference the documents throughout the EIS.

Title	Abbreviated notation	Preparer	Date
Environmental Information Document, Defense Waste Processing Facility, DPST-80-249 and supplement	EID	E. I. du Pont de Nemours & Co. (Inc.), Savannah River Laboratory	1981
DWPF Technical Data Summaries, DPSTD-77-13-3, DPSTD-80-38, DPSTD-80-39, updates	TDS	E. I. du Pont de Nemours & Co. (Inc.), Savannah River Laboratory	1980
Socioeconomic Baseline Characterization for the Savannah River Plant Area, ORNL/Sub-81/13829/5	SBC	NUS Corporation for Oak Ridge National Laboratory	1981

REFERENCES FOR FOREWORD

1. U.S. Energy Research and Development Administration, *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste at the Savannah River Plant*, Report ERDA 77-42, Washington, D.C., May 1977.
2. *Fed. Regist.* 44: 69320-1 (Dec. 3, 1979).
3. *Fed. Regist.* 45: 9763-4 (Feb. 13, 1980).
4. *Fed. Regist.* 45: 15606-8 (Mar. 11, 1980).
5. *Fed. Regist.* 46: 48751 (Oct. 2, 1981).

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1. INTRODUCTION

The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into both the selection of an appropriate strategy for the permanent disposal of the high-level radioactive wastes currently stored at the Savannah River Plant (SRP) and the subsequent decision to construct and operate a Defense Waste Processing Facility (DWPF) at the SRP site. The SRP, at which nuclear materials have been produced for national defense since the early 1950s, is a major installation of the U.S. Department of Energy (DOE) and is currently the nation's primary source of nuclear-reactor-produced defense material. The operations also generate high-level radioactive waste (HLW) that has been and is continuing to be safely stored at SRP in underground tanks. These tanks must be continuously monitored and replaced periodically to ensure environmental isolation of the radioactive contents. Approximately 83 x 10^3 m^3 (22 million gal) of high-level waste is currently stored at SRP, and it is composed of three components: (1) an insoluble sludge (15%), (2) a crystallized salt cake (60%), and (3) a supernatant aqueous solution (25%).

2. PURPOSE OF AND NEED FOR THE ACTION

The high-level defense waste at SRP must be managed in such a way that current or future generations will be protected from potential hazards. The long-term waste management system selected should not depend on the long-term stability or operation of social or governmental institutions for the security of waste isolation. In keeping with this objective — and influenced by the public response to an earlier EIS (DOE/EIS-0023) addressing the long-term management of the wastes at SRP — the DOE, on February 13, 1980, issued a Record of Decision to continue a Federal research and development (R&D) program directed toward immobilization of the high-level radioactive wastes stored at SRP. This EIS is prepared to provide environmental input into both the selection of an appropriate disposal strategy and the subsequent decision to build and operate an immobilization facility at the SRP. Selection of either the geologic media for disposal or a repository site is not within the scope of this EIS and is not addressed; these decisions would be made in siting the repository.

To provide a clear basis for choice, alternative actions are addressed in this EIS at two levels — (1) a strategy level (disposal) and (2) a process level (immobilization), as given in Table S.1. Each level has an identified preferred alternative for comparison with the other alternatives. Some alternatives are not considered practicable and therefore are not considered in detail, although they are outlined and reasons are given for not performing detailed analysis. Treatment of the two levels of action are dissimilar. Since both the disposal technologies and the environmental consequences of disposal strategies have been examined in a number of comprehensive public documents published within the last four years, these alternatives are summarized in this EIS, and the evaluation is tiered to the published analyses and the decisions resulting from them. The major portion of this EIS analyzes the environmental and health impacts of the immobilization alternatives for the proposed DWPF.

3. DISPOSAL STRATEGY ALTERNATIVES

The purpose of a disposal strategy is to dispose of high-level radioactive waste in such a manner that the materials are isolated from the environment and secured for a long enough period of time that they are unlikely to return to the biosphere before they have decayed to safe or harmless levels. Different disposal alternatives were studied in detail in the management program for commercially generated high-level waste (HLW), and geologic disposal in a mined repository emerged as the technologically preferred option. Consideration of the suitability of this disposal strategy for defense waste requires a comparison of defense waste with commercially generated waste. A comparison is given in Sect. 2.1 and Table 2.1 of the EIS. The estimated number of canisters required for the SRP waste is less than one-seventh of that |J-4
required for the commercial waste (Table 2.1). With the additional advantage of a higher repository loading possible for the defense waste, which produces only about one-tenth the heat output, the impacts of disposing of the SRP defense waste on the repository program

Table S.1. Alternative actions

	Preferred alternative	Other alternatives	"No action" alternative	Alternatives not considered in detail
Strategy level (Disposal)	Immobilization for geologic disposal	Rock melting Island disposal Subseabed disposal Icesheet disposal Deep-well disposal Partitioning and transmutation Space disposal Very deep hole disposal	Indefinite tank storage at SRP	Direct disposal in bedrock below SRP
Process level[a] (Immobilization)	Construction and operation of a DWPF to immobilize high-level waste for disposal in Federal repositories and disposal of saltcrete (by-product) as low-level radioactive waste on the SRP site[b]	Delayed alternative	c	Immobilization without separation Interim solidification

[a]Process level alternatives are options to implement the preferred disposal strategy.
[b]Discussions of the immobilization alternative are divided into two parts: the reference immobilization alternative and the staged process alternative. The staged process alternative was developed from the reference immobilization alternative by incorporating improvements resulting from the research and development program for reducing the initial and total cost required for the DWPF. The staged process alternative is the preferred immobilization alternative.
[c]Given the adoption of immobilization for geologic disposal alternative, there cannot be a "no-action" immobilization alternative.

should be minimal. Thus, the results of analyses of commercial HLW disposal strategies are considered appropriate bases for selection of the strategy for disposal of SRP defense wastes.

In this EIS, the preferred alternative for disposal of SRP HLW is selected to be the same as the preferred alternative for commercial HLW, namely, geologic disposal or long-term isolation in a mined geologic repository with very deep hole and subseabed disposal being retained as backup technologies. In implementing this isolation strategy, multiple barriers will be established between the radioactive waste and the biosphere: the waste form, canisters, engineered sleeves and backfill, and the geologic medium. The proposed DWPF will immobilize the SRP waste into an appropriate waste form for placement in a repository. Selection of a final waste form is scheduled by October 1983, and it will be accompanied by the appropriate environmental review. In the meantime, borosilicate glass is used as the reference waste form for facility and process design and for the preparation of this EIS. Additional barriers, such as overpacking, sleeves, and backfill materials, will be added as required at the repository. The repository itself will consist of a subsurface mined cavity excavated by conventional mining methods at about 600 m (2000 ft) below the surface. Immobilized waste will be stored within mined rooms designed to utilize the host formation and overlying geologic materials as permanent geologic barriers. Immobilized waste from the proposed DWPF can also be packaged for disposal in very deep hole or subseabed repositories.

The "no-action" alternative to immobilization for geologic disposal calls for continuing the existing method of management for the defense HLW at SRP. It requires continuous monitoring and maintenance of the tanks and periodic transfer of wastes to new tanks with retirement of old tanks. Surveillance has to be continued until either the radioactivity has decayed to safe levels (hundreds of years for some radionuclides and thousands of years for others) or until a permanent disposal scheme is implemented. Removal of strontium-90 and cesium-137 from the waste would significantly reduce the heat generated by the waste so that the remaining materials could be stored in uncooled tanks. The recovered strontium-90 and cesium-137 would probably have to be disposed of as HLW unless beneficial uses were developed. The recovery of cesium-137 and strontium-90 would require the construction of a new facility and would result in larger waste volumes. The increased handling of the waste would result in higher radiation exposure to operating personnel and greater risk of radiation exposure to the public. Recovery of strontium-90 and cesium-137 would not alter the management needs or the unacceptable environmental status for the "no-action" disposal alternative of continuing tank storage.

The environmental impacts of numerous additional disposal alternatives have recently been evaluated. The results are summarized in Sect. 2.4. The strategies include rock melting, island disposal, subseabed disposal, ice-sheet disposal, deep well injection, waste partitioning and transmutation, space disposal, and very deep hole disposal. Most of these strategies will require immobilization prior to disposal; however, all of these strategies have greater technological and environmental uncertainties than mined geologic disposal.

4. IMMOBILIZATION ALTERNATIVES FOR THE DWPF

Assuming adoption of the geologic disposal for the SRP defense waste, a facility would be needed to immobilize the waste. Three immobilization alternatives (reference, delay of reference, and staged) were analyzed in detail to show the possible range of environmental impacts associated with the construction and operation of a DWPF. Both the reference and staged design resulted from the R&D program undertaken to find a suitable method to immobilize HLW for disposal. The reference design preceded the staged design chronologically in the R&D program and is taken as the base case for comparing the environmental impacts of the alternatives. The staged-process alternative, however, is the preferred immobilization alternative. All three immobilization alternatives require the processing of the SRP waste into two fractions: a high-level radioactivity fraction for immobilization and offsite geologic disposal and a partially decontaminated salt fraction for solidification and disposal as low-level waste on the SRP site. A brief description of each alternative is given below:

1. Reference immobilization alternative. This alternative requires the construction of a large remotely operated facility for simultaneous processing of the sludge, salt cake, and supernatant. Construction would start in October 1982, with operations scheduled to begin in 1989.

2. Delay of reference immobilization alternative. This alternative assumes that construction and operation of the proposed DWPF are delayed for 10 years. It is assumed that a Federal repository would then be available to receive the immobilized waste so that no more than 90 days of interim storage would be required and that a decision on the waste form would have been made for the DWPF. For conservatism, the reference immobilization design was used in performing the impact analysis.

3. Staged process alternative. Because of on-going R&D effort, a staged process alternative was developed to first construct a facility to treat the sludge (Stage 1) and then construct a facility to treat the salt cake and supernatant (Stage 2). In this alternative, construction costs would be spread more evenly over the years of construction. Construction of the Stage 1 facility would start in October 1982 with operations scheduled by 1989; Stage 2 facility construction would start in 1985 with operation scheduled for 1991.

The selection of these three immobilization alternatives for analysis, the detailed description of processing steps, the available process flexibility, and the environmental impact assessments performed establishes a range of potential environmental impacts for possible immobilization alternatives for the SRP defense high-level radioactive waste. In the analyses given, the differential effects estimated for the delay of the reference alternative are applicable also to delay of the staged process alternative.

The immobilization process is generally similar for the three alternatives although specific design components may vary. The process to treat the sludge consists of the following steps: separation of the sludge solids from the soluble components (salt solution); immobilization of the sludge solids by either (a) calcining the sludge, mixing it with glass frit, and then melting or (b) feeding the sludge continuously to a liquid-fed glass melter; placing the sludge/glass mixture in stainless steel canisters; and transferring the canisters (sealed and decontaminated) to an interim-storage vault.* The process for treating the salt solution consists of separation of the soluble high-level radioactivity constituents from the salt solution by ion exchange (these constituents are to be immobilized with the sludge); formation of saltcrete from the residual decontaminated salts by mixing with cement; and burial of the low-level radioactivity saltcrete in an intermediate-depth-engineered disposal area.

Other immobilization alternatives considered were immobilization without separation and interim immobilization. These were not analyzed in detail because preliminary examination clearly showed these alternatives to have greater potential for environmental risk than the alternatives examined in detail.

*Borosilicate glass is used as the reference waste form; other waste forms are currently under research and development.

Three potential sites at SRP for the DWPF were considered. The site selection factors considered included the following: distance to the high-level waste storage tanks, site topography, geology, hydrology, ecology, soil condition, access to existing services, and distance to a suitable area for disposal of the decontaminated salt.

All the immobilization alternatives will generate decontaminated salt as a by-product. Based on the proposed Nuclear Regulatory Commission classification guide, the decontaminated salt can be disposed of as low-level radioactive waste. The DOE proposes to dispose of the decontaminated salt in a concrete mixture (saltcrete) in an engineered landfill meeting requirements appropriate for hazardous waste as well as those for low-level radioactive waste. Alternatives to saltcrete burial include returning the decontaminated salt to the waste tanks as salt cake or as saltcrete and packaging the decontaminated salt in appropriate form for shipment to a geologic repository.

The main criteria for locating an area for disposal of the decontaminated salt as saltcrete are the depth of the groundwater and the distance from the proposed DWPF. The Z Area, adjacent to the S Area, was selected from four potential sites as the proposed site for the disposal of saltcrete.

5. POTENTIAL ENVIRONMENTAL IMPACTS FOR IMMOBILIZATION ALTERNATIVES

Table S.2 summarizes the impacts and their significance from construction of the proposed DWPF. Table S.3 presents the same information for DWPF operations. Impacts of the staged alternative are compared in Tables S.4 and S.5. Impacts for the reference alternative, the delayed reference alternative, and the preferred alternative (staged-process) are compared in Table S.6. In evaluating effects, especially radiation-induced effects, conservative assumptions were generally used wherever assumptions were necessary. Conservative assumptions tend to maximize the intensity of an effect and provide a conservative (high) assessment of risk.

No severe adverse impacts are anticipated as a result of implementation of any of the immobilization alternatives. However, in general, the adverse effects of the staged-process alternative are anticipated to be somewhat less than those of the other alternatives. As described in the EIS, selected studies will be initiated, and others will be continued to monitor environmental parameters where needed. Control measures will be implemented as necessary to mitigate any environmental problems discovered as a result of the monitoring programs.

Table S.2. Impacts from construction of the reference immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects		
DWPF and Vogtle[a] construction on schedule	Work-force population will increase with a consequent increase in required public services. DWPF employment increases will coincide with Vogtle decreases.[a]	5.1.1.1, 5.9, H.1, K.1
DWPF construction on schedule and Vogtle delayed 2 years	Work-force demand for Vogtle and DWPF construction will peak simultaneously requiring more in-movers and greater demands on public services and housing. Minor impacts will be distributed over a large six-county area. Possible significant impacts expected only in services for one county and may require mitigation.	5.6, 5.9, H.2
Health risk to workforce		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced during construction.	5.1.1.2, 5.5.1
Radiological	Construction workers will be exposed to SRP background-level radiation. Exposures will be well below standards, and monitoring will be employed where necessary.	5.1.1.3
Ecological effects		
Nonradiological	Wildlife habitat will be disturbed; erosion and stream siltation will increase. Impacts will be on areas without unique ecological features, and recovery is expected after construction is completed.	5.1.1.2
Radiological	None.	5.1.1.3
Land use	About 140 ha of land will receive some construction impacts. Land is currently unused and within the SRP.	5.1.2, 5.6
Air quality	Impacts will be same as for conventional industrial plant construction (e.g., increase in total suspended particulates, carbon monoxide, and hydrocarbons). Emissions will be well within applicable standards.	5.1.1.2
Water quality	Siltation of surface streams will increase. Construction practices will be utilized to mitigate stream impacts.	5.1.1.2
Earthquake or tornado occurrence	Damage to facilities. Impacts during construction would be same as for any nonradiological construction project.	Appendix G
Cultural resources	None expected.	4.1.3
Endangered species	None expected.	5.1.1.2
Resource depletion	Resources committed include concrete, steel, and fuels. Amounts are nominal, and materials are ordinary.	5.7
Wetlands protection	One carolina bay will be eliminated. About 200 carolina bays exist on the SRP site, and this one is not unique.	4.5.1, 5.1.1.2, 5.6

[a]The Vogtle Power Plant is a nuclear power plant being constructed by the Georgia Power Company within 20 km of the proposed DWPF.

Table S.3. Impacts from operation of the reference immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Some economic turndown is expected when construction ends and operation begins. The effect is limited and absorbable; there will be a net gain of about 700 permanent jobs.	5.1.2.1, Appendix K
Health risk to work force		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced for all operations.	5.1.2.2, 5.5.2
Radiological (routine operations)	Operating personnel will work in controlled radiation exposure areas. All high-level radioactivity operations will be remotely controlled; occupational doses will be monitored and controlled to be as low as reasonably achievable.	5.1.2.3
Radiological (accidental occurrence)	Operating personnel may be exposed to radiation. Maximum precautions will be taken to protect personnel. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2
Health risk to public		
Nonradiological	Public will be exposed to coal-fired power-plant releases: particulates, SO_x, CO, HC, and NO_x; coal-pile runoff, and ash. Emissions will be controlled to within acceptable levels.	5.1.2.2
Radiological (routine releases)	Public will be exposed to radionuclides in DWPF atmospheric and liquid releases. Doses will be extremely small and insignificant health risk is anticipated.	5.1.2.3, Appendix J
Radiological (accidental releases)	Public will be exposed to radionuclides released accidentally. Accidents are highly unlikely and releases in the event of accident are so small that insignificant health risk is anticipated. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2, Appendix L
Ecological effects		
Nonradiological	Nonradioactive wastes (including ash-basin effluents) will be discharged into the environment. Wastes will be treated before discharge.	5.1.2.2
Radiological	None expected. Biota will not be severely affected.	5.1.2.3
Land use	Approximately 80 ha will be committed to the DWPF facility. Land is currently unused and is about 0.1% of land area within the SRP.	5.6.2
Air quality		
Nonradiological	Releases from coal-fired power plant will increase atmospheric levels of particulates, SO_x, CO, HC, and NO_x. Cooling towers will release drift. Releases will be controlled to maintain levels within Federal standards.	3.1.6.4, 5.1.2.2
Radiological	Radionuclides will be released in stack exhausts. Radionuclide levels will be extremely small.	3.1.6.4, 5.1.2.3
Water quality		
Nonradiological	Effluent from the industrial wastewater treatment facility will discharge to surface streams: secondary effluent from the sewage treatment plant will be disposed of by spray-irrigation on land. Waste will be treated before discharge, to meet all applicable regulations; possible impacts to soils from on-land disposal of sewage plant effluent will be mitigated.	3.1.6.4, 5.1.2.2
Radiological	Radionuclides will be released in DWPF liquid effluents. Liquid streams will be monitored before discharge; concentrations of radionuclides in surface water will be extremely small; no degradation of water quality will occur.	3.1.6.4, 5.1.2.3

Table S.3. (continued)

Issue	Impacts	Section
Earthquake or tornado occurrence	Damage to facilities with consequent release of radioactivity. Structures processing high-level radioactivity materials will be earthquake- and tornado-resistant.	3.1.3, 4.4.3
Transportation (routine operations)		
Nonradiological	Impacts will be similar to those of conventional common carriers. Vehicle emissions will be much less than allowable standards.	5.1.4.1, Appendix D
Radiological	Public will be exposed to radioactivity from passing vehicles. All phases of transport including packaging will be designed to comply with comprehensive Federal regulations ensuring public safety during transport of HLW.	5.1.4.2, Appendix D
Transportation (accidents)		
Nonradiological	Injuries and fatalities will be similar to those for conventional common carriers. Probabilities for injuries and fatalities from truck and rail transportation accidents will be similar to those in normal transportation.	5.5.3.1, Appendix D
Radiological	Public will be exposed to radioactive releases in the event a cask is ruptured during an accident. Rupture is highly unlikely; public exposure in the event of rupture is very low compared with normal background radiation.	5.5.3.2, Appendix D
Resource commitment	Resources committed include electricity, water, coal, cement, glass frit, and process chemicals. Materials are commonly available and amounts are reasonable.	5.7

Table S.4. Impacts from construction of the staged immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Work-force population will increase with a consequent increase in required public services. Area population increases will be less than 1% of the totals. Minor to negligible impacts will be offset by jobs created.	5.1.1, 5.9.1, Appendix K
Health risk to workforce		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced during construction.	5.1.1.2[a], 5.5.1
Radiological	Construction workers will be exposed to SRP background-level radiation. Exposures will be well below standards, and monitoring will be employed where necessary.	5.3.1.3
Ecological effects		
Nonradiological	Wildlife habitat will be disturbed; erosion and stream siltation will increase. Impacts will be on areas without unique ecological features, and recovery is expected after construction is completed.	5.3.1.2
Radiological	None.	5.1.2.3[a]
Land use	About 120 ha of land will receive some construction impacts. Land is currently unused and within the SRP.	3.3.2.1, 3.3.2.2
Air quality	Impacts will be same as for conventional industrial plant construction (e.g., increase in total suspended particulates, carbon monoxide, and hydrocarbons). Emissions will be well within applicable standards.	5.1.1.2[a]
Water quality	Siltation of surface streams will increase. Construction practices will be utilized to mitigate stream impacts.	5.1.1.2[a]
Earthquake or tornado occurrence	Damage to facilities. Impacts during construction would be same as for any nonradiological construction project.	Appendix G
Cultural resources	None expected.	4.1.3
Endangered species	None expected.	5.1.1.2[a]
Resource depletion	Resources committed include concrete, steel, and fuels. Amounts are nominal, and materials are ordinary.	3.3.4.4
Wetlands protection	One carolina bay will be eliminated. About 200 carolina bays exist on the SRP site, and this one is not unique.	5.1.1.2[a]

[a]Impacts are the same as for the reference alternative.

Table S.5. Impacts from operation of the staged immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Some economic turndown is expected when construction ends and operation begins. The effect is limited and absorbable; there will be a net gain of about 530 permanent jobs.	5.3.2.1, Appendix K
Health risk to work force		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced for all operations.	5.1.2.2[a]
Radiological (routine operations)	Operating personnel will work in controlled radiation exposure areas. All high-level radioactivity operations will be remotely controlled; occupational doses will be monitored and controlled to be as low as reasonably achievable.	5.1.2.3[a]
Radiological (accidental occurrence)	Operating personnel may be exposed to radiation. Maximum precautions will be taken to protect personnel. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2
Health risk to public		
Nonradiological	Releases will contain CO_2, NO_x, NH_3, and diesel generator emissions. Releases are very small and well within required emission standards.	3.3.5.4
Radiological (routine releases)	Public will be exposed to radionuclides in DWPF atmospheric and liquid releases. Doses will be extremely small and little health risk is anticipated.	5.3.2.3, 5.6.2, Appendix D
Radiological (accidental releases)	Public will be exposed to radionuclides released accidentally. Accidents are highly unlikely and releases in the event of accident are so small that little health risk is anticipated. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2, Appendix L
Ecological effects		
Nonradiological	Nonradioactive wastes will be discharged into the environment. Wastes will be treated before discharge to comply with NPDES permit requirements.	5.3.2.2
Radiological	None expected. Biota will not be affected.	5.1.2.3
Land use	Approximately 65 ha will be committed to the DWPF facility. Land is currently unused and is about 0.1% of land area within the SRP.	3.3.2, 4.1.2
Air quality		
Nonradiological	Releases from diesel generator exhaust will increase atmospheric levels of particulates, SO_x, CO, HC, and NO_x. Cooling towers will release drift. Releases will be very small and well within air quality standards.	3.1.6.4, 3.3.5.4
Radiological	Radionuclides will be released in stack exhausts. Radionuclide levels will be extremely small.	5.3.2.3
Water quality		
Nonradiological	Effluent from the industrial wastewater treatment facility will discharge to surface streams: secondary effluent from the sewage treatment plant will be disposed of by spray-irrigation on land. Waste will be treated before discharge, to meet all applicable regulations; possible impacts to soils from on-land disposal of sewage plant effluent will be mitigated.	3.1.6.4, 5.3.2.2
Radiological	Radionuclides will be released in DWPF liquid effluents. Liquid streams will be monitored before discharge; concentrations of radionuclides in surface water will be extremely small; no degradation of water quality will occur.	3.1.6.4, 5.1.2.3

Table S.5. (continued)

Issue	Impacts	Section
Earthquake or tornado occurrence	Damage to facilities with consequent release of radioactivity. Structures processing high-level radioactivity materials will be earthquake- and tornado-resistant.	3.1.3.1[a], 4.4.3
Transportation (routine operations)		
Nonradiological	Impacts will be similar to those of conventional common carriers. Vehicle emissions will be much less than allowable standards.	5.1.4.1, Appendix D
Radiological	Public will be exposed to radioactivity from passing vehicles. All phases of transport including packaging will be designed to comply with comprehensive Federal regulations ensuring public safety during transport of HLW.	5.1.4.2, Appendix D
Transportation (accidents)		
Nonradiological	Injuries and fatalities will be similar to those for conventional common carriers. Probabilities for injuries and fatalities from truck and rail transportation accidents will be similar to those in normal transportation.	5.5.3.1, Appendix D
Radiological	Public will be exposed to radioactive releases in the event a cask is ruptured during an accident. Rupture is highly unlikely; public exposure in the event of rupture is very low compared with normal background radiation.	5.5.3.2, Appendix D
Resource commitment	Resources committed include electricity, water, coal, cement, glass frit, and process chemicals. Materials are commonly available and amounts are reasonable.	5.7

[a]Impacts are the same as for the reference alternative.

Table S.6. Comparison of impacts by alternative[a]

Issue	Reference immobilization DWPF[b]	Delayed reference DWPF	Staged-process DWPF
Socioeconomic effects	(1) DWPF and Vogtle[c] construction on schedule: Minor impacts because of increase in work force—mitigated by release of workers from Vogtle[c] plant construction. One county may have school and housing impacts. (2) DWPF on schedule and Vogtle delayed 2 years: Impacts somewhat greater than for Vogtle on schedule due to increased level of in-movers above that of case (1) above.	Impacts greater than for reference DWPF because of sharp increase in work force without mitigation by Vogtle work-force release.	Impacts lower than for either reference DWPF or delayed DWPF—work force is roughly 60% of that for other alternatives.
Health risks	*Negligible impacts are anticipated (max. individual exposure of 0.16 millirem per year).*	*Same as for reference DWPF.*	*Negligible impacts are anticipated (max. individual exposure of 0.20 millirem per year).* |TC
Ecological effects	Wildlife habitat will be displaced; temporary siltation of surface streams will occur; one carolina bay wetlands area will be eliminated.	Same as for reference DWPF.	Similar to reference DWPF except that less land area will be disturbed.
Land use	About 140 ha will be disturbed during construction; about 80 ha will be retained for operation.	Same as for reference DWPF.	About 120 ha will be disturbed during construction: about 65 ha will be retained for operation.
Air quality	Particulates, SO_x, CO, HC, and NO_x will be released from coal-fired power plant; drift will be released from cooling towers, and diesel-generating exhaust will be emitted.	Same as for reference DWPF.	Only cooling-tower drift and diesel generator exhaust will be emitted; no power plant is required for this alternative. Incremental effects will result from generation of power at existing plants.
Water quality	Treated liquid effluents will be discharged to surface streams.	Same as for reference DWPF.	Similar to reference DWPF except that coal-associated effluents will be absent.
Transportation	Nonradiological accidents will account for a maximum of 1.6 injuries and 0.1 deaths per year.	Same as for reference DWPF.	Same as for reference DWPF.
Resource commitment	Resources include materials for both constructions and operation.	Same as for reference DWPF.	Quantities committed are lower than for the reference DWPF.
Postulated accidents involving radioactive releases	Negligible impacts are anticipated (maximum individual exposure of 0.32 millirem per year).	Same as for reference DWPF.	Negligible impacts are anticipated (maximum individual exposure of 0.04 millirem per year).

[a]See two preceding tables for summaries of impacts and their significance.

[b]*The reference DWPF is taken as the base case for comparison purposes only; the staged process DWPF is the preferred alternative.*

[c]The Vogtle Power Plant is a nuclear power plant being constructed by the Georgia Power Company within 20 km of the proposed DWPF.

1. NEED FOR AND PURPOSE OF DEFENSE WASTE PROCESSING FACILITY

1.1 NEED

1.1.1 Defense wastes

The Savannah River Plant (SRP) near Aiken, South Carolina, is a major installation of the U.S. Department of Energy (DOE) for the production of nuclear materials for national defense. It began operations in the early 1950s and is currently the nation's primary source of reactor-produced defense materials. These operations also generate liquid high-level radioactive waste from the chemical processing of fuel and target materials after their irradiation in the SRP nuclear reactors. The high-level radioactive waste contains the residual radioactive and stable fission products, some unrecovered uranium and target materials, some plutonium and other irradiation products, and most of the chemicals used in processing irradiated fuels and targets.

This waste has been and is continuing to be safely stored at SRP in underground tanks that are engineered to provide reliable interim storage of the waste, isolated from the environment. No onsite or offsite radiation exposures in excess of applicable standards have occurred from these operations, nor has there been any offsite contamination. Under current waste management procedures, most of the water is removed over a period of time by thermal evaporation facilities, and the residual sludge and saltcake remain in the tanks. If this procedure continues, it is projected that more than 100 million L (26 million gal) of high-level waste will have been stored by the year 2000. This waste will consist of sludge (15% by volume) and saltcake (60% by volume) and a supernatant aqueous solution (25% by volume).

This waste must be managed in such a way that current and future generations will be protected from potential hazards. Storage in underground tanks is an interim measure because tanks have finite lifetimes and require periodic replacement and continual surveillance to ensure that the contents of the tanks remain isolated from their surroundings until radiation levels have decayed to a safe level.

1.1.2 Goals and objectives

The ideal goal of nuclear waste management is isolation of high-level radioactive waste from the biosphere for all time. In recognition that isolation over geologic periods of time can never be guaranteed, the DOE has proposed that "disposal systems should provide reasonable assurance that wastes will be isolated from the accessible environment for a period of at least 10,000 years with no prediction of significant decreases in isolation beyond that time."[1]

The goal of the SRP high-level waste management program is to isolate SRP radioactive sludge and saltcake in a manner which does not rely on the continued vigilance of man to provide protection to current and future generations and their environment.

1.1.3 Relationship to other Federal actions

Significant quantities of radioactive wastes exist in the United States (see Table 1.1). These wastes have been produced by a variety of activities including those related to national defense, the commercial nuclear power industry, research investigations, medical diagnostics and therapy, and uranium mining and milling operations. Up to now, most of the volume and radioactivity excluding spent fuel from commercial nuclear power plants has been produced by defense-related activities. It is projected that the rate of defense nuclear waste generation will remain about the same but that the rate of nuclear waste generation by the commercial nuclear power industry will greatly increase.

About one-third of the defense high-level reprocessing wastes listed in Table 1.1 is stored in underground tanks at the SRP near Aiken, S.C. The rest is stored in underground tanks near Richland, Washington, and in bins near Idaho Falls, Idaho. All commercial reprocessing waste is currently stored in tanks near West Valley, New York. Separate environmental reviews are occurring for each of these facilities because of (1) differences in chemical and physical forms of the wastes, (2) different waste storage systems, (3) important environmental characteristic

Table 1.1. Quantities of existing radioactive wastes in the United States (1979)

	Volume (m^3)	Weight (kg)
High-level waste		
Defense (from reprocessing)	2.7E+5[a]	
Commercial (from reprocessing)	2.3E+3	
Spent fuel (discharged from commercial reactors)		2.3E+6
Transuranic waste		
Defense		1.1E+3
Commercial		1.2E+2

Source: Interagency Review Group, *Nuclear Waste Management*, Report to the President, TID-29442, March 1979, p. 11.

[a]Read as 2.7×10^5.

differences at the sites, and (4) different affected communities and interest groups at the sites.

1.2 PURPOSE

The purpose of this Environmental Impact Statement is to fulfill the requirements under Sect. 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA) by providing environmental inputs to the decisions regarding the proposed action and its reasonable alternatives.

1.2.1 Proposed action

The proposed action is (1) to select a disposal strategy for existing and future SRP high-level radioactive waste and (2) subsequently to decide on the construction and operation of a Defense Waste Processing Facility (DWPF) to immobilize SRP high-level defense waste into a form suitable for shipment to and disposal in a Federal repository. Key decisions related to the construction and operation of the DWPF include (1) facility location and (2) disposal of the decontaminated salt as low-level waste.

The preferred disposal strategy is disposition of the immobilized high-level radioactive waste in a mined geologic repository using conventional mining techniques. The technology is available for this type of disposal; however, this fact does not preclude further study of other disposal techniques. Section 2 will address the selection of a disposal strategy and is tiered on published reports and earlier decisions. Selection of the geologic medium and the repository site is not within the scope of this EIS and will be addressed separately in siting of a repository.

Assuming the selection of the preferred disposal strategy, the rest of the EIS (Sects. 3 through 6) is devoted to the construction and operation of a facility for processing the SRP high-level defense waste for disposal. The proposal is to separate the waste into a relatively low-volume, high-level radioactive fraction (sludge and radioisotopes recovered from the saltcake) and a relatively high-volume decontaminated salt fraction. The high-level radioactive fraction is to be immobilized and containerized for shipment to an offsite Federal repository. It is proposed that the decontaminated salt be buried onsite as saltcrete (mixture of salt and concrete) monoliths at intermediate depth on appropriately engineered sites. Two alternatives meet these criteria for a preferred immobilization alternative, both the reference and the staged process alternatives. Of the two, the staged approach has been identified as preferred by DOE.

In this EIS, borosilicate glass has been selected as the reference waste form for immobilizing the high-level radioactive fraction. The final decision on waste form is scheduled to be made by October 1983. Before a selection is made, an environmental review of the waste form options will be prepared in accordance with NEPA requirements. Because another waste form will not be chosen unless it has process/product characteristics equal to or better than those assumed for borosilicate monoliths, the analyses can be considered limiting for any waste form in that the analyses in this EIS will represent conservative conditions.

The potential environmental impacts for the immobilization alternatives and related decisions are presented with the discussions on the need for mitigating measures.

1.2.2 History

Since 1953, the SRP has been a major Federal installation for the production of nuclear materials for national defense. In 1973, when SRP was under the jurisdiction of the Atomic Energy Commission (AEC), a research and development (R&D) program on immobilization of the SRP high-level waste was initiated. R&D activity has continued and has been expanded by AEC's successors, the Energy Research and Development Administration (ERDA) and the U.S. Department of Energy (DOE). The purpose of the program has been to examine options for the long-term management of SRP wastes which would also be applicable to high-level wastes at other DOE sites. Included in the multiyear R&D program was development of the technology for removing the wastes from the tanks, concentrating them into a high-activity fraction, and immobilizing the radioactive nuclides in a high-integrity form for subsequent disposal.

Three important reports concerning SRP waste-management operations have been published in the last four years. *Alternatives for Long-term Management of Defense High-level Radioactive Waste, Savannah River Plant, Aiken, S.C.,*[2] describes 23 alternatives for long-range management and isolation of the SRP high-level radioactive waste and presents relative costs, risks, and uncertainties. *Final EIS, Waste Management Operations, Savannah River Plant, Aiken, S.C.,*[3] described the waste-management operations at the SRP and analyzes the associated actual and potential environmental effects. *Final EIS, Long-term Management of Defense High-level Radioactive Wastes (Research and Development Program for Immobilization), Savannah River Plant, Aiken, S.C.,*[4] analyzes the long-term management strategy for the SRP high-level radioactive waste. A decision was made to continue the extensive Federal R&D effort described in DOE/EIS-0023 directed toward the immobilization of the high-level radioactive waste at the SRP.[5]

Two important reports on commercially generated high-level radioactive wastes were published in 1980: (1) *Statement of Position of the United States Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste*[1] and (2) *Final EIS, Management of Commercially Generated Radioactive Wastes.*[6] Because both of these reports are applicable to defense wastes, they are discussed at length in Sect. 2, Disposal Strategy Alternatives.

REFERENCES FOR SECTION 1

1. U.S. Department of Energy, *Statement of Position of the United States Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste,* DOE/NE-0007, Washington, D.C., April 1980.

2. U.S. Energy Research and Development Administration, *Alternatives for Long-term Management of Defense High-Level Radioactive Waste, Savannah River Plant, Aiken, S.C.*, ERDA 77-42, Washington, D.C., May 1977.

3. U.S. Energy Research and Development Administration, *Final EIS, Waste Management Operations, Savannah River Plant, Aiken, S.C.*, ERDA-1537, Washington, D.C., September 1977.

4. U.S. Department of Energy, *Final EIS, Long-term Management of Defense High-level Radioactive Wastes (Research and Development Program for Immobilization), Savannah River Plant, Aiken, S.C.*, DOE/EIS-0023, Washington, D.C., November 1979.

5. "Record of Decision on DOE/EIS-0023," *Fed. Reg.* 45(31): 9763-4 (Feb. 13, 1980) (given in Appendix A).

6. U.S. Department of Energy, *Final EIS, Management of Commercially Generated Radioactive Wastes,* DOE/EIS-0046F, Washington, D.C., October 1980.

2. DISPOSAL STRATEGY ALTERNATIVES

The wastes at the SRP have been made alkaline and stored in large steel tanks located in underground concrete vaults. Experience with the stored waste over the past 25 years has led to improved tank design and storage procedures. This interim storage method has proven to be effective for the controlled containment of high-level waste. However, recent studies have concluded that the long-term disposition of high-level radioactive wastes should provide for disposal such that the material is unlikely to return to the biosphere before it has decayed to innocuous levels. Certain disposal strategy alternatives for high-level wastes at the SRP were considered in an EIS entitled *Long-term Management of Defense High-level Radioactive Wastes* (DOE/EIS-0023),[1] which led to a DOE policy decision issued Feb. 13, 1980,[2] to continue research and development (R&D) activities directed toward immobilization of those wastes (Appendix A). As indicated in that policy decision, the alternatives of continued tank storage (no action) and funding an R&D program for direct disposal in bedrock under the SRP were not chosen.

The principal objective for disposal of radioactive waste is to provide reasonable assurance that such waste, in biologically significant concentration, will be permanently isolated from the human environment. In evaluating the various technologies available for permanent disposal of the highlevel waste at SRP, this document relies heavily on the analyses and conclusions reached in the *Environmental Impact Statement, Management of Commercially Generated Radioactive Waste* (DOE/EIS-0046F).[3] This reliance is based on the determination that the characteristics of the SRP waste are comparable to those for commercial high-level wastes analyzed in DOE/EIS-0046F.

The following entire range of disposal technologies was evaluated in detail in DOE/EIS-0046F:

1. geologic disposal using conventional mining techniques (preferred alternative),
2. rock-melting disposal,
3. island disposal,
4. subseabed disposal,
5. icesheet disposal,
6. deep-well injection disposal,
7. partitioning and transmutation,
8. space disposal, and
9. very deep hole disposal.

Factors that were considered in each disposal method included: (1) radiological effects during the operational period, (2) non-radiological effects, (3) compliance with existing National and International law, (4) independence for future development of the nuclear industry, and (5) the potential for corrective or mitigating actions.

The proposed action in DOE/EIS-0046F is to adopt a national strategy to develop mined geologic repositories for disposal of commercially generated high-level radioactive and transuranic wastes and to conduct the necessary research and development program to ensure the safe long-term containment and isolation of the waste. This proposed action was adopted by the DOE as indicated in the Record of Decision.[4]

As indicated in the DOE/EIS-0046F,[3] systems that can adequately dispose of commercial radioactive wastes can reasonably be expected to adequately dispose of defense wastes because the processed wastes from the national defense program produce lower temperatures and lower radiation intensities than do wastes from the same quantity of similarly processed commercial fuel. Thus, assuming other factors are equal, repository-loading criteria would generally be less stringent (in terms of quantities of waste per unit area) for defense wastes than for commercial wastes. For these reasons, the analyses of impacts presented in DOE/EIS-0046F[3] should be of use in addressing the disposal of defense wastes. Likewise, if the characteristics of the immobilized SRP defense waste are similar to those of the immobilized commercial waste for disposal, the adopted disposal strategy for commercial high-level radioactive waste should be applicable to the disposal of defense high-level radioactive waste.

Because of their advanced stage of development, borosilicate glass monoliths have been utilized as the reference waste form in the analyses in this EIS and in DOE/EIS-0046F.3 These analyses used glass properties and characteristics that are believed reasonably attainable with near-term technology. Because another waste form will not be chosen unless it has equal or better process/product characteristics than determined for borosilicate glass monoliths, the EIS analyses can be considered limiting for any waste form. An R&D program is being conducted on other waste forms at various national laboratories, universities, and industrial plants (Appendix B). The decision on waste form is planned by October 1983, and it will be accompanied by the appropriate environmental review. The proposed DWPF project is planned to proceed prior to the waste form decision because the primary effort during the first year will be site preparation. Other disposal alternatives, including indefinite tank storage, are also addressed briefly in this section to indicate their viability and acceptability for disposal of high-level radioactive waste.

TC The R&D programs on the development of alternative waste forms are compatible with the schedules for waste package designs and repository construction. Waste package design interactions will occur in three steps. First, the reference glass has been identified and one alternative waste form will be identified before the conceptual waste package design begins. Second, the generic reference repository design conditions for all geologic media under consideration, interim waste form performance specifications, and the waste package conceptual designs will be known before the final defense waste form is selected. Third, three years of intensive waste form development and characterization under reference repository design conditions will be completed before the final waste package design begins. Figure 2.1 shows the schedule for these acitivities.

The first canistered defense HLW would be produced in DWPF by June 1989 and would be available for in situ testing in a terminal storage test facility, if appropriate. Canistered defense high-level waste may accumulate at DWPF for approximately eleven years (the first waste repository would be opened no sooner than 2000). Interim modular storage facilities will be constructed at DWPF as required to accommodate these canisters of immobilized waste.

2.1 CHARACTERISTICS OF WASTES

Since 1953, the SRP has been producing special nuclear materials for defense purposes. Chemical separations of irradiated fuel and targets at SRP result in product streams and acidic liquid streams that contain almost all of the fission products and small amounts of transuranics. Currently, this waste is chemically converted to an alkaline solution and stored in large underground tanks at SRP as insoluble sludges, precipitated salts, and supernatant (liquid).

Because of the nature of the processes producing the SRP high-level waste (HLW), the aging (decay) of the waste (Fig. 2.2), and the waste management procedures, there is some variability of waste compositions not only from tank to tank but also within a tank as a function of location and depth. For purposes of evaluation of alternatives, however, average waste compositions are appropriate. The estimated quantities and radionuclide contents of the solidified SRP high-level waste are given in Table 2.1.

There are now about 70 operating commercial light water power reactors (LWRs) in the United States, having about 50 GWe of installed nuclear-powered electrical generating capacity. Additional reactors are under construction or being planned. For comparison purposes, a moderate nuclear power growth scenario projects 250 GWe operating by year 2000 and normal reactor life (no new reactors after year 2000). In this scenario 239,000 metric tons of heavy metal (uranium and transuranic elements, primarily Pu) will be discharged by the year 2040. Assuming processing of commercial spent fuel similar to the processing of SRP defense waste, comparable waste quantities and key radionuclide contents for the solidified commercial waste are also given in Table 2.1. The quantity of commercial HLW in individual canisters would be adjusted, either by dilution or by varying canister diameter, to meet the allowable heat output imposed by the disposal system.

The defense waste processed at SRP differs from the commercial waste discussed in DOE/EIS-0046F in that it produces less heat and consequently has a lower disposal temperature and lower radiation intensity than a similar quantity of commercial waste. Less uranium has been fissioned in defense fuel; therefore, the quantity of fission products is less. Because of the lower quantity of fission products in SRP waste, the decay heat is much less than that in commercial waste.

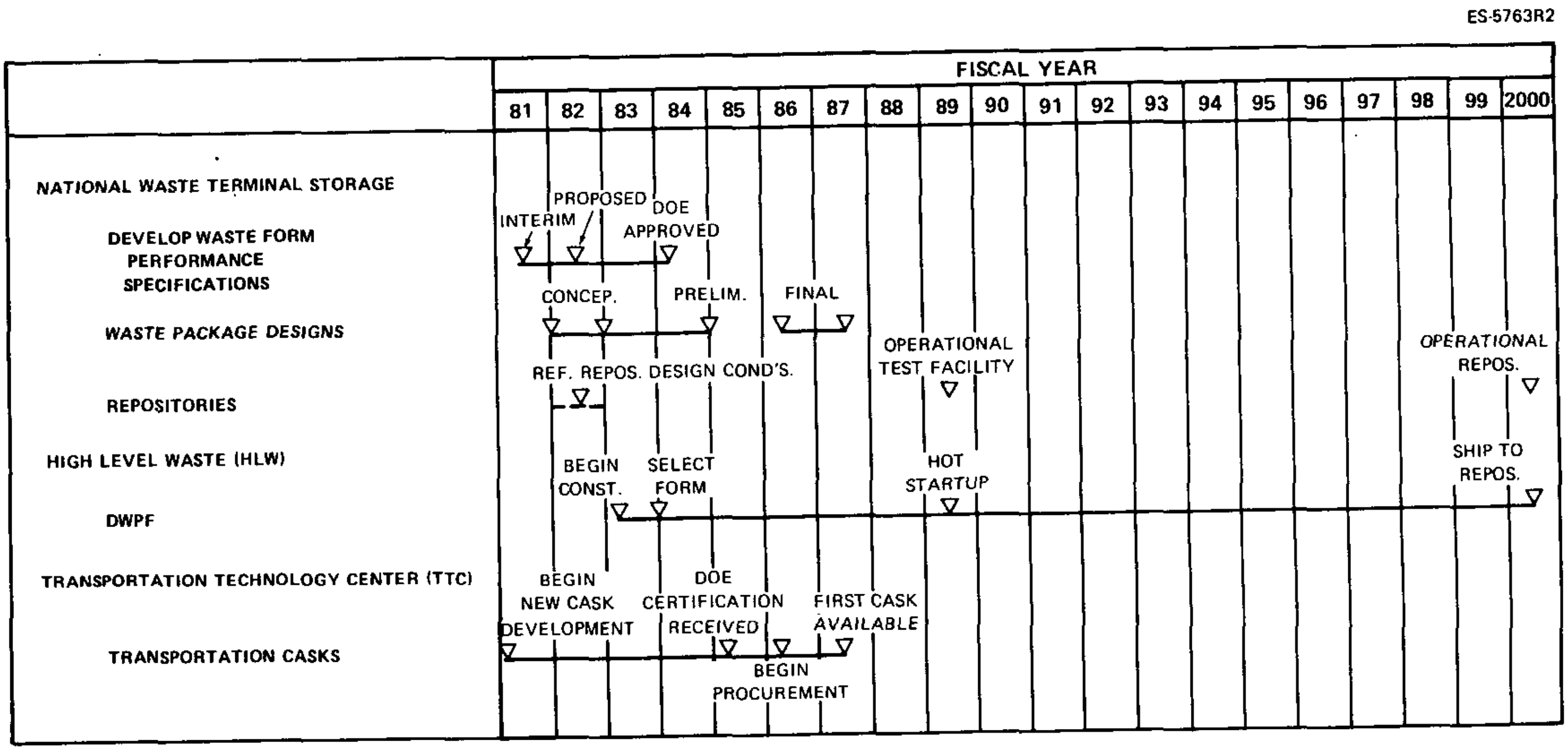

Fig. 2.1. Coordination of HLW facilities with repository and transportation programs.

TC

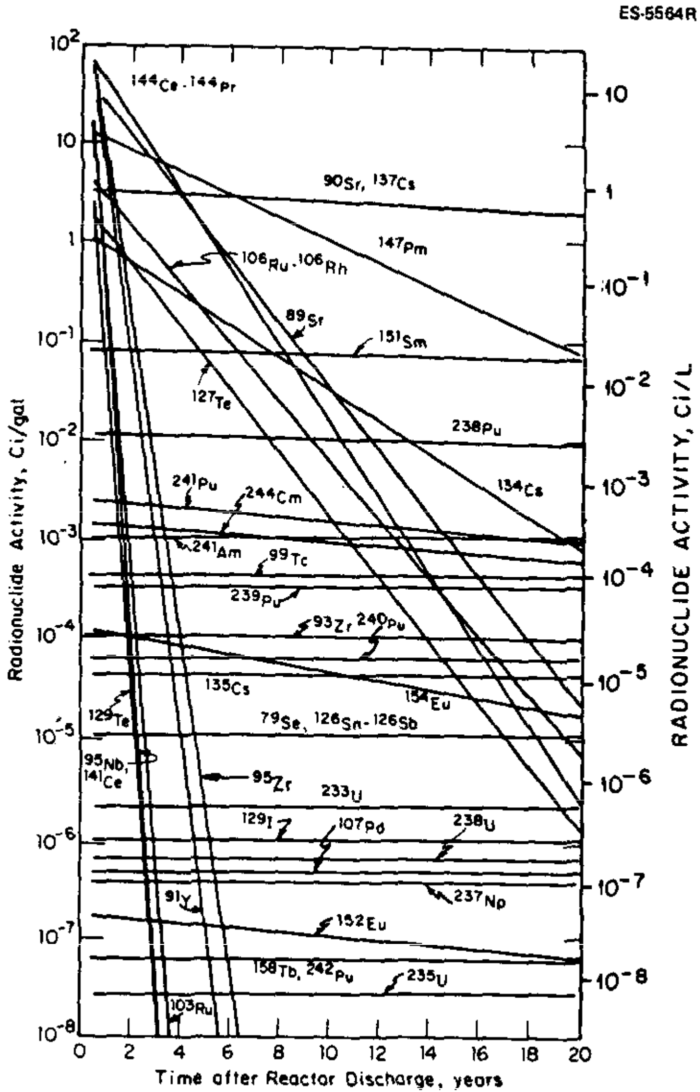

Fig. 2.2. Radionuclide composition of the SRP waste 0 to 20 years after irradiation. Source: U.S. Department of Energy, *Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken, South Carolina, Final Environmental Impact Statement*, DOE/EIS-0023, Washington, D.C., November 1979.

Examination of Table 2.1 shows that the radionuclide content and heat output of individual defense program HLW canisters is a factor of 5 to 10 or more below that of the commercial HLW canisters. The radionuclide content in the defense program HLW canisters relative to the commercial HLW canisters ranges from about the same magnitude for plutonium to orders of magnitude less for some of the other nuclides.

Thus, repository loading criteria generally would be less stringent (in quantities of waste per unit area) for SRP wastes than for commercial waste. Also, because the SRP waste contains a lower concentration of fission products, the environmental consequences will be less from dispersion of the SRP waste than from dispersion of an equal amount of commercial waste. Therefore, in the event of an accident involving the same quantity of wastes, consequences will be less severe for the SRP waste. An analysis of the commercial waste as given in DOE/EIS-0046F[3] applies to the SRP defense waste because the waste is well within the boundaries of the commercial

Table 2.1. Comparison of SRP defense and commercial high-level wastes

High-level waste type	Canisters required	Heat output (kW/canister)[a]	Radionuclide content (Ci/canister)[a]					
			^{90}Sr	^{137}Cs	^{238}Pu	^{239}Pu	^{241}Am	^{244}Cm
SRP defense[b]	1.0×10^4	0.2	1.9×10^4	1.8×10^4	6.0×10^2	6.4	22	8.2×10^{-2}
Commercial[c]	0.7×10^5 to 2.0×10^5	3.2 to 1.2	1.4×10^5 to 5.0×10^4	2.0×10^5 to 7.1×10^4	1.8×10^2 to 6.5×10^1	4.3 to 1.5	1.7×10^3 to 6.1×10^2	1.4×10^4 to 5.1×10^3

[a]Nominal values, assuming uniform distribution of waste radionuclides among the canisters.

[b]Estimated data for the year 2002. Canister requirements based on 0.6-m-diam X 3-m-long canisters, 80% full of treated waste; heat outputs based on the contained radionuclides.

[c]Data for the reprocessing of spent fuel containing 1.7×10^5 metric tons of heavy metal (Scenario Case 3) and radioactivity at 6.5 years after reactor discharge; canister requirement dictated by the heat output allowed by the disposal system. J-4

Sources: U.S. Department of Energy, *Management of Commercially Generated Radioactive Waste, Vol. 2, Final Environmental Impact Statement*, DOE/EIS-0046F, Washington, D.C., October 1980; letter from O. F. Brown, DOE, to M. E. Miller, NRC, March 27, 1981, concerning the Waste Confidence Rulemaking.

waste in all pertinent parameters. For these reasons, the DOE/EIS-0046F conclusion with respect to the preference for geologic disposal using conventional mining techniques compared with other disposal alternatives is also valid for the SRP waste. The estimated number of canisters required for the SRP waste is less than one-seventh of that required for the commercial waste. With the additional advantage of a higher repository loading possible for the defense waste, which produces only about one-tenth the heat output, the impacts of disposing of the SRP defense waste on the repository program should not be significant.

2.2 GEOLOGIC DISPOSAL USING CONVENTIONAL MINING TECHNIQUES (PREFERRED ALTERNATIVE)

There are locations on earth where changes of a geologic nature take place slowly — over millions of years. The rate of change for geologic systems, subject only to such long-term change mechanisms, would be so low that they could be assumed to be stable for periods of hundreds of thousands of years. Consequently, it is believed that locations within the earth's crust where primary change mechanisms require geologic time periods to occur and that appear to provide negligible hydrologic transport potential are suitable for the long-term isolation of nuclear waste. To be viable, the previous geologic history of a rock mass would need to indicate probable continued stability for at least the next 10,000 years; it should be relatively isolated from circulating groundwater; it must be capable of containing waste without losing its desirable properties; it must be amenable to technical analyses (i.e., within man's near-term ability to model); and it must be technologically feasible to develop a repository within it. To effectively use such a rock mass, man must be able to locate it, enter it, emplace waste in it, and seal it without permanently damaging its basic integrity.

As currently conceived, a mined geologic repository will embody three self-supporting and interrelated components to form a complete system for long-term isolation of radioactive waste: a qualified site, a suitable repository design, and an engineered waste-package system.

Using this alternative, SRP waste would be processed by the proposed DWPF into a monolith of stable material such as borosilicate glass, appropriately encapsulated, and shipped to a repository for disposal. The repository would consist of a subsurface mine in salt, basalt, granite, shale, or other suitable rock type. The repository sites would be selected based on factors such as geologic stability, absence of faulting, seismicity, surface and groundwater hydrology, stratigraphy, geologic structure, commitment of resources, and competing land uses. The repository, excavated by conventional mining techniques, would locate the disposal areas for emplacement of the immobilized waste about 600 m (2000 ft) below ground.

The concept of geologic disposal of radioactive wastes is one in which canistered, high-level radioactive wastes are placed in engineered arrays in conventionally mined rooms in geologic formations far beneath the earth's surface. The phrase "conventional mining techniques" refers to the method of repository construction. Drilling, blasting, and boring methods used for mine construction will be used to form the caverns and tunnels of the repository. The intent of the phrase is to indicate that existing, proven, conventional technologies would be used to construct the repository, as opposed to the need for, or application of, a new and innovative technology unique to nuclear waste management.

Geologic disposal, as considered in this statement, also employs the concept of multiple barriers. Multiple barriers include both engineered and geologic barriers to improve confidence that radioactive wastes, in biologically significant concentrations, will not return to the biosphere. Engineered barriers include the waste form itself, canisters, fillers, overpacking, sleeves, and backfill materials. Each of these components may be designed to reduce the likelihood of release of radioactive material and would be selected based on site- and waste-specific considerations. Geologic barriers include the repository host rock and adjacent and overlying rock formations. Engineered barriers are tailored to a specific containment need; geologic barriers are chosen for their in-situ properties for both waste containment and isolation.

Environmental and engineering studies leading to the identification and evaluation of potential geologic repository sites are currently in progress under the DOE Office of Nuclear Waste Isolation. The selection and development of a geologic repository will be the subject of a separate NEPA review, including the preparation and distribution of an EIS addressing that proposed action. It is thus outside the scope of this EIS.

The concept of geologic disposal using conventional mining techniques has been studied in detail and compared with the other disposal alternatives as part of the DOE evaluation of the management of commercially generated radioactive waste.[3] That study concluded, "Thus, state of the technology stands out as a major decision factor, and the geologic disposal option has an edge over other options as regards the technology status." DOE previously has considered alternative approaches to the long-term management of high-level radioactive wastes at the SRP. An EIS provided the basis for a decision (Appendix A) to continue a major R&D program "directed toward the immobilization of the high-level radioactive wastes at the SRP." This study considered specifically the feasibility of removing the waste from the storage tanks, processing and immobilizing the waste, and preparing the immobilized material for shipment to a repository. The process considered in DOE/EIS-0023[1] corresponds generally to the DWPF reference immobilization alternative described in Sect. 3.1.

2.3 INDEFINITE TANK STORAGE

2.3.1 Continuation of current program ("No Action" alternative)

This alternative is a continuation of current high-level waste management practices at SRP and is therefore the "No Action" alternative under CEQ designations. However, a considerable amount of positive action is required over a long time period to carry out this alternative.

By 1989, the backlog of high-level waste to be managed will be stored in 30 tanks. Each tank would contain about 3.8×10^3 m^3 (1×10^6 gal) of high-level waste, would have a capacity of 4.9×10^3 m^3, and would be the double-wall Type III design now being built at SRP. The expected service lifetime of these heat-treated and stress-relieved tanks is between 40 and 60 years.[5]

When indicated by periodic inspection of the tanks in service, new tanks would be constructed and the old tanks retired. Salt or sludge would be reconstituted to liquid by dissolving or slurrying with water; this solution slurry would be transferred to a new tank and evaporated to a damp salt cake or sludge, as it was before transfer. The old tank would be cleaned and retired from service. The cycle of reconstitution to liquid, transfer to new tanks and evaporation, and retirement of old tanks would be repeated about every 50 years. The process would cease when some future generation made a decision that some other disposal method would be more desirable or that the radioactivity had decayed enough so that the tanks could be covered and abandoned.

This alternative is a continuation of operations currently performed at SRP on a routine basis, backed by about 25 years of experience. The technology for all necessary phases is therefore fully demonstrated and at hand. This alternative was analyzed in DOE/EIS-0023;[1] however, it was rejected as a long-term management strategy for the SRP high-level radioactive wastes due to the need for continuous surveillance and maintenance.[2]

2.3.2 Mitigating measures

The potential environmental effects of continued tank storage can possibly be reduced by selective recovery of ^{90}Sr and ^{137}Cs from the waste. This action would significantly reduce the heat generation rate in the waste and would have the concommitant advantage of making these isotopes available for potential beneficial use. At DOE's Hanford Reservation, ^{90}Sr and ^{137}Cs removal was carried out on high-level radioactive wastes to reduce heat generation rates so that the wastes could be stored in uncooled tanks. The isotope removal operations at Hanford were undertaken to solve waste storage problems specific to that site. To date, most of the recovered ^{137}Cs and ^{90}Sr have been stored onsite as an encapsulated solid in anticipation of future possible beneficial uses or of ultimate disposal with the other high-level radioactive wastes. No market has yet developed for these encapsulated isotopes, and they remain in controlled storage pending disposal or use.

Recovery of the ^{137}Cs and ^{90}Sr would require removal of the sludge and salts from the storage tanks and chemical processing to isolate, solidify, and encapsulate the isotopes. The volume of the high-level radioactive waste would be increased by the volume of chemicals added to carry out the sludge dissolution and other isotope recovery steps. New facilities would be required for waste processing, isotope purification and encapsulation, and isotope capsule storage.

The increased handling of the high-level radioactive waste during isotope recovery would result in an increase in radiation exposure to operating personnel and a slight increase in the potential for exposure to the public. The facilities, procedures, and controls for handling the waste depleted in ^{137}Cs and ^{90}Sr would be unchanged from those described in Sect. 2.3.1 except that the required waste tankage would be increased. Removal of Cs and Sr from the HLW will not affect the long-term management strategy because actinides and other long-lived radioisotopes remain in the bulk waste. Thus, removal of ^{137}Cs and ^{90}Sr will not significantly mitigate the potential risks or environmental impacts from continued in-tank storage and would add substantially to costs.

2.4 OTHER ALTERNATIVES

Alternative strategies for the disposal of commercially generated radioactive waste have been extensively evaluated.[3] Because the SRP wastes fall within the envelope of waste characteristics for the commercially generated waste, it is appropriate to "tier" on the information and analyses presented in that EIS. Each of the alternatives is summarized below. The reader is referred to other published documents[3,6] for more detailed information and a discussion on these alternatives.

2.4.1 Rock melt

The rock-melting concept for radioactive waste disposal calls for the direct placement of liquids or slurries of high-level radioactive waste alone or with small quantities of other wastes into underground cavities. After the water has dissipated, the heat from radioactive decay melts the surrounding rock. It has been postulated that the rock forms a waste complex by reaction with the high-level radioactive waste. In about 1000 years, the waste-rock mixture resolidifies, trapping the radioactive material deep underground in what is believed to be a relatively insoluble matrix. Because solidification takes about 1000 years, the waste is most mobile during the period of greatest fission-product hazard.

The rock-melting concept has a large number of technologic and environmental uncertainties associated with it. As with the very deep hole concept, our ability to understand the fundamental geologic and hydrologic mechanisms that exist at reference depths (up to 2000 m) is somewhat limited. The use of conventional geologic exploration tools to verify conditions at reference depths is uncertain. Manned inspection is not likely to be feasible. In addition, retrieval of wastes from the process is probably not possible. The heat generation rate in the high-level radioactive wastes stored at the SRP is insufficient to initiate rock melting; therefore the rock-melting disposal method is not feasible for SRP wastes.

2.4.2 Island disposal

Island-based disposal involves the emplacement of wastes within deep, stable geological formations, much as in the conventional mined geologic disposal concept and in addition relies on a unique hydrological system associated with island geology. Island-based disposal would accommodate all forms of waste as does conventional mined geologic disposal; however, additional port facilities and additional transportation steps would be required. Remoteness of the probable candidate islands has been cited as an advantage in terms of isolation.

The island disposal concept has uncertainties associated with its potential environmental impact. The potential for dynamic interaction between the fresh and ocean water lenses in island geology may preclude confidence in the isolation mechanisms. This disposal concept would also be subject to adverse weather conditions. Several political issues, including international issues, may restrict this option. With these uncertainties, and because the concept does not appear to offer advantages over mined geologic disposal, the island disposal concept is not a prime candidate disposal technology.

2.4.3 Subseabed disposal

Wastes may be isolated from the biosphere by emplacement in the ocean sediment at ocean depths of thousands of meters, in formations which have been deposited over millions of years. The deposits have been shown by laboratory experiments to have high sorptive capacity for many radionuclides that might leach from breached waste packages. The water column is not considered a barrier; however, it will inhibit human intrusion and can contribute to dilution by dispersal of radionuclides that might escape the sediments.

One proposed subseabed disposal system concept incorporates the emplacement of appropriately treated waste or spent reactor fuel in free-fall, needle-shaped "penetrometers" that, when dropped through the ocean, would penetrate about 50 to 100 m into the sediments. A ship designed for waste transport and placement would transport waste from a port facility to the disposal site and emplace the waste containers in the sediment.

Subseabed disposal is an attractive alternative disposal technique because it appears technically feasible that the waste can be placed in areas having relatively high assurance of stability. If at some point in time all of the barriers failed, the great dilution and slow movement of the sea should retard the return of radionuclides to the human environment in biologically important concentrations. Like island-based geologic disposal, the subseabed concept has the disadvantage of the need for special port facilities and for additional transportation steps in comparison to mined repositories on the continent.

As noted, subseabed disposal is believed to be technologically feasible; however, international treaties may be required before it could be accomplished. Whether subseabed disposal can provide isolation of wastes equal to that of deep geologic repositories has not been fully assessed; however, it is a backup disposal technology.

The total number of uncertainties and issues to be resolved is still significant for this option, but efforts to resolve them are proceeding.

2.4.4 Ice-sheet disposal

Use of ice-sheet disposal as currently conceived would include the encapsulation and transportation of HLW by sea to a polar disposal site located in a region of stable and uniform ice. Canisters would be placed into a hole a few tens to a hundred meters deep and would be sealed over by water poured in place and allowed to freeze. Heat generated within the canister would melt the ice in a region around the canister, and the melt water and waste container, which are more dense than the ice, would slowly settle. This settling would be likely to proceed to the interface between the ice and the underlying rock. Eventually, hundreds of meters of solid ice would isolate the waste from the surface. The slow flow of the ice might provide isolation for long periods of time until the region of ice flowed to the ice sheet perimeter and was broken off.

Environmentally, ice-sheet disposal has been estimated to be unsuitable for nuclear waste disposal. Scientists representing the National Academy of Sciences, the Scientific Committee on Antarctic Research of the International Council of Scientific Unions, and the International Commission on Snow and Ice have concluded that the polar ice masses are not suitable for the disposal of radioactive wastes. The principal questions about the disposal capability of ice masses have to do with the uncertainty about the stability of an ice mass for at least a 10,000-year period and the possibility of wastes being mechanically disintegrated by the movement of the ice mass on the basement rock, leading to escape via unknown pathways. For these reasons, this concept is not currently being pursued.

2.4.5 Deep well injection

Two methods of well injection have been suggested: deep well liquid injection and shale/grout injection.

Deep well injection involves pumping acidic liquid waste to depths of 1000 to 5000 m into porous or fractured strata that are suitably isolated from the biosphere by relatively impermeable overlying strata. The waste is expected to remain in liquid form and thus may progressively disperse and diffuse throughout the host rock. Unless limits of movement are well defined, this mobility within the porous host media formation would be of concern regarding eventual release to the biosphere.

For the shale/grout injection alternative, the shale is fractured by high-pressure injection and then the waste, mixed with cement and clays, is injected into the fractured shale formations at depths of 300 to 500 m and allowed to solidify in place in a set of thin solid disks. The shale has very low permeability and predictably good sorption properties. The formations selected for injection would be those in which it can be shown that fractures would be created parallel to the bedding planes and the wastes would be expected to remain within the host shale bed. This requirement is expected to limit the injection depths to the range stated previously.

Many uncertainties exist for the concept, including uncertainties about migration pathways in groundwater that could preclude injecting a readily mobile, liquid, high-level radioactive waste into deep strata. Containment barriers possible through the use of stabilized solid waste forms and high-integrity containers would not be available using this technique. Additionally the deep well injection concept probably precludes retrievability of wastes.

Disposal of liquid high-level radioactive waste in bedrock at SRP was analyzed in DOE/EIS-0023.[1] Based on that study and on comments by the Environmental Protection Agency categorizing any bedrock disposal option at SRP as environmentally unsatisfactory, the DOE determined not to fund further R&D studies in support of this option.[2]

2.4.6 Partitioning and transmutation

Waste partitioning and transmutation is not a disposal concept, but rather a treatment alternative for nuclear wastes. Partitioning involves chemical separation of waste constituents to facilitate optimum management. Transmutation refers to a radiation treatment of wastes by which nuclides with undesirable properties are converted to other nuclides with more desirable properties (e.g., shorter half-life, lower radiation hazard, lower mobility, etc.). The partitioning and transmutation concepts together commonly imply the separation and subsequent "detoxification" by transmutation of selected radionuclides. Conceptually, the principal candidates for partitioning and transmutation are iodine, technetium, and certain actinides, which have very long radioactive half-lives. Transmutation concepts include use of thermal reactors, fast reactors, fusion reactors, accelerators, and nuclear explosives.

Extensive studies of the partitioning and transmutation process have revealed major difficulties. Principally, there appears to be no risk reduction in the waste disposal process because of technological limitations in the fraction of waste that could be converted by transmutation. Use of the process would require that some disposal concept be used to support it. Recent work has indicated that the process may result in an increased radiation hazard during the short term and no compensating decrease in long-term hazard.

2.4.7 Space disposal

Space disposal has been suggested as a unique option for permanently removing high-level nuclear wastes from the earth's environment. In a reference concept, high-level nuclear waste is immobilized and packaged in special flight containers for insertion into a solar orbit, where it would be expected to remain for at least one million years. The National Aeronautics and Space Administration (NASA) has studied several space-disposal options since the early 1970s. The concept involves the use of a special space shuttle that would carry the waste package to a low-earth orbit where a transfer vehicle would separate from the shuttle and place the waste package and another propulsion stage into an earth escape trajectory. The transfer vehicle would return to the shuttle while the remaining rocket stage inserts the waste into a solar orbit.

Space disposal is of interest because once the waste is placed in orbit its potential for environmental impacts and human health effects is judged to be nonexistent. However, the risk of launch pad accidents and low-earth orbit failure must be compared with the risk of breach of deep geologic repositories. Studies of space disposal, taking into account measures to mitigate its risks, have shown it to be much more expensive than other alternatives.

2.4.8 Very deep hole disposal

A very deep hole concept has been suggested that involves the placement of nuclear waste in holes as much as 9 km deep in geologic formations. Desirable site characteristics for this type of disposal include crystalline and sedimentary rocks located in areas of tectonic and seismic stability.

Both spent fuel and high-level waste canisters could be disposed in very deep holes. However, it is not economically feasible to dispose of high-volume wastes [e.g., transuranic (TRU) waste] in this manner. Thus an alternate disposal method, such as deep geologic repositories, would also be required if spent fuel were reprocessed. There is some question as to whether holes of the required size and depth could be drilled.

The principal advantage of the very deep hole concept is that certain HLW such as that produced at SRP can be placed farther from the biosphere in a location where it is believed that circulating groundwater is unlikely to communicate with the biosphere. Very deep hole concept is a backup disposal technology; development of this technology would take 12 to 25 years.

2.5 CONCLUSIONS AND RECOMMENDATIONS

The no-action disposal alternative involves continuing present practice, which consists of tank storage of the high-level wastes. Tank storage is considered temporary because of the need to replace the tanks periodically. Also, indefinite tank storage would require perpetual surveillance, maintenance, and administrative control to assure adequate long-term isolation of the SRP high-level radioactive wastes from the environment. Extended storage under these constraints increases the radiological risk to man. For these reasons, the no-action alternative is considered unacceptable.

The preferred disposal strategy calls for immobilization and disposal in a mined geologic repository. Identification of the preferred alternative is based on the considerations in DOE/EIS-0023[1] and the resulting policy decision[2] as well as on DOE/EIS-0046F[3] and the preceding discussion.

A mined geologic repository is the preferred disposal option based on its distinct advantages in minimizing radiological effects during the operating period; its advanced status of development and the ability (ease) for corrective or mitigative actions (e.g., retrievability) if its isolation from the human environment is threatened. With respect to the other evaluation factors, the only category in which an alternative technology might offer an advantage would be the radiological effects during the post-operational period for the space disposal option. However, this is considered a long-term advantage which would be more than offset by near term disadvantages.

From the standpoint of technical feasibility, only two of the alternative waste disposal methods appear to warrant further study: subseabed and very deep hole. For subseabed, the DOE has decided to continue studies of the environmental, technical, legal, and institutional feasibility of isolating wastes within the sedimentary geologic formations of the deep seabed. This concept is considered a longer-term complementary disposal method to mined repositories. The DOE also feels that very deep hole disposal warrants some additional study as a possible backup for high-level waste disposal. Further development of the very deep hole concept will emphasize the capability to take corrective or mitigative actions.

The other disposal methods (rock melting, island, icesheet, deep well injection, and transmutation) were found to not have clear advantages over mined geologic disposal and to provide no additional complementary function. In some cases these other technologies appeared clearly less desirable (for instance, in the rock melting disposal concept, the waste is expected to be mobile during the period of greatest hazard.)

In summary, there appear to be no environmental issues that would reasonably preclude pursuit of a strategy favoring disposal of high-level defense wastes in deep geologic repositories. Further, if for any reason this strategy were found to be unacceptable, the use of alternative strategies, very deep hole and subseabed, would not be affected by a decision to immobilize the SRP high-level waste. Various concepts of implementing the immobilization portion of this strategy for the SRP high-level defense waste are evaluated in this EIS.

REFERENCES FOR SECTION 2

1. U.S. Department of Energy, *Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken, South Carolina, Final Environmental Impact Statement,* DOE/EIS-0023, Washington, D.C., November 1979.

2. "Record of Decision for DOE/EIS-0023," *Fed. Regis.* 45(31): 9763-64 (1980).

3. U.S. Department of Energy, *Management of Commercially Generated Radioactive Waste, Vol. 1, Final Environmental Impact Statement,* DOE/EIS-0046F, Washington, D.C., October 1980.

4. "Record of Decision for DOE/EIS-0046F," *Fed. Regis.* 46 (93): 26677-79 (May 14, 1981).

5. U.S. Department of Energy, *Waste Management Operations, Savannah River Plant, Aiken, South Carolina, Final Environmental Impact Statement,* DOE/EIS-0062 (Suppl. to ERDA-1537), Washington, D.C., April 1980.

6. U.S. Department of Energy, *Statement of Position of the United States Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste,* DOE/NE-0007, Washington, D.C., April 1980.

3. IMMOBILIZATION ALTERNATIVES FOR THE DWPF

Assuming the adoption of the preferred disposal alternative (geologic disposal using conventional mining techniques), the SRP defense high-level radioactive waste would have to be processed into a form meeting the repository criteria. The purpose of this section is to describe the immobilization alternatives for an SRP high-level radioactive waste immobilization facility – DWPF – and to provide sufficient technical details to allow the reader to make an independent assessment of the environmental concerns.

Currently, waste awaiting further processing is stored in large underground tanks.[1,2] These wastes will be the feedstocks for each alternative. The total volume of waste to be processed during the lifetime of the facility is identical for each alternative. Timing and details of recovery and utilization of these stored feedstocks to produce immobilized high-level radioactive waste and decontaminated salt containing low levels of radioactivity, however, will differ among the alternatives to be described. Initial treatment of the waste was assumed to occur either in the tanks or in the DWPF itself, depending on the alternative.

Three immobilization alternatives were considered in detail: (1) reference immobilization alternative, (2) delay of reference immobilization alternative, and (3) staged process alternative.

The selection of these three immobilization alternatives for analysis, the detailed description of processing steps, the available process flexibility, and the environmental impact assessments performed should establish a range of potential environmental impacts for possible immobilization alternatives for the SRP defense high-level radioactive waste.

The reference immobilization alternative involves the construction of a large facility starting in 1983 for the integrated processing of sludge and salt to form (1) borosilicate glass* for disposal in a Federal repository and (2) decontaminated salt for disposal at SRP as low-level radioactive waste. The reference facility was developed based on research and development efforts up to 1978; it is based upon the remote operations technology used by the SRP chemical separations facility.

The delay of reference immobilization alternative is the same as the reference immobilization alternative except that construction and operation are delayed until there is assurance a Federal repository will be available to receive the immobilized waste, resulting in minimal interim storage of waste canisters at SRP. A ten-year delay is assumed for this alternative. In the analyses given, the differential effects estimated for the delay of the reference alternative are applicable also to delay of the staged process alternative.

Because of recent program research and planning efforts, a staged process alternative has been developed that begins with sludge processing and later adds salt processing. Utilization of current technology provides for reduction in the size and complexity of the facility and for use of existing facilities to the maximum degree practicable, thereby reducing the cost.

Although the reference design is a technically viable alternative, the staged design achieves the same objective with comparable safety and environmental impact (as discussed in Sect. 5) at less initial cost. The staged concept also allows additional time for technological improvements in salt processing. Accordingly, the staged design is the preferred alternative. J-1

A summary of the three alternatives is presented in Table 3.1. Regardless of the alternative selected for implementation, the ongoing research and development effort will further refine the design, construction, and operational aspects of the DWPF. The process description for the actual DWPF, as built, will probably not be exactly the same as given in any one of the three immobilization alternatives; however, process improvements will not be adopted unless safety analysis indicates acceptable risk and appropriate consideration is given to differences, if any,

*Borosilicate glass has been selected as the reference immobilized form. Research and development programs outside the scope of this EIS are ongoing to determine the preferred form by 1983; these programs are described in Appendix B.

Table 3.1 Summary of DWPF alternatives

A Technical summary

DWPF Alternative	Scope	Plant and process	Construction: Schedule start	Construction: Cost[a]	Construction: Peak manpower	Operation: Schedule start	Operation: Annual cost[a]	Operation: Manpower
Reference[b]	Vitrify sludge and decontaminate and immobilize salt	Canyon bldg , glass interim storage bldg Saltcrete plant and disposal area Canyon contains sludge preparation glass melting, ion exchange for salt decontamination, canister finishing equipment two calciners, and solid-feed glass melters	10 82	$1 6 × 10^9	5000	1989	$80 × 10^6	670
Delay	Same as for reference facility except delayed 10 years	Same as for reference facility except minimum sized interim storage building	10 92	$1 6 × 10^9	5000	1999	$80 × 10^6	670
Staged								
Stage 1	Vitrify sludge	Sludge preparation in waste tanks Building has one liquid-fed glass melter and modified canister finishing equipment Expandable glass storage building has initial capacity to store 2-years production	10 82	$520 × 10^6	3000[c]	1988	$28 × 10^6	240
Stage 2	Decontaminate and immobilize salt	Canyon has ion-exchange equipment and filters Salt preparation in waste-tank area Saltcrete facility to concentrate decontaminated supernatant by evaporation and mix it with concrete Engineered disposal area for saltcrete	10 85	$700 × 10^6	3000[c]	1991	$23 × 10^6	290
Total stages 1 and 2				1220 × 10^6			51 × 10^6	530

B Impact summary

Issue	Reference immobilization DWPF[b]	Delayed reference DWPF	Staged process DWPF
Socioeconomic effects	(1) DWPF and Vogtle[d] construction on schedule Minor impacts because of increase in work force - mitigated by release of workers from Vogtle plant construction One county may have school and housing impacts (2) DWPF on schedule and Vogtle delayed 2 years Impacts somewhat greater than for Vogtle on schedule due to increased level of in-movers above that of case (1) above	Impacts greater than for reference DWPF because of sharp increase in work force without mitigation by Vogtle work force release	Impacts lower than for either reference DWPF or delayed DWPF work force is roughly 60% of that for other alternatives
Health risks	Negligible impacts are anticipated (max individual exposure of 0 16 millirem per year)	Same as for reference DWPF	Negligible impacts are anticipated (max individual exposure of 0 20 millirem per year)
Ecological effects	Wildlife habitat will be displaced temporary siltation of surface streams will occur, one carolina bay wetlands area will be eliminated,	Same as for reference DWPF	Similar to reference DWPF except that less land area will be disturbed
Land use	About 140 ha will be disturbed during construction, about 80 ha will be retained for operation	Same as for reference DWPF	About 120 ha will be disturbed during construction about 65 ha will be retained for operation
Air quality	Particulates, SO_x, CO, HC, and NO_x will be released from coal-fired power plant, drift will be released from cooling towers, and diesel-generating exhaust will be emitted	Same as for reference DWPF	Only cooling tower drift and diesel generator exhaust will be emitted, no power plant is required for this alternative Incremental effects will result from generation of power at existing plants
Water quality	Treated liquid effluents will be discharged to surface streams.	Same as for reference DWPF	Similar to reference DWPF except that coal associated effluents will be absent
Transportation	Nonradiological accidents will account for a maximum of 1 6 injuries and 0 1 deaths per year	Same as for reference DWPF	Same as for reference DWPF
Resource commitment	Resources include materials for both constructions and operation	Same as for reference DWPF	Quantities committed are lower than for the reference DWPF
Postulated accidents involving radioactive releases	Negligible impacts are anticipated (maximum individual exposure of 0 32 millirem per year)	Same as for reference DWPF	Negligible impacts are anticipated (maximum individual exposure of 0 04 millirem per year)

[a]Cost in FY-1980 dollars

[b]The reference DWPF is taken as the base case for comparison purposes only the staged process DWPF is the preferred alternative

[c]Total for stages 1 and 2

[d]The Vogtle Power Plant is a nuclear power plant being constructed by the Georgia Power Company within 20 km of the proposed DWPF

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in environmental impacts. The proposed DWPF will be located on the SRP. The SRP physical security system and emergency response system will be modified to provide the necessary protection for the DWPF.

Descriptions of the alternatives use the reference immobilization alternative as the base and, unless there are changes, descriptions for the delay of reference immobilization alternative and the staged process alternative will not be repeated. Additional information on selected feed streams, effluent streams, and immobilized high-level waste product may be found in Appendix O.

3.1 REFERENCE IMMOBILIZATION ALTERNATIVE

3.1.1 Process description

High-level radioactive wastes are stored in tanks at SRP as insoluble sludges, precipitated salts, and supernatant liquid. The reference immobilization process (Fig. 3.1) includes the removal of wastes from tank storage; pretreatment of sludge to remove most of the alumina and soluble salts; treatment of the salt to remove cesium, strontium, and plutonium; immobilization of the high-level sludge and recovered cesium and strontium and plutonium in borosilicate glass; encapsulation of the waste/glass mixture in steel canisters; storage of the canisters in a surface facility until shipment to a repository; and processing the decontaminated salt into saltcrete monoliths for intermediate-depth burial onsite as low-level radioactive waste. The following discussion describes the wastes, the processes proposed for their treatment, and points of potential release to the environment.

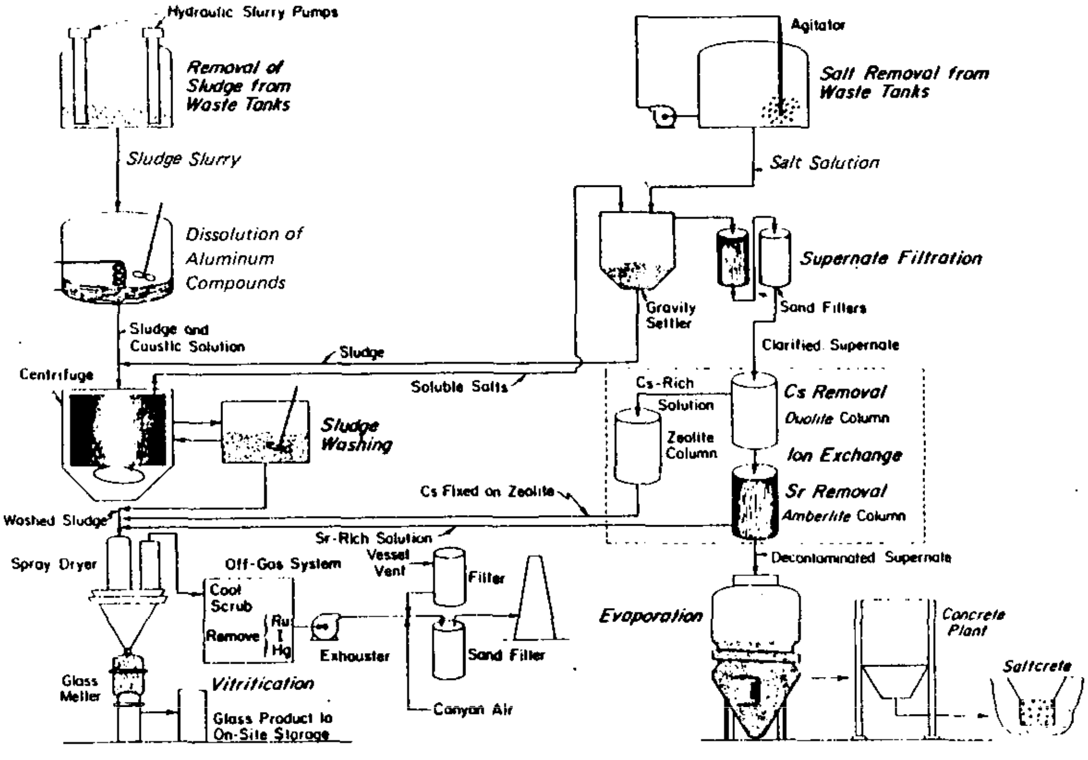

Fig. 3.1. Defense waste processing reference flowsheet. Source: E. I. du Pont de Nemours and Co., modified from *DWPF Technical Data Summary No. 3*, DPSTD-77-13-3, April 1980, Fig. 1.1.

3.1.1.1 Description of wastes[3]

Chemical separations of irradiated fuel and targets at SRP produce product streams, an acidic liquid waste stream containing almost all of the fission products, and minor releases to the atmosphere and to seepage basins. The acidic waste stream is changed chemically to an alkaline solution before being transferred to storage in large underground tanks in the F and H chemical separations areas.

In the tanks, waste components that are insoluble in the alkaline solution settle and form a layer of sludge on the tank bottom. Most of the radionuclides are contained in the sludge; however, the supernatant also contains some soluble radioactive elements, predominantly cesium and some strontium. Once the sludge has settled to the tank bottom, most of the supernatant is removed and concentrated by thermal evaporation. The hot concentrate is transferred to cooled waste tanks where the cooling causes salts to crystallize.

The projected total volume of wastes to be stored in tanks by 1989, when startup of the reference case DWPF is scheduled, is about 100,000 m^3. Estimated volumes of sludge, saltcake, and supernatant are 15, 62, and 24 x 10^3 m^3, respectively. A total of 27 tanks including 10 currently under construction are expected to be in service in 1989 to store these wastes. Four additional tanks will be constructed as feed and blend tanks for the DWPF.

Chemical separations of irradiated fuel will continue to the year 2002, from which 5 to 10 x 10^3 m^3 of additional fresh wastes per year are anticipated.* During this period water will continue to be removed from the stored wastes resulting in a total projected waste volume of 20 x 10^3 m^3 sludge and 87 x 10^3 m^3 saltcake. No additional tank requirements are anticipated, however, because of the storage that will be made available as a result of waste processing and immobilization. The average chemical and radionuclide compositions of fresh (aged six months after discharge from the reactors) high-level liquid wastes from chemical separations operations are summarized in Tables 3.2 and 3.3, respectively. Waste composition and characteristics are variable from tank to tank and within a tank as a function of location and depth because of variability in fresh wastes and because fresh and aged wastes have been mixed in some tanks. The processes and equipment selected for the DWPF will be designed to accept these variations.

Table 3.2. Average chemical composition of fresh (aged 6 months) SRP high-level waste

Constituent	Concentration	
	Molar	g/L
$NaNO_3$	3.3	281
$NaNO_2$	<0.2	<14
$NaAl(OH)_4$	0.5	59
NaOH	1	40
Na_2CO_3	0.1	11
Na_2SO_4	0.3	43
$Fe(OH)_3$	0.07	7.5
MnO_2	0.02	1.7
$Hg(OH)_2$	0.002	0.5
Other solids[b]	0.13[a]	7.8

[a]Assuming an average molecular weight of 60.

[b]Includes all radioactive components-fission products, uranium, and transuranics.

Source: U.S. Department of Energy, FEIS, *Long-Term Management of Defense High-Level Radioactive Wastes*, DOE/EIS-0023, November 1979, Sect. IV, Table IV-1, p. IV-2.

3.1.1.2 Removal of wastes from storage tanks[4]

About 280 x 10^3 m^3 of water will be required to remove the total projected sludge and saltcake (20 and 87 x 10^3 m^3, respectively) from the tanks. The total volume of waste to be processed

*This volume is based on the assumption that the three SRP reactors continue to operate through the year 2000. In addition, a fourth reactor is assumed to resume operation about 1984.

Table 3.3. Average radionuclide composition of fresh[a] SRP high-level waste

Radionuclide	Ci/L	Radionuclide	Ci/L
^{95}Nb	2.8E+1[b]	^{241}Am	3E-4
^{144}Ce-^{144}Pr	1.8E+1	^{99}Tc	1E-4
^{95}Zr	1.6E+1	^{239}Pu	8E-5
^{91}Y	1.2E+1	^{154}Eu	3E-5
^{89}Sr	9.5E0	^{93}Zr	3E-5
^{141}Ce	3.2E0	^{240}Pu	2E-5
^{147}Pm	3.2E0	^{135}Cs	1E-5
^{103}Ru	2.6E0	^{126}Sn-^{126}Sb	3E-6
^{106}Ru-^{106}Rh	1.1E0	^{79}Se	3E-6
^{90}Sr	8E-1	^{233}U	5E-7
^{137}Cs	8E-1	^{129}I	3E-7
^{129}Te	5E-1	^{238}U	2E-7
^{127}Te	5E-1	^{107}Pd	1E-7
^{134}Cs	3E-1	^{237}Np	1E-7
^{151}Sm	2E-2	^{152}Eu	5E-8
^{238}Pu	3E-3	^{242}Pu	2E-8
^{241}Pu	5E-4	^{158}Tb	2E-8
^{244}Cm	3E-4	^{235}U	8E-9

[a] After processing irradiated fuel and targets that have cooled six months after discharge from the reactor.
[b] Read as 2.8×10^1.
Source: U.S. Department of Energy, *FEIS, Long-Term Management of Defense High-Level Radioactive Wastes*, DOE/EIS-0023, November 1979, Sect. IV, Table IV-2, p.IV-3.

over the assumed 28-year life of the plant is, therefore, projected to be approximately 390 x 10^3 m^3. The supernate fraction (redissolved aged salt and decanted supernate) and the sludge-slurry fraction will be pumped as separate feedstreams to the DWPF for pretreatment and processing.

Recycle water from the DWPF, supplemented if necessary by water from the F and H chemical separations areas and fresh water, will be used for salt dissolution. The total radionuclide activities for salt/supernatant wastes aged 5 years* and 15 years* are about 2.1 and 1.5 Ci/L, respectively.

Sludge removal from tanks in each area will be accomplished by suspending the insoluble particles in a vigorously agitated water solution and transferring the resulting 1:1 sludge:water slurry in increments of about 760 m^3 to one of the two sludge feed tanks. Equivalent volumes of slurry from the storage tanks in the F and H chemical separations areas will be blended to provide the sludge-slurry feed. The radionuclide activities of sludge-slurry feed from wastes aged 5 years and 15 years are about 20 Ci/L and 9.5 Ci/L, respectively.

3.1.1.3 Sludge preparation[4]

Sludge slurry from slurry feed tanks will be processed in the DWPF at a design rate of 7.65 L/min. After the sludge stream is received in the DWPF, the sludge will be boiled with sodium hydroxide to dissolve approximately 75% of the insoluble aluminum compounds present. Aluminum removal will reduce the quantity of feed to be vitrified and will permit use of a lower vitrification temperature with attendant benefits in reduced volatility of radionuclides and melter corrosion.

Following dissolution of most of the aluminum compounds, the sludge slurry will be washed and centrifuged twice to separate the insoluble sludge from the water-soluble salts, producing a sludge containing a maximum of 2 wt % (2% based on weight) soluble salt on a dry basis. The wash solutions will be evaporated in the recycle evaporator. The evaporator condensate will be reused in the process, and the evaporator bottoms will be sent to the gravity settler.

*Specific design criteria for processes leading up to and including waste immobilization include the selection of sludge that has aged a minimum of 5 years and saltcake that has aged a minimum of 15 years.

3.1.1.4 Salt and supernatant preparation[4]

Salt solution from feed storage tanks will be processed in the DWPF at a design rate of 42 L/min. The salt feed solution initially will be clarified in two steps: (1) the addition of a polyelectrolyte and heat to agglomerate any entrained, suspended solids (the treated solution will be allowed to settle in a gravity settler); and (2) the clarified supernatant from the gravity settler will be decanted and filtered through two sand beds in series. The bottoms from the gravity settler (containing any insoluble sludge) and the sludge stream will be routed to the sludge preparation process.

Filtered supernatant will be processed through two ion-exchange steps in series — the first to remove cesium and plutonium and the second to remove strontium. These steps reduce the radioactivity in the salt solution to levels such that it can be handled and disposed of in a less restrictive manner than the immobilized high-level wastes. The decontaminated salt solution from the ion-exchange steps will be pumped to the saltcrete facility and concentrated by evaporation to a nominal 35 wt % solution. Condensate from the evaporation of salt solution will be reused in the process.

Cesium, plutonium, and strontium will be eluted from the loaded ion-exchange columns, concentrated by evaporation and mixed with the washed sludge for vitrification.

3.1.1.5 Selective recovery of waste constituents for beneficial use[5]

Because preparation of salt solution includes steps to remove soluble cesium and strontium via ion exchange, recovery of one or both of these radioisotopes for potential beneficial use(s) rather than immobilization is possible but not planned for the DWPF. Well-developed technology exists for separating and packaging ^{90}Sr and ^{137}Cs, for which plant-scale procedures have been devised and currently are in operation at the DOE Hanford Plant at Richland, Washington. The purpose for recovery and storage of these radionuclides at Hanford, however, has been to reduce the heat generation in the storage tanks, which, unlike the tanks at SRP, are not provided with cooling coils.

Experience at Hanford has demonstrated an increased production of secondary wastes because of the addition of salting agents or other compounds for isotope recovery. For example, nearly three volumes of intermediate liquid wastes are generated at Hanford to recover cesium (95% recovery) and strontium (70% recovery) from one volume of high-level waste. Additionally, ^{90}Sr and/or ^{137}Cs recovery can lead to increased transportation requirements and increased occupational and public exposure to radiation.[6] Potential commercial applications of these isotopes have been explored, including remote heat and power generation, sewage treatment, food preservation, and medical supply sterilization. To date, however, there has been only limited use of these radioisotopes. Sewage sludge sterilization is in the demonstration stage. None of the cesium and strontium stored at Hanford has found commercial application.

Recovery of potentially useful nonactinide products from defense radioactive wastes does not appear to be justified economically because of the high cost of waste processing compared with the value of available product. Limits on demand for the waste products, because of insufficient development of applications or restrictions on use of slightly radioactive materials, may further reduce cost effectiveness of waste-product recovery.[7]

3.1.1.6 High-level waste immobilization and transfer to storage[4,8]

Washed sludge, cesium-zeolite slurry, and concentrated strontium solution will be combined in the slurry mix tank and subsequently dried in an electrically heated spray calciner to convert the sludge-slurry mix into a powder or calcine. The dried waste, falling by gravity from the spray calciner into the joule-heated continuous glass melter, will be combined with glass frit on a 35% waste/65% frit basis (by weight). Figure 3.2 shows the vitrification process schematic.

B-1 Approximately 213 kg/h of water vapor and 118 kg/h of air will be generated as off-gases from the spray-calcining, glass-melting operations, along with much of the mercury in the waste and small amounts of iodine, ruthenium, and cesium. The off-gases will be cooled to remove water and the condensable chemical species and filtered before passing through ruthenium- and iodine-absorber beds. Mercury will be separated and sent to a mercury-recovery facility, where it will be cleaned, bottled, and stored for reuse. Water will be transferred to the recycle evaporator. Treated off-gas will be filtered and released up the stack.

The resulting molten borosilicate glass will be poured at 1150°C into a 304-L stainless steel canister (Fig. 3.3) at a rate of about 112 kg/h. When the canister is filled (625-L glass

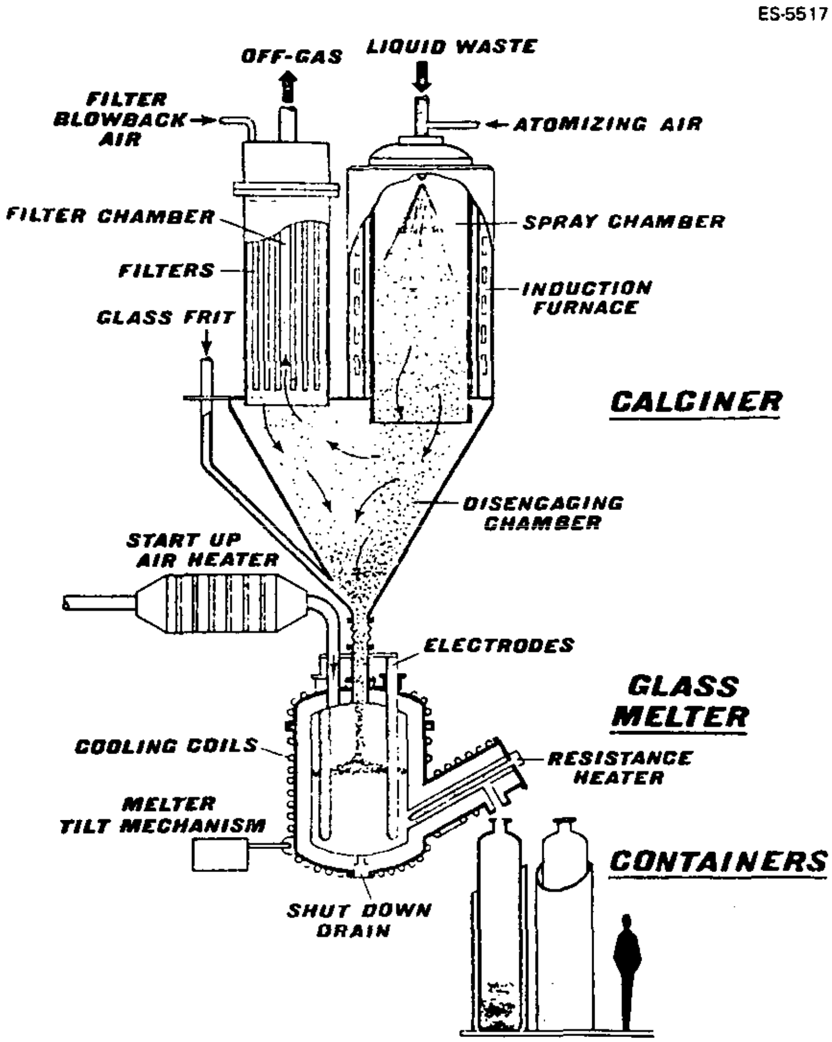

Fig. 3.2. Vitrification process schematic. Source: E. I. du Pont de Nemours and Co., *Process Arrangement Options for Defense Waste Immobilization,* DPST 80-203, February 1980.

weighing 1480 kg), the melter will be tilted to stop the glass flow, permitting the next canister to be located in the fill position. The filled canister will be transferred by crane and transfer car to a mechanical cell, at which point a plug is welded in place. The canister will be leak-tested and moved to other cells for surface decontamination using $HF-HNO_3$ and a final smear test.

The borosilicate glass will contain about 28 wt % waste oxides and have the nominal chemical composition shown in Table 3.4. The characteristics of waste in a single container are estimated to be:[9]

	5 year	15 year
Total activity	184,000 Ci	104,000 Ci
Heat generation	540 W	310 W

The DWPF will be designed for a production rate of 1.88 canisters of vitrified high-level waste per day.[4] The average production rate is expected to be about 1.4 canisters per day (500 canisters per year).

The filled, seal-welded, leak-tested, decontaminated canisters of waste will be moved on a transfer car to the final check station where they will be remotely measured for gamma radiation and surface temperature. The canisters will then be moved by transfer car through an airlock and loaded into a shielded cask for transfer to the waste storage building.

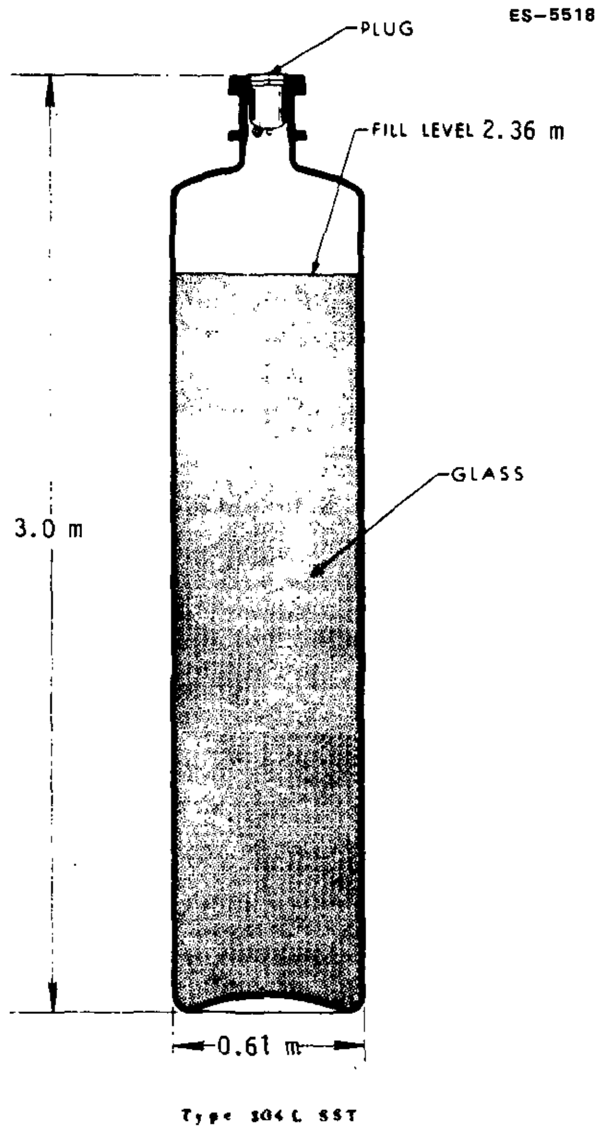

Fig. 3.3. Defense waste processing canister: glass volume, 625 L; glass weight, 1480 kg. Source: E. I. du Pont de Nemours and Co., *Process Arrangement Options for Defense Waste Immobilization,* DPST 80-203, February 1980.

3.1.1.7 Processing and disposal of decontaminated salt[4]

Salt solution from the salt pretreatment process (Sect. 3.1.1.4) will be transferred from the DWPF by pipeline to a salt solution storage tank at the saltcrete facility. The salt solution will be dewatered by evaporation to a nominal 35 wt % salt concentration and mixed with cement to bind any residual radioactivity in a concrete matrix. The saltcrete will be proportioned by weight to produce a formulation of 35 parts salt, 65 parts water, and 130 parts cement (15 wt % salts in concrete).[4] The resulting radioisotopic content and chemical composition are listed in Tables 3.5 and 3.6, respectively. Anticipated practice will be to process waste aged at least 15 years. Saltcrete will be produced in batches two days per week on a 6-h operating day. Approximately 530 m^3 of saltcrete will be produced each week, based on processing high-level waste at an average rate of 37 L/min.

Condensate from the evaporation (concentration) of salt solution will be reused in the process for flushing equipment and piping. Any excess condensate will be returned to the general purpose evaporator system.

Table 3.4. Chemical composition of reference glass waste form

Oxide	Source[a]	Amount (wt %)
Li_2O	F	4.08
B_2O_3	F	10.5
TiO_2	F	0.718
CaO	F + S	0.843
Na_2O	F + S	13.7
SiO_2	F + S	42.2
Fe_2O_3	S	11.8
Al_2O_3	S	2.38
MnO_2	S	3.39
U_3O_8	S	1.09
NiO	S	1.45
Zeolite	S	2.60
MgO	F	1.43
ZrO_2	F	0.357
La_2O_3	F	0.357
Other solids	F + S	3.03
Nonreactive salt	S	0.0984
Density		2.37 g/mL @ 1100°C 2.8 g/mL @ 120°C

[a]F = Frit; S = composite sludge.
Source: TDS, DPSTD-77-13-3, Table 3.1.

After mixing, the saltcrete will be transported by pipeline to trenches (6.1 m deep x 6.4 m wide x 15.8 m long) at an intermediate depth (≥10 m below ground level) for disposal as low-level waste. At the end of each operating period, the equipment and pipeline will be flushed with condensate under high pressure from the product-salt evaporator, and the flush water will be discharged to the trench. Before the transfer pipeline is flushed, a compressed-air-driven "pig" will be pushed through it to remove residual saltcrete.

3.1.1.8 Effluent control and processing[10,11]

Liquid wastes

DWPF operations will produce significant quantities of radioactive and nonradioactive liquid wastes that will require treatment before discharge. For radioactive liquid wastes, two treatment systems, a recycle evaporator and a general-purpose evaporator, will be provided. A flow diagram of the radioactive liquid waste treatment system is shown in Fig. 3.4.

The recycle evaporator system, located in the canyon building, will (1) receive the more contaminated waste streams (chemical and/or radioactive) at an average feed rate of 91 L/min, (2) concentrate them by evaporation, (3) isolate the evaporator overheads for process reuse or transfer to the general-purpose evaporator system, and (4) recycle the evaporator bottoms to the process.

The general-purpose evaporator system, located outside the canyon processing area in a lightly shielded facility, will (1) receive the condensate from other evaporation systems, (2) concentrate it by evaporation, and (3) isolate the evaporator overheads condensate for controlled discharge to Four Mile Creek or reuse in ion-exchange operations in the canyon process. The general-purpose evaporator bottoms will be returned to the recycle evaporator system.

All canyon floors will be sloped to drain to sumps provided in each building section to collect spillage and washdown liquids. The liquids will be returned to the recycle collection tank and subsequently to the recycle evaporator feed tank.

Nonradioactive chemical and industrial wastes resulting from water treatment operations, boiler and cooling tower blowdown, accidental spillage of cold-feed chemicals, or rainwater that has been contaminated by leaching of pyrites from the coal pile will be treated before release to comply with U.S. EPA[12-14] and South Carolina regulations[15] and pertinent National Pollutant Discharge Elimination System (NPDES) permits.

Table 3.5. Radionuclide content (nCi/g) of saltcrete[a] — 15-year waste

Isotope	Concentration	Isotope	Concentration
^{3}H	2.0E+1[b]	^{147}Sm	2.4E−7
^{60}Co	<4.0E−3[c]	^{148}Sm	5.6E−13
^{59}Ni	<1.9E−4	^{149}Sm	1.7E−13
^{63}Ni	<1.9E−2	^{151}Sm	2.2E+1
^{79}Se	7.0E−2	^{152}Eu	2.2E−2
^{87}Rb	1.8E−7	^{154}Eu	*c*
^{90}Sr	2.9E−1[d]	^{155}Eu	1.2E0
^{90}Y	2.9E−1[d]	^{206}Tl	7.9E−17
^{93}Zr	1.8E−2	^{207}Tl	9.6E−8
^{95}Zr	*c*	^{208}Tl	1.2E−3
^{94}Nb	<3.0E−7	^{209}Tl	1.0E−11
^{95}Nb	*c*	^{232}U	6.7E−5
^{99}Tc	1.9E+1[d]	^{233}U	9.8E−9
^{106}Ru	1.5E+1	^{234}U	3.6E−4
^{106}Rh	1.5E+1	^{235}U	5.2E−7
^{107}Pd	4.7E−3	^{236}U	1.1E−5
^{110}Ag	*c*	^{238}U	2.9E−6
^{121m}Sn	2.8E−3	^{236}Np	1.7E−10
^{123}Sn	7.9E−11	^{237}Np	8.8E−5
^{126}Sn	1.5E−3	^{236}Pu	6.1E−7
^{125}Sb	6.6E0	^{238}Pu	7.7E−2
^{126}Sb	2.1E−4	^{239}Pu	7.8E−4
^{126m}Sb	1.5E−3	^{240}Pu	5.0E−4
^{125m}Te	8.1E0	^{241}Pu	5.8E−2
^{127}Te	3.7E−12	^{242}Pu	6.6E−7
^{127m}Te	3.7E−12	^{241}Am	2.1E−1
^{129}I	7.3E−2	^{242}Am	1.4E−4
^{134}Cs	*c*	^{242m}Am	1.4E−4
^{135}Cs	6.0E−5	^{243}Am	5.7E−5
^{137}Cs	1.5E+1[d]	^{242}Cm	1.1E−4
^{137m}Ba	1.4E+1[d]	^{243}Cm	4.3E−5
^{142}Ce	9.5E−7	^{244}Cm	1.1E−3
^{144}Ce	*c*	^{245}Cm	6.6E−8
^{144}Pr	*c*	^{246}Cm	5.2E−9
^{144m}Pr	*c*	^{247}Cm	6.5E−15
^{144}Nd	4.8E−11	^{248}Cm	6.7E−15
^{147}Pm	1.6E0[d]		

[a]The isotope concentrations were computed by a computer model which simulates the flow of isotopes through the reference process. Unless otherwise noted, no credit was taken for decontamination by the ion exchange flowsheet except for cesium, plutonium, and strontium. Nuclide concentrations < 1.0E−20 nCi/g are not included.

[b]Read as 2.0×10^{1}.

[c]Based on chemical analyses (see footnote d) the total contribution from these isotopes is <0.5 nCi/g.

[d]These values were determined analytically after actual SRP waste supernate was clarified and treated by the reference ion exchange process.

J-9 Source: TDS, DPSTD-77-13-3, except ^{59}Ni, ^{63}Ni, and ^{94}Nb which are from unpublished data.

Table 3.6. Major chemical constituents of saltcrete

Compound	wt %
$NaNO_3$	5.89
$NaNO_2$	2.10
NaOH	3.07
$NaAlO_2$	1.29
Na_2CO_3	1.40
Na_2SO_4	1.18
$Na_2C_2O_4$	0.0169
NaCl	0.0419
NaF	0.00274
$Na[H_gO(OH)]$	0.00837
H_2O	29.2
Cement	55.8

Source: TDS, DPSTD-77-13-3.

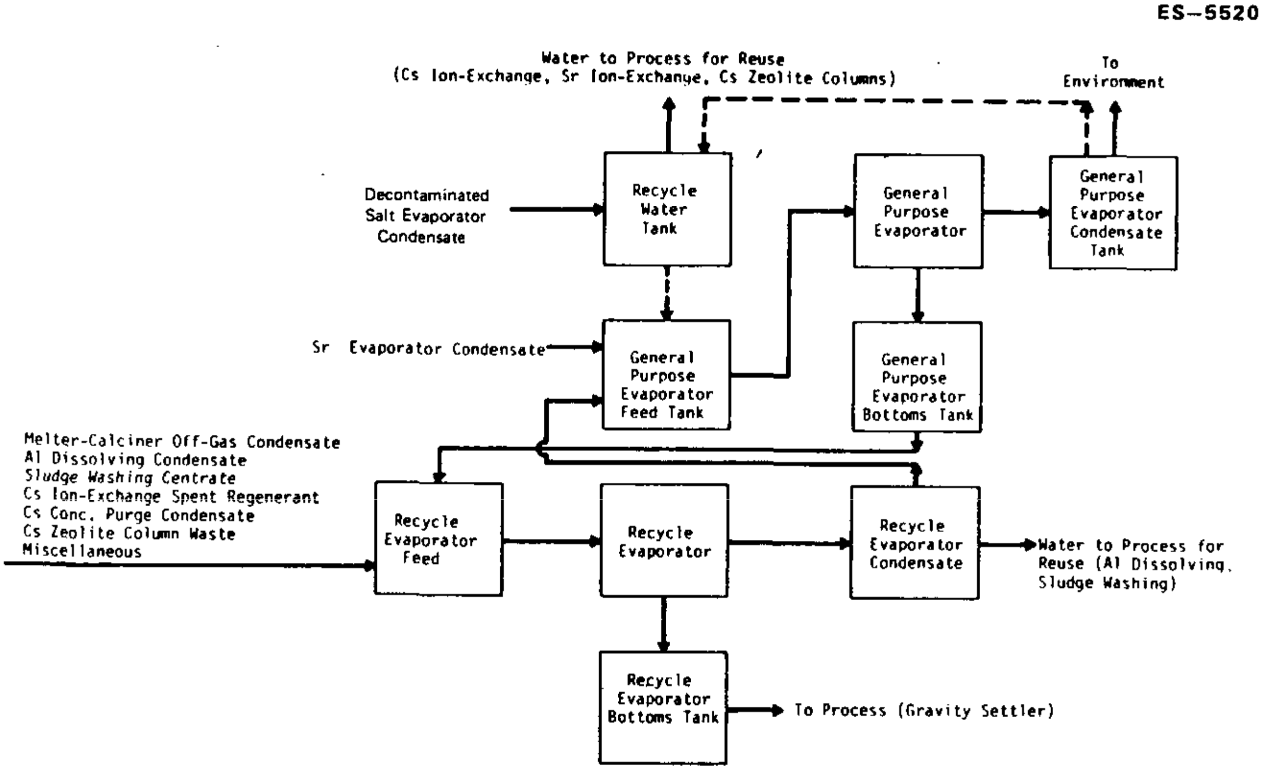

Fig. 3.4. Radioactive liquid waste treatment flow sheet. Source: EID, Fig. 3.5.1-1, Sect. 3.5.

Gaseous wastes

Facilities will be provided to collect vapors and off-gases from process vessels and tanks. The process vessel vent system (PVVS) will provide high-efficiency, first-step filtration of these gases for removal of radioactive particulates. To minimize the diffusion of radioactively contaminated process vapors and particulates into the canyon areas of the DWPF, all equipment will be connected into the PVVS. The vessel vent header, operated at subatmospheric pressure, will be connected to filters, one in each of the two main canyons. These headers will be sloped and positioned so that any condensate drains from the filter housing to the canyon for collection. The vessel vent blowers will exhaust the gases from the canyon operating area to the canyon exhaust air plenum, which is routed through a sand filter to remove particulates before the gases exhaust to the stack. Figure 3.5 shows the off-gas treatment flow sheet.

Off-gases from the calciner/melter will be scrubbed with the condensate. This scrub solution will be collected with other liquids and recycled to the liquid waste treatment process. Scrubbed off-gases will pass through primary and secondary deep-bed filters and subsequently be preheated to the ruthenium absorption temperature (approximately 10°C above the dew point of the gas stream). The hot off-gases will pass through two ruthenium absorbers and then through two iodine absorbers before being cooled and exhausted to the sand filter and stack. Condensate will be collected in the recycle collection tank, along with other collected liquids, for recycle to the liquid waste treatment process.

Solid wastes

Resins used in cesium and strontium ion-exchange operations will be subject to degradation as a result of chemical and/or radiation damage. When the ion-exchange performance deteriorates below an acceptable level, the degraded resins will be slurried from the columns and replaced with new resin. The resins are anticipated to require replacement about once a year, at which time they will be packaged for burial.

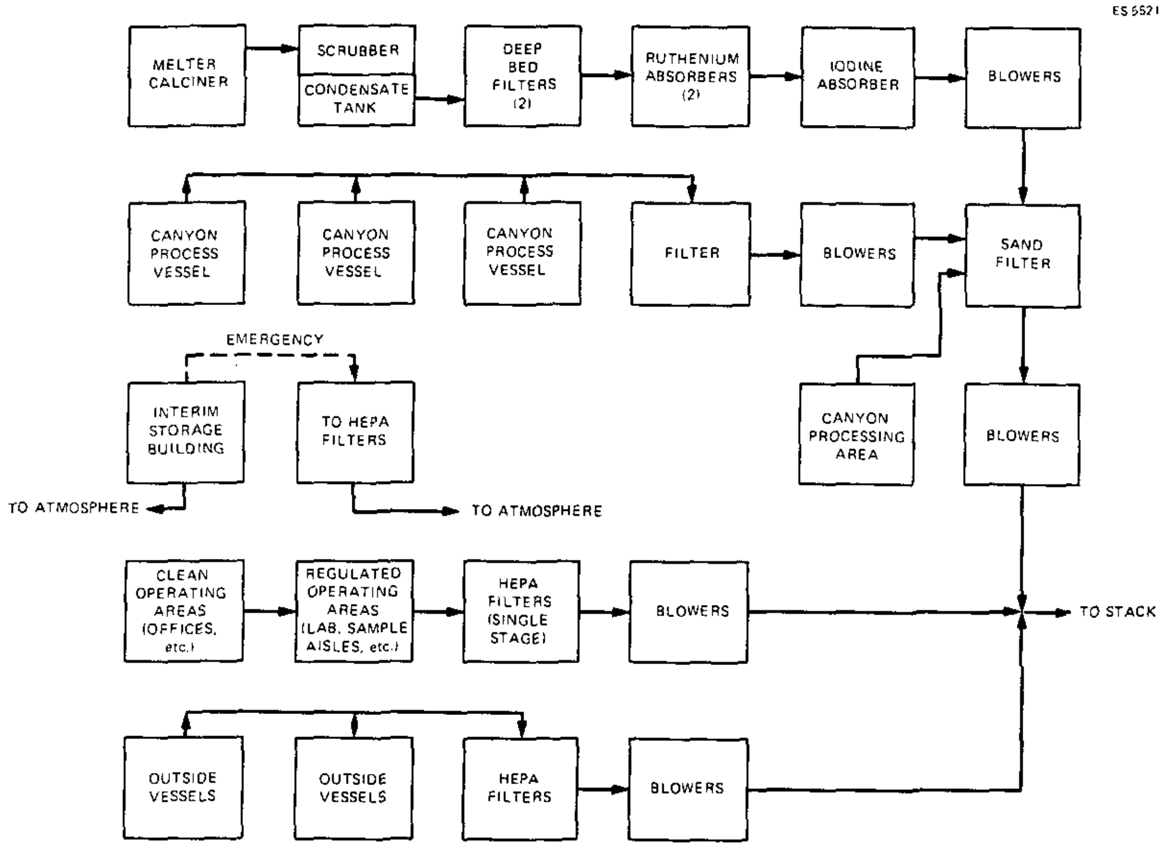

Fig. 3.5. Radioactive gaseous waste treatment system. Source: EID, Sect. 3.

Failed equipment will be emptied and flushed in place and then removed remotely to a decontamination cell. After decontamination, the equipment will be repaired in a regulated maintenance shop. Unrepairable equipment will be decontaminated, packaged, and transferred to the SRP burial facilities.

3.1.2 Site selection

Due to current regulations, which preclude transport of liquid high-level radioactive material, and the desire to minimize piping of the waste and the associated risk, the site selection process was carried out to include only those areas within the SRP. Alternative sites outside the SRP are not considered to be viable or reasonable alternatives to the choice of a site near the current HLW storage area.

3.1.2.1 DWPF site

The DWPF site will require about 60 ha (150 acres). When the site selection process began, many sites near both F- and H-Areas were considered potentially viable. The list of candidate sites was reduced to three (Fig. 3.6), which were then judged on the basis of many criteria including

J-10

1. Proximity to waste storage tanks in H-Area. It is desirable to keep the transport distance for contaminated waste as short as possible.
2. Proximity to the preferred salt disposal site (Z-Area).
3. Suitability of the terrain to construction. Should be relatively level with good drainage area and ample space for the initial facility, future expansion, and construction requirements.
4. Depth to water table.

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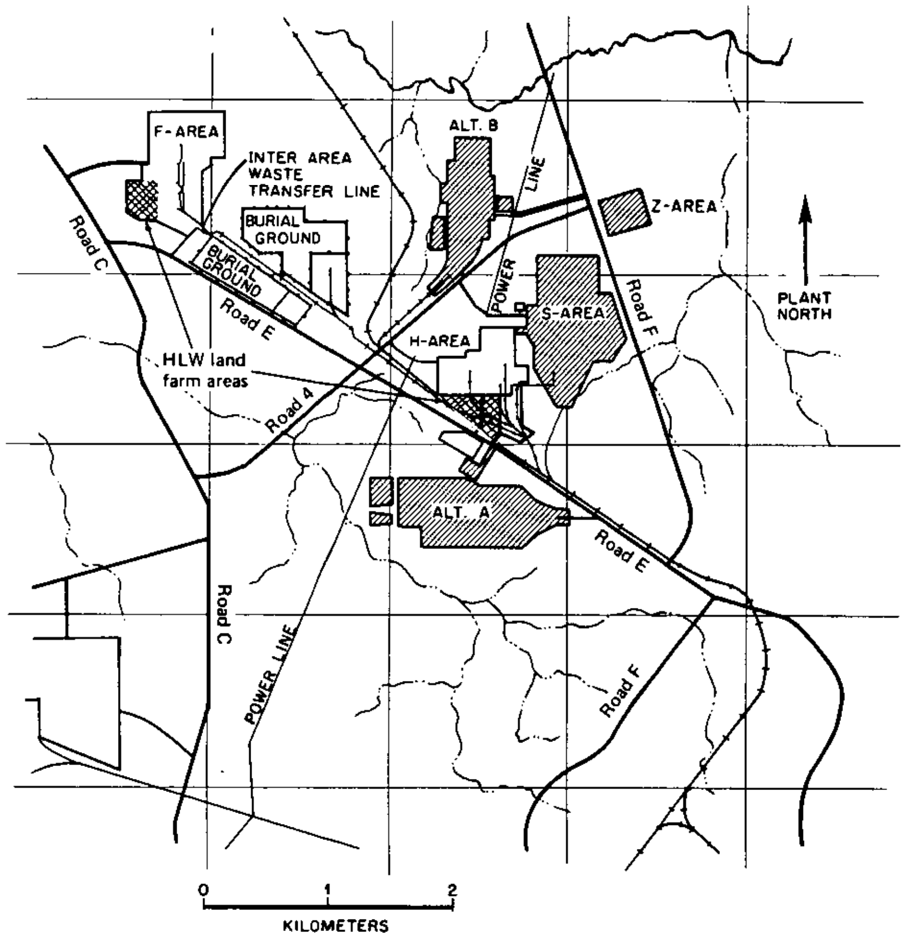

Fig. 3.6. Location of the proposed site for the DWPF (S-area) and alternative sites A and B. The proposed site for salt disposal (Z-area) lies to the north of S-area at the intersection of SRP roads F and 4. J-10

5. Distance from plant boundary. Facility should be as far as practical from plant boundary to minimize the potential of any routine or accidental stack releases to off-plant population.

6. Distance from rivers, creeks, and flowing streams. Facility should be as far from these as practical to reduce the risk of any radioactive liquids being released accidentally to the streams.

7. Ecological acceptability, with acceptable impacts on important species and habitats.

8. Adequacy of subsoil structure to support large, heavy concrete buildings. Hydrological and geological factors must be acceptable for critical structures.

9. Proximity to existing H-Area for access to utilities. J-10

10. Level of interference (should be minimal) with existing plant operations.

11. Accessibility to plant roads, railroads, electrical power, etc.

The three sites, sites S, A, and B, were then evaluated as follows:

1. Transport of high-level radioactive waste from F and H tank farms to site S or A requires about equal travel distance and considerably greater travel to site B. The shielded pipeline will require crossing plant road E to site A or plant road 4 to site B, either of which is undesirable. A pipeline to site A would also have to cross a drainage course to

Four-Mile Creek. Although double containment is provided with this pipe system, directly crossing the drainage course is undesirable. A pipeline to sites S and B would follow high ground.

2. Site S is close to Z-area. The distance for transporting salt is greater if sites A or B are selected.

3. Site S has a better topography for construction than do the other sites and will provide greater flexibility for future expansion, if required.

4. The railroad is readily accessible to both S- and A-sites, but to enter site A, an additional crossing at road E is required. The road crossing, although not difficult or impractical, is undesirable from an operating standpoint. Rail access to B-site is more difficult and requires a greater length of track.

5. The three sites are about equidistant from the plant boundary.

6. The depth to the water table at site A is about 3 to 4.5 m versus 10 to 15 m for sites S and B. Site A would require more extensive dewatering to excavate for the construction of the seismic- tornado- resistant structures. It is also undesirable to locate lower floors below the water table.

Potential impacts of DWPF releases to streams were of prime importance. The only significant discharge to streams from a DWPF site will be surface runoff from storm drainage. Waste effluents will be minor and will be treated to make their quality acceptable. These wastes will be piped to H-area for discharge into Four Mile Creek. Site A is the preferred site based on aquatic ecology, because construction would primarily affect Four Mile Creek, an already degraded stream, rather than Upper Three Runs Creek, the only relatively undisturbed stream on SRP. S-site is ecologically preferred to site B because it is farther from Upper Three Runs Creek and has less erosion potential.

Based on the evaluations of the three potential sites, it was concluded that S-area is the preferred site, A site ranks second, and B ranks third. A more detailed comparison of the sites is presented in Table 3.7.

3.1.2.2 Saltcrete burial site

The burial site that is selected for disposal of decontaminated salt from the DWPF will be designed and constructed to comply with DOE,[16] EPA, and South Carolina Department of Health and Environmental Control (SC-DHEC) guidelines and regulations applicable to the disposal of both low-level radioactive and hazardous wastes.[13-15] About 20 ha (Fig. 3.7) is needed to allow for operational and perimeter security needs; the preferred area was examined to determine the existance of wetlands or other valuable ecological resources and none were found as indicated below.

J-11 The decontaminated salt will be fixed in concrete or another medium to provide structural stability to the waste and to reduce the leachability of potentially hazardous components. The disposal method will be shallow burial in an engineered landfill. (Burial depths to 10 m are being considered.) Based on proposed NRC rules for low-level radioactive waste sites, active institutional controls will continue after the closure of the disposal site. (The period of active controls is not expected to exceed 100 years.) EPA guidelines and SC-DHEC Hazardous Waste Management Regulations prohibit the contamination of groundwater by potentially toxic substances and provide rules on the design, construction, operation, and monitoring of hazardous-waste landfills. Thus, restrictions imposed by these guidelines and regulations, the hydrological features of SRP, and the proximity to the proposed DWPF are the prime criteria for evaluation and consideration of sites for burial of decontaminated saltcrete.

TC The design of the engineered landfill for the saltcrete, which assumes burial depths to 10 m, as illustrated by Fig. 3.8 requires a minimum depth of at least 18 m from the final grade level to the maximum level of the water table. This criterion is not easy to meet at SRP, where areas of shallow water table are common. Four areas of ridgeland zones were found to be of potential interest by examination of topographic and aerial photographic maps. These are listed in Table 3.8 and are shown in Fig. 3.9. All are upland areas with no wetlands, with small stands of upland hardwoods interspersed in pine stands. Because the sites were ecologically similar and the presence of rare and endangered species on any of the sites was unlikely, ecological characteristics were not included in the comparative site evaluations. Water table data showed that one was borderline from that standpoint and it was eliminated for that reason. Of the three sites with satisfactory water tables, Site 1 offered the major advantage of being close enough to the preferred DWPF site and to the alternate Sites A and B to permit transfer of the partially decontaminated salt by doubly contained pipeline. Movement of this material by truck or rail to

Table 3.7. Comparison of site characteristics of S-area, alternative site A, and alternative site B

Characteristic or criterion	S-area	Alternative site A	Alternative Site B
1. Location to waste			
a. Distance from waste tank storage in H-area[a]	~600 m	~820 m	>1500 m
b. Construction of interarea transfer line			
1. Drainage crossings	None	Surface drainage to Four Mile Creek near H-area ash basin	Surface drainage to Upper Three Runs Creek
2. Road crossings	Service roads in H-area	Service roads in H-area and SRP Road E	Service roads in H-area and SRP Road 4
3. Railroad crossings	Service spurs in H-area	Railroad between F- and H-areas	Service spurs in H-area
2. Distance from plant boundary	10-13 km	10-13 km	10-13 km
3. Distance from streams and drainage	Critical structures about 0.8 km from tributaries to Upper Three Runs Creek	Critical structures other than 1.b above about 0.8 km from Four Mile Creek	Critical structures other than 1.b above about 0.4 km from tributaries to Upper Three Runs Creek
4. Accessibility to saltcrete burial sites			
a. Distance to site 1 (Z)	~700 m	~2500 m	~1100 m
b. Likely mode of transport to site 1	Pipeline	Pipeline	Pipeline
c. Likely mode of transport to other burial sites	Truck	Truck	Truck
5. Subsurface characteristics			
a. Geology	Similar to other sites	Similar to other sites	Similar to other sites
b. Hydrology	Water table 9-15 meters	Water table 3-4.5 meters	Water table 9-15 meters
6. Use of existing facilities			
a. Roads	Similar to other sites	Similar to other sites	Similar to other sites
b. Railroads	Spur will cross small drainage to Upper Three Runs Creek, similar length to alternative A	Spur will cross SRP Road E similar in length to S-area	Spur will cross small drainage to Upper Three Runs Creek, steeper terrain, longer length
c. Power lines	Similar to other sites	Similar to other sites	Similar to other sites
d. Communications	Similar to other sites	Similar to other sites	Similar to other sites
e. Other support facilities	Similar to other sites	Similar to other sites	Similar to other sites
7. Sufficient acreage and suitable terrain	Sufficient area and relatively level	Sufficient area and relatively level	Sufficient area but terrain is steeper
8. Ecological factors			
a. "Wetlands"	Small wetland will be eliminated	Small wetland will be impacted and drainage area near H-area ash basin	No wetlands present
b. Vegetational features	Mostly pine, small stands of upland hardwoods, some bottomland hardwoods will be impacted	Nearly all pine stands	Mostly pine, small stands of upland hardwoods, some bottomland hardwoods will be impacted
c. Drainage and erosion	Drains to tributaries of Upper Three Runs Creek potential for erosion impact to these tributaries	Drains to Four Mile Creek, least erosion potential because of level grades	Drains to Upper Three Runs Creek and its tributaries, high potential for erosional impact because of steep terrain
d. Dewatering during construction	Treated if necessary and released to tributaries of Upper Three Runs Creek	Treated if needed and released to Four Mile Creek	Treated if needed and released to tributaries of Upper Three Runs Creek
e. Endangered species			
1. Federal	None	None	None
2. State	Species of "Special Concern" present	Insufficient information	Insufficient information
f. Operational discharges			
1. Storm sewers	Drain to tributaries of Upper Three Runs Creek	Drain to Four Mile Creek	Drain to tributaries of Upper Three Runs Creek
2. Sanitary water	Spray irrigation	Spray irrigation	Spray irrigation
3. Liquid radioactive releases	Pumped to H-area and released to Four Mile Creek	Released to Four Mile Creek	Pumped to H-area and released to Four Mile Creek
4. Gaseous radioactive releases	Similar for all sites	Similar for all sites	Similar for all sites
5. Coal-fired power plant			
1. Gaseous releases	Similar for all sites	Similar for all sites	Similar for all sites
2. Liquid releases (ash basin discharge)	Treated and pumped to Four Mile Creek	Treated and released to Four Mile Creek	Treated and pumped to Four Mile Creek
6. Cooling tower releases			
1. Atmospheric releases	Similar for all sites	Similar for all sites	Similar for all sites
2. Blowdown	Treated and pumped to Four Mile Creek	Treated and released to Four Mile Creek	Treated and pumped to Four Mile Creek

Table 3.7. (continued)

Characteristic or criterion	S-area	Alternative site A	Alternative site B
7. Chemical and industrial waste discharge	Treated and pumped to Four Mile Creek	Treated and released to Four Mile Creek	Treated and pumped to Four Mile Creek
g. Construction impacts			
1. Terrestrial ecology	Eliminate wetland as breeding site Eliminate habitat for two plants of concern to S.C.	Reduce ecological value of wetland	
2. Aquatic ecology	Increased suspended solids level in Upper Three Runs Creek because of siltation and site dewatering discharges	Increased suspended solids level in Four Mile Creek because of siltation and site dewatering discharges	Increased suspended solids level in Upper Three Runs Creek because of siltation and site dewatering discharges
h. Operational impacts			
1. Terrestrial ecology	Similar for all sites	Similar for all sites	Similar for all sites
2. Aquatic ecology	Increased suspended solids level in Upper Three Runs Creek because of drainage of storm water Similar for other releases	Increased suspended solids level in Four Mile Creek because of drainage of storm water Similar for other releases	Increased suspended solids level in Upper Three Runs Creek because of drainage of storm water Similar for other releases

[a] F area and H area waste tanks are connected by existing interarea transfer lines. H area waste tanks will be used as the staging area before waste is transferred to the DWPF for processing.
Source: EID, Sect. 8.

any of the other areas would present safety and operational disadvantages which were judged to be of significantly more importance than the potential advantage of lower water tables at the other areas.

Detailed ecological examination and biotal surveys were made in the preferred site 1, which has subsequently been designated Z-Area. No unique or significant ecological or biological feature was found, and there are no evidences of rare or endangered botanical species. Specific examination was made to verify the absence of interference with the endangered Redcockaded Woodpecker (Appendix C). These studies have verified the ecological assumptions made during the initial site screening.

3.1.3 Facility description

The immobilization facility and the nearby burial site for the immobilized, slightly radioactive saltcrete are proposed to be located in two undeveloped areas identified as 200-S and 200-Z, respectively (see Fig. 3.6). Existing equipment in the F- and H-area tank farms, such as waste and chemical transfer lines, diversion boxes, and tank farm evaporators, will be used to the maximum extent possible. The additions and changes to the SRP by the new areas include the construction of buildings and facilities described in Table 3.9 and underground transfer lines connecting the S-area with the H-area tank farm and with the Z-area. The 200-S and 200-Z area plot plans are shown on Figs. 3.10 and 3.7 respectively.

3.1.3.1 Waste processing and canister storage facilities

The Canyon Building will be rectangular in shape, 290 m long x 41 m wide x 32 m high, not including the air-supply fan room on the main roof. The building will contain two parallel canyons (process equipment spaces) separated by a multilevel personnel operating area. The process equipment spaces will be surrounded by concrete biological shielding about 1.5-m thick. The Canyon Building and the Interim Storage Building will be designed and built as seismic- and tornado-resistant concrete structures.

The Interim Storage Building, to be located east of the Canyon Building (Fig. 3.10), will provide space for safe handling and temporary storage of filled, sealed waste canisters that are awaiting transfer to a permanent storage location at a Federal repository. The shielded vault will be expandable to store the immobilized waste in the canisters on an as-needed basis; for this analysis, storage capacity of 6500 canisters (13 years' production) was assumed. Natural convection cooling is to be provided with exhaust air directed to a chimney or diverted to HEPA filter systems if radioactivity is detected. The building above the vault will be an enclosed structure of standard construction.*

*Standard construction is of structural steel meeting normal industrial building codes for structures not required to meet seismic or tornado-proof requirements of radioactive containments.

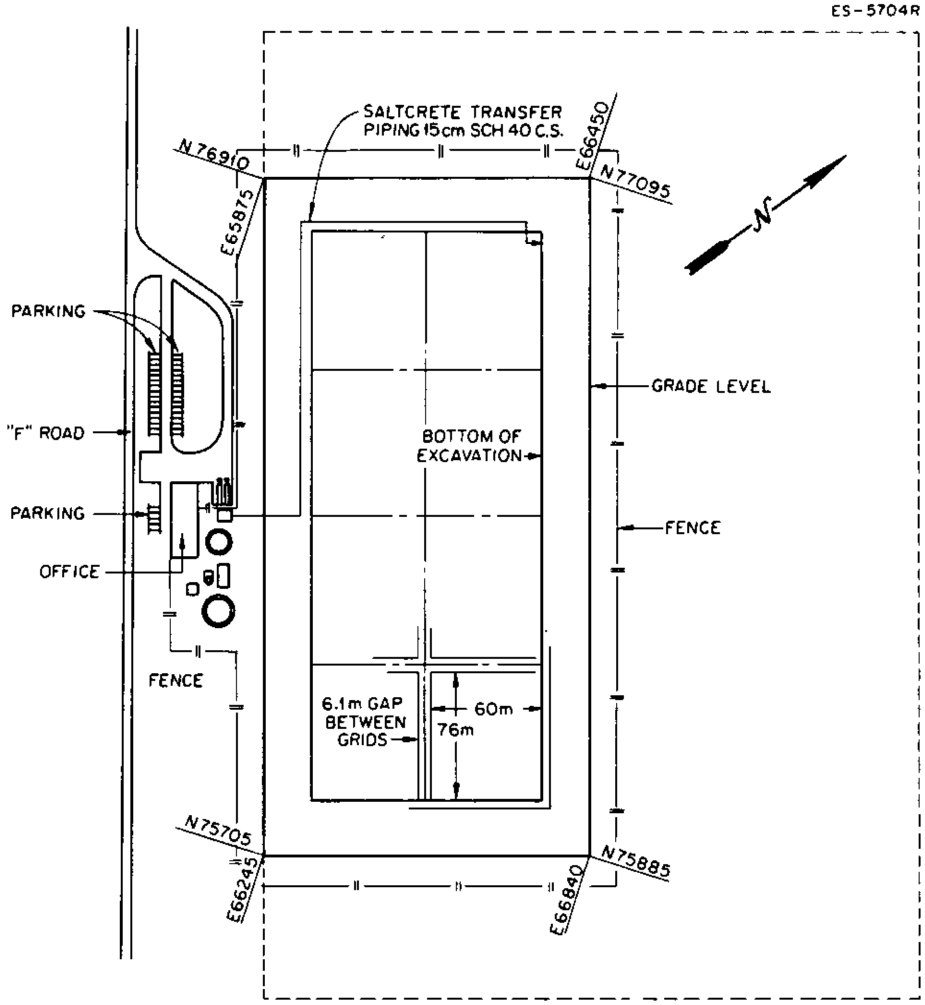

Fig. 3.7. Plot plan of the 200-Z area for saltcrete burial. Source: EID, Sect. 3.

3.1.3.2 Decontaminated salt solidification and disposal facility

The proposed landfill area (200-Z) for saltcrete disposal will be located to the east of and parallel to Road F as shown in Fig. 3.6. This location was selected to provide the maximum depth to the water table. The landfill will encompass about 15 ha exclusive of perimeter fencing. |TE

Saltcrete disposal is assumed to continue for about 28 years to process the total projected volume of saltcake initially stored and generated through the year 2002 (87×10^3 m^3). The landfill area needed to bury the saltcrete monoliths is about 11 ha. Because of the long time needed to dispose of the waste material and the ease of expansion of the landfill, construction of the initial landfill area will provide for disposal of about 40% of the salt waste available at DWPF startup.

The evaporator and the saltcrete production equipment will be housed in standard construction enclosures for weather protection. The evaporator condensers, condensate collection system, storage tanks, and cement silo will be unprotected. However, the storage tanks will be enclosed in dikes for containment of contents in the event of a tank failure.

After the concentrated decontaminated salt solution and the cement are mixed, the saltcrete will be transported to the landfill by pipeline to trenches 6.1 m deep x 6.4 m wide x 15.8 m long. Placing and curing saltcrete monoliths will be done in controlled and ventilated air-support buildings. The landfill will be sectioned into grids, each measuring 60 m by 76 m, with 6.1 m between grids. This sectioning will permit incremental disposal of saltcrete and optimum collection and removal of leachate. Each grid will be encased in a 1.5-m-thick clay barrier of

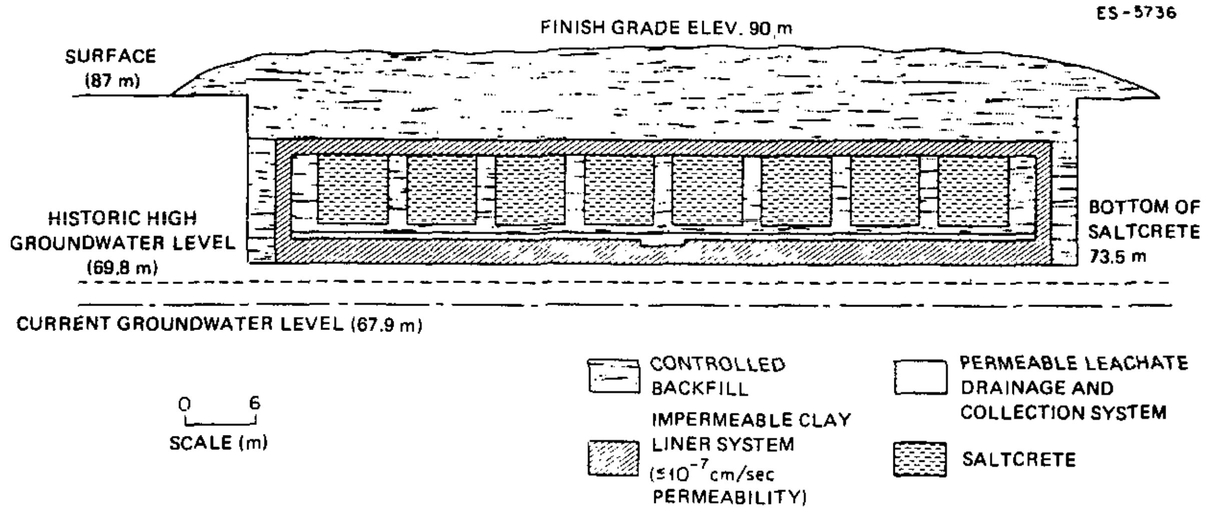

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Fig. 3.8. Typical vertical section, engineered landfill for burial of saltcrete.

Table 3.8. Comparison of proposed decontaminated saltcrete burial sites

Potential site[a]	Location	Depth to water table (m)	Watershed	Distance to S-area (km)	Most likely mode of transfer of salt from S-area
1	North of S-area	18	Upper Three Runs Creek	0.7	Pipeline
2	Southwest of C-reactor	18–21	Four Mile Creek	7.1	Truck
3	West of F-area	18–24	Upper Three Runs Creek	4.4	Truck
4	Southeast of K-reactor	15–18	Pen Branch	11.4	Truck

[a]See Fig. 3.9.
Source: EID, Sect. 8.

low permeability (10^{-7} cm/sec) on the bottom and sides. A collection sump 3.6 by 3.6 m and 0.3 m deep will be located in the middle of each grid. A 0.3-m layer of porous material, along with perforated piping, will be installed on the surface of the bottom clay layer to provide for leachate drainage. Risers (15 and 45 cm in diameter) will be installed between the sump and grade for monitoring and pumpout during operation of the landfill. As each grid is filled, it will be covered with a 1.5-m layer of compacted clay and a 7.6-m layer of compacted backfill.

3.1.3.3 Support facilities

The main process activities require support systems (buildings, facilities, and associated components) to carry out the function of the DWPF successfully. Building and facility locations currently defined are shown in Figs. 3.10 and 3.7. The support systems and their functions are summarized in Table 3.10.

3.1.4 Process/facility flexibility

Development of any major chemical facility is a dynamic operation in which various systems and unit operations/processes are modified and improved. Development of the DWPF is no exception. Major process equipment and facility changes in the reference design may be incorporated to improve process efficiency and reduce capital and operating costs without any reduction in safety requirements. Examples of process and facility changes that have evolved since the reference process was defined include:

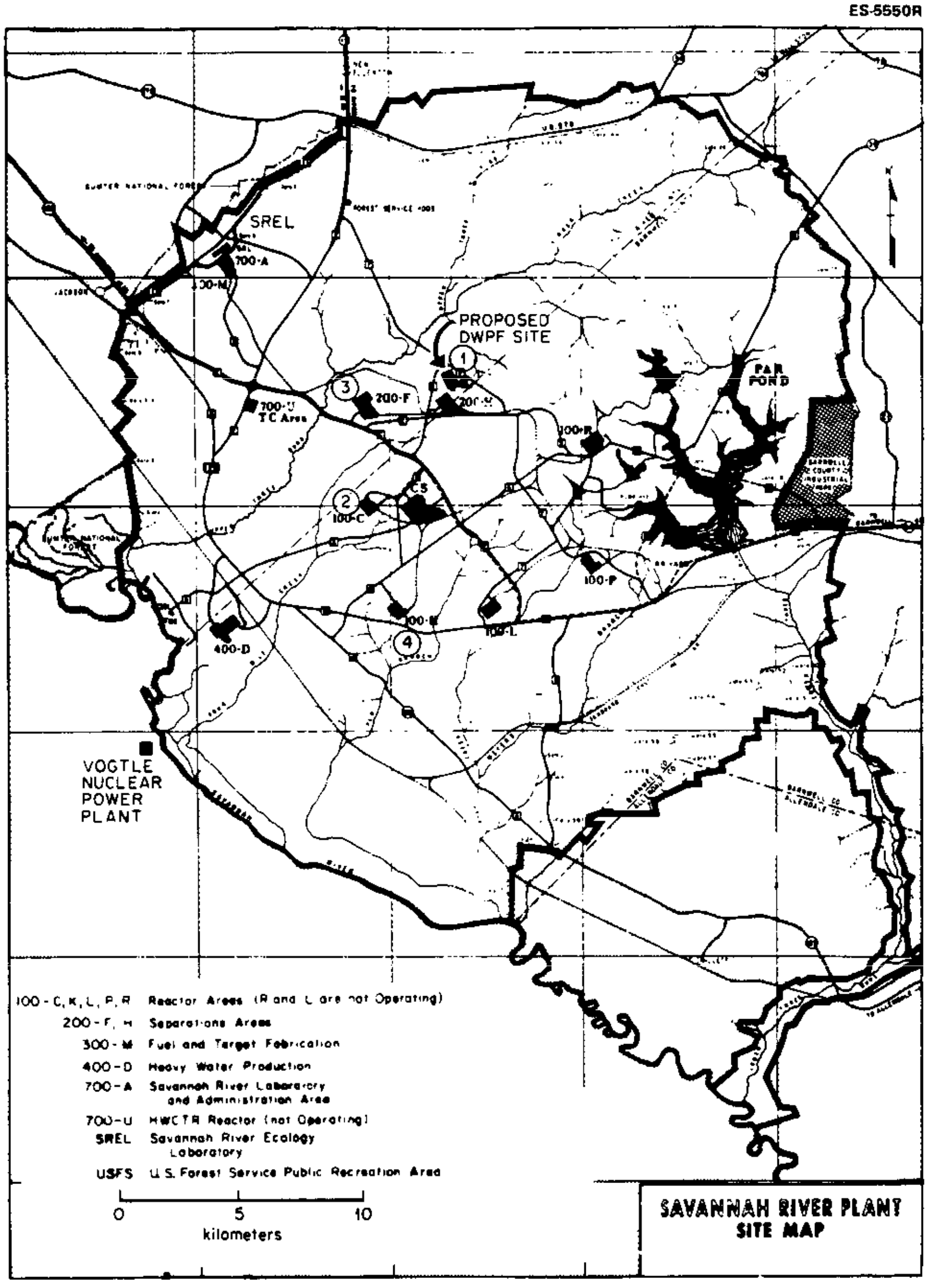

Fig. 3.9. General location of the proposed site for the DWPF and alternative saltcrete burial sites.

1. dissolution of insoluble aluminum compounds in existing storage tanks to reduce facility complexity,

2. utilization of a direct slurry-fed melter to eliminate the calcining step, and

3. reduction in the initial storage capacity of the canister storage building with modular expansion as needed.

These and other process/facility changes from the reference alternative are incorporated into the description of the staged alternative in Sect. 3.3. Inclusion of changes in this manner will illustrate how component modifications within the same general process sequence modifications could reduce capital and operating costs and improve operating efficiency without compromising safety and environmental criteria.

Table 3.9. DWPF buildings and facilities

Earthquake-resistant and tornado-resistant structures
Canyon (processing and local control facilities)
Interim storage (vaults only)
Sand filter
Fan house
Standard construction structures
Canyon (nonprocessing facilities)
Canyon control room
Interim storage (except storage vaults)
Canyon exhaust stack
Receiving and storage warehouse and cold feed area (partly inside, partly outside)
Mock-up and area shop (clean)
Administration and patrol
Water systems
Regulated facility (chemical and water treatment)
Powerhouse and utilities
Steam generation
Electrical supply and distribution
Water facilities
Coal handling
Ash handling
Sanitary and wastewater treatment
Compressed air
Saltcrete facilities

Source: EID, Sect. 3.

3.1.5 Facility construction

3.1.5.1 Construction schedule

The schedule for construction of DWPF assumes project authorization in October 1982 and plant completion in 1989.

The time requirements for the major construction work, including site development, is shown in Table 3.11.

3.1.5.2 Construction manpower

Peak construction manpower for the DWPF is expected to be about 5000 (Fig. 3.11). This figure presents the construction labor force and total construction staff, including supervisory and support personnel, as a function of years after construction begins.

3.1.5.3 Construction costs

The estimated total cost to design, construct, and equip the DWPF is $1.6 billion in 1980 dollars. A breakdown of the total cost follows.

	10^6 $
Process facilities and equipment	1100
Tank farm	150
Canister interim storage	150
Saltcrete facility and disposal site	40
Power, general, and service facilities	160
Total	1600

3.1.5.4 Expected releases and discharges

Chemicals used in significant quantities on site during construction include soaps, detergents, paints, cleaning fluids, concrete admixtures, sweeping compounds, oils, and fuels such as propane, gasohol, and diesel oil. The releases to the site environs of the solid materials such as waste from oil-spill cleanup, fire-extinguisher discharge, and used sweeping compound, are limited by burying them at an existing permitted site. Used soap and detergents are discharged to the construction sanitary system or processed through a waste disposal system. No disposal is required for those materials used consumptively, such as fuels.

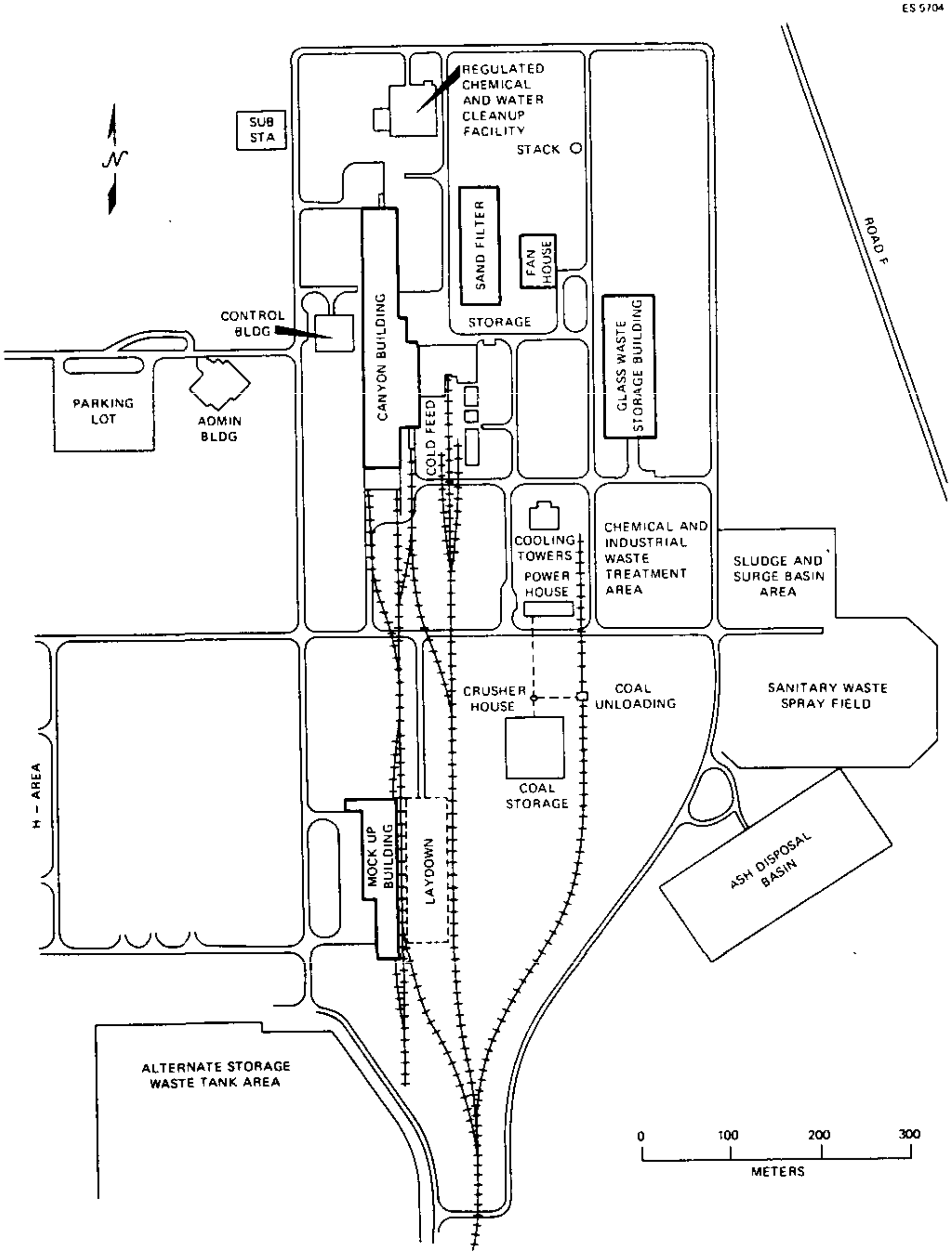

Fig. 3.10. Plot plan of the 200-S area for waste immobilization and interim storage of vitrified waste. Source: EID, Sect. 3.

Sanitary wastes will be treated in a prefabricated treatment system and chemical toilets. Wastewater from secondary treatment will be discharged to a spray field; no wastewater is discharged to streams. Sludge will be pumped from a holding tank into mobile tanks and disposed of on sludge drying beds. Dry sludge will be removed to an existing SRP landfill. Chemical toilet wastes will be trucked to an existing treatment facility. Conventional garbage will be collected and disposed of in an existing SRP landfill.

3.1.5.5 Energy and resource requirements

During construction, approximately 93 ha will be cleared, including about 40 ha of forested land that will be permanently changed to industrial usage. The power transmission line will remove

Table 3.10. Functions of support facilities

Facility	Function
Interarea transfer pipelines and auxiliary facilities	Will convey high-level wastes from SRP tank farms to the DWPF. Will convey treated salt solution from the DWPF to the 200-Z area disposal site. Will convey recycled water from Z-area to the DWPF and between F-area and H-area tank farms and the DWPF
Mock-up building	Will provide space and equipment for mock-up, fitout, and dimensional checkout of canyon equipment for remote removal and installation. Will provide space for nonregulated area shops
Receiving and storage warehouse, cold-feed facilities	Will provide space and facilities for storage and inspection of waste container components, for receipt of cold-feed chemicals, and for preparation of bulk quantities of cold-feed chemicals
Analytical laboratory and testing facilities in Canyon Building	Will provide analytical and testing services to support canyon operations
Chemical and industrial waste treatment facility	Will clarify and/or decontaminate rainwater runoff, ash basin overflow, and similar water wastes as necessary to meet applicable regulations
Water wells and treatment facilities	Will provide deep wells and auxiliaries to meet all DWPF water requirements for potable and nonpotable water
Sewage treatment facility	Will provide biological and chemical cleanup of sanitary waste to meet applicable regulations
Powerhouse and auxiliary facilities	Will provide control steam generation capacity to serve the DWPF
Ash disposal basin	Will provide settling and clarification of the water/ash slurry discharged from boiler operations at the powerhouse
Administrative building	Will provide offices, auxiliary services for administrative and technical personnel, and patrol headquarters
Security facilities	Will provide gatehouse for access control, outside lighting, and security fencing

Source: EID, Sect. 3.

Table 3.11. Relative sequence of major construction activities for DWPF

Activity	Approximate duration[a] (months)
General	
Mobilize field staff	6
Construct temporary facilities	18
Provide project management/ field office support	Continuous
Establish and maintain site security	Continuous
Receive and store construction materials	Continuous
Perform inspection and testing	Continuous
Site development	
Clearing and grubbing	5
Excavate, fill, and grade site[b]	15
Install roads and rail facilities	10
Major structures	
Place concrete footings, tunnels, and slabs[b]	17
Walls, elevated slabs, and roof[b]	36
Install equipment	13
Install piping	60
Install electrical equipment/wiring	42
Install instrumentation	36
Painting and insulation	24

[a]Duration periods typically overlap.
[b]Activity may be limited during rainy seasons.
Source: EID, Sect. 4.

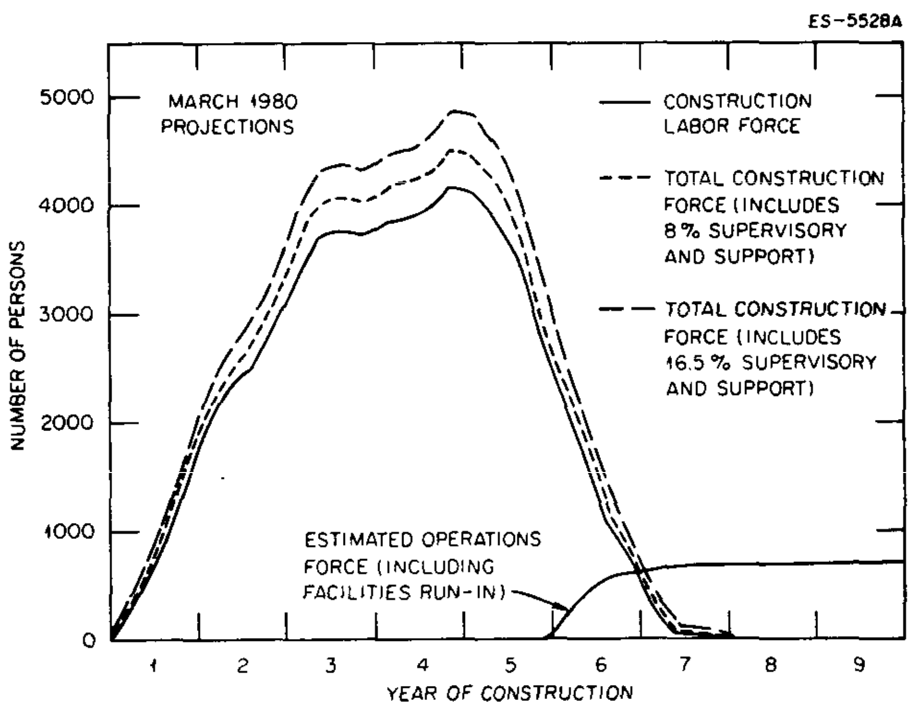

Fig. 3.11. Work force required to build and operate the reference DWPF.

about 0.8 ha of pine plantations and natural forest. Consumption of about 1000 m^3/d of water is expected during construction. No mineral deposits of commercial value are known to exist in the area of facility construction.

An estimated 2.5×10^5 m^3 of concrete and 36×10^3 t of structural steel and reinforcement bars will be irretrievably committed to construction. Fuel consumption for heavy machinery and related engine-driven equipment is estimated to be 8.7×10^3 m^3 of gasohol, 8.7×10^3 m^3 of diesel fuel, 75 m^3 of propane, and 190 m^3 of Chem-o-lene.

3.1.6 Facility operation

3.1.6.1 Schedule

The anticipated start-up date of the DWPF is 1989. About 15 years of operation is expected to be required to process the inventory of waste projected at start-up. The facility will operate until all high-level waste generated at SRP through 2002 has been immobilized (see Sect. 3.1.1.1).

3.1.6.2 Operating manpower

The operating force is expected to number about 700 workers for all DWPF activities to transfer the wastes to the 200-S area, process the wastes to produce canisters of immobilized waste and decontaminated salt solution, store the canisters, make saltcrete, and prepare and operate the saltcrete disposal area. Figure 3.11 shows the operating manpower required during the facility run-in period and by year after startup.

3.1.6.3 Operating costs

The estimated maximum annual operating cost of the DWPF is $60 million in FY 1980 dollars. These costs (in millions) are broken down as follows:

	10^6 $
Direct labor	21
Overhead	14
Glass canisters and major equipment replacement costs	10
Other materials and supplies	15
Total	60

Lower costs will prevail after the initial waste inventory has been processed. The total operating cost for 28 years of operations is $1350 million dollars in FY 1980 dollars.

3.1.6.4 Expected releases and discharges[11]

Radioactive releases

Annual atmospheric releases of total radioactivity resulting from routine processing of 5- or 15-year-old wastes at maximum expected operating capacity (50 L/min) are presented in Table 3.12. Releases are from the DWPF 84-m stack, regulated facility vessel vent, and the saltcrete plant vessel vent. Table 3.13 lists the total annual atmospheric releases from SRP.

The only source of radioactive liquid release is the condensate from the DWPF general purpose evaporator, which is discharged at a maximum flow rate of 73 L/min during normal operations. Monitored condensate will be pumped to Four Mile Creek by pipeline. The estimated annual release of radioactivity is listed in Table 3.12. The total annual liquid releases from SRP are presented in Table 3.13.

The radioactive solid waste handling operations are to be closely coupled with the process functions of the DWPF. Design of process equipment, cranes, hot and warm maintenance cells, and decontamination facilities will provide the dual functions of process maintenance and waste-management operations. Provisions will be made for shipping the largest process equipment (i.e., 3.7 m x 3.7 m x 6 m spray calciner) and the heaviest (27-t glass melter) process equipment to the burial ground by railroad car. Smaller equipment will be transported in a shielded cask car.

Table 3.12. Annual atmospheric and liquid radioactivity releases (Ci) from DWPF[a]

Release point and type of radioactivity	Radioactivity released during normal operations	
	5-year aged wastes	15-year aged wastes
Sand-filter stack		
Tritium	2.8E1	1.6E1
Fission products	1.1E-1	8.5E-3
Uranium	3.4E-10	6.8E-10
Transuranics	2.4E-5	1.9E-5
Regulated facility vessel vent		
Tritium	4.0	2.2
Fission products	2.2E-5	2.0E-7
Uranium	1.4E-13	2.8E-13
Transuranics	1.9E-10	2.3E-10
Saltcrete plant vessel vent		
Tritium	7.7	4.4
Fission products	4.6E-5	4.3E-7
Uranium	3.0E-13	6.0E-13
Transuranics	3.9E-10	4.7E-10
Liquid discharge		
Tritium	1.9E3	1.1E3
Fission products	5.1E-4	3.1E-4
Uranium	3.6E-11	7.1E-11
Transuranics	2.6E-6	2.0E-6

[a] Abstracted from lists of radionuclide releases in TDS, DPSTD-77-13-3, Sect. 8.

Table 3.13. Annual atmospheric and liquid radioactivity releases (Ci) from SRP

Atmospheric discharges	
Tritium	3.4E5
Fission products[a]	3.4E−1
Uranium	2.4E−3
Transuranics	2.6E−3
Liquid discharges	
Tritium	2.9E4
Fission products	1.8E0
Uranium	6.4E−2
Transuranics	8.7E−3

[a] Does not include noble gases.
Source: TDS, DPSTD-80-39, Table 7.7.

Much of the job control waste will be shipped by regulated truck because of its relatively low level of radioactivity. The waste types and projected annual volumes are given in Table 3.14.

Nonradioactive releases

Nonradioactive liquid, gaseous, and solid wastes will be generated during normal operation of DWPF. Gaseous wastes include diesel engine exhausts, powerhouse combustion products, and chemical releases from processing. Powerhouse combustion products are treated through a mechanical dust collector, an electrostatic precipitator, and a sulfur dioxide scrubber. Tables 3.15 and 3.16 list estimated emissions from diesel generators and the coal-fired power plant, respectively. All emissions to the atmosphere will be within emissions standards set by South Carolina and EPA. Table 3.17 lists the estimated drift releases from the DWPF cooling tower.

Liquid wastes include chemically contaminated wastewater and sanitary wastewater. Chemically contaminated wastewater will originate from ash basin effluent, cold-feed spills and wash down, coal pile runoff, and chemical contamination of rainwater runoff. Table 3.18 lists estimated average flow rates from each source. Streams from these sources will be collected, blended, and treated in a chemical and industrial waste treatment facility designed to accommodate a maximum flow rate of 950 L/min before discharge to the environment. Design objectives for the treatment facility are summarized in Table 3.19.

Table 3.14. Annual DWPF radioactive solid waste generation

Waste type	Volume (m^3)
Normal process	
Combustible	600
Noncombustible	
Job control	150
Miscellaneous	150
Resin beds	14
Adsorber columns	
Silica gel	0.1
Zeolite	1
Filters	
Deep bed washable filter	0.5
Sintered metal	2
Replacement process equipment	
Spray calciner	16
Glass melter	2
Centrifuge	1
Pumps	0.6
Valves	0.2
Jumpers	0.7
Vessels	0.6
Vessel vents	4

Source: TDS, DPSTD-77-13-3, Table 12.1.

Table 3.15. Estimated emissions from DWPF diesel generators per year[a]

Emissions[b]	kg/year
Carbon monoxide (CO)	220
Unburned hydrocarbons	80
Nitrogen oxides (NO_x)	1000
Sulfur dioxide (SO_2)	65
Particulates	75

[a]Based on estimated consumption of 18,000 L/year of diesel fuel.

[b]Emission factors from *Facilities General Design, DOE Manual,* Chap. 6301, Part II, B.R. (March 1977).

Source: EID, Sect. 5.

Sanitary wastewater generated in all S-area buildings will be discharged to sanitary sewers that terminate in a secondary treatment and disposal system capable of handling 100 m^3/d. The treated effluent will be spray irrigated or released to Four Mile Creek, which currently receives about 230 m^3/d of sewage effluent from the F- and H-areas. Sanitary wastewaters from Z-area will be sewered to a septic tank for treatment and discharge via a tile field.

Nonradioactive solid wastes will be typical of chemical and other nonnuclear industrial wastes and will be generated by DWPF support activities. An estimated 340 m^3/year of untreated solid waste composed of combustible and noncombustible materials collected from offices, lunchrooms, restrooms, and nonregulated utility and storage buildings is expected to be generated in the DWPF. About 60 m^3/year of these wastes can be salvaged. An estimated 5900 t/year of coal ash from the bottom of the powerhouse boilers, fly ash from the mechanical dust collectors, and particulates from the electrostatic precipitators will be transported to the ash basin.

Table 3.16. Emissions from the DWPF coal-fired power plant

	t/year
Coal consumed	46,000
SO_2 produced	1,150[a]
SO_2 emitted	170[b]
Ash produced	2,900[c]
Fly ash emitted	20[c]
NO_x emitted	360[d]

[a]Based on sulfur content of 2.5%

[b]Assumes 85% removal of SO_2 by scrubbers.

[c]Assumes ash content of coal is 6.3% of which 70% is fly ash and 99% of the fly ash is removed by electrostatic precipitators.

[d]Estimated from an emission rate of approximately 280 kg NO_x/TJ of heat input assuming a heating value of 28 MJ/kg.

Source: EID, Sect. 3.

Table 3.17. Estimated drift releases from the DWPF cooling tower[a]

Water quality parameter	Tuscaloosa groundwater quality[b] (ppm)	Estimated concentration in drift[c] (ppm)	Total released per year (kg)
Iron (Fe)	0.0–0.77	0.0–3.1	0–90
Calcium (Ca)	0.3–1.4	1.2–5.6	36–170
Magnesium (Mg)	0.0–0.9	0.0–3.6	0–110
Sodium and potassium (Na + K)	0.9–6.7	3.6–26.8	110–800
Sulfate (SO_4)	0.5–4.8	2.0–19.2	60–570
Chloride (Cl)	0.8–4.0	3.2–16.0	95–480
Flouride (F)	0.0–0.1	0.0–0.4	0–12
Nitrate (NO_3)	0.0–8.8	0.0–35.2	0–1000
Dissolved solids	14–28	56–112	1700–3300

[a]Assumes no change in Tuscaloosa water quality during use in the cooling system or from cooling water treatment.

[b]Source: EID, Sect. 2.

[c]Assumes a concentration factor of 4.

Source: EID, Sect. 5.

Environmental monitoring[17,18]

Monitoring at the DWPF area will follow the same general program type as used for other production areas on the SRP site. Ongoing onsite and offsite monitoring programs will continue during construction and operation of the DWPF without any specific modification. Monitoring programs specific to the DWPF area will evaluate gaseous, solid, and liquid releases. Effective quality assurance practices will be used to assure the accuracy and validity of the environmental monitoring programs. TC

Table 3.18. Sources and flow rates of nonradioactive aqueous streams to the chemical and industrial waste treatment facility

Source	Flow rate (L/min)
Ash basin effluent	
Cooling tower purge	190
Sodium cycle regenerant	11
Boiler blowdown	13
Cold feed area	
Chemical spills	<1
Rainfall runoff	1
Coal pile runoff	6
Mockup building effluent	<1
Total	~222

Source: EID, Sect. 3.

Table 3.19. Effluent design objectives for the chemical and industrial waste treatment facility

Total suspended solids, mg/L	10
pH	6–9
Oil and grease, mg/L	10
Heavy metals, mg/L	
Arsenic	0.5
Barium	10
Cadmium	0.10
Chromium	0.5
Lead	0.5
Mercury	0.02
Selenium	0.10
Silver	0.50

Source: EID, Sect. 3.

Air and stack emissions. Thermoluminescent dosimeters (TLDs) to be located in each corner of S- and Z-areas will be read quarterly for radiation exposure data. Air samplers for collecting particulates will be located at boundary locations in the S- and Z-area as well as at each of the atmospheric release points. Exhaust air from process facilities will be continuously monitored and equipped with audible alarms.

Groundwater. Sampling wells will be located in the S-area near the processing areas and around the ash disposal basin and in the Z-area in the vicinity of the saltcrete plant and the burial area.

Soil. Soil samples will be routingly collected in the S- and Z-areas for gamma, ^{90}Sr, ^{238}Pu and ^{239}Pu analysis.

Vegetation. Grasses near the Z-area burial ground and in the S-area will be sampled to evaluate deposition of particulates. The monthly samples will be checked for alpha activity, nonvolatile beta activity, and specific nuclide analyses.

Aqueous discharges. Discharges from the general purpose evaporator will be monitored for radioactive content prior to discharge to Four Mile Creek.

Other liquid discharges from the areas are rainwater and treated chemical and industrial wastes. These wastes will be monitored in accordance with EPA and SC permitting requirements before release to Four Mile Creek.

3.1.6.5 Energy and resource requirements

DWPF operating energy and resource requirements include major chemicals, water, liquid fuel, and coal. Table 3.20 lists the monthly consumption of major chemicals. Tables 3.21 and 3.22 list

Table 3.20. Bulk chemical consumption rates

Material	Concentration (%)	Consumption[a] (t/month)	Shipments	Quantity per shipment (t)
NaOH	50	390	7 Cars	58
HNO_3	51	23	1 Car	25
Glass frit 211	100	59	1 Car	85
CO_2	100	14		
Cement	100	3400	150 Trucks	23

[a]Consumption rate is based on design waste processing rate of 45 L/min.
Source: EID, Sect. 3.

Table 3.21. Inventory and consumption rate of other chemicals and supplies

Material	Consumption (kg/month)[a]	Normal inventory (kg)
Hydroxylamine sulfate	2,600	5,400
Potassium permanganate	1,100	2,700
Oxalic acid	7,700	15,000
Manganous nitrate	150	360
Starch	120	270
Ammonium carbonate[b]	*b*	13,000
Ammonium hydroxide (29%)[b]	*b*	16,000
Polyelectrolyte	0.3	5
Sodium ethylenediaminetetraacetate (39%)	4,200	17,000
Sodium fluoride	1,200	5,000
Smear papers, No.	3,650	15,000
Canisters, No.	60	90

[a]Based on waste processing rate of 45 L/min.
[b]More than 99% of all ammonia is expected to be recovered and reused; the inventory simply provides for replacement if, for example, all ammonia in the process is lost or contaminated.
Source: EID, Sect. 3.

Table 3.22. Inventory and consumption rate of other materials

Material	Consumption (m^3/year)	Normal inventory (m^3)
Duolite® ARC 359 ion-exchange resin[a]	11	33
Amberlite® IRC-718 Ion-exchange resin[b]	2.8	8.3
Zeolite	37	18
Coal, 20–30 mesh	1.0	0.8
Coal, 30–50 mesh	0.4	0.3
Sand, 25–45 mesh	2.8	2.1
Sand, 40–60 mesh	2.1	1.6
Silver mordenite	1.1	4.8
Silica gel, 6–12 mesh	*c*	*c*

[a]Diamond Shamrock Chemical Co.
[b]Rohm and Haas Co.
[c]Requirements not well defined, silica gel expected to last several years.
Source: EID, Sect. 8.

other chemical and material requirements. The amounts are nominal and the materials are ordinary and available. Table 3.23 lists the DWPF average groundwater consumption rate, which is about 20% of the current SRP use (Sect. F.4). The total liquid fuel consumption at the DWPF will equal about 18,000 L/year of diesel fuel for testing the emergency generators. The coal-fired steam plant at DWPF will consume about 43 x 10^3 t of coal per year. The DWPF will use approximately 150 GWh of electrical energy each year.

Table 3.23. DWPF average water consumption

System	Consumption (L/min)
Domestic water	
Drinking, sanitary, safety showers	49
Service water	
Boiler makeup	180
Sodium cycle softener regeneration	11
SO_2 scrubber system	190
Process cold chemical makeup	42
Laboratory sink and drain flushes	4
Equipment flushes, etc.	130
Cooling tower	
Evaporation	1700
Drift	57
Purge	190
Total	2550

Source: EID, Sect. 3.

3.1.7 Transportation of solidified high-level waste in canisters to a Federal repository

Periodically, canisters containing immobilized HLW will be transferred from an interim storage facility at SRP to a Federal repository for disposal. The SRP is well serviced by good railroad and highway networks. These networks from the DWPF to points about 150 km distant are described below. The 150-km distance was chosen because, once a shipment has reached this distance, the number of route alternatives becomes quite large. For example, at about 150 km from SRP, major centers of transportation are found from which a shipment could proceed to most any repository location. Because a repository site has not yet been selected, definition of shipping routes is not possible (4,800-km shipping distance was assumed in the EIS). Information on transportation technology, regulatory requirements, and risks are presented in Appendix D.

Casks containing waste canisters may be transported to a Federal repository by either rail or highway carriers. Conceptual casks have been proposed for each mode.

3.1.7.1 Railroad network

The SRP is traversed by one railroad, the Seaboard Coastline, which has one line of track running southeast from Augusta to Allendale and a branch that runs northeast across the southern portion of the plant (see Figs. 3.12 and 3.13), a route that eventually leads to Florence, South Carolina. SRP operates its own on-plant railroad, which services its in-house needs. DWPF will be so serviced. Interchange to the Seaboard Coastline Railroad is accomplished in the SRP Classification Yard located near the southeast corner of the plant (Fig. 3.12). A number of rail cars can be held or stored in the Classification Yard.

3.1.7.2 Highway network

SRP primary roads are paved and well maintained. The DWPF will be served by such a road. External roads providing access to the plant are South Carolina 125, South Carolina 19, South Carolina 781, South Carolina 64, and U.S. 278 (Fig. 3.14). These roads connect with interstate highways at Augusta, Georgia; and Columbia, Aiken, and Orangeburg, South Carolina; and other points.

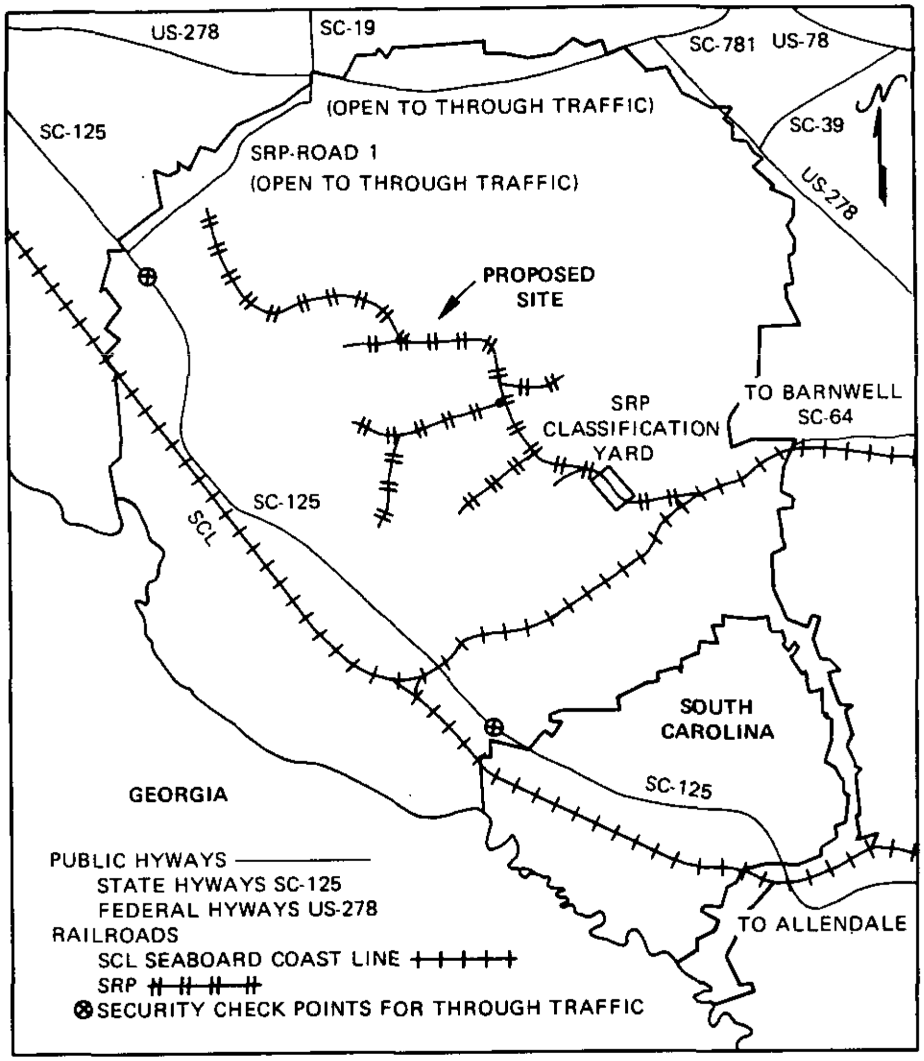

Fig. 3.12. Transportation networks on SRP.

3.1.8 Decontamination and decommissioning

The DWPF will be designed to facilitate decontamination for future decommissioning in accordance with DOE facilities General Design Criteria. Although an overall site plan for decontaminating and decommissioning (D&D) of all facilities at the SRP has not been developed, the DWPF itself will be another facility that will presumably be subject ultimately to D&D. However, it will not be a large factor in the overall total. Because the waste tank farms will be included in the SRP D&D, early installation of a DWPF will facilitate total D&D by reducing the total number of tanks to be decommissioned. Overall, only by having a DWPF in operation can the ultimate objectives of D&D be achieved, since it is needed for disposal of the SRP high-level radioactive wastes. The development of the SRP decontamination and decommissioning plan, which will include the DWPF and the waste tanks, will go through environmental and public review before adoption; the decontamination and decommissioning option includes, but is not limited to, decontamination and dismantlement for return of the land to the public and decontamination and entombment with access control. D&D activities have been carried out safely for other nuclear facilities.[19-22] Potential effects of D&D for the DWPF and waste tanks are described in DOE/EIS-0023.[23]

3.2 DELAY OF REFERENCE IMMOBILIZATION ALTERNATIVE

The authorization, construction, and startup of facilities for immobilizing the high-level wastes at SRP could be delayed until such time as a Federal repository would be available to receive the

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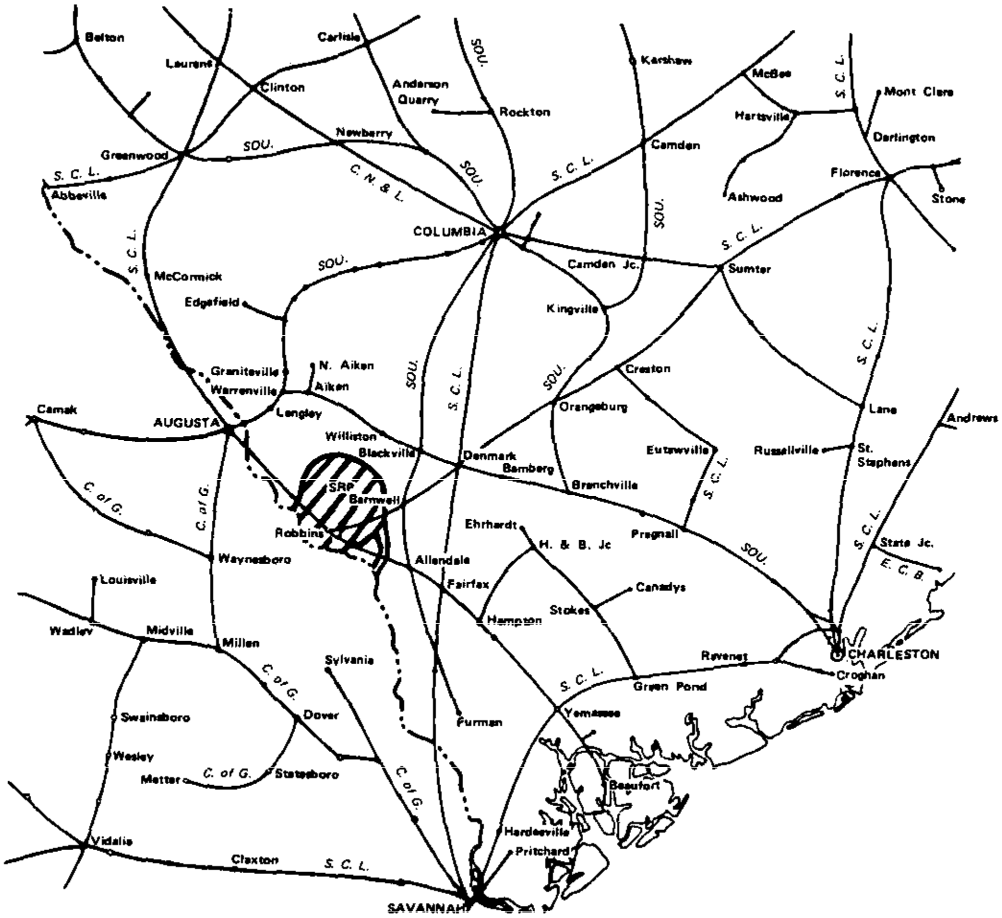

Fig. 3.13. Railroad network in the vicinity of SRP. [Note: The Central of Georgia (C of G), shown operating south of Augusta, is part of the Southern Railroad System and operates as a subsidiary.] Source: Rand McNally, "Handy Railroad Maps (By State)," 1980 edition.

canisters of solidified waste. The delayed DWPF assumes that processing of wastes will begin in 1999, a delay of 10 years. It is assumed that a Federal repository would then be available to receive the immobilized waste so that no more than 90 days of interim storage would be required and that a decision on the waste form would have been made for the DWPF. For conservatism the reference immobilization design was used in performing the impact analyses. In the analysis given, the differential effects estimated for the delay of the reference alternative are applicable also to delay of the staged process alternative.

Reactor operation at SRP is assumed to continue through 2000 and chemical separations of irradiated material to 2002, as stated in Sect. 3.1.1.1. Liquid wastes would continue to be generated and processed, producing sludge and saltcake, which would be stored in tanks. Because immobilization of these wastes is delayed, the quantity of liquid wastes requiring storage increases over the reference case. This increase requires the construction of additional waste storage tanks. Storage requirements for canisters are reduced because once waste immobilization begins, a repository that can receive canisters is assumed to be available.

Immobilization of the high-level waste has already been deferred for some 25 years at Savannah River. Although there have been no failures or releases, the longer the delay, the greater is the risk of leaks and spills. Obviously, it can be delayed for a few more years if necessary; however, the technology is now fully available to proceed with the DWPF, either in a reference or staged version. A 10-year delay in immobilization of the SRP wastes can result in both beneficial and adverse technical, economic, and environmental effects.

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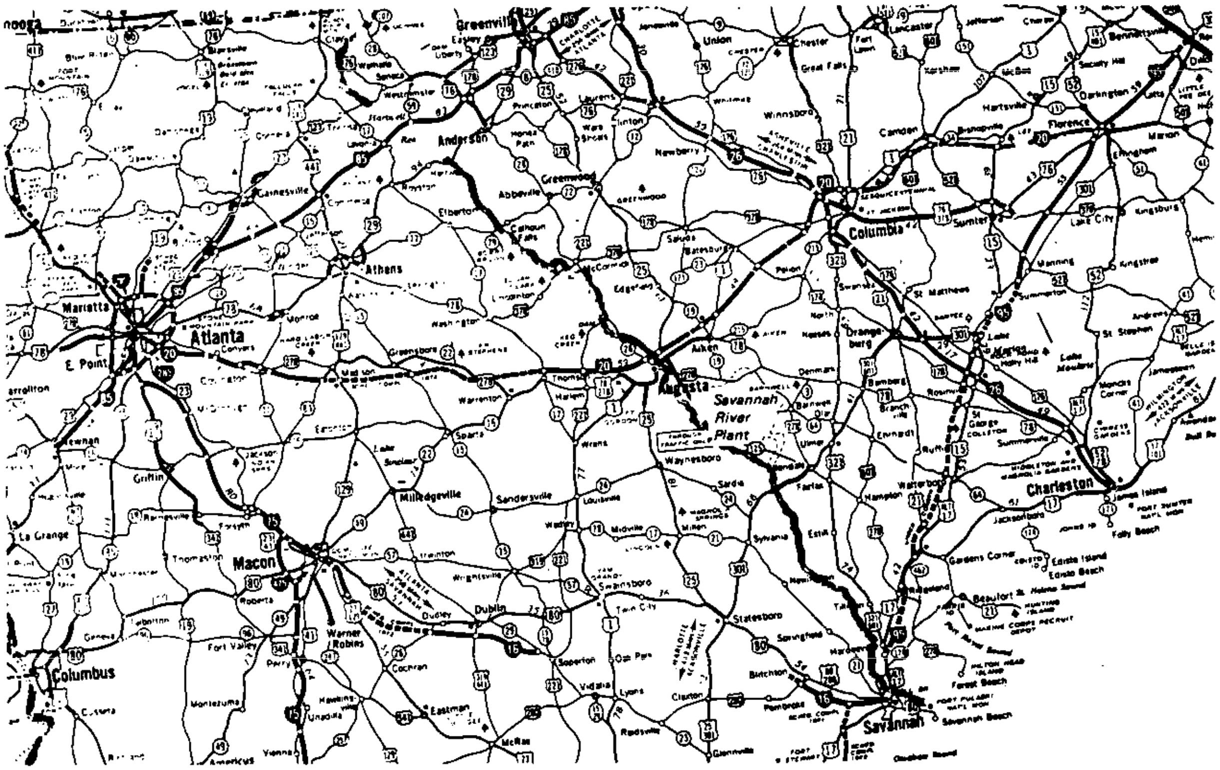

Fig. 3.14. Highway network in the vicinity of SRP.

Delay can make time available for additional studies for technical topics such as advanced waste forms, interactions between waste forms and the repository host rock, waste form processing technology, and alternatives to geologic storage. Delay can also reduce the following: the need for interim storage of the immobilized waste, which accounts for about 5% of the other DWPF expenditures; the socioeconomic impacts, by timing the construction to require a smaller more constant construction work force; and the level of activity of the waste which continues to decay with time. Reduction of the radioactivity of the waste is a minor consideration because the DWPF will be processing aged wastes in the existing inventory for at least the first half of its lifetime. After this time, the wastes being processed will have had sufficient time to decay to activity levels appropriate for processing.

The benefits of delay are offset by some important disadvantages. Untreated waste is more easily dispersible than the immobilized waste. It thus presents greater hazards and requires constant close surveillance not only as a normal procedure but also to protect against unforeseen events such as sabotage and natural catastrophies. Delay of the DWPF will require construction of new waste tanks throughout the delay period (about one each year at a cost of about $10 million each in 1980 dollars). Also, a prolonged delay may necessitate construction of additional replacement tanks. The Savannah River Plant is currently in full operation and can provide backup support for the DWPF by personnel experienced in waste operations. A long delay in DWPF construction and operation can result in dispersion of currently assembled R&D, design, and management teams with the consequent loss of accumulated knowledge and experience.

3.2.1 Process description

The general process steps for this alternative are the same as for the reference case described in the introduction to Sect. 3.1.1. However, the quantities of liquid wastes and the required number of tanks increase as described below.

3.2.1.1 Description of wastes

The total volume of high-level radioactive waste stored in tanks by 1999 is expected to be about 114×10^3 m^3, consisting of 76×10^3 m^3 of saltcake, 19×10^3 m^3 of sludge, and 19×10^3 m^3 of supernatant. These figures can be compared with 62×10^3, 15×10^3, and 24×10^3 m^3 of saltcake, sludge, and supernatant, respectively, in the reference case.

The number of waste tanks through year 2002 required for waste storage increases to a maximum of 38, compared to 27 in 1988 for the reference case. No additional tankage is planned beyond this number because waste immobilization begins in 1999.

3.2.1.2 Removal of wastes from storage tanks

The operations described in Sect. 3.1.1.2 apply to this alternative except that the start of operations and the quantities will change. Starting in 1999, removal of wastes aged more than 15 years (for Ru^{106} decay) from the 38 tanks expected to be in service will require about 250×10^3 m^3 of water to slurry the sludge and dissolve the saltcake resulting in about 370×10^3 m^3 of waste to be processed.

3.2.1.3 High-level waste immobilization and transfer to storage

The interim storage building will be of the same general type of construction but will be designed to store only 125 canisters of solidified waste (90 days' production) compared with 6500 canisters for the reference case.[24]

3.2.2 Facility description

All of the facilities discussed in Sect. 3.1.3 are required for this alternative. The waste-tank farm will need to be enlarged by the addition of eleven new tanks to store the wastes produced from chemical separations through the year 2002 when separations operation is assumed to cease. The canister interim storage building and vault area will be much smaller to provide interim storage of only 90 days' production of canisters (125) instead of the 13 years' production of canisters (6500) assumed for the reference case.

3.2.3 Facility construction

The start of construction for this alternative is assumed to be 1992, 10 years after the date given in Sect. 3.1.5. Construction costs (in 1980 dollars) are assumed to be less because of the reduced size of the canister interim storage building. However, during the 10-year delay period, a total of 11 additional waste storage tanks will need to be constructed at an estimated cost of $\$10 \times 10^6$ per tank (1980 dollars).

The expected releases and discharges and the energy and resource requirements are estimated to be the same as for the reference case.

3.3 STAGED PROCESS ALTERNATIVE (PREFERRED ALTERNATIVE)

J-25 The processing of the high-level wastes at SRP could commence in 1989 in stages in order to reduce the initial and total capital investment compared with that of the reference immobilization alternative. The saving in the initial capital investment is due to staging; the saving in the total capital investment is due to improvements resulting from an ongoing R&D program.

The first stage, Stage 1, will provide an immobilization facility to incorporate the insoluble sludge portion of the wastes, which contain most of the radionuclides, into a borosilicate glass that will be sealed in canisters and stored onsite until shipped to a Federal repository.

The second stage, Stage 2, will provide a facility to decontaminate waste salt solutions and transfer recovered radionuclides (Cs, Sr, and Pu) to the Stage 1 immobilization facility for incorporation into borosilicate glass. The decontaminated salt solution will be incorporated into a concrete matrix and placed in an engineered landfill (Sect. 3.1.1.7).

Operation of the Stage 1 facility will be initiated about three years prior to startup of the Stage 2 facility and will continue to be operated jointly with the Stage 2 facilities for the lifetime of the project. Operation of the Stage 1 facilities prior to Stage 2 startup is referred to as an uncoupled operation, whereas operation of the total facility is coupled operation.

The staged process incorporates the following major changes from the reference immobilization alternative (see Sect. 3.1.4), which reflect improvements resulting from the ongoing R&D program: J-25

1. Sludge feed to vitrification will have the aluminum compounds dissolved and will be washed using hydraulic mixing and gravity settling in 4.9 x 10^3 m^3 tanks in the 200-Area liquid radioactive waste handling and storage facilities (the waste tank farms). This change simplifies the sludge washing process by eliminating the centrifuges and reduces the size of the DWPF building. It also provides greater process flexibility by decoupling sludge and supernate processing. These steps are planned to be carried out in the normal operations of the waste tank farms independently of DWPF availability, as the older tanks are removed from service and replaced by new tanks of increased reliability now under construction. Gravity settling is the first step of supernate clarification.

2. The spray calciner and associated glass melter have been eliminated in favor of a direct liquid-fed continuous melter. This change decreases the required building height and should increase operational reliability.

3. The dual ejector-venturi scrubbers (contact condensers) and deep-bed washable filters have been replaced by a single ejector-venturi scrubber and a pair of high-efficiency venturi scrubbers. High-efficiency venturi scrubbers can be used because the liquid fed melter off-gas flow rate is lower than that of the original DWPF calciner/melter, which must handle the atomizing air. The high-efficiency scrubbers will be easier to maintain in a canyon environment.

4. The canister closure weld preparation step has been eliminated, and leak testing of the canister closure and closure rework facilities have been eliminated. The acceptance test for a weld closure will be visual inspection via a television monitor. Consideration will be given to later provision of leak testing, if required, in connection with facilities for shipping the canisters offsite.

5. The HF-HNO_3 canister decontamination process has been replaced with wet abrasive blasting using glass frit and water.

6. As a result of changes 3 through 5, the alternative DWPF mechanical cells are reduced to a single cell approximately the size of the principal original cell.

7. The need for a new coal-fired power plant has been eliminated due to less demand for steam and better steam utilization from existing boilers.

Flexibility in the staged process alternative results from beginning sludge processing and vitrification before supernate processing. This approach significantly lowers the initial capital investment required to begin immobilizing SRP waste.

3.3.1 Process description

High-level wastes stored in tanks at SRP as insoluble, highly radioactive sludge will be immobilized in borosilicate glass in the Stage 1 facilities. The encapsulated mixture of waste and glass will be stored in canisters in an expandable surface facility until shipment to a Federal repository. In the Stage 2 facilities, the remaining high-level wastes, stored as precipitated salts and supernatant (liquid), will be decontaminated and processed into saltcrete monoliths for burial on the SRP site. The cesium, strontium, and plutonium recovered during decontamination of the salt solution will be incorporated into the borosilicate glass.

Facility process flows for Stages 1 and 2 are pictured in Figs. 3.15 and 3.16. The following discussion describes the processes proposed for treatment of wastes during each stage and the points of potential radioactive release to the environment.

3.3.1.1 Removal of wastes from storage tanks

In 1988, 27 waste storage tanks (including emergency spares and evaporator feed tanks) are expected to be in service. These tanks will contain an estimated 60 x 10^3 m^3 of damp saltcake, 15 x 10^3 m^3 of settled sludge, and 30 x 10^3 m^3 of supernatant liquid. It is expected that about 165 x 10^3 m^3 of water, together with the supernatant, will be required to slurry the sludge and dissolve the saltcake, resulting in about 270 x 10^3 m^3 of waste to be processed.

Stage 1

The settled sludge will be slurried with water and treated with hot (90°C maximum) caustic solutions in an existing tank in order to reduce the volume of insoluble aluminum compounds by

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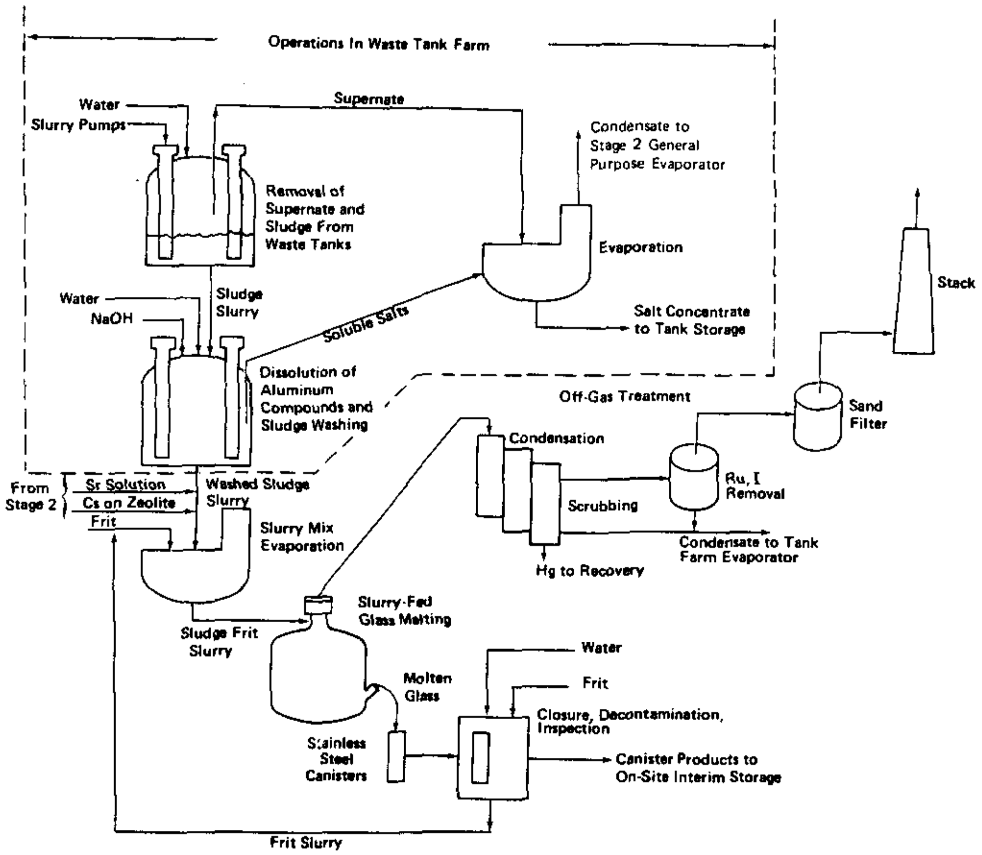

Fig. 3.15. Defense waste processing — staged alternative stage 1 operation (coupled).

about 75% by converting them to a soluble form. The sludge will be washed to remove soluble salts. These operations have been safely demonstrated with existing SRP waste and are planned to be part of the interim waste management program in transferring waste from existing older tanks to new tanks. Incorporation of these types of improvements to the ongoing interim waste management operations is discussed in ERDA-1537, *Final Environmental Impact Statement — Waste Management Operations, Savannah River Plant,* and discussed in more detail in DOE/EIS-0062, *Final Environmental Impact Statement (Supplement to ERDA-1537, Sept. 1977), Waste Management Operations, Savannah River Plant*; waste transfer and storage operations are part of the interim waste management operations and are independent of consideration in the scope of this EIS. Salts from the aluminum dissolution and sludge washing will be concentrated in the tank farm evaporators and added to the existing inventory of saltcake for eventual processing in Stage 2 facilities. The washed sludge-slurry, containing a maximum of 2 wt % salt (dry basis), will be pumped at a design rate of 3.2 L/min to the Stage 1 facility for immobilization.

The radionuclide activities of sludge-slurry feed from wastes aged 5 and 15 years* are about 49 and 18 Ci/L, respectively. The sludge slurry will contain about 19% solids.

Stage 2

At startup of the Stage 2 supernatant processing facilities, projected to be in 1991, the Stage 1 immobilization facility will have been in operation about three years. The waste inventory that is estimated to be on hand is 11 x 10^3 m^3 of sludge, 62 x 10^3 m^3 of salt, and 27 x 10^3 m^3 of liquid.

*Specific design criteria for processes leading up to and including waste immobilization include the selection of sludge that has aged a minimum of 5 years and saltcake that has aged a minimum of 15 years.

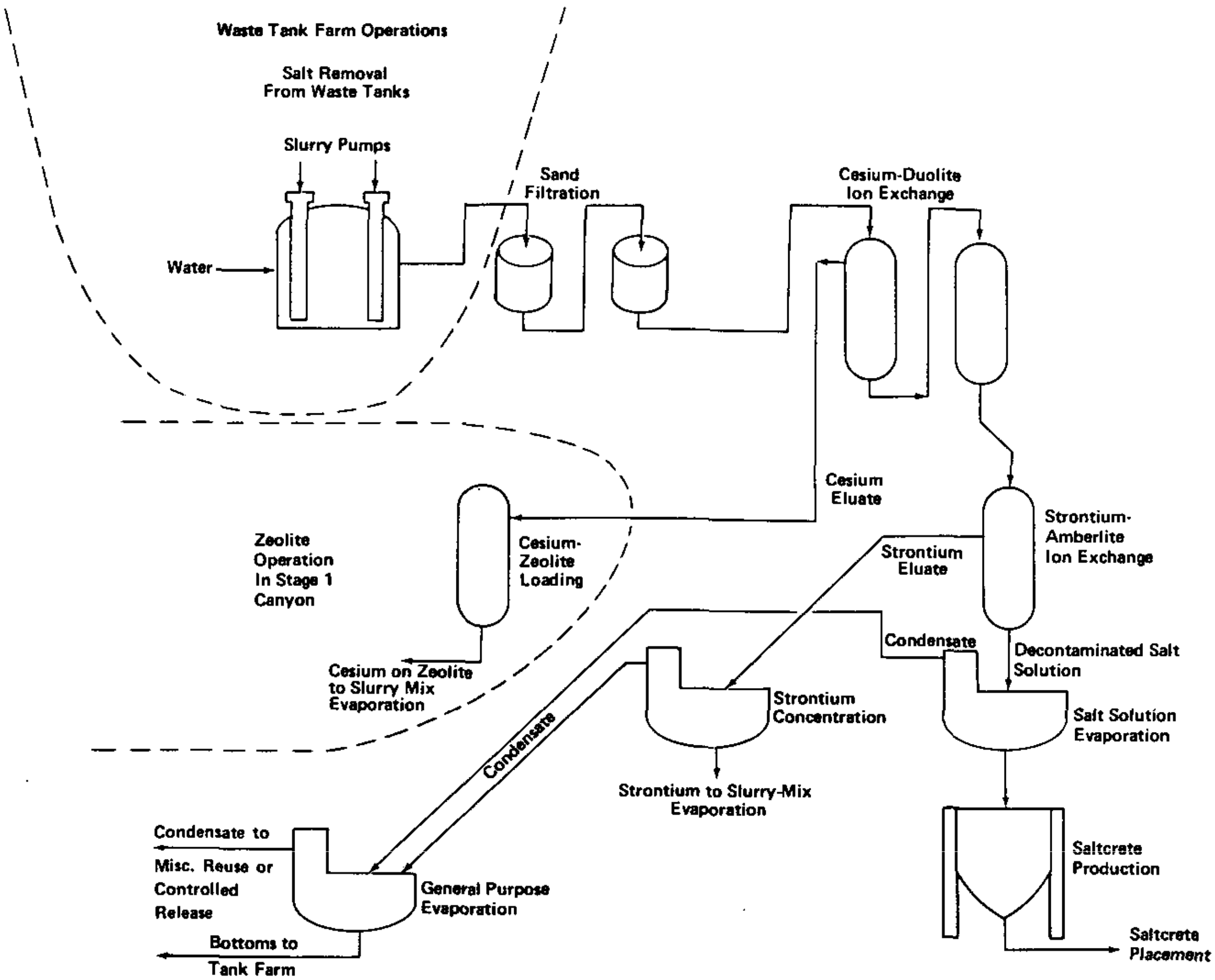

Fig. 3.16. Defense waste processing — staged alternative stage 2 operation (coupled).

Water from the F and H chemical separations areas and the Stage 2 evaporator supplemented by fresh water, will be used for salt dissolution. The water will enter through spray nozzles near each tank top to promote top and wall cleaning as layers of salt are removed. Efficient dissolving will be promoted by the use of circulating pumps for liquid agitation. In Stage 2 processing, the supernatant from the tank farm will be clarified by the addition of polyelectrolyte and sand filtration.

The collected solids will be fed to the Stage 1 immobilization facility and the clarified liquids to the Stage 2 supernatant processing facilities. The design feed rate for supernatant from the waste tank farm will be 48 L/min. The total quantity of supernatant feed through 2002 is estimated to be 350 x 10^3 m^3.

The salt/supernatant contains primarily sodium nitrate, nitrite, and hydroxide and has an average density of 1.23 kg/L. The total radionuclide activities for wastes aged 5 and 15 years are 2.1 and 1.5 Ci/L, respectively.

3.3.1.2 Waste immobilization

The products of the staged DWPF are the same as for the reference immobilization alternative, that is, they are canisters of immobilized high-level waste and concrete monoliths incorporating slightly radioactive salt.

Stage 1

The immobilization of washed sludge will produce about 500 canisters of borosilicate glass per year. The canister design is shown in Fig. 3.3. The facilities will be designed to process 5-year old sludge. The processing facilities for the Stage 1 immobilization facility will be similar to the reference process except that the multiple-spray calciners and the joule-heated continuous melters will be replaced by a single, large liquid-fed melter. Because the glass from Stage 1 processing before the start-up of Stage 2 will not contain cesium-loaded zeolite or any waste associated with Stage 2 facility operations, the glass will contain about 20% more sludge than the reference process. A summary process-flow diagram is shown in Fig. 3.15. The washed sludge-slurry will be transferred to the slurry receipt tank that feeds the slurry mix evaporator, to which is also added a slurry of new glass frit and spent frit/water from the mechanical decontamination cell. The composite slurry will be concentrated to 40 wt % solids, after which it will be transferred to the melter feed tank.

The liquid-fed, joule-heated melter will evaporate the water from the slurry feed, melt the borosilicate glass frit, and combine the melt with the waste to form the homogeneous molten glass to be poured into stainless steel canisters (Fig. 3.3). As in the reference design, the borosilicate glass will contain about 28 weight percent waste oxides. The characteristics of waste in a single container are estimated to be:

	Stage 1	Stage 1/Stage 2 coupled
Total activity	134,000 Ci	149,000 Ci
Heat generation	416 W	423 W

Actual content, at least initially, is expected to be somewhat lower because of the greater age of the stored waste.

After the canister is filled, it will be rapidly cooled to minimize devitrification. Cooled canisters will be moved to the mechanical area, plugged and welded closed. The welded canisters will be moved to the decontamination area and grit blasted with a slurry of 20% by weight glass frit in water. After one use, the slurry will be used as feed to the slurry mix evaporator.

Stage 2

The decontamination and immobilization of the supernatant will produce about 800 monoliths of saltcrete, each about 6 x 6 x 15 m. About 530 m^3 of saltcrete will be produced each week. Supernatant (salt solution) will be transferred from the tank farm to the sand-filter feed tank in the Stage 2 facilities at a design rate of about 48 L/min. In the facility (Fig. 3.16), the trace suspended solids will be removed from the salt solution by sand filtration through two filters in series. Following filtration, the supernatant will be processed sequentially through two stages of ion exchange, first to remove cesium and trace amounts of plutonium, and then to remove strontium. The recovered cesium, plutonium, and strontium will be eluted from the loaded ion-exchange columns, concentrated by evaporation, and transferred to the immobilization facility. The decontaminated but slightly radioactive salt solution will be incorporated into a concrete matrix and placed in an intermediate-depth burial ground. The design rate of salt production will be about 1200 kg/h (as salt in saltcrete). The radioisotopic content of the saltcrete is similar to that described for the reference immobilization alternative. Table 3.24 gives the radioisotopic composition of the saltcrete from coupled operations.

The decontaminated salt solution from the hold tanks will be processed as described in Sect. 3.1.1.7 to form the saltcrete monoliths in the intermediate-depth burial ground.

3.3.1.3 Transfer of waste to storage

The filled, seal-welded, decontaminated canisters, each containing 625 L of glass will be moved on a shielded vehicle from the mechanical cell to the interim storage building. The discussion for the reference process in Sect. 3.1.1.6 describes one method of transfer.

The interim storage building will receive and store canisters in a shielded, air-cooled environment. The building capacity will be for two years of production (1026 canisters), but provisions will be made for later expansion, depending upon availability of a Federal repository.

Table 3.24. Isotopic content of saltcrete from Stage 1/Stage 2 coupled operation using 15-year old wastes[a]

Isotope	Concentration (nCi/g)	Isotope	Concentration (nCi/g)
^{3}H	2.1E+1[b]	^{144}Pr	<5E−1
^{59}Ni	<1.9E−4	^{144m}Pr	<5E−1
^{60}Co	<5E−1	^{144}Nd	4.3E−11
^{63}Ni	<1.9E−2	^{147}Pm	1.6E0
^{79}Se	6.3E−2	^{148}Pm	1.6E−16
^{87}Rb	1.6E−7	^{148m}Pm	2.2E−15
^{89}Sr	2.4E−14	^{147}Sm	2.2E−7
^{90}Sr	3.0E−1	^{148}Sm	5.0E−13
^{90}Y	3.0E−1	^{149}Sm	1.6E−13
^{91}Y	4.4E−13	^{151}Sm	2.0E+1
^{93}Zr	1.6E−2	^{152}Eu	2.0E−2
^{94}Nb	<3.0E−7	^{154}Eu	<5E−1
^{95}Zr	<5E−1	^{155}Eu	1.0E0
^{95}Nb	<5E−1	^{160}Tb	2.5E−12
^{95m}Nb	2.8E−11	^{206}Tl	7.1E−17
^{99}Tc	1.9E+1	^{207}Tl	8.6E−8
^{103}Ru	2.6E−12	^{208}Tl	1.0E−3
^{106}Ru	1.4E+1	^{209}Tl	9.1E−12
^{103m}Rh	2.6E−12	^{232}U	6.1E−5
^{106}Rh	1.4E+1	^{233}U	8.9E−9
^{107}Pd	4.3E−3	^{234}U	3.3E−4
^{110}Ag	<5E−1	^{235}U	4.8E−7
^{115m}Cd	1.1E−14	^{236}U	1.0E−5
^{121m}Sn	2.6E−3	^{238}U	2.6E−6
^{123}Sn	5.9E−7	^{236}Np	1.6E−10
^{126}Sn	1.4E−3	^{237}Np	8.0E−5
^{124}Sb	1.6E−13	^{236}Pu	3.2E−7
^{125}Sb	6.0E0	^{238}Pu	4.0E−2
^{126}Sb	1.9E−4	^{239}Pu	4.1E−4
^{126m}Sb	1.4E−3	^{240}Pu	2.6E−4
^{125m}Te	7.3E0	^{241}Pu	3.0E−2
^{127}Te	2.0E−6	^{242}Pu	3.5E−7
^{127m}Te	2.0E−6	^{241}Am	1.9E−1
^{129}Te	5.0E−17	^{242}Am	1.2E−4
^{129m}Te	7.8E−17	^{242m}Am	1.2E−4
^{129}I	6.7E−2	^{243}Am	5.2E−5
^{134}Cs	<5E−1	^{242}Cm	1.0E−4
^{135}Cs	5.7E−5	^{243}Cm	3.9E−5
^{137}Cs	1.5E+1	^{244}Cm	1.0E−3
^{137m}Ba	1.4E+1	^{245}Cm	6.0E−8
^{141}Ce	8.0E−17	^{246}Cm	4.8E−9
^{142}Ce	8.5E−7	^{247}Cm	5.9E−15
^{144}Ce	<5E−1	^{248}Cm	6.1E−15

[a]Values less than 10^{-20} nCi/g are not included.
[b]2.1×10^{1}.
Source: TDS, DPSTD 80-39, Table 3.14, except ^{59}Ni, ^{63}Ni, ^{94}Nb which are from unpublished data.

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The cost of expansion in two-year increments will be about $32 million (1980 dollars) each, or an additional $160 million to be equivalent to the reference immobilization alternative (6500 canisters). The construction activities for the five additional increments would be spread over a much longer period than if the total facility were built initially, as in the reference alternative.

3.3.1.4 Effluent control and processing

Stage 1

Liquid wastes. During uncoupled operation liquid wastes will be returned to H-area and processed through the tank-farm evaporators. Overheads will be released to existing seepage basins after monitoring to verify compliance with existing release guidelines. The concentrated waste will be stored in tanks until it can be recycled into Stage 2 processing.

In coupled operations, the concentrated waste from the tank-farm evaporator may be recycled into either the Stage 1 or Stage 2 process. However, the evaporator overhead will be transferred to the general purpose evaporator that is constructed as part of the Stage 2 facility.

Gaseous wastes. The discussion in Sect. 3.1.1.8 for the reference process is applicable except that the off-gas is from the liquid-fed melter instead of from the spray calciner/melters (Fig. 3.5).

Stage 2

Liquid wastes. The discussion in Sect. 3.1.1.8 for the reference process is applicable except that recycle evaporation will be conducted in an existing tank farm evaporator instead of a new recycle evaporator.

Gaseous wastes. Discussion in Sect. 3.1.1.8 for the reference process is applicable except for the discussion concerning melter off-gases (melter operations are covered under Stage 1 operation).

3.3.2 Site selection

The proposed sites for the reference immobilization facility, the saltcrete facility and the burial area (S- and Z-areas) (Sect. 3.1.2) are also applicable to the Stage 1 and 2 facilities.

The Stage 1 facility will require about 37 ha (92 acres) of cleared land, including 16 ha for temporary construction facilities outside the 19 ha of fenced land. The site will ultimately require about 51 ha to accommodate future expansion of the canister interim storage facility and the Stage 2 facilities. The area map in Fig. 3.6 shows the proposed location of the S-area. Figure 3.17 is the S-area plot plan showing the Stage 1 facility locations. The Stage 2 operations will be located adjacent to the Stage 1 operations as described above. Figure. 3.18 is the S-area plot plan showing the Stage 2 facility locations. Criteria for the evaluation of potential sites and the selection of the S-area site are discussed in detail in Sect. 3.1.2.1, and the comparison of the three alternative sites is presented in Table 3.7.

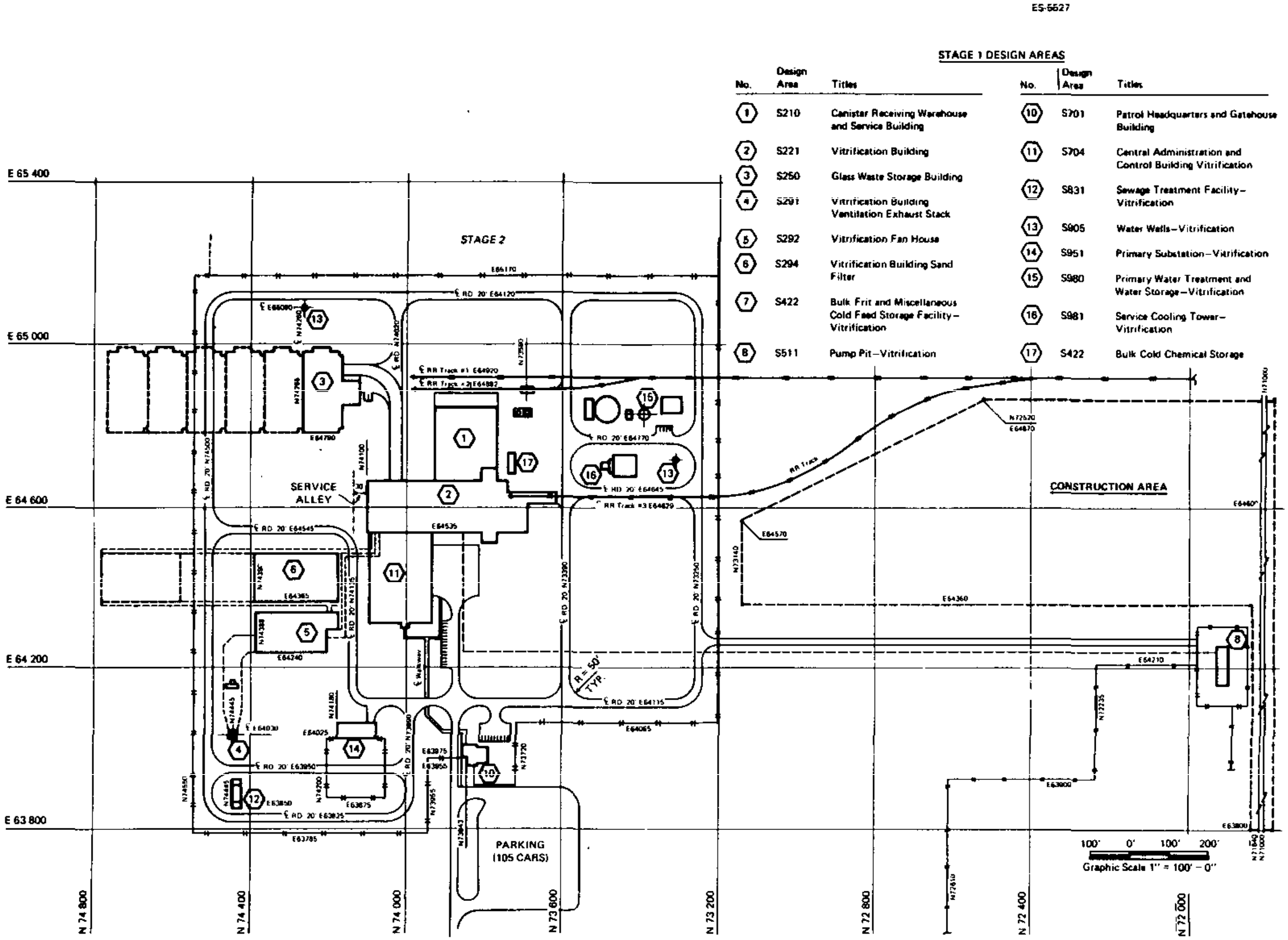
The saltcrete mixing and burial site is designated the Z-area and is expected to require about 14 ha, of which 9.3 ha will be fenced. Figure 3.9 shows the proximate location of four potential burial sites, and Table 3.8 compares the sites. The discussion in Sect. 3.1.2.2 is applicable to the Z-area site selection required for Stage 2 operations.

3.3.3 Facility description

Stage 1

New facilities in the waste-tank farm will not be required for Stage 1 operations. Waste-tank farm functions associated with the immobilization plant will be to (1) slurry and remove sludge from waste tanks and (2) store and evaporate waste solution from the immobilization plant. Tank farm evaporator overheads will be disposed of through existing systems having normal discharge to the seepage basin during "uncoupled" operations. In "coupled" operations, a general purpose evaporator will operate as described in the reference case.

New underground interarea transfer lines equipped with ventilated pump pits and diversion boxes will transport sludge feed and recycle waste between the S-area and the H-area tank farm.



STAGE 1 DESIGN AREAS

No.	Design Area	Titles
1	S210	Canister Receiving Warehouse and Service Building
2	S221	Vitrification Building
3	S250	Glass Waste Storage Building
4	S291	Vitrification Building Ventilation Exhaust Stack
5	S292	Vitrification Fan House
6	S294	Vitrification Building Sand Filter
7	S422	Bulk Frit and Miscellaneous Cold Feed Storage Facility–Vitrification
8	S511	Pump Pit–Vitrification
10	S701	Patrol Headquarters and Gatehouse Building
11	S704	Central Administration and Control Building Vitrification
12	S831	Sewage Treatment Facility–Vitrification
13	S905	Water Wells–Vitrification
14	S951	Primary Substation–Vitrification
15	S980	Primary Water Treatment and Water Storage–Vitrification
16	S981	Service Cooling Tower–Vitrification
17	S422	Bulk Cold Chemical Storage

Fig. 3.17. DWPF — Stage 1, 200-S area.

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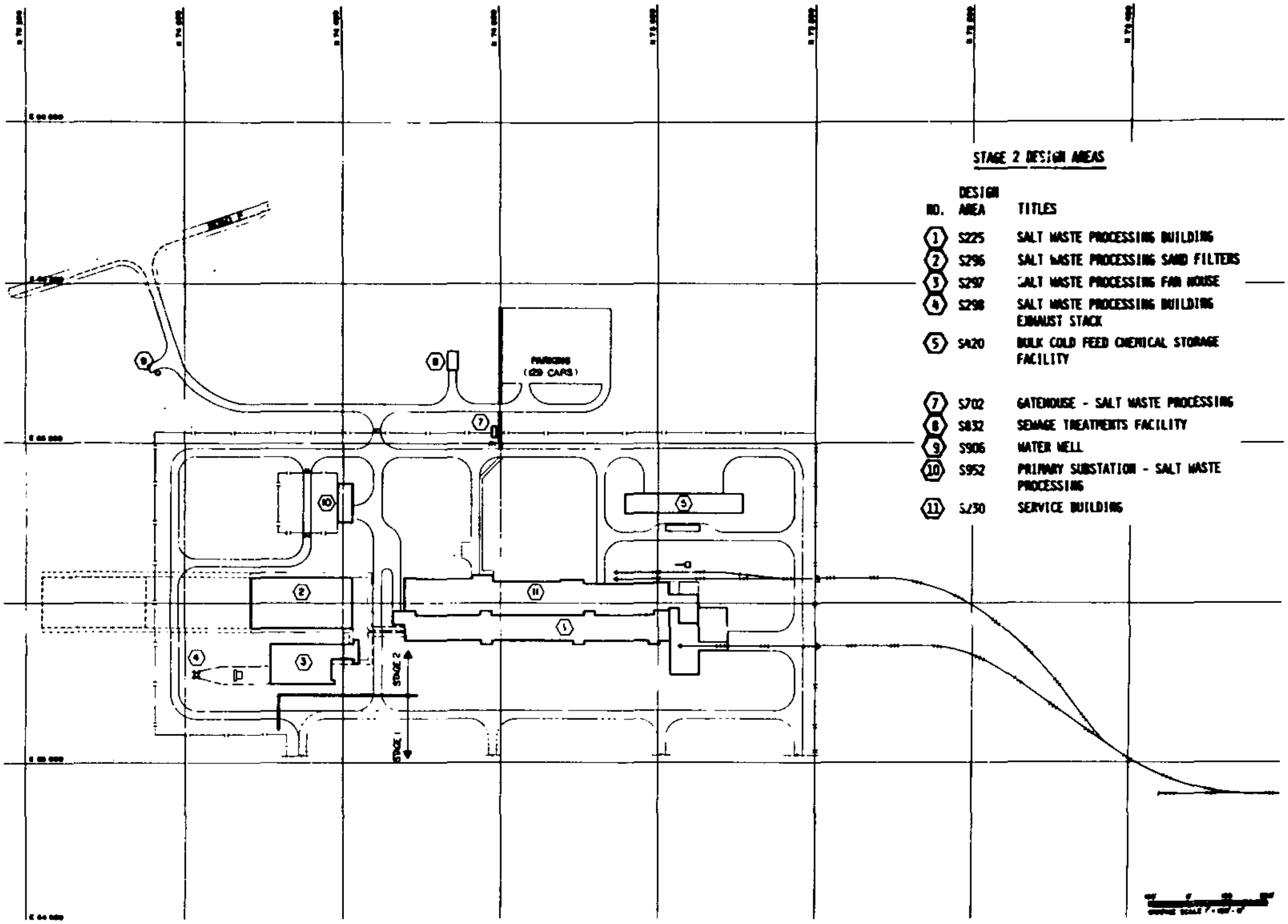

Fig. 3.18. DWPF — Stage 2, 200-S area.

The main processing building will house the glass melter and all associated equipment required to vitrify washed sludge. The rectangular building 99 m long by 40 m wide will house the process cell, which includes a segregated mechanical cell within the process cell for canister sealing and decontamination. The building will also house process cooling-water systems, process equipment decontamination facilities, a local control room for emergency operations, health protection facilities, and supporting electrical, instrument, and maintenance shops. Process areas will be of earthquake- and tornado-resistant construction. Areas, such as shops, railroad tunnels, etc., will be located in contiguous standard construction facilities. Process equipment will be in remotely operated cells, and maintenance will be performed remotely, except in certain locations where contact maintenance will be permitted. Clean area facilities, such as control rooms, locker rooms, cold feed, heating and ventilation equipment rooms, electrical substations, etc., will be either in contiguous or nearby buildings. Zone control ventilation will maintain proper air flow between zones, and exhaust air from specified operating areas will be routed through HEPA filters. All air from the process cell will go through a sand filter before release to the atmosphere.

The sand-filter and fan house will be earthquake- and tornado-resistant. The 43-m stack will be of standard construction.

Other buildings in the S-area will include the administration building, warehouse, and interim storage building. There will be no laboratory facilities in the S-area during "uncoupled" operations.

The interim storage building will include a vault area to receive and store canisters of immobilized glass waste, will provide for natural convection air cooling of the stored canisters, emergency filtration of ventilation exhaust air, and biological shielding for personnel. The storage vault, the exhaust air chimney, the supply air plenum and the emergency exhaust filtration system (including instrumentation, electrical power, and the diversion and air ducting system), and the canister support rack/storage system will be earthquake- and tornado-resistant. The electrical control room, maintenance shop, service room, office, and change rooms will be of standard construction. The initial building vault area will be designed to store two years' production capacity (1026 canisters), and provisions will be made for later expansion of the vault and ventilation systems to add storage capacity (in two-year increments) to a maximum capacity of 10,000 canisters. Building design will be similar to the reference process interim storage building described in Sect. 3.1.3.1, which has a capacity of 6500 canisters and provision for doubling the capacity to 13,000.

Shielding design for the interim storage building will be based on glass made from either five-year-old sludge alone or five-year-old sludge plus 15-year-old supernatant. Exposures will be limited to 0.5 millirem/h in continuously occupied areas and to 5 millirem/h in intermittently (less than 10%) occupied areas.

Steam will be available to the S-area via pipeline from the F- and H-areas. New facilities will be required to provide electricity, water, compressed air, refrigeration, and sewage treatment. Electrical power will be provided by constructing necessary lines and substations connecting to the existing SRP electrical system. A separate, redundant source of well water will be provided for the area. A cooling tower that has a recirculating water system will provide cooling for the process itself, air compressors, refrigeration equipment, and other nonprocess equipment. A central refrigeration facility will provide chilled water. Equipment mock-up for replacement process equipment during normal operations will be in an existing F-area mock-up facility. Regulated, as well as clean, maintenance shops and electrical and instrument shops will be provided. A master/slave manipulator repair shop and a regulated crane-repair cell will also be provided.

Stage 2

New facilities in the waste-tank farm will not be required for Stage 2 operations. Waste-tank farm functions associated with the salt decontamination plant are (1) dissolve and remove the saltcake in waste tanks using evaporator overheads or recycle water from the S-area, (2) separately store and evaporate waste solution from the salt decontamination process, and (3) transfer supernatant and recycle water between the F- and H-area tank farms.

New underground interarea transfer lines equipped with ventilated pump pits and diversion boxes will provide for (1) transfer of supernatant feed solution from H- to S-area, (2) transfer of waste-farm evaporator overheads from H- to S-area, and (3) return waste from supernatant processing to the waste farm. The spare interarea transfer line provided for DWPF Stage 1 will suffice as a spare for Stage 2 whenever the underground transfer routes permit common use of the spare line. Underground lines between S- and Z-area will provide for transfer of decontaminated salt solution to Z-area and return of salt evaporator overheads. A spare line will also be needed between the S- and Z-areas.

The main Stage 2 processing building (canyon) will house the supernatant processing equipment. The canyon building will be 206 m long by 20 m wide by 30 m high and will also house the process cooling-water and steam systems and supporting facilities such as maintenance shops, electrical and instrument shops, health protection offices, etc. The canyon building will be of earthquake- and tornado-resistant construction. Process equipment will be remotely operated and maintained except for certain areas where contact maintenance will be permitted. Design of equipment will facilitate decontamination. Clean areas, such as control rooms, change facilities, cold-feed, heating and ventilation equipment rooms, electrical substations, etc., will be maintained at air pressures higher than the pressure of the regulated areas and canyons. In addition, auxiliary canyon facilities will be provided for crane maintenance and for in-canyon storage areas for lifting yokes and crane tools.

Radiation shielding for personnel will be provided by canyon walls and roof, all having shield thicknesses to attenuate dose rates to 0.5 millirem/h in all normally occupied areas and to 5 millirem/h where personnel exposure is only intermittent.

Zone-controlled ventilation from personnel areas will exhaust through a single-stage HEPA filtration system. The processing area exhaust will be through an earthquake- and tornado-resistant Stage 2 sand filter and fan house. The Stage 2 (43-m) stack will be of standard construction.

Other facilities in S-area required for Stage 2 will be an expansion of the Stage 1 administration building to house the additional personnel, an additional warehouse for cold-feed make-up and control or expansion of the Stage 1 warehouse, a control building of standard construction contiguous to or adjacent to the canyon, a laboratory facility to provide analytical support of the supernatant process to be located in a separate building in the S-area, and a small chemical and industrial waste-treatment facility.

Stage 2 facilities in the Z-area include the concrete-mixing plant, the tank for supernatant feed, the supernatant evaporator, the condensate tank, and the supernatant product tank. Warehouse or shelter facilities will be used to store the cement. Saltcrete pumping facilities will be located in a standard construction building.

Utility requirements for Stage 2 may require an additional steam pipeline between F- and H-areas. The existing S-area water systems and cooling tower for Stage 1 will need to be expanded. The central refrigeration system will need to be expanded. A new electrical substation will be required to supply the Stage 2 load. Compressed air supply will use small compressors located throughout the site. Sanitary wastes will be processed by new equipment. Because of the geographical location of the Z-area and the relatively small work force, local septic tank disposal should be adequate.

Equipment mock-up and jumper fabrication will be provided in an existing F-area facility. Regulated as well as clean maintenance shops, electrical and instrument shops, crane maintenance and canyon equipment repair shops, and master/slave manipulator repair shops will be provided in the canyon building.

The Z-area will have two small equipment repair shops, one clean and one regulated for direct hands-on maintenance of equipment. These shops will be shared by electricity and instrument personnel.

3.3.4 Facility construction

3.3.4.1 Construction schedule

The Stage 1 facility construction will begin in October 1982 with completion in 1988. Construction of the Stage 2 facilities will start in October 1985 with completion in 1991.

3.3.4.2 Construction manpower

Construction manpower for the staged DWPF is expected to peak at about 3000 during the third quarter of 1987 (Fig. 3.19). This figure presents the construction labor force and total construction staff, including supervisory and support personnel, as a function of years after construction begins.

3.3.4.3 Construction costs

Preliminary construction cost estimates for the Stage 1 and Stage 2 facilities, expressed in millions of dollars (FY-1980), are:

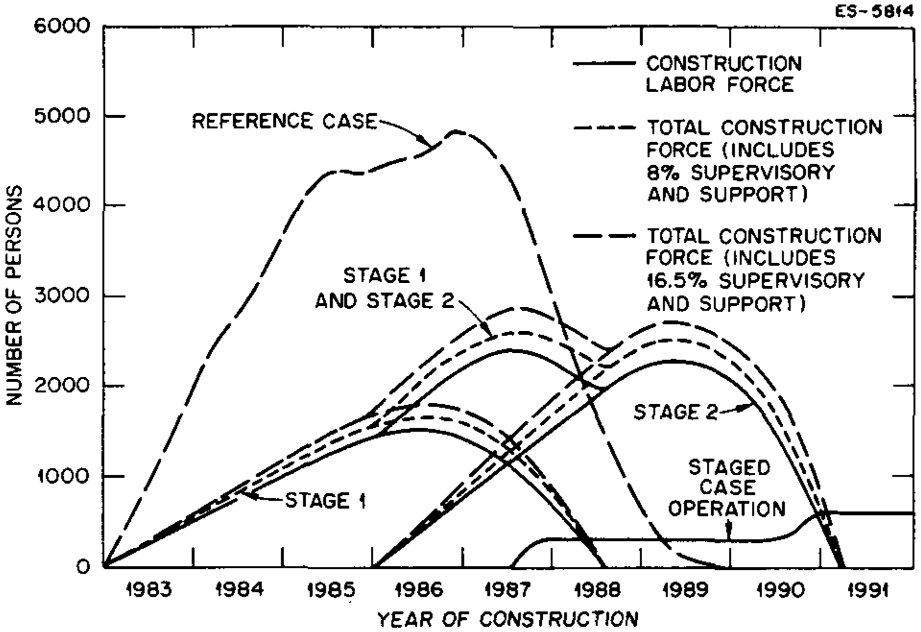

Fig. 3.19. Work force required to build and operate the staged alternative DWPF.

	Stage 1	Stage 2	Total
Process facilities	380	475	855
Tank-farm facilities	38	55	93
Interim glass storage	32		32
Saltcrete facility		40	40
Power, general, and service	70	130	200
Total	520	700	1220

3.3.4.4 Energy and resource requirements

The estimated energy and resource requirements for construction are:

	Stage 1	Stage 2	Total
Concrete, m^3	61,000	92,000	153,000
Steel (structural and rebar), t	9,100	13,600	22,700
Gasohol, L	1,500,000	2,300,000	3,800,000
Diesel fuel, L	1,500,000	2,300,000	3,800,000
Propane, L	12,100	18,200	30,300

3.3.5 Facility operation

Stage 1

The facilities are designed to vitrify sludge at an instantaneous production rate of 3.2 L/min or 104 kg/h of borosilicate glass. This rate will result in about 500 canisters of glass per year.

Stage 2

Supernatant processing will be at a rate of 48 L/min or 1200 kg/h of salt in saltcrete.

3.3.5.1 Schedule

Stage 1

Cold chemical testing is to be completed with hot startup of the Stage 1 facilities planned for 1988. Operations will continue for about 30 years to process the sludge waste generated through 2002.

Stage 2

Cold chemical testing is assumed to be completed with hot startup of the Stage 2 facilities in 1991. Stage 2 facilities will require about 28 years to process the salt and supernatant.

3.3.5.2 Operating manpower

Stage 1

The S-area work force during the operation of Stage 1 facilities will total 240 persons. Staffing is expected to begin about one year before full production to provide training and a run-in period for equipment.

Stage 2

Operations of the Stage 2 facilities will require an additional 290 persons bringing the total population of the S- and Z-areas to 530 persons, as shown in Fig. 3.19.

3.3.5.3 Operating costs

The annual average operating cost of the Stage 1 facility is projected as $28 million (FY-80 dollars). Excluding operating costs associated with the design and construction of the facility, the total operating cost to immobilize the sludge waste existing at startup and generated through 2002 is estimated at $680 million (FY-80 dollars; 6 months of cold chemical testing and about 30 years of hot operations).

The annual average operating cost of the Stage 2 facility is projected as $23 million (FY-80 dollars). Excluding operating costs associated with the design and construction of the Stage 2 facility, the total operating cost to immobilize the supernatant waste existing at startup and generated through 2002 of the Stage 2 facility is estimated at $500 million (FY-80 dollars; 6 months of cold chemical testing and about 28 years of hot operations). These costs include about $55 million for three years of continued operation of the Stage 1 facility at a reduced rate to immobilize the cesium and strontium recovered from the supernatant process after sludge processing has ceased.

Estimated maximum annual costs, expressed in millions of dollars (FY-80), are categorized as follows:

	Stage 1	Stage 2	Total
Direct labor	9	9	18
Overhead	5	5	10
Canisters and major equipment	9	1	10
Other materials and supplies	5	8	13
Total annual operating costs	28	23	51

3.3.5.4 Expected releases and discharges

Stage 1 (uncoupled)

The annual atmospheric releases of radioactivity from routine processing 5-year-old sludge at full operating capacity are presented in Table 3.25.

Table 3.25. Annual atmospheric radioactive releases (Ci)—Stage 1 operation

Isotopic group	DWPF
Tritium	4.3E–1[a]
Fission products	1.1E–2
Uranium	2.1E–9
Transuranics	1.5E–4

[a]Read as 4.3×10^{-1}.

The only source of radioactive liquid releases is the condensate from the evaporator in the waste-tank farm, which is discharged at a maximum flow rate of 11 L/min during normal operations. Table 3.26 presents the annual aqueous release from Stage 1 operations to existing seepage basins as discussed in Sect. 3.3.1.6.

Table 3.26. Estimated annual aqueous releases (Ci) to the environment from Stage 1 operation

Tritium	3.1E+1[a]
Fission products	4.6E0
Uranium	9.4E−7
Transuranics	6.7E−2

[a]Read as 3.1×10^1.

Nonradioactive liquid, gaseous, and solid wastes will be generated during normal operation of Stage 1 facilities. Gaseous wastes include diesel engine exhausts (backup power generation during electrical power outages) and chemical releases from processing. Estimated emissions from diesel generators will be less than those shown in Table 3.15 for the reference immobilization alternative. All emissions to the atmosphere will be within emission standards set by South Carolina and EPA. The estimated drift releases from the refrigeration system cooling tower are less than those presented in Table 3.17.

Nonradioactive liquid wastes include chemically contaminated wastewater and sanitary wastewater. Chemically contaminated wastewater will originate from cold-feed spills and wash down, chemical contamination of rainwater runoff, and cooling-tower purge solutions. The estimated average flow rates from each source are listed in Table 3.27. Streams from these sources will be collected, blended, and treated in a chemical and industrial waste treatment facility. Design objectives for the treatment facility are summarized in Table 3.19 for the reference immobilization alternative. Sanitary waste treatment facilities in the S-area will provide a secondary treatment and disposal system for release to spray fields or release to Four Mile Creek. Sewage sludge disposal will be the same as for existing operations.

Table 3.27. Sources and estimated average flow rates of nonradioactive aqueous streams

Source	Flow rate (L/min)	
	Stage 1	Stage 2
Cooling-tower purge	50	70
Rainfall runoff	<0.04	<0.04
Chemical spills and washdown	0.3	0.3

Source: EID.

Stages 1 and 2 (coupled operation)

The annual atmospheric releases of radioactivity for coupled operation are presented in Table 3.28. Releases will be from the Stage 1 and 2 stacks, the regulated facility vessel vent, and the saltcrete plant vessel vent.

The radioactive liquid releases will be condensate from the general purpose evaporator as described in Sect. 3.1.6.4 for the reference process. The estimated annual release is presented in Table 3.28.

The nonradioactive liquid, gaseous, and solid waste will be similar to those described in Sect. 3.1.6.4 except neither Stage 1 nor Stage 2 operations will require the coal-fired powerhouse and its associated combustion products, dust collector, electrostatic precipitator, sulfur dioxide scrubber, and contaminated water from the ash basin and coal pile runoff.

Table 3.28. Annual atmospheric and liquid radioactivity releases (Ci) from combined Stage 1 and Stage 2

Stage 1 and Stage 2 sand-filter stacks	
Tritium	5.4E0[a]
Fission products	1.3E−2
Uranium	1.6E−9
Transuranics	1.1E−4
Regulated facility vessel vent	
^3H	2.4E0
FP	1.9E−7
U	2.6E−13
TRU	1.7E−10
Saltcrete plant vessel vent	
^3H	2.3E0
FP	2.5E−7
U	3.4E−13
TRU	2.3E−10
Liquid discharges	
^3H	8.5E2
FP	4.6E−5
U	8.5E−14
TRU	5.6E−11

[a]Read as 5.4×10^0.

Sanitary waste treatment facilities will be provided as for Stage 1. The Z-area waste will be sewered to a septic tank for treatment and discharge via a tile field.

3.3.5.5 Energy and resource requirements

Stage 1

The Stage 1 immobilization facility energy and resource requirements include major chemicals, water, liquid fuel, steam, and electrical power. The vitrification will require borosilicate glass frit. The mercury scrubber and recovery operations will require 50% NaOH and 3M HNO_3 solutions, and the mechanical cell will require frit for decontamination of the canisters. Table 3.29 lists the annual quantities of major chemicals expected to be consumed by the Stage 1 facilities.

Table 3.29. Chemical consumption and inventory for Stage 1

Material	Concentration (%)	Consumption rate	Inventory
Sodium hydroxide	50	2.4E3 kg/month[a]	4.7E3 kg
Nitric acid	51	3.7E3 kg/month	7.4E3 kg
Glass frit	100	5.9E4 kg/month	2.4E5 kg
Hydroxylamine sulfate	100	6.4E2 kg/month	2.3E3 kg
Potassium permanganate	100	2.7E2 kg/month	1.4E3 kg
Silver mordenite	100	9.0E1 L/month	4.8E3 L

[a]Read 2.4×10^3.

Stage 2

The Stage 2 supernatant processing facility energy and resource requirements include major chemical, ion exchange resins, zeolite, coal and sand for filters, and cement. Table 3.30 presents the annual quantities required and warehouse inventory of the major supplies expected to be consumed by the Stage 2 facilities.

Table 3.30. Chemical consumption and inventory for Stage 2

Material	Concentration (%)	Consumption rate	Inventory
Sodium hydroxide	50	1.5E5 kg/month[a]	3.1E5 kg
Nitric acid	51	1.4E4 kg/month	2.7E4 kg
Carbon dioxide	100	1.5E4 kg/month	1.5E4 kg
Cement		3.2E6 kg/month	3.2E6 kg
Hydroxylamine sulfate		1.3E3 kg/month	2.7E3 kg
Potassium permanganate		8.2E2 kg/month	1.8E3 kg
Sodium EDTA	39	3.9E3 kg/month	1.5E4 kg
Polyelectrolite		3.2E−1 kg/month	4.5E0 kg
Ammonium carbonate			1.6E4 kg
Ammonium hydroxide	29		1.3E4 kg
Duolite ARC-359 resin		1.1E1 m^3/year	3.3E1 m^3
Amberlite IRC-718 resin		2.8E0 m^3/year	8.3E0 m^3
Zeolite		3.1E1 m^3/year	1.6E1 m^3
Coal, 20–30 mesh		1.0E0 m^3/year	7.6E−1 m^3
Coal, 30–40 mesh		3.4E−1 m^3/year	2.8E−1 m^3
Sand, 25–45 mesh		2.8E0 m^3/year	2.1E0 m^3
Sand, 40–60 mesh		2.2E0 m^3/year	1.6E0 m^3

[a]Read 1.5×10^5.

Water is required for domestic use, cooling towers, and service (make-up for an existing boiler). Table 3.31 is the estimated annual water consumption for Stage 1 and Stage 2 facilities. The estimated water withdrawal rate is about 14% of the total SRP groundwater usage. This incremental increase is expected to have negligible impact on the Tuscaloosa aquifer.

Table 3.31. Estimated average water consumption

Use	Consumption L/min	
	Stage 1	Stage 2
Domestic water		
Drinking, sanitary, safety showers	20	25
Cooling tower		
Cooling tower evaporation	430	780
Cooling tower drift	15	25
Cooling tower purge	95	95
Service water		
Boiler makeup (in another plant area)	110	310
Total usage	670	1235

The estimated annual energy requirements for operation of the facilities are:

	Stage 1	Stage 2	Total
Coal, t	8,200	22,700	30,900
Electricity,[a] GWh	50	60	110
Diesel fuel (emergency diesel testing and operation), L	9,000	9,000	18,000

[a]Electricity will be purchased from South Carolina Electric and Gas Company which has 4,242.5 [redacted] of on-line generating capacity and 1,854 [redacted] of capacity under construction.
MW MW

3.4 SALT DISPOSAL ALTERNATIVES

Disposal methods for the decontaminated salt were discussed in DOE/EIS-0023 with analysis of the potential environmental effects. Alternative modes that were considered were: store in the tanks at SRP; can and store in an onsite storage vault; and can and ship to an offsite Federal repository. The now-proposed use of saltcrete came later. Based on regulatory development for the disposal of hazardous waste and low-level radioactive waste, saltcrete burial in an engineered landfill is the preferred disposal method (Sect. 3.1.1.7). Storage in a surface vault was not considered because it does not meet the hazardous waste disposal requirements.

3.4.1 Return of decontaminated salt (crystallized form) to waste tanks

The return of decontaminated salt to waste tanks for storage in crystallized form requires most of the same processing steps as making saltcrete except that the decontaminated salt solution is returned to the tank farm for evaporation and storage in decontaminated waste tanks instead of being mixed with concrete and buried as saltcrete monoliths in a prepared, impervious clay-lined burial ground. This alternative would utilize the empty waste storage tanks, eliminating the need for the saltcrete processing facility and burial operations.

The principal advantage of this alternative is a relatively lower capital and operating cost compared with other salt-disposal alternatives. A disadvantage is the potential for radionuclide and chemical contamination of surroundings by release of high solubility nitrate-nitrite salt and contaminant mercury in the event of a massive accidental tank rupture, as by an earthquake. Other, less abrupt modes of failure of unattended tank systems are also possible over long periods. Tank storage of crystalline salt is not preferred because the hazards would be greater than those for saltcrete in an engineered landfill.

3.4.2 Return of decontaminated salt to waste tanks as saltcrete[25]

The return of decontaminated salt as saltcrete to used or new waste tanks requires all of the processing steps for making saltcrete described in Sect. 3.1 except that the saltcrete is placed in waste tanks instead of being pumped into the prepared, impervious clay-lined burial ground. The potential for chemical contamination of surrounding areas in the event of a massive tank rupture would be avoided. Containment would initially be better than that of saltcrete disposal in an engineered landfill. However, some modes of tank failure such as corrosion or mechanical failure leave this method of disposal in doubt.

Among the advantages are costs saved from the elimination of the decommissioning of the waste tanks and of constructing and operating the saltcrete burial facility that would have occupied the 20-ha 200-Z area. Offsetting these savings, however, is the need for construction of 55 to 60 new tanks, costing about $0.6 billion (1980 dollars), required to contain the five-fold increase in volume of waste in this form as compared with crystallized salt, and the commitment of land area (19 ha) required to contain the new tanks.

Consideration has been given to placing saltcrete in the tanks that are available, and storing the additional saltcrete in engineered landfill rather than building additional tanks specifically for saltcrete disposal. Such a combination plan appears advantageous in some respects. However, closer examination indicates that the operational and safety problems of transporting the partially decontaminated salt to three different areas, operating and servicing three separate saltcrete plants, and improvising transport of the saltcrete to various tanks as they become available would create cost and operational problems that appear larger than the potential benefits.

3.4.3 Ship decontaminated salt offsite for disposal[25]

Shipment of decontaminated salt offsite would be done only if disposal in a geologic repository were considered necessary. Based on the existing NRC-proposed radioactive waste classification
TC guide,[26] the decontaminated salt is considered to be low-level waste suitable for near-surface burial. Since SRP has acceptable low-level radioactive waste disposal sites within its boundary, no offsite disposal was considered. If geologic disposal were required, the salt would have to be packaged in a form suitable for shipment and disposal. The waste form will depend on DOT packaging requirements and repository acceptance criteria. Each of these factors would introduce a complete new spectrum of problems and additional costs. The following rationale provides adequate basis for considering this alternative to be not preferred.

1. Saltcake form. Use of this product form would: eliminate the saltcrete processing facility and the saltcrete burial ground construction and operations; increase the radiation and vehicle accident risk due to transportation requirements; and result in a higher cost for packaging, interim storage, transport, and final disposal. The costs would be slightly offset by the elimination of the capital and operating costs of the saltcrete processing facility and burial ground. The increase in cost over the reference case would total about $200 million.

2. Other forms. Use of fused salt or saltcrete would entail even higher costs with essentially no change in radiation risk during transport. The fused salt form would result in fewer drums of waste but would require a special facility for fusing the salt and loading and cooling the drums. The saltcrete form would result in about a five-fold increase in the number of drums of waste to be loaded, stored, transported, and buried.

For these reasons, shipment offsite for disposal in Federal repositories will not be considered unless future regulations preclude the disposal of saltcrete in the SRP-engineered landfill.

3.5 ALTERNATIVES EXCLUDED FROM DETAILED CONSIDERATION

The following alternatives were addressed but have been excluded from detailed consideration for the reasons discussed below.

3.5.1 Immobilization without separation of sludge and salt[8]

The high-level waste, currently stored as alkaline sludge and damp saltcake, would be mixed and slurried with excess water to be immobilized with glass. The processing steps and equipment requirements are significantly different from those for the reference or staged processes. The primary benefit of the immobilization without separation is that the process eliminates the need for separate facilities to purify and dispose of salt and all waste would be moved offsite to a geologic repository. However, the volume of glass projected to be produced from this alternative is about 1×10^5 m^3, or about 20 times the volume of glass produced in the reference immobilization alternative. The reference canister, 0.61 m in diameter by 3.0 m high, holds 625 L of glass. Over 170,000 of these canisters would be required to contain the immobilized waste produced by this process.

Preliminary examination of combined immobilization (immobilization of the unseparated SRP high-level radioactive waste), which appeared to be a promising alternative initially, showed that the technological, environmental, economic, and safety problems far outweigh the benefits. Therefore, this immobilization method was not considered a viable alternative for the DWPF. Both the benefits and cost in comparison with the reference design are given below.

The combined process eliminates the costs and impacts of salt processing and disposal. Processing is simplified by eliminating the steps associated with purification and treatment of the salt. No saltcrete plant or burial area would be required, reducing air emissions and terrestrial impacts associated with the saltcrete facility and burial area. The cost of saltcrete processing and of development of the burial area would be eliminated along with any potential long-term impacts from saltcrete burial.

Counterbalancing these benefits are penalties that result primarily from the very much larger volumes of waste to be immobilized and the consequent much larger number of canisters to be stored and transported, as well as from the uncertainties of the process. Despite the expected simplification of the combined process, this waste-form immobilization is at an early state of development and will require substantial testing to demonstrate its long-term viability. There could be problems in producing a low-leachate waste form considering the large amounts of sodium in the waste. Because of the much larger volume of combined waste, all of which must be vitrified, the immobilization facility would need to be much larger with parallel process trains to handle the larger volume of high-level radioactive material. This alternative would require more than ten times the number of melter cells and associated process and handling facilities than are required for the reference process. Despite the savings from elimination of salt processing and burial, the facility would cost more than twice as much as the reference alternative.

The scope of operations for combined immobilization would require a larger facility and an expanded work force. A greater commitment of personnel increases the possibility for greater radiological dose to the work force compared with the reference alternative. About 20 times the volume of waste must be transported to a repository and a larger number of shipments would be required, with a proportional increase in fuel use and emissions. Radiation impacts to the public along transportation routes would be increased. Consequences of an accident during shipment would be approximately the same as for the reference alternative; however, the probability of an accident is proportional to the number of shipments, which is considerably greater for the combined immobilization alternative. Similarly, the probability of an accident during handling (transfer) would increase proportionally with the increase in the number of canisters handled. The cost of transporting the waste to the repository would be increased by a factor of 2 to 5. The repository area required for the immobilized waste would also be increased with a corresponding increase in repository cost. Overall, the disadvantages of immobilizing combined salt and sludge far outweigh the advantages. Therefore, it is not considered a viable alternative.

3.5.2 Interim solidification

As in the consideration of immobilization without separation of sludge and salt, the stored high-level radioactive wastes can be solidified (although not immobilized) into an interim waste form pending future immobilization for final emplacement in a repository. The primary purpose for interim solidification is to convert the existing wastes to a form less subject to accidental dispersal. The singular advantage is to have the wastes in an apparently safer form while exploring immobilization alternatives and deferring final action. At least three interim waste solidification approaches have been considered in some detail:

1. low-temperature waste solidification of molten sludge/salt slurry,

2. powdered calcine from sludge/salt slurry, and

3. powdered calcine from sludge with other decontaminated salt disposal options.

The first two approaches require the ultimate immobilization of the entire sludge/salt mixture. Separation of the high-level radioactive component from the overall solidified mixture can be effected only with great difficulty and high cost. Therefore, immobilization will require combined vitrification and will produce about 20 times the number of canisters anticipated for either the reference or staged alternatives. The disadvantages associated with combined immobilization are described in Sect. 3.5.1 and discourage further consideration of the first two approaches for interim solidification.

Although only sludge is calcined, the third approach will result in nearly three times the number of canisters as will be produced if either the reference or staged alternatives are implemented. Furthermore, as with the other two interim solidification approaches, it will require double processing to put the waste into a final immobilized form. Double processing is clearly more costly than single processing (direct immobilization) and results in increased occupational exposure, as well as increased potential for environmental impacts.

Due to the large quantity of high-level radioactive waste stored at SRP and the large increase in volume of the final immobilized waste form that results from interim immobilization, this alternative was considered to be unreasonable and was not considered in detail in this EIS.

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11. EID.

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J-11 26. U.S. Nuclear Regulatory Commission, *Proposed 10 CFR Part 61 -- Licensing Requirements for Land Disposal of Radioactive Waste*, Federal Register 46(142): 38089-38100, July 24, 1981.

4.1 GEOGRAPHY

4.1.1 Site location

The DWPF is proposed for DOE's Savannah River Plant (SRP) in southwestern South Carolina. Augusta, Georgia, is about 37 km (23 miles) northwest; Aiken, South Carolina, is about 27 km north; Barnwell, South Carolina, is about 10 km east; and Columbia, South Carolina is about 93 km northeast (Fig. 4.1). Two small South Carolina towns lie within 20 km of the proposed DWPF site, Jackson (population 2000) and New Ellenton (population 2500). The Barnwell Nuclear Fuel Plant of Allied-General Nuclear Services lies within the 20-km radius, as does the Vogtle Nuclear Power Plant and Chem-Nuclear Systems, Inc. The remaining area within 20 km is primarily the controlled access area of SRP (Fig. 4.2).

ES-5549

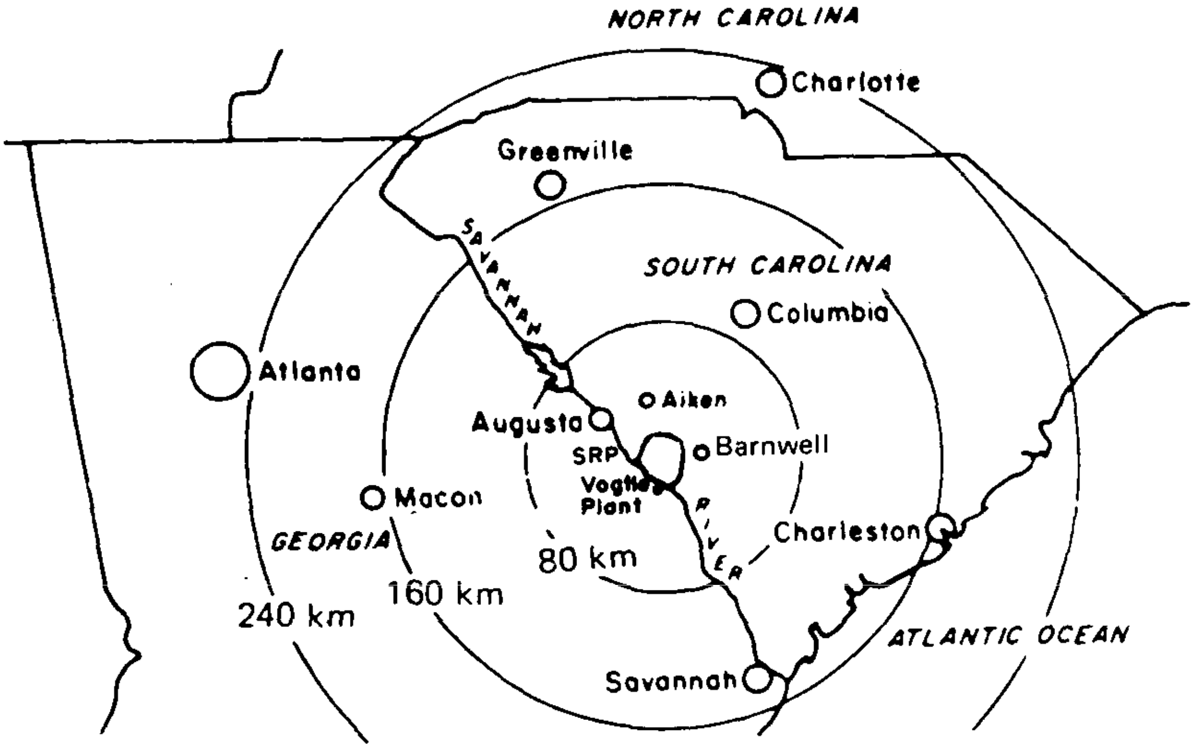

Fig. 4.1. Location of SRP relative to surrounding population centers. Source: *Final Environmental Impact Statement, Long-term Management of Defense Wastes, Savannah River Plant, Aiken, South Carolina,* DOE/EIS-0023, November 1979.

4.1.2 Site description and land use

The SRP is an 800-km^2 (300-square-mile) controlled area set aside by the U.S. government in the 1950s for the production of nuclear materials for national defense. The SRP facilities, which may be characterized as heavy industry, occupy less than 5% of the SRP area. Plantation pine and native vegetation occupy the remainder of the plant area.[1]

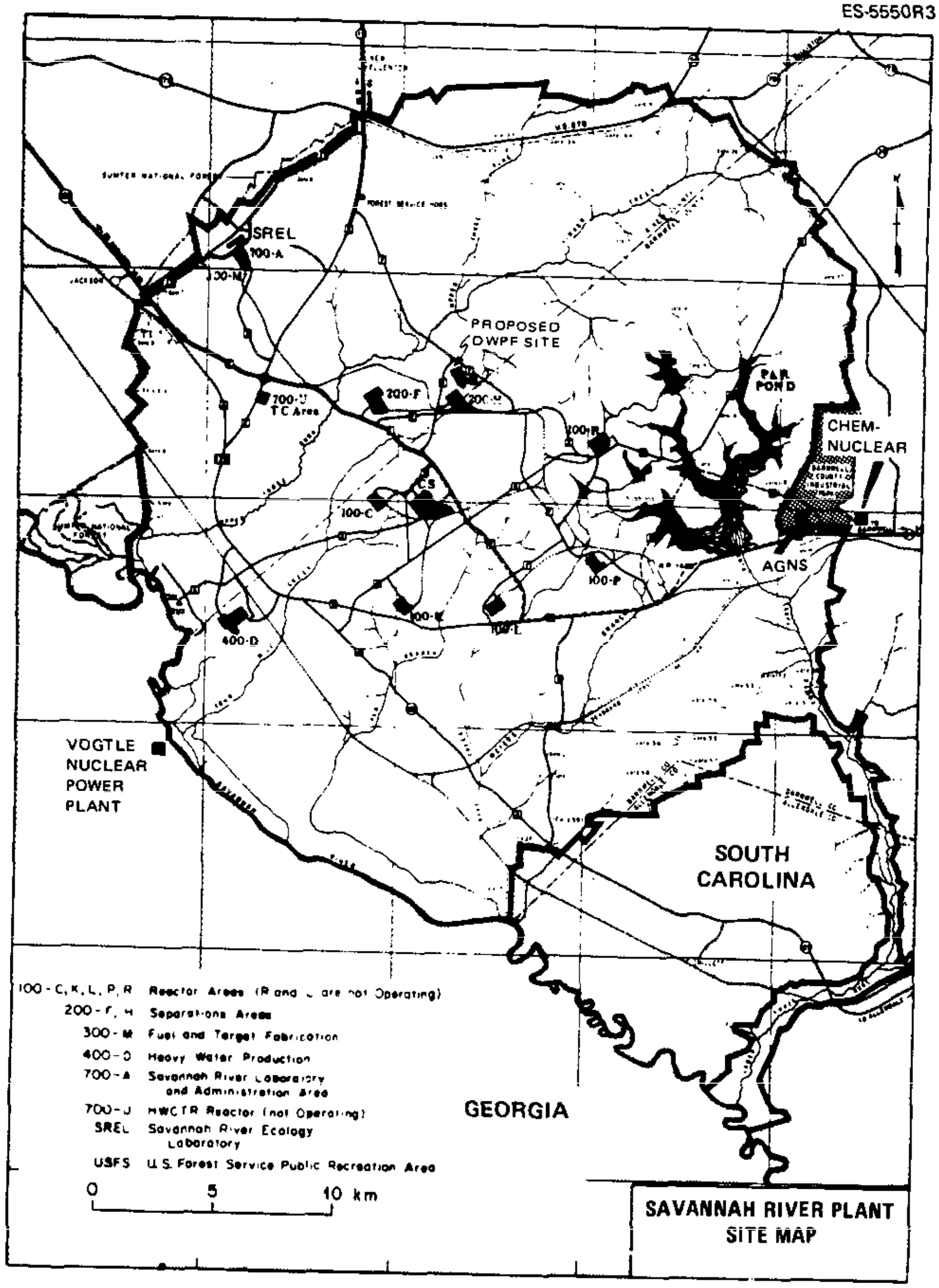

Fig. 4.2. The Savannah River Plant.

The proposed DWPF site is within 600 m of H-area where defense wastes are now stored (Fig. 4.3). The proposed site would occupy approximately 60 ha adjacent to H-area. Topography is relatively flat with drainage to Upper Three Runs Creek. The flora of the area is now young plantation pine and native vegetation.

An area of approximately 20 ha about 1200 m north of H-area has been proposed for salt disposal. The area is relatively flat (local relief <6 m); drainage is to Upper Three Runs Creek. The site is now a forest of slash and loblolly pine.

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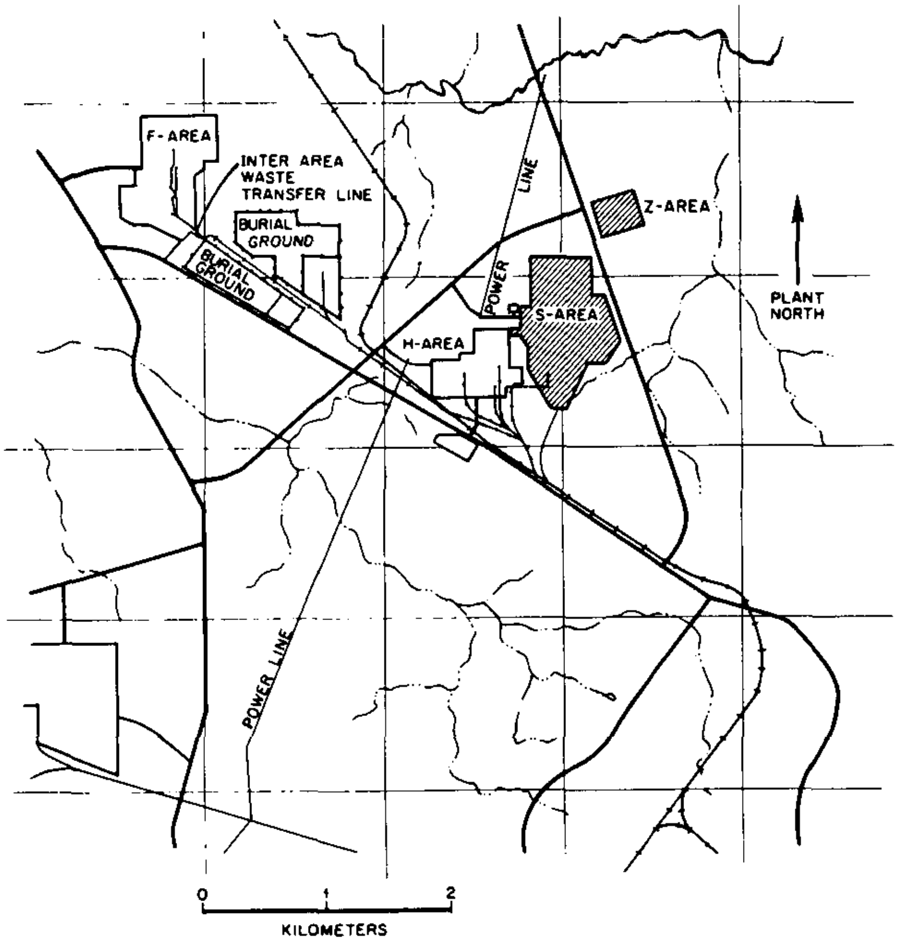

Fig. 4.3. Location of the proposed site for the DWPF (S-area) and for salt disposal (Z-area).

4.1.3 Historic and archaeological resources

The proposed site for the DWPF was surveyed (December 1978 through January 1979) for archaeological resources and for sites that might qualify for inclusion in the *National Register of Historic Places.*[2]

The archaeological survey was conducted by establishing transects through and around the DWPF site (approximately 10,000 m total) and raking and inspecting 4-m^2 plots every 20 m along each transect. No archaeological or historical artifacts were found within the DWPF area, although two sites were identified nearby, 38 AK 169 and 38 AK 261. Site 38 AK 169 was known previously to be a site having few artifacts and considerable site disturbance. The site is prehistoric but contained insufficient information to be useful in archaeological research. Site 38 AK 261 contained historic artifacts of the 1880 to 1940 period which were interpreted to be associated with a dwelling that had been destroyed intentionally. The building did not appear on aerial photographs taken in 1951 prior to government acquisition of the land nor was it indicated on a 1943 U.S. Army Corps of Engineers map. It was concluded that the site was not of value to research (Appendix I).

4.2 SOCIOECONOMIC AND COMMUNITY CHARACTERISTICS*

Additional information on the topics presented in Sect. 4.2 can be obtained in Appendix E.

4.2.1 Past impacts of the SRP

The socioeconomic impacts of the SRP upon the people and communities in its vicinity began with the relocation of the resident population from the SRP site and construction of the first facilities in 1951. By 1952, a work force of 38,350 was on site, populations of nearby towns swelled, and trailer courts and new homes proliferated. These early days and the changes induced by plant construction are described in the book *In the Shadow of a Defense Plant* by Stuart Chapin et al.[4]

A primary socioeconomic impact of the SRP has been the large number of permanent jobs created. The permanent operating force has averaged around 7500 ranging from a low of 6000 to the current 8300 (June 1980). About 95% of this total are employed by E. I. du Pont de Nemours & Company, Inc., and its subcontractors; the remainder are employed by DOE (220), the University of Georgia (70), and the U.S. Forest Service (30).

The substantial contribution of SRP to the rise in the standard of living in the impact area is a major secondary socioeconomic benefit. The 1979 SRP payroll of over $209 million was one of the largest in South Carolina. In addition, more than $40 million was spent by SRP in South Carolina and Georgia for services, energy, materials, equipment, and supplies in 1979; about one-half of the expenditure was made in the primary impact area (see Sect. 4.2.2 for definition of the primary impact area).

The greatest impact of the SRP has been on Aiken County, especially the city of Aiken, and small towns immediately around the SRP site, as may be seen in the SRP worker distribution pattern (see Table 4.1). SRP workers and families comprise roughly one-half of the city of Aiken's 15,000 people and account in large measure for the high median family incomes in the county.

Table 4.1. Distribution of the June 1980 SRP employees by place of residence and as a percentage of the June 1980 labor pool

Location of residence	Number of SRP employees	Percent of SRP labor force	June 1980 labor pool	SRP employees as a percentage of the labor pool
Primary study area	7447	89.3	142257	5.2
South Carolina counties	5955	71.4	59790	10.0
Aiken	4904	58.8	40260	12.2
Allendale	149	1.8	3580	4.2
Bamberg	165	2.0	6830	2.4
Barnwell	737	8.8	9120	8.1
Georgia counties	1492	17.9	82467	1.8
Columbia	256	3.1	15197	1.7
Richmond	1236	14.8	67270	1.8
Secondary study area	643	7.7	129609	0.5
South Carolina counties	553	6.6	113370	0.5
Edgefield	92	1.1	8090	1.1
Hampton	104	1.2	7080	1.5
Lexington	133	1.6	57980	0.2
Orangeburg	142	1.7	33590	0.4
Saluda	82	1.0	6630	1.2
Georgia counties	90	1.1	16239	0.6
Burke	25	0.3	8176	0.3
Screven	65	0.8	8063	0.8
Outside study area	245	2.9[a]	[b]	[b]
South Carolina	163	2.0	[b]	[b]
Georgia	71	0.9	[b]	[b]
Other states	11	0.1	[b]	[b]

[a] Numbers may not add due to rounding.
[b] Not applicable.
Source: SBC 1981.

*All material used in Sect. 4.2 is based on the report *Socioeconomic Baseline Characterization for the Savannah River Plant Area*,[3] ORNL/Sub-81/13829/5, prepared by NUS Corporation for ORNL, except as otherwise noted.

4.2.2 The study area

The DWPF, proposed for construction on the SRP site, is anticipated to have most of its socioeconomic impact on a 13-county area in South Carolina and Georgia (Fig. 4.4). The nine counties in South Carolina are Aiken, Allendale, Bamberg, Barnwell, Edgefield, Hampton, Lexington, Orangeburg, and Saluda; the four Georgia counties are Burke, Columbia, Richmond, and Screven. Together they house 97% of the current SRP work force. These counties are expected to provide most of the labor pool for the DWPF and to sustain the most concentrated community impacts from potential workers moving into the area.

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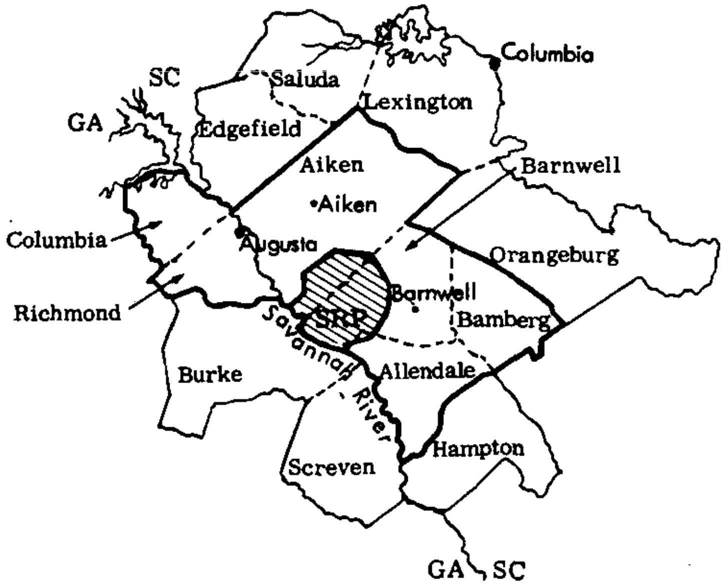

Fig. 4.4. The study area.

The study area can be divided into a six-county primary impact area and a seven-county secondary impact area on the basis of expected impacts from construction and operation of the proposed DWPF. The primary impact counties were estimated to be the residence choice of a large majority of relocating workers and, thus, the site of the most concentrated community effects. The six primary impact counties are Aiken, Allendale, Bamberg, and Barnwell, South Carolina, and Columbia and Richmond, Georgia. Together they house 89% of the current SRP work force. An additional 8% of current SRP workers are housed in the secondary counties of Edgefield, Hampton, Lexington, Orangeburg, and Saluda, South Carolina, and Burke and Screven, Georgia.

Five levels of government function in the 13-county area, providing services, implementing policies, and interacting with each other and the citizens. These levels include 78 communities, 13 counties, several regional councils (or planning and development commissions), two states, and the Federal government. In addition to these multipurpose governing units, there are "special purpose" (e.g., school and water) taxing districts in both South Carolina and Georgia.

4.2.3 Land use

The 13-county impact area, encompassing over 20,000 km^2, is generally rural. Table 4.2 lists the primary land uses as percentages of the total area.

Agricultural lands, although maintaining their primary economic importance in the area, are undergoing a transition from smaller operations to larger consolidated farms, a trend that is expected to continue. Other observed land use trends are the conversion of some forest lands managed by timber companies to crop or pasture lands and the reforestation of other areas within the 13-county region.

Table 4.2. Study area land use (13 counties)

Land use	Percentage
Woods, forests, wetlands	37.5
Agricultural	35.7
Urban	4.7
Other developed (public, semi-public)	0.5
Water bodies	1.4
Vacant, open space and unclassified	20.2

Source: *Socioeconomic Baseline Characterization for the Savannah River Plant Area*, prepared for ORNL by NUS Corporation, 1981.

The most intensively developed land in the study area is concentrated in the urbanized counties surrounding the cities of Aiken and Columbia, South Carolina, and Augusta, Georgia. Accordingly, the highest concentrations of residential, industrial, and commercial development in the primary impact area are found in Richmond and Columbia counties, Georgia, and Aiken County, South Carolina. In the secondary impact area, Lexington County is experiencing the most intensive development as a result of suburban growth from the city of Columbia.

All study area counties, except Hampton and Burke, have comprehensive long-range plans. The land-use controls most commonly used by local and county governments to shape area development patterns are zoning ordinances, subdivision regulations, building codes and permits, and the regulation of mobile homes and trailer park development.

Forty-six of the approximately 80 incorporated communities in the study area have at least one of the above four regulations in force. Table 4.3 lists the regulations and plans in effect in the six primary impact counties.

Table 4.3. Land use regulations and plans

Counties	Land use plan	Zoning ordinances	Subdivision regulations	Building codes	Mobile home/ trailer park regulations
			South Carolina		
Aiken	X		X	X[a]	
Allendale	X[b]				
Bamberg	X			X	X
Barnwell	X			X	
			Georgia		
Columbia	X	X	X	X	X
Richmond	X	X	X	X	X

Source: SBC 1981.

[a]Under consideration.

[b]As part of Lower Savannah Region Plan.

4.2.4 Demography

Table 4.4 lists the 1980 populations for counties and communities in the six-county primary impact area. The largest cities in the primary area are Augusta (47,500), Aiken (15,000), North Augusta (13,600), and Barnwell (5600). The other 27 incorporated communities have populations of less than 5000. Aiken, Richmond, and Columbia counties make up the Augusta Standard Metropolitan Statistical Area (SMSA)* with a total population of 317,300. A majority of SMSA residents live outside the boundaries of any city or town, and two-thirds of all residents of the six-county primary impact region live in rural areas and in 47 unincorporated communities.

*A Standard Metropolitan Statistical Area is comprised of a central city or cities with a population of 50,000 or more and the contiguous counties that are economically integrated with the central city.

Table 4.4. 1980 populations for counties and communities in the primary impact area

Location	Population
South Carolina	
Aiken County	105,625
City of North Augusta	13,593
City of Aiken	14,978
Allendale County	10,700
Town of Allendale	4,400
Bamberg County	18,118
City of Bamberg	3,672
City of Denmark	4,434
Barnwell County	19,868
City of Barnwell	5,572
Georgia	
Columbia County	40,118
City of Grovetown	3,491
Richmond County	181,629
City of Augusta	47,532
Primary impact area total	376,058

Source: U.S. Bureau of Census, 1980 Census of Population and Housing, South Carolina, PHC80-V-42; Georgia, PHC80-V-12; March 1981.

Over the last 30 years, the rate of population change has varied considerably from county to county within the primary and secondary impact areas, primarily reflecting differing rates of urbanization. Since 1950, most of the population increase has occurred in the three primary impact counties of Aiken, Richmond, and Columbia (Augusta SMSA). Of the three, Columbia County has had the highest rate of growth, increasing from the smallest to third largest among the primary impact counties between 1950 and 1978. In the same period, the fastest growing county in the secondary area was Lexington County, which now accounts for nearly one-half of the total population of all seven secondary counties. Significant declines in rural county populations in both primary and secondary areas that occurred in the 1950s and 1960s were reversed in the 1970s.

According to area planners, the greatest population growth is expected to occur in Aiken, Columbia, and Richmond counties because of anticipated Augusta metropolitan expansion. Within the secondary impact region, large increases in population are projected for Lexington County because of anticipated growth in the Columbia, South Carolina, metropolitan area. Additional demographic information is in Appendix E.

During the last 30 years, the populations of the primary study area counties have been younger (as measured by the median age) than that of the U.S. population. Following national trends, the population in the primary study area aged between 1970 and 1978, with the percentage of those under 19 declining from 40.6% to 37% and the percentage of those over 65 increasing from 7% to 8%.

From 1958 to 1978, the crude birth rates for the counties of the primary study area declined from 25.3 to 17.7 per thousand persons. This decline reflected national trends although birth rates exceeded the national average throughout the period. This slightly higher birth rate is reflected in average household sizes that are larger than those for the nation as a whole. In 1978, there were 3.0 persons per household in Georgia and 3.1 in South Carolina, compared to the national average of 2.8. Rural counties in the primary study area typically have larger average household sizes than SMSA counties.

In 1978 majorities of the population in Bamberg and Allendale were black, 60 and 56%, respectively. Richmond, Barnwell, and Aiken counties had smaller percentages of blacks, 37, 35, and 24%, respectively. Columbia County, with 15%, was closest to the national average of 11%.

With the exception of Aiken County, family incomes in the primary counties have been lower than the respective state medians. The relatively low median family incomes of the study area are partly attributable to a high percentage of impoverished families. In 1969, only the more urbanized counties, Lexington, Aiken, Richmond, and Columbia, had percentages of families at poverty levels (12 to 16%), approximating the national average of 10%. The remaining counties had percentages of poor families greater than 23%.

4.2.5 Economic profile

Much of the employment at establishments within the 13-county study area is in the manufacturing industries concentrated in the Augusta, Georgia, and Columbia, South Carolina, metropolitan areas. As a percentage of total employment, manufacturing activity at establishments is greatest in Barnwell and Aiken counties. Significant percentages of employment at retail and wholesale trade establishments exist in Allendale and Richmond counties, whereas the concentration of service employment is highest in Richmond County, where the U.S. Army Fort Gordon military base is located.

Table 4.5 shows county employment by types of establishment for the primary impact counties.

Table 4.5. Employment percentages at establishments in primary impact counties for 1977[a]

	Aiken	Allendale	Bamberg	Barnwell	Columbia	Richmond
Agriculture	0.4	0.2	1.1	0.1	0.6	0.5
Mining	1.1	0	0	0.1	1.0	0.2
Contract construction	2.7	5.1	1.6	4.1	17.7	7.2
Manufacturing	65.6	46.8	53.0	72.1	41.6	29.4
Transportation and public utilities	4.0	4.4	4.7	1.4	3.7	4.3
Wholesale and retail trade	14.6	32.6	21.1	15.3	23.0	31.8
Finance insurance and real estate	2.9	1.4	2.1	2.2	2.4	6.5
services	8.5	9.3	16.4	4.6	9.6	20.0
Other	0.2	0.2	0	0.1	0.4	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

[a]Figures represent percentages of total employment within establishments, excluding self-employed persons, in each primary impact county.

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns for South Carolina* and *County Business Patterns for Georgia*, Washington, D.C., 1977.

A discussion of construction worker availability in the SRP area is included in Appendix E. The proposed DWPF project will be competing for these workers with at least one other large construction project in this area. The Georgia Power Company's Vogtle Nuclear Power Plant, now under construction in Burke County, Georgia, is expected to employ over 4000 construction workers in 1983, soon after DWPF construction is expected to begin.

Table 4.6 lists income statistics for primary impact area counties along with the unemployment rates for 1980. Aiken and Richmond counties had the highest per capita incomes, and Allendale had both the lowest household income level and highest unemployment rate for the study area.

4.2.6 Public services

In the six-county primary impact area there are nine public school systems, seven in South Carolina and two in Georgia, operating 81 elementary schools, 26 intermediate schools, 23 high schools, 10 special schools, 9 vocational/technical schools, and 6 colleges. Approximately 93.6% of the area school-age children are enrolled in these nine public school systems, with the remainder either attending private schools or receiving instruction at home. Table 4.7 lists capacities available for increased enrollment in selected county schools and number of schools which have exceeded or are near capacity.

Additional planned facilities include three new high schools (a total of 3900 student spaces) in Aiken County, scheduled to open in early 1981, and two new high schools (2500 student spaces) in Columbia County. Other area school districts are adding mobile units to increase classroom capacities.

Table 4.6 Income and unemployment for primary impact area counties

	1979 per capita income ($)	1980 median household incomes ($)	1980 unemployment (%)
	South Carolina		
Aiken	5,229	17,130	6.9
Allendale	3,318	10,186	11.7
Bamberg	3,109	10,906	8.3
Barnwell	4,067	13,412	9.8
	Georgia		
Columbia	4,858[a]	14,537[c]	4.3
Richmond	6,991[b]	13,636[c]	6.7

[a]1977.
[b]1978.
[c]Estimated by ORNL Staff using 1979 data from *Sales and Marketing Management Survey of Buying Power*, July 1980. Estimate is the product of the ratio of the median effective buying income of the county of interest to that of Aiken County and Aiken County's 1980 median income.
Sources: Personal communication with Candler Spence, S.C. Employment Security Commission, Columbia, S.C., and Lorraine Powell, Central Savannah River Planning and Development Commission, Augusta, Ga.

Table 4.7. Number of public schools and enrollment capacities by school districts (1979–80 school year)

School district	Number of facilities	Number of schools where a 10% increase in enrollment would exceed capacity[b]	Schools with capacity enrollments or near capacity enrollments	Available capacity (number of students)
Aiken[a]	36	7	10	3644
Allendale	6	0	6	0
Bamberg No. 1	6	6	0	60–90
Denmark-Olar No. 2	3	2	0	91
Barnwell No. 45	3	1	0	275
Blackville No. 19	3	0	0	299
Williston	2	0	0	480
Columbia	13	2	5	1168
Richmond	54	13	15	2583
Total	126	31	36	8600

[a]1980–81 school year.
[b]A 10% increase in enrollment would represent two additional students per class, assuming 20 students to the classroom.

Of the 120 public water systems operating in the primary impact area, 30 are county and municipal systems that serve 75% of the local population. The other 90 systems are generally smaller and serve individual subdivisions, water districts, trailer parks, and miscellaneous facilities such as nursing homes and schools. All but four of the municipal and county water systems obtain their water from deep wells. Those systems utilizing surface-water sources are the cities of Aiken, Augusta, and North Augusta, and Columbia County. All systems can accommodate some degree of additional use except one in Richmond County, which is currently operating at 100% of design capacity. Another five systems are now functioning at over 70% of capacity; three of these are also in Richmond County, with one each in Barnwell and Allendale counties. On the other end of the scale, a total of 19 systems in Aiken, Allendale, Bamberg, and Barnwell counties are operating at or below 50% of design capacity. Table 4.8 shows current usage for 28 county and municipal water systems and the 17 sewerage systems in the primary impact area.

The adequacy of municipal sewage treatment in the primary study area varies widely among systems. The counties of Allendale, Bamberg, Barnwell, and Richmond are currently experiencing sewage treatment capacity problems. Both Allendale County treatment facilities have reached plant

Table 4.8. Current average use of water and sewage systems in the primary impact area as percentage of design capacities

	Water systems[a]			Sewage systems		
	0–25%	25–70%	70–100%	0–25%	25–70%	70–100%
Aiken	3	4	0	0	4	1
Allendale	2	1	1	0	0	2[b]
Bamberg	2	3	0	0	0	1[b]
Barnwell	2	2	1	1	1	2[b]
Columbia	0	2	0	1	2	0
Richmond	1	0	4	0	1	1

[a]Two of the 30 area systems had insufficient data for calculating operating capacities.

[b]These systems have exceeded design capacity. System expansions are planned for the near future.

Source: SBC 1981.

capacity; however, expansions are currently planned. At the Denmark Plant in Bamberg County, the amount of sewage is double the treatment capacity as a result of infiltration/inflow. Expansion of the Denmark Plant is currently being planned. In Barnwell County, sewage is exceeding treatment capacity at the Blackville Plant because of infiltration/inflow. A rehabilitation program is currently being planned. The Augusta Plant in Richmond is operating at below treatment capacity, but about 15% of the effluent is discharged untreated. A proposed expansion of the Augusta wastewater treatment plant is currently being planned as well as a program to remove points of raw wastewater discharge.

The primary study area is generally well serviced by electric and natural gas utilities, which consist of private, investor-owned, municipal, and rural cooperative companies. Natural gas is used primarily by industrial customers, whereas residential customers consume most of the electricity. Most of the area's electric power is generated from coal, natural gas, oil, and hydropower by two utility companies, South Carolina Electric & Gas and Georgia Power. Power is sold directly to residential customers or wholesale to municipal and cooperative utilities.

Forty-three fire departments service the 13-county study area. Within the primary impact area, 60% of existing fire departments are currently providing adequate service, according to Insurance Service Office ratings. In the urban counties of Aiken, South Carolina, and Richmond, Georgia, services are most heavily concentrated in the cities of Aiken and Augusta, leaving some of the more rural areas without protection.

Health services in the primary study area follow a similar pattern to fire protection, with most services concentrated in the urban areas of Augusta and Aiken. However, except for Columbia County, every county in the primary area has at least one hospital.

Law enforcement agencies serving the primary study area include three levels of protection: the county sheriff, and state and community police. Highest 1979 crime rates in the six-county area were reported in Richmond and Aiken; the four rural counties experienced lower rates. The urban counties of Richmond and Aiken have law enforcement staffs below the national average of 2.1 law enforcement officers per 1000 population. Allendale, Bamberg, and Barnwell counties have staffs above the national average for counties, while Columbia County fell below the national law enforcement staff average for counties (1.5 full-time officers per 1000 population).

All primary area counties except Allendale have active civil defense departments and state-approved emergency preparedness plans. In addition, the SRP has various service agreements for mutual assistance or special support with Fort Gordon and Talmadge Hospital in Augusta. In addition, SRP shares fire-fighting mutual aid with Allied-General Nuclear Service, the city of Aiken, and the South Carolina Forestry Commission. Memos of understanding between SRP and the States of South Carolina and Georgia cover notification and emergency responsibilities in the event of an actual or potential radiological emergency at the SRP.

4.2.7 Housing

As shown in Table 4.9, about 86% of the total housing stock in the primary impact area is located in Aiken, Columbia, and Richmond counties, the three counties that make up the Augusta SMSA. Since 1970, the greatest rates of increase in the housing stock have occurred in Aiken, Barnwell, and Columbia counties. Of the three, Columbia County has grown the fastest, nearly doubling its number of housing units in the past decade. In Aiken County, one-half of the increase in housing

Table 4.9. Housing statistics for primary study area

County and year	Number of units	Vacancy rate (%)	Annual increase in units (%)
	South Carolina		
Aiken			
1980	39,791		3.6
1977	35,893	8.2	
1970	29,333	8.0	
Allendale			
1980	3,973		3.2
1977	3,511	4.0	
1970	3,002	9.3	
Bamberg			
1980	6,384		3.4
1977	5,663	4.2	
1970	4,748	10.1	
Barnwell			
1980	7,282		3.5
1977	6,698	4.7	
1970	5,379	9.5	
	Georgia		
Columbia			
1980	14,099		10.9
1977			
1970	6,740	3.7[a]	
Richmond			
1980	64,846		3.6
1977			
1970	47,754	5.2[a]	

[a]Based on number of units for sale or rent only.

Sources: U.S. Bureau of Census, 1980 Census of Population and Housing, South Carolina, PHC80-V-42; Georgia, PHC80-V-12; March, 1981. *Socioeconomic Baseline Characterization for the Savannah River Plant Area,* prepared for ORNL by NUS Corporation, 1981, ORNL/Sub-81/13829/5.

in the past decade (about 5200 units) results from that county's especially high rate of mobile home growth. More than half of the total mobile home growth in the Augusta SMSA in 1979 occurred in Aiken County, reflecting less stringent regulation than in the other metropolitan counties. Since 1950, the majority of Aiken County's increased demand for all types of housing has been generated by the nearly 5000 SRP employees that live there. Over half of these workers (2600) live in the city of Aiken.

In the secondary impact area, growth in the housing stock has been most rapid in Lexington and Orangeburg counties. As in Aiken County, the increase in the number of mobile homes in Orangeburg County since 1970 has been dramatic.

The rapid increase in housing values experienced nationally in the past decade is most strongly reflected in the high-growth areas of Columbia, Lexington, and Aiken counties. Realtors estimate that average new home costs are around $36,000 in southern Augusta, $55,000 in western Augusta, $75,000 in North Augusta, $40,000 in Barnwell, and $60,000 in Aiken. Median housing values will remain much lower in the low-growth counties because the average age of the housing stock is older. Historical trends and state estimates of construction industry growth indicate that ample capacity exists to meet large increases in demand for housing in South Carolina, especially around urban or growth centers. The largest number of rental units is found in the counties that make up the Augusta and Columbia SMSAs.

The percentage of units lacking some plumbing facilities is higher in the rural counties than in the more urban areas, ranging from 5% in Richmond County to 38% in Allendale and 44% in Burke County (1970). Similarly, more crowded housing (more than one person per room) is predominantely found in rural areas.

4.2.8 Transportation

Figure 4.5 is a map of the highway and road systems surrounding the SRP site. The major U.S. highways intersecting the study area include U.S. 1, 25, 301, 321, 601, 78, 178, 278, and 378, parts of which are multilane. Other multilane highways include Interstate 20, 26, and S.C. 19, 64, and 125. Controlled public access through the SRP is allowed on Route 125.

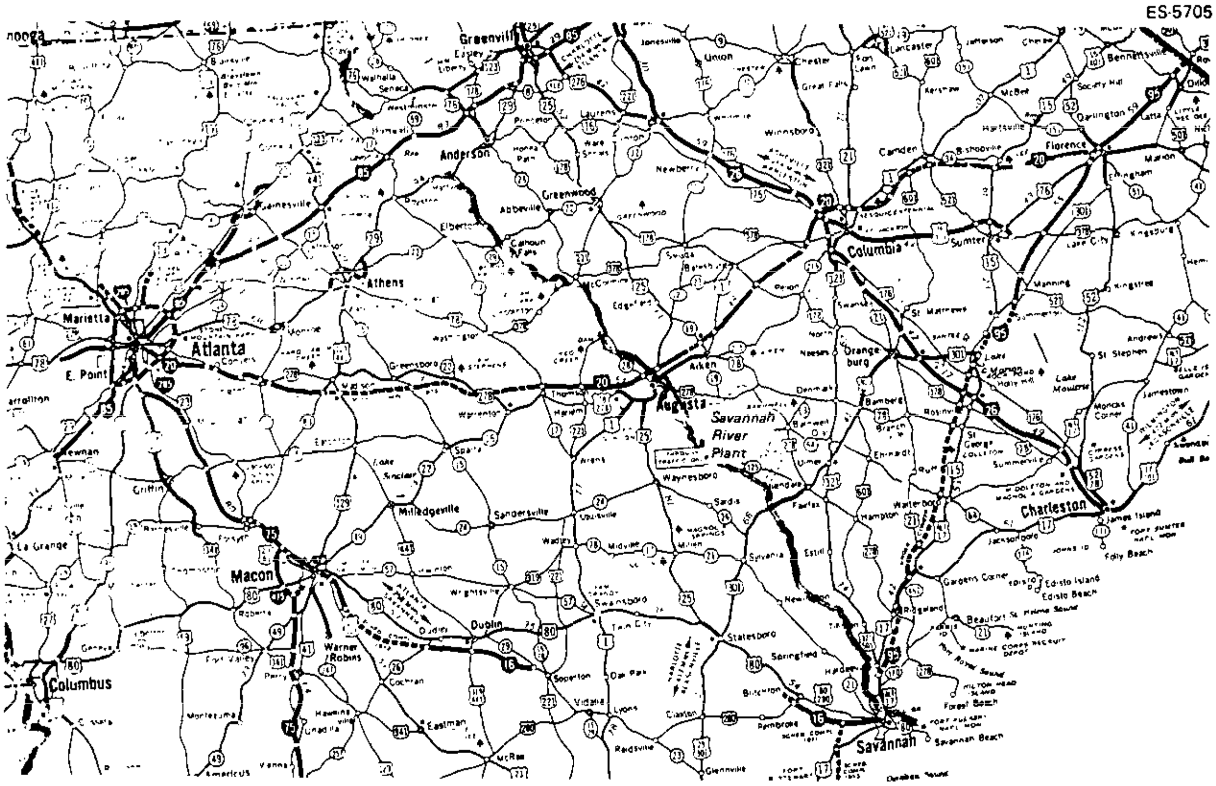

Fig. 4.5. Highway and road systems.

In a 1978 survey, the highest traffic volumes in the area were observed near Augusta, where vehicles on select roads exceed 30,000 per day. Outside the Augusta urbanized area, the highest average daily traffic volumes were along the Aiken-Augusta corridor (U.S. 1 and 78 and S.C. 19). Roads and highways near the SRP averaged from 2000 to 10,000 vehicles per day. Traffic generated by the SRP itself was estimated at approximately 6150 vehicle trips per day in 1980.

With no improvements to the existing road system, major congestion problems within the Augusta urbanized area could be expected to develop in the future. The Augusta Regional Transportation Study (1974 update) identified 25.9% of the road and highway network in urban Augusta as being moderately congested by the year 2000, and 13% of this network is projected to be severely congested.

The primary study area is served by several branches of three main rail systems: the Seaboard Coast Line Railroad (SCL), Central of Georgia, and Southern Railroad (see Fig. 3.16). In addition, the SRP owns and operates a railroad system within the plant boundaries (see Sect. 3.1.7.1, Fig. 3.15). Of four tracks operated by SCL in the study area, one extends westward from the towns of Denmark and Barnwell, South Carolina, and provides services to the SRP along with another conjoining SCL branch that parallels the Savannah River.

There are ten aviation facilities in the primary study area, one of which provides scheduled passenger service. Within the primary area there is a restricted air zone above the Fort Gordon military reservation.

The commercial waterborne traffic on the Savannah River below Augusta increased dramatically in the mid 1970s, growing from approximately 45,000 t/year in the early 1970s to 100,000 t in 1976. Since 1977, traffic has decreased because of difficulties in maintaining navigational channels for barge traffic.

4.2.9 Historical and archaeological resources

In 1979, there were 55 sites listed in the *National Register of Historic Places* within the six-county primary impact area. (See Appendix E for a listing of these sites.) Richmond County has the largest number of sites (23), with a majority located in the city of Augusta. Approximately another 20 National Register sites are found in Aiken and Allendale counties. In addition, five historic districts, Graniteville, Pinched Gut, Broad Street, Summerville, and Augusta Canal, are found in the study area. Nine of the 55 sites are within a 15-km radius, including one in the secondary area (Burke County). Five of the sites are in Barnwell County.

In the South Carolina State Archaeological File, 489 sites are listed in the four primary counties of Aiken, Allendale, Bamberg, and Barnwell; the Georgia State Archaeological Site File lists 80 80 sites in Columbia and Richmond counties.

4.2.10 Community attitudes toward nuclear facilities

Attitudes toward nuclear facilities expressed by local leaders in the impact area remain generally positive with the exception of Allendale County, where the majority of the leaders interviewed have adopted an attitude of cautious concern and uncertainty. The economic benefits (jobs, purchases, and taxes) of the existing nuclear facilities and potential new ones are generally seen by community leaders as far outweighing any potential risks; however, both supporting and opposing groups in the local area appear to have little detailed information about the existing and planned nuclear facilities at the SRP. The differences in attitudes between Allendale and the other five counties contacted reflect in part the differences in benefits received by them. Allendale County has fewer residents employed at SRP than any of the other primary impact counties. Allendale, despite its proximity to the SRP, has received very little Federal payment because payments are based on value of land purchased years ago.

4.2.11 Local government taxation and spending

There are 39 jurisdictions within the primary study area that currently exercise the right to levy taxes. These jurisdictions include 6 counties, 5 school districts, and 28 cities and towns. A discussion of revenues and expenditures with respect to these entities follows.

Taxing jurisdictions generate revenue from a number of sources, including property (real and personal) taxes, state and Federal government, licenses and permits, fees and fines, and charges for services. The major sources of revenue are property taxes and state, and Federal government assistance (Table 4.10).

Real property consists of housing and commercial establishments, whereas personal property includes such belongings as cars and boats. Within the impact region, property tax rates are set by the state legislatures of South Carolina and Georgia. The 1979 personal property tax assessment rate in the four South Carolina primary counties was 10.5% of market value; in Georgia, this rate was also 10.5% of market value. During the same year, the tax levy on real property in South Carolina was 4% of assessed value for owner-occupied housing and 6% of assessed value for rental property. As expected, the more developed Aiken and Richmond counties generated the largest property tax revenue. Property tax revenues generally increased between 1975 and 1979. The largest percentage increase (27%) occurred in Allendale County during this period. Such revenue increases are attributed to increases in property valuation, changes in assessment procedures, and/or increases in the tax base. Property taxes constitute about 17% of the total primary study area revenues.

State and Federal governments were also a major source of revenue to local jurisdictions. City governments received increased proportions of their general revenues from Federal and state grants-in-aid and tax sharing. Revenue from state government represented 11% of the total 1979 primary study area revenue, while Federal intergovernmental revenue represented about 8% of the total. A comparison of per capita revenues and expenditures among major study area taxing jurisdictions is given in Table 4.10. The magnitude of the educational expenditures is at least 2 to 3 times greater; however, they are not included in Table 4.10.

Major expenditures in study area jurisdictions were made for transportation and public works, public safety, health and welfare, recreation, tax administration, judicial service or the judiciary, general administration, and community development. Of these, the largest expenditures

Table 4.10. Revenues and expenditures ($, excluding education) for major taxing jurisdictions in primary study area (PSA), FY-1979

Major PSA taxing jurisdiction	Revenues					Expenditures				
	State government	General property taxes	Other	Total revenues	Per capita	Public Safety	Transportation and public works	Other	Total expenditures	Per capita
Aiken county	1,692,581[a]	1,446,851[a]	1,708,035	4,847,467[b]	47.73	1,014,313[a]	910,768[a]	2,545,650	4,470,731[a]	44.02
City of Aiken	166,707	1,520,859	3,023,200	3,340,766	222.69	1,064,761	438,224	1,653,251	3,156,236	210.38
City of North Augusta	188,130	641,237	921,468	1,750,835	129.70	574,335	518,741	604,707	1,697,783	125.76
Allendale county	282,115	210,713	465,390	958,218	93.07	64,952	32,863	459,074	556,889	54.09
Town of Allendale	51,222	134,945	173,842	360,009	84.13	139,077	148,474	236,963	524,444	122.56
Bamberg County	412,986	100,497	615,449	1,128,932	66.62	128,589	44,935	935,350	1,108,874	65.44
City of Bamberg	47,773	74,386	262,458	384,617	106.87	184,353	118,512	68,721	371,586	103.25
City of Denmark	51,252	109,796	266,427	427,475	109.61	218,462[b]	114,071[b]	41,573	290,960[b]	74.86
Barnwell county	481,472	392,049	887,215	1,760,736	92.29	96,296	183,594	1,304,698	1,584,588	83.06
City of Barnwell	60,401	185,087	573,366	818,854	151.64	261,297	337,630	405,524	1,004,451	186.00
Columbia county	285,096	1,258,925	1,596,660	3,140,681	80.58	505,107	1,204,123	1,508,759	3,217,989	82.56
City of Grovetown	194,502	37,000	135,480	366,982	108.31	179,003	11,600	203,979	394,582	116.46
Richmond county	1,638,054	2,779,213	10,754,330	15,171,597	85.82	5,606,978	2,804,356	12,556,764	20,968,098	118.61
City of Augusta	826,110[a]	1,497,070[a]	24,762,065	27,085,245[a]	579.59	3,959,238[a]	11,160,274[a]	11,045,409	26,164,921	559.89
Total	6,606,210	10,747,362	45,522,341	62,875,913	127.91	14,329,958	18,263,671	34,599,129	67,192,758	184.78

[a] FY-1978.
[b] FY-1980.
Source: SBC 1981.

were for transportation and public works and for public safety (Table 4.10). Expenditures for transportation and public works constituted 27% of the total 1979 study area expenditures, and another 21% of local expenditures went for public safety. As expected, more money was spent in the urban counties of Aiken, Richmond, and Columbia, where greater investments for roads, sewers, and water facilities are more essential than they are in the rest of the primary impact area.

4.3 METEOROLOGY

The description of the meteorology of the DWPF site is based on data collected at the SRP site and at nearby Bush Airport in Augusta, Georgia.

Wind data are measured at seven 62-m meteorological towers on the SRP site and at the 366-m WJBF-TV tower located off site. Temperature data are also measured at the TV tower and at one onsite station that records continuous temperature, maximum and minimum temperature, daily rainfall, relative humidity, and barometric pressure. Rainfall is also monitored at the seven meteorological towers at SRP.

4.3.1 Regional climate

The SRP is located in the Atlantic Coastal Plains province. This area, which is subject to continental influences, is protected by the Blue Ridge Mountains to the north and northwest from the more vigorous winters prevailing in the Tennessee Valley. The terrain does not moderate the summer heat. The SRP site and surrounding areas are characterized by gently rolling hills with no unusual topographic features (except the Savannah River along the western boundary) that would influence the general climatology significantly.

The summers are long and humid with many thunderstorms. The summer season has the heaviest rainfall of the year, contributing about 30% of the annual total. Hail at a given location occurs about once every two years.

The fall season has many cool mornings and warm afternoons. About 18% of the annual rainfall is recorded during the fall.

Winters are mild and although the cold weather usually lasts from late November to late March, less than one-third of the days have a minimum temperature below freezing. Snowfall is not unusual but does not last long (more than three days of sustained snow coverage is very rare). The winter rainfall represents 25% of the annual total.

Spring is the most changeable season of the year. Infrequent tornadoes occur most often in the spring. An occasional hailstorm may occur in the spring or early summer. Spring rainfall represents 27% of the annual total.[5]

4.3.2 Local climate

The local climate of the SRP site is typical of the region because the topography of the site is similar to that of the area.

4.3.2.1 Temperature and humidity

The temperature data for SRP covered a period of 16 years. Table 4.11 lists temperature averages and extremes.

The average winter temperature is approximately 9°C; the average summer temperature, 27°C. The annual average temperature is 18°C with an average daily temperature variation of about ±7°C.

The annual average relative humidity at the SRP site, measured from 1964 through 1978, is 66%; the average minimum is 43% and the average maximum is 90%.

The growing season lasts about 240 days. The date of the last frost averages March 16, and the date of the first frost averages November 12.

4.3.2.2 Precipitation

The average annual rainfall at the SRP site is 120 cm for 1952 through 1978. On the average, rainfall is greatest in March and least in November (Table 4.12). Snowfall and freezing rain are infrequent and seldom cover the ground for more than a few days. Approximately 40 cm of the total precipitation infiltrates into the soil; of the remainder, about 40 cm is lost as runoff and J-28
a similar amount is lost as evapotranspiration.

Table 4.11. Average[a] and extreme temperatures at the SRP site, 1961 through 1976

Month	Average daily temperature (°C)			Extreme monthly temperature (°C)	
	Max.	Min.	Monthly	Max.	Min.
January	13	2	8	30	−16
February	15	3	9	27	−10
March	20	7	13	32	−6
April	25	12	18	35	1
May	28	16	22	37	5
June	32	19	26	41	9
July	33	21	27	39	14
August	32	21	27	40	13
September	29	18	24	38	5
October	25	12	19	33	−2
November	19	6	13	32	−8
December	15	4	9	28	−9

[a]Average annual temperature = 18°C.
Source: EID.

Table 4.12. Precipitation at SRP, 1962 through 1978

Month	Monthly rainfall (cm)		
	Max	Min	Av
January	25.5	3.2	11.0
February	20.2	2.4	10.6
March	22.0	3.8	12.8
April	20.8	3.2	8.7
May	27.7	3.4	10.3
June	27.7	6.3	11.5
July	26.7	5.0	12.1
August	31.3	2.6	12.0
September	22.1	2.5	10.1
October	15.6	0	6.2
November	16.4	0.5	5.9
December	19.1	1.2	9.1
Average annual rainfall			120.3

Source: EID.

The plant site is protected to a great extent from flooding of the Savannah River by two upstream dams. During the heaviest rainfalls some flooding does occur in low-lying areas near the river.

4.3.2.3 Severe weather

Tornadoes

The SRP site is in an area where occasional tornadoes are to be expected. Recent data, 1959 through 1971, show that South Carolina is struck by an average of 10 tornadoes per year.[6] Most of the tornadoes occur from March through June and have maximum wind speeds up to 418 km/h.

No SRP facilities have suffered significant tornado damage. Several tornado funnels have been sighted but apparently did not touch ground. Studies covering a period from 1916 through 1975 were used to assess the risk of tornado damage to the DWPF and show that the probability for a tornado striking a large building is about 1×10^{-3} per year, compared with 1×10^{-4} per year for striking a single point.

Hurricanes and high winds

Thirty-eight hurricanes caused damage in South Carolina over the 272-year record (1700 through 1971), an average of one every seven years. Hurricanes occur predominantly during August and September. Because the plant site is approximately 160 km inland from the coast and the high winds of the hurricanes tend to diminish as the storms move over land, winds of 120 km/h have been measured only once during the history of the SRP.

An occasional winter storm may bring strong and gusty surface winds; wind speeds as high as 116 km/h have been recorded. During the summer the only strong surface winds are associated with thunderstorms, during which winds up to 64 km/h, with stronger gusts, can be generated.

4.3.2.4 Air pollution potential

Ambient air quality

Aiken and Barnwell Counties in South Carolina, and Burke and Richmond Counties in Georgia have been designated as attaining with respect to the national ambient air quality standards for total suspended particulates, sulfur and nitrogen oxides, ozone, and carbon monoxide. In accordance with the Clean Air Act Amendments of 1970, the States of Georgia and South Carolina each have implemented air-sampling networks. Air quality measurements in South Carolina (1979) and Georgia (1980) in the vicinity of SRP indicated no violation of standards for sulfur dioxide and nitrogen dioxide, and one violation at two stations in Augusta, Georgia, of the average 24-hour Georgia standard for particulates.[44] J-27

Temperature inversions

Temperature inversion data are available from instruments on the 366-m WJBF TV tower approximately 24 km from the center of the SRP site. The 1974 temperature measurements between 3 and 335 m elevation were analyzed by comparing the temperature profiles with the adiabatic lapse rate (i.e., the rate at which the temperature would change with height under adiabatic conditions).[7] About 30% of the time, a temperature inversion (stable conditions) extended to or beyond the 3- to 335-m layer. About 9% of the data showed an inversion developing at the lower levels with an unstable layer above; this represents the transition period between the unstable daytime regime and the onset of the nighttime inversion. Thus, conditions were considered stable about 39% of the time.

Other data taken at the 36- to 91-m layer and at the 182- to 335-m layer indicated that stable conditions existed 30 to 32% of the time from 1966 through 1968, in good agreement with the analysis based on the 1974 data.

Mixing depths

The depth of the nocturnal mixed layer at SRP is measured by an acoustic sounder that has been operated continuously since 1974.[8] The average morning mixing depth is about 400 m in winter, spring, and summer, decreasing to about 300 m in fall. The average afternoon mixing depth is about 1000 m in winter, 1700 m in spring, 1900 m in summer, and 1400 m in fall. Based on these data, an average annual mixing depth of 938 m was assumed for this study.

Wind and dispersion characteristics

Atmospheric diffusion estimates were obtained from meteorological data for a two-year period from January 1976 through December 1977. The data were obtained from the seven meteorological towers at SRP and the WBJF TV tower 15 km from the plant boundary (Fig. 4.6). Wind direction and velocity at SRP were measured at 62 m aboveground to match the height of the major SRP stacks and at 9.7 to 305 m aboveground at the offsite television tower. Tower locations are representative of the general landscape of the area and are located where the prevailing winds do not pass over buildings before reaching the towers.

The meteorological data required to calculate the atmospheric dispersion are joint frequency distributions of wind velocity and direction summarized by stability class. These data for the SRP are shown in Tables 4.13 and 4.14.

The wind direction frequency near SRP is shown in Fig. 4.7 as percent of time the wind was blowing from different directions at a height of 62 m at the offsite television tower. For the period 1976 and 1977 the winds blew mainly from the west and southwest quadrant.

4.4 GEOLOGY AND SEISMOLOGY

Located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain, the proposed DWPF site (S-area) lies about 40 km (25 miles) southeast of the fall line separating the coastal plain from the Piedmont tectonic province of the Appalachian system. Site relief, about 30 m, is primarily related to stream incision (Fig. 4.8). However, numerous shallow ellipsoidal depressions, similar to Carolina Bays, occur across the site region and the SRP.[9]

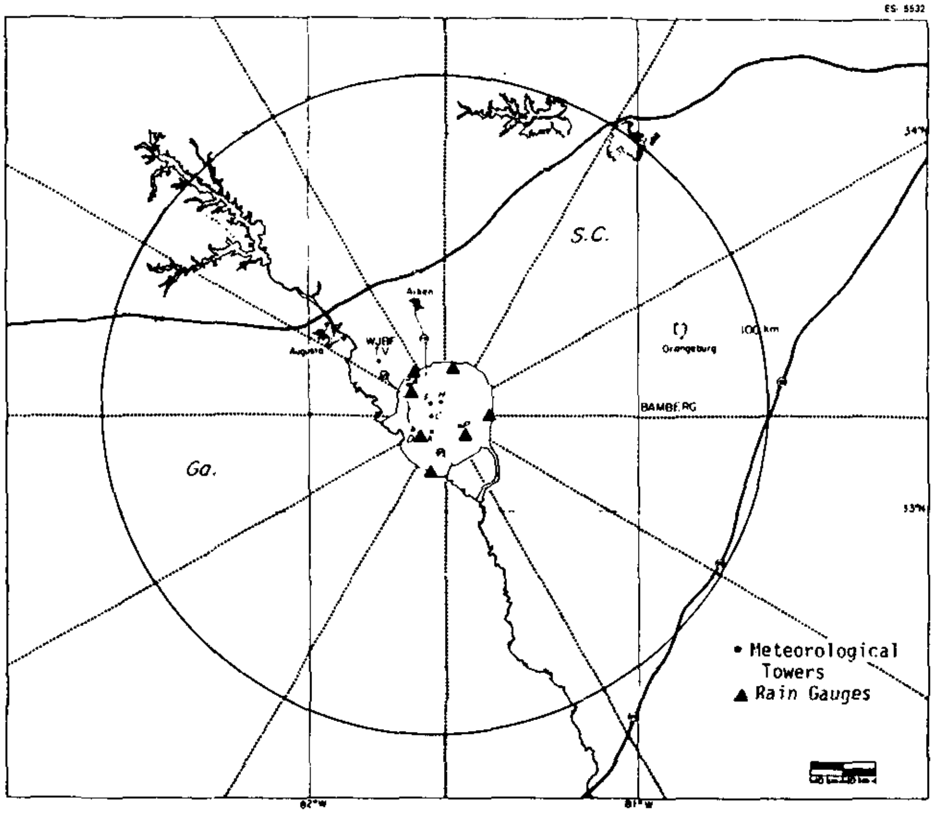

Fig. 4.6. Atmospheric data sources for SRP. Source: EID.

Table 4.13. Frequencies of wind directions and true-average wind speeds

Wind from	Frequency	Wind speeds for each stability class (m/s)						
		A	B	C	D	E	F	G
S	0.074	3.39	3.42	3.56	3.41	3.96	4.28	4.10
SSE	0.066	3.34	3.24	3.21	3.43	4.23	3.71	3.16
SE	0.049	2.85	2.60	2.58	2.97	3.38	3.14	2.40
ESE	0.054	3.17	2.99	3.09	3.14	1.15	3.24	2.75
E	0.061	3.99	3.51	3.43	3.33	3.02	3.79	3.87
ENE	0.068	4.25	3.71	3.52	3.75	3.10	4.16	2.93
NE	0.052	3.76	3.62	3.31	3.24	3.03	3.71	2.87
NNE	0.029	3.02	3.33	3.58	3.33	3.29	3.90	2.31
N	0.014	2.98	2.83	2.36	2.55	2.64	2.55	2.60
NNW	0.027	3.49	2.64	1.33	2.49	2.87	3.45	3.39
NW	0.055	3.86	4.02	3.66	3.42	3.54	4.22	3.16
WNW	0.090	4.44	3.69	2.98	4.26	4.69	4.34	4.01
W	0.093	4.29	3.43	3.58	3.34	4.32	4.40	2.34
WSW	0.085	3.09	3.18	3.06	3.26	3.91	4.34	3.06
SW	0.092	3.71	3.51	3.28	3.26	3.85	3.91	4.32
SSW	0.089	3.57	3.19	3.23	3.16	3.71	4.21	3.53

Table 4.14. Frequency of atmospheric stability classes for each direction

Sector	Fraction of time in each stability class						
	A	B	C	D	E	F	G
S	0.106	0.050	0.043	0.262	0.227	0.220	0.092
SSE	0.103	0.033	0.037	0.207	0.336	0.192	0.092
SE	0.148	0.043	0.042	0.242	0.319	0.161	0.045
ESE	0.212	0.044	0.041	0.206	0.331	0.134	0.031
E	0.216	0.050	0.046	0.170	0.296	0.177	0.045
ENE	0.198	0.053	0.046	0.168	0.276	0.205	0.055
NE	0.212	0.040	0.040	0.163	0.290	0.206	0.049
NNE	0.148	0.035	0.030	0.146	0.336	0.233	0.070
N	0.109	0.030	0.035	0.156	0.356	0.246	0.068
NNW	0.109	0.024	0.026	0.179	0.422	0.187	0.052
NW	0.109	0.031	0.029	0.181	0.387	0.208	0.056
WNW	0.113	0.030	0.037	0.204	0.314	0.225	0.076
W	0.158	0.044	0.039	0.213	0.275	0.194	0.077
WSW	0.163	0.038	0.047	0.245	0.286	0.161	0.061
SW	0.118	0.044	0.058	0.297	0.282	0.156	0.044
SSW	0.068	0.041	0.058	0.295	0.312	0.180	0.047

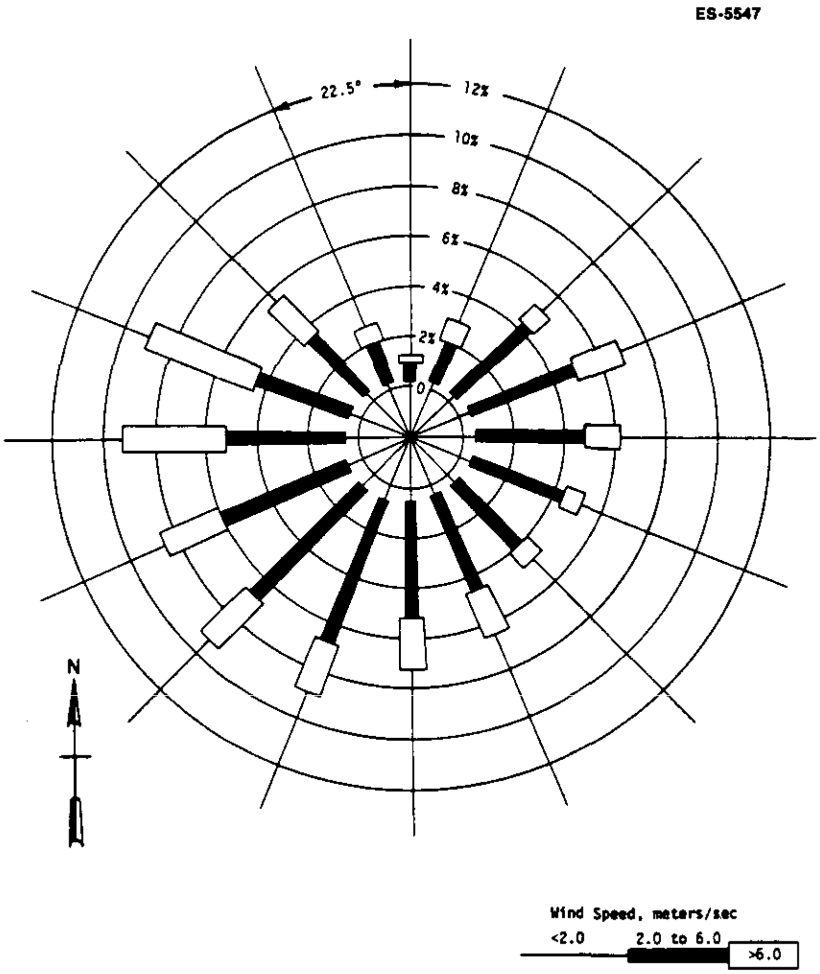

Fig. 4.7. Wind direction frequency near SRP from 1976 to 1977 (62 m above ground level at WJBT-TV tower). <u>Source</u>: EID.

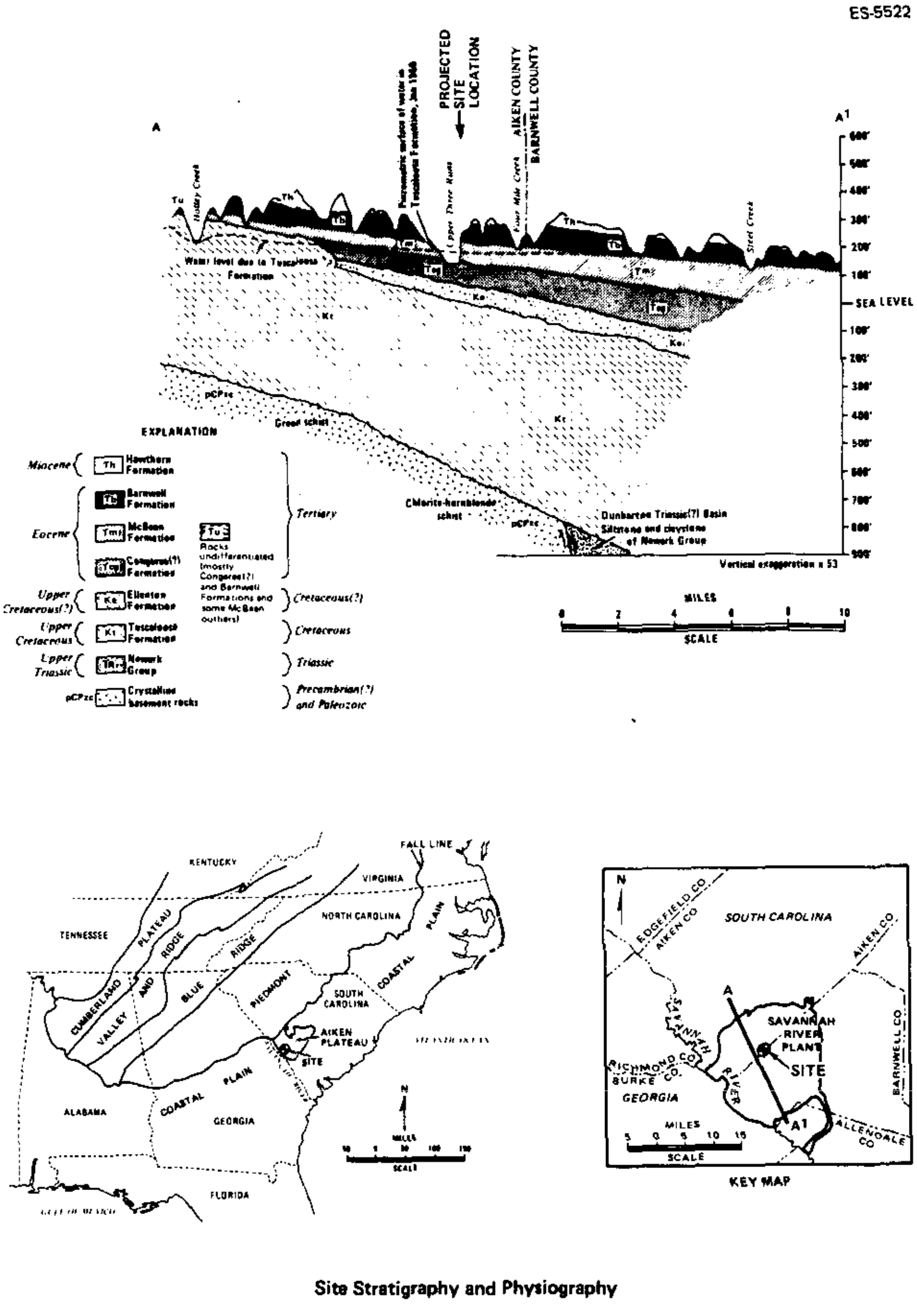

Fig. 4.8. Generalized northwest to southeast geologic profile across the Savannah River Plant.

4.4.1 Stratigraphy

Atlantic Coastal Plain sediments in South Carolina range in age from Cretaceous to Quaternary and form a seaward-dipping and thickening wedge of interstratified beds of mostly unconsolidated sediments (Fig. 4.8). At the SRP sites these sediments are approximately 300 m (1000 ft) thick. The base of the sedimentary wedge rests on Precambrian and Paleozoic crystalline basement similar to the metamorphic and igneous rocks of the Piedmont as well as on siltstone and claystone conglomerates of the Dunbarton Triassic Basin. Immediately overlying the basement is the Upper Cretaceous, 180-m-thick Tuscaloosa Formation, composed of prolific water-bearing sands and gravels separated by prominent clay units. Overlying the Tuscaloosa is the Ellenton Formation. This 18-m-thick formation consists of sands and clays interbedded with coarse sands and gravel. Four formations listed in Fig. 4.8, the Congaree, McBean, Barnwell, and Hawthorn, compose the 85-m-thick Tertiary (Eocene and Miocene) sedimentary section. These sediments consist predominantly of clays, sands, clayey sands, and sandy marls. The near-surface sands of the Barnwell and Hawthorn formations are usually in a loose to medium-dense state. They frequently contain sediment-filled fissures (clastic dikes) less than 0.3 m in thickness.

Quaternary alluvium has been mapped at the surface in floodplain areas adjacent to the DWPF site. Soil horizons at the site are generally uniform and relatively shallow, on the order of 1 m deep. They are characterized by bleached Barnwell-Hawthorn sediments, which results in a light tan sandy loam.

4.4.2 Structure

The Dunbarton Triassic Basin underlies the SRP almost 5 km southeast of the DWPF site. Other Triassic-Jurassic basins have been identified in the coastal plain tectonic province within 300 km of the site. Northwest of the fall line are the Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces associated with Appalachian mountain building. Several major fault systems occur in and adjacent to these tectonic provinces, but none within 300 km of the SRP site are believed to be capable (as defined by 10 CFR 100, Appendix G).[10] Subsurface investigations did not detect any faulting of the sedimentary strata in the DWPF site area. Several surficial faults, generally less than 300 m in length and with less than 1-m displacement, were mapped within 8 km of the site. None of these faults is considered capable and none poses a threat to the DWPF site.[10]

4.4.3 Seismicity

The Savannah River Plant is located in a region where definite correlations between earthquake epicenters and tectonic structures have not been established. Only two major earthquakes have occurred within 300 km of the SRP site: (1) the Charleston earthquake of 1886, which had an epicentral Modified Mercalli Intensity (MMI) of X, was located some 150 km distant and (2) the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII-VIII, was located approximately 160 km distant.[11,12] An estimated peak horizontal shaking of 7% of gravity (0.07 g) was experienced at the site during the Charleston 1886 earthquake.[10]

Seismological studies indicate that the site is located in an area where moderate damage might occur from earthquakes.[13] The USGS has estimated that a maximum horizontal ground acceleration in sound bedrock of 0.11 g could be experienced in the area with a 90% probability of not being exceeded within 50 years.[14]

Additional information on stratigraphy, structure, and seismology is given in Appendix G.

4.5 HYDROLOGY

4.5.1 Surface waters

The SRP site adjoins and is almost entirely drained by the Savannah River, which comprises one of the major drainage networks in the Southeastern United States. Approximately 77% of the 27,394-km^2 area drained by the Savannah River is upstream from the SRP;[15] operation of two large upstream reservoirs has stabilized the flow of the river. Average flow during 1962 through 1978, as measured by the U.S. Geological Survey at nearby Augusta, Georgia (station No. 02197000), was 299 m^3/s; minimum daily flow was 126 m^3/s. The peak historical flood for the period between 1796 to the present — 10,190 m^3/s — corresponds to a stage of about 36 m. This peak flood stage is about 40 m below most areas in the proposed DWPF site.

The Savannah River is a Class B waterway downstream of Augusta, Georgia, suitable for domestic use after treatment, for propagation of fish, and for industrial and agricultural uses.[16,17] The reach upstream of SRP supplies municipal water for Augusta, Georgia, and North Augusta, South Carolina, and, downstream, for Beaufort and Jasper counties, South Carolina; it supplements the water supply of Savannah, Georgia.[18,19] The SRP withdraws about 26 m^3/s from the Savannah River, primarily for cooling water used in nuclear reactors and coal-fired power plants. Most of the water withdrawn returns via tributaries draining the plant.[19] The Savannah River receives sewage treatment effluents from the communities and industries of Augusta, Georgia, and North Augusta, Aiken, and Horse Creek Valley, South Carolina, and obtains heated water and other waste discharges from the SRP via tributaries.[20] Other uses of the Savannah River in this region are navigation (barge traffic from Savannah to Augusta, Georgia) and recreation (primarily boating and sport fishing).[21] Upstream, recreational use of impoundments on the Savannah River, including water contact recreation, is more extensive than it is near the SRP and downstream.

The SRP site is drained almost entirely by five principal systems: (1) Upper Three Runs Creek (490 km^2); (2) Four Mile Creek (including Beaver Dam Creek) (90 km^2); (3) Pen Branch (90 km^2); (4) Steel Creek (90 km^2); and (5) Lower Three Runs Creek (470 km^2). These streams arise on the

Aiken Plateau and descend 30 to 60 m before discharging to the Savannah River (Fig. 4.2). The sandy soils of the area permit rapid infiltration of rainfall, and seepage from these soils furnishes the streams with a rather constant supply of water throughout the year. A large forested swamp bordering the Savannah River receives the flow from Four Mile Creek, Beaver Dam Creek, Pen Branch, and Steel Creek. The swamp borders the river for a distance of about 16 km and averages a width of about 2.5 km. Its waters discharge to the river through breaches in the river levee. During periods of high water, river water overflows the levee and floods most of the swamp.

Four of the five streams draining the SRP (all but Upper Three Runs Creek) have received intermittent reactor cooling-water discharges. Although effects on the Savannah River itself are small, the large flow of hot water (many times the natural flow of the streams) has altered the characteristics of several SRP streams and some areas of the river floodplain swamp. Over one-third of the trees and plants in the floodplains of Four Mile Creek, Pen Branch, and Steel Creek and in about 500 ha (16%) of the river swamp have died as a result of increased silt deposition and exposure to high or hot water.[19] Since the discharge of hot water from L-reactor was discontinued in 1968, fish have returned and plant life has made a partial recovery in Steel Creek.[22]

Upper Three Runs Creek differs from the other major streams in several respects. Besides the fact that it is a blackwater stream and the only major stream that does not receive cooling water discharges, its headwaters and about 225 km^2 (46%) of its watershed lie upstream of the SRP site and consist primarily of forestland and farmland. Upper Three Runs Creek above the SRP was designated by the U.S. Geological Survey in 1966 as a National Hydrologic Bench-Mark Stream (EID). Streamflow and various water quality parameters are routinely monitored at a station on U.S. 278 (Fig. 4.2).

In addition to the flowing stream, surface water is held in over 50 man-made impoundments on the SRP site covering an area of over 12 km^2. The largest of these, Par Pond, has an area of 11 km^2. Surface water is also collected in about 200 natural depressions on the SRP site, called carolina bays.[23] These wetlands are shallow (1 to approximately 2 m maximum relief) and vary in size from less than 0.1 to 50 ha; the median size is 1 ha.[23] They are precipitation dominated, receiving no appreciable surface runoff and probably little exchange with groundwater during most periods.[24] The origin of the bays, though still in doubt, is generally believed to be surface subsidence following solution of subsurface strata by groundwater.[9] Most estimates of their age fall in the range of 10,000 to 100,000 years.[24]

The proposed DWPF site, S-area, lies in an upland area entirely within the Upper Three Runs Creek drainage basin (Fig. 4.3). It is adjacent to and northeast of H-area, about 1.5 km to the east of Upper Three Runs Creek. The eastern half of the site is drained by a small unnamed tributary to Tinker Creek, just upstream of its confluence with Upper Three Runs Creek. The western half of the site drains into another small unnamed tributary to Upper Three Runs Creek. These streams lie in narrow, moderately sloped, wooded valleys and descend sharply (about 30 m) before discharging to Tinker Creek and Upper Three Runs Creek. Upper Three Runs Creek lies in a broad, wooded valley with very steep slopes to the east and a more gentle rise to the west. It has a low-gradient, meandering channel bordered by a floodplain swamp, particularly in the lower reaches. Streamflow of Upper Three Runs Creek during 1966 and 1976 at a station about 8 km upstream from S-area averaged 3.2 m^3/s with an instantaneous maximum of 11.9 m^3/s and a minimum of 1.9 m^3/s. At a station about 7 km downstream from S-area drainage (at road C, Fig. 4.3), streamflow averaged about 7.5 m^3/s. The S-area contains one small (about 0.5-ha) carolina bay, Sun Bay, which has been partially drained.

The proposed saltcrete burial site (200-Z) lies in upland areas within the Upper Three Runs drainage basin. It is at least 500 m from the nearest permanent stream.

4.5.2 Subsurface hydrology

Three distinct geologic systems underlie the SRP: (1) the coastal plain sediments, where water occurs in porous sands and clays; (2) the buried crystalline metamorphic bedrock, where water occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton basin, where water occurs in intergranular spaces in mudstones and sandstones (Fig. 4.8). The coastal plain sediments, which contain several prolific and important aquifers, consist of a wedge of stratified sediments that thicken to the southeast from zero meters at the fall line to more than 1200 m at the mouth of the Savannah River. Near S-area the sediments are about 300 m thick and consist of sandy clays and clayey sands.[10] The sandier beds form aquifers and the clayier beds form confining beds. The coastal plain sediments consist of the Hawthorn Formation, which is successively underlain by the Barnwell, McBean, Congaree, Ellenton, and Tuscaloosa formations (Fig. 4.9).

The Barnwell Formation commonly contains the water table with water depths ranging from 9 to 15 m below the ground surface. The overall vertical flow pattern near S-area is infiltration of precipitation into the Barnwell Formation and percolation downward to the Congaree Formation.

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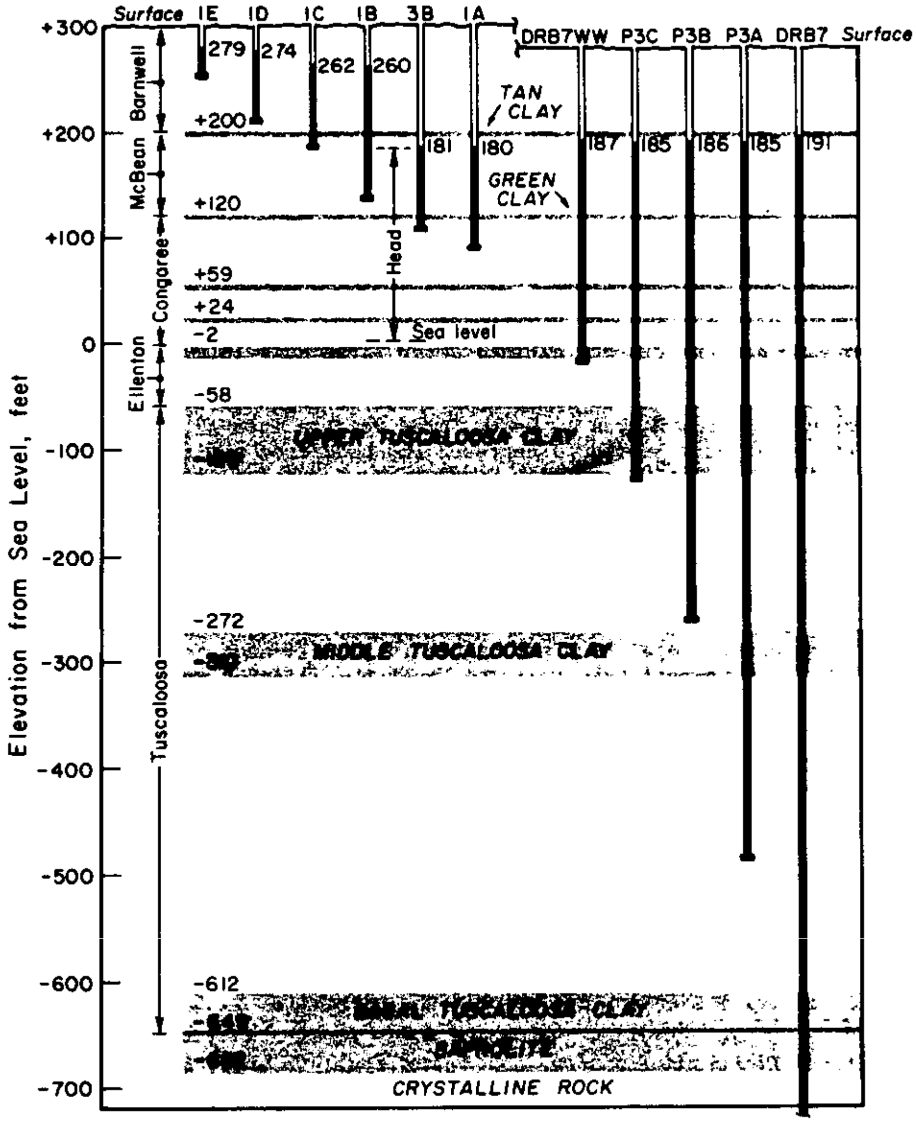

Fig. 4.9. Stratigraphic column at the SRP site.

The "tan clay" diverts some water in the Barnwell Formation laterally to creeks. The "green clay" diverts most of the water in the McBean Formation laterally to creeks. The Ellenton and Tuscaloosa formations are hydraulically separated from the Congaree Formation and are not recharged near S-area.

The observed potentiometric contours near S-area indicate that (1) flow in the Barnwell Formation generally follows ground surface contours and drains toward Upper Three Runs Creek and an unnamed tributary; (2) the McBean Formation also drains toward Upper Three Runs Creek and an unnamed tributary; and (3) the Congaree Formation drains toward Upper Three Runs Creek. Both the recharge and discharge controls for the water in the Tuscaloosa Formation are outside S-area. The Tuscaloosa Formation acts as a water conduit through which water passes beneath the SRP in going from recharge zones in the Aiken Plateau to discharge zones in the Savannah River Valley upstream of the SRP.

The direction and rate of groundwater flow are determined by the hydraulic conductivity, hydraulic gradient, and effective porosity. Near S-area, typical groundwater velocities in the Barnwell, McBean, and Congaree formations are 1 to 1.5 m/year, 2 to 4 m/year, and 14 m/year, respectively.[10]

The water in the coastal plain sediments is generally of good quality and suitable for municipal and industrial use with minimal treatment. The water is generally soft, slightly acidic, and low in dissolved and suspended solids. The Tuscaloosa and Congaree formations are prolific aquifers and are major sources of municipal and industrial water. The McBean and Barnwell formations yield sufficient water for domestic use. See Appendix F for detailed information on subsurface hydrology.

4.6 ECOLOGY

The SRP was designated as a National Environmental Research Park (NERP) by the U.S. Atomic Energy Commission (DOE predecessor agency) in 1972. The NERP program was established to provide for research into the environmental impacts of man's activities. The SRP site provided a unique opportunity to launch this program because of its large buffer zones. Natural resource inventories and characterizations of the site were summarized by Brisbin et al.[25]

4.6.1 Terrestrial

The Savannah River Plant was approximately two-thirds forested and one-third cropland and pasture when acquired by the U.S. government some 30 years ago. The abandoned fields were allowed to pass through vegetational succession or were planted with pine so that 90% of the site is now forested. Because the area is large, is topographically variable, has a diverse vegetational history, and human access is limited, its floral and faunal diversity and abundance have high ecological value.

4.6.1.1 Vegetation

Although the whole SRP is ecologically valuable, the proposed DWPF site is not ecologically unique within the SRP. Table 4.15 lists estimates of areas by habitat type for the proposed S-area. Loblolly and slash pine occupy approximately 65% of the site. Both are important in local old-field succession and are, therefore, abundant on the SRP. The proposed area has significant bottomland hardwood communities (~12%). The bottomland hardwood forests have greater species diversity, and presumably greater productivity, than the upland communities and, therefore, are considered to have greater ecological value. The proposed site contains a small wet area known as a carolina bay (Sun Bay). Because of the moisture conditions of carolina bays, vegetation differs significantly from surrounding vegetation and locally is an important wildlife habitat. Approximately 200 carolina bays have been identified on the SRP.

Table 4.15. Area habitats potentially disrupted by DWPF (ha[a])

Habitat type	S-area
Slash pine	61
Loblolly pine	29
Longleaf pine	16
Pine-oak-hickory	3
Turkey oak	7
Upland hardwoods	4
Bottomland hardwoods	16
Wetlands	1
Disturbed areas	3
Total	140

[a] 1 ha = 2.47 acres.

Source: Data from H. Mackey (SRL) and C. Westberry (SRL). Memorandum of Jan. 17, 1980 to W. Holmes (SRL), J. Caldwell (SREL), J. McBrayer (ORNL), and P. Mulholland (ORNL).

A site for disposal of decontaminated salt mixed with concrete has been proposed for the northeast side of the intersection of plant roads F and 4. Plant communities affected are slash and loblolly pine or, depending on placement, longleaf pine. No hardwood forests should receive direct construction impacts, although the site is bordered on the north and east by bottomland hardwood forest.

4.6.1.2 Wildlife

The SRP contains considerable wildlife diversity because of its range of diverse habitats and its protection from the public. The proposed DWPF area has been extensively surveyed for wildlife. Identified insect species numbered 262, one-third of which were aquatic insects that were collected at Sun Bay. Seven lizard species, 11 snake species, and five turtle species were identified. One snake species and four turtle species are aquatic and were also collected at Sun Bay. Six salamander species, three toad species, and 12 frog species were captured at Sun Bay. In all, approximately 5400 adult amphibians were observed entering Sun Bay in 1979. Eighty-one species of birds and 21 species of mammals were observed.

No faunal surveys have been received for the salt disposal area, but the fauna should be similar to that of upland pine communities at the nearby sites under consideration for the DWPF.

4.6.1.3 Rare and endangered species

Four species listed as endangered or threatened by the U.S. Fish and Wildlife Service[26] have been identified on the SRP:[19] bald eagle, red-cockaded woodpecker, Kirtland's warbler, and American alligator. Only the red-cockaded woodpecker possibly could find suitable habitat in any of the areas to be affected by the DWPF. The proposed site (S-area) was surveyed in May 1979, and evidence of this species was not found; the U.S. Fish and Wildlife Service has concurred in the DOE finding of no impact (Appendix C).

The State of South Carolina has a Nongame and Endangered Species Conservation Act (§50-15, 1976, S.C. Code of Laws). Rules established to implement the act protect federally protected endangered and threatened wildlife that occurs in South Carolina (R123-150) — sea turtles (R123-150.1) and predatory birds of the orders Falconiformes and Strigiformes (R123-160). No plant species currently receive state-level protection.

According to the endangered species specialist of the Wildlife and Marine Resources Department (T. Kohlsaat, personal communication, Jan. 15, 1980), additions to the state protection listings may be made by the Wildlife and Marine Resources Commission and would probably be taken from species lists compiled for the First South Carolina Endangered Species Symposium.[27] Although these species do not now enjoy legal protection, they warrant consideration both because they are perceived by experts to be in need of protection[28] and because legal protection could be extended to them. One such species (the green-fringed orchid *Habenaria lacera*) has been sighted in bottomland hardwood forest near S-area. Two have been found in Sun Bay, the creeping water-plantain *Echinodorus parvutus* and the spathulate seedbox *Ludwigia spathulata*. These species are considered to be of special concern" (i.e., the species is either of undetermined status or is vulnerable to loss if not now endangered or threatened).[27]

The eastern slender glass lizard *Ophisaurus attenuatus* and eastern tiger salamander *Ambystoma t. tigrinum* have been collected in S-area. Both have been listed as of "special concern."[27] Cooper's hawk *Accipiter cooperii*, listed as "threatened," and loggerhead shrike *Lanius ludovicianus*, listed as of "special concern," have been observed in S-area.

4.6.2 Aquatic

4.6.2.1 Water quality

Generally, surface water on the SRP site and surrounding areas is very low in dissolved solids and relatively low in pH (usually 5 to 7 pH units).[19] All of the major drainage systems on the SRP site, with the notable exception of Upper Three Runs Creek, have received relatively large additions of reactor cooling-water that was originally withdrawn from the Savannah River. Currently, Four Mile Creek and Pen Branch receive large volumes of heated effluent (Table 4.16). Temperatures in these streams can reach 50°C or more during periods when reactors are operating. Additionally, all streams receive some level of wastewater discharge resulting from SRP operations (Table 4.16). Industrial effluents are authorized under NPDES Industrial Effluent Permit SC 0000175 by the U.S. Environmental Protection Agency (EPA), Region IV, Atlanta, Georgia. Sanitary effluents are authorized by the U.S. EPA under NPDES Waste Water Permit SC 0023710. The NPDES permit authority has been transferred from the U.S. EPA to the South Carolina Department of Health and Environmental Control (DHEC); SRP is in the process of reviewing its NPDES permit with DHEC.

As mentioned previously, the Savannah River in the region of SRP site has been designated by the South Carolina Department of Health and Environmental Control as a Class B waterway, suitable for domestic supply usage.[17] Man's activities have affected water quality in a number of ways. Upstream dams have reduced silt load and turbidity. Wastewater discharges by municipalities and industries, including the SRP, add organic wastes, nutrients, metals and other trace contaminants,

Table 4.16. Compilation of wastewater and cooling water discharges to the major drainage on SRP

Stream	Estimated wastewater discharge rate (L/sec)	Wastewater type[a]
Upper Three Runs Creek	0.5	Ash basin effluent from F-area (012)
Via Tims Branch	6.3–50	Process sewer, cooling water, and surface runoff from A-area (026)
	6.3–13	Process sewer, treatment plant effluent, surface runoff from M-area (027)
	Runoff	Ash pile runoff from A-area (024)
Four Mile Creek	7000	Cooling water from C-area (007)
	63–240	Process sewer from C-area (031)
	5.1	Ash basin effluent from H-area (013)
	1.1	Sanitary wastewater effluent from F-area (002)
	1.5	Sanitary wastewater effluent from H-area (003)
	0.7	Sanitary wastewater effluent from central shops (006)
	Runoff	Coal pile runoff from H-, F-, and C-areas (016, 019, 020)
	Runoff	Ash pile runoff from C-area (023)
Beaver Dam Creek	880–1600	Process sewer from D-area (028)
	58	Ash basin effluent from D-area (011)
	6.3–63	Treatment plant – filter backwash, deionizer regenerants, and precipitator blowdown from D area (025)
	1.1	Sanitary wastewater effluent from D-area (005)
	Runoff	Coal pile runoff from D-area (022)
Pen Branch	11,000	Cooling water from K-area
	125	Process sewer from K-area (029)
Steel Creek	125	Process sewer from P-area (030)
	4.4	Ash basin effluent from P-area
	0.1	Sanitary wastewater effluent from P-area (formerly received cooling water discharge from P- and L-reactors)
Lower Three Runs Creek		(Formerly received cooling water from R-reactor, currently receives drainage from Par Pond)

[a]Numbers in parentheses are NPDES outfall numbers.

Sources: NPDES Industrial Effluent Permit SC 0000175 and Sanitary Wastewater Effluent Permit SC 0023710.

and heat.[20] Recently, improved wastewater treatment by municipalities has reduced nutrient and BOD loading, but industrialization in the basin has resulted in additional waste loading.

Some water quality characteristics of the Savannah River, Upper Three Runs Creek, and Four Mile Creek upstream of heated effluent discharge are listed in Table 4.17. Upper Three Runs Creek has a median pH of 5.8 and is low in dissolved solids (mean of about 25 mg/L), characteristics typical of low-gradient blackwater streams in the coastal plain of the southeastern United States. In contrast, Four Mile Creek is of higher pH (median 6.4) and has higher levels of total dissolved solids (mean of 60.1 mg/L). Concentrations of chloride, nitrate, sulfate, sodium, and calcium are substantially higher in Four Mile Creek than in Upper Three Runs Creek but are similar to those in the Savannah River.

Of the major streams draining the SRP site, Upper Three Runs Creek has the highest water quality and lowest impacts from SRP operations. The only waste discharge from SRP upstream of its confluence with Tims Branch (Fig. 4.2) is a small ash basin effluent from F-area of 0.5 L/s (Table 4.17). The flowing streams laboratory, located on Upper Three Runs Creek immediately upstream of the confluence with Tims Branch, has been the site of past aquatic ecological studies.[29]

Table 4.17. Comparison of water quality characteristics of Upper Three Runs Creek, Four Mile Creek, and the Savannah River with water quality standards

Data given in mg/L unless indicated otherwise

	Upper Three Runs Creek[a]				Four Mile Creek[a,b]		Savannah River[a,c]				Water Quality Standards	
	Upstream[d]		Downstream[e]				Upstream[f]		Downstream[g]		Drinking water[h,i]	Protection of aquatic life[j]
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range		
Temperature (°C)		5.0–24.0		2.0–26.0		5.0–27.0		7.0–25.0		7.3–24.2		
pH[k]	5.8	4.8–7.7	5.8	4.6–7.6	6.4	5.8–7.4	6.7	5.9–7.0	6.6	5.5–7.0	6.5–8.5	
Dissolved oxygen	8.8	6.0–11.7	8.7	6.2–12.0	8.3	5.2–12.6	10.1	8.4–12.3	9.9	8.4–11.9		
BOD							1.2	<1–2.5	1.0	0.5–2.6		
COD	8.8	<5–27	13.2	<5–53	8.4	<5–43						
Suspended solids	8.8	1–93	10.2	<1–47	12.3	2–150	23.1	11–74	19.4	10–33		
Total dissolved solids	23.4	7–105	27.3	4–80	60.1	21–98	46.2	31–541	46.2	33–54	500	
Alkalinity ($CaCO_3$)	2.1	<1–6.0	3.8	1.0–8.0	11.2	4.0–18.0	13.8	0.7–18.5	13.0	0.8–18.8		
Sodium (Na)	1.3	0.7–2.5	1.5	0.9–4.8	9.7	4.3–27.5	7.7	4.0–9.8	7.6	4.0–10.2		
Calcium (Ca)	0.5	<0.1–0.8	1.5	1.1–2.2	3.4	2.2–8.6	1.8	1.3–2.8	1.9	1.3–2.8		
Chloride (Cl)	2.1	1.2–4.8	2.2	1.2–4.9	3.1	1.6–6.3	4.7	3.2–7.5	4.8	3.5–6.9	250	
Nitrite (NO_2-N)	0.02		<0.02		<0.02		<0.02		<0.02			
Nitrate (NO_3-N)	0.20	0.02–0.62	0.12	<0.01–0.18	2.86	0.37–6.5	0.80	<0.02–3.80	0.58	<0.02–2.3	10	
Sulfate (SO_4-S)	1.2	<1–2.6	1.6	<1–4.0	5.6	<2–23.0	5.1	4.2–6.9	4.55	<2–9.4	250	
Total phosphorus (P)					0.04	<0.02–0.17	0.13	<0.02–0.60	0.20	<0.02–0.60		
Ammonia (NH_4-N)					0.03	0.01–0.05		<0.10–0.20		<0.10–0.20		0.02
Aluminum (Al)						<0.5–0.8		<0.5–2.5		<0.5–2.5		
Total iron (Fe)					*0.4*	*<0.1–1.0*	*0.46*	*<0.1–1.5*	*0.46*	*<0.1–1.5*	*0.3*	*1.0*
Lead (Pb)					<0.5						0.05	

[a]Source: Unpublished data, H. Mackey in a memorandum to P. J. Mulholland (ORNL) and W. Holmes (SRL), Jan. 17, 1980. Samples were collected monthly over the five-year period 1974 through 1978.

[b]Samples taken at Road A-7, upstream of heated effluent discharges.

[c]Source: EID.

[d]At US-278 about 8 km upstream from drainage of S-area.

[e]At Road C about 7 km downstream from drainage of S-area.

[f]Upstream from SRP drainage.

[g]Downstream from SRP drainage.

[h]Source: "Proposed National Secondary Drinking Water Standards," *Fed. Regist.* 42(62): 17143-17147 (1977).

[i]*Source:* U.S. Public Health Service, *Drinking Water Standards*, PHS publication 956, 1962.

[j]Source: U.S. Environmental Protection Agency, *Quality Criteria for Water*, EPA-440/9-76-023, July 1976.

[k]Data are medians.

4.6.2.2 Biological systems

The most complete data on the biological characteristics of the Savannah River and some of its tributaries that drain the SRP site are contained in a series of reports issued by the Philadelphia Academy of Natural Sciences (ANSP).[30,31] The streams draining the SRP site originate in upland areas and have moderate gradients and relatively narrow floodplains over much of their lengths; however, their lower portions are bordered by floodplain swamp. Heated reactor effluents discharged to Four Mile Creek, Pen Branch, and Steel Creek have eliminated much of the swamp vegetation bordering these streams as well as portions of the large riverine swamp (bordering the Savannah River) into which they flow.[32] The flora and fauna of each of these streams below heated effluent discharges are extremely impoverished; only a few species of thermophilic bacteria and algae are able to survive in some of the hotter areas.[22] Some fish and insects are found in the cooler portions of these streams (<40°C). Heated discharge to Steel Creek ceased around 1968. Initial recovery of its biota has been slow,[32] but it has accelerated more recently.

Biological communities of the Savannah River near the SRP site are generally typical of those of large southeastern U.S. rivers. Two anthropogenic alterations to the river – dredging in the main channel up to Augusta, Georgia, during the 1950s and completion of upstream reservoirs (Clark Hill Reservoir in 1952; Hartwell Reservoir in 1961) – have affected biota by reducing shallow habitat and reducing transport of sediment and allochthonous particulate organic material. The flora of the Savannah River is dominated by diatoms although blue-green algae are at times an important component of the assemblage. The most diverse algal flora consistently occurs during summer, coincident with low flow and less turbid water when light penetration is greater. *The abundance and species distribution of phytoplankton result, to some extent, from* overflow from upstream reservoirs. Macrophytes, most of which are rooted, are limited to shallow areas of reduced current, such as in oxbows, behind sand bars, in swamp areas, and along the shallow margins of tributaries.

Shallow areas and backwaters of the Savannah River near the SRP site support diverse benthic populations; however, the bottom of most open portions of the river consists of shifting sand that does not provide optimum habitat for bottom-dwelling invertebrates. The total number of invertebrate species decreased sharply during the 1950s primarily as a result of dredging, and diversity had not recovered fully by the mid 1960s.[33]

As is typical of southeastern coastal plain rivers and streams, the Savannah River and its associated swamp and tributaries have a very diverse fish fauna.[34] Seventy-nine species have been found in the region near the SRP site.[35] Dredging and reservoir completion (and perhaps water quality degradation) may have been responsible for a gradual decline in the total number of species present since 1960.[35]

The Savannah River supports both a commercial and sport fishery. Important commercial species are the American shad *Alosa sapidissima*, hickory shad *Alosa mediocris*, and striped bass *Morone saxatilis*, all of which are anadromous. Warm water fishing constitutes the bulk of the sport fishing in the Savannah River. The most important game species are largemouth bass, smallmouth bass, pickerel, crappie, bream (sunfish), and catfish. Reservoirs and lakes upstream from the SRP provide a large portion of the available fishing waters.

The flora and fauna of Upper Three Runs Creek are characteristic of relatively undisturbed, soft, blackwater streams of the southeastern United States. A diverse assemblage of attached diatoms is present; occasional mats of the yellow-green alga *Vaucheria* sp. occur during summer.[36,37] Blue-green algae are rare. Shading by the dense hardwood overstory limits light penetration and algal growth during summer. Where the forest canopy is open, rooted aquatic plants, such as *Vallisneria americana* and *Potamogeton epihydrous*, occur.

The macroinvertebrate assemblage in Upper Three Runs Creek and its tributaries is extremely diverse. In addition to the endemic southeastern fauna, many typical northern and mountain species occur, reflecting its cool temperature (because of shading in summer) and low suspended particulate load.[37,38] It also contains many rare species and has been described as an outstanding example of a relatively unpolluted, spring-fed, sandhills stream.[38] Although the stream bottom is mostly sand and soft silt with occasional rock outcrops, abundant submerged logs and tree limbs form excellent substrates for aquatic insects.

Fifty-eight species of fish have been reported from Upper Three Runs Creek, and although some evidence indicates that the total number of species now present may be somewhat fewer than in the early 1950s, the fish community is still very diverse.[15,36,39] Upper Three Runs Creek may be seasonally important as a nursery habitat for a number of important species found primarily in the Savannah River, including the American shad *Alosa sapidissima*, the blueback herring *Alosa aestivalis*, and the striped bass *Morone saxatilis*. Upper Three Runs Creek may also be an important spawning habitat for the blueback herring. Fish have also been reported in the small unnamed tributary to Upper Three Runs Creek that drains the proposed DWFP site (S-area). Ten species were caught during a study by the Savannah River Ecology Laboratory,[40] indicating that small headwater streams in the Upper Three Runs Creek basin may be important as feeding areas or refuges for the fish community.

The floodplain swamp ecosystem bordering Upper Three Runs Creek probably plays an important role in stream functioning. Exports of organic material to the stream via litterfall and fluvial transport support heterotrophic processes, thereby increasing stream secondary productivity. In addition, the swamp litter layer seasonally supports large aquatic invertebrate populations that may be foraged by juvenile or small adult fish able to migrate into these waters during periods of high water level. Finally, conditions in the swamp may modify various physical or chemical conditions in the stream system, such as water velocity, nutrient concentrations, and sediment loads, particularly during periods of high streamflow.

Four Mile Creek lies in a narrow, wooded, moderately sloped valley. The average flow upstream of any plant discharge is less than 15 L/s and is increased by effluents from F- and H-areas and natural drainage to about 550 L/s just above the confluence with C-reactor discharge, about 10 km downstream from alternative site A.[19] The natural stream channel downstream of its confluence with C-reactor discharge canal has been scoured and widened considerably, and much of the bordering vegetation has been eliminated as a result of the heated discharge from C-reactor.

Water quality characteristics of Four Mile Creek upstream of heated effluent discharge are presented in Table 4.17. Four Mile Creek has higher pH (median 6.4), levels of total dissolved solids (mean 60 mg/L), and concentrations of chloride, nitrate, sulfate, sodium, and calcium than does Upper Three Runs Creek.

The flora and fauna of Four Mile Creek downstream of the cooling water discharge from C-reactor are reduced, reflecting the overriding influence of large flows and high temperatures. Temperatures of sections of Four Mile Creek up to 3 km downstream of the thermal discharge regularly exceed 50°C. Thermophilic bacteria and blue-green algae comprise the flora of these waters, filamentous green algae are abundant in cooler regions downstream where temperatures are commonly 30 to 37°C.[22] An investigation during the early 1950s indicated that Four Mile Creek had a diverse fish and presumably a diverse invertebrate fauna before thermal impacts were felt.[39] Currently, however, aquatic invertebrate populations downstream from the thermal discharge are very limited.

With the exception of the mosquito fish, *Gambusia affinis*, which can tolerate temperatures up to about 41°C, few fish occur in the thermally altered areas.[35] During reactor shutdown, heated effluent ceases, the stream returns to ambient temperatures, and fish, particularly the spotted sunfish, *Lepomis punctatis*, and the redbreast sunfish, *Lepomis auritus*, reinvade from downstream areas. However, even in sections of Four Mile Creek upstream of heated effluent discharge, the diversity and abundance of fish and, to some extent, aquatic invertebrates, are reduced in comparison with Upper Three Runs Creek, probably as a result of the isolating influence of the thermal effluent on recruitment downstream.[35]

Sun Bay, a carolina bay on the S-area site, was partially drained and bulldozed in 1978. As a result of this disturbance, Sun Bay has a shorter hydroperiod than most carolina bays of similar size, and its central area is being colonized by weedy pioneer species in what appears to be an early stage of old field succession.[19] The tree, shrub, and herbaceous zones surrounding the central area are still relatively intact. Compared with undisturbed carolina bays, drained Sun Bay provides a somewhat reduced habitat for aquatic species and for those that use the open water portion of the bay for mating, breeding, or as a nursery area (particularly amphibians). The low abundance of vertebrate fauna in and around Sun Bay compared with that of an undisturbed carolina bay has been attributed to lack of juvenile recruitment of amphibians at Sun Bay because of the lack of water during the growing season. A recent SREL study has demonstrated the importance of carolina bays to reptile, amphibian, and small mammal populations in the surrounding area.[40]

4.6.2.3 Rare or unique biota

The South Carolina Wildlife and Marine Resources Department maintains a list of confirmed sightings and collections of biota assigned as endangered, threatened, or of special statewide or regional concern or unique aquatic species. Among the species listed, and occurring or expected in the Savannah River Plant area (Table 4.18), only the American alligator *Alligator mississipiensis* is on the Federal list of endangered species. Alligators have been observed in Par Pond, Lower Three Runs Creek, Steel Creek, and in the swamp bordering the Savannah River.[41] It is estimated that approximately 100 adult alligators reside in Par Pond.[41,42] Alligator activity in Four Mile Creek is unlikely because of the thermal effluent. Upper Three Runs Creek is generally unsuitable habitat upstream from Road F (Fig. 4.2) because of the swift current and steep banks. However, limited alligator activity could occur in impounded portions of the stream and areas downstream from Road A, particularly in oxbow lakes. No alligators were observed in Upper Three Runs Creek by Murphy;[41] however, nests have been reported previously near the creek.[43] The swamp bordering the Savannah River would appear to be suitable alligator habitat because of its slow-moving water, deep sloughs, nesting areas, and abundant prey.

Of the aquatic plants listed as being of special concern (Table 4.18), the pink tickseed *Coreopsis rosea*, spathulate seedbox *Ludwigia spathulata*, little burhead *Echinodorus parvulus*, and green-fringed orchid *Habenaria lacera* have been collected on the SRP site. Among the herpetiles, the spotted turtle *Clemmys guttata* has been reported from Upper Three Runs Creek. The eastern bird-voiced tree frog *Hyla avivoca* is locally common, largely in the river swamp. The eastern tiger salamander *Ambystoma tigrinum tigrinum* is found throughout the SRP area.[43] The pine barrens tree frog *Hyla andersoni* has not been reported at the SRP site.

Table 4.18. Rare or unique aquatic species in the vicinity of the SRP

Scientific name	Common Name	Occurrence in vicinity[a]	Status
	Macrophytes		
Coreopsis rosea	Pink tickseed	X	Statewide concern (Threatened)
Ludwigia spathulata	Spathulate seedbox	X	Statewide concern (Threatened)
Echinodorus parvulus	Little burhead	X	Statewide concern (Threatened)
Habenaria lacena	Green-fringed orchid	X	Statewide concern (Threatened)
Utricularia olivacea	Dwarf bladderwort	X	Statewide concern (Threatened)
Utricularia floridana	Florida bladderwort	X	Statewide concern (Endangered)
Myriophyllum laxum	Loose water-milfoil		National concern (Threatened)
Ptilimnium nodosum	Savannah bishop-weed	X	Statewide concern (Endangered)
Mavaca fluviatilis	Stream bog-moss		Of concern (Unresolved)
Rhexia aristosa	Awn-petaled meadow beauty	X	Regional concern (Threatened)
Peltandra sagittaefolia	White arrow-arm		Regional concern (Threatened)
	Herpetiles		
Alligator mississippiensis	American alligator	X	Federal endangered
Clemmys guttata	Spotted turtle	X	Special concern in S.C.
Hyla andersoni	Pine barrens tree frog		Endangered in S.C.
Ambystoma tigrinum tigrinum	Eastern tiger salamander	X	Special concern in S.C.
Hyla avivoca ogechiensis	Eastern bird-voiced tree frog		Special concern in S.C.

[a]Confirmed in Aiken, Barnwell, or Allendale Counties, S.C.

Source: Greeter, S. Endangered species information for South Carolina. South Carolina Wildlife and Marine Resources Department, P.O. Box 167, Dutch Plaza, Building D, Columbia, South Carolina 29202.

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5. ENVIRONMENTAL IMPACTS FROM IMMOBILIZATION ALTERNATIVES

Potential impacts to the environment of the three alternative actions are described in this section. Potential environmental effects for the reference immobilization alternative will be used as the base for discussion. Potential environmental effects for the delay of reference immobilization alternative and the staged process alternative will not be repeated unless they differ from those given for the reference immobilization alternative.

5.1 REFERENCE IMMOBILIZATION ALTERNATIVE

5.1.1 Construction

5.1.1.1 Land use and socioeconomic impacts*

For the reference immobilization alternative, the number of construction workers required will approach 5000, including 4200 craft and 800 management† and other workers.[1] Depending on the schedule of the Vogtle Nuclear Power Plant, with a work force peaking in 1983 or 1985 (assuming a two-year delay for worst-case analysis), the number of potential in-movers‡ into the primary impact area will range from 870 to 1450. The total expected population associated with these in-movers will be within the range of 2100 to 3500.

The anticipated number of school-age children in the total in-mover population is expected to range from 410 (see Table 5.1) if the peak work force at Vogtle occurs in 1983, to 700 (see Table 5.2) if the peak work force at Vogtle occurs in 1985. Given a peak work force at Vogtle in 1983, the projected 410 school-age children associated with the DWPF are not expected to affect any of the primary impact area counties except Barnwell County, where enrollments in the cities of Barnwell, Williston, and Blackville may increase around 1.3%. If the peak work force at Vogtle is delayed two years until 1985, the projected in-migrant 700 school-age children associated with the DWPF may have a significant impact in the city of Barnwell, where a 2.6% increase in school enrollment may occur; this conclusion is based on the assumption that one-half of the in-movers to Barnwell County relocate in the city of Barnwell. Additionally, the 700 school-age children may have an impact on the school systems within Allendale and Bamberg counties because in 1986 a shortfall in school capacity is expected to occur; however, the DWPF contribution to this shortage is expected to constitute only 0.8%.

The total number of in-movers into the primary impact area is not anticipated to significantly affect housing in the area except for those counties where a shortage in housing types and units is projected to occur because of indigenous population growth. If Vogtle remains on schedule and the peak work force at Vogtle occurs in 1983, the expected 2100 in-mover population attributable to DWPF peak construction in 1986 may increase the potential housing demand in Barnwell County by 10%, adding to a preexisting shortage of multifamily homes and mobile home units. If the peak construction period at Vogtle is delayed until 1985, the expected 3500 in-movers associated with the DWPF in 1986 will increase the demand in Barnwell County for multifamily and mobile home units by 15%. Additionally, the 3500 in-movers for the DWPF may also add to the already significant shortfall in housing in Allendale and Bamberg counties, but the DWPF contribution to this shortage will be less than 0.5% of total demand.

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*Assessment conclusions in this section are based upon *Socioeconomic Assessment of Defense Waste Processing Facility Impacts in the Savannah River Plant Region* by E. B. Peelle, J. H. Reed, and R. H. Stephenson, ORNL/TM-7893 unless otherwise noted.

†The construction industry average of 16.5% overhead, and support staff for nuclear power projects was used in calculating total work force for this project.[1] Hence, it is estimated that 800 management and support workers will be required. Different estimates utilizing 8% overhead and support staff were presented by du Pont construction department, as shown in Figs. 3.11 and 3.19. The higher estimates add conservatism to the socioeconomic impact assessment.

‡Because of model and data limitations, "in-movers" as used here also includes some weekly travelers as well as workers who move into the area. (Weekly travelers are those workers who live near the work site during the week and travel home only on weekends.)

Table 5.1. Socioeconomic impact on primary impact area from the construction of the reference immobilization alternative, Vogtle on schedule: 1986 DWPF peak

County	Baseline population 1986	Work force[a]		Population increase (DWPF)		Schools increase[b] (DWPF)		Housing demand-supply
		Commuters[c]	In-migrants[d]	No.	(%)	No.	(%)	
South Carolina								
Aiken	115,650		425	1,040	(0.9)	198	(0.8)	Adequate
Allendale	11,550		25	60	(0.5)	13	(0.5)	Shortage in single family units. DWPF demand <0.1% of total demand
Bamberg	19,275		25	55	(0.3)	11	(0.3)	Shortage in single family units. DWPF demand <0.1% of total demand
Barnwell	23,050		150	360	(1.6)	73	(1.3)	Shortage in mobile home and multi family units, DWPF demand = 2%.
Georgia								
Columbia	46,625		40	100	(0.2)	20	(0.2)	Adequate
Richmond	193,250		200	490	(0.3)	96	(0.3)	Adequate
Total[e]	409,400	3,900	870	2,100	(0.5)	411	(0.4)	

General impacts[f]

Public services: No noticeable impact on police and fire services. Negligible water and sewer demand increases.

Public finance: Moderate impacts. No DWPF property tax paid to local jurisdictions. Additional tax revenue from new worker homes property taxes, sales and use taxes may not equal cost of services.

Economic base: Significant impact on area economic base from $65.8 million in direct salaries. Slightly fewer indirect and induced jobs than for reference case with Vogtle delayed. Some inflation in local prices, increases in local wage rates, and rise in consumer demand.

Roads and traffic: Minor impacts off the site. Major onsite congestion may occur during shift changes.

Land use change: No noticeable impacts. Normal growth changes will overshadow DWPF effects.

Historical and archaeological: No impact. Five Barnwell historic sites may be disturbed by commercial and residential development.

[a] Local movers (250) not included. Total overall = 5000.

[b] Entire increase assumed to occur in one year. Peak in-migrant enrollment is divided by total student enrollment.

[c] Jobs filled by existing residents. Individual county commuting totals are not given because (1) all will be existing residents whose road use in home areas is already felt, and (2) maximum traffic impacts as workers converge on the roads near the SRP were found not to affect levels of service significantly.

[d] Some weekly travelers included. Most are local mover category.

[e] Numbers may reflect rounding errors.

[f] Impacts apply to all counties in primary impact area.

Only minor impacts on fire and police services (up to a maximum of three additional police officers and seven additional fire personnel per county) will occur despite the peak construction period at Vogtle occurring in 1983 or 1985. The in-movers associated with the DWPF are expected to have negligible impact on the demand for water and sewage services in relation to the overall demand.

The DWPF construction work force will contribute to the local economy of the area directly through the payment of income and property taxes, licenses, and user fees and indirectly through the purchase of goods and services in the local area. To the contributions of the construction work force, particularly those who are in-movers, will also be added the direct purchase of goods and services within the area for the actual construction of the DWPF. The economic benefits accruing to the primary impact area will be offset by increased local governmental costs for additional services to the in-mover population. Local government costs may not be fully offset by higher tax revenues.

Land use changes are expected to be minor, especially in relation to the numerous land use changes expected from normal growth and development in the area independent of the DWPF. Construction of the DWPF will not entail the acquisition by the Federal government of any additional property.

Table 5.2. Socioeconomic impact on primary impact area of reference immobilization alternative with Vogtle delayed — construction 1985 Vogtle peak, 1986 DWPF peak (maximum impact case)

County	Population 1986	Work force[a]		Population increase (DWPF)		Schools[b] increase (DWPF)		Housing: demand-supply
		Commuters[c]	In-migrant[d]	No.	(%)	No.	(%)	
South Carolina								
Aiken	115,600		630	1,530	(1.3)	300	(1.2)	Slight shortage in multifamily and mobile homes
Allendale	11,550		45	110	(1.0)	23	(<0.8)	Shortage in single-family units; DWPF demand, <0.5% of total demand
Bamberg	19,275		45	110	(0.6)	21	(<0.5)	Shortage in single-family units; DWPF demand, <0.5% of total demand
Barnwell	23,050		290	690	(3.0)	140	(2.6)	Shortage in mobile homes DWPF demand = 10 + % of total
Georgia								
Columbia	46,625		70	165	(0.3)	33	(<0.3)	Adequate
Richmond	193,250		375	900	(0.5)	179	(<0.5)	Adequate
Total[e]	409,400	3,350	1,450	3,500	(0.9)	696	(<0.8)	

General impacts[f]

Public services: Minor impacts on police and fire services. Negligible impacts on water and sewer services because of current excess capacity.

Public finance: Moderate impacts. No DWPF property tax paid to local governments. Additional tax revenue from new property tax and sales and use taxes may not equal cost of services.

Economic base: Significant impact from $66 million worker salaries and additional indirect and induced salaries. Some inflation in local prices, increase in local wage rates and strong consumer demand.

Roads and traffic: Minor impacts offsite. Major onsite congestion may be created at shift changes.

Land use change: Minor impacts. Normal growth overshadows DWPF impacts except for possible mobile home increases in Aiken and Barnwell counties.

Historical and archaeological: No impact expected. Five Barnwell National Historic Register sites may be affected by ancillary residential and commercial development.

[a] Local movers (200) not included. Total workforce = 5000.

[b] Entire increase assumed to occur in one year. Percentage is calculated by dividing peak enrollment by total student enrollment.

[c] Jobs filled by local residents. Individual county commuter totals are not given because (1) all will be existing residents whose road use in home areas is already felt, and (2) maximum traffic impacts as workers converge on the roads near the SRP were found not to affect levels of service significantly.

[d] Some weekly travelers included in both in-migrant and local mover categories.

[e] Discrepancies may occur as a result of rounding.

[f] Impacts apply to all counties in primary impact area.

No direct impacts from the DWPF on area historical or archaeological sites are expected, although the five sites in Barnwell listed in the *National Register of Historic Places* could be disturbed by ancillary commercial and residential development in the area.

Additional traffic increases can be expected on roads leading to SRP, particularly from Aiken, Augusta, and Barnwell, because of increases in construction worker commuting. These major roads are multilane highways; so normal traffic congestion during periods of construction worker commuting is not anticipated to reduce highway capacity below an acceptable level of service (Appendix E.9).

The most significant economic impact is on the regional economic base because about 3500 jobs are filled by existing residents and about 15,000 indirect and induced jobs, based on national input/output multipliers, might be created in response to the payroll of $66 million in the peak year. These jobs will create additional consumer demand throughout the area and, in turn, create some increase in local prices and local wage rates during the peak period. These effects are intensified by the simultaneous construction of Vogtle and the DWPF. TC

5.1.1.2 Nonradiological impacts

Construction safety

Construction of the DWPF is expected to be the responsibility of E. I. du Pont de Nemours & Company, DOE's prime contractor for operation of the SRP. During construction of the original SRP, the construction forces reached a maximum of about 35,000 workers, and the organization established world records for construction safety. In 1980, Du Pont Construction at SRP achieved eleven million man-hours of work without a lost-time injury. For that year, the accident rate for Du Pont Construction forces at SRP was 0.10 lost-time injuries per 200,000 exposure house, the normal units of the National Safety Council (NSC). This rate is almost forty-fold better than the 1980 NSC average of 3.89 for the construction industry overall. Figure 3.14 indicates that about 13,500 man-years of construction work is required to build the proposed DWPF. This estimate corresponds to about 13-14 lost-time injuries for the DWPF construction project at the 1980 rate, versus 500 for the project at the construction industry average rate.

Terrestrial ecology

The DWPF will require approximately 60 ha of land to be committed for the life of the project and an additional 40 ha to be altered by construction activity. Up to an additional 40 ha may receive some construction impact. Construction of the DWPF in S-area would result in the loss of approximately 3 ha of bottomland hardwood forest, 7 ha of turkey oak forest, and Sun Bay (a previously disturbed carolina bay). The remaining area to be lost now consists of forests of loblolly, slash, or longleaf pine.

Construction of the DWPF will result in the death or dislocation of some wildlife and reduce habitat availability. In S-area, Sun Bay (one of about 200 carolina bays on the SRP site) is a locally important reproductive habitat (Sect. 4.6.1) that supports a much larger, but undefined, area, which is characteristic of all carolina bays. The loss of Sun Bay would have an impact on the local amphibian and aquatic reptile population.

No Federally protected endangered or threatened species would be affected by construction in S-area (Sect. 4.6.1). Three plant species identified by state experts as needing protection would be affected by construction in this area, however. A local population of the creeping water-plantain *Echinodorus parvulus* and the spathulate seedbox *Ludwigia spathulata* would be destroyed along with Sun Bay. The potential terrestrial ecological impacts of construction at the S-area include removal of hardwood forest and the loss of Sun Bay as a breeding area for upland species.

A 15-ha 200-Z site has been proposed for burial of salt adjacent to Road F immediately north of S-area. The entire area is forested in pine, approximately 20% loblolly, 27% longleaf, and 53% slash pine. No terrestial ecological constraints to salt burial at the preferred site have been identified. The vegetation types are abundant on the SRP, are not considered high-quality wildlife habitat, and contain no identified rare or endangered species.

Nonradiological emissions expected to result from construction of the DWPF will be similar to those for construction of any industrial facility of comparable size. These would result primarily from construction equipment, truck traffic, and site disturbance and consist of small quantities of carbon monoxide and hydrocarbons from engine exhausts as well as suspended particulates or dust from ground surface disturbance. Dust can be controlled during hot dry weather by wetting the ground surfaces.

Aquatic ecology

Aquatic ecosystems in the vicinity of the proposed DWPF site will be affected by construction of the (1) main facilities; (2) railroad spur; (3) ash basin; (4) various power, communication, and interarea transfer lines; (5) access roads; and (6) saltcrete burial site. Principal potential impacts associated with these construction activities are (1) increased erosion and subsequent stream siltation, (2) water chemistry changes and increased flow in streams receiving groundwater during dewatering of excavated areas, and (3) disturbance or destruction of a carolina bay on the construction sites (see Sect. 6 for regulations governing wetlands and Appendix N for an overview of the carolina bay as a wetland). The severity of these impacts depends upon the construction practices used and mitigating measures employed.

Whenever land is denuded of vegetation, a potential for greatly increased rates of erosion exists and, as a result, increased siltation can occur in streams draining the disturbed site. Some of the factors that determine the extent of increased stream siltation resulting from construction activities are the proximity of these activities to streams, land slope, soil type, and rainfall.

The adverse effects of siltation on aquatic organisms and their habitat are well documented. Increased siltation will reduce primary productivity, reduce populations of benthic invertebrates, and eliminate some fish spawning and feeding habit downstream.[2-11]

The adverse impact of increases in suspended sediment concentration on Upper Three Runs Creek could be severe although temporary unless mitigated as discussed below because its biota are adapted to the low sediment loads of this relatively undisturbed southeastern blackwater stream. In addition, construction could significantly modify the valley and channel of a small permanent tributary of Upper Three Runs Creek at the east end of the site, increasing the potential for siltation problems in both streams. Increases in suspended sediment concentration in Upper Three Runs Creek or its tributaries could result in reduced primary and secondary productivity and reduction in their value as spawning and nursery areas for fish. Mitigating measures would reduce the adverse impacts mentioned. Construction of the burial site (200-Z) will involve denudation of approximately 15 ha and will cause some erosion and subsequent siltation of streams draining the site. The effects of siltation will be much less for this facility compared with the S-area construction.

Most adverse impacts from increased siltation in streams are temporary, and biota quickly recolonize after the disturbance has ceased.[6] The adverse impacts from construction on Upper Three Runs Creek and its tributaries may be significant but will be largely limited to the period of construction and a few years thereafter (a total of from five to eight years). Other major construction has occurred in the Upper Three Runs Creek basin in the past (SRP facilities at F- and H-areas), and the stream has recovered. However, because Upper Three Runs Creek is the only stream at the SRP that does not have major disturbances, its degradation during construction activities could adversely affect the fish community to a greater degree than degradation of one of the other SRP streams.

Excavation for the main process buildings will require local dewatering of the Barnwell Formation and pumping to lower the piezometric head in the McBean Formation (Sect. 4.5.2). Dewatering will be conducted at a rate of 12 to 65 L/s and will extend over a 12- to 14-month period. The water will be discharged to the small unnamed tributary to Upper Three Runs Creek east of S-area, increasing its flow by 5 to 29%. The dewatering volume would range from 0.2 to 1.2% of the average flow of Upper Three Runs Creek in this area. Water from the Barnwell Formation typically has a pH of less than 6, calcium concentration of less than 6 mg/L, and total dissolved solids of less than 30 mg/L (Appendix G, Table G.2). The McBean Formation has two distinct subunits, an upper Eocene sand with water quality characteristics similar to the Barnwell Formation and a lower Eocene limestone with a pH of about 7, calcium concentration of 11 to 14 mg/L, and total dissolved solids of 50 to 70 mg/L. Water quality of the unnamed tributary draining S-area to which dewatering volumes will be released is similar to the groundwater of the Barnwell and upper McBean formations but is lower in pH, calcium concentration, and total dissolved solids than the calcareous portion of the McBean Formation. Considering the relative volumes of water involved and the similarity of water quality in the unnamed tributary and in groundwater, impacts on the aquatic biota of this tributary as a result of dewatering discharge will be negligible during the early dewatering period. As the lower portions of the McBean Formation are dewatered, probable increases in calcium concentration of about 2 mg/L and increases in total dissolved solids of about 10 to 15 mg/L in the receiving tributary probably will have no effect on aquatic biota. Because a further dilution of about 100 times occurs at the confluence with Upper Three Runs Creek, effects on the latter stream will be negligible as well.

Impacts on Upper Three Runs Creek resulting from DWPF construction would be reduced by the use of construction practices that minimize site erosion and stream siltation, such as careful contouring, use of sediment fences, routing of storm runoff water to temporary holding basins, maintenance of natural buffer strips along stream channels, and quickly revegetating barren land. Construction of the DWPF at S-area will result in the destruction of a carolina bay (Sun Bay, Appendix N).

Monitoring

Aquatic impacts in the Upper Three Runs Creek during construction and for some period afterward could be significant. Consequently, studies designed to monitor water quality and biota, particularly benthic organisms, will be initiated.

To comply with wetland protection regulations and to determine the ecological impacts of eliminating Sun Bay (one of about 200 on the SRP site), DOE has requested SREL to conduct comprehensive ecological studies at Sun Bay and another similar wetland — Rainbow Bay (as baseline for comparison).[12] The studies were initiated in the spring of 1979, and they will continue through construction and, if necessary, three to four years into operations, to determine the ecological impacts of constructing the proposed DWPF at the S-area. Reports will be published annually to document the study results.

Mitigation

An erosion and sediment control plan will be formulated to mitigate potential impacts from the construction and operations phases of the facility. Control methods will consist of two basic types, namely, stabilization and retention of materials in place and entrapment of transported materials prior to discharge off the site. In situ erosion control methods will consist of one or more of the following: (1) vegetative cover; (2) mulches, including stone, wood chips, fiber, straw or other suitable materials; (3) tackifiers, including asphalt emulsions or chemical stabilizers; (4) netting, anchors, riprap or similar physical restraints; and (5) controlled surface flow by interceptor or diversion ditches, check dams or similar structures. Entrapment of transported materials can be accomplished by the use of sediment basins, filters, flocculents or similar measures.

5.1.1.3 Construction radiological impact

Because the proposed site for the DWPF is within and part of the DOE-owned SRP, the onsite construction personnel will encounter slightly elevated background levels of radiation produced by the normal operation of the plant facilities. The incremental external gamma dose rates measured at the proposed construction site averaged 0.23 mR/24 h. Assuming the construction worker spends 2000 hours in the area (40 h/week for 50 weeks per year) the annual dose to the worker is estimated to be 20 millirems. The dose commitment from the inhalation of radionuclides released to the atmosphere from existing SRP operating facilities is estimated to be 0.4 millirem/year. Resuspension of previously deposited radionuclides is not a significant exposure pathway as determined by radiological surveys. All doses are well below the standards established by DOE for uncontrolled areas (500 millirems per year);[13] thus, no routine monitoring of construction workers will be required.

Should construction activity involve existing SRP facilities, such as making connection to existing contaminated piping, the procedure and personnel will be appropriately monitored not only to preclude any exposure to personnel above existing standards for working in controlled areas[13] but also to maintain exposure levels to as low as reasonably achievable.

5.1.2 Operation

5.1.2.1 Land use and socioeconomic impacts

Because the number of operation workers is so much smaller than the construction force, the impact of operation on surrounding areas is expected to be barely noticeable. About 350 of the 700 operation workers will be local residents; so population and school enrollment increases are expected to be minimal. These numbers, when distributed throughout the impact area,* are not considered significant for public services or other factors. Some economic turndown can be anticipated when construction ends and operation begins. Salaries of the direct workers amount to $21 million and will sustain only some (about 2900) of the potential 15,000 indirect and induced jobs created during the construction period. This decline in employment will have some impacts on local commercial receipts if excess expansion of local economies has occurred. However, the decline in employment would have occurred earlier, after the completion of the Vogtle project, had DWPF not been built. Thus, operation of the DWPF represents a net gain of 700 permanent jobs to the area.

5.1.2.2 Nonradiological impacts

Terrestrial ecology

The major impacts to terrestrial ecosystems would occur during the construction phase (Sect. 5.1.1.2) when the plant site will be converted from natural vegetation or pine plantation into an industrial complex. The operational impacts discussed herein are less severe.

A small power plant [$\sim$40 MW(t)] will burn 5300 kg/h of coal. The plant will be equipped with both electrostatic precipitators and scrubbers to ensure that all atmospheric emissions from burning coal will be within regulated limits. Estimated releases are shown in Table 5.3. Approximately 6.0 x 10^6 kg/year of ash will be generated from the burning of coal, including the particulates retained by the electrostatic precipitators. Ash will be sluiced to ash basins, which have been designed for eight years' service. Assuming that the DWPF will operate for 28 years, additional ash disposal capacity will be required.

*Unlike the construction work force, operational workers are expected to distribute themselves throughout the six counties in the same pattern as do current permanent workers at SRP.

Table 5.3. Estimated release of nonradioactive pollutants from the powerhouse to the atmosphere

Material	Emission rate[a] (kg/h)	Emission rate (lb/10^6 Btu)	S.C. air emission standards (lb/10^6 Btu)	Estimated annual average concentration at site boundary ($\mu g/m^3$)	S.C. Annual average ambient air quality standards ($\mu g/m^3$)
Particulates	2.3	0.04	0.6	0.006	75
Sulfur oxides, SO_x	20	0.32	3.5	0.05	60
Carbon monoxide, CO	2.7	*b*	*b*	0.007	80
Organics as methane	2.7	*b*	*b*	0.007	*c*
Nitrogen oxides, NO_x	41	*b*	*b*	0.11	100
Aldehydes	0.01	*b*	*b*	0.00003	*c*
Carbon dioxide, CO_2	17,000	*b*	*b*	44.	*c*

[a] From the combustion of 5,300 kg/h of coal.
[b] No emission standards for coal-fired power plants.
[c] No air quality standards.
Source: EID, Section 3.

Condenser cooling and air conditioning will be accomplished by mechanical-draft cooling towers. Makeup water will come from the Tuscaloosa aquifer (less than 20% of existing SRP usage) and will be of high quality. SRP usage of Tuscaloosa water has no observable impact on the aquifer. Water circulation will be 1.9 m^3/s with a drift rate of 9.5 x 10^{-4} m^3/s. The 0.05% drift rate is well above current state of the art for cooling towers, but the high quality of the circulating water (~112 ppm TDS) is not likely to lead to ecological damage.

Chemical wastes that have the potential for degradation of the terrestrial environment will arise from equipment wash down, coal pile runoff, ash basin effluent, and spills. These liquids are to be directed to a chemical wastewater treatment facility and ultimately discharged to Four Mile Creek. Dried sludge will be disposed of in existing landfills. Nothing should escape into natural surroundings before it is treated, and no negative impact on terrestrial systems should result.

Sewage will be treated in a package sewage treatment plant. Treated sewage effluent from the proposed DWPF will be disposed of by means of a spray field sized to avoid soil saturation and runoff. Two potential problems are associated with on-land disposal: (1) it is possible to maintain a saturated soil if the irrigation rate is too high, and (2) the nutrient ions in the effluent can saturate the exchange sites in the soil column. Saturated soils become depleted of oxygen and cannot support the kinds of upland vegetation found in the SRP. Once saturated, added nutrients are no longer scavenged from the sewage effluent and are free to pass into groundwater. Both effects can be mitigated by proper sizing of the spray field and by harvesting the vegetation.

Nonradioactive solid wastes, generated at the rate of 340 m^3/year, will be disposed of in an existing landfill on the SRP. No significant increase in landfill area will be required to accommodate the waste load.

Atmospheric emissions will come from the power plant discussed previously, diesel generators, and from process gaseous releases. Gaseous releases from DWPF process operations are expected to be 7.7 kg/h CO_2, 450 g/h NO_x, and 23 g/h NH_3. These releases are small and are not expected to have adverse environmental impacts.

Emergency power will be supplied by diesel-powered generators. Testing of generators will consume 18 m^3 of diesel fuel annually, less than that used by one truck hauling commercial freight. Atmospheric emissions are expected to be proportional to fuel use.

Aquatic ecology

Principal impacts on aquatic ecosystems resulting from operation of the DWPF are wastewater and stormwater discharges to nearby streams. Effluents from industrial wastewater treatment facilities will be piped and discharged to Four Mile Creek. Stormwater will be collected and discharged to tributaries of Upper Three Runs Creek.

Sources and average flow rates of nonradioactive wastewater to the industrial waste treatment facility are listed in Table 3.8 and discussed in Sect. 3.1.6.4. Because of the variety of sources, the chemical concentrations of the blended wastewater will be variable. Because 95% of the wastewater flow will be effluent from the ash basin, comparison with ash basin effluents from other SRP facilities with coal-fired power plants will provide a reasonable estimate of wastewater quality before treatment. Water quality of ash basin effluents from F-area, H-area, and P-area are listed and compared with water quality criteria in Table 5.4. Inspection of this data indicates that at some times pH, chromium, iron, and zinc in the ash basin effluent exceed water quality criteria. Dvorak et al. have indicated that barium, boron, chromium, mercury, and selenium concentrations in leachates from the ash generated in coal combustion can exceed U.S. Environmental Protection Agency drinking water standards and are of particular concern.[14] Although barium and boron concentrations were not measured (Table 5.4), among chromium, mercury, and aluminum, only chromium concentrations appear to be high in SRP ash basin effluents. The effluent from the industrial waste treatment facility will be treated to comply with applicable NPDES permit requirements.

Table 5.4. Concentration of various parameters in ash basin effluents from three facilities on the SRP site and comparison with water quality criteria

Parameter	F-area	H-area	P-area	Drinking water standard[a]	Protection of freshwater biota[a]
Flow, L/s	<1–35	<1–22	<1–18		
pH, range	4.1–7.5	4.8–7.6	6.5–7.9	6.5–8.5	
Suspended solids, mg/L	2–7	1–10	3–27		
Arsenic, μg/L	<10	<10–18	<10	50	500–1000[b]
Cadmium, μg/L	<10	<10	<10	10	0.4–12
Chromium, μg/L	<10–60	<10–10	<10–15	50	100
Copper, μg/L	<10–40	<10–40	<10–14	1000	60–100[b]
Iron, μg/L	60–250	80–600	125–8000	300	1000
Lead, μg/L	<10	<10	<10	50	30–100[b]
Mercury, μg/L	<0.2	<0.2	<0.2	2	0.05
Nickel, μg/L	<10–55	<10–26	<10–55		100
Selenium, μg/L	<10	<10	<10	10	
Zinc, μg/L	<15–117	<10–40	<10–32	5000	10–100[b]

[a]Data from U.S. Environmental Protection Agency, *Quality Criteria for Water,* EPA-440/9-76-023, July 1976.

[b]Lowest range of values that have been shown to have an adverse effect on various aquatic organisms in low alkalinity waters similar to those at SRP (from U.S. Environmental Protection Agency, *Quality Criteria for Water,* EPA-440/9-76-023, July 1976).

Source: *NPDES Discharge Monitoring Reports* covering periods from Apr. 1, 1980 to Sept. 1, 1980. Permit Number SC 0000175 to E.I. du Pont de Nemours and Company for operations at the SRP site.

G-4 Effluents from the industrial and sanitary wastewater treatment facilities will be pumped and discharged to Four Mile Creek. Average discharge from the industrial wastewater treatment facility will be approximately 0.7% of average stream flow, or 2.5% of minimum daily flow, in Four Mile Creek just upstream of the confluence with C reactor heated effluent. Thus, average stream flow will dilute wastewater effluents from DWPF operation to Four Mile Creek by about 100 times, and minimum flow will provide about 40-fold dilution. Impacts on water quality and aquatic biota of Four Mile Creek as a result of this additional wastewater discharge from DWPF facilities will be negligible. Four Mile Creek already receives large volumes of industrial and sanitary wastewater (Table 4.16), which amount to more than 20 times the projected effluents from DWPF operations, and its water quality and biota are degraded (Sect. 4.6.2).

Discharge of stormwater collected from the DWPF site during operation will have no significant impact on Four Mile Creek and at most only minor impact on Upper Three Runs Creek. Upper Three Runs Creek currently receives stormwater drainage from part of A-, F-, H-, and M-areas via tributaries.

There will be negligible impact on aquatic ecosystems as a result of operation of salt disposal facilities at the proposed 200-Z area (Sect. 5.4).

Monitoring[12]

Operational impacts to terrestrial and aquatic systems were assessed to be of little probable consequence. As discussed in Sect. 5.1.1.2, the aquatic monitoring programs for Upper Three Runs Creek will continue for several years if significant construction impacts are observed. Other monitoring will be carried out as necessary and to provide verification that all requirements are met for permits and certification. If unexpected operational impacts are found, appropriate mitigation measures will be taken.

5.1.2.3 Radiological impacts

The radiological impacts of the DWPF are assessed by estimating the dose commitments to individuals and populations which may result from exposure to the radionuclides expected to be released during normal operations. The concentrations of radionuclides in the air and on the soil surface at various distances and directions from the plant or in the water around the plant are used to estimate the doses.

The potential pathways for radiation exposure to man from radionuclides released from a nuclear facility are represented schematically in Fig. 5.1. External doses result from immersion in contaminated air, submersion in contaminated water, and exposure to contaminated ground surfaces. Internal doses result from the inhalation of contaminated air and the ingestion of contaminated food and water.

Where site-specific information is not available, conservative assumptions (which tend to maximize the dose) are used; for example, in calculating doses from atmospheric releases, the individual is assumed to be exposed to contaminated air and ground surfaces for 100% of the time with no shielding. Further, all food consumed is assumed to be grown at the location of the dose calculation. For doses from liquid releases, all drinking water and fish are assumed to be obtained from local rivers and streams.

Radioactive materials introduced into the body by inhalation or ingestion pathways (internal exposure) continue to irradiate the body until they are removed by metabolism or radioactive decay. Thus, the dose calculated for an individual for one year of radionuclide intake represents the total dose he will receive as a result of that one year's intake integrated over the next 50 years (his remaining lifetime), that is, a 50-year dose commitment. In this report, all internal doses are given as 50-year dose commitments. The methodology and assumptions for estimating doses to man from airborne and aqueous releases are presented in Appendix J.

Maximum individual dose commitment from airborne effluents

The maximum doses to the individual (living at the nearest plant boundary in the prevailing wind direction) are shown in Tables 5.5 and 5.6 for the processing of 5-year-old waste and 15-year-old waste, respectively, at each of the three processing facilities. To account for differences in eating patterns, life span, etc., doses are calculated for an infant, child, teenager, and adult when considering maximum dose commitments. During the processing of 5-year-old waste, the highest total-body dose (0.0083 millirem per year of operation) is to the "child" and primarily results from the Canyon operation (99%); the major contributing radionuclide (see Table 5.7) is strontium-90 (87.2%) via the ingestion pathway. The highest organ dose (0.18 millirem per year of operation) is to the thyroid of the "adult," primarily from the iodine-129 (97.7% of the dose) released from the Canyon exhaust stack.

The doses resulting from processing 15-year-old waste are listed in Table 5.6. The highest total-body dose (0.0062 millirem per year of operation) is about 75% of the highest dose from processing 5-year-old waste because of the decay of the shorter half-life radionuclides (see Tables O.10 and O.11). The thyroid dose remained essentially unchanged from one waste decay period to the other because of the long half-life of iodine-129. The contribution of major radionuclides to dose is presented in Table 5.8.

The total body and organ doses of the maximally exposed individual resulting from the processing of both types of waste are only a small fraction of the applicable limits established by the Department of Energy regulations (500 millirems per year to the total body, gonads, and bone marrow and 1500 millirems per year to the other organs).[13]

Additionally, the total body dose to the maximally exposed individual from the routine airborne releases of the DWPF (0.0083 millirem per year of operation) is only 0.007% of the normal background radiation to area residents of 117 millirems per year. Thus, the maximum doses to the individual represent only a very small increase in the radiation dose above background.

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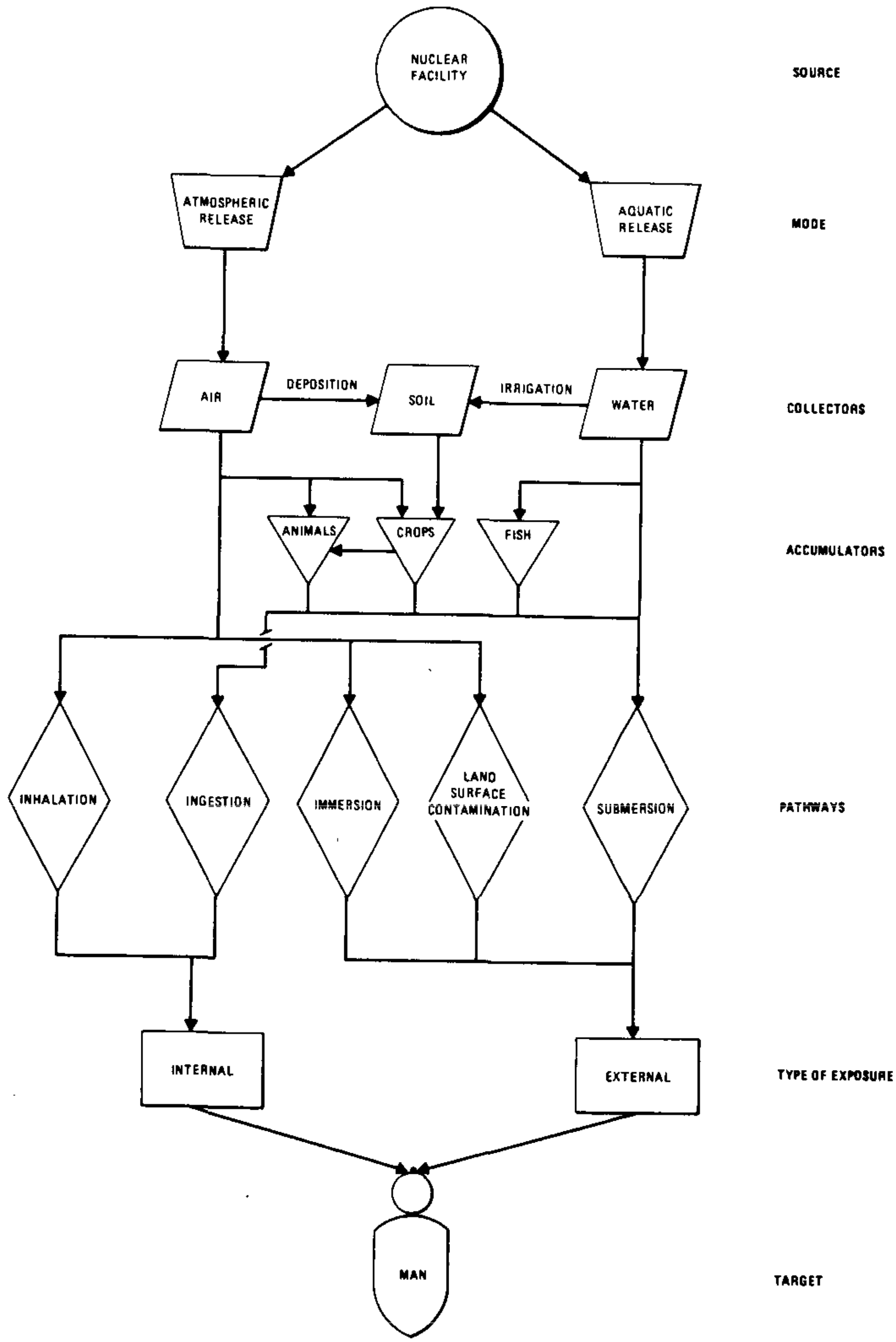

Fig. 5.1. Schematic representation of assessment methodology used to calculate the radiological impact on man.

Table 5.5. Maximum 50-year dose commitment to the individual[a] from routine annual airborne releases from the DWPF — 5-year-old waste

Facility	Dose commitment[b] (millirem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant					
Canyon operation	1.4E-3[c]	4.0E-3	1.1E-1	1.5E-3	1.5E-3
Regulated chemical facility	4.1E-5	4.1E-5	4.1E-5	4.1E-5	4.1E-5
Saltcrete plant	7.9E-5	7.9E-5	7.9E-5	7.9E-5	7.9E-5
Total	1.5E-3	4.1E-3	1.1E-1	1.6E-3	1.6E-3
Child					
Canyon operation	8.2E-3	3.1E-2	1.3E-1	8.4E-3	9.6E-3
Regulated chemical facility	4.4E-5	4.4E-5	4.4E-5	4.4E-5	4.4E-5
Saltcrete plant	8.5E-5	8.5E-5	8.5E-5	8.5E-5	8.5E-5
Total	8.3E-3	3.1E-2	1.3E-1	8.5E-3	9.7E-3
Teen					
Canyon operation	5.2E-3	1.9E-2	1.4E-1	5.3E-3	5.9E-3
Regulated chemical facility	4.5E-5	4.5E-5	4.5E-5	4.5E-5	4.5E-5
Saltcrete plant	8.6E-5	8.6E-5	8.6E-5	8.7E-5	8.7E-5
Total	5.3E-3	1.9E-2	1.4E-1	5.4E-3	6.0E-3
Adult					
Canyon operation	4.4E-3	1.5E-2	1.8E-1	4.3E-3	4.6E-3
Regulated chemical facility	4.4E-5	4.5E-5	4.4E-5	4.4E-5	4.4E-5
Saltcrete plant	8.6E-5	8.6E-5	8.6E-5	8.6E-5	8.6E-5
Total	4.5E-3	1.5E-2	1.8E-1	4.4E-3	4.7E-3

[a] Maximally exposed individual is assumed to be at the nearest boundary approximately 10.5 km downwind from the plant effluent.

[b] Per year of operation.

[c] Read as 1.4×10^{-3}.

Population dose commitments from airborne effluents

As described in Appendix J, all population doses are 100-year environmental dose commitments (EDC). Appendix J-3 presents a detailed discussion of the EDC concept. The 100-year EDC represents an accounting of population doses caused by exposure to and injestion of environmentally available radionuclides for 100 years following a one-year release of radioactivity.

Population dose to the regional population (within an 80-km radius of the DWPF)

The 100-year environmental dose commitments (EDC) for various age groups of the projected population for 1990 (reference-case facility) during the processing of 5-year-old waste and 15-year-old waste are listed in Table 5.9. The dose commitment for the total body from exposure to the airborne effluents of processing 5-year-old waste is 0.38 man-rem; the comparable dose from processing 15-year-old waste is 0.25 man-rem, or about 66% of dose from the 5-year-old waste. The highest organ dose — 11.0 man-rems to the thyroid — results primarily from the ingestion of iodine-129. Since ^{129}I has a long half-life, the dose is not significantly different for the 5-year-aged and 15-year-aged wastes.

The adult population makes up about 68% of the total 1990 population; thus, the population dose to this age group contributes about 60% of the collective population dose to the total body and about 70% of the total thyroid dose.

The annual total-body dose from natural background radiation within the 80-km radius of the DWPF is estimated to be 7.1×10^4 man-rems (assuming an average background dose rate of 117 millirems/year). The highest total-body dose of 0.38 man-rem is only 0.0005% of the background dose; thus, the population environmental dose commitments resulting from normal operations of the DWPF represent only very small increases in the population dose above background.

Table 5.6. Maximum 50-year dose commitment to the individual[a] from routine annual *airborne releases from the DWPF — 15-year-old waste*

Facility	Dose commitment (millirem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant					
Canyon operation	8.9E-4[c]	2.8E-3	1.1E-1	8.7E-4	9.9E-4
Regulated chemical facility	2.3E-5	2.3E-5	2.3E-5	2.3E-5	2.3E-5
Saltcrete plant	4.5E-5	4.5E-5	4.5E-5	4.5E-5	4.5E-5
Total	9.6E-4	2.9E-3	1.1E-1	9.4E-4	1.1E-4
Child					
Canyon operation	6.1E-3	2.3E-2	1.3E-1	6.1E-3	6.3E-3
Regulated chemical facility	2.5E-5	2.5E-5	2.5E-5	2.5E-5	2.5E-5
Saltcrete plant	4.8E-5	4.8E-5	4.8E-5	4.8E-5	4.8E-5
Total	6.2E-3	2.3E-2	1.3E-1	6.2E-3	6.4E-3
Teen					
Canyon operation	3.8E-3	1.4E-2	1.3E-1	3.7E-3	3.8E-3
Regulated chemical facility	2.5E-5	2.5E-5	2.5E-5	2.5E-5	2.5E-5
Saltcrete plant	4.9E-5	4.9E-5	4.9E-5	4.9E-5	4.9E-5
Total	3.9E-3	1.4E-2	1.3E-1	3.8E-3	3.9E-3
Adult					
Canyon operation	3.2E-3	1.2E-2	1.8E-1	3.1E-3	3.0E-3
Regulated chemical facility	2.5E-5	2.5E-5	2.5E-5	2.5E-5	2.5E-5
Saltcrete plant	4.9E-5	4.9E-5	4.9E-5	4.9E-5	4.9E-5
Total	3.3E-3	1.2E-2	1.8E-1	3.2E-3	3.1E-3

[a] Maximally exposed individual is assumed to be at the nearest boundary approximately 10.5 km downwind from the plant effluent.
[b] Per year of operation.
[c] Read as 8.9×10^{-4}.

Table 5.7. Contribution to dose by major radionuclides released in the airborne effluents of the canyon exhaust stack — 5-year-old waste

Age group	Radionuclide	Percent of dose				
		Total body	Bone	Thyroid	Lungs	Kidneys
Infant	^{3}H	1.5	0.54	0.02	1.4	1.1
	^{90}Sr	47.0	66.2	0.62	43.1	44.8
	^{106}Ru	24.1	10.7	0.26	31.8	20.1
	^{129}I	13.1	8.9	98.9	10.0	15.7
	^{137}Cs	13.5	12.31	0.14	12.5	16.0
Child	^{3}H	0.74	0.20	0.05	0.73	0.64
	^{90}Sr	87.2	90.6	5.4	85.9	74.7
	^{106}Ru	5.6	4.4	0.30	7.8	16.7
	^{129}I	2.8	1.4	94.0	2.4	3.7
	^{137}Cs	3.2	2.9	0.17	2.8	3.8
Teen	^{3}H	1.2	0.33	0.05	1.2	1.1
	^{90}Sr	80.2	90.6	3.1	79.0	71.5
	^{106}Ru	7.5	4.4	0.24	11.5	18.2
	^{129}I	4.7	1.4	96.4	4.0	3.9
	^{137}Cs	5.8	2.7	0.20	3.9	4.8
Adult	^{3}H	1.4	0.42	0.04	1.7	1.4
	^{90}Sr	74.9	90.2	1.9	76.5	71.8
	^{106}Ru	8.5	4.5	0.18	11.4	16.9
	^{129}I	6.5	1.4	97.7	5.9	3.5
	^{137}Cs	7.8	2.7	0.17	4.4	5.3

Table 5.8. Contribution to dose by major radionuclides released in the airborne effluents of the canyon exhaust stack – 15-year-old waste

Age group	Radionuclide	Percent of dose				
		Total body	Bone	Thyroid	Lungs	Kidneys
Infant	^{3}H	3.6	1.1	0.03	3.8	3.3
	^{90}Sr	58.3	72.0	0.49	60.1	52.9
	^{106}Ru	0.04	0.02	0.00	0.06	0.03
	^{129}I	20.9	12.4	99.4	17.9	23.7
	^{137}Cs	17.0	13.6	0.12	17.7	19.3
Child	^{3}H	0.57	0.15	0.03	0.58	0.55
	^{90}Sr	92.1	94.6	4.3	92.8	89.0
	^{106}Ru	0.01	0.01	0.0	0.01	0.03
	^{129}I	3.8	1.9	95.5	3.4	5.7
	^{137}Cs	3.5	3.0	0.14	3.1	4.6
Teen	^{3}H	0.93	0.25	0.03	0.96	0.94
	^{90}Sr	86.2	94.5	2.4	88.6	86.3
	^{106}Ru	0.01	0.0	0.0	0.02	0.03
	^{129}I	6.4	1.8	97.4	5.7	6.1
	^{137}Cs	6.4	2.8	0.16	4.5	6.0
Adult	^{3}H	1.1	0.31	0.02	1.2	1.2
	^{90}Sr	81.1	94.2	1.5	85.3	86.0
	^{106}Ru	0.01	0.01	0.0	0.02	0.03
	^{129}I	9.0	1.8	98.4	8.4	6.0
	^{137}Cs	8.6	2.9	0.14	4.9	6.4

c)

Table 5.9. One-hundred-year environmental dose commitments[a] for 1990 projected population[b] from routine airborne releases from the DWPF

Waste decay period (years)	Age group	Dose (man-rem)				
		Total body	Bone	Thyroid	Lungs	Kidneys
5	Infant	3.1E–3[c]	6.6E–3	1.5E–1	3.1E–3	2.9E–3
	Child	1.2E–1	4.2E–1	2.0E0	1.2E–1	1.3E–1
	Teen	3.6E–2	1.1E–1	8.7E–1	3.4E–2	3.6E–2
	Adult	2.2E–1	6.2E–1	7.6E0	2.1E–1	2.1E–1
	Total	3.8E–1	1.2E0	1.1E1	3.7E–1	3.8E–1
15	Infant	1.7E–3	4.3E–3	1.5E–1	1.5E–3	1.6E–3
	Child	8.6E–2	3.1E–1	2.0E0	8.0E–2	8.3E–2
	Teen	2.4E–2	7.8E–2	8.7E–1	2.3E–2	2.3E–2
	Adult	1.4E–1	4.5E–1	7.5E0	1.3E–3	1.3E–1
	Total	2.5E–1	8.4E–1	1.1E1	2.3E–1	2.4E–1

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]Projected U.S. population from Bureau of Census, Series P-25 No. 704 (July 1977).

[c]To be read as 3.1×10^{-3}.

Population dose to the continental United States

Of all radioactive materials released by the DWPF which are susceptible to long-range transport, only tritium and iodine-129 have a long enough half-life and a high enough release rate to be considered in predicting doses to the U.S. and world populations. Table 5.10 lists the 100-year environmental dose commitment to the population of the continental United States from routine releases of tritium and iodine-129 during the DWPF processing of 5-year-old waste and 15-year-old waste. Total body doses for all age groups (0.0097 man-rem per year from processing 5-year-old waste) is an insignificant percentage of the population dose from natural background radiation.

Table 5.10. One-hundred-year environmental dose commitments[a] to the 1990 population of the continental United States[b] for the airborne releases of tritium and iodine-129 from the DWPF[c]

Waste decay period (years)	Age group	Dose per year of operation (man-rem)			
		Total body	Bone	Thyroid	Kidneys
5	Infant	1.6E−4[c]	1.6E−4	5.0E−3	1.6E−4
	Child	1.7E−3	1.7E−3	5.4E−2	1.7E−3
	Teen	7.7E−4	7.7E−4	2.5E−2	7.7E−4
	Adult	7.1E−3	7.1E−3	2.3E−1	7.1E−3
	Total	9.7E−3	9.7E−3	3.1E−1	9.7E−3
15	Infant	9.0E−5	9.0E−5	4.8E−3	9.0E−5
	Child	9.6E−4	9.6E−4	5.2E−2	9.6E−4
	Teen	4.4E−4	4.4E−4	2.5E−2	4.4E−4
	Adult	4.1E−3	4.1E−3	2.3E−1	4.1E−3
	Total	5.6E−3	5.6E−3	3.1E−1	5.6E−3

[a]Population doses from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]Projected U. S. population from Bureau of Census, Series P-25 No. 704 (July 1977).

[c]Read as 1.6×10^{-4}.

The 100-year EDC to the thyroid for the continental U.S. population from the release of iodine-129 is 0.31 man-rem per year of operation and is only a small percent of the comparable dose from other sources at present levels. Thus, the dose to the U.S. population from the releases of tritium and iodine-129 will result in only a slight increase in the population dose from other sources.

Population doses to the world

The world population doses from the releases of tritium and iodine-129 are shown in Table 5.11. Any increase to the world population dose above that from existing background sources of tritium and iodine-129 is considered negligible. Due to the long half-life and environmental transport
J-35 of iodine-129, this nuclide effectively becomes a permanent addition to natural background radiation.

Table 5.11. One-hundred-year environmental dose commitment[a] for a projected world population[b]—routine airborne releases from the DWPF vs all other sources

Radionuclide and organ	Dose per year of operation (man-rem)		
	5-year-old waste	15-year-old waste	Existing background
^{3}H (total body)	6.7E−2[c]	4.0E−2	6.5E6
^{129}I (thyroid)	7.0E0	7.0E0	3.6E6

[a]Based on one-hundred-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]World population figures based on United Nations report No. 56, UN Rep. ST/ESA/SER/A-56 (1974). Population considered to be made up entirely of adults.

[c]Read as 6.7×10^{-2}.

Maximum individual dose commitment from liquid effluents

The 50-year dose commitments for the total body and important organs of age-specific individuals exposed to the various aquatic pathways associated with the use of the Savannah River are listed in Table 5.12 for the processing of 5-year-old waste. The maximum dose to an individual is only 0.021 millirem per year of operation and results almost entirely from the tritium concentration in the drinking water.

Table 5.12. Maximum 50-year dose commitment[a] to individuals from liquid effluents of the DWPF (processing 5-year-old waste) released into the Savannah River

Age group	Aquatic pathways	Dose[b] (millirem)			
		Total body	Bone	Thyroid	Kidneys
Infant	Immersion in water[c]	0.0	0.0	0.0	0.0
	Ingestion of water[d]	2.1E–2	2.1E–2	2.1E–2	2.1E–2
	Ingestion of fish[e]	0.0	0.0	0.0	0.0
	Total	2.1E–2	2.1E–2	2.1E–2	2.1E–2
Child	Immersion in water	1.2E–9	1.3E–9	9.2E–10	1.1E–9
	Ingestion of water	2.1E–2	2.1E–2	2.1E–2	2.1E–2
	Ingestion of fish	2.9E–4	2.9E–4	2.9E–4	2.9E–4
	Total	2.1E–2	2.1E–2	2.1E–2	2.1E–2
Teen	Immersion in water	1.2E–9	1.3E–9	9.2E–10	1.1E–9
	Ingestion of water	1.1E–2	1.1E–2	1.1E–2	1.1E–2
	Ingestion of fish	3.6E–4	3.8E–4	3.6E–4	3.6E–4
	Total	1.1E–2	1.1E–2	1.1E–2	1.1E–2
Adult	Immersion in water	1.2E–9	1.3E–9	9.2E–10	1.1E–9
	Ingestion of water	1.6E–2	1.6E–2	1.6E–2	1.6E–2
	Ingestion of fish	4.8E–4	4.8E–4	4.8E–4	4.8E–4
	Total	1.7E–2	1.7E–2	1.7E–2	1.7E–2

[a]Internal doses are 50-year dose commitments for one year of radionuclide intake.
[b]Per year of operation.
[c]Based on swimming in the river for 1% of the year, except 0% for "infant."
[d]Based on water intake of 330 L/year for "infant," 510 L/year for "child" and "teen," and 730 L/year for "adult."
[e]Based on fish consumption of 0.0 kg/year for "infant," 6.9 kg/year for "child," 16.0 kg/year for "teen," and 21.0 kg/year for "adult."

The comparable doses from aquatic pathways resulting from the liquid effluents from processing 15-year-old waste are listed in Table 5.13. The doses are about one-half of those of the 5-year-old waste because the additional decay time resulted in the lower release rate for tritium, which contributed essentially 100% of the total dose from all pathways.

All doses from the processing of 5-year-aged or 15-year-aged waste are only a small fraction of the DOE standards[13] for the maximum allowable exposure to the individual (500 millirems to the total body, gonads, and bone marrow and 1500 millirems to the other organs). Additionally, the maximum individual dose (0.02 millirem per year of operation) is only about 0.02% of the average natural radiation background dose (117 millirems per year) in the vicinity of the plant.

Population dose commitments from liquid effluents

The Savannah River water is not known to be used for human consumption for a distance of about 160 km downstream from the DWPF effluent. Table 5.14 lists the 100-year environmental dose commitment to the projected 1990 population within 80 km of the plant for the processing of 5-year-old and 15-year-old waste. The highest EDC (0.25 man-rem per year of operation) for the collective age-group population is only about 0.0004% of the comparable annual dose from natural background (7.1×10^4 man-rems). At about 160 km downstream from the plant effluent, a total of 69,500 persons (estimated average for the years 1990 through 2020) will take their drinking water from the river. At this distance, complete dilution by the river is assumed. Tables 5.15 and 5.16, respectively, list the 100-year dose commitment for the population drinking river

Table 5.13. Maximum 50-year dose commitment[a] to individuals from liquid effluents of the DWPF (processing 15-year-old waste) released into the Savannah River

Age group	Aquatic pathways	Dose[b] (millirem)			
		Total body	Bone	Thyroid	Kidneys
Infant	Immersion in water[c]	0.0	0.0	0.0	0.0
	Ingestion of water[d]	1.1E−2	1.1E−2	1.1E−2	1.1E−2
	Ingestion of fish[e]	0.0	0.0	0.0	0.0
	Total	1.1E−2	1.1E−2	1.1E−2	1.1E−2
Child	Immersion in water	6.7E−10	7.9E−10	5.2E−10	6.1E−10
	Ingestion of water	1.1E−2	1.1E−2	1.1E−2	1.1E−2
	Ingestion of fish	1.6E−4	1.6E−4	1.6E−4	1.6E−4
	Total	1.1E−2	1.1E−2	1.1E−2	1.1E−2
Teen	Immersion in water	6.7E−10	7.9E−10	5.2E−10	6.1E−10
	Ingestion of water	6.1E−3	6.1E−3	6.1E−3	6.1E−3
	Ingestion of fish	1.9E−4	1.9E−4	1.9E−4	1.9E−4
	Total	6.3E−3	6.3E−3	6.3E−3	6.3E−3
Adult	Immersion in water	6.7E−10	7.9E−10	5.2E−10	6.1E−10
	Ingestion of water	8.3E−3	8.3E−3	8.3E−3	8.3E−3
	Ingestion of fish	2.5E−4	2.5E−4	2.5E−4	2.5E−4
	Total	8.6E−3	8.6E−3	8.6E−3	8.6E−3

[a]Internal doses are 50-year dose commitments for one year of radionuclide intake.
[b]Per year of operation.
[c]Based on swimming in the river for 1% of the year, except 0% for "infant."
[d]Based on water intake of 330 L/year for "infant," 510 L/year for "child" and "teen," and 730 L/year for "adult."
[e]Based on fish consumption of 0.0 kg/year for "infant," 6.9 kg/year for "child," 16.0 kg/year for "teen," and 21.0 kg/year for "adult."

Table 5.14. One-hundred-year environmental dose commitments[a] for a projected 1990 population from routine liquid releases from the DWPF

Waste decay period (years)	Age group	Dose per year of operation (man-rem)			
		Total body	Bone	Thyroid	Kidneys
5	Infant	0	0	0	0
	Child	3.6E−2[b]	3.8E−2	3.6E−2	3.6E−2
	Teen	1.9E−2	2.1E−2	1.0E−2	1.9E−2
	Adult	1.9E−1	1.9E−1	1.9E−1	1.9E−1
	Total	2.5E−1	2.5E−1	2.5E−1	2.5E−1
15	Infant	0	0	0	0
	Child	1.9E−2	1.9E−2	1.9E−2	1.9E−2
	Teen	1.1E−2	1.1E−2	1.1E−2	1.1E−2
	Adult	1.0E−1	1.0E−1	1.0E−1	1.0E−1
	Total	1.3E−1	1.3E−1	1.3E−1	1.3E−1

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year. No irrigation or drinking water is taken from the river within this 80-km area.
[b]Read as 3.6×10^{-2}.

Table 5.15. One-hundred-year environmental dose commitment to 1990–2020 population[a] from liquid effluents of the DWPF (processing 5-year-old waste) released into the Savannah River

Point of usage	Age group[b]	Dose per year of operation (man-rem)[c]			
		Total body	Bone	Thyroid	Kidneys
Beaufort-Jasper	Infant	1.4E–2[d]	1.4E–2	1.4E–2	1.4E–2
	Child	1.7E–1	1.7E–1	1.7E–1	1.7E–1
	Teen	4.8E–2	4.8E–2	4.8E–2	4.8E–2
	Adult	4.6E–1	4.6E–1	4.6E–1	4.6E–1
Port Wentworth	Adult	4.8E–1	4.8E–1	4.8E–1	4.8E–1
	Total	1.2E0	1.2E0	1.2E0	1.2E0

[a]Population usage is based upon the population average for the years 1990–2020 of 40,300 consumers for the Beaufort-Jasper supply and 29,200 (adults only) for the Port Wentworth industrial complex.

[b]Age distribution for the Beaufort-Jasper population is 1.6% for "infant," 19.4% "child," 10% "teen," and 69% "adult."

[c]Dose includes doses from the pathways of ingestion of water and fish and immersion in water. Water intake paramters are 260 L/year for "infant," "child," and "teen" and 370 L/year for "adult." Intakes of fish are 0.0 kg/year for "infant," 2.2 kg/year for "child," 5.2 kg/year for "teen," and 6.7 kg/year for "adult." Immersion in water (swimming) except for the "infant" is for 1% of the year.

[d]Read as 1.4×10^{-2}

Table 5.16. One-hundred-year environmental dose commitment to 1990–2020 population[a] from liquid effluents of the DWPF (processing 15-year-old waste) released into the Savannah River

Point of usage	Age group[b]	Dose per year of operation (man-rem)[c]			
		Total body	Bone	Thyroid	Kidneys
Beaufort-Jasper	Infant	7.3E–3[d]	7.3E–3	7.3E–3	7.3E–3
	Child	9.0E–2	9.0E–2	9.0E–2	9.0E–2
	Teen	2.5E–2	2.5E–2	2.5E–2	2.5E–2
	Adult	2.5E–1	2.5E–1	2.5E–1	2.5E–1
Port Wentworth	Adult	2.5E–1	2.5E–1	2.5E–1	2.5E–1
	Total	6.2E–1	6.2E–1	6.2E–1	6.2E–1

[a]Population usage is based upon the population average for the years 1990–2020 of 40,300 consumers for the Beaufort-Jasper supply and 29,200 (adults only) for the Port Wentworth industrial complex.

[b]Age distribution for the Beaufort-Jasper population is 1.6% for "infant," 19.4% "child," 10% "teen," and 69% "adult."

[c]Dose includes doses from the pathways of ingestion of water and fish and immersion in water. Water intake paramters are 260 L/year for "infant," "child," and "teen" and 370 L/year for "adult." Intakes of fish are 0.0 kg/year for "infant," 2.2 kg/year for "child," 5.2 kg/year for "teen," and 6.7 kg/year for "adult." Immersion in water (swimming) except for the "infant" is for 1% of the year.

[d]Read as 7.3×10^{-3}.

water for the processing of 5-year-old and 15-year-old waste. Because tritium contributes essentially 100% of the dose, drinking water is the primary pathway. The highest EDC to the entire population is 1.2 man-rems. While this dose (1.2 man-rems per year of DWPF operation) to the population drinking river water is almost 5 times that to the regional population, it is still only about 0.015% of the comparable annual dose from natural background. The population dose commitments as a result of normal operations of the DWPF represent only very small increases in the population radiation dose above background.

Occupational dose

The DWPF will be designed and built to minimize radiation exposure of plant workers and the general public. In addition, occupational exposures for workers will be monitored and kept below the DOE limits, in accordance with the requirement of maintaining such exposures as low as is reasonably achievable.

Although no facility quite the same as the DWPF exists, the SRP chemical separations facilities have similar operations and handle high-level radioactive materials. The occupational exposure records for the SRP workers in the chemical separations areas show that an average worker did not exceed 12% of the total permissible dose per year.

Radiation-induced health effects — routine operations of reference immobilization alternative

The radiation-induced health effects that might be caused by the operation of the reference immobilization alternative are quantified in Appendix J.4.1 and summarized here. The results (Table J.5, Appendix J.4.1) indicate that the excess cancer risk from a single year's operation of the reference DWPF is trivial. The best estimate is that 0.0003 premature cancer deaths will occur as a result of the radioactive discharges during that one year. The maximum possible risk will be 0.001 cancer deaths per year of operation and a minimum of no excess cancers.

Based on the assumption that these impact rates continue throughout the 28-year operating life of the DWPF, the results in Table 5.17 indicate that the cancer risk from the facility during its entire operating life (28 years) will be about 0.009 cancer deaths (0.009 probable, 0 minimum, 0.03 maximum). It is important to note that these cancer risk estimates represent a full accounting of risk for the next 100 years. The data in Table 5.17 indicate that the likelihood anyone will ever die of cancer as a result of the operation of the DWPF is remote.

Table 5.17. Summary of radiation-induced health effects committed over the 28-year routine operating life of the reference design DWPF processing 5- and 15-year-old waste

Health effect	Organ	Processing 5-year-old waste			Processing 15-year-old wastes		
		Probable	Minimum	Maximum	Probable	Minimum	Maximum
1990 population							
Committed genetic disorders/28 years of operation		1.3E−2	3.1E−3	5.6E−2	1.1E−2	2.7E−3	4.9E−2
Committed premature cancer deaths/28 years of operation	Bone	1.5E−3		3.4E−3	1.2E−3		2.7E−3
	Thyroid	2.5E−3		8.9E−3	2.4E−3		8.9E−3
	Lungs	1.4E−3		5.0E−3	1.2E−3		4.4E−3
	Kidneys	1.6E−4		6.2E−4	1.4E−4		5.3E−4
	Other	3.1E−3		1.1E−2	2.8E−3		9.8E−3
	Total	8.7E−3	0	2.9E−2	7.7E−3	0	2.6E−2
2000 population							
Committed genetic disorders/28 years of operation		1.4E−2	3.2E−3	5.9E−2	1.2E−2	2.8E−3	5.1E−2
Committed premature cancer deaths/28 years of operation	Bone	1.6E−3		3.6E−3	1.3E−3		2.8E−3
	Thyroid	2.7E−3		9.8E−3	2.7E−3		9.6E−3
	Lungs	1.5E−3		5.3E−3	1.3E−3		4.5E−3
	Kidneys	1.7E−4		6.4E−4	1.4E−4		5.3E−4
	Others	3.4E−3		1.2E−2	2.8E−3		1.0E−2
	Total	9.3E−3	0	3.1E−2	8.2E−3	0	2.7E−2

As with cancer risk, the risks of genetic disorder from the DWPF operation are trivial. The prediction shows that an average of 0.01 genetic disorders (range 0.003 to 0.06) could be caused by the normal operation of the DWPF over an operating life of 28 years. It is unlikely that any genetic disorders will be caused by DWPF operation.

Impacts on biota other than man

Doses to biota other than man have not been estimated in this report. The radiosensitivity of organisms other than man may be generally assumed to be less than that for man; therefore, if man is protected from the potentially harmful effects of radiation, other organisms will be protected.[15-19] Effluents of the facility will be monitored and maintained within safe radiological protection limits for man; thus, no adverse radiological impact on resident animals is expected.

Mitigating measures

Although the dose estimates for man resulting from the potential airborne and liquid releases of radionuclides to the environment are quite low and well below existing standards for safe operation of the DWPF, every effort will be made to minimize these exposures through proper design and operation as well as a quality assurance program. Also, the objective of keeping radiation exposure as low as reasonably achievable will be emphasized, and an environmental sampling and monitoring program will be maintained to provide an early alert for potential problems.

5.1.3 The long-term effects of salt disposal

The long-term effects of salt disposal for the reference case are presented in Sect. 5.4 Salt Disposal Alternatives.

5.1.4 Impacts of normal transportation of reference waste

Both radiological and nonradiological impacts of normal or accident-free transportation of SRP HLW were calculated for four different mixes of rail and truck shipments. In each case, or mix of transport modes, a certain percent of the SRP HLW canisters are transported by each mode. The cases, defined in Table 5.18, are not intermodal mixes. The radiological and nonradiological impacts of normal transportation are very small and are well within established limits.

Table 5.18. Definition of rail/truck mixes for cases 1, 2, 3, and 4

Case	Canisters shipped (%)	
	Rail	Truck
1	100	0
2	70	30
3	30	70
4	0	100

The impacts are based on shipments of 8176 canisters over the 28-year operating period of the DWPF. Each rail shipment will contain five canisters, and each truck shipment will contain one canister. Each shipment is assumed to be 4800 km (3000 miles). This is a reasonable estimate of the shipment distance from SRP to the State of Washington, which would be the greatest distance possible for shipment within the continental United States. The selection of 4800 km as the shipment distance is not an implication of a policy decision in any way. It merely serves as a conservative estimate that will yield maximum consequences. Information on shipment mode and kilometers shipped is shown in Table 5.19.

Table 5.19. Annual shipment data for four shipment cases

Shipment case	Total number of canisters shipped		Number of shipments made		Shipment (10^6 km)	
	Rail	Truck	Rail	Truck	Rail	Truck
1	500	0	100	0	0.48	0
2	350	150	70	150	0.34	0.73
3	150	350	30	350	0.15	1.7
4	0	500	0	500	0	2.5

5.1.4.1 Nonradiological consequences

Nonradiological consequences are calculated for diesel tractor trailer rigs and locomotives passing a point 500 and 100 times a year, respectively. The primary pollutants from diesel fuel
J-36 combustion are particulates, SO_2, NO_2, hydrocarbons, and carbon monoxide. The DWPF truck shipments account for 0.0001% of the pollutants emitted from highway vehicles, and the train shipments account for 0.0004% of the pollutants from nonhighway vehicles.

5.1.4.2 Radiological impacts of normal transportation of reference waste

Radiological impacts that result from normal transportation were calculated using RADTRAN II[20] to generate population exposure. The exposure to various population groups was calculated in man-rem/km of waste shipment, or man-rem/shipment made. These impacts were converted to latent cancer fatalities (LCF) using BEIR III health risk estimators. Two sets of health risk estimators were used, probable cancer deaths and maximum cancer deaths. These unit consequence factors were then multiplied by the appropriate number of kilometers shipped annually or shipments made annually (Table 5.19). The resulting consequences for both probable cancer deaths and maximum cancer death are shown in Table 5.20. Consequences for the general population exposed while transport vehicles are stopped are based on number of shipments made. All other population group consequences are based on number of kilometers shipped.

Table 5.20. Normal transportation consequences given as probable cancer deaths per year and maximum cancer deaths per year

Shipment case	Occupational[a] Crewmen		General population On link		Off link		Stops		Totals		
	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Overall
1	0.0 (0.0)	0.0 (0.0)	3.5E−5 (1.2E−4)	0.0 (0.0)	9.2E−4 (3.1E−3)	0.0 (0.0)	1.2E−2 (3.8E−2)	0.0 (0.0)	1.3E−2 (4.1E−2)	0.0 (0.0)	1.3E−2 (4.1E−2)
2	0.0 (0.0)	4.7E−3 (1.5E−2)	2.4E−5 (7.9E−5)	3.8E−3 (1.3E−2)	6.7E−4 (2.1E−3)	7.9E−3 (2.7E−2)	8.6E−3 (2.7E−2)	8.6E−3 (2.8E−2)	9.3E−3 (2.9E−2)	2.5E−2 (8.3E−2)	(3.4E−2) (1.1E−1)
3	0.0 (0.0)	1.1E−2 (3.7E−2)	1.0E−5 (3.5E−5)	9.2E−3 (3.1E−2)	2.8E−4 (9.2E−4)	1.8E−2 (6.1E−2)	3.6E−3 (1.1E−2)	2.0E−2 (6.7E−2)	3.9E−3 (1.2E−2)	5.8E−2 (2.0E−1)	6.2E−2 (2.1E−1)
4	0.0 (0.0)	1.7E−2 (5.4E−2)	0.0 (0.0)	1.3E−2 (4.3E−2)	0.0 (0.0)	2.6E−2 (9.2E−2)	0.0 (0.0)	2.9E−2 (9.8E−2)	0.0 (0.0)	8.5E−2 (2.9E−1)	8.5E−2 (2.9E−1)

[a] HLW casks will be loaded on the carrier vehicle at the SRP by DWPF personnel and unloaded at its destination by repository personnel. There will be no reloading in transit and, therefore, no radiation exposure to transportation workers accountable to cask handling will occur.

One other type of radiological impact was calculated: exposure to a maximum individual who sat 30 meters away from every single truck or rail shipment. This impact is shown in Table 5.21.

Further discussion on the methodology and assumptions used for these calculations can be found in Appendix D.

Table 5.21. Maximum annual dose (millirem) to individual from normal transportation of waste canisters

Shipment case	Rail	Truck
1	0.06	0.0
2	0.04	0.09
3	0.02	0.21
4	0.0	0.30

5.2 DELAYED REFERENCE ALTERNATIVE

In the analyses given, the differential effects estimated for the delay of the reference alternative are applicable also to delay of the staged process alternative.

5.2.1 Construction

The reference immobilization alternative delayed ten years differs from the previous alternative primarily in that there is no interaction with the Vogtle project in the 1990s (the Vogtle project is assumed to be completed). Because no competition with another project will exist, as in the Vogtle delayed scenario, the number of in-movers is less (around 1100) than the reference immobilization alternative in which Vogtle is delayed (1450 in-movers) but more than the reference immobilization alternative in which Vogtle is on schedule and Vogtle's work force is gradually released, becoming available for DWPF construction (870 in-movers). As may be seen in Table 5.22, the six-county area is expected to experience significant population growth in the decade from 1986 to 1996, to around 468,000. Because of this significant (14%) expansion of the baseline population and related facilities (housing, schools, economic base, etc.), the impacts of this alternative upon the surrounding area are expected to be similar to or only slightly higher than those of the reference immobilization alternative in which both projects are on schedule, despite the higher rate of in-movers (22% for the delayed reference immobilization alternative).

5.2.2 Operation

5.2.2.1 Land use and socioeconomic impacts

The impacts of operation of the delayed immobilization alternative are expected to be the same as those of other reference immobilization alternatives: insignificant for population growth or public services, but providing around 700 permanent jobs after the significant employment declines following the completion of DWPF construction.

5.2.2.2 Radiological impacts

The environmental assessment pathways, methodology, and assumptions discussed in Appendix J are applicable to this alternative.

Maximum individual dose commitment from airborne releases

The doses to the maximally exposed individual from exposure to airborne releases during normal operation of the delayed immobilization alternative are about the same as for the reference immobilization alternative and are discussed in Sect. 5.1.2.3 and presented in Tables 5.7 and 5.8.

Population dose commitments from airborne releases

As described in Sect. 5.1.2.3, all population doses are 100-year environmental dose commitments.

Population dose to the regional population (within 80-km radius of the DWPF). The 100-year environmental dose commitments (EDC) for the various age groups for the projected year 2000 (delayed immobilization alternative) during the processing of 5-year-old and 15-year-old waste are listed in Table 5.23. The total-body dose commitments, of 0.43 man-rem per year of operation and 0.28 man-rem per year of operation, respectively (summed for all age groups), from exposure to the effluents of processing 5-year-old and 15-year-old waste are only slightly higher than those for the reference immobilization alternative. This is a result of the

Table 5.22. Socioeconomic impact of reference immobilization alternative delayed ten years on primary impact area—construction: 1996 DWPF peak (no Vogtle impacts)

County	Population 1996	Work force[a]		Population increase (DWPF)		Schools[b] increase (DWPF)		Housing: demand-supply
		Commuters[c]	In-migrants[d]	No.	(%)	No.	(%)	
South Carolina								
Aiken	129,600		500	1,134	(0.9)	217	(0.8)	Adequate
Allendale	12,725		35	79	(0.6)	16	(0.5)	Shortage in single family units; DWPF demand <0.1% of total demand
Bamberg	21,550		30	66	(0.3)	14	(0.3)	Shortage in single family units; DWPF demand <0.1% of total demand
Barnwell	26,700		210	463	(1.7)	92	(1.4)	Shortage in mobile home and multifamily units, DWPF demand = ~2%
Georgia								
Columbia	59,400		60	185	(0.2)	26	(0.2)	Adequate
Richmond	218,000		280	623	(0.3)	123	(0.3)	Adequate
Total[e]	468,000	3,680	1,120	2,500	(0.5)	488	(0.5)	

General impacts[f]

Public services: No noticeable impact on police and fire services. Negligible water and sewer demand increases.

Public finance: Moderate impacts. No DWPF property tax paid to local jurisdictions. Additional tax revenue from new worker homes property tax, sales and use taxes may not equal cost of services.

Economic base: Significant impact from $65.8 million in direct salaries and additional indirect and induced salaries. Some inflation in local prices, and increases in local wage rates and consumer demand.

Roads and traffic: Same as Reference Alternative with Vogtle delayed. Minor offsite impacts. Major onsite congestion may occur during shift changes.

Land use change: Minor impacts. Normal growth changes overshadow DWPF impacts except for possible mobile home increases — Barnwell and Aiken.

Historical and archaeological: No impact.

[a] Local movers (200) not included. Overall total = 5000.

[b] Entire increase assumed to occur in one year. Peak inmigrant enrollment is divided by total student enrollment.

[c] Jobs filled by existing residents. Individual county commuting totals are not given because (1) all will be existing residents whose road use is already felt, and (2) maximum traffic impacts as workers converge on the roads near the SRP were found not to affect levels of service significantly.

[d] Some weekly travelers included in both in-migrant and local mover category.

[e] Numbers may reflect rounding errors.

[f] Impacts apply to all counties in primary impact area.

increase in population during the 10-year delay period (about 70,000 persons). Similarly, the highest organ dose, to the thyroid (12 man-rem per year of operation), represents an increase over the reference immobilization alternative related to the population increase; other parameters used in dose determination remain unchanged.

The annual total-body dose to the regional population from natural background (assuming an average annual dose rate from natural background to be 117 millirems) is 7.9×10^4 man-rems. The highest total-body dose (0.43 man-rem per year of operation) is only 0.0005% of the background dose.

Population dose to the continental United States. The 100-year environmental dose commitments to the continental United States from the routine airborne release of tritium and iodine-129 during the processing of 5-year-old and 15-year-old waste are listed in Table 5.24. The doses are only slightly higher than those for the reference immobilization alternative (see Table 5.10) because of the projected increase in population. The highest total-body dose (0.011 man-rem per year of operation processing 5-year-old waste) is only a very small fraction of the comparable background dose.

Table 5.23. One-hundred-year environmental dose commitments[a] for a projected population for the year 2000 from routine airborne releases from the DWPF

Waste decay period	Age group	Dose per year of operation (man-rem)				
		Total body	Bone	Thyroid	Lungs	Kidneys
5 years	Infant	2.9E−3[b]	6.6E−3	1.5E−1	3.1E−3	2.8E−3
	Child	1.3E−1	4.3E−1	2.0E0	1.2E−1	1.4E−1
	Teen	5.3E−2	1.6E−1	1.3E0	5.2E−2	5.4E−2
	Adult	2.4E−1	6.9E−1	8.4E0	2.3E−1	2.3E−1
	Total	4.3E−1	1.3E0	1.2E1	4.1E−1	4.2E−1
15 years	Infant	1.6E−3	4.3E−3	1.5E−1	1.5E−3	1.6E−3
	Child	8.8E−2	3.1E−1	2.0E0	8.4E−2	8.6E−2
	Teen	3.4E−2	1.2E−1	1.3E0	3.1E−2	3.3E−2
	Adult	1.6E−1	5.0E−1	8.2E0	1.4E−1	1.4E−1
	Total	2.8E−1	9.3E−1	1.2E1	2.6E−1	2.6E−1

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]Read as 2.9×10^{-3}.

Table 5.24. One-hundred-year environmental dose commitments[a] to the population of the continental United States[b] for the year 2000 for the airborne release of tritium and iodine-129 from the DWPF

Waste decay period	Age group	Dose per year of operation (man-rem)			
		Total body	Bone	Thyroid	Kidneys
5 years	Infant	1.4E−4[c]	1.4E−4	4.7E−3	1.4E−4
	Child	1.7E−3	1.7E−3	5.5E−2	1.7E−3
	Teen	9.6E−4	9.6E−4	3.2E−2	9.6E−4
	Adult	7.7E−3	7.7E−3	2.8E−1	7.7E−3
	Total	1.1E−2	1.1E−2	3.7E−1	1.1E−2
15 years	Infant	8.2E−5	8.2E−5	4.7E−3	8.2E−5
	Child	9.5E−4	9.5E−4	5.4E−2	9.5E−4
	Teen	5.5E−4	5.5E−4	3.2E−2	5.5E−4
	Adult	4.4E−3	4.4E−3	2.7E −1	4.4E−3
	Total	6.0E−3	6.0E−3	3.6E−1	6.0E−3

[a]Population doses from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]Projected U.S. population from Bureau of Census, Series P-25 No. 704 (July 1977).

[c]Read as 1.4×10^{-4}.

The thyroid doses to the continental United States resulting from the release of ^{129}I from the DWPF are listed in Table 5.24. The total thyroid dose (0.36 man-rem per year of operation) is only a small percentage of the existing background dose from all other sources.

Population doses to the world. The world population doses from the release of tritium and ^{129}I are listed in Table 5.25. The doses are higher than the comparable doses for the reference immobilization alternative (Table 5.11) due solely to population increases, and represent a negligible increase over that from existing tritium and ^{129}I background sources.

Table 5.25. One-hundred-year environmental dose commitment[a] for a projected world population[b] for the year 2000—routine airborne releases from the DWPF vs all other sources

Radionuclide and organ	Dose per year of operation (man-rem)		
	5-year-old waste	15-year-old waste	Existing background
^{3}H (total body)	7.9E−2[c]	4.7E−2	7.7E5
^{129}I (thyroid)	8.2E0	8.2E0	4.2E6

[a]Based on one-hundred-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]World population figures based on United Nations report No. 56, Rep. ST/ESA/SER/A-56 (1974). Population considered to be made up entirely of adults.

[c]Read as 7.9×10^{-2}.

Maximum individual dose commitments from liquid effluents

The doses to the maximally exposed individual from liquid releases to the Savannah River are the same as those for the reference immobilization alternative and are listed in Tables 5.12 and 5.13 and discussed in Sect. 5.1.2.3.

Population dose commitment

The 100-year environmental dose commitments for the year 2000 are listed in Table 5.26. The highest total-body dose (summed for all age groups) is 0.28 man-rem per year of operation (processing 5-year-old waste) and is approximately 10% higher than the similar dose for the reference immobilization alternative because of the increase in the exposed population. The dose is a very small fraction of the comparable dose from natural background sources (7.9×10^4 man-rems). The population doses from the consumption of drinking water for the reference alternative (Table 5.16) also apply to the delayed reference alternative. The projected usage in Table 5.16 is for the period 1990-2020, encompassing both the reference alternative and the delayed reference alternative.

Radiation-induced health effects — delayed immobilization alternative

Radiation-induced health effects for the delayed immobilization alternative are within the range of those presented in the part of Sect. 5.1.2.3 that deals with radiation-induced health effects during routine operations of the reference immobilization alternative. These predicted health effects are very small.

5.3 STAGED PROCESS ALTERNATIVE (PREFERRED ALTERNATIVE)

5.3.1 Construction

5.3.1.1 Land use and socioeconomic impacts

Having only 60% of the maximum work force of the reference alternatives previously considered, the staged process alternative has markedly fewer in-migrants and produces correspondingly smaller population or school enrollment increases. Only 465 of the 3000 workers are expected to move into the area (bringing with them about 215 children), producing a population increase of 1130 (Table 5.27). Because this increase is less than 1% of the totals even in Barnwell, the most affected area in previous alternatives, potential impacts are considered to be insignificant

Table 5.26. One-hundred-year environmental dose commitments[a] for a projected population for the year 2000 from routine liquid releases from the DWPF

Waste decay period	Age group	Dose per year of operation (man-rem)			
		Total body	Bone	Thyroid	Kidneys
5 years	Infant	0	0	0	0
	Child	3.8E–2[b]	4.0E–2	3.8E–2	3.8E–2
	Teen	2.9E–2	3.1E–2	2.9E–2	2.9E–2
	Adult	2.1E–1	2.1E–1	2.1E–1	2.1E–1
	Total	2.8E–1	2.8E–1	2.8E–1	2.8E–1
15 years	Infant	0	0	0	0
	Child	2.1E–2	2.1E–2	2.1E–2	2.1E–2
	Teen	1.5E–2	1.5E–2	1.5E–2	1.5E–2
	Adult	1.1E–1	1.1E–1	1.1E–1	1.1E–1
	Total	1.5E–1	1.5E–1	1.5E–1	1.5E–1

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year. No irrigation or drinking water is taken from the river within this 80-km area.

[b]Read as 3.8×10^{-2}.

in all public service, land use, traffic, housing, and historical and archaeological impact areas. Minor impacts will be sustained in public finance which may be partially offset by the economic contributions of the construction workforce and the purchase of services and equipment. The only impact of note is that of direct and indirect worker salaries, which total $48 million and $148 million, respectively, and their corresponding effect on the regional economic base. Overall, the staged process alternative has minor to negligible impacts and some economic benefits from the 3000 jobs it will create; it has the lowest offsite land use and socioeconomic impact of the three alternatives considered here.

5.3.1.2 Nonradiological impacts

Aquatic ecological impacts from staged construction may be lesser in degree but persist for a longer period of time than those described for the reference immobilization alternative (Sects. 5.1.1.2 and 5.1.2.2). Staged construction will involve site clearing and excavation in two phases, each of which will involve less land area than for the reference immobilization alternative. Consequently, stream siltation impacts resulting from construction may be lower in the staged process because of the smaller area on which construction activity occurs at any one time. However, stream impacts will occur over a longer period of time for the staged process compared to the reference immobilization alternative.

5.3.1.3 Radiological impact

The radiological impacts and recommended controls for the staged process alternative construction activities are about the same as for the reference immobilization alternative (see Sect. 5.1.1.3). However, stage 2 construction activities would be expected to involve exposures more nearly like those found for construction workers in the chemical separations areas with average exposures of 0.35 rem/year from 1973 through 1978.[21]

5.3.2 Operation

5.3.2.1 Land use and socioeconomic impacts

The impacts of operation of the staged process alternative are similar to but less than those of the reference immobilization alternatives: insignificant effects upon population growth or public services, but provision for around 530 permanent jobs after the significant declines in employment entailed by completion of DWPF construction.

Table 5.27. Socioeconomic impact of staged process alternative on primary impact area — construction: 1987 DWPF peak with Vogtle on schedule (peak in 1983)

County	Population 1987	Work force[a]		Population[c] increase (DWPF)		Schools[b] increase (DWPF)		Housing: demand-supply
		Commuters[c]	In-migrants[d]	No.	(%)	No.	(%)	
South Carolina								
Aiken	117,000		240	580	(0.5)	110	(0.4)	Adequate
Allendale	11,675		10	30	(0.3)	5	(0.2)	Shortage in single family units; DWPF demand <0.1%
Bamberg	19,500		10	30	(0.1)	5	(0.1)	Shortage in single family units; DWPF demand <0.1%
Barnwell	23,425		75	185	(0.8)	35	(0.7)	Shortage in mobile home and multi-family units; DWPF demand = 1%
Georgia								
Columbia	47,900		25	55	(0.1)	10	(0.1)	Adequate
Richmond	195,600		105	250	(0.1)	50	(0.1)	Adequate
Total[e]	415,100	2,380	465	1,130	(0.3)	215	(0.2)	

General impacts[f]

Public services: No impact on fire, police, water or sewer services.

Public finance: Minor impacts. No DWPF property tax paid to local jurisdictions. Additional tax revenue from property, sales and use taxes paid by workers may not equal cost of services.

Economic base: Significant impact from $48 million in direct and additional indirect and induced worker salaries. Some inflation in local prices, and increases in local wage rates and consumer demand.

Roads and traffic: Minor offsite impacts. Moderate on-site congestion may occur during shift changes.

Land use change: Negligible impact.

Historical and archaeological: No impact.

[a] Local movers (150) not included. Total overall = 3000.
[b] Entire increase assumed to occur in one year. Peak in-migrant enrollment is divided by total student enrollment.
[c] Jobs filled by existing residents. Individual county commuting totals are not given because (1) all will be existing residents whose road use in home areas is already felt, and (2) maximum traffic impacts as workers converge on the roads near the SRP were found not to affect levels of service significantly.
[d] Some weekly travelers included.
[e] Totals may not agree with sub-items because of rounding.
[f] Impacts apply to all counties in primary impact area.

5.3.2.2 Nonradiological impacts

Terrestrial and aquatic ecological impact from operation of a staged DWPF will be less than those for the reference immobilization alternative (Sects. 5.1.1.2 and 5.1.2.2) due to elimination of the coal-fired power plant.

5.3.2.3 Radiological impacts

The environmental assessment pathways, methodology, and assumptions discussed in Sect. 5.1.2.3 and Appendix J are applicable to this alternative case.

Dose commitments from airborne effluents

During the operation of the staged process alternative facilities, effluents from two stages of operation, as described in Sect. 3.3, are considered. The annual releases of radionuclides to the atmosphere for uncoupled Stage 1 are all through the sand-filter stack. The sand-filter stack measures 43 m high and 3.7 m in diameter; the effluent velocity is 16.1 m/s. The annual releases of radionuclides for coupled operation are from the sand-filter stack, the regulated chemical facility, and the saltcrete plant.

Dose commitments to the maximally exposed individual. The maximum doses to the individual (living at the nearest boundary in the prevailing wind direction) are shown in Tables 5.28 and 5.29 for Stage 1 and Stage 2, respectively. The maximum total-body dose commitment (0.063 millirem per year of operation) occurs to a child during the Stage 1 operation (Table 5.28) as does the highest organ dose (0.25 millirem per year of operation) to the bone. The dose (total-body dose to "child") primarily is from ^{90}Sr (~100%) for the Stage 1 process (Table 5.30) and from ^{90}Sr (98%) and ^{137}Cs (2.0%) for the Stage 2 processes (Table 5.31).

Table 5.28. Maximum 50-year dose commitment to the individual[a] from routine annual airborne releases from the DWPF — staged alternative: Stage 1, sand filter stack release

Age group	Dose Commitment[b] (millirem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant	5.9E−3[c]	2.3E−2	2.0E−2	5.9E−3	5.9E−3
Child	6.3E−2	2.5E−1	7.9E−2	6.3E−2	6.3E−2
Teen	3.7E−2	1.5E−1	5.4E−2	3.7E−2	3.7E−2
Adult	2.9E−2	1.2E−1	5.1E−2	2.9E−2	2.9E−2

[a]Maximally exposed individual is at the nearest boundary approximately 10.5 km downwind from the plant effluent.

[b]Per year of operation.

[c]Read as 5.9×10^{-3}.

Table 5.29. Maximum 50-year dose commitment to the individual[a] from routine annual airborne releases from the DWPF — staged alternative: coupled 15-year-old waste

Age group and facility	Dose commitment[b] (millirem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant					
Sand filter stack[c]	5.1E−3[d]	1.9E−2	1.5E−2	5.2E−3	5.3E−3
Regulated chemical facility	2.3E−5	2.3E−5	2.3E−5	2.3E−5	2.3E−5
Saltcrete plant	2.2E−5	2.2E−5	2.2E−5	2.2E−5	2.2E−5
Total	5.1E−3	1.9E−2	1.5E−2	5.2E−3	5.3E−3
Child					
Sand filter stack[c]	4.8E−2	1.9E−1	5.9E−2	4.8E−2	4.8E−2
Regulated chemical facility	2.4E−5	2.4E−5	2.4E−5	2.4E−5	2.4E−5
Saltcrete plant	2.4E−5	2.4E−5	2.4E−5	2.4E−5	2.4E−5
Total	4.8E−2	1.9E−1	5.9E−2	4.8E−2	4.8E−2
Teen					
Sand filter stack[c]	2.9E−2	1.1E−1	4.1E−2	2.8E−2	2.9E−2
Regulated chemical facility	2.5E−5	2.5E−5	2.5E−5	2.5E−5	2.5E−5
Saltcrete plant	2.3E−5	2.3E−5	2.3E−5	2.3E−5	2.3E−5
Total	2.9E−2	1.1E−1	4.1E−2	2.8E−2	2.9E−2
Adult					
Sand filter stack[c]	2.3E−2	9.0E 2	3.9E 2	2.2E 2	2.3E−2
Regulated chemical facility	2.5E 5	2.5E−5	2.5E 5	2.5E 5	2.5E−5
Saltcrete plant	2.4E 5	2.4E−5	2.4E 5	2.4E 5	2.4E−5
Total	2.3E 2	9.0E 2	3.9E 2	2.2E−2	2.3E−2

[a]Maximally exposed individual is at the nearest boundary approximately 10.5 km downwind from the plant effluent.

[b]Per year of operation.

[c]Combined Stage 1 and Stage 2 operations.

[d]Read as 5.1×10^{-3}.

The total-body and organ doses are only a small fraction of the applicable Federal regulation of 500 millirems to the total body, gonads, and bone marrow and 1500 millirems to the reference organs.[13] The highest total-body and organ doses are only about 0.01% and 0.05%, respectively, of the established limits.

Table 5.30. Contribution to dose by major radionuclides released in the airborne effluents of the staged alternative: Stage 1, sand filter stack release

Age group	Radionuclide	Percentage of dose				
		Total body	Bone	Thyroid	Lungs	Kidneys
Infant	^{90}Sr	98.8	98.4	29.4	98.1	98.5
	^{129}I	0.4	0.2	70.4	0.3	0.5
	^{238}Pu	0.1	1.2	0.0	0.8	0.4
Child	^{90}Sr	99.9	99.6	79.4	99.7	99.7
	^{129}I	<0.1	<0.1	20.5	<0.1	<0.1
	^{238}Pu	<0.1	0.4	<0.1	0.1	0.1
Teen	^{90}Sr	99.7	99.2	68.1	99.5	99.7
	^{129}I	<0.1	<0.1	31.8	<0.1	<0.1
	^{238}Pu	<0.1	0.7	<0.1	0.3	<0.1
Adult	^{90}Sr	99.7	99.1	56.0	99.5	99.4
	^{129}I	0.1	<0.1	43.9	0.1	<0.1
	^{238}Pu	0.1	0.8	<0.1	0.2	0.4

Table 5.31. Contribution to dose by major radionuclides released in the airborne effluents of the staged alternative: *coupled sand filter stack release*[a]

Age group	Radionuclide	Percentage of dose				
		Total body	Bone	Thyroid	Lungs	Kidneys
Infant	^{3}H	0.5	0.1	0.2	0.4	0.4
	^{90}Sr	85.4	89.5	29.4	84.7	82.4
	^{129}I	0.3	0.2	66.5	0.3	0.4
	^{137}Cs	13.2	8.9	3.7	13.2	15.9
	^{154}Eu	0.3	0.1	0.1	0.3	0.2
	^{238}Pu	0.1	1.1	<0.1	0.7	0.4
Child	^{3}H	0.1	<0.1	<0.1	0.1	0.1
	^{90}Sr	97.9	97.9	79.2	98.0	97.0
	^{129}I	<0.1	<0.1	19.4	<0.1	0.1
	^{137}Cs	1.9	1.7	1.4	1.7	2.6
	^{154}Eu	<0.1	<0.1	<0.1	<0.1	<0.1
	^{238}Pu	<0.1	0.3	<0.1	0.1	0.1
Teen	^{3}H	0.1	<0.1	0.1	0.1	0.1
	^{90}Sr	95.9	97.7	67.6	96.9	96.1
	^{129}I	0.1	<0.1	29.8	0.1	0.1
	^{137}Cs	3.7	1.5	2.3	2.6	3.5
	^{154}Eu	0.1	<0.1	<0.1	<0.1	<0.1
	^{238}Pu	0.1	0.7	<0.1	0.3	0.1
Adult	^{3}H	0.1	<0.1	0.1	0.1	0.1
	^{90}Sr	94.3	97.5	55.7	96.5	95.6
	^{129}I	0.1	<0.1	41.3	0.1	0.1
	^{137}Cs	5.3	1.6	2.8	3.0	3.8
	^{154}Eu	0.1	<0.1	<0.1	0.1	0.1
	^{238}Pu	0.1	0.8	<0.1	0.2	0.3

[a] Combined Stage 1 and Stage 2 operations.

Additionally, the highest total-body dose of 0.063 millirem per year of operation is only about 0.05% of the normal background radiation to area residence of 117 millirems per year.

The maximum total-body dose from the staged process alternative (coupled operation) is more than 7.5 times the comparable dose resulting from the reference-process release rate. The higher dose for the staged alternative primarily results from the increase in the ^{90}Sr released in the Stage 1 process.

Population dose commitment. As described in Appendix J, all population doses are 100-year environmental dose commitments (EDC).

Population dose to the regional population (within 80-km radius of the DWPF). The 100-year EDCs, from airborne releases, to various age groups of the projected population for 1990 for the Stage 1 and Stage 2 coupled processes are shown in Tables 5.32 and 5.33, respectively. The higher doses occur during the Stage 1 process in which the total-body dose for all age groups in the population is 1.6 man-rems and the highest organ dose (dose to the bone) is 6.8 man-rems.

The annual total body dose from natural background radiation within 80-km radius of the DWPF is estimated to be 7.1 x 10^4 man-rems (based on an average background dose rate of 117 millirems/year). The annual total-body dose from Stage 1 operation (1.6 man-rems per year of operation) is only 0.002% of the background dose.

Although the highest total-body 100-year EDC to the population for the staged alternative case (1.6 man-rems) is more than 4 times the comparable dose for the reference case (0.38 man-rem, see Table 5.9), the dose still represents only a small increase in the population dose from background radiation sources.

Population dose to the continental United States. The 100-year EDCs to the population of the continental United States from tritium and iodine-129 routinely released during the Stage 1 and coupled operations are listed in Table 5.34. The highest total-body dose, 0.0024 man-rem (coupled), is lower than the comparable dose from the reference facility (processing 5-year-old waste) by a factor of 4. The highest 100-year EDCs for the thyroid resulting from the release of ^{129}I from the staged alternative is 0.029 man-rem per year of operation (Stage 1) for all age groups. The population thyroid doses are a very small fraction of the comparable dose from all other sources.

Population doses to the world. The 100-year EDCs for the world population from releases of tritium and ^{129}I are shown in Table 5.35. The doses are below those for the reference alternative (Table 5.11), and any increase to the world population dose above that from existing background sources of tritium and ^{129}I is considered negligible.

Maximum individual dose commitment from liquid effluents

The 50-year dose commitment to the total body and organs are shown in Table 5.36. The maximum total body and organ dose is 0.0095 millirem per year of operation, about 45% of the comparable dose for the reference alternative. As in the reference alternative, almost all of the doses result from the tritium released to the stream. The doses represent only a small fraction of the applicable Federal standards (500 millirems to the total body and 1500 millirems to the organs).[13]

Population dose commitments from liquid effluents

The 100-year EDCs to the projected 1990 population within 80 km of the DWPF are listed in Table 5.37. The total body and organ dose 0.11 man-rem is approximately 45% of the comparable dose for the reference alternative for processing 5-year-old waste (Table 5.14). None of the drinking water for the population within 80 km of the effluent is taken from the Savannah River; thus, the dose is primarily from eating fish from the stream (it is conservatively assumed that all fish in the diet are taken from the river). The highest dose of 0.11 man-rem per year of operation is only about 0.0002% of the comparable annual dose from natural background of 7.1 x 10^4 man-rems.

At about 160 km downstream from the plant effluent a certain portion of the population takes its drinking water from the Savannah River. The doses to this population are shown in Table 5.38. The highest dose is 0.52 man-rem, about 45% of the highest dose estimated for the reference alternative (processing 5-year-old waste) and only about 0.006% of the comparable annual dose from natural background to the people drinking river water.

Table 5.32. One-hundred-year environmental dose commitments (EDC)[a] for a 1990 projected population[b] from routine airborne releases from the DWPF – staged alternative: Stage 1, sand filter stack release

Age group	Dose per year of operation (man-rem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant	6.2E–3[c]	2.4E–2	2.1E–2	6.2E–3	6.2E–3
Child	6.4E–1	2.6E0	8.3E–1	6.4E–1	6.4E–1
Teen	1.5E–1	6.4E–1	2.5E–1	1.5E–1	1.5E–1
Adult	8.2E–1	3.5E0	1.6E0	8.3E–1	8.3E–1
Total	1.6E0	6.8E0	2.7E0	1.6E0	1.6E0

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.
[b]Projected U.S. population from Bureau of Census, Series P-25 No. 704 (July 1977).
[c]To be read as 6.2×10^{-3}.

Table 5.33. One-hundred-year environmental dose commitments (EDC)[a] for a projected 1990 population[b] from routine airborne releases from the DWPF–staged alternative: coupled

Age group and facility	Dose per year of operation (man-rem)				
	Total body	Bone	Thyroid	Lungs	Kidneys
Infant					
Sand filter stack[c]	6.1E–3[d]	2.1E–2	1.7E–2	6.2E–3	6.1E–3
Regulated chemical facility	3.2E–5	3.2E–5	3.2E–5	3.2E–5	3.2E–5
Saltcrete plant	3.0E–5	3.0E–5	3.0E–5	3.0E–5	3.0E–5
Child					
Sand filter stack[c]	4.9E–1	1.9E0	6.4E–1	5.1E–1	5.1E–1
Regulated chemical facility	4.4E–4	4.4E–4	4.4E–4	4.4E–4	4.4E–4
Saltcrete plant	4.2E–4	4.2E–4	4.2E–4	4.2E–4	4.2E–4
Teen					
Sand filter stack[c]	1.3E–1	4.8E–1	2.0E–1	1.3E–1	1.3E–1
Regulated chemical facility	1.9E–4	1.9E–4	1.9E–4	1.9E–4	1.9E–4
Saltcrete plant	1.8E–4	1.8E–4	1.8E–4	1.8E–4	1.8E–4
Adult					
Sand filter stack[c]	7.0E–1	2.6E0	1.2E0	6.9E–1	7.0E–1
Regulated chemical facility	1.5E–3	1.5E–3	1.5E–3	1.5E–3	1.5E–3
Saltcrete plant	1.4E–3	1.4E–3	1.4E–3	1.4E–3	1.4E–3
Total	1.3E0	5.2E0	2.1E0	1.3E0	1.4E0

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.
[b]Projected U.S. population from Bureau of Census, Series P-25 No. 704 (July 1977).
[c]Combined Stage 1 and Stage 2 operations.
[d]Read as 6.1×10^{-3}.

Table 5.34. One-hundred-year environmental dose commitments (EDC)[a] to the 1990 population of the continental United States[b] from the airborne release of tritium and iodine-129 from the DWPF

Age group	Dose per year of operation (man-rem)			
	Total body	Bone	Thyroid	Kidneys
		Stage 1		
Infant	1.7E−6[c]	1.7E−6	4.6E−4	1.7E−6
Child	1.8E−5	1.8E−5	4.9E−3	1.8E−5
Teen	8.3E−6	8.3E−6	2.3E−3	8.3E−6
Adult	7.7E−5	7.7E−5	2.1E−2	7.7E−5
Total	1.1E−4	1.1E−4	2.9E−2	1.1E−4
		Coupled		
Infant	3.9E−5	3.9E−5	3.7E−4	3.9E−5
Child	4.2E−4	4.2E−4	3.9E−3	4.2E−4
Teen	1.9E−4	1.9E−4	1.8E−3	1.9E−4
Adult	1.8E−3	1.8E−3	1.7E−2	1.8E−3
Total	2.4E−3	2.4E−3	2.3E−2	2.4E−3

[a]Population doses from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]Projected U.S. population from Bureau of Census, Series P-25 No. 704 (July 1977).

[c]Read as 1.7×10^{-6}.

Table 5.35. One-hundred-year environmental dose commitment (EDC)[a] for a projected 1990 world population[b]—*routine releases from the* DWPF: staged alternative vs all other sources

Radionuclide and organ	Dose per year of operation (man-rem)		
	Stage 1	Coupled	Existing background
^{3}H (total body)	7.7E−4[c]	1.6E−2	6.5E5
^{129}I (thyroid)	6.5E−1	4.6E−1	3.6E6

[a]Based on one-hundred-year exposure period to environmental media concentrations resulting from constant releases over one year.

[b]World population figures based on United Nations report No. 56, *UN Rep.* ST/ESA/SER/A-56 (1974). Population assumed to be made up entirely of adults.

[c]Read as 7.7×10^{-4}.

Table 5.36. Maximum 50-year dose commitment[a] to individuals from liquid effluents of the DWPF released into the Savannah River—staged alternative (coupled)

Age group	Aquatic pathways	Dose per year of operation (millirem)			
		Total body	Bone	Thyroid	Kidneys
Infant	Immersion in water[b]	0.0	0.0	0.0	0.0
	Ingestion of water[c]	9.5E−3[e]	9.5E−3	9.5E−3	9.5E−3
	Ingestion of fish[d]	0.0	0.0	0.0	0.0
	Total	9.5E−3	9.5E−3	9.5E−3	9.5E−3
Child	Immersion in water[b]	4.7E−14	5.4E−14	3.8E−14	4.1E−14
	Ingestion of water[c]	9.5E−3	9.5E−3	9.5E−3	9.5E−3
	Ingestion of fish[d]	1.3E−4	1.3E−4	1.3E−4	1.3E−4
	Total	9.6E−3	9.6E−3	9.6E−3	9.6E−3
Teen	Immersion in water[b]	4.7E−14	5.4E−14	3.8E−14	4.1E−14
	Ingestion of water[c]	5.2E−3	5.2E−3	5.2E−3	5.2E−3
	Ingestion of fish[d]	1.5E−4	1.5E−4	1.5E−4	1.5E−4
	Total	5.4E−3	5.4E−3	5.4E−3	5.4E−3
Adult	Immersion in water[b]	4.7E−14	5.4E−14	3.8E−14	4.1E−14
	Ingestion of water[c]	7.3E−3	7.3E−3	7.3E−3	7.3E−3
	Ingestion of fish[d]	2.1E−4	2.1E−4	2.1E−4	2.1E−4
	Total	7.5E−3	7.5E−3	7.5E−3	7.5E−3

[a]Internal doses are 50-year dose commitments for one year of radionuclide intake.
[b]Based on swimming in the river for 1% of the year. Infant is assumed not to swim.
[c]Based on water intake (maximum values) of 330 L/year for "infant," 510 L/year for "child" and "teen," and 730 L/year for "adult."
[d]Based on fish consumption (maximum values) of 0.0 kg/year for "infant," 6.9 kg/year for "child," 16.0 kg/year for "teen," and 21.0 kg/year for "adult."
[e]Read as 9.5×10^{-3}.

Table 5.37. One-hundred-year environmental dose commitments (EDC)[a] for a projected 1990 population from routine liquid releases from the DWPF—staged alternative (coupled)

Age group	Dose per year of operation (man-rem)			
	Total body	Bone	Thyroid	Kidneys
Infant	0	0	0	0
Child	1.4E−2[b]	1.4E−2	1.4E−2	1.4E−2
Teen	8.4E−3	1.4E−2	8.4E−3	8.4E−3
Adult	8.4E−2	8.4E−2	8.4E−2	8.4E−2
Total	1.1E−1	1.1E−1	1.1E−1	1.1E−1

[a]Population doses within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over one year. No irrigation or drinking water is taken from the river within this 80 km area.
[b]Read as 1.4×10^{-2}

Table 5.38. One-hundred-year environmental dose commitment (EDC) to 1990–2020 population[a] from liquid effluents of the DWPF released into the Savannah River—staged alternative (coupled)

Point of usage	Age group[b]	Dose per year of operation (man-rem)[c] Total body	Bone	Thyroid	Kidneys
Beaufort-Jasper	Infant	6.2E–3[d]	6.2E–3	6.2E–3	6.2E–3
	Child	7.3E–2	7.3E–2	7.3E–2	7.3E–2
	Teen	2.1E–2	2.1E–2	2.1E–2	2.1E–2
	Adult	2.1E–1	2.1E–1	2.1E–1	2.1E–1
Port Wentworth	Adult	2.1E–1	2.1E–1	2.1E–1	2.1E–1
	Total	5.2E–1	5.2E–1	5.2E–1	5.2E–1

[a]Population usage is based upon the population average for the years 1990–2020 of 40,300 consumers for the Beaufort-Jasper supply and 29,200 (adults only) for the Port Wentworth industrial complex.

[b]Age distribution for the Beaufort-Jasper population is 1.6% for "infant." 19.4% "child," 10% "teen," and 69% "adult."

[c]Dose includes doses from the pathways of ingestion of water and fish and immersion in water. Water intake parameters (maximum values) are 260 L/year for "infant," "child," and "teen" and 370 L/year for "adult." Intakes of fish (maximum values) are 0.0 kg/year for "infant," 2.2 kg/year for "child," 5.2 kg/year for "teen" and 6.7 kg/year for "adult." Immersion in water (swimming) except for the "infant" is for 1% of the year.

[d]Read as 6.2×10^{-3}.

Radiation-induced health effects — routine operation of staged-design DWPF

The radiation-induced health effects that might be caused by a staged design DWPF are reported in Appendix J.4.2 and summarized in Table J.8. The results are similar to those for the reference design: 0.0003 predicted cancer deaths (range 0 to 0.001) and 0.0005 predicted genetic disorders (range 0.0001 to 0.002) per year of operation. For the full 28-year operational life of the facility the cancer risk is estimated at about 0.009 cancer death (0.009 probable, range 0 to 0.03) and about 0.01 genetic disorders (0.01 probable, range 0.003 to 0.06). As with the reference design, risks of cancer death or genetic disorders from the staged design DWPF are insignificant.

5.4 SALT DISPOSAL

5.4.1 Introduction

As noted in Sect. 3.1.1.7, a slightly radioactive salt solution is one of the processing effluents of defense waste immobilization. The actinide radioactivity of this salt solution is about 0.4 nCi/g, which is less than that of uranium ore (0.25% uranium content). The main chemical component in DWPF salt is $NaNO_3$, which together with $NaNO_2$ accounts for approximately 53% by (dry) weight. Mercury is the most chemically toxic trace constituent (4.4×10^{-4} g of mercury per gram of salt).

Environmentally, the most significant impacts resulting from the disposal of DWPF decontaminated salt solution would be associated with the possible contamination of the groundwater of the Barnwell Formation* and neighboring surface water systems. The following paragraphs evaluate the impacts associated with the three disposal alternatives.

The reference alternative, described in Sect. 3.1, calls for land disposal by burial of saltcrete at an intermediate depth in an engineered, landfill to be constructed in the Z-area (see Figs. 3.6, 3.7, and 3.8). The decontaminated salt solution will be mixed with Portland cement and poured in place by conventional methods to form saltcrete monoliths.

Disposal of decontaminated salt in Type III Waste Storage Tanks as saltcake or saltcrete is described in Sect. 3.4. As noted there, tank storage of saltcake is not perceived to be the final deposition of the decontaminated salt solution. Further, due to corrosion of the tanks and water infiltration, the potential long-term environmental consequences from saltcake disposal in

*Some downward movement of salt into the McBean aquifer will occur. This will tend to reduce the concentration buildup calculated for the Barnwell aquifer.

tanks are unacceptable because sodium hydroxide, mercury, nitrate, and nitrite might contaminate SRP surface streams and groundwater.[22] The disposal of saltcrete in Type III tanks[23] affords a similar degree of environmental protection at substantially increased costs compared with saltcrete burial in an engineered landfill.

5.4.2 Engineered landfill disposal

Analysis of the landfill design shows that water that enters the engineered landfill as infiltration will become contaminated by permeating the saltcrete monoliths in the following manner.

A small amount of the total rainfall on the burial site will enter the containment system by permeating through the clay cap. Once inside the landfill, some of this water will migrate downward through the saltcrete monoliths, dissolving salt from the saltcrete. The salt solution and associated radionuclides, after permeating the monolith, will pass through the basal clay liner and enter the groundwater.

B-1, E-9, & J-37 The primary drinking water standard for nitrate, expressed as nitrogen (N), is 10 ppm; the toxicity for nitrite is about 10-fold higher and the design limit for the nitrate/nitrite combination in DWPF salt is about 2.7 ppm (N). The calculations of the radionuclide concentrations in the groundwater at the boundary of the saltcrete landfill (Table 5.39) were based on the conservative assumption that the radionuclides would leach from the landfill at the same relative rates as sodium nitrate and sodium nitrite. The landfill design criterion is to limit the nitrate/nitrite to ≤2.7 ppm. Research is underway to develop a disposal system that will meet all radioactive and nonradioactive requirements. Preliminary calculations show concentrations of mercury in the groundwater to be less than 10% of the safe drinking water limit standard (0.002 ppm). These calculations were based on leach data from saltcrete samples made from both actual and simulated DWPF salt solutions.*

Once in the groundwater, N, Hg, ^{129}I, and other species having no potential for retardation by ion exchange (i.e., $K_d = 0$) move with the groundwater at its flow rate. Laboratory and field tests show that groundwater velocities are likely to be less than 12 m/year between the base of the landfill and an unnamed tributary of Upper Three Runs Creek, the nearest point of discharge. Because this creek is approximately 300 m distant, the groundwater travel time through the Barnwell Formation would be about 25 years. Table 5.39 lists the concentrations of the radioactive constituents entering the groundwater at the boundary of the engineered, secure landfill after its closure. These concentrations are not corrected for radioactive decay subsequent to placement of the saltcrete in the landfill. Table 5.39 also shows concentrations of radionuclides in the groundwater outfall† as it enters the tributary to Upper Three Runs Creek. These latter concentrations have been corrected for radioactive decay during the period of groundwater transport. Maximum groundwater concentrations and annual releases to the surface stream are given below for N, Hg, and total salt.

Species	Maximum groundwater concentration (ppm)	Maximum quantity discharged per year (kg)
Nitrogen	2.7	1.6×10^{2}
Mercury	<0.002	1.2×10^{-1}
Salt	29	1.7×10^{3}

Maximum doses would occur from releases of radionuclides that migrated through the soil at the same rate as the groundwater ($K_d = 0$). Based on an annual river flow of 8.9×10^{9} m^3, the related individual dose commitments are presented in Table 5.40. The maximum individual dose commitments are approximately a factor of 10^7 less than received from natural background radiation. The 100-year total body dose commitment to the local population is expected to be about 0.001 man-rem, as shown in Table 5.41.

The EDCs from the salt disposal area are lower than those from the reference DWPF by a factor of 4000. The resulting health effects from salt disposal will also be lower by a factor of 4000.

TE| *Extraction procedure tests are being performed on saltcrete. Preliminary results indicate that saltcrete is not a hazardous waste and that the mercury is bound in the concrete. Leachability of mercury is typically a factor of 300 to 1000 less than that of a material that is not bound, such as nitrite.

†The outfall is estimated to consist of 5.9×10^{4} m^3 of groundwater that is discharged from beneath the landfill each year. The transit time for this groundwater to reach the outcrop is estimated to be 25 years.

Table 5.39. Radionuclide concentration at the boundary of the landfill and discharge quantities to the Savannah River (corresponding to 2.7 ppm N in the groundwater)

Nuclide	Concentration in saltcrete (nCi/g)	Maximum concentration in groundwater[a] (Ci/L)	Ion exchange (K_d)	Transit time from burial site to outfall[b] (years)	Maximum release to Savannah River (Ci/year)
^{3}H	2.0E1	3.8E-9	0	2.5E1	5.4E-2
^{59}Ni	<1.9E-4	<3.7E-14	c	2.5E1	2.1E-6
^{63}Ni	<1.9E-2	3.7E-12	c	2.5E1	2.1E-4
^{79}Se	7.0E-2	1.4E-11	c	2.5E1	8.0E-4
^{90}Sr	2.9E-1	5.6E-11	1.0E2	1.0E4	0
^{93}Zr	1.8E-2	3.5E-12	c	2.5E1	2.0E-4
^{99}Tc	1.9E1	3.7E-9	c	2.5E1	2.1E-1
^{107}Pd	4.7E-3	9.1E-13	c	2.5E1	5.4E-5
^{121m}Sn	2.8E-3	5.4E-13	c	2.5E1	2.2E-5
^{126}Sn	1.5E-3	2.9E-13	c	2.5E1	1.7E-5
^{129}I	7.3E-2	1.4E-11	c	2.5E1	8.2E-4
^{135}Cs	6.0E-5	1.2E-14	7.3E2	7.3E4	7.0E-7
^{137}Cs	1.5E1	2.9E-9	7.3E2	7.3E4	0
^{147}Pm	1.6E0	3.1E-10	c	2.5E1	2.4E-5
^{151}Sm	2.2E1	4.3E-9	c	2.5E1	2.0E-1
^{232}U	6.7E-5	1.3E-14	6.0E1	6.0E3	0
^{234}U	3.6E-4	7.0E-14	6.0E1	6.0E3	4.0E-6
^{236}U	1.1E-5	2.1E-15	6.0E1	6.0E3	1.2E-7
^{238}U	2.9E-6	5.6E-16	6.0E1	6.0E3	3.3E-8
^{237}Np	8.8E-5	1.7E-14	6.0E2	6.0E3	1.0E-6
^{238}Pu	7.7E-2	1.5E-11	1.4E3	1.4E5	0
^{239}Pu	7.8E-4	1.5E-13	1.4E3	1.4E5	1.5E-7
^{240}Pu	4.9E-4	9.5E-14	1.4E3	1.4E5	2.3E-12
^{241}Pu	5.8E-2	1.1E-11	1.4E3	1.4E5	0
^{242}Pu	6.6E-7	1.3E-16	1.4E3	1.4E5	5.9E-9
^{241}Am	2.1E-1	4.1E-11	1.0E3	1.0E5	0
^{242m}Am	1.4E-4	2.7E-14	1.0E3	1.0E5	0
^{243}Am	5.7E-5	1.1E-14	1.0E3	1.0E5	5.4E-11
^{243}Cm	4.3E-5	8.5E-15	1.0E3	1.0E5	0
^{244}Cm	1.1E-3	2.1E-13	1.0E3	1.0E5	0
^{245}Cm	6.6E-8	1.3E-17	1.0E3	1.0E5	2.2E-13
^{246}Cm	5.2E-9	1.0E-18	1.0E3	1.0E5	2.5E-17
^{247}Cm	6.4E-15	1.2E-24	1.0E3	1.0E5	7.0E-17
^{248}Cm	6.7E-15	1.3E-24	1.0E3	1.0E5	6.2E-17

J-9

[a]Maximum concentration associated with 2.7 ppm N.
[b]Transit time to Upper Three Runs Creek and the Savannah River.
[c]Value unknown; K_d assumed to be 0.

The DWPF decontaminated salt fixed in saltcrete and buried in an engineered landfill results in exposures to an individual from well-water (groundwater) consumption of less than 0.1 millirem/year when the nitrogen concentration is 2.7 ppm. This value is less than 0.4% of the dose rate limit currently being proposed by NRC for incorporation into 10CFR61, which regulates the disposal of commercial low-level radioactive wastes.[25] J-11 & J-38

5.4.3 Dose commitment to intruders

Reference 25 indicates that 10 CFR 61 will require low-level waste repositories to be designed so that the waste will not present an undue risk to an intruder into the disposal site, assuming secondary controls are maintained for 500 years after closure and limited controlled access is maintained for 100 years. The saltcrete disposal technology presented here appears not to subject the hypothetical intruder to undue risk.

5.5 ACCIDENT ANALYSIS

5.5.1 Construction accidents

Construction accidents affecting the safety of the construction workers were discussed in Sect. 5.1.1.2.

Construction accidents having ecological consequences are primarily spills of oil, gasoline, and diesel fuel. Spills of these types would be relatively small and localized and are not expected to have significant ecological consequences. The SRP Spill Prevention Control and Contingency Plan will be used to minimize these types of accidents. In case of an oil or hazardous substance spill corrective action will be taken to protect personnel and to contain and clean up the spill.

Table 5.40. Maximum 50-year dose commitments[a] to individuals from the leaching of radionuclides to the Savannah River via ground water from the saltcrete burial facility of the DWPF

Age group	Aquatic pathways	Dose (millirem)			
		Total body	Bone	Thyroid	Kidneys
Infant	Immersion in water[b]	0.0	0.0	0.0	0.0
	Ingestion of water[c]	5.0E−6[e]	1.8E−5	4.3E−4	9.4E−5
	Ingestion of fish[d]	0.0	0.0	0.0	0.0
	Total	5.0E−6	1.8E−5	4.3E−4	9.4E−5
Child	Immersion in water	1.2E−10	1.9E−10	1.2E−10	5.1E−10
	Ingestion of water	4.0E−6	1.8E−5	2.6E−4	8.5E−5
	Ingestion of fish	1.4E−6	2.2E−5	5.6E−5	1.9E−5
	Total	5.4E−6	4.0E−5	3.2E−4	1.0E−4
Teen	Immersion in water	1.2E−10	1.9E−10	1.2E−10	5.1E−10
	Ingestion of water	1.6E−6	3.9E−6	2.3E−4	4.2E−5
	Ingestion of fish	1.2E−6	1.5E−5	1.0E−4	2.0E−5
	Total	2.8E−6	1.9E−5	3.3E−4	6.2E−5
Adult	Immersion in water	1.2E−10	1.9E−10	1.2E−10	5.1E−10
	Ingestion of water	2.1E−6	6.9E−6	4.9E−4	4.3E−5
	Ingestion of fish	1.2E−6	1.5E−5	2.1E−4	2.0E−5
	Total	3.3E−6	2.2E−5	7.0E−4	6.3E−5

[a] Internal doses are 50-year dose commitments for one year of radionuclide intake.
[b] Based on swimming in the river for 1% of the year, except 0% for "infant."
[c] Based on water intake of 300 L/year of "infant," 510 L/year for "child" and "teen," and 730 L/year for "adult" (from Reg. Guide 1.109).
[d] Based on fish consumption of 0.0 kg/year for "infant," 6.9 kg/year for "child," 16.0 kg/year for "teen," and 21.0 kg/year for "adult" (from Reg. Guide 1.109).
[e] Read as 5.0×10^{-6}. J-9

Table 5.41. One-hundred-year environmental dose commitments[a] for a projected 2025 population[b] from the leaching of radionuclides from the saltcrete burial facility to the Savannah River

Age group	Dose per year of operation (man-rem)[c]			
	Total body	Bone	Thyroid	Kidneys
Infant	5.1E−5[d]	2.1E−4	4.4E−3	9.2E−4
Child	3.8E−4	2.3E−3	2.4E−2	7.6E−3
Teen	7.7E−5	5.2E−4	1.0E−2	1.9E−3
Adult	7.1E−4	4.2E−3	1.6E−1	1.4E−2
Total	1.2E−3	7.2E−3	2.0E−1	2.4E−2

[a] Population dose within 80 km of the plant from a 100-year exposure period to environmental media concentrations resulting from constant releases over 1 year. Releases from the saltcrete burial facility will continue into the future; releases from the processing facilities cease when operations end. J-9

[b] Based on projection of population growth for area equal to that for U.S. in general (see Bureau of Census, Series P-25 No. 704, 1977). Within 80 km the "infant" population is estimated to be 11,872; "child," 154,064; "teen," 66,272; "adult," 502,878.

[c] Based on water and fish intake for the average individual within the appropriate age group (see Reg. Guide 1.109) and swimming in the river for 1% of the year.

[d] Read as 5.1×10^{-5}.

5.5.2 Operational accidents

The Department of Energy and the du Pont Company, DOE's prime contractor for the SRP, have a firm policy that gives strongest emphasis to proper design, construction, and safe operation of facilities. The DWPF will be designed and constructed to mitigate the occurrence and consequences of accidents. Operation of the DWPF will be carried out in accordance with procedures developed to minimize the possibility, number, and severity of accidents and injuries. TC

5.5.2.1 Nonradiological accidents

Nonradiological operational accidents having ecological consequences are primarily fires, chemical spills, and ash basin failure. Depending on the area burned and the fire intensity, wildfire will have varying ecological effect. Wildfire is anticipated to be controlled quickly and to have little ecological effect. Spills in chemical unloading and handling areas will be contained by curbing, collected, and treated; thus, these spills should have no significant ecological consequences. Ash basin failure could result in significant degradation to the unnamed tributary nearby and downstream in Upper Three Runs Creek if a large portion of its contents escape. Local aquatic biota could experience high rates of mortality as a result of the low pH and relatively high concentrations of some heavy metals in ash basin waters (see Table 5.4). Impacts on the Savannah River are expected to be small due to dilution.

5.5.2.2 Accidents involving releases of radioactivity

Occasionally, minor incidents will occur during plant operation because of operator error or failure of a plant component or system. Such events will result in the release of little or no radioactivity to the environment and are, therefore, not discussed in this report.

Major accidents are those postulated events in which significant amounts of radioactive materials could be released into the environment; accidents in this category are discussed in Appendix L, and the impacts are summarized in this section. Most of these accidents would have minor effects on the environment; however, a few accidents may have a substantial impact.

In the postulated accidents, radionuclides are released into the environment through the DWPF stack. The 99 radionuclides that could be released from the DWPF for each accident were evaluated based on the product of the inhalation dose conversion factor and the source term, and the most significant radionuclides by dose contribution were tabulated. For each of the postulated accidents, 50-year dose commitments from inhalation and doses from external exposure to the total body, bone, lungs, and thyroid of the maximally exposed individual from the released radionuclides were computed using the AIRDOS-EPA computer code and are presented later in this section.

The details of source terms and dose calculations for the reference (and delayed) and staged alternatives are presented in Appendix L. Two sets of postulated accidents have been analyzed: nine for the reference alternative and ten for the staged alternative. Many of the accidents are similar for the reference and staged alternatives. However, differences between the two alternatives result in different source terms and potential impacts.

The source terms calculated for the postulated accidents are small. The largest single release was calculated to be 0.12 Ci of cesium-137 from the burning of the cesium ion exchange material (reference alternative). Most other source terms are many orders of magnitude lower than this. For those accidents that could occur in both the reference and staged alternatives, the source terms for the staged alternative were slightly higher than those for the reference alternative because of minor differences in assumed component design and operation.

Radiation doses from accidental releases of radionuclides

Radiation doses to man were calculated for each of the postulated accidents. Fifty-year dose commitments to the maximally exposed individual located approximately 9.2 km downwind of the process building on the nearest road accessible to the public are presented in Tables 5.42 and 5.43 for the reference- as well as staged-design operations. The 9.2 km location was selected to provide a conservative (high) estimate of maximum accident doses. Even the doses calculated with the conservative assumption are very low. Maximum dose is obtained using atmospheric dispersion values determined from onsite meteorological data at the 50% probability level.

Doses were estimated for radionuclide releases from the ventilation stack of the process building by the AIRDOS-EPA computer code.[26] All radionuclides were assumed to be released to the environment from an 84-m stack in the reference design and from a 43-m stack in the staged design alternative. Doses were calculated for total body, bone, lungs, and the thyroid for four age groups: infant, child, teen, and adult.

Table 5.42. Fifty-year dose commitments to the maximally exposed individual[a] from potential accidental releases of radionuclides to the atmosphere[b]—reference alternative

Accident description	Age group	Dose commitments (millirem)[c] Total body	Bone	Lungs	Thyroid	Major contribution radionuclides to total-body dose	Estimated probability per year
1. Failure of centrifuge suspension system	Infant	6.4E-9[d]	4.5E-8	2.4E-9	8.8E-8	^{129}I (55%), ^{239}Pu (11%)	1E-3
	Child	7.5E-9	8.9E-8	1.4E-8	9.7E-8	^{90}Sr (5%), ^{3}H (24%)	
	Teen	7.8E-9	1.1E-7	1.5E-8	1.7E-7	^{137}Cs (3%)	
	Adult	7.8E-9	1.0E-7	1.1E-8	2.5E-7		
2. Eructation of the process sand filters	Infant	2.0E-9	1.2E-9	2.1E-9	1.6E-9	^{3}H (22%), ^{129}I (13%)	1E-2
	Child	2.1E-9	1.3E-9	2.3E-9	1.7E-9	^{134}Cs (12%), ^{137}Cs (51%)	
	Teen	2.3E-9	1.3E-9	2.5E-9	2.9E-9		
	Adult	2.3E-9	2.3E-9	2.3E-9	4.0E-9		
3. Burning of process sand filter material	Infant	1.2E-3	3.2E-3	3.6E-3	1.2E-3	^{106}Ru (46%), ^{134}Cs (10%)	1E-2
	Child	1.2E-3	3.3E-3	4.0E-3	1.2E-3	^{137}Cs (43%)	
	Teen	1.2E-3	3.4E-3	4.2E-3	1.3E-3		
	Adult	1.2E-3	3.3E-3	3.2E-3	1.3E-3		
4. Explosion in the recycle evaporator	Infant	1.4E-7	5.3E-7	1.2E-7	2.4E-6	^{129}I (91%), ^{137}Cs (5%)	3E-2
	Child	1.4E-7	5.8E-7	1.3E-7	2.7E-6		
	Teen	1.4E-7	6.4E-7	1.3E-7	4.8E-6		
	Adult	1.5E-7	6.1E-7	1.3E-7	7.2E-6		
5. Burning of cesium ion-exchange material	Infant	7.2E-4	1.4E-3	1.7E-4	6.8E-4	^{134}Cs (15%), ^{137}Cs (82%)	1E-2
	Child	7.2E-4	1.5E-3	1.7E-4	6.8E-4	^{238}Pu (3%)	
	Teen	7.2E-4	1.5E-3	1.7E-4	7.2E-4		
	Adult	7.2E-4	1.5E-3	1.7E-4	7.2E-4		
6. Burning of strontium ion-exchange material	Infant	3.5E-6	1.1E-4	2.1E-5	3.9E-6	^{90}Sr (100%)	1E-2
	Child	8.7E-6	2.6E-4	2.9E-5	9.7E-6		
	Teen	8.7E-6	2.9E-4	3.1E-5	9.7E-6		
	Adult	7.9E-6	2.6E-4	1.8E-5	8.8E-6		
7. Breach of calciner by explosion	Infant	7.4E-3	1.1E-1	2.0E-2	6.9E-3	^{137}Cs (2%), ^{144}Pr (2%)	3E-5
	Child	9.3E-3	2.6E-1	2.8E-2	9.3E-3	^{239}Pu (63%), ^{90}Sr (29%)	
	Teen	9.9E-3	3.2E-1	3.0E-2	1.0E-2		
	Adult	9.3E-3	2.9E-1	2.2E-2	9.3E-3		
8. Steam explosion in a glass melter	Infant	4.1E-4	5.3E-3	1.7E-3	3.8E-4	^{134}Cs (20%), ^{137}Cs (39%)	3E-5
	Child	5.2E-4	1.2E-2	2.3E-3	5.1E-4	^{154}Eu (13%)	
	Teen	5.2E-4	1.4E-2	2.5E-3	5.4E-4	^{238}Pu (24%)	
	Adult	5.2E-4	1.4E-2	1.6E-3	5.1E-4		
9. Breach of waste canister	Infant	1.7E-6	2.7E-5	5.1E-6	1.7E-6	^{90}Sr (29%), ^{144}Pr (2%)	2E-4
	Child	2.1E-6	5.9E-5	6.9E-6	2.2E-6	^{137}Cs (2%)	
	Teen	2.2E-6	7.1E-5	7.5E-6	2.3E-6	^{239}Pu (62%)	
	Adult	2.2E-6	6.8E-5	5.1E-6	2.2E-6		

[a]The maximally exposed individual is located approximately 9.2 km downwind from the effluent; ingestion pathway is not considered for doses from accidental releases.

[b]All releases were from exhaust stack; height 84 m, diameter 5.5 m, and effluent velocity 14 m/s.

[c]Doses were calculated based on x/q values determined from onsite meteorological data at the 50% probability level (NRC Reg. Guide 4.2 Rev. 1).

[d]Read as 6.4×10^{-9}.

In general, doses in the staged alternative are higher than the doses in the reference alternative. However, the maximum dose in the staged design is less than the maximum dose in the reference design.

Dose by organ. In five out of nine accidents analyzed for the reference design, the dose to the bone was predicted to be higher than the doses to the lung, thyroid, or total body. In three of the remaining four accidents, the dose to the thyroid was predicted to be higher than the doses to other organs and the total body. In only one accident, predicted lung dose was higher than the dose to other organs and the total body. For the staged alternative, the bone dose was predicted to be higher than the doses received by lung, thyroid, or the total body for all but one postulated accident.

Table 5.43. Fifty-year dose commitments to the maximally exposed individual[a] from potential accidental releases of radionuclides to the atmosphere[b] – staged alternative

Accident description	Age group	Dose commitments (millirem)[c] Total body	Bone	Lungs	Thyroid	Major contributing radionuclides to adult total-body dose	Estimated probability per year
Stage 1							
1. Spill from slurry receipt tank (uncoupled operation)[d]	Infant	1.2E-5[e]	1.5E-4	5.8E-5	5.9E-5	^{90}Sr (12%), ^{106}Ru (47%)	2E-2
	Child	1.5E-5	3.3E-4	7.3E-5	1.3E-4	^{129}I (15%), ^{238}Pu (26%)	
	Teen	1.6E-5	4.3E-4	8.3E-5	1.1E-4		
	Adult	1.6E-5	4.0E-4	5.3E-5	1.5E-4		
2. Eructation in slurry mix evaporator (coupled operation)[d]	Infant	2.7E-3	4.3E-2	9.6E-3	2.7E-3	^{90}Sr (30%), ^{137}Cs (2%)	3E-2
	Child	3.9E-3	1.0E-1	1.3E-2	3.7E-3	^{238}Pu (64%), ^{144}Pr (3%)	
	Teen	4.2E-3	1.3E-1	1.5E-2	4.1E-3		
	Adult	3.9E-3	1.2E-1	9.6E-3	4.1E-3		
3. Spill from melter feed tank (coupled operation)	Infant	3.3E-6	3.3E-6	1.2E-5	1.1E-5	^{90}Sr (8%), ^{106}Ru (35%)	2E-2
	Child	4.0E-6	6.9E-6	1.5E-5	1.2E-5	^{129}I (10%), ^{137}Cs (27%)	
	Teen	4.2E-6	8.5E-6	1.7E-5	2.0E-5	^{238}Pu (19%)	
	Adult	4.2E-6	8.1E-6	1.1E-5	2.8E-5		
4. Explosion of liquid fed glass melter (coupled operation)	Infant	1.6E-3	2.8E-2	5.6E-3	1.5E-3	^{90}Sr (15%), ^{137}Cs (48%)	3E-5
	Child	2.3E-3	6.4E-2	7.8E-3	2.3E-3	^{238}Pu (34%)	
	Teen	2.4E-3	7.4E-2	8.4E-3	2.4E-3		
	Adult	2.4E-3	7.4E-2	5.6E-3	2.4E-3		
5. Canister rupture (uncoupled operation)	Infant	5.0E-6	8.1E-5	1.7E-5	4.5E-6	^{90}Sr (15%), ^{137}Cs (48%)	2E-4
	Child	6.6E-6	2.0E-4	2.4E-5	6.5E-6		
	Teen	7.0E-6	2.4E-4	2.6E-5	7.3E-6		
	Adult	7.0E-6	2.3E-4	1.7E-5	6.9E-6		
Stage 2							
6. Fire in cesium ion-exchange	Infant	3.9E-2	9.4E-2	5.4E-2	3.5E-2	^{137}Cs (99%)	1E-2
	Child	3.9E-2	9.7E-2	5.4E-2	3.5E-2		
	Teen	4.0E-2	9.7E-2	5.4E-2	3.6E-2		
	Adult	4.0E-2	9.7E-2	5.4E-2	3.5E-2		
7. Fire in strontium ion exchange	Infant	9.0E-6	2.8E-4	5.8E-5	1.0E-5	^{90}Sr (100%)	1E-2
	Child	2.2E-5	7.0E-4	7.7E-5	2.5E-5		
	Teen	2.4E-5	7.4E-4	8.5E-5	2.7E-5		
	Adult	2.1E-5	6.7E-4	5.0E-5	2.4E-5		
8. Burning of sand filter material	Infant	3.0E-3	9.0E-3	1.3E-3	2.8E-3	^{137}Cs (98%), ^{238}Pu (2%)	1E-2
	Child	3.1E-3	1.2E-2	4.4E-3	2.8E-3		
	Teen	3.1E-3	1.3E-2	4.6E-3	2.9E-3		
	Adult	3.1E-3	1.3E-2	4.4E-3	2.9E-3		
9. Eructation of strontium concentrator	Infant	1.1E-4	3.3E-3	6.8E-4	1.2E-4	^{90}Sr (~100%)	3E-2
	Child	2.6E-4	7.9E-3	8.9E-4	2.9E-4		
	Teen	2.6E-4	8.4E-3	1.0E-3	2.9E-4		
	Adult	2.5E-4	7.9E-3	6.0E-4	2.8E-4		
10. Eructation of cesium concentrator	Infant	2.4E-2	5.7E-2	3.2E-2	2.0E-2	^{137}Cs (99%)	3E-2
	Child	2.4E-2	5.7E-2	3.2E-2	2.0E-2		
	Teen	2.4E-2	5.7E-2	3.2E-2	2.0E-2		
	Adult	2.4E-2	5.7E-2	3.2E-2	2.0E-2		

[a]The maximally exposed individual is located approximately 9.2 km downwind from the effluent; ingestion pathway is not considered for doses from accidental releases.

[b]All releases were from exhaust stack; height 42.7 m, diameter 3.7 m, and effluent velocity 16.1 m/s.

[c]Doses were calculated based on x/q values determined from onsite meteorological data at the 50% probability level (NRC Reg. Guide 4.2 Rev. 1).

[d]Uncoupled operation is stage 1 process only; coupled operation includes stage 1 and stage 2 processes combined.

[e]Read as 1.2×10^{-5}.

Dose by age group. In general, teen and adult groups would receive higher doses than the infant and child age groups in the reference as well as staged alternative.

In reference-design operation, bone dose to the teenage group was higher than bone dose to adults in six of the nine accidents. In two accidents, teen and adult age groups received the same bone dose, and in one accident, the adult group received a higher bone dose than the teenage group. For the staged-design alternative, bone dose to the teenage group was higher than the bone dose to the adult group in seven of the ten accidents. In three accidents, teen and adult age groups received the same bone dose. For this reason, the discussion of impacts focuses on bone dose to the teenage group for all accidents in the reference as well as staged alternative.

Dose by accident. Among all potential accidents analyzed for the reference design, the maximum dose (Table 5.42) would result from an explosion in the calciner. For this postulated accident, the largest dose would be 0.32 millirem to the bone of a maximally exposed teenager. In the case of the staged alternative, the highest dose would be 0.13 millirem, resulting from an eructation of the slurry-mix evaporator (Table 5.43).

The accident involving steam explosion in the glass melter would deliver the second highest dose in the reference alternative, whereas the postulated accident involving fire in the cesium ion exchange material would deliver the second highest dose in the staged alternative. In the case of reference design, the dose was 0.14 millirem, and in the case of staged design, it was 0.097 millirem to the bone of a teenager. The consequences of a steam explosion in the liquid-fed glass melter would also deliver doses comparable to those from a fire in the cesium ion exchanger. Other accidents analyzed would yield much smaller maximum doses.

Impact of radiation doses to individuals. As discussed above, the highest individual bone dose received from an accident at the DWPF is calculated to be 0.32 millirem. (For most postulated accidents, the doses would be much smaller.) The predicted maximum bone dose is nearly two orders of magnitude less than the individual internal dose of 18 to 24 millirems per year received from natural terrestrial radiation by all individuals. By comparison, the average external individual dose received by the airplane-travelling public is about 4 millirems per cross-country flight.[27]

Because the probability of a major accident at the DWPF is small, the chance that an individual would receive even 0.32 millirem is remote. Therefore, the impact of the postulated DWPF accidents on human health is expected to be extremely small for either the reference or staged alternative.

5.5.3 Impacts resulting from transportation accidents involving reference waste

5.5.3.1 Nonradiological impacts

Nonradiological transportation accident impacts were calculated for two categories, injuries and fatalities. The risks of these impacts were calculated using accident probabilities for truck and rail, probabilities of injury and death if an accident occurs, and the number of kilometers travelled annually. The expected values are about one to two injuries per year of shipment and about one fatality for every ten years of shipment as shown in Table 5.44. Further discussion on these impacts is included in Appendix D.

Table 5.44. Expected nonradiological injuries and fatalities per year from transportation accidents

Shipment case	Injuries			Fatalities		
	Rail	Truck	Total	Rail	Truck	Total
1	1.2	0.0	1.2	0.09	0.0	0.09
2	0.9	0.7	1.6	0.07	0.03	0.10
3	0.4	1.5	1.9	0.03	0.08	0.11
4	0.0	2.2	2.2	0.0	0.12	0.12

5.5.3.2 Radiological impacts

Two types of transportation accidents were considered: (1) a particulate release accident, wherein the shipping cask is subjected to severe impact and fire, and some of its contents are released into the environment, and (2) a loss-of-shielding accident, wherein the cask experienced severe impact and developed cracks, allowing increased gamma radiation to escape but allowing no particulate release.

In both accident cases, exposure was calculated for an individual standing 30 m from the cask for 0.1 h. In the particulate-release case, calculations are done for three age groups: adult, child, and infant. Two exposure pathways are considered, exposure from inhalation of released particulates and exposure to gamma radiation from particulates settled on the ground, called groundshine. Table 5.45 shows exposures that could occur in the event of the aforementioned accidents, and these do not exceed 10 millirems per accident. Table 5.46 shows expected values that represent the annual risk of accidental exposure are very low.

A more detailed discussion of the methodology, assumptions, and models used for these calculations is included in Appendix D.

Table 5.45. Accident consequences: maximum individual exposure resulting from partial loss of contents or loss of shielding, in millirem

Type of accident	Release (Ci)		Exposure[a]					
			Infant		Child		Adult	
	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
Loss of contents								
Groundshine	9.4E–1	1.9E–1	7.5E0	1.5E0	5.5E0	1.1E0	4.0E0	8.0E–1
Inhalation	1.6E–4	3.2E–5	2.5E–3	4.9E–4	5.3E–3	1.1E–3	3.5E–3	6.9E–4
Loss of shielding[b]							7.8E0	1.8E0

[a]For reference, the maximum individual exposure to average background radiation in the United States is approximately 170 millirems per year.

[b]Gamma exposure only.

Table 5.46. Annual risk to maximum individual (millirem) from postulated accident

Shipment case	Particulate release						Loss of shielding	
	Adult		Child		Infant			
	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
1	3.7E–6	0.0	4.9E–6	0.0	6.7E–6	0.0	3.5E–3	0.0
2	2.6E–6	9.2E–7	3.4E–6	1.3E–6	4.7E–6	1.7E–6	2.4E–3	1.9E–3
3	1.1E–6	2.2E–6	1.5E–6	3.1E–6	2.0E–6	4.0E–6	1.0E–3	2.6E–3
4	0.0	3.1E–6	0.0	4.3E–6	0.0	5.8E–6	0.0	6.1E–3

5.6 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Measures to mitigate potential environmental impacts include an effective quality assurance program and administrative controls as well as engineered systems. These measures will alleviate some of the adverse environmental effects caused by construction and operation. However, certain probable adverse effects on the environment cannot be avoided regardless of which alternative is chosen. These unavoidable effects are discussed in this section. In evaluating possible adverse effects, it should be noted that construction and normal operations will be in compliance with applicable Federal, state, and local laws and regulations. |TC

5.6.1 Construction

The impacts of construction will be like those of other large industrial projects. They include increased noise levels near the site, increased air pollution caused by earth-moving and vehicular activity, and the disruption of existing land uses on the site and along new road and utility rights-of-way.

Approximately 140 ha, including a carolina bay, will be removed from wildlife habitat during construction. Although animals will lose some habitat, the losses will be insignificant because extensive areas of similar habitat exist throughout the site region. A loss of individuals of the more sedentary species (e.g., rodents, lizards) during construction will have an insignificant impact on the population of these species in the area.

The influx of construction workers may exceed Barnwell County's available housing, particularly multifamily units. The primary impact is predicted to occur in Barnwell City, with a 10% shortfall of multifamily units. Additionally, during the peak construction period, local wage rates and retail prices will increase. It is likely that increases in local tax revenues will not fully offset the increased demands for government services caused by the influx of construction workers.

The impacts caused by construction of the reference immobilization alternative and staged process alternative are summarized in Tables 5.47 and 5.48. A comparison of impacts for the three alternatives is given in Sect. 5.9 and Table 3.1.

5.6.2 Operation

During the operation phase, approximately 80 ha of land will remain unavailable for wildlife habitat. The impacts of this removal are discussed in Sect. 5.1.2.2.

Unavoidable radiation exposures will include occupational exposures and exposures to the general population. The occupational and public exposures are discussed in Sects. 5.1.2.3, 5.2.2.2, and 5.3.2.3. All the offsite exposures are very small compared to those from natural radiation.

Unavoidable nonnuclear events include occupational lost-workday injuries and fatalities during construction and operation of new facilities. On a statistical basis, these events can be expected to occur; however, the trend of industrial accident rates has been downward, which indicates that safety programs will have the effect of causing some avoidance of expected casualties.

The unavoidable adverse impacts caused by operation of the reference immobilization alternative and the staged process alternative are summarized in Tables 5.49 and 5.50. A comparison of impacts for the three alternatives is given in Sect. 5.9 and Table 3.1.

5.7 IRREVERSIBLE AND/OR IRRETRIEVABLE COMMITMENTS OF RESOURCES

Numerous resources are used in constructing and operating major plant facilities. Some of the resource commitments are irreversible and irretrievable. Irreversible commitments are changes set in motion which, at some later time, could not be altered to restore the present order of environmental resources. Irretrievable commitments are the use or consumption of resources that are neither renewable nor recoverable for subsequent utilization. Generally, resources that may be irreversibly or irretrievably committed by construction and operation of facilities for any of the alternative plans are (1) biota destroyed in the vicinity, (2) construction materials that cannot be recovered and recycled, (3) materials that become contaminated with radionuclides and cannot be decontaminated for recycle, (4) materials consumed or reduced to unrecoverable forms of waste, and (5) land areas rendered unfit for their preconstruction uses and/or potential postconstruction uses.

Implementation of any of the alternative plans would involve construction activities on less than 0.1% of the land on the Savannah River plant site. Although there would be an irretrievable loss of a previously disturbed carolina bay and of some individuals of the site biota during construction of facilities for any alternative, minimal adverse effects would be expected on the structure or stability of the plant and animal populations inhabiting the plant site. The primary resource commitments are shown in Table 5.51.

For each alternative, the facility construction would be similar to the two chemical separation facilities currently in use at SRP. At the end of the useful life of the waste immobilization facility, it would have to be decommissioned. It is expected that decommissioning the waste immobilization facility would require about the same degree of effort as decommissioning one of the chemical separation facilities, and it will be addressed in the environmental review for the D&D of the SRP. D&D was discussed in Sect. 3.1.8.

Most of the disturbed area will be restored to its original contours, reseeded, and permitted to revert to its natural state after plant decommissioning.

Table 5.47. Impacts from construction of the reference immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects		
DWPF and Vogtle[a] construction on schedule	Work-force population will increase with a consequent increase in required public services. DWPF employment increases will coincide with Vogtle decreases.[a]	5.1.1.1, 5.9, H.1, K.1
DWPF construction on schedule and Vogtle delayed 2 years	Work-force demand for Vogtle and DWPF construction will peak simultaneously requiring more in-movers and greater demands on public services and housing. Minor impacts will be distributed over a large six-county area. Possible significant impacts expected only in services for one county and may require mitigation.	5.6, 5.9, H.2
Health risk to workforce		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced during construction.	5.1.1.2, 5.5.1
Radiological	Construction workers will be exposed to SRP background-level radiation. Exposures will be well below standards, and monitoring will be employed where necessary.	5.1.1.3
Ecological effects		
Nonradiological	Wildlife habitat will be disturbed; erosion and stream siltation will increase. Impacts will be on areas without unique ecological features, and recovery is expected after construction is completed.	5.1.1.2
Radiological	None.	5.1.1.3
Land use	About 140 ha of land will receive some construction impacts. Land is currently unused and within the SRP.	5.1.2, 5.6
Air quality	Impacts will be same as for conventional industrial plant construction (e.g., increase in total suspended particulates, carbon monoxide, and hydrocarbons). Emissions will be well within applicable standards.	5.1.1.2
Water quality	Siltation of surface streams will increase. Construction practices will be utilized to mitigate stream impacts.	5.1.1.2
Earthquake or tornado occurrence	Damage to facilities. Impacts during construction would be same as for any nonradiological construction project.	Appendix G
Cultural resources	None expected.	4.1.3
Endangered species	*None expected.*	5.1.1.2
Resource depletion	Resources committed include concrete, steel, and fuels. Amounts are nominal, and materials are ordinary.	5.7
Wetlands protection	One carolina bay will be eliminated. About 200 carolina bays exist on the SRP site, and this one is not unique.	4.5.1, 5.1.1.2, 5.6

[a]The Vogtle Power Plant is a nuclear power plant being constructed by the Georgia Power Company within 20 km of the proposed DWPF.

Table 5.48. Impacts from construction of the staged immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Work-force population will increase with a consequent increase in required public services. Area population increases will be less than 1% of the totals. Minor to negligible impacts will be offset by jobs created.	5.1.1, 5.9.1, Appendix K
Health risk to workforce		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced during construction.	5.1.1.2[a], 5.5.1
Radiological	Construction workers will be exposed to SRP background-level radiation. Exposures will be well below standards, and monitoring will be employed where necessary.	5.3.1.3
Ecological effects		
Nonradiological	Wildlife habitat will be disturbed; erosion and stream siltation will increase. Impacts will be on areas without unique ecological features, and recovery is expected after construction is completed.	5.3.1.2
Radiological	None.	5.1.2.3[a]
Land use	About 120 ha of land will receive some construction impacts. Land is currently unused and within the SRP.	3.3.2.1, 3.3.2.2
Air quality	Impacts will be same as for conventional industrial plant construction (e.g., increase in total suspended particulates, carbon monoxide, and hydrocarbons). Emissions will be well within applicable standards.	5.1.1.2[a]
Water quality	Siltation of surface streams will increase. Construction practices will be utilized to mitigate stream impacts.	5.1.1.2[a]
Earthquake or tornado occurrence	Damage to facilities. Impacts during construction would be same as for any nonradiological construction project.	Appendix G
Cultural resources	None expected.	4.1.3
Endangered species	None expected.	5.1.1.2[a]
Resource depletion	Resources committed include concrete, steel, and fuels. Amounts are nominal, and materials are ordinary.	3.3.4.4
Wetlands protection	One carolina bay will be eliminated. About 200 carolina bays exist on the SRP site, and this one is not unique.	5.1.1.2[a]

[a]Impacts are the same as for the reference alternative.

Table 5.49. Impacts from operation of the reference immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Some economic turndown is expected when construction ends and operation begins. The effect is limited and absorbable; there will be a net gain of about 700 permanent jobs.	5.1.2.1, Appendix K
Health risk to work force		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced for all operations.	5.1.2.2, 5.5.2
Radiological (routine operations)	Operating personnel will work in controlled radiation exposure areas. All high-level radioactivity operations will be remotely controlled; occupational doses will be monitored and controlled to be as low as reasonably achievable.	5.1.2.3
Radiological (accidental occurrence)	Operating personnel may be exposed to radiation. Maximum precautions will be taken to protect personnel. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2
Health risk to public		
Nonradiological	Public will be exposed to coal-fired power-plant releases: particulates, SO_x, CO, HC, and NO_x; coal-pile runoff, and ash. Emissions will be controlled to within acceptable levels.	5.1.2.2
Radiological (routine releases)	Public will be exposed to radionuclides in DWPF atmospheric and liquid releases. Doses will be extremely small and insignificant health risk is anticipated.	5.1.2.3, Appendix J
Radiological (accidental releases)	Public will be exposed to radionuclides released accidentally. Accidents are highly unlikely and releases in the event of accident are so small that insignificant health risk is anticipated. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2, Appendix L
Ecological effects		
Nonradiological	Nonradioactive wastes (including ash-basin effluents) will be discharged into the environment. Wastes will be treated before discharge.	5.1.2.2
Radiological	None expected. Biota will not be severely affected.	5.1.2.3
Land use	Approximately 80 ha will be committed to the DWPF facility. Land is currently unused and is about 0.1% of land area within the SRP.	5.6.2
Air quality		
Nonradiological	Releases from coal-fired power plant will increase atmospheric levels of particulates, SO_x, CO, HC, and NO_x. Cooling towers will release drift. Releases will be controlled to maintain levels within Federal standards.	3.1.6.4, 5.1.2.2
Radiological	Radionuclides will be released in stack exhausts. Radionuclide levels will be extremely small.	3.1.6.4, 5.1.2.3
Water quality		
Nonradiological	Effluent from the industrial wastewater treatment facility will discharge to surface streams; secondary effluent from the sewage treatment plant will be disposed of by spray-irrigation on land. Waste will be treated before discharge, to meet all applicable regulations; possible impacts to soils from on-land disposal of sewage plant effluent will be mitigated.	3.1.6.4, 5.1.2.2
Radiological	Radionuclides will be released in DWPF liquid effluents. Liquid streams will be monitored before discharge; concentrations of radionuclides in surface water will be extremely small; no degradation of water quality will occur.	3.1.6.4, 5.1.2.3

Table 6.49. (continued)

Issue	Impacts	Section
Earthquake or tornado occurrence	Damage to facilities with consequent release of radioactivity. Structures processing high-level radioactivity materials will be earthquake- and tornado-resistant.	3.1.3, 4.4.3
Transportation (routine operations)		
Nonradiological	Impacts will be similar to those of conventional common carriers. Vehicle emissions will be much less than allowable standards.	5.1.4.1, Appendix D
Radiological	Public will be exposed to radioactivity from passing vehicles. All phases of transport including packaging will be designed to comply with comprehensive Federal regulations ensuring public safety during transport of HLW.	5.1.4.2, Appendix D
Transportation (accidents)		
Nonradiological	Injuries and fatalities will be similar to those for conventional common carriers. Probabilities for injuries and fatalities from truck and rail transportation accidents will be similar to those in normal transportation.	5.5.3.1, Appendix D
Radiological	Public will be exposed to radioactive releases in the event a cask is ruptured during an accident. Rupture is highly unlikely; public exposure in the event of rupture is very low compared with normal background radiation.	5.5.3.2, Appendix D
Resource commitment	Resources committed include electricity, water, coal, cement, glass frit, and process chemicals. Materials are commonly available and amounts are reasonable.	5.7

Table 5.50. Impacts from operation of the staged immobilization DWPF

Issue	Impacts	Section
Socioeconomic effects	Some economic turndown is expected when construction ends and operation begins. The effect is limited and absorbable; there will be a net gain of about 530 permanent jobs.	5.3.2.1, Appendix K
Health risk to work force		
Nonradiological	Risks will be similar to those for nonradiological industrial plant construction. Safety procedures will be enforced for all operations.	5.1.2.2[a]
Radiological (routine operations)	Operating personnel will work in controlled radiation exposure areas. All high-level radioactivity operations will be remotely controlled; occupational doses will be monitored and controlled to be as low as reasonably achievable.	5.1.2.3[a]
Radiological (accidental occurrence)	Operating personnel may be exposed to radiation. Maximum precautions will be taken to protect personnel. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2, 5.6.2
Health risk to public		
Nonradiological	Releases will contain CO_2, NO_x, NH_3, and diesel generator emissions. Releases are very small and well within required emission standards.	3.3.5.4
Radiological (routine releases)	Public will be exposed to radionuclides in DWPF atmospheric and liquid releases. Doses will be extremely small and little health risk is anticipated.	5.3.2.3, 5.6.2, Appendix D
Radiological (accidental releases)	Public will be exposed to radionuclides released accidentally. Accidents are highly unlikely and releases in the event of accident are so small that little health risk is anticipated. Facilities are designed, constructed, and operated to mitigate the occurrence and consequence of accidents.	5.5.2, Appendix L
Ecological effects		
Nonradiological	Nonradioactive wastes will be discharged into the environment. Wastes will be treated before discharge to comply with NPDES permit requirements.	5.3.2.2
Radiological	None expected.	5.1.2.3
Land use	Approximately 65 ha will be committed to the DWPF facility. Land is currently unused and is about 0.1% of land area within the SRP.	3.3.2, 4.1.2
Air quality		
Nonradiological	Releases from diesel generator exhaust will increase atmospheric levels of particulates, SO_x, CO, HC, and NO_x. Cooling towers will release drift. Releases will be very small and well within air quality standards.	3.1.6.4, 3.3.5.4
Radiological	Radionuclides will be released in stack exhausts. Radionuclide levels will be extremely small.	5.3.2.3
Water quality		
Nonradiological	Effluent from the industrial wastewater treatment facility will discharge to surface streams: secondary effluent from the sewage treatment plant will be disposed of by spray-irrigation on land. Waste will be treated before discharge, to meet all applicable regulations; possible impacts to soils from on-land disposal of sewage plant effluent will be mitigated.	3.1.6.4, 5.3.2.2
Radiological	Radionuclides will be released in DWPF liquid effluents. Liquid streams will be monitored before discharge; concentrations of radionuclides in surface water will be extremely small; no degradation of water quality will occur.	3.1.6.4, 5.1.2.3

Table 5.50. (continued)

Issue	Impacts	Section
Earthquake or tornado occurrence	Damage to facilities with consequent release of radioactivity. Structures processing high-level radioactivity materials will be earthquake- and tornado-resistant.	3.1.3.1[a], 4.4.3
Transportation (routine operations)		
Nonradiological	Impacts will be similar to those of conventional common carriers. Vehicle emissions will be much less than allowable standards.	5.1.4.1, Appendix D
Radiological	Public will be exposed to radioactivity from passing vehicles. All phases of transport including packaging will be designed to comply with comprehensive Federal regulations ensuring public safety during transport of HLW.	5.1.4.2, Appendix D
Transportation (accidents)		
Nonradiological	Injuries and fatalities will be similar to those for conventional common carriers. Probabilities for injuries and fatalities from truck and rail transportation accidents will be similar to those in normal transportation.	5.5.3.1, Appendix D
Radiological	Public will be exposed to radioactive releases in the event a cask is ruptured during an accident. Rupture is highly unlikely; public exposure in the event of rupture is very low compared with normal background radiation.	5.5.3.2, Appendix D
Resource commitment	Resources committed include electricity, water, coal, cement, glass frit, and process chemicals. Materials are commonly available and amounts are reasonable.	5.7

[a]Impacts are the same as for the reference alternative.

Table 5.51. Primary resource commitments

Resource	Reference Design	Stage Design
Construction stage		
Concrete	2.5E5 m^3	1.5E5 m^3
Steel	3.6E4 t	2.3E4 t
Gasohol	8.7E6 L	3.8E6 L
Diesel fuel	8.7E6 L	3.8E6 L
Propane	7.5E4 L	3.0E4 L
Operation stage		
Electricity	1.7E4 kw	1.3E4 kw
Water	3.7E6 L/day	2.7E6 L/day
Coal	1.2E2 t/day	8.4E-1 t/day
Cement	1.1E2 t/day	1.1E2 t/day
Glass frit	2.0E0 t/day	2.0E0 t/day
Process chemicals	15.0E0 t/day	5.0E0 t/day

5.8 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

This section compares the short-term and long-term environmental gains and losses of implementing any of the alternative plans. For purposes of this discussion, short-term effects are those that occur during the period of construction and operation of the facilities. Long-term effects are those that extend past facility operations and into the indefinite future. Short-term effects are generally considered in terms of trade-offs in impact on the environment, land use, and cost. Long-term effects have to do with conservation of energy reserves, environmental effects, and land use.

The fundamental purpose of implementation of any of the alternative plans is to remove the SRP defense high-level waste (HLW) from interim storage and place it in environmentally acceptable long-term storage or disposal.

5.8.1 Short-term effects

The positive short-term effect of any of the DWPF alternatives is that the HLW will be placed in a solid, leach-resistant form that will enhance its isolation from man's environment particularly during transportation and storage.

Implementation of any of the alternative plans will consume some depletable resources, such as cement, steel, and lumber; however, these are all common industrial products, and SRP consumption would not significantly affect their supply. Also, implementation of any of the alternative plans will require short-term dedication of land for construction and operation of the facilities.

5.8.2 Long-term effects

Even though the defense HLW is stored safely in waste tanks, any of the alternative plans will immobilize the waste in a form that would give greater assurance that it will remain isolated from man's environment.

Disposal of the immobilized waste in a geologic repository will commit the subsurface area to that purpose indefinitely and will restrict the development at that location of potential mineral resources by drilling or mining. (These considerations would be addressed fully in the programs and environmental evaluations that lead to the selection and development of the repository site.)

Burial of the residual salt onsite will restrict indefinitely the potential development of the surface above the 20-ha burial area.

5.9 COMPARISON OF IMPACTS BY ALTERNATIVE

The impacts of the three alternatives are compared in Table 5.52. No significant or unmitigable impacts are anticipated as a result of the implementation of any of the immobilization alternatives. However, in general, the adverse effects of the staged-process alternatives are anticipated to be somewhat less than those of the other alternatives.

Table 5.52. Comparison of impacts by alternatives for key environmental parameters

Key environmental parameters	Reference immobilization alternative	Delay of reference immobilization alternative	Staged process alternative
Normal operations			
Socioeconomic Effects	Minor Impacts due to increase in work force mitigated by release of workers from Vogtle Plant construction. One county may have school and housing impacts.	Impacts greater than Reference DWPF due to sharp increase in work force without mitigation by Vogtle work force release.	Impacts less than other alternatives; work force is roughly 60% of other alternatives.
Maximum offsite individual exposure from gaseous releases (millirem/year)	8.3E-3	8.3E-3	6.3E-2
From liquid releases (millirem/year)	2.1E-2	2.1E-2	9.6E-3
Total (millirem/year)	2.9E-2	2.9E-2	7.3E-2
Maximum offsite individual health effects (cancer deaths/year)	1.1E-3	1.1E-3	9.6E-4
Normal transportation			
Maximum individual exposure (millirem/year)	1.3E-1	1.3E-1	1.3E-1
Maximum individual health effects (cancer deaths/year)	3.4E-2	3.4E-2	3.4E-2
Postulated accident			
DWPF maximum offsite individual exposure (millirem)	3.2E-1	3.2E-1	4.2E-2
Transportation			
Radiological			
Maximum individual exposure (millirem)	4.3E-3	4.3E-3	4.3E-3
Nonradiological			
Maximum injuries/year	1.6E0	1.6E0	1.6E0
Maximum deaths/year	1.0E-1	1.0E-1	1.0E-1

5.9.1 Socioeconomic effects

Potential socioeconomic impacts of the proposed action are regional and are associated primarily with the construction phase parameters (i.e., the size of the construction work force and the timing of the construction). The alternatives can be ranked as to their socioeconomic impact potential from most to least as follows: (1) reference immobilization alternative with Vogtle delayed, (2) reference immobilization alternative delayed ten years, (3) reference immobilization alternative with Vogtle on schedule, and (4) staged immobilization alternative. On the whole, impacts are predicted to be minor because of the relatively low number of in-movers and the dispersion of the work force over a large, six-county impact area. Because construction of the staged-process DWPF requires a smaller maximum work force (roughly 60% of the reference DWPF work force), this alternative is expected to cause the least impact on services and housing. The largest expected socioeconomic impacts would be caused by the demand for public schools by children of the in-movers and exacerbation of an existing housing shortage in some areas. In the one county where potentially significant school and housing impacts may be expected under all alternatives, the effect is graduated and diminishes with a decreasing number of in-movers. A monitoring program will be established to monitor key socioeconomic parameters for determining the severity and location of impacts. Mitigation measures, such as public aid, if needed, will require additional authorization before implementation.

5.9.2 Health risks

Protection of human health, both now and well into the future, is the primary consideration in proposing the immobilization and permanent geologic disposal of the SRP defense waste. The calculated radiation-induced regional or public health risks associated with the DWPF are extremely small. Routine releases, integrated over a 100-year period, will result in exposures amounting to only a very small fraction of those obtained from background radiation. Consequently, no significant health effects are anticipated as a result of routine radioactive releases from the DWPF. The probability of an accidental release of radioactivity from the DWPF is very small.

However, as with routine releases, calculations of exposures from postulated accidents that could result in radioactive releases show that regional or public health risk from accident-related releases is expected to be small. No substantial differences in health risks are evident among the alternatives.

5.9.3 Ecological effects

The ecological impacts of the DWPF are expected to be nonradiological, site-dependent, and primarily construction-related. Construction will probably disturb about 140 ha of wildlife habitat and temporarily affect a portion of the local aquatic environment. Recovery is anticipated when construction is complete, although about 80 ha will remain unavailable to wildlife and one carolina bay will be eliminated. The DWPF will occupy only about 0.1% of the SRP site and the carolina bay is one of about 200 at the SRP site. Additionally, construction activities will be planned to mitigate the occurrence of aquatic impacts, and an ecological monitoring program will be conducted during both DWPF construction and early operation to ensure minimum ecological impact.

5.9.4 Transportation

Transportation of the immobilized waste to a geologic repository has the potential for causing higher environmental risk than DWPF construction and operation. Nevertheless, radiological calculations of maximum population exposures during routine transport and maximum individual exposures in the event of an accident, made on the basis of conservative assumptions, show that exposure risks are very small compared with exposures from background radiation. Calculations of nonradiological transportation risks, based on the statistical incidence of injuries and fatalities in ordinary transportation accidents, show that this could be an important source of risk. Because impacts will depend on a number of factors, such as mode of transportation and distance travelled, mitigation measures may be possible. Disposal of the immobilized waste at SRP has been excluded as an alternative, necessitating the selection of another site. Final selection will be preceded by an environmental review, which will include an assessment of transportation effects and mitigation measures, if necessary.

5.10 CUMULATIVE EFFECTS

A review of existing and known-planned facility operations in the vicinity of the proposed DWPF was made to determine potential cumulative effects and to provide an understanding of the sensitivity of the analyses presented in this EIS to synergistic effects from other facilities. The potential for cumulative effect exists mainly in the socioeconomic area during the construction period for the proposed DWPF; however, these impacts are expected to be small. Radiological impacts from current and planned nuclear facilities are also small and well within applicable standards. Nonradiological releases are expected to be well within applicable standards and, because of the large distance to the site boundary, the incremental impacts on the air quality are expected to be well within the ambient air quality standards for South Carolina and Georgia.

5.10.1 Description of nearby facilities

5.10.1.1 Savannah River Plant

As discussed earlier, SRP is a DOE facility used to produce special nuclear materials. The plant comprises one fuel manufacturing facility, one heavy water plant, three operating reactors (plus two on standby), two chemical separations facilities and associated waste management operations, one burial ground, and process development laboratories. Present employment at the SRP is more than 8000 people.

Projects ongoing at the SRP include the upgrading of all SRP facilities to replace obsolete equipment and the preparation of a standby reactor (L-Reactor) for operation starting in October 1983.

A future project under consideration includes the possible construction of a fuel fabrication plant to produce fuel components for the naval reactor program.

5.10.1.2 Vogtle Power Plant

The Vogtle Power Plant is a nuclear power plant under construction within 20 km from the proposed DWPF by the Georgia Power Company. As discussed in Sect. 5.1.1, the socioeconomic impacts of Vogtle construction and operation have been considered in the analysis for the proposed DWPF.

The Vogtle Power Plant is licensed by the Nuclear Regulatory Commission, and its emissions will also be limited to the as-low-as-reasonably-achievable level.

5.10.1.3 Chem-Nuclear Systems, Inc.

The Chem-Nuclear Systems operates a low-level radioactive waste burial ground less than 20 km from the proposed DWPF under license from the South Carolina Department of Health and Environmental Control. No interaction between the proposed DWPF and the Chem-Nuclear burial ground is expected.

5.10.1.4 Barnwell Nuclear Fuel Plant

The only other major facility in the immediate vicinity of the proposed DWPF with potential synergistic effects is the Allied-General Nuclear Services's Barnwell Nuclear Fuel Plant. Future status of this facility is unknown, but at present time it is not operating.

5.10.2 Cumulative effects

The cumulative potential radiological effects of the proposed DWPF and the nearby nuclear facilities are presented in Table 5.53 for the hypothetical individual residing at all the site boundary locations with predicted maximum doses. These composite radiation doses are the sum of the maximum doses to different individuals at the site boundary of the SRP, including SRP, the proposed DWPF, and the Vogtle Power Plant; these doses are small for all three immobilization alternatives and less than 2% of the doses from natural background radiation.

Table 5.53. Composite radiological impacts of major nuclear facilities in the vicinity of the proposed DWPF[a] (millirem/year)

Exposure pathway	DWPF alternatives: Reference immobilization alternative	DWPF alternatives: Delay of reference immobilization alternative	DWPF alternatives: Staged process alternative	Nearby nuclear facilities: Savannah River Plant[b]	Nearby nuclear facilities: Vogtle power plants[c]
Gaseous	8.3E−3	8.3E−3	6.3E−2	7.0E−1	1E−1
Liquid	2.1E−2	2.1E−2	9.6E−3	2.2E−1	4E−1
Total	2.9E−2	2.9E−2	7.3E−2	9.2E−1	5E−1
Composite[d]	1.45EO	1.45EO	1.49EO		
Natural Back-round (SRP Area)	9.0E1	9.0E1	9.0E1	9.0E1	9.0E1

[a]Maximum individual dose from each facility. Radiation doses are not to the same individual.
[b]C. Ashley, *Environmental monitoring in the vicinity of the Savannah River Plant—Annual Report for 1980*, DPSPU 81-30-1 (May 1981).
[c]Vogtle EIS.
[d]Composite = DWPF + SRP + Vogtle.

The principal known, potentially significant cumulative impact of the proposed DWPF project is in the socioeconomic area. There are three major construction projects in the area: the two-unit Vogtle nuclear power plant in Burke County, just across the Savannah River from SRP, production upgrade projects at SRP, and the preparation of the standby L-Reactor for operation. The major impact will result from competition for very similar labor skills if the projects peak during the same period as the proposed DWPF alternatives. For instance, the number of in-movers to the six-county impact area doubles if both Vogtle and DWPF peak in the same period, and the socioeconomic impacts increase accordingly. If both Vogtle and DWPF stay on schedule (Vogtle peaks in 1983 and DWPF peaks in 1986 or 1987), however, the DWPF serves to minimize cumulative socioeconomic impacts by preventing a sharp decline in employment as Vogtle releases workers; the DWPF rising demand acts to stabilize and maintain the high employment levels in the area.

The effect of other simultaneous SRP projects, such as the restart and upgrade programs, will be to increase impacts by increasing the work force. The combined construction and operating workers for these two projects total more than 1000 for six years (1983-1988), creating a cumulative total about 30% greater than the DWPF staged process case for three years (1986-1988). The cumulative socioeconomic effects due to the demand for construction workers for the preferred staged process alternative would still be less than the impacts predicted for the reference immobilization alternative.

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6. ENVIRONMENTAL PERMITS AND APPROVALS

6.1 INTRODUCTION

This section examines the permits, certifications, licenses, and other approvals from the Federal government or the State of South Carolina that may be needed for the Defense Waste Processing Facility (DWPF). The emphasis is on air quality, water quality, disposal of solid and hazardous wastes, protection of critical wildlife habitats, and preservation of cultural resources Table 6.1).

Table 6.1. Required regulatory permits and notifications

Facility/activity	Requirement[a]	Agency[b]
DWPF project	EIS required for "major Federal action"	CEQ/EPA
DWPF site	Historic and archaeological site survey	South Carolina State Historic Preservation Officer
	Site use permit	DOE,SRO
	Endangered species	U.S. Fish and Wildlife
Construction activities	Authorization for open burning	DHEC-BAQC
	Concrete batch plant	
	Permit to construct (air)	DHEC-BAQC
	Permit to construct (water)	DHEC-IAWD
	Permit to operate (air)	DHEC-BAQC
	NPDES permit to discharge	DHEC-IAWD
Coal-fired steam generating plant	PSD permit to construct	DHEC-BAQC
	PSD permit to operate	DHEC-BAQC
Emergency diesel generators	PSD permit to construct	DHEC-BAQC
	PSD permit to operate	DHEC-BAQC
Chemical and industrial waste treatment facility	Permit to construct	DHEC-IAWD
	NPDES permit to discharge	DHEC-IAWD
Domestic water supply system	Permit to construct ground-water wells, treatment and distribution systems	DHEC-WSD
Sanitary wastewater treatment plant	Permit to construct	DHEC-IAWD
	NPDES Permit to discharge	DHEC-IAWD
Canyon exhaust stack	Notification of stack 61 m (200 ft)	FAA
	Permit to construct	DHEC-BAQC
	Permit to operate	DHEC-BAQC
Process sewer	Permit to construct	DHEC-IAWD
	NPDES permit to discharge	DHEC-IAWD
Surface runoff	Permit to construct	DHEC-IAWD
Saltcrete plant	Permit to construct	DHEC-BAQC
	Permit to operate	DHEC-BAQC
Storage of materials	SPCC plan	DHEC-IAWD/EPA

[a]NPDES = National Pollutant Discharge Elimination System, PSD = Prevention of Significant Deterioration, SPCC = Spill Prevention, Control, and Contingency.

[b]CEQ = Council on Environmental Quality, EPA = Environmental Protection Agency, DHEC = Dept. of Health and Environmental Control, BAQC = Bureau of Air Quality Control, IAWD = Industrial and Agricultural Wastewater Division, WSD = Water Supply Division, and FAA = Federal Aviation Administration.

The health and safety aspects of the handling of radioactive materials, the transport of radioactive materials, and associated activities governed by the Atomic Energy Act (AEA) of 1954 as amended (40 USC 2011 et seq.) and related legislation are outside the scope of this section and are discussed in Appendix D and ref. 1.

The DOE, as a Federal agency, is required to comply with a number of environmental requirements under various Federal laws. The Federal requirements include, but are not limited to, those outlined in the six laws and three executive orders described herein.

National Environmental Policy Act of 1969, as amended (NEPA) (42 USC 4321 et seq.). This Act requires "all agencies of the Federal Government" to prepare a detailed statement on the environmental effects of proposed "major Federal actions significantly affecting the quality of the human environment." In accordance with the requirements of NEPA, the DOE is filing with the Environmental Protection Agency (EPA) and circulating to the public this environmental impact statement (EIS) on the DWPF. This EIS has been prepared in accordance with the Council on Environmental Quality (CEQ) Regulations on Implementing National Environmental Policy Act Procedures (40 CFR 1500-1508) and DOE Guidelines for Compliance with the National Environmental Policy Act.[2]

Executive Order 12088 (October 13, 1978). This Executive Order, issued by the President of the United States, requires every Federal agency to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the following Federal laws:

1. Toxic Substances Control Act (15 USC 2601 et seq.),
2. Federal Water Pollution Control Act (33 USC 1251 et seq.),
3. Public Health Service Act, as amended by the Safe Drinking Water Act (42 USC 300 (f) et seq.),
4. Clean Air Act (42 USC 7401 et seq.),
5. Noise Control Act (42 USC 4901 et seq.), and
6. Solid Waste Disposal Act (42 USC 6901 et seq.).

The Executive Order also requires Federal compliance with radiation guidance pursuant to Section 2174(h) of the Atomic Energy Act of 1954, as amended [42 USC 2021(h)].

Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) (May 24, 1977). These executive orders require governmental agencies to avoid to the extent possible any short- and long-term adverse impacts on wetlands wherever there is a practicable alternative. The DOE has issued regulations 10 CFR Part 1022 for compliance with these Executive Orders.

Clean Air Act (42 USC 7401 et seq.) as amended by the Clean Air Act Amendments of 1977 (PL 95-95). Section 118 provides for the control of air pollution by Federal facilities. It requires that each Federal agency, such as the DOE, having jurisdiction over any property or facility that may result in the discharge of air pollutants comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution. Authority for regulation of air emissions has been delegated by the EPA to the South Carolina Department of Health and Environmental Control (DHEC), Bureau of Air Quality Control.

Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 (33 USC 1251 et seq.). This Act requires all branches of the Federal government engaged in any activity that may result in a discharge or runoff of pollutants, excluding materials regulated under the Atomic Energy Act of 1954, to comply with Federal, state, interstate, and local requirements. Authority for implementation of these requirements has been delegated to DHEC and to the U.S. Army Corps of Engineers for dredge and fill operations. D-1, H-2

Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 3251 et seq.). This Act governs the generation, management, transportation, and disposal of solid and hazardous wastes. It does not apply to source, by-product, or special nuclear material that is regulated by the AEA of 1954 (42 USC 2011 et seq.). DOE has also taken the position that hazardous waste generated by DOE activities pursuant to the AEA are subject to DOE standards and, therefore, not subject to regulations under RCRA.

Noise Control Act of 1972 (42 USC 4901 et seq.). Section 4 of this Act directs all Federal agencies "to the fullest extent within their authority" to carry out programs within their jurisdiction in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health or welfare. The DOE will comply with such requirements to the fullest extent possible.

Endangered Species Act of 1973 (16 USC 1531 et seq.). The Endangered Species Act of 1973, as amended, is intended to prevent the further decline of endangered and threatened species and, also, to bring about the restoration of these species and their habitats. The Act, which is jointly administered by the Departments of Commerce and Interior, does not require a permit, certification, license, or other formal approval. Section 7 does, however, require a consultation to determine whether endangered and threatened species are known to have critical habitats on or in the vicinity of the site. The DOE will comply with this law by taking all necessary precautions to ensure that its proposed action will not jeopardize the continued existence of any threatened or endangered species and/or their critical habitats.

The sections that follow summarize the Federal and South Carolina applicable requirements with which the DWPF project will comply.

6.2 FEDERAL AND STATE PERMITS AND APPROVALS

6.2.1 Historic preservation

No particular permits, certifications, or approvals are required relative to historic preservation. However, the DOE must provide an opportunity for comment and consultation with the Advisory Council on Historic Preservation as required by the Historic Preservation Act of 1966 (16 USC 470(f) et seq.). Section 106 of the Act requires Federal agencies with jurisdiction over a Federal "undertaking" to provide the Council an opportunity to comment on the effect that activity might have on properties included in, or eligible for nomination to, the National Register of Historic Places.

Executive Order 11593 of May 13, 1971, requires Federal agencies to locate, inventory, and nominate properties under their jurisdiction or control to the National Register of Historic Places if the properties qualify. Until this process is complete, the agency must provide the advisory council an opportunity to comment on the possible impacts of proposed activities on eligible properties.

An archeological and historic survey of the DWPF site was completed in 1979 and that of the salt burial area in 1980. The surveys revealed no sites that meet the criteria for eligibility for inclusion in the national register. The DWPF site survey results were reviewed by the South Carolina State Historic Preservation Officer, who concurred with the survey findings. The salt burial area survey results are currently under review.

6.2.2 Solid waste disposal

The DWPF process and operations, in addition to the immobilized high-level waste containerized for disposal in a Federal repository, will produce the following types of solid waste materials containing radioactivity:

1. salt (or saltcrete),
2. low-level waste (LLW) from immobilization operations, and
3. contaminated equipment.

The disposal of all these materials is governed by the AEA, as amended, and related DOE requirements. As described in Sects. 3.1.2.2 and 3.1.3.2, the salt will be disposed of in a burial facility that is designed and constructed to comply with the DOE, EPA, and DHEC guidelines and regulations applicable to both low-level radioactive and hazardous wastes. DOE regulations for the disposal of the radioactive waste[2] govern the disposal of the salt in accordance with the AEA; thus, no specific permits are required. Other solid radioactive waste from the DWPF will be appropriately packaged and transported for disposal to a currently operating onsite radioactive waste burial area at the Savannah River Plant (SRP).

The DWPF will also generate several types of nonradioactive solid waste. These include:

1. sanitary waste sludges,
2. deionizing resins and other nonradioactive process waste,
3. trash,
4. fly ash and bottom ash,
5. scrubber sludges, and
6. industrial and chemical waste treatment sludge.

The fly ash, bottom ash, and scrubber sludges will be disposed of in an ash pond near the DWPF. All other nonradioactive solid wastes will be transported from the DWPF to existing storage or disposal facilities at the SRP and will be processed and/or buried as appropriate.

6.2.3 Endangered species

Ecological surveys[3] of the DWPF area by the Savannah River Ecology Laboratory identified no species on the Federal list of endangered species. The results of these surveys have been reviewed and concurred in by the U.S. Fish and Wildlife Service to Wildlife Service (see Appendix C).

6.2.4 Water quality

Industrial and domestic water for the DWPF will be provided from new water wells constructed for that purpose at the DWPF site. Before wells are drilled, the DOE will obtain a permit to construct a noncommunity public water supply system from the Water Supply Division of DHEC.

Section 402 of the Clean Water Act as amended is the basis for controlling "point-source" discharges of pollutants into the navigable waters of the United States through the National Pollutant Discharge Elimination System (NPDES) administered by the USEPA. In South Carolina the USEPA has delegated permitting authority under NPDES to the state. Most liquid effluents from the DWPF, such as boiler ash basin effluents, storm runoff, cooling-tower blowdown, etc., will be collected by the chemical and industrial waste treatment system and processed, if necessary, before discharge. Other effluents, such as general purpose evaporator blowdown and storm runoff from the salt burial area will be discharged separately. The DOE will obtain a permit to construct the discharge facilities from the Industrial and Agricultural Wastewater Division (IAWD) of DHEC. Six months before startup, DOE will request from DHEC an amendment to the NPDES permit for the overall SRP operations to include discharges from the DWPF.

D-1, H-2 Section 404 of the Clean Water Act, as amended, is the basis for requirements controlling dredge and fill operations. This act gives the Corps of Engineers the broad authority to regulate activities in wetlands of greater than 10 acres (33 CFR 323). Because of Sun Bay's size of about 1 hectare (2 acres), DOE has determined that a Section 404 permit will not be required.

6.2.5 Air quality

The purpose of the USEPA regulations for the prevention of significant deterioration (PSD) is to protect the clean air areas of the nation from the degradation of air quality. The PSD requirements are based on the 1977 amendments to the Clean Air Act. The act establishes a classification system for areas where air quality is better than that required by the national ambient air quality standards and limits the permitted incremental increases in pollutant concentrations. Authority to apply PSD controls in South Carolina has been delegated by the USEPA to the DHEC Bureau of Air Quality Control.

Should a coal-fired power plant be required, the DOE will obtain from DHEC a permit to construct the coal-fired boiler that satisfies the PSD requirements and conforms to the New Source Performance Standards established by the USEPA. Before the beginning of normal operation DOE will submit to DHEC an application for an operating permit. DHEC will then evaluate the installation and may measure actual emissions to determine compliance with South Carolina Air Pollution Control Regulations and Standards. Following this evaluation (normally within 90 days of the beginning of normal operation) DHEC will issue DOE a Permit to Operate.

The concrete batch plant used during DWPF construction and the saltcrete plant will each require a permit to construct from the DHEC-BAQC and a Permit to Operate from the same regulatory agency.

REFERENCES FOR SECTION 6

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2. U.S. Department of Energy, "Guidelines for Compliance with the National Environmental Policy Act," *Fed. Regist.* 45(62): 20694-20701 (Mar. 28, 1980).

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7. LIST OF PREPARERS

Name	Area of responsibility: Section S	1	2	3	4	5	6	Appendix A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
L. A. Abrams				X																		
S. C. Allen				X																		
L. G. Berry																		X				
J. W. Boyle		X																				X
R. B. Braid, Jr.																		X				
H. M. Braunstein	X					X																
L. M. Bronfman																		X				
S. K. Breslauer			X				X															
S. A. Carnes																		X				
S. J. Cotter						X													X			
D. K. Dougherty						X											X		X			
G. F. Edgley																		X				
P. H. Feldhausen					X	X								X								
R. B. Garey															X							
G. S. Hill, Jr.					X	X											X		X			
E. G. Llewellyn																		X				
J. F. McBrayer					X	X																
L. F. Menendez					X																	
P. J. Mulholland					X	X															X	
J. P. O'Brien					X	X							X									
E. B. Peelle					X	X						X			X			X				
R. K. Rao						X											X		X			
J. H. Reed																		X				
I. J. Samec																		X				
M. Schweitzer					X																	
E. J. Soderstrom																		X				
R. H. Stevenson												X										
J. C. Tseng								X	X	X						X				X		
D. O. Wicks																		X				
T. A. Wheeler				X		X					X											
E. L. Wilmot				X		X					X											
H. E. Zittel				X																		

NAME and AFFILIATION	Leonard A. Abrams NUS Corporation
EDUCATION	B.S., Metallurgical Engineering, Virginia Polytechnical Institute Graduate courses in metallurgy, ORINS
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 30 years (Publications). Nuclear technology background; nuclear fuel cycle waste processing, packaging, and transportation; facility safety analysis.
EIS RESPONSIBILITY	Assisted S. C. Allen in preparation of Sect. 3.

NAME and AFFILIATION	S. Clark Allen NUS Corporation
EDUCATION	Ph.D., Chemical Engineering, U. of Missouri M.S., Chemical Engineering, U. of Missouri B.S., Chemical Engineering, U. of Missouri
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 16 years (Publications — 6). Management responsibilities — multi-disciplinary environmental baseline studies, trace metal analysis; EPA technical advisor.
EIS RESPONSIBILITY	Lead responsibility for preparation of Sect. 3.

NAME and AFFILIATION	Linda G. Berry Oak Ridge National Laboratory
EDUCATION	Ph.D., Sociology, U. of Tennessee M.A., Sociology, U. of Tennessee B.A., Sociology, U. of California, Riverside
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 6 years (Publications — 16). Demography, social impact assessment, evaluation research.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	John W. Boyle Oak Ridge National Laboratory
EDUCATION	M.S., Chemistry, Emory University B.S., Chemical Engineering, Emory University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 38 years (Publications — 25). Chemical effects of ionizing radiations and photons; management responsibilities multidisciplinary environmental impact statements.
EIS RESPONSIBILITY	Project manager for preparation of EIS; prepared Sect. 1.

NAME and AFFILIATION	Robert B. Braid, Jr Oak Ridge National Laboratory
EDUCATION	Ph.D., Political Science, University of Tennessee M.A., Political Science, University of Tennessee B.S., Political Science, Lambuth College
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 10 years (Publications — 25). Political science, energy policy, social impact analysis.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Helen M. Braunstein Oak Ridge National Laboratory
EDUCATION	Ph.D., Physical Chemistry, University of Maine M.S., Chemistry, University of Maine B.A., Chemistry, University of Maine
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 10 years (Publications — 29). Environmental health, trace elements in the environment, coal conversion, biomass, thermodynamics of solutions.
EIS RESPONSIBILITY	Prepared summary, Sects. 5.6, 5.9, 5.10, glossary, index, and assisted in revisions.

NAME and AFFILIATION	Lois M. Bronfman Oak Ridge National Laboratory
EDUCATION	Ph.D., Political Science, University of Oregon M.A., International Relations, Johns Hopkins University, School of Advanced International Studies, Washington, D.C. B.A., Political Science, Michigan State University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 7 years (Publications — 15). Social impacts and policy analysis; management of radioactive and hazardous wastes.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Stephen K. Breslauer NUS Corporation
EDUCATION	Graduate courses in Nuclear Engineering, University of Cincinnati B.A., Physics, Cornell University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 23 years (Publications). Management in environmental programs, nuclear-plant siting studies, multidisciplinary studies. Reprocessing of nuclear wastes and storage. Safety evaluation of nuclear facilities.
EIS RESPONSIBILITY	Manager for NUS Corporation DWPF related activities. Prepared Sects. 2, 5.7, 5.8, and 6. Assisted in revisions.

NAME and AFFILIATION	Samuel A. Carnes Oak Ridge National Laboratory
EDUCATION	Ph.D., Political Science, Northwestern University M.A., Political Science, University of New Mexico B.A., Chemistry, University of New Mexico
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 6 years (Publications — 15). Social impacts and policy analysis, land-use, hazardous and radioactive waste management.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Sherri J. Cotter Oak Ridge National Laboratory
EDUCATION	M.S., Bionucleonics, Purdue University B.S., Physics, Berea College
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 5 years (Publications — 15). Calculations of radiation dose to man, computer codes pertaining to radioactive releases, model validation, health physics.
EIS RESPONSIBILITY	Radiation dose estimations to maximum individual and 80 km population dose from atmospheric releases.

NAME and AFFILIATION	David K. Dougherty NUS Corporation
EDUCATION	B.S., Biochemistry (Honors and Distinction), University of Delaware
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 8 years (Publications). Pathway and radiation dose assessments, radiological impact analysis, environmental monitoring.
EIS RESPONSIBILITY	Major contributor to Sect. 5 and Appendices J and L. Prepared sections on radiation health effects from routine and accidental releases; 100-year environmental dose commitment; accident scenarios.

NAME and AFFILIATION	Gerald J. Edgley NUS Corporation
EDUCATION	Master of Urban and Regional Planning, George Washington University B.S., Conservation and Resource Development, University of Maryland
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 9 years (Publications). Urban and regional planning, socioeconomics, fiscal analysis, transportation analysis, community development and land use.
EIS RESPONSIBILITY	Assisted in the preparation of Appendix K.

NAME and AFFILIATION	Peter H. Feldhausen NUS Corporation
EDUCATION	M.S., Geology, University of Wisconsin B.S., Geology, University of Wisconsin
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 13 years (Publications — 21). Registered geologist, registered geophysicist; multidisciplinary environmental projects, oceanographic and continental shelf studies, siting of high-level radioactive waste repository.
EIS RESPONSIBILITY	Prepared Sect. 4.4 and Appendix G.

NAME and AFFILIATION	Robert B. Garey Oak Ridge Associated Universities
EDUCATION	Ph.D., Political Science, University of South Carolina M.A., Political Science, University of South Carolina B.S., Mathematics, University of South Carolina
EXPERIENCE, TECHNICAL SPECIALITY	Experience — 4 years (Publications — 7). Labor market analysis, public policy analysis, assessment of nuclear waste policy options, assessment of energy related programs.
EIS RESPONSIBILITY	Prepared Appendix H.

NAME and AFFILIATION	Gorman S. Hill, Jr. Oak Ridge National Laboratory
EDUCATION	M.S., Zoology, University of Tennessee B.S., Zoology, Lincoln Memorial University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 35 years (Publications — 20). Certified by U.S. Board of Health Physics. Radiation biology and health physics, environmental impact assessment, radiation dose assessment to maximum individual and regional population.
EIS RESPONSIBILITY	Prepared Sect. 4.3. Major contributor to Sects. 5.1, 5.2, 5.3, 5.5 and Appendices J and L. Responsible for radiological impacts including radiological doses from routine liquid and airborne releases and accidents involving radioactivity.

NAME and AFFILIATION	Elaine G. Llewellyn Oak Ridge National Laboratory
EDUCATION	B.A., Political Science, University of Tennessee
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 5 years (Publications — 2). Environmental impact assessment.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	James F. McBrayer Oak Ridge National Laboratory
EDUCATION	Ph.D., Ecology, University of Tennessee M.S., Entomology, Purdue University B.S., Biology, Miami (Ohio) University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 9 years (Publications — 30). Research and assessment on environmental consequences of energy production, utilization, and waste disposal, ecosystem ecology, cycling of radionuclides.
EIS RESPONSIBILITY	Prepared Sect. 4.1. Major contributor to Sect. 4.6. Contributor to Sect. 5.1 and 5.5. Responsible for impacts to terrestrial ecology.

NAME and AFFILIATION	Luisa Freeman Menendez TRW, Incorporated
EDUCATION	M.S., (in progress) Urban and Economic Geography, University of Tennessee B.S., Economics, Mary Washington College
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 2 years (Publications — 8). Socioeconomic impact analysis, cost/benefit economic analysis, energy systems, regulatory, and urban impact analysis.
EIS RESPONSIBILITY	Prepared Sect. 4.2.

NAME and AFFILIATION	Patrick J. Mulholland Oak Ridge National Laboratory
EDUCATION	Ph.D., Environmental Biology, University of North Carolina M.S., Sanitary Engineering, Cornell University B.S., Civil and Environmental Engineering, Cornell University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 3 years (Publications — 9). Aquatic ecology, environmental impact assessment of nuclear fuel cycle facilities and coal-fired plants, nutrient spiralling in stream ecosystems, wetland ecology.
EIS RESPONSIBILITY	Major contributor to Sects. 4.5, 4.6, 5.1, 5.2, 5.3, 5.5 and Appendix N. Responsible for impacts to aquatic ecology.

NAME and AFFILIATION	Joseph F. O'Brien NUS Corporation
EDUCATION	M.E., Water Resources Engineering, Clemson University M.S., Chemistry, Lehigh University B.A., Chemistry, Lehigh University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 32 years (Publications — 17). Hydrology, land-use and water-use analysis, nuclear weapons effects, new materials development.
EIS RESPONSIBILITY	Major contributor to Sects. 4.5 and 5.4. Prepared Appendix F. Responsible for ground water hydrology.

NAME and AFFILIATION	Elizabeth B. Peelle Oak Ridge National Laboratory
EDUCATION	M.S., Sociology, University of Tennessee B.A., Chemistry, Western College
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 12 years (Publications — 22). Community impacts of energy facilities; mitigation of social impacts; institutional analysis of siting.
EIS RESPONSIBILITY	Contributor to Sects. 4.2, 5.1, 5.2, 5.3, and 5.9; also Appendices E, H, and K. Responsible for socioeconomic sections.

NAME and AFFILIATION	Ramana K. Rao NUS Corporation
EDUCATION	Ph.D., Meteorology, University of Utah M.S., Oceanography and Meteorology, University of Michigan B.S., Math and Physics, Andhra University, India
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 10 years (Publications — 3). Atmospheric dispersion modeling, health effects from air emissions, radiological impact assessments, site selection studies, monitoring assessment.
EIS RESPONSIBILITY	Contributor to Sect. 5 and Appendices J and L.

NAME and AFFILIATION	John H. Reed Oak Ridge National Laboratory
EDUCATION	Ph.D., Sociology, Cornell University M.A., Sociology, Cornell University B.S., Sociology, Iowa State University
EXPERIENCE, TECHNICAL SPECIALTY	Experience – 7 years (Publications – 20). Environmental sociology, social impact and policy analysis, statistics and methodology.
EIS RESPONSIBILITY	Contributor to Appendix K.

NAME and AFFILIATION	Irwin J. Samec NUS Corporation
EDUCATION	Masters of Urban and Regional Planning, Michigan State University B.A., Sociology, Illinois Wesleyan University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 11 years (Publications). Environmental planning, environmental impact statements, and socioeconomic impact analysis; socioeconomic and land-use characterization; water pollution abatement; transportation analysis.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Martin Schweitzer Oak Ridge National Laboratory
EDUCATION	M.S., Planning, University of Tennessee B.A., Psychology, University of Michigan
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 3 years (Publications — 10). Urban planning, social change analysis, environmental impact analysis.
EIS RESPONSIBILITY	Assisted in preparation of Sect. 4.2 and Appendix K.

NAME and AFFILIATION	E. Jonathan Soderstrom Oak Ridge National Laboratory
EDUCATION	Ph.D., Psychology, Northwestern University B.A., Psychology, Hope College
EXPERIENCE, TECHNICAL SPECIALTY	Experience – 4 years (Publications – 10). Evaluation and social impact analysis.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Robert H. Stevenson Oak Ridge National Laboratory
EDUCATION	M.S., (in progress) Urban Planning, University of Tennessee M.P.H., Public Health, University of Tennessee B.S., Health Sciences, Ball State University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 1 year (Publication — 1). Environmental health, urban planning, environmental education.
EIS RESPONSIBILITY	Major preparer of Appendix E.

NAME and AFFILIATION	John C. Tseng Savannah River Operations, Department of Energy
EDUCATION	M.S., Environmental Health Engineering, Northwestern University B.S., Aeronautical and Astronautical Sciences, Massachusetts Institute of Technology
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 10 years (Publications). Professional Engineer — State of Illinois. Environmental engineering and radiation protection, compliance with regulations, environmental monitoring, environmental impact assessment.
EIS RESPONSIBILITY	Primary reviewer for Savannah River Operations. Responsible preparer for Appendices A, B, C, I, M.

NAME and AFFILIATION	Dennise O. Wicks NUS Corporation
EDUCATION	B.A., Geography, University of Delaware
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 2 years (Publications). Environmental planning, socioeconomic impact assessment, siting of plant facilities.
EIS RESPONSIBILITY	Assisted in preparation of Appendix K.

NAME and AFFILIATION	Timothy A. Wheeler Sandia National Laboratories
EDUCATION	M.S., Systems Engineering, University of Virginia B.S., Mechanical Engineering, University of New Hampshire
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 1 year (Publications). Radiological impact analysis of transporting radioactive materials.
EIS RESPONSIBILITY	Contributor to Sects. 5.1, 5.5, and Appendix D.

NAME and AFFILIATION	Edwin L. Wilmot Sandia National Laboratories
EDUCATION	M.S., Ceramic Engineering, University of Washington B.S., Ceramic Engineering, University of Washington
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 9 years (Publications). Nuclear technology, environmental impact statement support.
EIS RESPONSIBILITY	Major preparer of Sects. 3.1, 5.1, 5.5, and Appendix D. Responsible for transportation impacts.

NAME and AFFILIATION	H. E. Zittel Oak Ridge National Laboratory
EDUCATION	Ph.D., Chemistry, Vanderbilt University M.S., Chemistry, Vanderbilt University B.S., Chemistry, Vanderbilt University
EXPERIENCE, TECHNICAL SPECIALTY	Experience — 28 years (Publications — 50). Environmental impact statements for nuclear power reactors and the nuclear fuel cycle, reactor safeguards, electrochemistry, spectrochemistry, radiation chemistry.
EIS RESPONSIBILITY	Contributor to Sect. 3.1, sections on site selection.

Appendix A

RECORD OF DECISION ON LONG-TERM MANAGEMENT OF DEFENSE HLW, SRP

DEPARTMENT OF ENERGY

Assistant Secretary for Nuclear Energy

Long-Term Management of Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization), Savannah River Plant; Record of Decision

Decision

The decision has been made to continue a large Federal research and development (R&D) program directed toward the immobilization of the high-level radioactive wastes at the Savannah River Plant (SRP) and not to undertake an R&D program on direct disposal of the wastes in bedrock.

Background

The SRP near Aiken, South Carolina, is a major installation of the Department of Energy (DOE) for the production of nuclear materials for national defense. It began operations in the early 1950's and is currently the Nation's primary source of reactor-produced defense materials. The SRP operations also produce liquid high-level radioactive waste from the chemical processing of fuel and target materials after irradiation in the SRP nuclear reactors. The high-level waste has been and is continuing to be stored safely in underground tanks that are engineered to provide reliable storage of the waste isolated from the environment. DOE is developing methods for permanent disposal of these wastes.

DOE published the final environmental impact statement "Long-Term Management of Defense High-Level Radioactive Wastes (Research and Development Program for Immobilization), Savannah River Plant, Aiken, South Carolina," (DOE/EIS-0023) in November 1979. Notices of its availability were published in the **Federal Register** by DOE on December 3, 1979 (44 FR 69320) and by the Environmental Protection Agency on December 7, 1979 (44 FR 70563).

Description of Action

The multi-year R&D program being continued is aimed at developing the technology for removing the wastes from the tanks, concentrating them into a high activity fraction, and immobilizing the radioactive nuclides in a high integrity form for subsequent disposal. Since the method of disposal has not been chosen, the R&D program is sufficiently broad in its initial stages so that it can be modified in later stages as appropriate, to satisfy the immobilization requirements of a variety of disposal techniques. Moreover, the R&D program provides for the development of a variety of waste forms, to permit the ultimate waste form to be specifically tailored to the exigencies of the disposal method ultimately selected.

Description of Alternatives

The alternatives to carrying out the immobilization R&D program considered by DOE in reaching this decision are:

1. terminate the immobilization R&D program and continue tank storage of the wastes indefinitely with transfer to new tanks about every 50 years (no action alternative).
2. fund an R&D program for direct disposal of the waste in bedrock under the Savannah River Plant.

Basic for Decision

Orientation of the Savannah River technology development program toward conversion of the waste to a high-integrity form for subsequent disposal has been influenced by public opinion and perception of risks, as expressed through governmental bodies and special interest groups. For example, comment letters on DOE/EIS-0023D were received from the Governor of the State of Georgia indicating opposition to bedrock disposal of waste under the SRP site, and from the U.S. Environmental Protection Agency categorizing any bedrock disposal option at SRP as Environmentally Unsatisfactory.

The decision to continue the R&D program is consistent with the recommendation of the Interagency Review Group on Nuclear Waste Management (IRG) that:

"DOE accelerate its R&D activities oriented toward improving immobilization and waste forms and review its current immobilization programs in the light of the latest views of the scientific and technical community. Since final processing of defense waste has been deferred for three decades the IRG also recommends that remedial action, including immobilization of the waste, should begin as soon as practicable."

A great deal of uncertainty is associated with the prediction of the environmental impacts which could result over very long periods of time from the disposal of radioactive wastes. Accordingly, DOE has selected the conservative approach of proceeding with the immobilization R&D program. Although the environmental impacts which are predicted to result from implementing any of the alternatives are small, proceeding with the immobilization R&D program is the most conservative approach to provide an option to help assure that the waste will not enter the biosphere and will pose no significant threat to public health and safety.

The most significant quantifiable differences between the alternatives are the differences in budgetary costs. The estimated capital and operating cost of the alternatives in constant 1980 dollars are: perpetual tank storage, $510 million; bedrock disposal, $755 million; and immobilization for disposal, $3600 to $3750 million. Although implementation of the immobilization R&D program is the costliest alternative, retaining SRP waste disposal method flexibility and responding to the expressed public concern to minimize the risk of exposure to the general population from radioactive waste disposal justify continuation of the immobilization R&D program.

Discussion of Environmentally Preferred Alternatives

There are no substantial environmental impacts arising from nuclear radiation for any of the alternatives. The offsite population exposure risk from the alternative with the highest risk (liquid waste stored in SRP bedrock cavern) is more than one-thousand fold lower than natural radiation exposure to the same population. Nonnuclear fatalities to be expected from construction and operating activities related to each alternative are greater than those that would be expected for radiation effects, but are no larger than the risks voluntarily accepted by industrial workers. Off-site radiation risks, occupational exposures, nonnuclear risks, and other environmental effects are small in absolute magnitude for all options analyzed.

On a relative basis, some differences in environmental impact among the alternatives are evident. The no action alternative would result in lower occupational exposures but higher offsite population dose risk and more nonnuclear accidental fatalities than would implementation of the immobilization R&D program. Alternative 2 (bedrock disposal) is estimated to result in the lowest occupational radiation exposure and the lowest estimated fatality rate from nonnuclear accidents but the highest offsite population dose risk. Based on the judgment that offsite population radiation dose risk over time is a more important consideration than either occupational dose risk or fatalities from nonnuclear accidents, the analysis in DOE/EIS-0023 indicates that the immobilization R&D program with the lowest potential offsite population dose risk is the environmentally preferable alternative. This is primarily due to the degree of isolation afforded by rendering the wastes less mobile in the environment.

Occupational related risks such as occupational radiation exposure and nonnuclear accidents generally are voluntary in nature; conversely, offsite radiation exposures are involuntary in nature and involve a greater number of people. Accordingly, the offsite population dose was the *controlling* consideration in selecting continuation of the immobilization R&D program as the environmentally-preferred alternative.

Considerations in Implementation of the Decision

The continuation of the DOE R&D program to immobilize the SRP liquid high-level radioactive waste will not pose any significant adverse environmental impact prior to a proposal for a specific facility which would be addressed in a separate NEPA review. No mitigation activities are anticipated.

For the United States Department of Energy.

Dated: February 1, 1980.

George W. Cunningham,

Assistant Secretary for Nuclear Energy.

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Appendix B

DWPF ALTERNATIVE WASTE FORMS PROGRAM

Appendix B

DWPF ALTERNATIVE WASTE FORMS PROGRAM

B.1 SUMMARY

Evaluation of potential waste forms for immobilization of SRP high-level waste began in 1973; borosilicate glass was selected as the reference waste form in 1977. As a backup to borosilicate glass, several alternative waste forms were evaluated for possible application to SRP waste. Final selection of the waste form for the proposed Defense Waste Processing Facility (DWPF) will be made by October 1983, based on results of this Alternative Waste Form (AWF) Program and the associated environmental review.

The current AWF Program is divided into three stages: (1) an assessment and selection of AWFs for further analysis, which ended in December 1979; (2) preliminary development of selected alternative forms for characterization of performance potential and conceptual processes, which ended October 1981, with the selection of one alternative form (in addition to borosilicate glass); and (3) an assessment of environmental and economic impacts of the two forms to support a final waste form decision by October 1983. TC

The first step in this program, a screening evaluation and the selection of the alternative forms, has been completed.[1] In addition to the reference borosilicate glass form, three generic forms were selected for more analysis: high silica glass from a porous glass matrix process; generic crystalline ceramic, such as SYNROC or tailored supercalcine ceramic; and generic coated ceramic particles. In the second step, these forms were compared to the reference borosilicate glass form for safety, processing, performance characteristics, and resulted in the selection of crystalline ceramic as the alternative waste form.

Basic elements of the AWF assessment program include: development and characterization of waste forms; process development; conceptual design studies; and risk assessments for all components of the waste manufacturing and disposal system. An environmental review will be performed to assess and document the potential environmental impact of alternative waste form(s). This review will serve in conjunction with data from the waste form development programs as the bases for the final waste form decision.

It is recognized that selection of a waste form other than borosilicate glass for SRP waste would impact the DWPF program and would result in some nonrecoverable costs and delays in design, construction, and start-up of the facility. To minimize these potential impacts, results of the AWF evaluation program are being followed closely and will be integrated into the DWPF design effort insofar as is practical.

B.2 PROGRAM

The program to develop an immobilization process for SRP high-level radioactive waste began in 1973. The characteristics of SRP waste were investigated to define tentative criteria for acceptable waste forms. Subsequently, a literature study was made of the properties of available candidate solid waste forms and of the processes that are used to prepare them. An evaluation of each of these waste forms was made by (1) comparing their properties with the criteria for acceptance and (2) determining if the processes for making them are compatible with SRP waste. The results of this study are provided in the report, *Solid Forms for Savannah River High-Level Wastes*.[2]

Based on the above study, concrete and borosilicate glass were selected for further evaluation. Waste forms were produced using simulated and actual SRP waste, and conceptual designs were completed. After evaluation[3-5] of the waste form properties and process requirements, borosilicate glass was selected as the reference DWPF waste form in 1977. A major effort is currently underway to develop the technology required to immobilize SRP high-level waste in borosilicate glass.

In addition, DOE has investigated several alternative waste forms that appeared to possess better product performance characteristics than borosilicate glass. Preliminary repository acceptance criteria have been established, and preliminary performance and process data on alternative forms have been developed.

To provide the technical information to enable final selection of the waste form for the DWPF, viable alternative forms with the highest potential for improved performance over the reference borosilicate glass form were evaluated in a Savannah River Laboratory (SRL) assessment program. Forms with poorer product performance properties were not considered further. A recent screening evaluation[1] indicated that processing complexity for all forms evaluated except one was greater than for borosilicate glass. That exception was similar to glass in process complexity but had poorer product performance properties.

Information on the selected alternative will be developed for fabrication and performance characteristics; on processing characteristics including production feasibility, complexity, equipment requirements, and compatibility with remote operation; and on impact of the alternative form on the safety of the total immobilization system from manufacturing to terminal storage in the repository. Processing and equipment considerations will be addressed in the development and assessment programs.

TC

The principal elements of the AWF assessment program are listed below and discussed in detail in the next section:

1. assessment of alternative waste forms, selection of most promising forms for detailed evaluation, and final selection of waste form for the DWPF;
2. development and characterization of waste forms;
3. comparative testing of alternative forms containing simulated waste;
4. process development;
5. conceptual design studies to determine impacts of AWFs on the DWPF; and
6. risk assessments (dose-to-man) associated with all components of the waste form manufacturing-disposal system.

The AWF assessment program for SRP waste relies on the development of the selected forms and their processes by contractors of DOE's National HLW Technology Program.[6,7,8] The basis for final waste form selection for the DWPF will be the combined results of contractor development programs and the SRL assessment program. Final selection will consider results of repository studies by the Office of Nuclear Waste Isolation (ONWI), including the specifications of repository conditions and radiation risk assessments; transportation safety studies under the Transportation Technology Center at Sandia National Laboratories; and the development of waste form acceptance criteria by the Nuclear Regulatory Commission (NRC) in conjunction with ONWI. Figure B.1 gives the schedule for DWPF construction and operation, including the waste form selection, and its relationship to the repository and transportation programs.

B.2.1 Program elements

B.2.1.1 Assessment and selection of waste form

The preliminary screening evaluation[1] of eleven waste form candidates was completed and three generic forms, in addition to borosilicate glass, were selected for more detailed analysis:

1. high silica glass from a porous glass matrix process,
2. generic crystalline ceramic such as SYNROC and other tailored ceramic, and
3. generic coated ceramic particles.

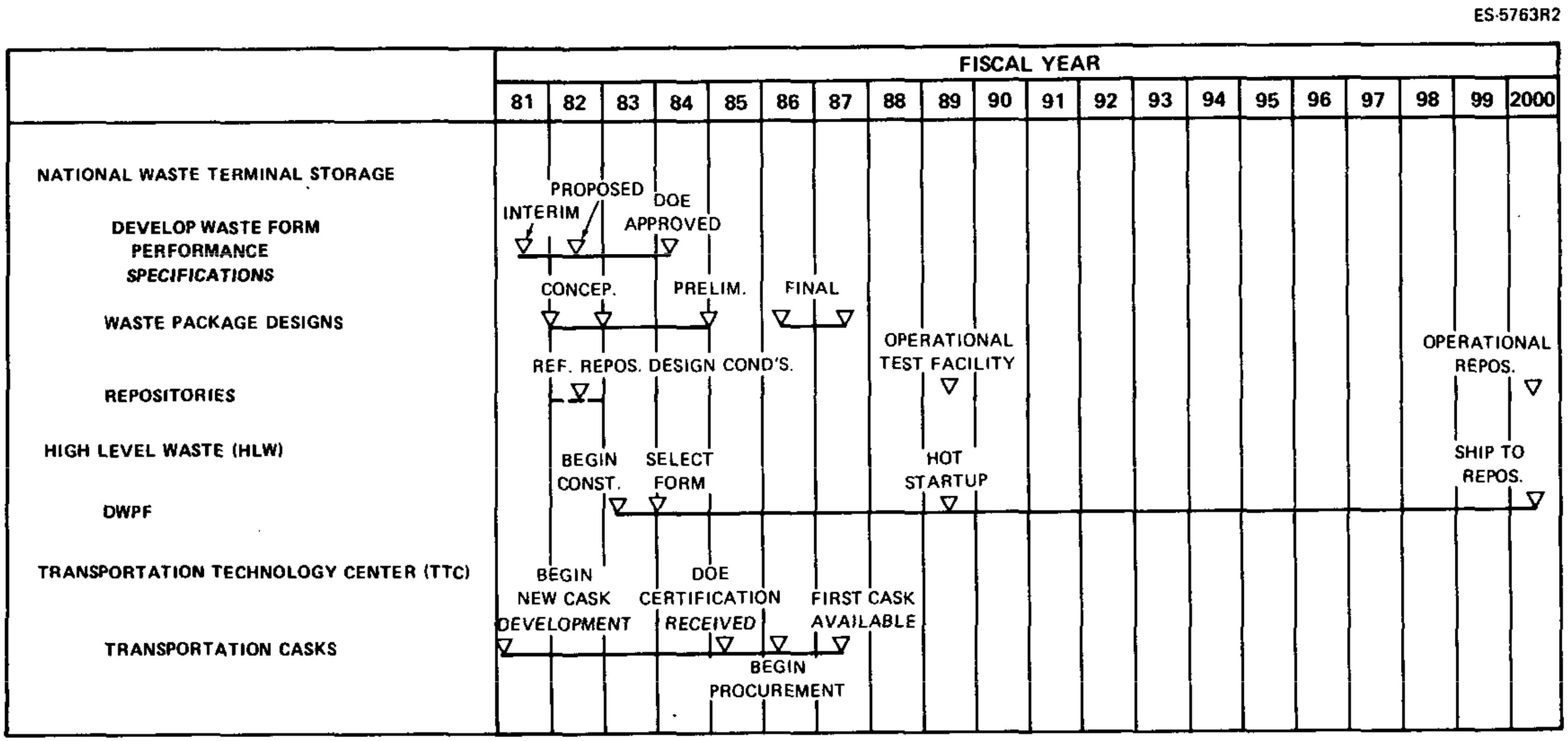

Fig. B.1. Coordination of HLW facilities with repository and transportation programs.

TC

TC The generic forms selected represented at least five specific forms and process alternatives. Other conclusions reached from the preliminary assessment were:

1. borosilicate glass is the best overall choice of waste form at this time, having the highest ranking for a combination of performance (product) and process factors;

2. none of the ten alternative forms assessed appear to offer improvements in processing over borosilicate glass; and

3. additional R&D of the alternative forms will be required to demonstrate the existence of viable forms and practical processes.

TC Assessment of the alternative waste forms has been a continuous process as new data were developed. Based on product and process data developed on leaching tests of candidate forms at SRL and on engineering studies of the conceptual processes, the crystalline ceramic form in addition to borosilicate glass was selected for further study. The final selection of the waste form for the DWPF will be made by October 1983 or earlier.

B.2.1.2 Development and characterization of waste forms

TC The National HLW Technology Program has made an intensive effort to expedite R&D on candidate alternative waste forms at DOE laboratories, industrial contractors, and universities. The initial emphasis of each of these programs was on the development, production, and characterization of candidate forms with simulated SRP waste. For the four forms selected after the preliminary screening, the following contractors participated:

1. borosilicate glass at SRL and Pacific Northwest Laboratory (PNL);

2. high silica glass at Catholic University of America (CU);*

3. tailored ceramic at Rockwell International (RI)/Penn State University; SYNROC at LLNL, Argonne National Laboratory (ANL), North Carolina State University; and

4. coated ceramic form and coating development at PNL/Battelle Columbus Laboratory (BCL); coated ceramic particles via sol-gel processing at Oak Ridge National Laboratory (ORNL).

The program in FY-1982 and beyond for the SRP defense waste application will focus on demonstration of compatibility with SRP waste. Basic form development will probably be continued by the National HLW Technology Program for application to other defense or commercial waste but the most promising alternative form for SRP waste should be established by the end of FY-1981.

B.2.1.3 Characterization of waste form performance

TC A comparative examination of the waste form properties, especially leach resistance, is essential in determining the relative merit of candidate forms. A comparative leach testing program was implemented in FY-1980. The Materials Characterization Center at Pacific Northwest Laboratory (PNL) provided similar data for more forms under the National program. Samples of candidate waste forms were provided by the developers for the SRL leach testing program. Data from these comparative tests were used in conjunction with data generated by the developers and with results of preliminary process studies to provide the basis for continuing with the development of borosilicate glass as the reference form and further product and process development of a crystalline ceramic form.

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*Developer of high-silica glass waste form under subcontract to NPD Nuclear Systems, Inc.

B.2.1.4 Process and equipment development

Preliminary process development and testing will be done primarily by the waste form contractors culminating in the establishment of reference processes in FY-1982. (Testing of unit processes also may be conducted by SRL and the contractors to ensure production feasibility.) TC

If a form other than borosilicate glass is selected, the hot start-up of the DWPF would be delayed. To minimize this delay, integrated pilot-scale development and large-scale tests could be initiated in FY-1983 to develop and demonstrate the production process.

B.2.1.5 Engineering design studies

Translation of the bench-scale processes under development in the AWF program to full-scale processes that can operate reliably in a remote, shielded facility is essential for the ultimate utilization of any of the AWFs. Preliminary conceptual designs were completed by August 1981 for the three generic forms selected. These studies will provide conceptual flowsheets, scope equipment requirements, develop impacts on the DWPF, and produce estimates of incremental costs relative to the borosilicate glass reference case. TC

B.2.1.6 Risk assessments

The waste form selected for the DWPF must provide acceptably low exposure risks to people. Risk assessments will be required for waste form production in the DWPF, interim storage at the DWPF of waste canisters, transportation to the repository, and terminal storage in the repository. Although the pre-repository phases will likely have the greatest risk to man, repository risk considerations may dominate because of the difficulty of quantifying risk over $\sim 10^6$ years. A preliminary release consequence analysis for borosilicate glass in a salt repository was developed by ONWI. A more extensive analysis covering the forms of interest for SRP waste in salt, basalt, and granite is being developed by Lawrence Livermore National Laboratory (LLNL) and should be completed in FY-1982. Comparative risk assessments covering production, interim storage, transportation, and disposal in a repository of the candidate waste forms will be performed in FY-1982. These risk assessments will be an important part of the environmental review of the DWPF waste forms. TC

B.2.2 Key milestones

The AWF Program involves a continuing effort to reduce the number of waste forms and processes under consideration so that the maximum available resources can be devoted to the most promising alternatives. Key decision points coincide with this selection process at December 1979 (the reduction from 11 to 4 generic forms), by October 1981 (the choice of the crystalline ceramic form, in addition to glass), and by October 1983 (the final selection of the waste form for the DWPF). TC

B.3 RELATIONSHIP TO DWPF AND REPOSITORY PROGRAMS

The schedule for the Defense Waste Processing Facility calls for construction to begin early in FY-1983 and operation (for the Stage I facility) to begin in late FY-1988. Design of the DWPF is proceeding based on the reference borosilicate glass process. If, however, an alternative form is selected instead of borosilicate glass by October 1983, the major impacts would be

1. delay in the DWPF schedule by 1 to 4 years to allow for process development and design changes to the immobilization facility,

2. costs of abandoned design, estimated to be less than 10% of the project cost; and

3. increased cost of a larger production facility.

The first two impacts will be minimized by the continuing process of reassessing the alternatives and taking appropriate action. For example, the DWPF construction start-up could be delayed should the crystalline ceramic form show an outstanding promise. Also, process development of
TC the crystalline ceramic form could be accelerated to minimize the overall delay. Sufficient data from the development program will be available in FY 1982 to indicate whether the crystalline ceramic form or borosilicate glass has the better chance of becoming the DWPF waste form.

The waste form assessment and selection process for the DWPF will involve a continuing evaluation of results of the development program, described in Sect. B.2, and an environmental review that will make use of these results. Results from these studies and from comparative risk analyses of
TC the candidate forms for the production, transportation, and repository systems (Sect. B.2.1.7) will provide the bases for the environmental review. The environmental review will be completed and documented on time to support the final waste form decision by October 1983, or earlier, depending on results of the AWF studies.

B.4 WASTE FORM DESCRIPTION AND DEVELOPMENT STATUS

The four waste forms that were selected for study in the AWF assessment program have varied
TC product performance and process characteristics. Major attributes of the forms are summarized in Table B.1. A brief description of earlier forms and their development status is presented below.

Table B.1 Features of alternative waste forms

Waste form	Advantages	Major disadvantages
Borosilicate glass	Simplest process Lowest cost Adequate leachability Low sensitivity	Glass melter required
High-silica glass	Low leachability Low sensitivity	Calciner required Dry powders handled Higher cost than borosilicate glass
Crystalline ceramics	Low leachability High-temperature stability High waste loading	Complex mechanical operations Very fine powders (milling) required Calciner and hot isostatic pressing required Tailoring required Higher cost than borosilicate glass
Coated ceramic	Multiple barriers Very low leachability High-termperature stability	Very complex process High cost Calciner and high-temperature coaters required Dry powders handled Difficult off-gas treatment
Via Sol-Gel	No dry powders	Highest complexity, cost Much process waste

B.4.1 Borosilicate glass (DWPF reference form)

The reference process and the alternative staged process for making the borosilicate glass waste form are described in Sects. 3.1 and 3.3, respectively. Both involve formation of a vitrified waste form by melting a glass-frit/waste mixture at about 1150°C. The molten glass is poured into cans measuring 0.61 m in diameter by 3 m high filled to about 2.4 m, to form monoliths that partially fracture on cooling. The waste is incorporated into the glass matrix (density of ∿2.8 g/mL) with about 28 wt % loading on an equivalent oxide basis, or about 0.78 g/mL waste density.

Major advantages of the borosilicate glass form include its relatively simple process and low cost and its very low sensitivity to variations in waste composition and process conditions.

Borosilicate glass is the most developed waste form and continues to receive the major share of the overall development effort. In the United States, development is primarily concentrated at the Savannah River Laboratory (SRL) for SRP waste.[9] Initial development was accomplished at Pacific Northwest Laboratory (PNL).[10-12] At SRL, the borosilicate glass process is being successfully demonstrated on an engineering scale with simulated (non-radioactive) waste and tested on a laboratory scale with actual SRP waste. Physical property data have been obtained on full-size nonradioactive forms and on small-scale forms made with actual waste.[9] Results, which include extensive data on leaching behavior and data on mechanical and radiation stability, indicate that borosilicate glass is a most satisfactory immobilization form for SRP waste.[9] |F-8

B.4.2 High-silica glass

High-silica natural glasses (obsidians and tektites) are known to have survived for long periods of time in terrestrial environments. However, these glasses melt at about 1600°C, which is high enough to volatilize ruthenium and cesium radionuclides from the waste. The Catholic University of America (CUA) has developed a Porous Glass Matrix (PGM) Process for making the high-silica glass waste form at much lower temperatures.[13]

One option of the PGM process is similar to the in-can melting process developed by PNL for borosilicate glass. In this process, the waste sludge is calcined, the calcine is blended with powdered porous-glass frit, and the mixture is loaded into Inconel Canisters and sintered under vacuum at 900° to 1200°C into large glass monoliths. The key to this process is the high surface area of the porous glass frit, which allows the glass to flow at a relatively low temperature. The final form would be essentially identical in size and shape to the reference glass form and would contain about 25 Wt % of calcined waste.

The major advantages of the high-silica glass form are its potential for lower leachability than borosilicate glass and its low sensitivity to variations in waste composition. The in-can melting option to the PGM process would be the least complex of the alternative processes but still would be more complex than the reference process.

Initial development of the high-silica glass form at CUA has been performed on a bench-scale with simulated (nonradioactive) SRP waste. Early leach test results conducted at expected repository temperatures indicate factors of 30 to 300 decrease in leachability relative to borosilicate glass may be achievable. A potential production process for this form has been defined and is being evaluated in conceptual design studies.

B.4.3 Crystalline ceramics

Two crystalline ceramic forms are being developed which would bind the waste elements within mineral-like, leach-resistant phases: the "Tailored Ceramic" form[14] under development at Rockwell International (RI) and the "SYNROC" form under development for defense wastes at Lawrence Livermore Laboratory. The Tailored Ceramic form, which is mainly comprised of spinel-like oxide phases, is a spin-off of the supercalcine form originally proposed by Penn State University. The SYNROC form is an assemblage of titanate mineral and spinel phases. SYNROC was originally developed by A. E. Ringwood of the Australian National University,[15] who is presently a consultant on SYNROC development to LLL.

The most feasible process for making crystalline ceramic forms involves hot isostatic pressing (HIP) large ceramic monoliths. In this process, chemical additives tailored for the waste composition would be mixed with the waste sludge, the mixture calcined and milled to obtain a ceramic-grade powder, and the powder sealed into a metal canister and then sintered under pressure by hot isostatic pressing at temperatures of 1100°-1200°C to form a dense, encapsulated ceramic with the desired cyrstalline phases. The final form envisioned is a cylinder about 0.5 m in diameter by 1.1 m high, with waste loadings of 30 to 70 wt % on a dry oxide basis.

Major advantages of ceramic waste forms are their lower leachability and higher thermal stability, although high thermal stability is not necessary for the low heat containing defense wastes. These improved properties, however, can only be realized through use of a significantly more complex process than the reference glass process.

Initial development of the crystalline ceramic forms has been performed on a bench-scale with simulated SRP waste. Preliminary formulations have been developed which incorporate 30 to 90 wt % waste, depending on composition. Early leach test results indicate factors of 10 to 100 decrease in leachability relative to borosilicate glass for expected repository temperatures. A potential production process for these forms has been defined and is being evaluated in conceptual design studies.

B.4.4 Coated particles

Additional barriers to leaching could be provided by coating ceramic waste particles (0.1- to 10-mm diameter) with impervious materials, such as pyrolytic carbon, alumina, or silicon carbide. PNL is developing technology to apply coating materials by chemical vapor deposition to disk-pelletized waste-bearing ceramic or glass particles.[16,17] The development of technology to apply coating materials to sol-gel derived ceramic-waste spheres is being performed at Oak Ridge National Laboratory.[18]

Both the PNL and ORNL processes for obtaining mechanically stable, coatable particles are extremely complex and contain many uncertainties at the present stage of development. The coating operations, in either fluidized bed or mechanically assisted coaters, are also very complex. Because of processing difficulties, development of coated particle waste forms has lagged behind the other alternatives. Very little relevant data exist for coated particle forms.

A preliminary conceptual design study by du Pont Engineering Department of a potential production process indicates that the building size and cost, the overall process complexity, and the areas requiring major development and invention significantly exceed those for the other alternatives.

REFERENCES FOR APPENDIX B

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Appendix C

COMPLIANCE WITH ENDANGERED SPECIES ACT

Eco-Inventory Studies, Inc.
Box 1896
Mississippi State, MS 39762

30 May 1979

Dr. Jan Caldwell
Savannah River Ecology Laboratory
Drawer E
Aiken, SC 29801

Dear Jan:

As you requested, we have surveyed the site on SRP you referred to as "S" area for evidence of Red-cockaded Woodpeckers. I visited the area on 15 and 16 May 1979 along with my work crew consisting of C. D. Cooley, B. J. Schardien, D. Cavin, N. Pitcher, and K. Day. We walked north-south transects at 300 foot intervals through the entire area but found no Red-cockaded Woodpeckers nor signs of their having been in the area. In general the pine forest in the area is either too young or too overgrown with thick hardwood understory. There are some older trees in the area and much potential habitat for this endangered species. If hardwoods are thinned, a controlled burn is run through the area at about three year intervals, and the pines are allowed to reach ages of 80 years or more, Red-cockaded Woodpeckers might colonize the area. Without such efforts I doubt that they would use the site.

During our visit to the area we recorded the following other bird species:

Chuck-will's-widow - (including a nest with one egg laid on pine straw in open ca 20-year-old pine woods)
Yellow-shafted Flicker - probably nesting near the clearcut area
Brown Thrasher
Great Crested Flycatcher
Bobwhite
Yellow-breasted Chat
Common Crow
Tufted Titmouse
Summer Tanager
Prairie Warbler - (numerous and probably nesting)
Pine Warbler
Turkey Vulture
Pileated Woodpecker
Hairy Woodpecker
Red-bellied Woodpecker - (a male was excavating a nest cavity in a dead stub at the edge of the clearcut)

Carolina Chickadee
Eastern Wood Pewee
Red-eyed Vireo
Blue-gray Gnatcatcher
Indigo Bunting
Acadian Flycatcher

We will be returning to the Savannah River Plant next week and would be happy to visit the area with you if you have any questions concerning our observations or if you have additional sites for us to check.

Best regards,

Jerry

Jerome A. Jackson

Eco-Inventory Studies, Inc.
Box 1896
Mississippi State, MS 39762

21 June 1980

Dr. Jan Caldwell
Savannah River Ecology Laboratory
Drawer E
Aiken, SC 29801

Dear Jan:

At your request Bernard Rowe, Bette Schardien, and I have completed a survey of the approximately 1280 acres of forest area identified on the attached maps as "alternate areas A and B." We worked in these areas on 22 May and on 17, 18, and 19 June 1980. Of the acreage included in these areas, some has already been cleared for other purposes and some is very dense bottomland hardwood forest - there was no need to systematically search these areas for Red-cockaded Woodpeckers since these habitats are unsuitable for the species. We did carefully and systematically search approximately 850 acres and found no sign of past or present use of the area by this endangered species. With proper management and long rotations (80-100 years) the higher portions of either area could become suitable habitat for Red-cockaded Woodpeckers *these include particularly the areas hatched in red on the attached maps.* From a wildlife point of view, I would recommend the use of alternate site A for the proposed facility because of the already extensive disturbance in the area.

During our survey efforts we recorded the following bird species on the areas:

Alternate Site A

Mourning Dove	Blue Jay	Eastern Kingbird
Tufted Titmouse	Prairie Warbler	Summer Tanager
White-eyed Vireo	Blue Grosbeak	Red-shouldered Hawk
Indigo Bunting	Brown-headed Nuthatch	Bachman's Sparrow
Bobwhite	Red-winged Blackbird	Brown-headed Cowbird
Rufous-sided Towhee	Mockingbird	Carolina Wren
Orchard Oriole	Belted Kingfisher	Common Crow
Carolina Chickadee	Barn Swallow	Downy Woodpecker
Blue-gray Gnatcatcher	Common Yellowthroat	
Chimney Swift	Yellow-breasted Chat	
Black Vulture	Red-headed Woodpecker	
Red-tailed Hawk	Eastern Bluebird	
Eastern Wood Pewee	Great Crested Flycatcher	
Pine Warbler	Field Sparrow	

Bird species identified incidental to Red-cockaded Woodpecker survey of Alternate Site B

Red-bellied Woodpecker
Pine Warbler
Carolina Chickadee
Mourning Dove
Bobwhite
Red-tailed Hawk
Rufous-sided Towhee
Yellow-billed Cuckoo
Blue-gray Gnatcatcher
Downy Woodpecker
Carolina Wren
Brown-headed Nuthatch
Barn Swallow
White-eyed Vireo
Tufted Titmouse
Common Yellowthroat
Indigo Bunting
Brown-headed Cowbird
Red-eyed Vireo
Common Crow
Acadian Flycatcher
Hooded Warbler
Cardinal
Ruby-throated Hummingbird
Summer Tanager
Hairy Woodpecker
Eastern Wood Pewee
Pileated Woodpecker
Common Nighthawk
Yellow-throated Vireo
Eastern Bluebird
Prothonotary Warbler
Yellow-shafted Flicker

The above species likely nest in both of the areas visited - along with several species that were not encountered (because we were not really looking for them -e.g. owl species).

Thank you for the opportunity to do this survey. Please note on the attached invoice that the check for payment should be made payable to Eco-Inventory Studies, Inc., rather than to me personally.

If I can be of further assistance, please let me know.

Sincerely,

Jerome A. Jackson, Ph.D.

November 7, 1981

Mr. R. N. Smith, Regional Director
United States Department of the Interior
Fish and Wildlife Service
75 Spring Street, S.W.
Atlanta, GA 30303

Dear Mr. Smith:

PROPOSED CONSTRUCTION OF THE DEFENSE WASTE PROCESSING FACILITY, SAVANNAH RIVER PLANT, LOG NUMBERS 4-2-80-I-260 AND 4-2-80-I-83

The Department of Energy is considering the construction and operation of the *Defense Waste Processing Facility* (DWPF) at the Savannah River Plant for immobilizing the high-level radioactive waste in storage for disposal. A Notice of Intent to prepare an environmental impact statement (EIS) was published in the Federal Register (45 FR 15606, March 11, 1980), and comments were received from W. C. Hickling of your Asheville Office (letter to G. Oertel dated June 16, 1980, Re 4-2-80-I-260). This letter is a followup to Dr. Oertel's response to Mr. Hickling dated August 25, 1980.

Reference is also made to the letter from P. Mulholland, Oak Ridge National Laboratory, to K. Lack of your office dated January 29, 1980, and your response dated March 3, 1980 (Re 4-2-80-I-83), concerning the presence of any threatened or endangered species at the proposed construction site (S-Area) for preparing the DWPF-EIS. Your letter indicates the possible presence of the endangered Red-cockaded Woodpecker (Picoides borealis).

At the request of this office, the Savannah River Ecology Laboratory (SREL) of the University of Georgia initiated an ecological study of the proposed S-Area and other related areas in February 1979. This study includes a survey to determine the presence of any nationally threatened or endangered species. As documented in the enclosed SREL report, "A Biological Inventory of the Proposed Site of the Defense Waste Processing Facility on the Savannah River Plant in Aiken, South Carolina" (Oct. 1980), there are no Federally listed endangered species on the proposed S-Area and the related areas. This determination was made by the experts from SREL for the American Alligator (Alligator mississippiensis) and the Pine Barrens Tree frog (Hyla andersoni), and by J. A. Jackson of Mississippi State University for the Red-cockaded Woodpecker (Picoides borealis).

Mr. R. N. Smith

November 7, 1980

It is our judgment that the Department of Energy has satisfactorily completed the "Step-down Process - Construction Project" by submitting the enclosed report as the Bilogical Assessment and by the determination of "no effect" on endangered species of the proposed construction project. We are ready to discuss our findings with you if you feel it necessary. Questions your staff have may be directed to S. R. Wright (FTS 239-3093) or J. C. Tseng (FTS 239-3969) of my staff.

Sincerely,

R. L. Morgan
Manager

EE:JCT:DTC

Enclosure

cc w/encl:
W. C. Hickling, Fish and Wildlife
Service, Asheville, NC

United States Department of the Interior
FISH AND WILDLIFE SERVICE
ROOM 279, FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA 28801

November 24, 1980

Mr. R. L. Morgan, Manager
Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29801

Re: 4-2-80-I-250 and 4-2-80-I-83

Dear Mr. Morgan:

We have reviewed the biological assessment on the proposed construction of the defense waste processing facility for the endangered red-cockaded woodpecker at the Savannah River Plant in Aiken and Barnwell Counties, South Carolina.

The biological assessment is adequate and supports the conclusion of no impact, with which we concur. In view of this, we believe that you have satisfied the requirements of Section 7 of the Endangered Species Act.

Your interest and initiative in enhancing endangered and threatened species is appreciated.

Sincerely yours,

William C. Hickling
Area Manager

MISSISSIPPI STATE UNIVERSITY

DEPARTMENT OF BIOLOGICAL SCIENCES
P. O. DRAWER GY
MISSISSIPPI STATE, MISSISSIPPI 39762
PHONE (601) 325-5722

13 Feb. 1981

Dr. Jan Caldwell
Savannah River Ecology Laboratory
Drawer E
Aiken, SC 29801

Dear Jan:

We have examined the approximately 50 acre tract designated as the "Salt-crete Burial Site." We found no evidence of present or past use of the site by the endangered Red-cockaded Woodpecker. Pines in the area are generally too young to be of use as cavity trees by this bird.

If I can be of further help, please let me know.

Sincerely,

Jerome A. Jackson
Profesor of Biological Sciences

Appendix D

TRANSPORTATION

Appendix D

TRANSPORTATION

D.1 SHIPPING RADIOACTIVE WASTE FROM SRP

Shipment of radioactive waste from SRP to the repository can be by rail or by truck. If private industry is able and willing to assist DOE, common carriers could be hired to move the wastes. Common carriers transport materials for the general public under published tariffs and rate schedules. They would be subject to DOE directives and Department of Transportation (DOT) and Interstate Commerce Commission (ICC) regulations when carrying wastes from the SRP site to a repository.

If private industry is unable or unwilling to provide the necessary transportation services or equipment, DOE would then have to purchase its own casks and overpacks and arrange for transport of the waste.

D.2 APPLICABLE REGULATIONS

No HLW has been shipped in the United States, but because the relative amounts of radioactivity in HLW and in spent fuel are similar and because the HLW casks will be similar to the spent fuel casks, the experience gained with spent fuel casks is being directly applied to ensure safe HLW cask designs. Experience gained in the design and use of spent fuel casks has resulted in comprehensive regulations covering the performance of the casks, vehicle safety, routing of shipments, handling of shipments, and physical protection, many of which apply to HLW. The organizations responsible for writing and enforcing these regulations are discussed next. Subsequently, the regulations concerning each of the areas mentioned previously will be discussed briefly.

D.2.1 Responsible organizations

Four Federal agencies are currently charged with responsibilities related to the transportation of radioactive waste in the United States: Department of Transportation (DOT), the Nuclear Regulatory Commission (NRC), DOE, and the Interstate Commerce Commission (ICC). Where overlapping responsibilities exist, Memoranda of Understanding (MOU) have been issued between the agencies to define areas of responsibility.

Shipments of HLW made by the SRP are not governed by the regulations of the NRC, which has regulatory authority over its licensees (commercial shippers). As a result, the functions of the NRC will not be discussed. The ICC is the principal authority for regulating rates, charges, and conditions of truck and rail services operating in interstate commerce. Because most ICC regulations are related to the economics of transportation and because the primary concern of this section is safety, the regulatory function of the ICC will not be discussed further.

DOT and DOE are responsible for the safety of transporting radioactive material from the SRP. DOT has the primary responsibility for safety in transporting radioactive material, and DOE has the authority to design and certify its own packagings to be used by government shippers and is not required to license its packagings through the NRC. Nevertheless, the DOE certifies that an HLW packaging (cask) will meet DOT and corresponding NRC test criteria.

DOE, through its management directives and contractual agreements, protects public health and safety by imposing, on its transportation activities, standards similar to those of DOT and NRC.

DOT specifies and enforces regulations to ensure that hazardous material is properly classified, described, packaged, marked, labeled, placarded, and prepared in the required condition for shipment. DOT has recently published proposed rules for the highway routing of radioactive materials (discussed in Sect. D.2.4).

DOT is responsible for enforcing vehicle safety standards, setting allowable radiation levels, and requiring the use of tamper-indicating seals. DOT also specifies criteria governing the loading or location of radioactive cargo relative to other materials being shipped. For rail shipment, the location of the car carrying radioactive cargo in relation to other placarded railcars, the engine, or caboose are covered by other DOT criteria.

The role of state and local governments in regulating nuclear materials transportation, particularly in relation to Federal jurisdiction, continues to be an unresolved question. An act recently enacted in South Carolina[1] is one example of a state attempt to control and regulate the interstate and intrastate movement of radioactive materials shipped by the Federal government. This law established state requirements for carrier permits, prenotification, routing, and emergency response procedures.

An agreement was reached between DOE and the State of South Carolina[2] to exempt all shipments of spent nuclear fuel and radioactive wastes that are being shipped to or from SRP from State controls. These controls are specified in the "South Carolina Radioactive Transportation and Disposal Act of 1980."[1] DOE has agreed that the Savannah River Operations Office will monitor these shipments and advise the State of the movement of spent nuclear fuel or liquid low-level radioactive wastes.

Many state governments have passed legislation[3] requiring special actions regarding radioactive material shipments. One state, Louisiana,[4] has a law prohibiting shipment of HLW into the state. Some states require advance notices of shipments, permits, and/or registration (some with fees). All states require compliance with DOT regulations and some include compliance with NRC, ICC, Coast Guard, or postal regulations. Some states also require liability insurance coverage up to $1 million. Other requirements by certain states include accident notification; routes to be prescribed by the state agency; limited hours or days of travel; special permits for (or restricted use of) certain bridges, toll roads, sites, and tunnels; detailed bills of lading to accompany each shipment; and special quarterly or annual reports of shipments.

Because many such laws, including the Louisiana regulations, will be inconsistent with the DOT routing regulations[5] to take effect in February 1982, they are likley to be preempted (refer to D.2.4).

D.2.2 Packaging

The primary means for ensuring safety during the transportation of radioactive material is proper packaging. Consequently, many radioactive-material transport regulations are concerned with packaging standards.

DOT regulations applicable to packaging are contained in 49 CFR Part 173: Shippers — General Requirements for Shipments and Packagings. This regulation states that HLW packagings must meet all requirements to prevent the dispersal of radioactive contents without loss of shielding during normal transport. Tests and environments that simulate extreme conditions of normal transport are outlined in 49 CFR Part 173.398(b). HLW casks must also survive hypothetical accident conditions. Hypothetical accident conditions are described and allowable releases are defined in 49 CFR Part 173.398(c). Surface contamination for HLW packagings is limited to specified levels, and the method for assessing the amount of surface contamination is described in 49 CFR Part 173.397.

D.2.3 Vehicle safety

No additional or special vehicle regulations are imposed on the carrier of radioactive materials beyond those required for a carrier of any hazardous material. Truck safety is governed by the Bureau of Motor Carrier Safety of DOT, which imposes vehicle-safety standards on all truck carriers (49 CFR Part 325, 386-398). Along with other functions, the Bureau conducts unannounced wayside inspections of vehicles and drivers. During the inspection, the condition and loading of the vehicle and the drivers' documents are checked. These checks are performed on all truck carriers.

Rail cars and trucks carrying HLW will be placarded according to 49 CFR Part 172. DOT Regulation 49 CFR Part 174.8 specifies that each placarded rail car and each adjacent car be inspected by a duly authorized representative of the carrier or DOT at each required inspection point to ensure that the cars are in a safe condition for transportation. The inspection includes a visual inspection for obvious defects of the running gear and any leakage of contents.

D.2.4 Routing

The DOT proposed routing regulations (HM-164)[6] were published on Jan. 30, 1980, for comment. Final routing regulations were published by DOT on Jan. 19, 1981,[5] and will become effective on

Feb. 1, 1982. HM-164 attempts to reduce potential hazards through avoiding heavily populated areas and minimizing travel times. Hazards will be reduced by using interstates or alternatives selected by states, referred to as "preferred highways." Under its authority to regulate interstate transportation safety, DOT can prohibit bans and restrictions imposed by state and local laws as "undue restriction of interstate commerce." DOT holds that different, conflicting requirements among jurisdictions may be unduly restrictive to shippers and carriers and may add to accident risks by diverting shipments to highways having higher accident rates. State and local requirements would be preempted by the proposed regulations if they

1. completely prohibit travel between any two points served by highway;

2. prohibit the use of an interstate highway, including prohibition of travel based on time of day, without designation of an equivalent preferred highway as a substitute in accordance with the provisions of the regulation;

3. require use of a preferred highway except in accordance with the provisions of the regulation;

4. require prenotification of state and/or local authorities or escort;

5. require special personnel or equipment.

The DOT rule will require a placarded vehicle carrying a large-quantity package of radioactive materials, other than spent fuel, to be operated with an advance written route plan prepared by the carrier for a route on preferred highways that would result in risk to the fewest persons and minimized transit times. Carriers of HLW shipments would be required by DOT to use interstate urban circumferential or bypass routes, if available, to avoid cities. If circumferential or bypass routes are not available, carriers could use interstate or preferred highways that pass through urban areas.

Rail transportation of HLW would be similar to other loads routinely transported, including hazardous nonradioactive materials. Routes are fixed by rail locations, and urban areas cannot be readily bypassed by alternative routes. Certain routing restrictions may also be established by the states or dictated by poor track conditions in some areas. DOT has not issued any regulations regarding routing of hazardous material for rail shipment.

D.2.5 Handling

During handling, DOT requires the carriers of radioactive materials to perform special actions in addition to those required for other hazardous materials. Because the safety of radioactive material transport is primarily governed by packaging design regulations, the special actions are largely limited to administrative actions such as documenting, certifying, and placarding. However, one important action is to ensure that radiation levels are not exceeded in any shipment. Regulations describe the allowable radiation levels, the requirement for tamper-indicating seals, and inspections to ensure that packaging remains within acceptable radiation levels. Regulations also describe special handling requirements such as the restrictions on the switching of rail cars that are loaded with radioactive material and placarded (49 CFR Part 174.83) and the position of the placarded car on a moving or standing train (49 CFR Part 174.89).

D.2.6 Physical protection

HLW contains almost all of the fission products from the processed spent fuel and also small quantities of unrecovered uranium and plutonium. HLW would not be a credible source of strategic quantities of plutonium because the residual plutonium concentration in the HLW is very dilute and extraction of the plutonium is not practical. Thus, unlike spent fuel, physical protection of HLW shipments is not required.

D.3 PACKAGINGS FOR TRANSPORTING SOLID HLW

HLW generated at SRP will be solidified in canisters that have a 0.61-m outside diameter and are 3 m long. The packaging used to transport these canisters will be heavily shielded casks similar to those used to ship spent reactor fuel by truck or by rail.

D.3.1 General description of HLW packaging

Packagings used to transport HLW are being designed to protect the public during normal and accident conditions of transport. Packagings are designed to specified shielding levels and are required to contain the HLW during normal and accident conditions expected during transportation of HLW. The accident conditions are simulated by a set of sequential tests [49 CFR Part 173.398(c)]:

1. free drop through 9 m onto a flat, essentially unyielding surface, striking in a position for which maximum damage is expected,
2. puncture from 1-m drop onto a 15-cm-diam, perpendicular mild steel bar that has a flat end and is mounted on an unyielding surface,
3. exposure of the whole packaging to a temperature environment of 800°C for 30 min, and
4. immersion under 1 m of water for 8 h (for fissile materials packaging only).

These conditions are designed to produce severe damage that exceeds the damage that would be expected for the vast majority of transportation accidents. A cask must be shown to survive these conditions either by actual test or using analytical methods. Survival consists of (1) containment of the HLW, allowing only limited release of radioactive material [as specified by regulation — 49 CFR 173.398(c)] and (2) no loss of shielding beyond specified limits.

D.3.2 Package descriptions for HLW

HLW casks are currently being designed and a reference design concept has been completed for both truck and rail modes. This concept is referred to as a convertible cask. The reference rail cask will have interchangeable baskets that can accommodate various numbers of canisters. The cask design is flexible so it can be used to transport HLW from Idaho National Engineering Laboratory and Hanford, as well as from the Savannah River Plant. Because the wastes at these facilities vary in composition, the convertible cask design will be effective and efficient for transporting the many types of wastes.

Figure D.1 is a drawing of a convertible rail cask and shows the selections of baskets that would be available. The waste with the largest amount of activity would have to be shipped with the greatest relative amount of shielding, which in turn would be provided by the basket with the least capacity.

The truck cask design is also convertible, except that the baskets are interchangeable to reduce weight. Because only one canister can be accommodated, only the weight of the basket can be changed. A canister that does not need to be shielded as heavily can be shipped with a lighter basket to reduce the overall weight, thus minimizing the cost of transportation by taking advantage of lower shipping costs for hauling lighter loads.

For the reference case of glass HLW form, the most likely rail cask configuration for SRP incorporates the five-canister basket. This configuration provides the equivalent of 23 cm of solid steel shielding, and fully loaded, a cask of this configuration would weigh about 85 tonne.

D.4 METHODOLOGY

This section discusses the methodologies used to calculate the radiological and nonradiological impacts of transporting SRP wastes.

D.4.1 Radiological impacts

The radiological impacts of transport are calculated for both normal and accident conditions. Impacts from normal transport are consequences (i.e., they will occur), whereas impacts from accidents during transport, estimated on the basis of expected accident rates, are risks (i.e., they may or may not occur). Risks are presented here as expected impacts (consequences × accident rates).

D.4.1.1 Impacts resulting from normal transport

In normal transport, a cask of waste arrives at its destination without releasing its contents and without loss of shielding. The exposure of people to radiation arises only from the radiation that penetrates the cask. Even though radiation shields are incorporated into cask design to protect the public as the cask passes by, the cask of HLW exposes the nearby population at a very low dose rate; after it has passed, however, no further exposure occurs.

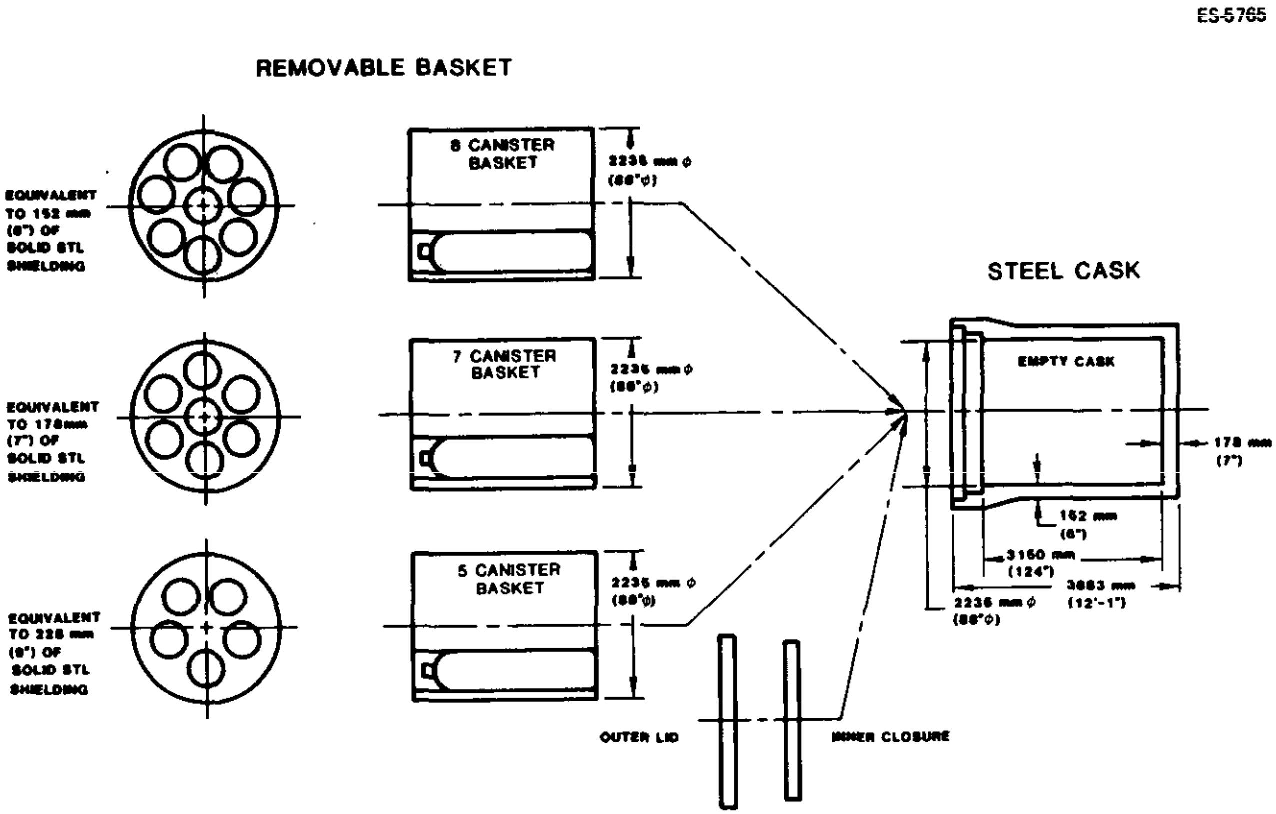

Fig. D.1. Convertible rail cask and various basket configurations.

People nearest the routes used to transport the HLW receive the greatest doses. The population groups exposed to radiation are, in order of decreasing exposure, people working in the vicinity of the casks and those accompanying them (train crew or truck drivers) and bystanders, including those living or working along a route; passing motorists; and train passengers. A computer code, RADTRAN-II, was developed to calculate exposures to these population groups.

In RADTRAN-II,[7] the assessment of population dose during normal transport is based on the assumption that the source of radiation (e.g., the cask) is a point source of external penetrating radiation. Using the dimensions of a cask, the strength of an equivalent point source is calculated, from which exposures to various population groups are calculated. The actual equations used to calculate exposures differ between population groups and transportation modes, but their basis in the point-source assumption is the same. Derivations of the various equations are discussed thoroughly in the RADTRAN-II documentation.[7]

A maximum individual dose, the dose to an individual who lives beside a rail track or highway, is not calculated by RADTRAN-II but is calculated by using the following equation and by assuming that the person lives 15 m from the highway or rail track and that the vehicles or trains pass by at 24 km/h.

$$\text{Dose/shipment (millirem)} = 2.0 \times 10^{-3}\ (K/v)\ I(x)\ , \qquad (D.1)$$

where

$$I(x) = \int_x^\infty \frac{e^{-ur} B(r)\ dr}{r(r^2 - x^2)^{1/2}}\ ,$$

K = dose rate factor, mrem-m^2/h,

x = perpendicular distance of individual from shipment path, m,

v = average velocity (kph) of the shipment passing that point,

r = distance of individual from the vehicle passing, m,

$B(r)$ = Berger buildup factor for exposure increase. As a photon beam travels toward a target, some of the energy is attenuated by collisions with air molecules. This is expressed by the exponential decay function, e^{-ur}. However, some of the scattered energy will be rescattered back towards the target. The Berger buildup factor accounts for this and is defined as:

$$B(d) = 0.0006r + 1\ .$$

u = absorption coefficient for air $3.6 \times 10^{-4}\ m^{-1}$.

The values for $(2.0 \times 10^{-3})\ I(x)$ versus distance are plotted in Fig. D.2. The values read from this curve can then be adjusted for the particular vehicle speed and dose-rate factor to produce a consequence factor per shipment.

D.4.1.2 Impacts due to accidents involving HLW

The impacts that could result from transportation accidents are calculated in RADTRAN-II, but the results are given in terms of population exposure. To be consistent with other parts of this environmental impact statement, these population results were not presented. Instead, accident scenarios were defined and doses were estimated for an individual exposed to the maximum extent.

Two types of accidents were considered: one involving a partial loss of contents and the other a loss of shielding. In each of these accidents, the individual exposed to the maximum extent stood within 30 m of the cask for 0.1 hour.

In the loss of contents scenario, the cask experiences both severe impact and fire. The cask and canister are assumed to be breached, allowing a release of radionuclides into the environment. Two exposure pathways are considered: inhalation of suspended radionuclides and groundshine resulting from gamma emitters deposited onto the ground surrounding the individual. These are the two pathways for accidents involving release that are considered in RADTRAN-II and that

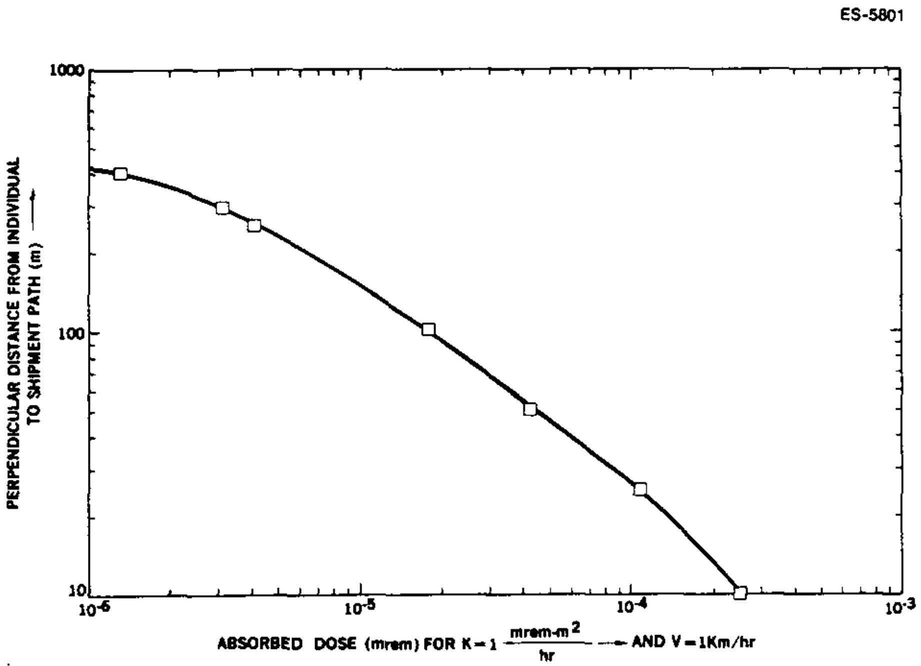

Fig. D.2. Values for absorbed dose per shipment.

were found to provide the majority of exposure. For the inhalation pathway, the consequence is calculated with the following equation:

$$\text{Dose(millirem)} = C(x) \times D_c \times Br \times t \times 10^3, \qquad \text{(D.2)}$$

where

$C(x)$ = $1/(2\pi x^2 V)$, the concentration of released activity at a distance x(m) from the source, μCi/m^3; the velocity at which material spreads out uniformly from the source, V = 1 m/s,

D_c = dose commitment factor for the waste,

Br = breathing rate of an excited individual (1175 L/h for adults, 780 L/h for children, and 350 L/h for infants),

t = the time an individual stands breathing at x m from the source.

The groundshine dose is calculated using the following model:

$$\text{Dose (millirem)} = \frac{q\Gamma}{r^2} \ln\left(\frac{h^2 + r^2}{r^2}\right) \times t \ , \qquad \text{(D.3)}$$

where

q = millicuries released,

r = radius of a source disk = 100 m,

h = height above ground of target (100 cm for adults, 50 cm for children, and 20 cm for infants),

Γ = gamma radiation function for a radionuclide (millirem-cm^2/h-millicurie),

t = time an individual stands at a point x m from the source.

The second type of accident considered is a loss-of-shielding accident, wherein impact (no fire is assumed) compromises cask shielding but does not breach the cavity or contents. The result of such damage is an increase of gamma radiation in the area around the cask. The following point-source exposure model was used:

$$\text{Dose (millirem)} = 5.2 \times 10^{6} \frac{CE}{r^2} \times t \ , \qquad (D.4)$$

where

C = curies "released," see discussion on pseudorelease fractions in Sect. D.5,

E = radionuclide photon energy level, MeV,

r = distance between source and individual, cm,

t = time the individual was exposed, h.

These equations calculate the consequence of an accident should it occur. Because these accidents are not likely to happen, their consequences are weighted by multiplying them by their probability of occurrence. The product of the multiplication is the risk, which oftentimes is referred to as the expected consequence.

D.4.2 Nonradiological impacts

The nonradiological impacts of transportation are calculated for both normal and accident conditions, but only the methodology for normal conditions are considered here. Because of its simplicity, the methodology used in calculating impacts from transportation accidents will be evident from the discussion of the accidents themselves.

For this analysis it is assumed that the HLW will be transported by a diesel-powered truck or train. The nonradiological impacts of transporting nuclear material, including the impacts from accidents, are the same as those transporting nonnuclear material. That is, the nonradiological impacts do not consider the characteristics of the cargo.

Fugitive dust will be generated in the turbulent wake behind a shipment, and chemical effluents, including particulates, sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), and hydrocarbons (HC), will be emitted because of the combustion of diesel fuel. Additionally, heat will be generated from the combustion of diesel fuel and by the radioactive decay of the waste.

Procedures used to obtain amounts of the pollutants emitted and to predict a concentration due to an assumed amount of traffic are discussed in this section.

D.4.2.1 Fugitive dust source terms

Fugitive dust generated on roads is computed using the following equation developed for paved roads. As the equation (Eq. D.5) indicates, the source term is a function of vehicle weight. Because the HLW casks are very heavy, more fugitive dust will be generated when they are hauled than when loads more representative of general commerce are hauled.

$$E = (0.45)\left(\frac{S}{10}\right)\left(\frac{L}{5000}\right)\left(\frac{W}{3}\right)^{0.8} (SZ)(F) \ , \qquad (D.5)$$

where

E = source term, g/km;

S = % of silt on the highway (10);

L = dust loading (1500 lb/mile);

W = weight of truck-trailer (37 ton);

SZ = fraction of dust less than 15 μm (0.5);

F = conversion factor $284 \frac{\text{mile-g}}{\text{km-lb}}$.

The values given in parentheses are the values used in this report and are taken from Ref. 8.

No recommended method is available for computing the fugitive dust entrained in the turbulent wake of a passing rail car. For this report, the quantity entrained is assumed to be 10% of that entrained behind a truck, based on work presented in Ref. 9.

D.4.2.2 Vehicular exhaust emissions

Emission factors for particulates, SO_2, CO, hydrocarbons, and NO_x from heavy-duty, diesel-powered trucks and trains are calculated using EPA recommendations.[10,11]

D.4.2.3 Pollutant concentrations

The pollutant concentration is calculated using the classic line-source model of diffusion in which the wind is assumed to be blowing in a direction perpendicular to the roadway. The geometry is represented in Fig. D.3 and the equation is given below.

$$\bar{X} = \frac{K}{(D_{max} - D_{min})\, u} \left(\frac{2}{\pi}\right)^{1/2} IQ \,, \quad \text{(D.6)}$$

where

$\bar{X}$ = average concentration,

$I = \int_{D_{min}}^{D_{max}} x^{-0.78} dx$,

$Q = 1.3\left[\left(\frac{\text{km}}{\text{m}}\right)\left(\frac{\mu\text{g}}{\text{g}}\right)\left(\frac{\text{h}}{\text{s}}\right)\right]$,

D_{max} = 805 m (see Fig. D.3),

D_{min} = 30 m (see Fig. D.3),

u = wind speed: 3 m/sec,

x = downwind distance (m),

K = source term $\left(\frac{\text{g}}{\text{km-h}}\right)$.

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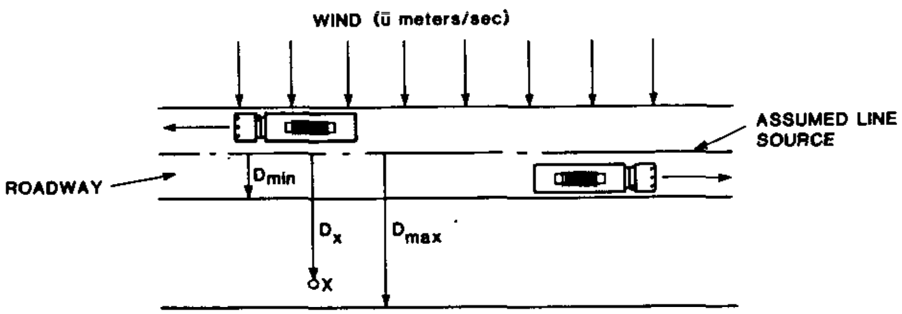

Fig. D.3. Geometry used in nonradiological impacts for normal transport.

Furthermore, the travel is assumed to occur along a generic mile with population densities as described in Ref. 12. Neutral atmospheric conditions are assumed, and the traffic flow is one truck or train passing a location per hour.

D.5 ACCIDENTS

This section discusses accident environments and the releases that might occur when the most extreme credible environments are postulated and defines how likely these accident environments would be.

D.5.1 Accident environments

Because HLW has not been shipped in the United States, accident experience for spent fuel will be discussed. The casks that carry spent fuel have been proven, either by actual testing or by analysis, to survive hypothetical test conditions that are more severe than the vast majority of transportation accidents. These test conditions are described in Sect. D.3.1. HLW casks will also have to be shown to survive these accident test conditions. Actual accident experience involving spent fuel casks is limited, and no accident has occurred that was severe enough to cause release of radioactive material.

Tests conducted on spent fuel casks at Sandia National Laboratories have simulated very severe accident conditions. Despite the extreme severity of the conditions in these tests, only limited damage resulted to the casks.[13]

Generally, to cause a cask to release any of its contents, extremely severe accident conditions must be created or postulated for analysis. A credible scenario that could result in a release of radioactive material would have to include very severe impact, the velocity of which is dependent on impact geometry, and/or a very severe fire of long duration. Such postulated conditions are very unlikely during rail or truck transport.[14]

D.5.2 HLW release fractions during accidents

In this section, the release fractions that could result from accidents involving the waste shipments from SRP will be defined and assumptions will be discussed. These release fractions will be presented in terms of the fraction of total inventory released. The inventories of these wastes have been defined in Sect. 3.3.1.4.

The release fractions and assumptions given here are meant to be independent of the mode of transport or cask capacities.

The release of material during a transportation accident involving an HLW glass is assumed to occur in two steps: (1) material is released from the canister containing the glass to the cask cavity and (2) material is then released from the cavity to the environment. In this analysis, a fraction of 10^{-4} is chosen for the release fraction from the HLW canister to the cask cavity because the canister will deform on impact and would not crack substantially. Actual tests of glass-filled canisters (unprotected by the cask) conducted by Ross[15] indicate that material is not expected to be released from the canister even after impacts of 48 kph; only traces may be released after impacts of up to 128 kph.

Based on analyses of Ross[15] and Bunnel[16], severe impacts on HLW glasses are not expected to generate much glass powder that is a respirable size. The data that Ross obtained show values for the percentage of material, generated (not released to the cask) from an impact that would be respirable, range from 10^{-8} wt % for a 30-kph impact to 7×10^{-2} wt % for a 128-kph impact. The value selected for this analysis was 10^{-2} wt % or a fraction of 10^{-4}. This is equivalent to saying that for each kilogram of HLW glass in the cask, 1×10^{-4} kg would be in a powder of respirable size after an impact; the total quantity of respirable material generated inside the cask would be dependent upon the total weight of glass in the cask. The fraction of material less than 10μ released from the HLW canister to the cask cavity would then be 10^{-8} (as shown below).

	Fraction glass released to the cavity	Fraction of released material less than 10μ	Total fraction of material less than 10μ released to cavity (not yet to the environtment)
Glass	10^{-4}	10^{-4}	10^{-8}

The question now becomes how much of this fraction reaches the environment through the damaged cask. Because HLW casks will be very similar to spent fuel casks, this analysis bases its release fractions from the cavity to the environment on the collective judgment of a workshop conducted to analyze spent-fuel transportation accidents.[15] The judgment inherently relies on the engineering judgment of cask designers and cask transporters. Five percent of the particulates was estimated to be released from the cavity of a gas-filled cask to the environment.[17] The total fraction of respirable material released from the HLW canister to the cask cavity and then to the environment is 5×10^{-10} (see Table D.1). This is the fraction used for the inhalation pathway because all of the respirable material is assumed to be aerosolized because of the fire. For groundshine calculations, a fraction of 5×10^{-6} is assumed because material in particles of all sizes including those larger than 10μ, contribute to this exposure.

Table D.1. Release of HLW to the environment in loss-of-contents accident

Pathway	Groundshine and respirable release fractions		
	HLW to cavity	Cavity to environment	Total
Inhalation	1E–8	5E–2	5E–10
Groundshine	1E–4	5E–2	5E–6

Release fractions for the other type of accident considered are calculated for a cask damaged only enough to compromise its shielding. The shielding is assumed to fail along a circumferential crack of varying widths (0.1 cm to 1.0 cm), and "pseudorelease" fractions are calculated as defined in NUREG 0170.[12]

D.5.3 Accident rates and probabilities

According to the Transportation Technology Center's Nuclear Material Transportation Accident data base,[18] only one accident involving spent fuel has occurred since 1971. In this accident, a truck hauling a spent fuel cask containing an assembly ran off a road and overturned, killing the driver. The spent fuel cask was undamaged, and no release occurred. No accidents involving spent fuel have occurred during rail transportation.

The probabilities used in this report are based on overall accident rates for rail and truck that have been reported previously.[19,20] The values are: 9.3×10^{-7} rail car accidents per car-km and 1.6×10^{-6} accidents per truck-km.

Because of the limited number of severe transportation accidents that have occurred, the fraction of accidents that would allow releases from a HLW cask must be estimated. McClure[19] has estimated the fraction of accidents involving only impacts (as in the loss-of-shielding accident) that are more severe than the regulatory test conditions to be 0.1% for both truck and rail. Estimates for the fraction of accidents involving only fire that are more severe than the regulatory test conditions are 0.2% for rail and 0.1% for truck.

Because a loss-of-contents accident involves both fire and impact, the above fractions must be combined. Because the probabilities for impact-only and fire-only accidents were derived considering them as independent events, the percentages of accidents involving both fire and impact (as in the loss-of-contents accident) that are more severe than the regulatory test conditions are 0.0002 for rail and 0.0001 for truck. The precision of such numbers can rightly be questioned because of the lack of data for severe accidents; the order of magnitude of the probability is more important and is probably in the range of one in one million. That is, in every one million accidents of all severities, one or two accidents at least as severe as the scenarios involving impact and fire could be expected.

Table D.2 is a tabulation of probabilities for accidents for SRP HLW; the probabilities are very small. To determine the accident rates of these extremely severe accidents, the probability that an accident is so severe is multiplied by the overall accident rate for truck and rail.

Table D.2. Accident rate for worst-case accidents for SRP HLW

Accident	Overall accident rates (km^{-1})		Probability that an accident will be a worst case ($accident^{-1}$)		Accident rate for worst case (km^{-1})	
	Truck	Rail	Truck	Rail	Truck	Rail
Loss-of-shielding	1.6E–6	9.3E–7	<1.0E–3	<1.0E–3	<1.6E–9	<9.3E–10
Loss-of-contents	1.6E–6	9.3E–7	<1.0E–6	<2.0E–6	<1.6E–12	<1.9E–12

D.6 IMPACTS OF TRANSPORTATION DURING NORMAL CONDITIONS

In this section, the impacts of normal transport will be calculated according to the methodology described (Sect. D.4). The input data used to calculate these impacts are also presented.

D.6.1 Input data for calculations

Many input data are required to calculate the impacts from normal transport and from accidents. Much of the data used in this analysis is consistent with data used in NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes,*[12] and with recommended data that are available as default input to RADTRAN-II.[7]

Table D.3 lists some of the miscellaneous data used in this analysis. The data in the table are self-explanatory with the exception of the bottom row of data. The dose rate at 2 m from an extended vertical plane of a rail car or trailer edge is assumed to be 10 millirem/h which is the regulatory limit. Using this value will result in a greater than expected dose to the public (i.e., it would be a conservative estimate).

D.6.2 Unit-consequence factors

The unit-consequence factors for normal transport are given in Table D.4. Separate factors are listed for the truck and rail modes. The first factor listed is for an individual exposed to a shipment of HLW as it passes. Implicit in the individual dose values are the assumptions: (1) the shipment passes at 24 kph, (2) the individual resides at a point 15 m from the shipment path, and (3) the HLW is five years old. This factor, as with all subsequent factors, should only be applied when the conditions in the assumptions are met. If they are not met, the value of the factor changes. This factor can be used to evaluate the dose to the individual exposed to the maximum extent by simply multiplying it times the number of shipments that pass by him.

The next three factors are for the population affected by the shipments, that is, the population living within 0.8 km of the route (off link), the population moving along the route (on link), and the population surrounding the shipment when it is stopped. The first two are consequence factors that have a per-kilometer basis, while the last has a per-shipment basis. Once again, these factors are calculated using assumptions, given in Table D.3, that must be satisfied when the factors are to be applied.

The crew factors are on a per-kilometer basis; the assumptions used are given in Table D.3. The factor for the rail crew has been set at zero for rail because the exposures are so low. For all cases, the factors are very small.

D.7 IMPACTS OF ACCIDENTS DURING TRANSPORTATION

In this section, the impacts of accidents that may occur during transportation are calculated using the methodology described earlier. The impacts will be presented in units of expected equivalent-whole-body dose to an individual exposed to the maximum extent as a result of a

Table D.3. Miscellaneous data used in RADTRAN-II calculations

Parameter	Truck	Rail
Number of crewmen	2	5
Distance from source to crew, m	3	150
Persons/km^2		
High-population zone	3861	3861
Medium-population zone	719	719
Low-population zone	6	6
Stopover time (4800-km trip), h	8	8
Average exposure distance while stopped, m	20	20
Persons exposed while stopped	50	100
Speed		
High-population zone, km/h	24	24
Medium-population zone, km/h	40	40
Low-population zone, km/h	88	64
Fraction of travel		
High-population zone	0.05	0.05
Medium-population zone	0.05	0.05
Low-population zone	0.90	0.90
Traffic count		
High-population zone, vehicles/h	2800	5
Medium-population zone, vehicles/h	780	5
Low-population zone, vehicles/h	470	1
Persons per vehicle	2	3
Cask length, m	5	5
Dose rate 2 m from the edge of cask railcar or truck trailer, millirem/h	10	10

Table D.4. Unit-consequence factors for normal transport expressed as latent cancer fatalities per kilometer of travel (LCF/km)

	Truck		Rail	
	Probable[a]	Maximum[a]	Probable[a]	Maximum[a]
Maximum individual[b]	6.0E–4		6.0E–4	
Population				
On link	5.3E–9	1.8E–8	7.2E–11	2.4E–10
Off link	1.1E–8	3.7E–8	1.9E–9	6.4E–9
Stops[c]	5.8E–5	1.9E–4	1.2E–4	3.8E–4
Crew	6.5E–9	2.2E–8	*d*	*d*

[a]For a discussion of the meaning of these terms, refer to Appendix J.4.
[b]For the maximum individual, exposure is recorded in terms of radiological dose (millirem) per shipment, not LCF per kilometer.
[c]LCF per shipment.
[d]Very small relative to other factors.

single kilometer of travel. The input data used to calculate these impacts, which will be referred to as unit-risk factors, are also presented.

D.7.1 Input data for calculations

Much of the data presented earlier for normal transport will be used to calculate impacts for accidents that may occur during transport. However, additional data are required for the accident impact analysis. Other radiological factors used to describe the HLW are the curie inventory in the HLW, gamma-decay energies, and dose conversion factors. Standard and current references for gamma-decay energies[21] and dose conversion factors[22] were selected.

The unit-risk factors for the impacts of accidents during transportation are given in Table D.5. Separate factors are listed for truck and rail modes. The unit-risk factors are given for both the accident involving a loss of shielding and the accident that involves the loss and dispersal of contents. Both factors have a *per-kilometer basis*. As a result, total risk is calculated by multiplying these unit-risk factors by total kilometers shipped.

Table D.5. Unit-risk factors for accidents during transportation[a]

	Truck	Rail
Loss of shielding and no release of contents, millirem/km	2.6E−9	7.3E−9
Loss of shielding and release of contents,[b] millirem/km	1.3E−12 (adult)	7.6E−12
	1.8E−12 (child)	1.0E−11
	2.4E−12 (infant)	1.4E−11

[a] Risk to an individual exposed to the maximum extent.

[b] Separate risk factors are not given for each pathway (groundshine and inhalation) because the overwhelming majority of exposure during a loss-of-contents accident results from groundshine.

To calculate the unit-risk factors, the consequence of the accident scenarios had to be calculated according to the equation in Sect. D.4.1.2 and then multiplied by the accident rates in Table D.2. The consequences are given in Table D.6 and are presented for each scenario for each mode of transport and for each population age group.

Table D.6. Accident consequences: Maximum individual exposure resulting from partial loss of contents or loss of shielding, in millirem

Type of accident	Release (Ci)		Dose					
			Infant		Child		Adult	
	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck
Loss of contents								
Groundshine	0.94	0.19	7.5	1.5	5.5	1.1	4.0	8.0E−1
Inhalation	1.6E−4	3.2E−5	2.5E−3	4.9E−4	5.3E−3	1.1E−3	3.5E−3	6.9E−4
Loss of shielding[a]							7.8	1.5

[a] Calculated only for adult.

D.8 NONRADIOLOGICAL IMPACTS OF NORMAL TRANSPORT

D.8.1 Pollutants and their health effects

Pollutants are emitted during normal transport by combustion of diesel fuel, by the passage of a shipment over a dusty road surface, and by tire wear. Combustion of diesel fuel generates SO_2, CO, hydrocarbons, NO_2, and particulates. The passing of a shipment over a roadbed or highway generates fugitive dust, and tire particulates are generated from the abrasion of tires on the pavement. Each of these pollutants has a unique character, and they may affect health. Each pollutant will be described briefly, and the health implications of each will be discussed.

Sulfur dioxide is a nonflammable, nonexplosive, colorless gas. The gas is first detected by taste and, at higher concentrations, can be detected by odor. In the atmosphere, it is at least partially converted to more hazardous products by photochemical or catalytic processes.

Sulfur dioxide and its products irritate the lining of the respiratory tract. The injury, which may be temporary or permanent, is more severe for the products of SO_2 than for SO_2 itself. The irritation may result in constriction of airways, which may be assessed by increases in airway resistance.

Particulates and sulfur oxides are often treated jointly in health impact analyses because they are often present together in ambient air and because SO_2 is transformed into a particulate. Particulates will often contain or carry other absorbed toxic materials, such as lead or other heavy metals, but the composition of particulates depends on their origin (particles emitted during combustion of diesel fuel will not be the same as fugitive dust particles generated on a country road). The size, shape, and composition of a particle determines its health effects.

Nitrogen dioxide is known to be toxic at relatively high concentrations and is a strong irritant. Acute and chronic injury of the lungs has been observed at extremely high concentrations causing irreversible damage. It is also involved in many complex chemical reactions. In the presence of sunlight, it may be converted to even more toxic intermediates.

Carbon monoxide has an affinity for hemoglobin, with which it combines, reducing the capability of the blood to carry oxygen. From a physiological viewpoint, symptoms of CO inhalation are similar to anemia symptoms.

Because of the large variety of possible hydrocarbons pollutants, a discussion of each is restricted. It is sufficient to note that some are definitely carcinogenic and many produce adverse health effects, but little information is available from long-term studies of hydrocarbons on humans.

The character of each of the pollutants can be described from detailed laboratory experiments in which they can be isolated. However, "air pollution" generally contains all of these pollutants and very rarely can their effects be isolated. Pollutants can also interact and form new and intermediate toxic pollutants.

Some quantities of pollutants are emitted during routine transport. Estimates of the quantities are made using EPA documentation[10,11] and are listed in Table D.7.

Table D.7. Emissions from transportation[a]

Pollutant	Truck (g/km)	Rail (g/km)
Particulates	0.81	4.5
SO_2	5.1	10
NO_2	13	65
Hydrocarbons (HC)	3.3	19
CO	22	24
Tire particulates	0.54	*b*
Fugitive dust	140	14

[a]Assumes 24-kph (15-mph) speed in urban area.
[b]Not applicable.

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The significance of the health effects produced by these emissions is difficult to quantify. It is particularly difficult to isolate the effects of each of the pollutants because they can interact among themselves and may simply mask the effects of other influences (e.g., smoking, income, availability of doctors) that may actually cause observed health effects. Nevertheless, *without specification of pollutants, it is generally believed that air pollution can cause* increased mortality and that pollutant levels at the relatively low ambient concentrations occasionally associated with transportation can result in increased respiratory symptoms.

A major goal of epidemiologists studying the effects of air pollution has been to quantify the effects. Many believe that their attempts to date have met with little success as reflected in a quote from a recent Ford Foundation study[23]

> "There is convincing evidence that air pollution is associated with mortality; but there is no reliable quantitative information on the magnitude of the effect or on the number of lives that would be saved by reduction in the level of any one or all air pollutants."

Quantitative estimates exist but must be qualified carefully.

To facilitate a somewhat quantitative comparison of emissions to current pollution standards, the emissions resulting from the hourly passing of one diesel-powered truck or locomotive hauling an HLW cask will be used to calculate an average air pollutant concentration, which in turn will allow a comparison to the primary air quality standards. The concentrations were calculated implicitly assuming travel over the generic mile (defined in Ref. 12).

Table D.8 compares the calculated concentrations to the air quality standards. It is currently believed that the primary standards for the six regulated pollutants seem adequate to protect the health of the public.[24] For each pollutant, the calculated concentration is much lower than the standard, even when one truck or train per hour is considered. Since the number of shipments of HLW from the DWPF would more likely average one shipment per day, the nonradiological impacts from the DWPF would be even smaller.

Table D.8. Comparison of calculated pollutant concentrations for rail and truck transportation with air quality standards

Pollutant	Pollutant concentration[a] ($\mu g/m^3$) Truck	Pollutant concentration[a] ($\mu g/m^3$) Rail	Primary standard ($\mu g/m^3$)
Particulates	0.63	0.09	260 (24 h)
SO_x	0.02	0.05	365 (24 h)
NO_x	0.06	0.3	100 (annual mean)
HC	0.02	0.09	160 (3 h)
CO	0.1	0.1	40,000 (1 h)

[a]Hourly concentrations are calculated assuming that a truck or locomotive passes a point once an hour and that the generic area is 90% rural, 5% suburban, and 5% urban land area.

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D.8.2 Heat generation

From each conceptual truck cask containing one canister filled with high-level waste, less than 0.5 kW of heat will be generated. This is approximately 0.3% of the heat (150 kW) dissipated by a 224 kW (300 hp) diesel engine truck hauling the wastes, assuming a 34% conversion efficiency. From a rail cask containing five canisters of high-level waste, less than 2.5 kW of heat will be dissipated. This is less than 0.2% of the heat (1500 kW) generated by a 2240 kW (3000 hp) locomotive, assuming a 34% conversion efficiency.

The impact on the environment of the heat dissipated from the casks containing the high-level waste and diesel engines of the truck and the locomotive carrying the wastes is extremely small compared to the heat generated daily by vehicular traffic.

D.9 NONRADIOLOGICAL IMPACT OF TRANSPORTATION DURING ACCIDENT CONDITIONS

The nonradiological human health impacts that would be expected from accidents during transportation of HLW are the deaths and injuries that would result directly from any transportation accident, regardless of the material being hauled. This section discusses the unit-risk factors derived from published data.

The potential for transportation accidents involving shipments of HLW is assumed to be comparable to that for general truck and rail transportation in the United States. Table D.9 shows that 1.6×10^{-6} truck accidents per kilometer and 9.3×10^{-7} rail car accidents per rail car kilometer are projected. From an analysis of transportation accidents, 0.51 injuries and 0.03 fatalities per truck accident and 2.7 injuries and 0.2 fatalities per rail accident have been estimated.[25] Based on these injury and fatality rates and the projected accident rates, injuries and fatalities for a travel distance of 1 km have been computed. As shown in Table D.9.1, 8.2 [redacted] $\times 10^{-7}$ injuries and 4.8×10^{-8} deaths are expected to occur per kilometer of truck travel and 2.5×10^{-6} injuries and [redacted] 1.9 $\times 10^{-7}$ deaths per kilometer of rail travel.

Table D.9. Projected accidents, deaths, and injuries per kilometer of travel during transportation of spent fuel

Mode	Accident rate (accidents/km)	Injury rate[a] (injuries/accident)	Fatality rate[a] (fatalities/accident)	Injuries (per km)	Fatalities (per km)
Truck	1.6E−6[b]	0.51	0.03	8.2E−7	4.8E−8
Rail	9.3E−7[c]	2.7	0.2	2.5E−6	1.9E−7

[a]From U.S. Atomic Energy Commission, *Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants*, WASH-1238, December 1972.

[b]From R. K. Clarke, J. T. Foley, W. F. Hartman, and D. W. Larson, *Severities of Transportation Accidents*, SLA-74-0001, Sandia National Laboratory, Albuquerque, N.M., July 1976.

[c]From A. W. Dennis, J. T. Foley, W. F. Hartman, and D. W. Larson, *Severities of Transportation Accidents Involving Large Packages*, SAND 77-0001, Sandia National Laboratory, Albuquerque, N.M., May 1978.

D.10 EMERGENCY RESPONSE

The responsibilities for dealing with nonroutine events such as radioactive material transportation accidents is divided. For example, on the Federal level, the Federal Emergency Management Agency (FEMA) has the primary responsibility for planning and response to transportation accidents involving radioactive materials. In general, however, the ultimate responsibility for the establishment of emergency response plans lies with state and local governments. Most state governments and many local governments have emergency response plans to cope with such events. The logic for having state and local governments assume responsibility follows the manner in which a typical emergency response is apt to be made: the first responder to a transportation accident or other reported event that involves radioactive material is probably going to be a local law enforcement officer or member of the local fire department.

An emergency response plan represents an attitude of preparedness and the ability of a state or local government (with Federal assistance) to cope with some "nonroutine" event that constitutes some level of threat. It does not prevent such unexpected events.

The implementation of emergency response planning and the coordination of this authority will commence with the publication of a guidance document for state and local governments on emergency response plan development, which, when published by FEMA, will detail the necessary components of emergency response plans including organizational responsibilities and jurisdictions, accident characteristics, a statement of emergency response planning elements, an analysis of radioactive material transportation, continuous state and local cooperation, emergency equipment and resources required, notification methods and procedures, emergency communications, public information, accident assessment, protective response, radiological exposure control, medical support, emergency response training activities, and post-accident operations.

The Federal support, which is available to state and local governments, will be provided by:

1. Department of Energy (DOE) and its regional assistance teams through the Interagency Radiological Assistance Program (IRAP),
2. Environmental Protection Agency (EPA),
3. Department of Health and Human Services through the Food and Drug Administration (FDA),
4. Federal Emergency Management Agency (FEMA),
5. Department of Transportation — Material Transportation Bureau (DOT/MTB), and
6. Nuclear Regulatory Commission (NRC).

D.11 SABOTAGE

The possibility that terrorists might sabotage either a truck or rail shipment of high-level radioactive waste for the purpose of either dispersing or threatening the dispersal of the waste
has been given increasing attention by the government, the news media, and the public. The threat J-41
to disperse radioactive waste for contamination is considered an unlikely, but viable, action by

terrorists. Theft of the radioactive waste in itself, without intent to disperse, is not considered a likely, viable event because the waste has neither monetary value nor sufficient fissile material content for even a crude nuclear bomb.

D.11.1 Potential terrorist actions

Unauthorized penetration of the HLW cask will probably require energy-intensive techniques, such as the use of explosives or some mechanical devices, because special tools and heavy equipment are normally required to safely handle and open these casks. Because of the massive size of the packages and the probable uncertainty of the saboteurs in placing the explosives (detailed knowledge of the design features of the package, access to it, and other logistical considerations), the likelihood of successful sabotage is decreased. The use of "hands-on" mechanical techniques (e.g., gas cutting torches, power saws, burn-bars) would also be unattractive because the levels of external penetrating radiation near the exposed waste could lead to lethal doses in seconds, and once the cask was opened, the HLW would still have to be dispersed in some way.

The uncertainties of success would probably cause a terrorist to select another means of expressing his demands other than the dispersal of HLW. Furthermore, if a terrorist tries to breach a cask with energy-intensive devices, the immediate nonradiological effects of a sabotage attack in a densely populated area may be as significant or more significant than the radiological effects.[26] Most assuredly, there are more certain ways for a terrorist to cause a large number of immediate deaths and injuries than attempting to explode a massive shipping cask.

D.12 DECONTAMINATION AND DECOMMISSIONING OF TRANSPORTATION EQUIPMENT

Either truck or rail casks will be used for moving canisters of HLW from the DWPF. The useful life of either type is estimated to be 20 to 30 years.

The casks, whether transported by truck or rail, are expected to be loaded dry with decontaminated stainless-steel canisters containing HLW. The casks and baskets are expected to be inspected before and after each shipment to ensure no contamination exists and to be thoroughly cleaned. Rail cars, trucks (tractors and trailers), mounting frames, external impact limiters, and accessories (other parts of the cask system) are not expected to become contaminated during normal shipping operations. Therefore, a decommissioned and uncontaminated truck- or rail-cask system will probably be disposed of as scrap metal.

Casks and cask internals (baskets and impact limiters) could become contaminated in abnormal or accident situations. It is unlikely that a failed canister would be loaded into a cask for transport, but a canister could fail in transit as the result of a severe accident. Detection of a failed canister or detection of radioactive debris in the cask would result in the initiation of appropriate cask decontamination operations. Decontaminated casks could be disposed of as scrap metal, but those parts with residual contamination still evident would be disposed of as radioactive waste, particularly if additional decontamination would cost too much.

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Appendix E

SOCIOECONOMIC CHARACTERIZATION OF THE SAVANNAH RIVER PLANT AREA

Appendix E

SOCIOECONOMIC CHARACTERIZATION OF THE SAVANNAH RIVER PLANT AREA

Material in this Appendix is based on the report *Socioeconomic Baseline Characterization for the Savannah River Plant Area* by NUS for ORNL, 1981 (except as otherwise noted). The sections in this Appendix correspond to sections in the baseline characterization report, and additional information may be obtained by referring to the latter.

E.1 THE PLANT

The socioeconomic impacts of the SRP upon the people and communities in its vicinity began with the relocation of the resident population off of the site and construction of the first facilities in 1951. By 1952, a work force of 38,350 was onsite, populations of nearby towns swelled, and trailer courts and new homes proliferated. These early days and the changes induced by plant construction are described in the book *In the Shadow of a Defense Plant* by Stuart Chapin et al.[1]

A primary socioeconomic impact of the SRP has been the large number of permanent jobs created. As the initial major construction ended, the work force dropped in the late 1950s to the permanent operating force of around 7500. After employment reductions in the 1960s to around 6000, the work force increased again to the current 8300 (July 1980). About 95% of this total are employed by E. I. du Pont de Nemours and Company, Inc., and its subcontractors; the remainder are employed by DOE (220), the University of Georgia (70), and the U.S. Forest Service (30).

The large contribution of SRP to the rise in the standard of living in the impact area is a major secondary socioeconomic benefit. The 1979 SRP payroll of over $209 million was one of the largest in South Carolina. In addition, more than $40 million was spent by SRP in South Carolina and Georgia for services, energy, materials, equipment, and supplies in 1979; about one-half of the expenditure was made in the primary impact area (see Sect. E.2 for definition of the primary impact area).

The greatest impact of the SRP has been on Aiken County, especially the city of Aiken, and the small towns immediately around the SRP site, as may be seen in the SRP worker distribution pattern (see Table E.1). SRP workers and families comprise roughly one-half of the city of Aiken's 15,000 people and account in large measure for the high median family incomes in the county.

E.2 THE STUDY AREA

The DWPF socioeconomic study area includes nine counties in South Carolina and four in Georgia. These counties house 97% of the current SRP work force. These 13 counties are expected to provide most of the labor pool for the DWPF and to sustain the most concentrated community impacts from potential in-moving workers. The nine counties in South Carolina are Aiken, Allendale, Bamberg, Barnwell, Edgefield, Hampton, Lexington, Orangeburg, and Saluda; in Georgia, Burke, Columbia, Richmond, and Screven. Inclusion of these counties in the study area is based, in part, on a Savannah River Laboratory (SRL) review of distribution of residence of current employees and, in part, on other analyses of the effects of SRP on adjacent communities (see Table E.1). A previous study addressed dislocation of the resident population associated with original facility construction in 1951 to 1953 as well as impacts of construction and operation phases upon the area.[1] It presented a limited socioeconomic baseline characterization.

The 13 counties are categorized into primary and secondary impact areas on the basis of expected impacts from construction and operation of the proposed DWPF. The six primary counties were estimated to be the residence choice of a large majority of relocating workers and, thus, the site of most concentrated community and services impacts. The vast majority of future DWPF construction workers already live in this area, however, and will make no additional demands upon services except for their travel to work. Counties in the South Carolina primary study area include Aiken, Allendale, Bamberg, and Barnwell; in Georgia they include Columbia and Richmond. These six counties house 89.3% of the current SRP work force. Most of the SRP site is in Aiken and Barnwell counties; a small part is in Allendale County. Most of the SRP employees resided in

Table E.1. Distribution of the June 1980 SRP employees by place of residence and as a percentage of the June 1980 labor pool

Location of residence	Number of SRP employees	Percent of SRP labor force	June 1980 labor pool[a]	SRP employees as a percentage of the labor pool
Primary study area	7447	89.3	142257	5.2
South Carolina counties	5955	71.4	59790	10.0
Aiken	4904	58.8	40260	12.2
Allendale	149	1.8	3580	4.2
Bamberg	165	2.0	6830	2.4
Barnwell	737	8.8	9120	8.1
Georgia counties	1492	17.9	82467	1.8
Columbia	256	3.1	15197	1.7
Richmond	1236	14.8	67270	1.8
Secondary study area	643	7.7	129609	0.5
South Carolina counties	553	6.6	113370	0.5
Edgefield	92	1.1	8090	1.1
Hampton	104	1.2	7080	1.5
Lexington	133	1.6	57980	0.2
Orangeburg	142	1.7	33590	0.4
Saluda	82	1.0	6630	1.2
Georgia counties	90	1.1	16239	0.6
Burke	25	0.3	8176	0.3
Screven	65	0.8	8063	0.8
Outside study area	245	2.9[b]	c	c
South Carolina	163	2.0	c	c
Georgia	71	0.9	c	c
Other states	11	0.1	c	c

[a]Labor pool includes agricultural, Federal, self-employed and all other workers.
[b]Numbers may not add due to rounding.
[c]Not significant.
Source: SBC.

the six primary counties in 1980: 71.4% resided in South Carolina compared with 17.9% in Georgia. Table E.1 indicates that the highest percentage (58.8%) and number (4904) of SRP employees lived in Aiken County and comprised 12.2% of the total Aiken County labor force in June 1980. The secondary study area comprises the next "ring" of counties around the SRP, housing 7.7% of the current SRP labor force and being the likely source of most additional labor for the DWPF. Community and services impacts are not expected to be as significant in the secondary area, though some new workers may choose to relocate in these seven counties. As may be seen in Table E.1, Orangeburg County has the largest number of the current SRP work force (142) in this secondary study area, but this number is quite small (0.4%) when viewed in terms of Orangeburg's large labor pool. Though Burke County, Georgia, ranks lowest on all indicators (only 25 SRP employees comprising 0.3% of the county labor pool), it is included in the secondary study area because of possible work force interactions between the DWPF and the Georgia Power Company Vogtle nuclear plant now under construction there.

E.3 LAND USE OFFSITE

E.3.1 Existing land-use patterns

The primary and secondary study area, encompassing over 20,000 km^2 (7700 sq. miles) is generally rural. Over 37% of the total area is woods, forests, and wetlands, whereas agricultural lands comprise about 35.7%. Vacant, open space, and unclassified lands constitute about 20.2% of total area. Lake Murray, the Clarks Hill Reservoir, the Savannah River, and other water resources constitute 1.4% of the total area. The developed land (residential, commercial, industrial, institutional, and recreational uses) includes approximately 5% urban development, primarily concentrated in the Columbia and Augusta Standard Metropolitan Statistical Areas (SMSAs), and 3.5% publicly owned, such as Richmond County's Bush Field Airport, or semi-publicly owned, such as the Clarks Hill Reservoir lands managed by the U.S. Army Corps of Engineers. Major Federally owned lands include the Savannah River Plant (3.9% of the combined study area lands) and the Fort Gordon military base in Richmond County (1.1% of the total).

Most primary area counties have vast areas of forest, open space, and agricultural and unimproved lands often totaling 80 to 90% of the county. In some counties, Bamberg for instance, forests managed by timber companies are being converted to agricultural crop or pasture lands. In Aiken and Barnwell counties, a significant SRP reforestation program exists in which trees are commercially harvested under the supervision of the U.S. Forest Service.

Higher fractions of developed land are found in the SMSA counties in and around Augusta and Aiken. The extent of urban development is approximately 28,000 ha (68,000 acres — 32%) in Richmond County, 16,000 ha (7%), in Aiken County, and 9700 ha (13%) in Columbia County. By contrast, the rural counties of Allendale and Bamberg each have only about 600 ha of developed land (0.5%).

Highest concentrations of residential development in the primary area are in the counties comprising the SMSA: Richmond, Columbia, and Aiken. Residential development in Richmond County, which constitutes approximately 17,000 ha (20% of county total 84,000 ha), is mainly found in Augusta, Blythe, and Hephzibah. Residential development constitutes about 7500 ha (10% of county total) centered in Martinez, Evans, Grovetown, and Harlem in Columbia County. Aiken County has around 4000 ha of residential development (2.0% of county total 250,000 ha), mainly in the cities of Aiken and North Augusta.

Extensive commercial development is found in Richmond, Aiken, and Columbia counties and along major interstate and state highways. Of the total Richmond County commercial development (approximately 2500 ha), a majority is located in the Augusta area and much smaller amounts in the towns of Blythe and Hephzibah. The majority of commercial land use in Aiken County is strip development located in the urban cities of Aiken and North Augusta. In Columbia County, Georgia, commercial development is centered in the Martinez-Evans area.

Significant primary area industrial development is found in Richmond, Aiken, and Columbia counties. Industrial land usage in Richmond County (5% of county) is mainly concentrated in Augusta near the Savannah River. Of the Aiken County industrial land external to the SRP, 1600 ha (0.6% of county total) is near Beech Island, Salley, Horse Creek, and the Aiken city fringe. Industrial development in Columbia County is primarily located near the town of Martinez along the Seaboard Coastline Railroad and Interstate-20 and near the town of Evans.

Fort Gordon Military Reservation, located mainly in Richmond County, comprises about 18,000 ha (21% of county). This large reservation restricts further development.

In the secondary study area, the most extensive urban development occurs in the Lexington County portion of the Columbia SMSA. All remaining secondary counties have extensive forest, agricultural, and open-space lands.

E.3.2 Proposed future land-use patterns

Most future area land uses, as projected by area planning agencies, will be similar to existing land uses. The greatest population growth is expected to occur in Aiken, Columbia, and Richmond counties because of anticipated Augusta metropolitan expansion. Although Augusta will remain the region's primary metropolitan center, Sylvania in Screven County is expected to become a secondary regional center attaining approximately 15,000 population by year 2000. Because of anticipated growth in the Columbia SMSA, population increases for Lexington County are expected. All counties in the study area, except Hampton and Burke, currently have comprehensive long-range land-use plans.

Agricultural land throughout the study area is undergoing a transition from smaller operations to larger consolidated farms, a trend that is expected to continue. Agriculture will continue to have a major role in the economic viability of the study area, especially in the rural counties.

A majority of the county land-use plans identified a need to preserve environmentally sensitive lands such as carolina bays and other wetlands. Other natural areas, such as forests and woodlands, are projected to be more extensively used for lumbering operations. In addition, forestlands that serve an important area recreational function are likely to be expanded. The two largest outdoor recreational areas are the Sumter National Forest and the Clarks Hill Reservoir, as mentioned in Sect. E.7.2. Future expansion and development of recreational areas is expected in every study-area county.

E.3.3 Land-use regulation

The land-use controls most commonly used by local and county governments to shape area development patterns are zoning ordinances, subdivision regulations, building codes and permits, and the regulation of mobile homes and trailer park development. Other potential planning tools not widely used or totally absent from the study area are development standards, utility extensions or moratoriums, floodplain regulation and insurance, environmental regulations, and tax incentives.

Only two primary counties, Richmond and Columbia, and one secondary county, Burke — all in the state of Georgia — have county zoning ordinances. Zoning ordinances typically divide planning jurisdications into use districts such as residential, commercial, industrial, and agricultural.

Six of the 13 study-area counties have county subdivision regulations. These are Aiken, Columbia, Richmond, Lexington, Burke, and Saluda (Lake Murray area) counties. Normally, subdivision regulations are applied in advance of the development of the community to ensure proper design and construction.

Building codes or permits to ensure minimum construction standards are issued and/or enforced in Aiken, Richmond, Columbia, Bamberg, Barnwell, Burke, Edgefield, Hampton, and Lexington counties but not in the remaining counties.

The counties of Bamberg, Burke, Columbia, and Richmond have some form of county-wide mobile home or trailer park regulation in addition to the state health regulations concerning mobile home water and sewage systems.

Within the study area, more than 40 of the approximately 80 communities have at least one of the following regulations: (1) zoning ordinances, (2) subdivision regulations, (3) building codes and permits, and (4) mobile home and trailer park regulations. In the South Carolina portion of the primary study area, the towns of Aiken, North Augusta, Bamberg, and Denmark have all four of the above land-use controls, as do the Georgia communities of Grovetown, Harlem, and Augusta. Communities in Richmond County that have no land-use controls are subject to county-wide land-use regulations. Within the secondary study area, only the communities of Batesburg, Cayce, Lexington, Springdale, Orangeburg, Sylvania, and Waynesboro have the aforementioned four land-use regulations. In contrast, 10 communities in the primary study area and 22 in the secondary area have none of these four regulations and are not subject to county regulations except for minimum state health standards.

E.3.4 Local planning efforts

Major land use plans have generally been adopted and in-house professional planners employed only in the large metropolitan counties (Richmond, Aiken, Columbia, and Lexington) and in the high-growth cities such as Aiken and North Augusta. A single city-county planning commission is utilized by Richmond County and the city of Augusta. All but two of the rural counties depend on the professional planning assistance of their regional planning commission or council of governments for selected planning tasks.

E.4 DEMOGRAPHY

E.4.1 Population and its distribution

E.4.1.1 Population in incorporated communities and unincorporated areas

Incorporated towns and cities in the six primary counties contained one-third of the total county population (376,000), according to the 1980 U.S. Census. Table E.2 shows the population estimates for these 31 communities, a total of about 118,100. The largest cities in the primary area are Augusta (47,500), Aiken (15,000), North Augusta (13,600), and Barnwell (5600). The other 27 communities have populations of less than 5000. Aiken, Richmond, and Columbia counties comprise the Augusta SMSA* and have a total population of 327,400. Most of the population within this SMSA live outside the boundaries of any city or town. Two-thirds of the six-county population live in rural areas and in 47 unincorporated communities. Further examination of population percentages reveal wide differences between the two states and between counties within states with regard to the percentage of the population living within incorporated communities. Both Georgia counties (Columbia, 12%, and Richmond, 27%) rank lower than any South Carolina county. Aiken county has 33% of its population in towns, whereas all the rural South Carolina counties have one-half or more of their populations in towns: Bamberg, 49%; Allendale, 64%; and Barnwell, 64%.

These differences are associated with significantly different patterns of local government and provision of public services and, hence, significantly different potential for dealing with population growth.

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*A standard metropolitan statistical area (SMSA) is comprised of a central city or cities with a population of 50,000 or more and the contiguous counties that are economically integrated with the central city.

Table E.2. Preliminary 1980 populations for counties and communities in the primary impact area

Jurisdiction	1980 population	Population in incorporated communities by county	Percent population in incorporated communities by county
South Carolina			
Aiken County	105,625	35,252	33
City of North Augusta	13,593		
City of Aiken	14,978		
City of New Ellenton	2,628		
Town of Jackson	1,771		
Town of Burnettown	359		
Town of Salley	584		
Town of Windsor	55		
Town of Perry	273		
Town of Wagner	903		
Town of Monetta	108		
Allendale County	10,700	6,813	64
Town of Fairfax	2,061		
Town of Sycamore	261		
Town of Ulmer	91		
Town of Allendale	4,400		
Bamberg County	18,118	8,949	49
Town of Bamberg	3,672		
City of Denmark	4,434		
Town of Govan	109		
Town of Olar	381		
Town of Ehrhardt	353		
Barnwell County	19,868	12,695	64
Town of Williston	3,173		
Town of Blackville	2,840		
City of Barnwell	5,572		
Town of Elko	329		
Town of Snelling	111		
Town of Kline	315		
Town of Hilda	355		
Georgia			
Columbia County	40,118	4,976	12
City of Grovetown	3,491		
City of Harlem	1,485		
Richmond County	181,629	49,349	27
City of Augusta	47,532		
Town of Hephizbah	1,452		
Town of Blythe	365		
Primary study area	376,058	118,034	31

Source: U.S. Bureau of Census, 1980 Census of Population and Housing, South Carolina, PHC80-V-42; Georgia, PHC80-V-12; March 1981.

E.4.1.2 Population change

The populations of Georgia and South Carolina have increased from 9 to 16% each decade since 1950. For the period 1970 to 1978, growth rates in these states (10.8% and 12.6%, respectively) exceeded the U.S. national average (7.4%). Among area counties, population changes have varied considerably, primarily because of differing rates of urbanization. Most of the population increases since 1950 have occurred in the three counties of Aiken, Richmond, and Columbia, which together comprise a SMSA. Columbia County was added to the SMSA in 1973. The greatest percentages increases in primary area population occurred in Columbia County between 1950 and 1978; it increased from smallest to third largest among the primary counties. Since 1950, the fastest growing county in the secondary area is Lexington County. Having a growth rate of 47% between 1970 and 1978, this county now approaches one-half of the total secondary area population. Significant declines in rural county populations in both primary and secondary areas (1950 through 1970) were reversed in the seventies.

E.4.1.3 Population density

Both Georgia and South Carolina population densities have been steadily increasing since 1950. The 1978 average number of persons per square mile in Georgia (87.5) and South Carolina (94.4) was higher than the U.S. national average (61.6).

The primary study area population density historically has been greater than the secondary area. In 1978, the primary county densities ranged from 538.5 persons per square mile in Richmond to 24.4 (Allendale) and 35.4 (Barnwell). Seven of the rural counties had steadily declining population densities until the mid-seventies when they began to grow again. Among secondary counties, densities range from Lexington (128.0) and Orangeburg (71.4) to Screven (20.4) and Burke (22.5).

E.4.2 Population characteristics

E.4.2.1 Age and sex

Median ages of the South Carolina and Georgia population including all primary counties have been as much as four years younger than the U.S. median (approximately 30.0 years) since 1950. As elsewhere, however, there is an aging trend in all primary counties since 1960. From 1970 to 1978 the percentage of the population under 19 of the study area generally decreased, whereas the percentage over 65 increased.

Area males have consistently outnumbered females in the 19-and-under age group since 1950. The proportion of area males declined with increasing age, however, similar to the U.S. population.

E.4.2.2 Race and ethnicity

In 1978, there were high percentages of blacks in Georgia (27%) and South Carolina (31%) when compared with the U.S. national average (11%). Among primary counties in 1978, the highest percentages of blacks resided in Bamberg (60%) and Allendale (56%), whereas the lowest percentages resided in Columbia (15%) and Aiken (24%); 1978 percentages for Barnwell and Richmond ranged between 35 and 37%, respectively. The general decline in the black-white ratio since 1950 can be explained by differential migration: declines in Aiken and Columbia counties appear to result from white in-migration, whereas in most rural counties the decreasing percentage of blacks results from black out-migration. The increasing black-white ratio in Richmond is a result of black in-migration and white out-migration. Other races, including American Indians, constituted only about 1% of the primary area populations in 1978.

E.4.2.3 Persons per household

The 1978 average number of persons per household in Georgia (3.0) and South Carolina (3.1) was higher than the U.S. national average (2.8) reflecting the pattern of higher birth rates and larger households in the region which has occurred since 1960. Rural counties in the primary study area, such as Allendale and Bamberg, typically have larger households than the urban counties.

E.4.2.4 Family income and impoverished families

The median 1969 family income in Georgia ($8165) and South Carolina ($7620) was considerably below the U.S. median of $9867. With the exception of Aiken County, family incomes in the primary counties have been even lower than the respective state medians. The secondary study area, except for suburban Lexington County, has been poorer yet. The lowest median family income in the entire study area in 1969 (Screven County, $4810) was less than one-half the national average that year. Between 1960 and 1969, the percentage increase in median family income in the counties varied from 77 to 168%. These increases still left the study area behind the 1969 national average, indicating how poor the area population has been even with these dramatic changes. The relatively low median family incomes of the study area are partly attributable to a high percentage of impoverished families. In 1969, only the more urbanized counties, Lexington, Aiken, Richmond, and Columbia, had percentages of families at poverty levels (12 to 16%) that approached the national average (10%). The remaining counties had from 23 to 43% impoverished families, significantly higher than the state and national averages. However, both states* (especially South Carolina) show declining numbers and percentages of families below poverty levels from 1969 to 1975.

*Trend data not available for counties from 1969 to 1975.

E.4.2.5 Births and deaths

The birth rates in South Carolina, Georgia, and the primary study area have steadily declined, as have national rates. From 1950 to 1978, the primary study area average births per 1000 persons declined from 25.3 to 17.7 per year, though they exceeded the national average, which ranged from 24.1 to 15.3 during that period.

Following state and national trends, area death rates declined in the 1950s, increased in the 1960s, and then declined again in the seventies. The differences in the age composition of the county populations in the primary study area largely accounts for significant death rate fluctuations. In 1978 primary county death rates varied per 1000 population from 5.9 to 10.6 per year, though rates over 9.0 were most common for counties in the entire study area.

E.4.2.6 Migration

Since 1970, migration patterns have reversed in both primary and secondary areas. A slight increase of 3579 people in the primary study area occurred in the decade to 1970 as net losses in Aiken, Allendale, Bamberg, and Barnwell were slightly exceeded by net gains in the two Georgia counties. By 1975 this area had experienced a net out-migration of around 13,400 people caused primarily by loss of 17,200 people from Richmond County, whereas Columbia and Barnwell counties showed gains. On the other hand, the net loss of 5000 people in the secondary-area counties was reversed in 1975 by a net in-migration of around 25,800 people caused almost entirely by gains in Lexington County. In some counties (Barnwell, Hampton, and Orangeburg) the 1970 net out-migration trend has reversed to net in-migration in 1975. The more populous counties, such as Aiken and Richmond, have shown varying migration patterns since 1960. Net migration has shifted in Aiken from positive (in-migration) in 1960 to negative (out-migration) in 1970 and 1975. The most urban county (Richmond) showed fluctuating migration patterns: net out-migration in 1960 and 1975, and net in-migration in 1950 and 1970. Those counties with consistent migration trends over the past 25 years are the two suburbanizing counties in the two SMSAs (Lexington in the secondary area and Columbia in the primary area always showed a net increase) and five rural counties (Allendale, Bamberg, Saluda, Burke, and Edgefield) which continue to lose population.

E.4.2.7 Journey to work

Workers in both primary and secondary study areas were generally employed in the counties of their residence. Most Columbia County residents, however, work outside the county, reflecting the suburban orientation relative to the greater Augusta area in Richmond County. Major county employment centers are in Richmond and Aiken followed by Orangeburg and Lexington. Smaller, but significant, employment centers are in Bamberg, Barnwell, and Hampton counties.

E.5 ECONOMIC PROFILE AND TRENDS

Among the combined study area counties, even those with the highest industrial payrolls and per capita incomes remain below the national average. Aiken County provides a major contribution to the regional value added to economic outputs. Though the growth rate in gross state products of South Carolina and Georgia in the late seventies nearly equals the gross national product growth rate in the United States, the high-growth state sectors differ significantly from national patterns. Significant growth has occurred in labor force and labor participation rates. The construction labor market for future SRP projects includes three major zones in the states of South Carolina and Georgia.

E.5.1 Major employment sectors

Most study area employment is in the manufacturing industries concentrated in both Augusta and Columbia SMSAs, though trade sector industries are expanding. Manufacturing employment percentages are highest in Aiken, Barnwell, and Edgefield counties, although the largest number of manufacturing jobs exists in Aiken, Richmond, and Lexington counties. Counties with the highest percentages of employment in trades are Richmond and Allendale. Richmond County accounted for approximately one-half of the total study area retail and wholesale service in 1977. Concentrations of government services and employment were also highest in Richmond County. Area agricultural sales as of 1972 were greatest in Orangeburg ($46.4 million), Burke ($25.3 million), and Screven ($21.3 million) counties, though the highest per-hectare sales were recorded in Orangeburg ($328) and Bamberg ($292).

Major private employers in the primary area are the Graniteville Company (multifabric mills employing over 6500); the E. I. du Pont de Nemours and Co., Inc., (SRP) employing 8300; Owens Corning Fiberglass in Aiken County; and Babcock and Wilcox Refractories in Richmond County.

Murray Biscuits and Continental Forest Industries each employ more than 1000 persons. Major private employers in secondary counties include Western Electric and Allied Chemical companies (over 1600 employees each) in Lexington and Hampton, counties, respectively. A new Michelin plant in Lexington County at full operation will employ more than 1000 people. The principal public employer in the area is the Federal government through the Fort Gordon military base in Richmond County. Although more than 30,000 new recruits and trainees are trained at the base each year, the average military population in 1980 was 17,800. One of the major economic contributions to the area results from the 4500 permanent civilian employees of Fort Gordon.*

E.5.2 Per capita income and median family income

The industrial payrolls and per capita incomes were highest in the study area in Aiken, Lexington, and Richmond counties and ranked in the top 50% of the 1974 U.S. county averages. Most of the counties in the remaining area, however, ranked in the bottom 11% among 1974 U.S. county averages. From 1969 to 1974, per capita incomes of the urban or suburban counties — Aiken, Lexington, Orangeburg, Richmond, and Columbia — grew at approximately the same rates (from 8.9 to 9.6%). Per capita income increases were more variable in the rural counties during this period (8.9 to 10.2%). In 1969, those counties in the study area with the highest median family incomes — Lexington ($8754), Aiken ($8712), Columbia ($8027), and Richmond ($7988) — still ranked below the U.S. median family income ($9586). Other 1969 median family incomes ranged from $4480 (Burke) to $6997 (Barnwell).

E.5.3 Earnings per employee

Employee earnings were highest in the more economically diversified counties of Aiken, Richmond, and Lexington, although high earnings were also recorded in rural Hampton County as a result of a large number of skilled manufacturing jobs. As of 1977, the U.S. average income per employee ($9836) was greater than any county average in the area except Aiken ($11,265), largely because many SRP employees chose to live in this county. Earnings per employee in Bamberg, Saluda, Allendale, and Burke counties ($7135 to $7817) were also considerably below the 1977 state averages of $9434 in South Carolina and $10,049 in Georgia.

In general, highest incomes in the study area were reported in manufacturing, transportation/utilities, wholesale trade, and nonclassifiable service sectors. In addition, employees in Richmond and Lexington counties had higher earnings than their state averages in the mining, construction, wholesale trade, and finance/insurance/real estate sectors. Lowest earnings per employee were reported in the retail and service trades, as well as in the agricultural sector.

E.5.4 Value added†

From 1967 to 1977, the Augusta SMSA has consistently reported the highest level of value added (VA) in the study area, reflecting the dominance of Aiken county's contribution to the SMSA and Aiken's unusually high value added rates (64%). Gradually declining value added/value shipments‡ (VA/VS) ratios in the study area since the mid-1970s recession indicate either declining importance of vertical integration, labor intensity, or captive raw materials. Principal products contributing to a high Aiken County VA/VS ratio are primary clay minerals, finished apparels, chemical and allied products, and machinery-related products. Since 1970, VA/VS percentage decreases have been greatest in Orangeburg (-10%) and Lexington (-6.2%) counties.

The 1977 total value added for Richmond ($464 million) and Aiken ($611 milling) counties accounted for 97% of the entire Augusta SMSA value added ($1.108 billion). The SRP value added in 1977 amounted to approximately $187 million (17% of the total in the Augusta SMSA). State value added totals in 1977 were nearly $8.1 billion in South Carolina and almost $13 billion in Georgia.

Of the 1979 value added contributed by SRP ($280 million), approximately 76% is from plant operation, 18% is from plant construction, and 6% is from government employment.

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*Fort Gordon data from Augusta Chamber of Commerce, 1980.

†Value added (VA) is the economic value of inputs needed to produce a particular good or service that originate entirely within the producing establishment or sector. It is the increment in value at each stage in the production of a good, indicating net income created, and measured in the form of wages, profit, rent, interest, and taxes.

‡A high ratio of value added to value shipment (VS) indicates greater independence from regional imports.

Large annual increases in area value added (constant dollar growth) from 1972 to 1977 have occurred in Columbia (19.8%), Burke (9.3%), and Saluda (7.8%) counties, indicating the addition of new plants or the expansion of existing ones. Annual value added percentage decreases of 2 to 3% were reported for Hampton, Orangeburg, and Allendale counties, as well as the state of South Carolina (3%).

E.5.5 Gross state product of Georgia and South Carolina

From 1976 to 1978, the gross state product (GSP) percentage growth rates of both South Carolina and Georgia were slightly behind that of the U.S. gross national product (GNP). The GSP and GNP are measures of the economic output of a state and the nation, respectively. The 1976 GNP ($1.647 trillion) increased approximately 3.8% annually to 1978 ($1.775 trillion using constant 1976 dollars). By comparison, the South Carolina GSP ($17.6 billion in 1976) increased annually by 3.5% to 1978 (18.8 billion); the Georgia GSP ($34.8 billion) increased about 2.9% annually to 1978 ($36.8 billion using 1976 constant dollars).

A comparison by industry of the 1978 South Carolina and Georgia GSPs to the 1978 GNP indicates similarities and differences in economic activity. Gross product output percentages in the two states are most similar to the nation's (<1% different) in state and local government, electric and gas services, communication, construction, and agriculture sectors. In addition, Georgia and the United States are similar in sector output percentage for finance, insurance, and real estate. The greatest differences between the United States and the two states occur in nondurable goods (South Carolina about 10% higher and Georgia 5% higher), durable goods (U.S. about 5% higher), Federal government activities (states about 2% higher) and mining (U.S. about 2% higher). Georgia GSP percentages were greater than South Carolina in wholesale and retail trades, services, finance, insurance, real estate, and transportation, whereas South Carolina exceeded Georgia only in the nondurable goods sector.

The direct, indirect, and induced SRP impacts on both South Carolina and Georgia economies have been estimated from respective GSPs and 1979 SRP construction and operation labor force salaries. The estimated 1979 SRP impact totaled about 1% ($651 million) of combined South Carolina and Georgia GSPs.

E.5.6 Labor market

Employment levels in the primary study area increased significantly in recent decades as both total labor force and participation rates increased. For instance, employment in the Lower Savannah region (all four South Carolina primary counties plus Orangeburg county) grew 20,000 to 91,400 in the decade 1960 to 1970, whereas participation rates increased from around 34 to 43% of the total adult population.

Future SRP construction labor forces are likely to be drawn from three zones devised for the DWPF construction labor demand analysis.[2] Zone one includes those areas within daily commuting distance of up to 110 km from the work site. Construction employees living in the second zone, around 110 to 240 km from the work site, will usually commute to the site once per week and stay in mobile homes or rental housing near the site during the work week. Other workers in this zone may relocate their entire families to locations nearer to the construction site. The 240-km radius from the SRP construction project includes all of the major South Carolina population centers (cities of Anderson, Greenville, Spartanburg, Columbia, and Charleston) and three major Georgia population centers (Augusta, Macon, and Savannah). The Atlanta SMSA, 260 to 290 km away, is an unlikely market for SRP construction labor force because of current and projected demand of its own. The third zone consists of all South Carolina and Georgia counties and represents the probable maximum work force recruitment area.

The total population within a 240-km radius of the SRP was around 3.75 million people in 1979 and included 35 South Carolina and 55 Georgia counties. Within the 110-km radius, 13 South Carolina counties and 7 Georgia counties comprise a total population of around 800,000. Of this total, approximately 18,000 were construction employees, the largest contributions arising from Richmond County in Georgia and Aiken (including over 1700 then employed at the SRP), Lexington, and Dorchester counties in South Carolina. Unemployment in this zone ranged from a low of 3.4% (Lexington County, South Carolina) to a high of 9.2% (Burke County, Georgia); the zone average was 5.2%, more than one-half a percent below national unemployment levels in 1979.

Estimated 1979 construction industry employment in specific needed crafts is indicated in Table E.3 for all three zones. Employment in these crafts represents approximately 67% of the total construction work force from these zones.

At the present time the only other large construction project within 110 km of the SRP that will create a significant demand for skilled laborers is the Georgia Power Company's Vogtle Nuclear

Table E.3. Construction employment by craft and zone, 1979 estimates[a]

Craft[b]	110-km (70-mile) commuting zone	240-km (150-mile) traveling zone	Two-state region
Boilermakers	62	179	532
Carpenters	2,678	13,105	26,910
Insulators	188	932	2,850
Electricians	1,231	5,796	11,869
Concrete finishers	460	1,944	4,358
Ironworkers	332	1,210	1,939
Painters	620	3,017	6,120
Millwrights	189	962	1,644
Heavy-equipment operators	977	4,803	10,735
Teamsters	464	2,237	4,810
Pipefitters/plumbers	1,290	4,926	10,360
Laborers	2,644	11,665	32,200
Sheet-metal workers	471	2,477	4,550
Total	11,606	53,253	117,860

Sources: South Carolina Employment Security Commission, *South Carolina: Nonmanufacturing Industries, Occupational Profile 1978*, Columbia, S.C., 1979; Georgia Department of Labor, *1978 OES Results for Selected Crafts* (unpublished). This table is taken in its entirety from Robert Garey et al., *Preliminary Analysis of Projected Construction Employment Effects of Building the Defense Waste Processing Facility at the Savannah River Plant* prepared for ORNL by Oak Ridge Associated Universities, 1981. ORNL/TM-7892(1981).

[a]Construction employment by craft for the two-state region equals the sum of craft employment in South Carolina and Georgia as reported in the 1978 Occupational Employment Surveys of those states, multiplied by 1.018, the annual projected rate of growth. Craft employment in the 110- and 240-km zones was obtained by first dividing 1979 construction employment in these zones into crafts of the same proportions as in the South Carolina and Georgia occupational employment surveys. To these craft figures, the employment by craft at the SRP in 1979, and 1979 employment by craft at the Vogtle Nuclear Power Plant near Waynesboro, Georgia, were added, giving an estimate of total construction employment in the crafts of interest in 1979. (The 1979 SRP construction workers were included in the state totals for South Carolina, but not in the county level figures on which the 110- and 240-km zone totals are based. Vogtle's construction workers similarly were not included in the county level figures in Georgia.) Craft estimates include helpers.

[b]Machinists, who will be required in extremely small numbers during construction, are not included because this craft is not normally considered part of the construction industry, and thus there are no figures available on their employment levels in that industry. It is very probable that all will be hired from the local area.

Plant now under construction in Burke County. Projected peak construction employment at this plant is over 4000 workers by 1983; completion is scheduled for 1988.*

E.6 GOVERNMENTS AND FISCAL POLICY IN THE REGION

Five levels of government function in the 13-county area, providing services, implementing policies, and interacting with each other and the citizens. These levels include 81 communities, 13 counties, five regional councils or planning and development commissions, two states and the Federal government.

Most of the 39 Federal agencies serving the study area have regional offices, such as the U.S. Nuclear Regulatory Commission and the Environmental Protection Agency, in Atlanta or Columbia. Federal aid to Georgia in 1979 totalled over $1.36 billion ($296 per capita) and represented about 33% of state revenue. Federal aid to South Carolina totalled over $870 million ($297 per capita) and constituted about 32% of total state revenue.

*In June, 1981, Georgia Power Company announced this schedule had been accelerated.

Major differences exist between the South Carolina and Georgia judicial systems and organization of state government agencies. In South Carolina, considerable local variation exists in all courts except the state supreme court and circuit courts that are governed according to the state constitution; the entire Georgia court system is uniformly based on its state constitution. Further, South Carolina has over 130 state government agencies and many responsibilities overlap; Georgia has 22 consolidated state agencies.

County governments operate under authorization of their respective state constitutions; municipalities operate under authorization of state legislatures. In addition to local county and municipal governments in South Carolina and Georgia, "special purpose" (such as school and water) taxing districts exist. Both states also have granted local "home rule" authorization for certain powers (Georgia in 1966; South Carolina in 1975) that replaces control of local government affairs by legislative delegation. In South Carolina, local home rule for counties and municipalities allows for taxation, regulatory, and other powers. In Georgia, home rule does not include the power of levying taxes for either type of jurisdiction.

The county government organizations in South Carolina may be of the following types: council, council-administrator , council-supervisor, or council-manager. In Georgia, the governing authority of counties is the Board of County Commissioners. Officials in each state are elected for four-year terms.

The forms of municipal government organization in both South Carolina and Georgia are council, mayor-council, or council-manager.

In South Carolina regional planning councils of government (COGs) were formed in 1971 to promote area governmental coordination through planning services, Federal grants administration, economic development, and other management assistance. Regional planning councils are financed by local, state, and Federal government funds. The lower Savannah River COG includes Aiken, Allendale, Bamberg, Barnwell, and Orangeburg counties. The Upper Midlands COG includes Lexington County. Hampton County is in the Low County COG, whereas Edgefield and Saluda counties are in the Upper Savannah COG.

The area planning and development commissions in Georgia provide similar services of regional planning and are funded 25% by local governments, 25% by Georgia state government, and 50% by the Federal government. The Central Savannah River Area Planning and Development Commission serves Burke, Columbia, Screven, and Richmond counties in the study area.

E.7 PUBLIC AND PRIVATE SERVICES IN THE PRIMARY STUDY AREA

Variations in formal organization and scope of services provided result from contrasting urban and rural environments in the study area. Large urban areas, such as Augusta and Aiken, generally offer more comprehensive services provided by full-time paid employees, whereas smaller rural areas usually depend less upon formal organization. When formal organizations exist in rural areas, they are staffed on a paid part-time or volunteer basis.

E.7.1 Education

In the six-county primary area there are nine public school systems: seven in South Carolina and two in Georgia. There are 78 elementary schools, 27 intermediate schools, 21 high schools, 10 special schools, 8 vocational/technical schools, and 6 colleges in the study area. Approximately 93.6% of area school-age children are enrolled in these nine public systems and are transported by 612 buses to their schools. The remainder attend private schools or are not in school.

Because the construction and operation of the DWPF will generate changes in area school enrollments, existing school enrollments were compared with school capacities. Population shifts and growth have left some areas with too many or too few classroom spaces and facilities. As of the 1979-80 school year, about 8600 extra students could have been accommodated in existing public schools. Table 4.7 shows the excess facility capacity available by school district. It is clear from the table that the Allendale, Bamberg No. 1, and Denmark-Olar No. 2 districts are using their facilities to capacity or near capacity. It would be difficult for these districts to handle new growth in school enrollments. Barnwell, Blackville and Williston districts have sufficient capacity to sustain growth in school enrollments. In the aggregate, the urban counties, Aiken, Columbia, and Richmond, have substantial excess physical capacity to handle additional students. However, about half of the individual facilities within these communities are already utilized near capacity or above capacity levels.

To alleviate enrollment problems, plans for facility expansion exist in some counties, and new facilities are already in place in others. In Aiken County, three new high schools opened in 1980 and 1981, with a capacity totalling 3275 students. Because of shifts in enrollment and availability of these facilities, a major rezoning of school boundaries occurred. Also, the school districts of Allendale, Denmark-Olar, and Blackville have recently added mobile units to increase classroom space. Further, Columbia County is constructing two new high schools to accommodate a total of 2400 to 2500 students. In anticipation of a possible SRP expansion, the Barnwell School District has devised three contingency development plans to accommodate an increase of from 240 to 320 students.

The average student to teacher ratio in each district ranges from 18.5:1 in the Williston District to 25:1 in the Columbia and Allendale County school systems. Five of the seven South Carolina districts are below the 1978 statewide student to teacher average of 23:1. On the other hand, the two Georgia school systems have ratios considerably above the Georgia 1979 state average of 16.8:1.

E.7.2 Recreation and cultural facilities

A wide variety of both public and private outdoor recreation facilities exists in the study area. Participation in activities and demand for appropriate facilities varies among counties. Federal outdoor recreation facilities include the Santee National Wildlife Refuge, the Clarks Hill Reservoir operated by the U.S. Army Corps of Engineers, and sections of Sumter National Forest. Five state parks exist in the study area. Privately owned, but publicly available, swimming pools, fishing and boating facilities, golf and tennis clubs, and other facilities serve an important area recreational function.

There is heavier usage of Federal and state recreation sites than of local facilities. Evaluations of the study area have indicated a deficiency in public recreational facilities and programs.[3] In addition, the existing county school facilities are heavily used.

Cultural opportunities are primarily offered in the major cities of Augusta and Aiken, which offer museums, libraries, historic sites and tours, and other programs. Popular attractions include the performing arts, offered by the Greater Augusta Arts Council, and major sporting events such as horse racing held in Aiken and the Masters Golf Tournament held each April in Augusta. Additional cultural opportunities are hindered by the lack of adequate facilities for staging these events.

E.7.3 Fire, emergency medical, and ambulance services

Of the 41 fire departments in the study area, 23 raise their own funds and rely on an all-volunteer staff. Approximately 10% of the publicly supported fire departments are also dependent upon an all-volunteer staff. Over 60% of the fire departments in the primary study area are judged to have adequate service by virtue of their having an Insurance Service Office (ISO) ratings of 8 or less. The remainder had ratings of 9 or 10 or were unrated. Fire services are rated from 1 to 10 by ISO: 1 is highest and 10 is inadequate. Although the cities of Aiken and Augusta are judged to have adequate protection (rated 5 and 3 respectively), nearly one-half of the fire service area within the counties of Aiken and Richmond are judged to have little or no protection (ISO ratings of 9 and 10).

Approximately 18 emergency medical/rescue services operate in the primary study area, most of which are staffed by volunteers, and charge on a fee-for-service basis. The area's two publicly supported services are the Aiken County Emergency Medical Service and the Ambulance Service in Richmond County provided by University Hospital in Augusta.

E.7.4 Police protection and jails

Law enforcement agencies servicing the primary study area include county sheriff and community and state police. The highest reported 1979 crime rates of the six primary counties were in Richmond and Aiken, whereas the four rural counties experienced lower crime rates, as expected. Relative to the FBI's national average of 1.5 full-time law enforcement officers per 1000 population in counties, Columbia County has the least protection (0.97) and Allendale County the most (2.26). Richmond county, (1.99) which is basically urban, approximates the national average of 2.0 policemen per 1000 population for cities the size of Augusta.

The physical condition and specific functions of the area's six municipal and six county jails varies. The Barnwell County jail also serves Allendale County. The average number of inmates per day does not exceed average facility capacity. An expansion of the Barnwell County facility is currently under way; plans to upgrade the Richmond County jail are currently being considered.

E.7.5 Health services

The greatest concentration of health services in the primary study area occurs in the two urban centers of Augusta and Aiken. Augusta is a leading regional medical center providing general and specialized medical care to the U.S. Army and the Veterans Administration as well as to the general public. While every county except Columbia has at least one hospital, the urban centers provide 91% of the hospital beds (Richmond, 82%), 94% of the outpatient care, 63% of the nursing home facilities, and most of the specialized medical services. Only Allendale and Bamberg counties are without nursing home facilities.

Bed vacancies usually exist at the nine hospitals in the primary study area. Barnwell County Hospital has the lowest occupancy rate (30%), whereas the other hospitals average 70 to 90% occupancy.

Ten of the 13 area counties are designated as "manpower shortage areas" based on criteria from the U.S. Public Health Service Act amendments of 1976 and 1979. (Exceptions are Aiken, Richmond, and Columbia counties.) Shortages in the more rural counties were most prevalent for physicians, nurses, podiatrists, and dentists.

E.7.6 Sewage treatment

The status of municipal sewage treatment in the counties in the primary study area ranges from those five systems that regularly discharge some of their effluent untreated to the several that operate well below capacity. The systems within the counties of Allendale, Bamberg, Barnwell, and Richmond are currently experiencing sewage problems. Both Allendale County treatment facilities have reached plant capacity; however, expansions are currently being planned. At the Denmark Plant in Bamberg County the amount of sewage is double the treatment capacity because of infiltration/inflow. Expansion of the Denmark Plant is currently being planned. In Barnwell County, sewage is also exceeding treatment capacity at the Blackville Plant because of infiltration/inflow. A rehabilitation program is currently being planned. The Augusta Plant in Richmond County is operating below treatment capacity. About 15% of the effluent is discharged untreated. A proposed expansion of the Augusta wastewater treatment plant is currently being planned as well as a program to remove points of raw wastewater discharge. Adequate facilities are in place in the city of Bamberg, in the Columbia County towns of Martinez, Evans, and Harlem, and in western Aiken County (Horse Creek Plant). Facility improvements are being planned for Allendale County and the city of Barnwell. No significant treatment problems exist in Columbia County.

For areas beyond the reach of public sewage treatment, septic tank operation is commonplace. Soil suitability for septic tank use is classified as slight, moderate, or severely limited. The percent of each county having severe soil limitations is Columbia (80), Allendale (50), Richmond (40), Bamberg (25), Aiken (20), and Barnwell (5).

E.7.7 Public water systems

Of the approximately 120 public water systems in the area, 30 county and municipal systems serve 75% of the population; the remainder serve individual subdivisions, water districts, trailer parks, and miscellaneous facilities such as restaurants, nursing homes, motels, and schools. All but four of the municipal and county water systems obtain their water from deep wells. Those systems utilizing surface-water sources are the cities of Augusta and North Augusta and Columbia County (the Savannah River) and the city of Aiken (Shaws Creek and Shilo Springs). All systems can accommodate additional use, except the Pine Hill Plant located in Richmond County, which is operating at 100% capacity. Area systems approaching maximum service capacity and, therefore, which can supply the *least* relative increase in service demand are located in Richmond County [Pine Hill (100%), County plant-1 (85%), -2 (90%), and Augusta (70%)], Barnwell County [Barnwell Plant (84%)], and Allendale County [Fairfax Plant (80%)]. Those systems currently operating at or below 50% service capacity and, therefore, which can support the greatest service volume increase are located in Aiken county (Jackson, Monetta, New Ellenton, North Augusta, Perry, and Salley), Allendale County (Allendale and Sycamore), Bamberg County (Bamberg, Denmark, Erhardt, Govan, and Olar), Barnwell County (Blackville, Elko, and Williston), Columbia County (Grovetown) and Richmond County. In general, from the inventory of 30 water systems, one-third (10) are operating at around 25% capacity, and approximately another third (8) are operating below 25% service capacity (see Table 4.8).

E.7.8 Sanitary landfills and disposal

Of the seven public domestic landfills in the area, five are publicly owned, all are publicly operated, and four will experience waste-capacity problems in the short-range future (0 to

5 years). The waste capacity at the Columbia County landfill is currently exhausted because of an unanticipated doubling of this county's population since 1970. Further, two sites in Aiken County (DWP-97 and the City of Aiken Sanitary Landfill) will reach capacity in five years, as will the Richmond County Sanitary Landfill. At other area county sites, projected maximum waste capacities will be reached in 10 years at Aiken DWP-72 and 20 years in both Bamberg and Barnwell.

Collection systems range from "do-it-yourself" operations in portions of Columbia and Aiken counties, to house-to-house collection in Augusta and incorporated communities, to collection boxes stationed in rural portions of Bamberg, Barnwell, and Aiken Counties. Private contractors provide collection service in portions of Aiken, Richmond, and Columbia counties.

E.7.9 Social services

A variety of public and private social-service agencies providing legal counseling, health services, housing and aging assistance, recreation, youth and adult services, medical care and employment, and educational services are found in the primary study area. More than one-half of the 347 agencies are located in the urban counties of Richmond (147) and Aiken (84); lesser concentrations are found in rural counties such as Allendale (42) and Columbia (12). Except for Columbia County, each county has at least one agency for each major social service.

E.7.10 Libraries

The primary study area is served by three regional library systems: Aiken-Bamberg-Barnwell-Edgefield (ABBE), Allendale-Hampton-Jasper (AHJ), and the Augusta Regional Library System (ARLS). The ABBE regional system includes a main library in the city of Aiken, three county libraries, six branches, and one bookmobile. The AHJ system includes one library located in Allendale County plus one bookmobile. The ARLS includes a main library in Augusta, three branches, and two bookmobiles.

Book collection size per service population was slightly below recommended standard in 1979 at two area regional library systems (ABBE and ARLS) and above standard at the third (AHJ).

E.7.11 Utilities

The primary study area is generally well-serviced by electric and natural gas utilities, which consist of private, investor-owned, municipal, and rural cooperative companies. Natural gas is used primarily by industrial customers; residential customers consume most of the electricity. Most of the area power is generated by two utility companies, South Carolina Electric & Gas (SCE&G) and Georgia Power, from coal, natural gas, oil, and hydropower. Power is sold directly to residential customers or wholesale to municipal and cooperative utilities. The 1979 summer peak demands were 67% of total generating capacity (3.66 GW) at the SCE&G, and 96% of total generating capacity (10.57 GW) at the Georgia Power Company.

Two power generating facilities are located within the primary study area and another is under construction. Although the SRP is the largest customer of SCE&G, it also consumes power produced by its own coal-burning facility. The Urquhart Steam Plant, a coal/natural gas facility, with 250,000 kW capacity, is located in Aiken County on the Savannah River. The Vogtle Nuclear Plant located in Burke County is under construction for the Georgia Power Company and scheduled for operation after 1984.

Natural gas, used mainly for industrial purposes, is transported into the study area by the Carolina Pipeline Company and distributed by the SCE&G, the Bamberg Board of Public Works, the Atlanta Gas Light Company, and the Georgia Natural Gas Company. The natural gas lines in Columbia County have limited service capacity that may hinder future industrial expansion.

E.7.12 Civil defense and emergency preparedness

All primary area counties, except Allendale, have active civil defense departments and state-approved emergency preparedness plans. In Allendale County, the sheriff acts as civil defense coordinator. Staffing varies from a totally volunteer basis (Burke County) to two full-time employees plus 100 to 300 volunteers (Aiken, Barnwell, and Richmond counties). Funding is provided by one or more Federal, state, county, and local government appropriations and from private donations. Emergency preparedness plans outline county civil defense roles in communications, law enforcement, search and rescue missions, transportation, and medical services. Plans also address natural disasters including those from high winds, severe storms, earthquakes, and floods, and man-made disasters from hazardous chemical spills, nuclear releases, fires, mass transportation accidents, and explosions. All of the active civil defense departments hold training sessions for volunteers including at least one simulated mass-scale emergency per year. None of the seven counties has an emergency operating center fully qualified by Federal standards, but all have buildings that serve as their major communication centers. Though the counties utilize a wide variety of communication networks and the degree of practice is highly variable, all are attempting, with the assistance of their state civil defense agencies, to adopt more uniform and comprehensive practices. A 1980 South Carolina law on emergency preparedness provides for development of minimum standards, definition of roles and responsibilities of state agencies, designation of state and local contact points for official public information, and guidelines for a public education program.[4]

In addition, the SRP has various service agreements for mutual asistance or special support with Fort Gordon and Talmadge Hospital in Augusta. SRP also has fire-fighting mutual aid agreements with Allied-General Nuclear Services in Barnwell, the city of Aiken, and the South Carolina Forestry Commission. Memos of understanding between SRP and the states of South Carolina and Georgia cover notification and emergency responsibility in the event of a potential or actual radiological emergency at the SRP.

E.8 HOUSING

Because some workers for the proposed DWPF facility will require housing in addition to that currently available, the existing housing stock will be characterized herein with respect to its location, condition, and other characteristics. The capacity of the housing industry is assessed.

Most of the available housing stock in the study area is located in the Augusta (Georgia) SMSA and in Lexington County of the Columbia (South Carolina) SMSA. As shown in Table E.4, about 87% of the total primary area housing stock exists in the three Augusta SMSA counties (118,750 units in 1979), whereas the three smaller rural counties of Barnwell, Bamberg, and Allendale contain the remaining 13% (17,650 units in 1977). The greatest percentage increases in housing stock are occurring in Columbia County, which more than doubled its total housing stock in the past decade, increasing at an average rate of nearly 11% per year. Both Aiken and Richmond counties added more than 1000 units per year since 1970, increasing at average rates of 3.6% per year. Demand in Barnwell county averaged about 3.5% per year in the period 1970 to 1977, whereas Allendale and Bamberg county rates were slightly lower at 3.4% and 3.2%, respectively.

Although Allendale and Bamberg counties increased their stock in the past decade, both showed decreases between 1950 and 1960. In the secondary area, Screven County's stock decreased between 1950 and 1970.

The greatest absolute and percentage increases in secondary area housing stock occurred in Lexington and Orangeburg counties: Lexington averaged a 4.6% increase per year (1960 to 1970) while Orangeburg increased about 4.0%.

One-half of the Aiken County increase in housing in the past decade (about 5200 units) resulted from that county's especially high rate of mobile home growth. More than one-half of the total mobile home growth in the SMSA in 1979 occurred in Aiken County, reflecting less stringent regulation than in the other SMSA counties.[5]

Orangeburg County in the secondary area showed a similarly high increase in mobile homes (Table E.4) in the early 1970s.

The majority of Aiken County's increased demand since 1950 can be attributed to the nearly 5000 SRP employees who live there. About one-half of these workers live in the City of Aiken. They occupied about half of the estimated 5800 housing units in 1980.

E.8.1 Tenure patterns and costs

The majority of housing in the combined study area is owner occupied, ranging from 45% in Burke County to 70% in Lexington county in 1970. The largest number of rental units exist in the SMSA counties (around 33,500 in the Augusta SMSA in 1979),[5] reflecting the concentration of rental units in the larger urban areas. More than one-half (53%) of the housing in the City of Augusta is rental units.

The median value of owner-occupied housing in 1970 ranged from \$8700 in Screven County to \$17,200 in Lexington County. Other high-value housing counties were Columbia (\$16,300), Richmond (\$14,700), and Aiken, (\$13,000). In addition to Screven, other counties with median values around \$10,000 in 1970 were Allendale, Hampton, Barnwell, and Bamberg. The rapid increase in

Table E.4. Selected housing information in the primary study area and Orangeburg County

County and year	Number of units	Number of vacancies	Number of rental units	Increase in regular units per year 1970–1980	Increase in mobile homes 1970–1980	County mobile home regulations
Aiken, S.C.						
1980	39,791			1,046	5,230	
1977	35,893	2,974	8,559	3.6%		No
1970	29,333	2,360	7,002			
Allendale, S.C.						
1980	3,973					
1977	3,511	143	1,426	97	395	
1970	3,002	282	1,141	3.2%		No
Bamberg, S.C.						
1980	6,384					
1977	5,663	238	2,045	164	750	Yes
1970	4,748	483	1,607	3.4%		
Barnwell, S.C.						
1980	7,282					
1977	6,968	334	2,448	190	820	
1970	5,397	514	1,795	3.5%		No
Columbia, Ga.						
1980	14,099			735		
1970	6,740	253[a]	1,806	10.9%	648	Yes
Richmond, Ga.						
1980	64,846			1,709		
1970	47,754	2,482[a]	18,345	3.6%	1,651[b]	Yes
Orangeburg, S.C.						
1980	29,114			826	2,850[b]	Yes
1970	20,857			4.0%		

[a] For sale or rent.
[b] 1970 to 1975.

Source: *Socioeconomic Baseline Characterization for the Savannah River Plant area,* prepared for Oak Ridge National Laboratory by NUS Corporation, 1981 ORNL/Sub-81/13829/5 and U.S. Bureau of Census, 1980 Census of Population and Housing; South Carolina, PHC 80-V-42; Georgia, PHC 80-V-12; March 1981.

housing values in the past decade is most strongly reflected in the high-growth areas of Columbia, Lexington, and Aiken counties. In 1980, realtors estimated that average new home costs were around $36,000 in southern Augusta, $55,000 in western Augusta, $40,000 in Barnwell, $75,000 in North Augusta and $60,000 in Aiken (city). Median housing values will remain much lower in the low-growth counties because the average age of the housing stock is older.

E.8.2 Vacancy trends and physical condition

In general, vacancy rates (1950 to 1970) have decreased in the counties and increased in the incorporated cities and towns. Vacancy rates normally vary by type of housing also: around 3% for single family homes and around 7% for multifamily units. The homeowner vacancy rates in the Augusta SMSA remained constant at 2.4% from 1970 to 1979, whereas the 1979 renter vacancy rate decreased from around 10% in 1970 to 7% in 1979.[5] See Table 4.9 for additional vacancy information.

The percentage of units lacking some plumbing facilities is higher in the rural counties than in the more urban areas, ranging from 5% in Richmond County to 38% in Allendale and 44% in Burke County (1970).

Similarly, more crowded housing (more than one person per room) is found in rural rather than urban areas. SMSA counties have 7 to 12% crowded housing (1970), whereas rural counties have as much as 19%.

E.8.3 Hotels and motels

The greatest concentration of hotel and motel rooms exists in urban areas. Augusta has around 2700 rooms, Orangeburg County approximately 1000 rooms, and Aiken County approximately 500 rooms.

Excess motel capacity exists in the town of Allendale and elsewhere along U.S. 301 because of the major traffic decline on U.S. 301 since the opening of I-95 in that area. Barnwell, on the other hand, has a shortage of rooms. Columbia County is the only county with no hotels or motels.

E.8.4 Housing construction labor force and capacity of housing industry

Past history and estimates by state agencies of the growth in the construction industry by craft indicate that there is ample capacity to meet large increases in demand for housing in South Carolina, especially around urban or growth centers.

The housing industry in Aiken, Richmond, Columbia, and Barnwell counties is considered strong by local informants and capable of responding fairly quickly to increased demands for housing. The City of Barnwell, for instance, has five active housing contractors, and the industry in the City of Aiken is considered "very strong."[6]

E.9 TRANSPORTATION

E.9.1 Roads and highways

The area is served by major interstates, U.S. and state highways, and minor access roads including those within the SRP. Figure E.1 shows the principal roads in the primary study area. Of the three interstate highways within the study area, I-20 intersects the primary counties of Aiken, Richmond, and Columbia as it extends from the city of Florence, South Carolina, westward through the capitol city of Columbia and through Augusta and Atlanta, Georgia. Interstate 26 extends from Asheville, North Carolina, southeast to Charleston, South Carolina, as it intersects secondary area counties of Lexington and Orangeburg, South Carolina. Interstate 95 parallels the eastern U.S. coast and intersects secondary area counties of Orangeburg and Hampton, South Carolina.

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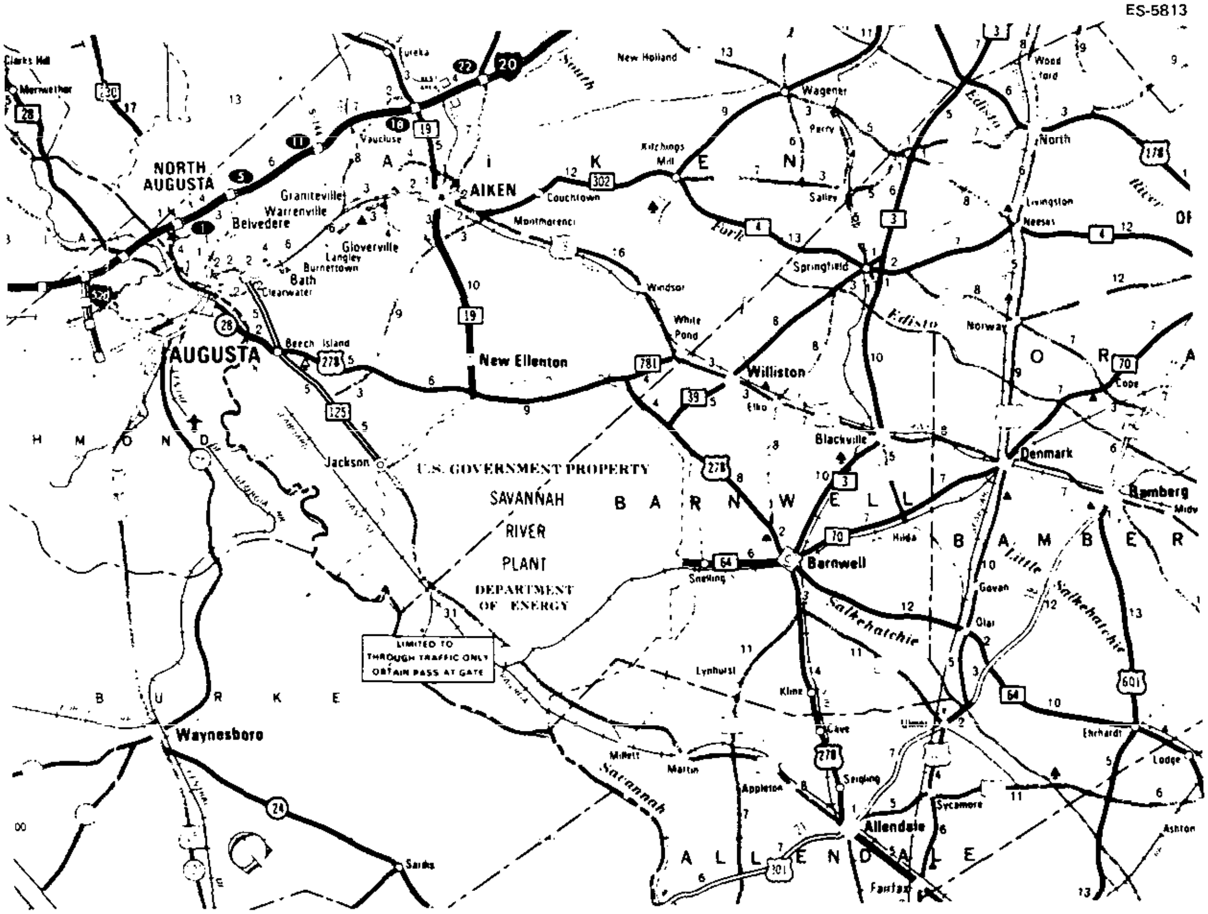

Fig. E.1. Highway network in the vicinity of SRP.

Major U.S. highways intersecting the study area counties include U.S. 321, (through Lexington, Orangeburg, Bamberg, Allendale, and Hampton), U.S. 301 (through Orangeburg, Bamberg, Allendale, and Screven), U.S. 78 (through Columbia, Richmond, Aiken, Barnwell, and Bamberg counties), U.S. 378 (from Columbia, South Carolina, through Lexington and Saluda counties), and U.S. highways 1, 178, 601, 278, and 21, parts of which are multi-lane. Other multi-lane state highways include S.C. 125 (from Augusta through the SRP to Allendale), S.C. 19 (from Aiken to U.S. 278 north of the SRP), S.C. 64 (from the SRP to Barnwell), and others near Augusta, Georgia.

Various South Carolina state highways lead to the SRP's northern, eastern, and southern boundaries, although public access into SRP is limited. Northern access to the SRP boundary includes S.C. 125 (multi-lane) from the town of Jackson, South Carolina, and S.C. 19 (multi-lane) from the towns of Aiken and New Ellenton, South Carolina. Eastern SRP boundary access includes S.C. 781 and S.C. 39 from the town of Williston, S.C. 39 from the town of Elko, and S.C. 64 (multi-lane) from the town of Barnwell. The SRP southern boundary access is S.C. 125 from the town of Allendale. No access roads exist across the SRP's western boundary, the Savannah River. Public access into the SRP is allowed on six designated roads and restricted to employees only on other roads by seven barricades. The six public roads are U.S. 278, S.C. 125, a 0.7 km section of SRP Road 2 (leading to S.C. 19), and three other roads near the SRL administrative building.

Although the SRP is Federally owned, by virtue of a deed of easement and South Carolina state enabling legislation, the state of South Carolina is responsible for maintenance of the S.C. 125 easement through the site. State highway 125 was opened to the public in July 1967, although pedestrians, bicycles, and horse-drawn vehicles are prohibited. The road may be closed at any time, however, in the event of accident or other SRP related activities.

Traffic volumes in the area vary from more than 30,000 per day in the Augusta region (1978) to a few hundred per day in some rural areas. Outside the Augusta urbanized area, highest average daily traffic volumes recorded were along the Aiken-Augusta corridor, consisting of U.S. 1 and 78, and S.C. 19. Roads and highways near the SRP average from 2,000 to 10,000 vehicles per day. Further, traffic generated from the SRP in 1980 approximated 6150 vehicle trips per day.

With no improvements to the existing system, major long-range congestion problems within the Augusta urbanized area would be most severe along Washington Road, Gordon Highway, 15th Street, Jefferson Davis Highway, and at all river crossings. The Augusta Regional Transportation Study 1974 update projected 25.9% of the road and highway network in urban Augusta to be moderately congested by the year 2000; 13% of this network is projected to be severely congested.

E.9.2 Railroads

The primary study area is served by several branches of three main rail systems: the Seaboard Coast Line Railroad (SCLR), the Georgia Railroad, and Southern Railway. In addition, the SRP owns and operates a railroad system within plant boundaries. Of four tracks operated by SCLR in the study area, one extends westward from the towns of Denmark and Barnwell, South Carolina, and provides service to the SRP along with another conjoining SCLR branch that parallels the Savannah River. During March 1977, the Augusta SCLR yard served an average of 1635 cars per day. A third track extends south from SRP through the towns of Allendale and Fairfax. The fourth track extends from Ehrhardt in Bamberg County to Green Pond in Colleton County.

The Georgia Railroad main track extends from Augusta's Harrisonville yard westward through the primary counties of Columbia and Richmond and into Atlanta. In March 1977, the Harrisonville yard served over 22,750 cars and averaged 735 cars per day. In Augusta, the Georgia Railroad provides primary service to the Belt Line and Savannah River Terminal industries.

Southern Railway maintains three track systems in the primary area. One extends from the town of Furman in Hampton County, South Carolina, to the towns of Allendale, Barnwell, and Blackville, to the capitol city of Columbia, South Carolina. Another extends from the town of Edgefield, South Carolina, through the towns of Aiken, Blackville, and Denmark within the study area, to Charleston, South Carolina. The third Southern Railway track extends from the city of Columbia, through Augusta, and on to Atlanta, Georgia. It's yards served an average of about 1200 cars per day in March, 1977.

E.9.3 Airports

There are 10 aviation facilities in the primary study area — four private and six general aviation fields. Bush Field in Augusta and the Columbia, South Carolina, Metropolitan Airport in Lexington County (in the secondary area) are the only two airports that provide scheduled air passenger services.

The entire Fort Gordon military installation is a restricted air zone as was the entire SRP reservation before 1976.

E.9.4 Water transportation

During the period 1958 to 1965, a channel was constructed on the Savannah River from Savannah Harbor to Augusta (2.7 m deep x 27 m wide x 290 km long), as authorized by the U.S. Rivers and Harbor Act of 1950. Dams controlling water levels of two upstream reservoirs, Clarks Hill and Hartwell, assist in ensuring minimum Savannah River channel flow requirements.

The commercial waterborne traffic on the Savannah River below Augusta has increased from about 45,000 t/year in the early 1970s to 100,000 t in 1976 but has since declined because of failure to maintain a 2.7 m channel in the river. The Corps of Engineers has taken the position that traffic does not warrant maintaining a 2.7 m channel. Principal products shipped include petroleum, concrete pipe, minerals, and metals.

E.10 HISTORICAL, SCENIC, AND ARCHAEOLOGICAL RESOURCES OF THE PRIMARY STUDY AREA

Within the primary impact area in 1979, 55 sites were listed in the *National Register of Historic Places*. Table E.5 lists these sites. Richmond County has the largest number of sites (23), the majority located in the City of Augusta. Of the total historic sites in the region, 78% are located in Aiken, Allendale, and Richmond counties. In addition, five historic districts, Graniteville, in Aiken County, and the Augusta Canal, Broad Street, Pinched Gut, and Summerville historic districts in Richmond County, are found in this study area. Nine sites are located within a 16-km radius of the SRP, including one in the secondary area (Burke County). Five of the sites are in Barnwell County.

South Carolina has a formal list of historic resources in the State Archaeological File. In the four primary counties, 489 sites are listed: 219 in Aiken, 96 in Allendale, 51 in Bamberg, and 123 in Barnwell. These include churches, old homes, and archaeological sites. In addition to sites listed in the *National Register of Historic Places*, 113 locally recognized sites are identified by *A Survey of Historical Sites in the Lower Savannah Region*.

In the Georgia study area, approximately 80 sites are identified in the State Archaeological Site File; the majority are located in Richmond and Columbia counties. Little systematic work has been done on these or other potential sites. In addition to the National Register, 42 sites are included in *The Environmentally Sensitive Areas and Sites of Historical Significance*. These include homes, churches, industrial facilities, and one natural feature.

Scenic resources include Heggie Rock, a large outcropping of solid rock in Columbia County; the south fork of the Edisto River; and a number of parks and recreation areas such as the Clarks Hill Reservoir, which covers over 31,000 ha. In addition to the approximately 200 carolina bays within the SRP, several hundred more of these unique natural wetland basins exist within the study area (see Sect. 4.5.1 for a description of carolina bays). These oval-shaped depressions range in size up to 50 ha and are filled with water at least part of the year.

E.11 ATTITUDES[6]

In six of the seven counties where contacts were made, the attitudes of local leaders toward nuclear facilities in the impact area remain generally positive.* The economic benefits (jobs, purchases, taxes) of the four existing nuclear facilities and potential new ones are generally seen as far outweighing any potential risks. Opposition to the facilities (primarily commercial waste storage at Barnwell) has been raised by national and regional antinuclear organizations as well as some local individuals. Differences between the existing facilities are often unclear or unrecognized by local residents, although a consensus has emerged that it is acceptable to deal with "our own" or "old" nuclear wastes, but no "new outside wastes" are welcome.

E.11.1 Attitudes toward nuclear facilities

The great preponderance of attitudes expressed by local leaders toward area nuclear facilities was positive in six of the seven counties where interviews were conducted. Because attitudes of

*This discussion is based upon interviews with 75 local residents and officials in seven impact counties (primary study area plus Burke County) as well as newspaper files and opponent literature. Though some members of the general public were contacted, most of those interviewed were a purposive, nonrandom sample of leaders (elected and appointed officials and business representatives) in the seven counties. No general surveys were employed. It is a well documented fact that attitudes of local leaders toward industrial facilities and development tend to be more positive than those of the general public. Interviews were conducted by E. Peelle, Oak Ridge National Laboratory, in April to June, 1980, and by R. Garey, Oak Ridge Associated Universities, in November to December, 1980.

Table E.5. ***National Register*** **sites within the primary study area**

Name	Location
Aiken County, South Carolina	
1. Chancellor James Carrol House	Aiken
2. Coker Springs	Aiken
3. Legare-Morgan House	Aiken
4. Phelps House	Aiken
5. Dawson-Vanderhorst House	NE of Aiken
6. Fort Moore-Savano Town Site	Beech Island vicinity
7. Redcliffe	NE of Beech Island
8. Graniteville Historic District	Graniteville
9. Silver Bluff	W of Jackson
10. Charles Hammond House	North Augusta
11. Rosemay Hall	North Augusta
12. Joye Cottage	Aiken
Allendale County, South Carolina	
13. Antioch Christian Church	SW of Allendale
14. Erwin House	SW of Allendale
15. Gravel Hill Plantation	SW of Allendale
16. Red Bluff Flint Quarries	Allendale vicinity
17. Roselawn	SW of Allendale
18. Smyrna Baptist Church	S of Allendale
19. Lawton Mounds	Johnsons Landing vicinity
20. Fennell Hill	Peeples vicinity
Bamberg County, South Carolina	
21. General Francis Marion Bamberg House	Bamberg
22. Woodlands	SE of Bamberg
23. Rivers Bridge State Park	Ehrhardt vicinity
Barnwell County, South Carolina	
24. Banksia Hall	Barnwell
25. Church of the Holy Apostles	Barnwell
26. Church of the Holy Apostles Rectory	Barnwell
27. Old Presbyterian Church	Barnwell
28. Bethlehem Baptist Church	Barnwell
Columbia County, Georgia	
29. Kiokie Baptist Church	Appling
30. Stallings Island	NW of Augusta
31. Woodville	Winfield vicinity
32. Columbia County Courthouse	Appling
Richmond County, Georgia	
33. Academy of Richmond County	Augusta
34. Augusta Canal Industrial Historic District	Augusta
35. Augusta Cotton Exchange	Augusta
36. Stephen Vincent Benet Home	Augusta
37. Brake House	Augusta
38. Landmark Baptist Church of Augusta	Augusta
39. Fitzsimons-Hampton House	Augusta
40. Gertrude Herbert Art Institute	Augusta
41. Harris-Pearson-Walker House	Augusta
42. Meadow Garden	Augusta
43. Old Medical College Building	Augusta
44. Old Richmond County Courthouse	Augusta
45. Sacred Heart Catholic Church	Augusta
46. St. Paul's Episcopal Church	Augusta
47. Augusta National Golf Club	Augusta
48. Gould-Weed House	Augusta
49. Lamar Building	Augusta
50. Reid-Jones-Carpenter House	Augusta
51. Woodrow Wilson Boyhood Home	Augusta
52. College Hill	Augusta vicinity
53. Broad Street Historic District	Augusta
54. Pinched Gut Historic District	Augusta
55. Summerville Historic District	Augusta

Source: U.S. Department of the Interior, Heritage Conservation and Recreation Service, *National Register of Historic Places*, Washington, D.C., Government Printing Office, 1979, 1980.

local leaders toward industrial facilities and development tend to be more positive than those of the general public, we asked the leaders about the views of the general public, in particular, divergent views. Most leaders could not identify any local persons or groups who were opposed. Leaders note both that people feel that the economic benefits outweigh possible risks and that "most people are not concerned (interested, informed, etc.) about health or environmental risks." Across the Savannah River in Georgia, the views are similar though leaders say that "South Carolina is as close as we want the wastes."

Allendale County is the only county where the majority of leaders has adopted an attitude of cautious concern and uncertainty rather than unreserved support. The number of wholehearted supporters of SRP (3) was the same as that of avowed opponents. Twenty other leaders expressed concern about possible health effects, requested more information, or are reassessing their previous support in favor of a more cautious position.

The sharp differences in attitudes between Allendale and the other six counties reflect in part the differences in benefits between the counties. In 1979, Aiken County had 4900 residents who were SRP employees and received $61,000 in payments in lieu of taxes (PILOT) and $380,000 in school-impact aid; Allendale County had only 106 residents employed at SRP and received less than $5,000 in both PILOT and impact monies. Even Bamberg County, which is not adjacent to SRP, had more SRP employees (165).

Opponents of the area nuclear facilities include various national and regional antinuclear organizations such as the Palmetto Alliance, Friends of the Earth, the Sierra Club, and the Southeastern Natural Guard. These groups have been active for specific events and protests in the past but currently have no local offices. They have protested nuclear waste or defense activities both in concert with and independent of any local opposition.

Other environmental organizations have expressed concerns on nuclear matters as these affect their particular interests. For example, the Friends of the Savannah River have questioned possible contamination of the Savannah River by the nuclear facilities on both sides of the river, but their orientation is not explicitly antinuclear.

The lack of local concerns about nuclear activities was highlighted by Burke County and other officials who noted the absence of protests at the Georgia Power Vogtle nuclear plant now under construction across the river from SRP.

All counties share another characteristic: lack of detailed information about the various nuclear facilities. Most citizens and some officials do not distinguish between the different facilities (private and Federal), different purposes (defense, commercial), and different processes that are (or may be) carried out. These activities include power generation at the Vogtle plant, production of defense materials, such as plutonium, at SRP, storage of low-level wastes by the Chem-Nuclear company, and potential reprocessing of commercial wastes or potential storage of spent reactor fuel elements (away from reactor-AFR-storage) at the Allied General-Nuclear Services facility. A given facility and rulings or events concerning it are often confused with other facilities.

The only nuclear issue on which some clear distinctions are made seems to be that of new and old nuclear wastes; many people oppose bringing in "new" wastes though they feel that proper handling of "old" or existing wastes is acceptable and desirable. Many individuals expressed the view that South Carolina should not become the nation's nuclear waste dump.

E.11.2 Community relationships with the SRP

Although the SRP is generally considered a "safe industrial plant" and a "good place to work" and leaders are aware of its substantial contribution to area employment and economic health, few formal or informal contacts occur between the SRP plant and the public or local officials. Most people feel that they are uninformed about the nature of SRP operations or plans, and most officials and leaders indicated they have never received a communication from either SRP or the Department of Energy.* Some information about SRP activities is given via speeches and presentations to certain Aiken business or professional organizations. Outside of Aiken, we found only two leaders (a Barnwell media owner and the Augusta mayor) who had any regular contact with SRP. This lack of contact and information is a source of mild irritation to most officials who feel their city or town is neglected. They expressed the opinion that impacts of future SRP plans

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*About 52 letters and information packets were sent to local officials in the 13-county study area in April and August of 1980 announcing the information gathering activities for the DWPF Draft Environmental Statement.

could be accommodated *if* they knew what to plan for. Leaders and citizens were generally unaware of the SRP environmental monitoring and protection efforts,* and only one was aware of SRP-sponsored health effects studies. Only six officials recalled receiving notification letters about the Defense Waste Processing Facility project. Of those who knew of the proposed DWPF effort, almost all favored solidifying liquid wastes and removing them from temporary tank storage for eventual removal from the area. Two opinion leaders from the Augusta area emphasized the need for widely announced public hearings on the draft EIS to be held at accessible locations and at convenient times so that the general public has the opportunity for commenting on the conclusions.

Since 1968, payments in lieu of taxes (PILOT) have been made to Aiken, Barnwell, and Allendale counties, based on the value of unimproved lands. These payments were retroactive to 1954 and now total around $120,000 per year (1979): $55,000 to Barnwell County, $61,000 to Aiken County, and $2,800 to Allendale County.

Some concern was expressed by leaders that PILOT payments were too low and not distributed to all counties that are affected by SRP. Several officials were aware that existing PILOT payments are not tied to impacts but only to land values for land previously removed from taxation. School officials are concerned that school impact payments are declining as the number of children rises (in South Carolina) or that impact aid for Georgia counties will be terminated altogether as of 1981.†

*Three hundred and thirty SRP monitoring reports were sent in 1979 to area news media, state and local officials, and those who requested them.

†The extension of school impact funds for FY-1981 was qualified by the U.S. House of Representatives to exclude all jurisdictions outside the state in which the Federal facility exists. Thus, Georgia counties will no longer receive aid.

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6. Interviews in primary study area by R. Garey, ORAU, in November and December, 1980, and by E. Peelle, ORNL, in April, May, and June, 1980.

Appendix F

SUBSURFACE HYDROLOGY

Appendix F

SUBSURFACE HYDROLOGY

Three distinct geologic systems underlie the SRP: (1) the coastal plain sediments, where water occurs in porous sands and clays; (2) the buried crystalline metamorphic bedrock, where water occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton basin, where water occurs in intergranular spaces in mudstones and sandstones. The coastal plain sediments contain several prolific and important aquifers, which will be described in subsequent paragraphs.

F.1 OCCURRENCE OF WATER

The coastal plain sediments consist of a wedge of stratified sediments that thicken to the southeast from zero meters at the fall line to more than 1200 m (4000 ft) at the mouth of the Savannah River (Fig. F.1). Near S-area the sediments are about 300 m thick and consist of sandy clays and clayey sands.[1] The sandier beds form aquifers and the clayier beds form confining beds. The coastal plain sediments consist of the Hawthorn Formation, which is successively underlain by the Barnwell, McBean, Congaree, Ellenton, and Tuscaloosa formations.

The Tuscaloosa Formation rests on saprolite, a residual clay weathered from the crystalline metamorphic bedrock (Fig. F.2). The Tuscaloosa Formation is about 180 m thick near S-area[2] and consists of a sequence of sand and clay units.[3] The combined saprolite and basal Tuscaloosa clay form an effective seal that separates water in the coastal plain sediments from water in the crystalline metamorphic rock. The Tuscaloosa Formation does not outcrop near S-area. The sand units combined are about 140 m thick and supply water to the SRP. In areas of the South Carolina Coastal Plain within 40 km (25 miles) of the Fall Line, the Tuscaloosa Formation is a major supplier of groundwater;[4] wells commonly yield over 5500 m^3/day (1000 gpm) of good quality water.

The Ellenton Formation overlies the Tuscaloosa Formation (Fig. F.2). It is about 18 m thick near S-area and consists of clay with coarse sand units. The known Ellenton sediments are entirely within the subsurface. Although the Tuscaloosa Formation can be distinguished from the Ellenton Formation, the water-bearing units within the formations are not completely separated by an intervening confining bed and the water-bearing units of the two formations are considered to constitute a single aquifer.[5] The clays that separate the Ellenton Formation and the overlying Congaree Formation are apparently extensive and continuous enough to act as a confining bed that separates the water in the Ellenton Formation from the water in the Congaree Formation.[6]

The Congaree Formation (Fig. F.2) is about 40 m thick near S-area and consists of a lower unit of sand with clay layers and an upper clay layer known as the "green clay." The "green clay" appears continuous and supports a large head differential between water in the overlying McBean Formation and water in the Congaree Formation. The Upper Three Runs Creek incises the Congaree Formation (Fig. F.3). The Congaree sand beds constitute an aquifer that is second only to the Tuscaloosa Formation in importance with yields of up to 3600 m^3/day.[7]

The McBean Formation (Fig. F.2) is about 25 m thick near S-area and consists of a lower unit of calcareous clayey sand and an upper unit of clayey sands.[8] The McBean Formation is incised by Upper Three Runs Creek and Four Mile Creek (Fig. F.3). Groundwater occurs in both units, but neither are prolific aquifers near S-area.

The Barnwell Formation is overlain by the Hawthorn Formation (Fig. F.2). In some instances the Barnwell and Hawthorn formations are considered a single unit because of the difficulty in distinguishing between them. The two units together are about 30 m thick near S-area (EID, vol. I). From bottom to top, they consist of: (1) a clay unit known as the "tan clay," which usually consists of two thin clay beds separated by a sandy bed; (2) a silty sand unit; and (3) a clayey sand unit that may include beds of silty clay or lenses of silty sand. The Barnwell and Hawthorn formations are incised by Upper Three Runs Creek, Four Mile Creek, and their unnamed tributaries (Fig. F.3). The water table is usually within the Barnwell Formation. Because of the large amounts of clay and silt mixed with Barnwell sands, it does not generally yield water to wells except from occasional sand lenses.

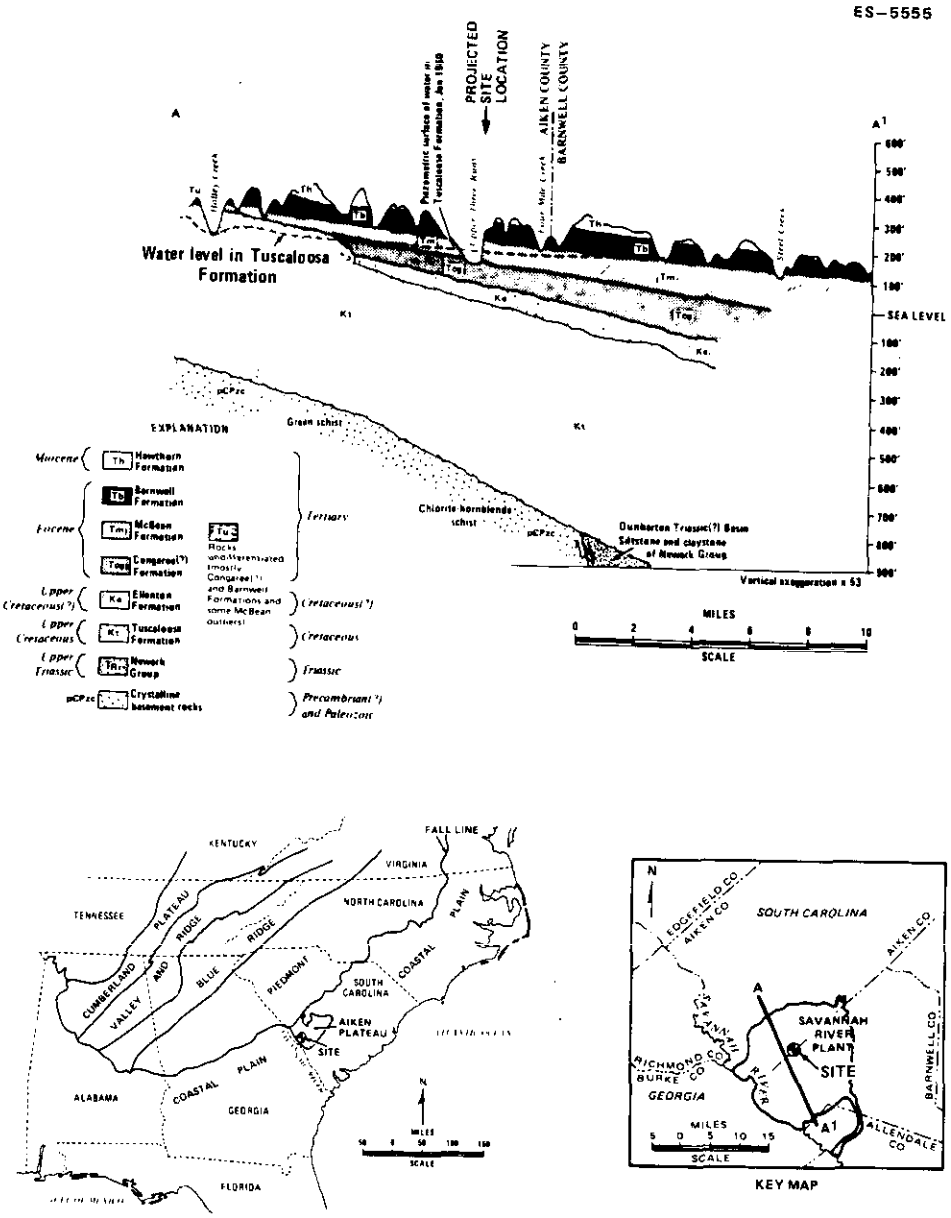

Fig. F.1. Generalized northwest to southeast geologic profile across the Savannah River Plant.

F.2 GROUNDWATER FLOW

The Barnwell Formation commonly contains the water table with water depths ranging from 9 to 15 m below the ground surface. Static heads (Fig. F.2 and Table F.1) in the McBean Formation are slightly lower than those in the Barnwell Formation, indicating a tendency for downward flow. The Barnwell and McBean formations are separated by the "tan clay," a relatively low-permeability material located about 30 m below the ground surface. Static heads in the Congaree Formation are about 18 to 21 m lower than those in the McBean Formation. The McBean and Congaree formations are separated by the "green clay," a confining bed located about 50 m below the ground surface. Static heads in the Ellenton Formation are about 3 m higher than the Congaree Formation, indicating the formations are hydraulically separated by clay confining beds located about 90 m below the ground surface.

The overall vertical flow pattern near S-area is infiltration of precipitation into the Barnwell Formation and percolation downward to the Congaree Formation. The "tan clay" diverts some water in the Barnwell Formation laterally to creeks. The "green clay" diverts most of the water in

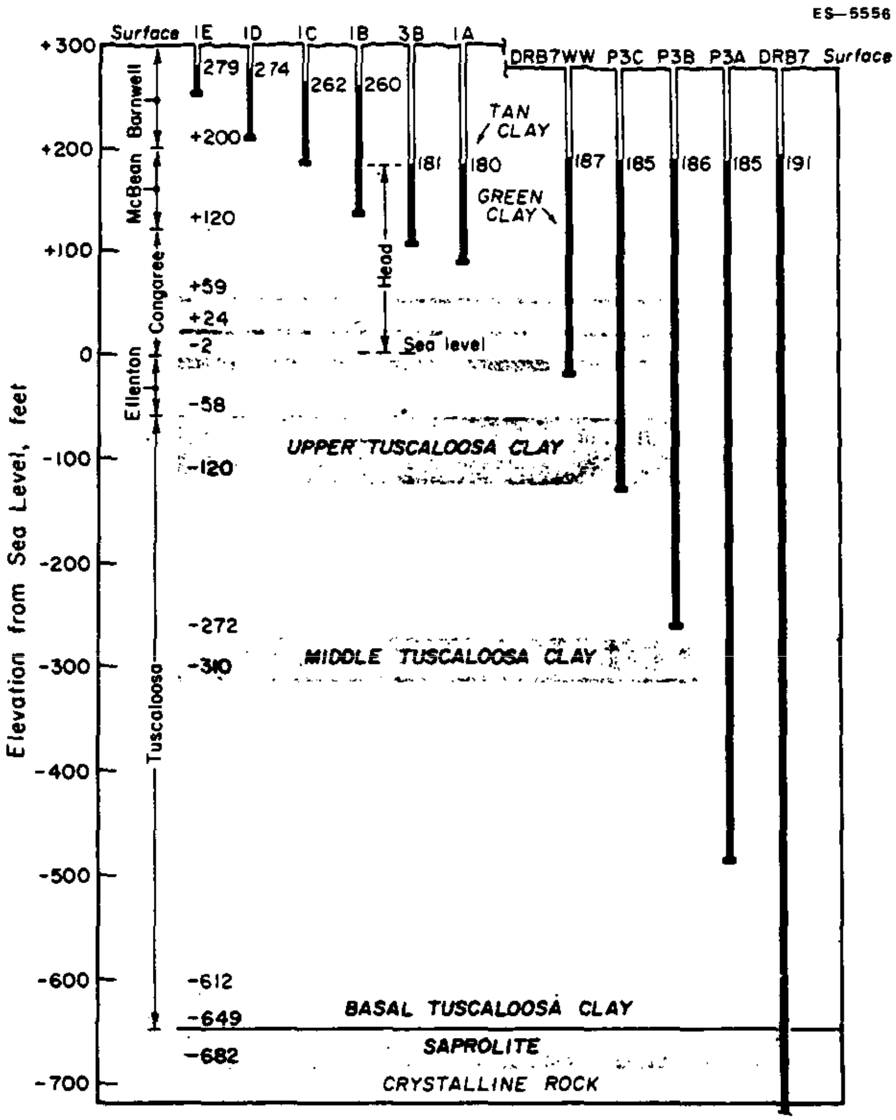

Fig. F.2. Geology and hydrostatic head in groundwater near the center of the Savannah River Plant.

water in the McBean Formation laterally to creeks. The Ellenton and Tuscaloosa Formations are hydraulically separated from the Congaree Formation and are not recharged near S-area.

The observed potentiometric contours near S-area indicate that: (1) flow in the Barnwell Formation (Fig. F.4) generally follows ground surface contours and drains toward Upper Three Runs Creek and an unnamed tributary; (2) the McBean Formation (Fig. F.5) also drains toward Upper Three Runs Creek and an unnamed tributary; and (3) the Congaree Formation (Fig. F.6) drains toward Upper Three Runs Creek. Both the recharge and discharge controls on the water in the Tuscaloosa Formation are outside of S-area. The Tuscaloosa Formation acts as a water conduit through which water passes beneath the SRP in going from recharge zones in the Aiken Plateau to discharge zones in the Savannah River Valley (Fig. F.7).

Hydraulic conductivities were determined by laboratory and pump tests near S-area.[9] The direction and rate of groundwater flow are determined by the hydraulic conductivity, hydraulic gradient, and effective porosity. Laboratory-determined hydraulic conductivities are more variable than those determined from pumping tests. The latter data, shown on Fig. F.8, are considered more reliable than the laboratory determinations because they represent a larger portion of the aquifer being tested.

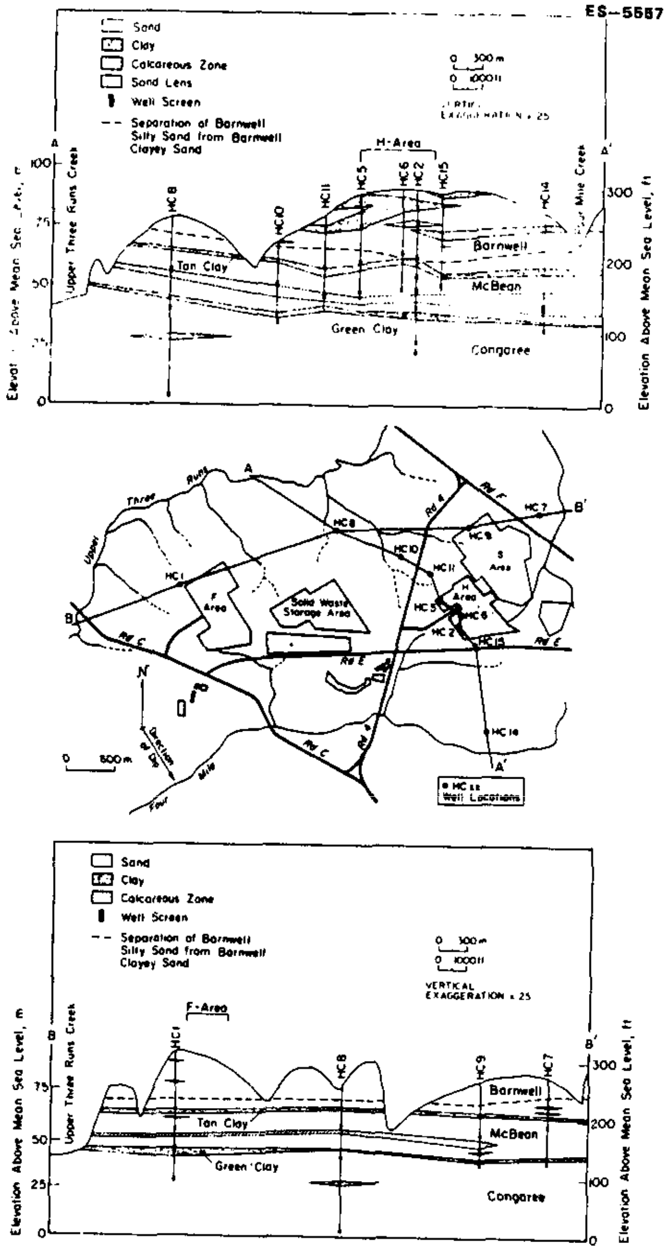

Fig. F.3. Hydrologic sections near S-area.

In the Barnwell Formation, the median hydraulic conductivity for the clayey sand unit is 0.04 m/day. Although no pumping tests were made on the silty sand unit, pumping tests in a sand lens within this unit determined the median hydraulic conductivity to be 0.3 m/day. In the McBean Formation, the median hydraulic conductivity of the upper sand unit is 0.13 m/day and that of lower unit of calcareous clayey sand is 0.07 m/day.[10] Fluid losses in the calcareous unit during drilling operations make it appear very permeable. Apparently zones of high permeability are not continuous over large distances and the hydraulic conductivity of the calcareous unit is lower than it appears from drilling experience. The median hydraulic conductivity in the Congaree Formation is 1.5 m/day.[9] The effective porosity of each of the formations is estimated to be 20%.

The presence of mica and kaolinitic clays in the subsurface materials will make ion exchange a significant factor in controlling contaminant transport in groundwater. The pH and the concentration of strontium and cesium in a postulated leak must be known to estimate the distribution coefficient Kd. The effect of pH and concentration on the distribution coefficients is shown in Fig. F.9.[11]

Table F.1. Piezometer data at DWPF

Formation sensed	Piezometer number	Ground surface elevation (m-MSL)	Wellpoint elevation (m-MSL)	Static head (m-MSL)
Barnwell	BH-6B	84.43	70.41	74.07
	BH-14	87.02	74.83	75.29
	BH-23A	87.90	72.66	73.91
	BH-75A	82.60	67.36	73.37
	HC-13C	88.97	63.12	75.77
	HC-16B	80.04	55.96	71.66
	RSSF-1	89.43	66.14	73.88
	RSSF-2	84.40	61.27	71.78
	RSSF-4	88.12	72.54	73.61
	RSSF-5	89.22	65.53	73.06
McBean	BH-3	84.25	46.45	70.20
	BH-6	84.43	54.25	72.60
	BH-48B	86.38	49.20	70.96
	BH-98A	84.31	44.07	73.00
	HC-9B	82.08	53.25	71.63
	HC-13B	88.79	58.92	74.59
	RSSF-3	80.53	60.35	72.79
Congaree	BH-4	86.62	29.17	52.79
	BH-8	83.00	13.20	52.88
	BH-15	81.72	30.51	54.53
	BH-64A	84.09	13.23	53.07
	BH-69	86.78	25.21	53.19
	HC-9A	82.08	37.73	51.69
	HC-16A	80.04	36.00	54.59
Ellenton	BH-2	79.52	-14.39	55.50
	BH-9	83.45	-7.38	55.72
	BH-13	93.03	-0.55	54.16
	BH-20A	86.26	-10.06	56.21
	BH-50A	86.23	-8.26	55.99

Source: EID.

ES-5784

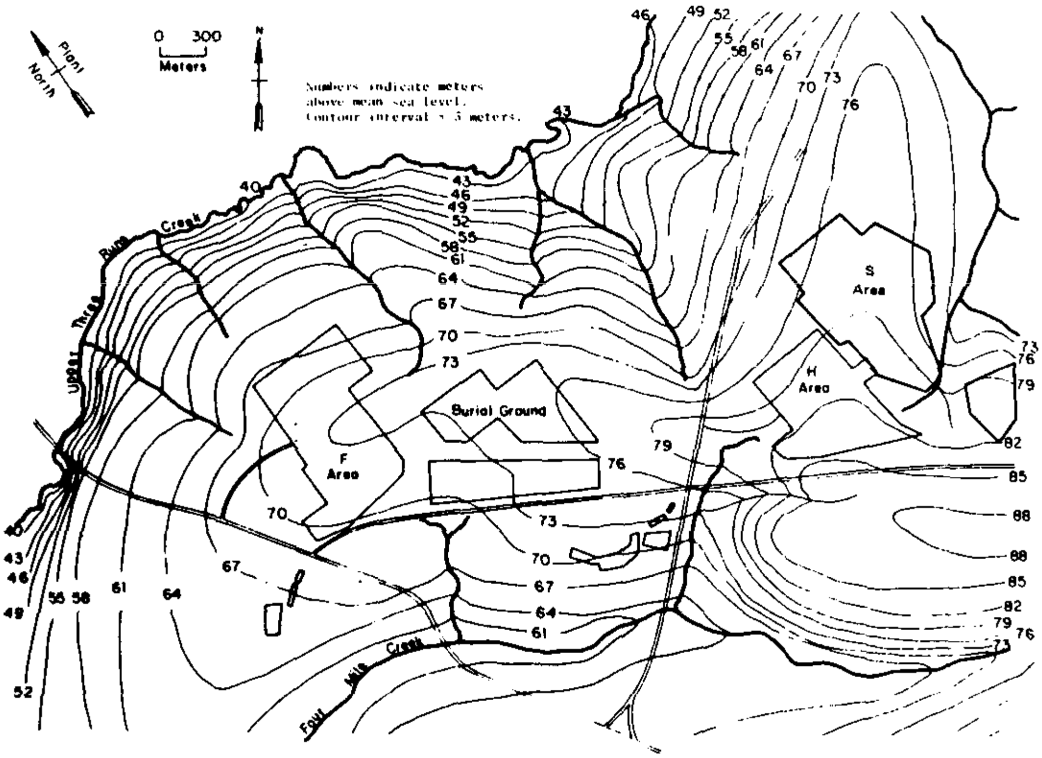

Fig. F.4. Average elevation of the water table in the Barnwell Formation near S-area during 1960.

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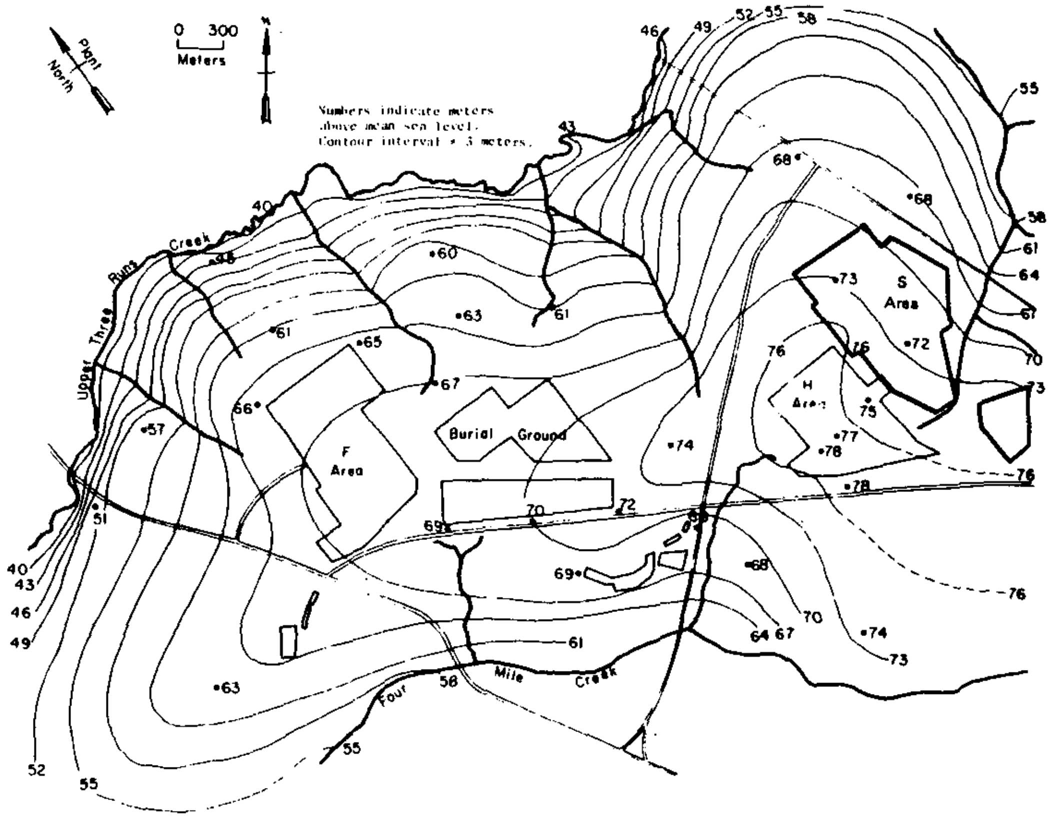

G-1 Fig. F.5. Potentiometric contours in the McBean Formation. Source: Map based on measurements made August 29, 1977.

F.3 GROUNDWATER QUALITY

The water in the coastal plain sediments is generally of good quality and suitable for municipal and industrial use with minimal treatment. The water is generally soft, slightly acidic, and low in dissolved and suspended solids. Typical values of selected water quality characteristics of groundwater near the S-area are shown in Table F.2.[2]

F.4 GROUNDWATER USE

The Tuscaloosa and Congaree formations are prolific aquifers and are major sources of municipal and industrial water supplies. The McBean and Barnwell formations yield sufficient water for domestic use.

Twenty municipal users (Table F.3) within 30 km of S-area were identified with a total pumpage of about 39,000 m^3/day. Of this, 21,000 m^3/day came from the Tuscaloosa Formation, 15,000 m^3/day came from the Congaree Formation, and the remainder came from the McBean Formation.[12] The closest user to S-area is Talatha at a distance of about 10 km, which uses about 150 m^3/day. The largest user is Barnwell, distance of about 30 km, which uses about 15,000 m^3/day.

Sixteen industrial users (Table F.4) within 30 km of S-area were identified with a total pumpage of about 44,000 m^3/day, all from the Tuscaloosa Formation. The closest user to S-area is H-area, distance less than 2 km, which uses about 5600 m^3/day. The largest user is the Sandoz Company, distance of about 30 km, which uses 11,000 m^3/day. Projected future use includes pumpage of 15,000 m^3/day at the Barnwell Nuclear Fuel Plant at a distance of about 20 km from S-area and pumpage of 11,000 m^3/day at the Alvin W. Vogtle Nuclear Power Station at a distance of 25 km from S-area.[12]

Total current groundwater use at the SRP is about 18,500 m^3/day. The projected groundwater use at S-area is about 3700 m^3/day.

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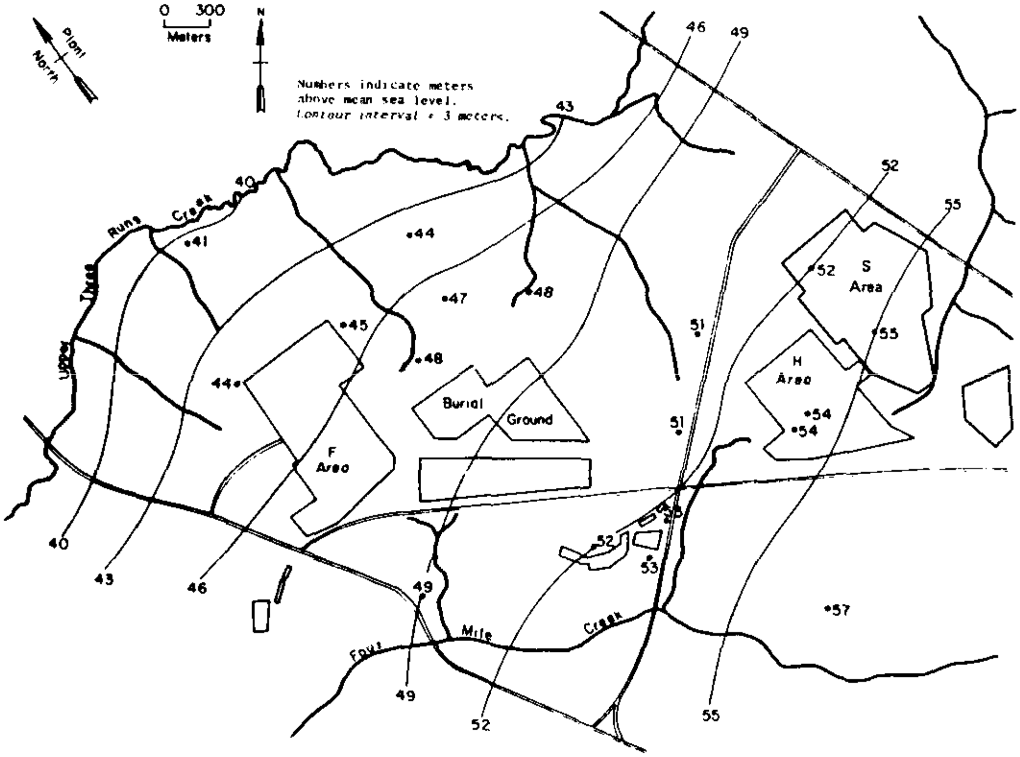

Fig. F.6. Potentiometric contours in the Congaree Formation. Source: Map based on measurements made August 29, 1977. G-1

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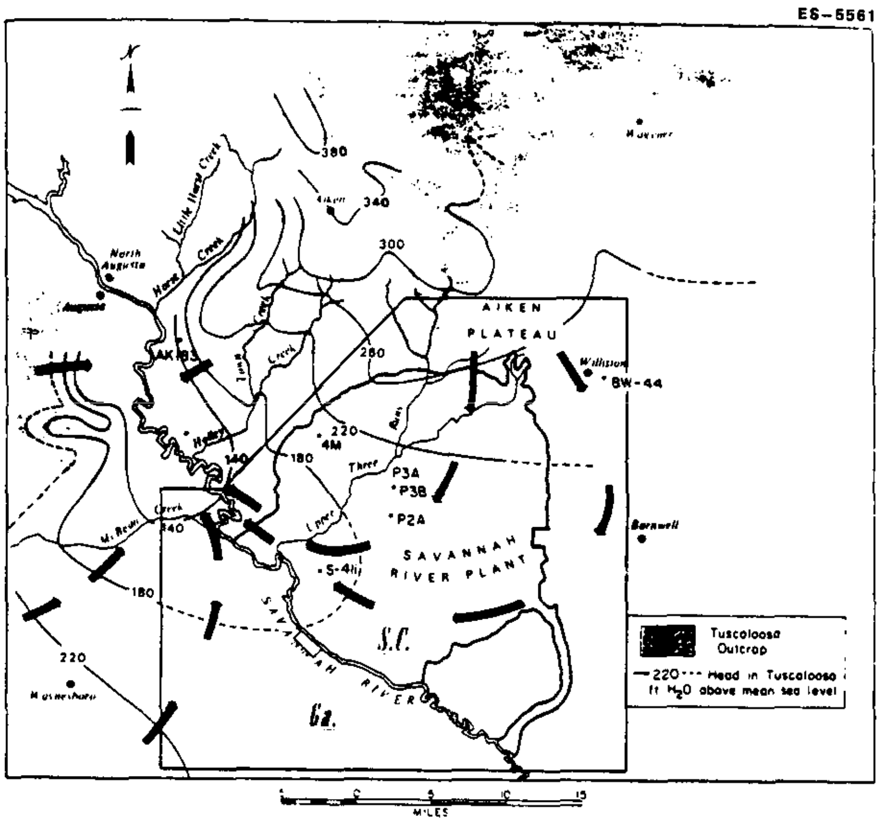
Water levels in the Tuscaloosa Formation have been measured both on and off the Plant site since the construction of the Savannah River Plant began. These water levels show fluctuations in response to climatic variation but no progressive upward or downward trend. Water levels in the Congaree Formation, which have been measured since 1965, also reflect climatic variations but no long-term trend. Thus, in the absence of any unexpected major sources of water withdrawal, no future trend can be forecast. In any event, the minor withdrawals projected for DWPF would have no discernible impact. G-1



G-1 Fig. F.7. Potentiometric contours in the Tuscaloosa Formation. <u>Source</u>: Siple, 1967.

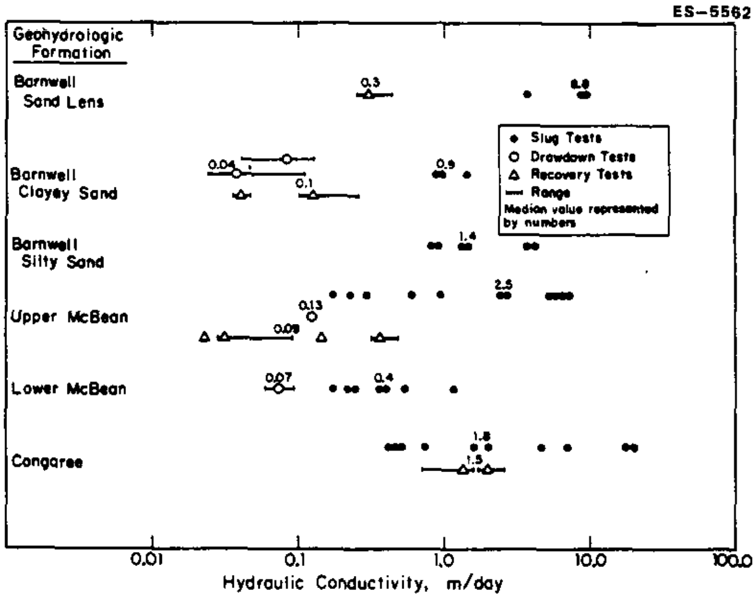


Fig. F.8. Hydraulic conductivity values in the coastal plains sediments as determined by pumping tests.

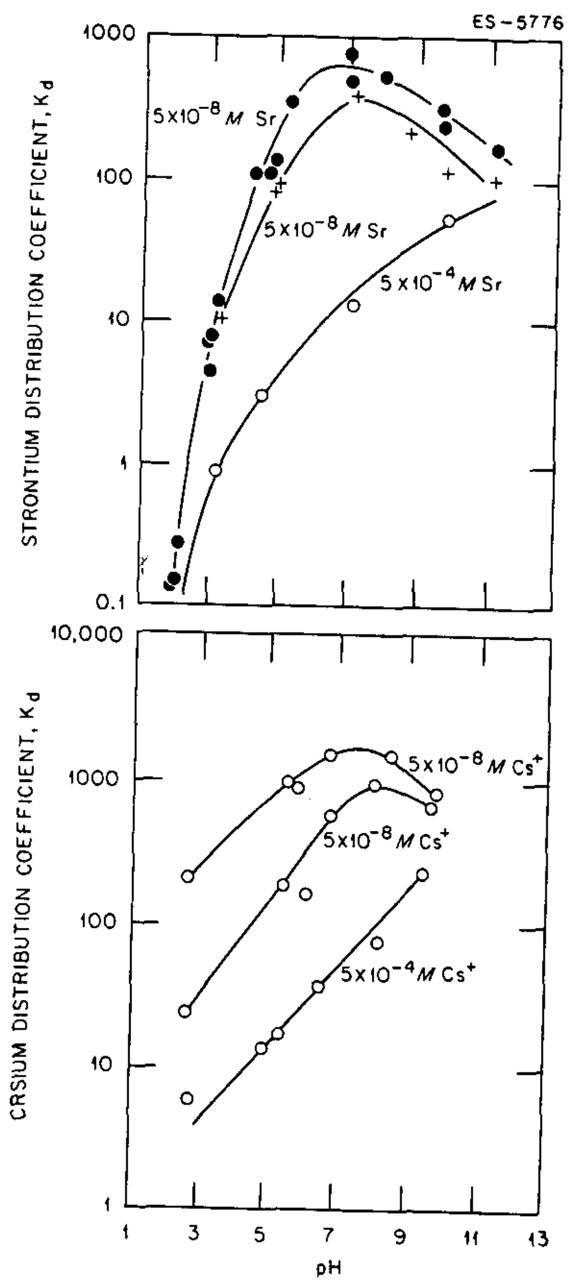


Fig. F.9. Effect of pH and concentration on absorption of strontium and cesium by soil.