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# FINAL
# ENVIRONMENTAL IMPACT STATEMENT

# L-Reactor Operation
# Savannah River Plant

## Aiken, S.C.

## Volume 1

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Abstract: The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into the proposed decision to restart L-Reactor at the Savannah River Plant (SRP). The Savannah River Plant is a major U.S. Department of Energy (DOE) installation for the production of nuclear materials for national defense. The L-Reactor operated from 1954 until 1968, when it was placed in standby status due to a decreasing demand for defense nuclear materials. This EIS assesses the potential environmental effects of the restart of L-Reactor on air and water quality, ecological systems, health risk, archeological resources, endangered species, and wetlands.

## FOREWORD

The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into the proposed decision to restart L-Reactor operation at the Savannah River Plant (SRP). The Savannah River Plant is a major U.S. Department of Energy (DOE) installation for the production of defense nuclear materials. The proposed restart of L-Reactor would provide defense nuclear materials (i.e., plutonium) to meet current and near-term needs for national defense. L-Reactor operated originally from 1954 until 1968, when it was placed in standby status due to a decreasing demand for defense nuclear materials. In March 1981, activities were initiated to renovate and upgrade L-Reactor to the same condition as that of the currently operating SRP Reactors. Renovation and upgrading activities were essentially complete in October 1983.

DOE published an environmental assessment (DOE/EA-0195) on the proposed restart of L-Reactor, and a Finding of No Significant Impact on August 23, 1982 (47 FR 36691). After the publication of the Finding of No Significant Impact in the Federal Register, a number of environmental concerns were raised, and a lawsuit seeking to enjoin the restart of L-Reactor prior to issuance of an environmental impact statement was filed in November 1982.

DOE issued a Floodplain/Wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The Floodplain/Wetlands assessment has been updated and modified in this EIS, and a new determination will be made following completion of the final EIS.

At the request of Senator Strom Thurmond, the Senate Armed Services Committee scheduled a public hearing on February 9, 1983, to provide an opportunity for the public to express their views on the environmental consequences of the proposed restart of the L-Reactor (Senate Hearing 98-18). Subsequently, at the request of Senators Thurmond and Mack Mattingly, the DOE held a 90-day comment period on the Senate hearing record and conducted a series of four additional hearings between May 23 and 27, 1983.

In July 1983, Congress enacted and the President approved the Energy and Water Development Appropriations Act, 1984, which states:

> None of the funds appropriated by this Act, or by any other Act, or by any other provision of law shall be available for the purpose of restarting the L-Reactor at the Savannah River Plant, Aiken, South Carolina, until the Department of Energy completes an Environmental Impact Statement pursuant to section 102(2)(C) of the National Environmental Policy Act of 1969 and until issued a discharge permit pursuant to the Federal Water Pollution Control Act (33 U.S.C. 1251, et. seq.) as amended, which permit shall incorporate the terms and conditions provided in the Memorandum of Understanding entered into between the Department of Energy and the State of South Carolina dated April 27, 1983, relating to studies and mitigation programs associated with such restart. For purposes of this paragraph the term "restarting" shall mean any activity related to the operation of the L-Reactor that would achieve criticality, generate fission products

within the reactor, discharge cooling water from nuclear operations directly or indirectly into Steel Creek, or result in cooling system testing discharges which exceed the volume, frequency and duration of test discharges conducted prior to June 28, 1983.

Consistent with the National Environmental Policy Act of 1969, and in consultation with State officials of South Carolina and Georgia, the preparation and completion of the Environmental Impact Statement called for in the preceding paragraph shall be expedited. The Secretary of Energy may reduce the public comment period, except that such period shall not be reduced to less than thirty days, and the Secretary shall provide his Record of Decision, based upon the completed Environmental Impact Statement, not sooner than December 1, 1983, and not later than January 1, 1984.

In response to the November 1982 suit, the Federal District Court of Washington, D.C., in July, also directed DOE to prepare an EIS on the restart of L-Reactor as soon as possible.

A Notice of Intent to prepare this EIS was published in the Federal Register on July 19, 1983 (48 FR 32966). That notice solicited comments and suggestions for consideration in preparing the EIS. The preliminary scope was included in the Notice of Intent; this scope was based on public comments received at the Senate Armed Services Committee hearing held in February 1983 and the 90-day comment period on the record of this hearing.

In response to the Notice of Intent, 42 individuals, organizations, and governmental representatives provided comments to assist in the preparation of the Final EIS. Appendix K provides the issues raised at four scoping meetings and cross references to the appropriate Draft EIS sections. In this Final EIS, Appendix K has been revised to correct typographical errors.

On September 23, 1983, DOE began the public distribution of the Draft EIS to all interested individuals, agencies, and groups for review. On September 28, 1983, a Federal Register Notice (FR 48 44244) announced the availability of the Draft EIS and the conduct of a 45-day review/comment period on the document from October 1 to November 14, 1983. During the comment/review period, DOE conducted four public meetings--in Augusta and Savannah, Georgia, and Aiken and Beaufort, South Carolina.

More than 100 comment letters were received during the 45-day period. Many have led to revisions in this Final Environmental Impact Statement. Appendix M (Volume 3) of this statement contains the comments received during the public comment/review period and DOE's responses to these comments. A copy of the transcripts of the public meetings, public notification procedures used for the public comment/review period, and a copy of all the comments as received during the public review/comment period are contained in the Public Comment/Hearing Report (DOE/SR-5009), which has been placed in local libraries.

In this Final EIS, changes from the draft have been indicated by a vertical line in the margin of each page. Minor typographical and editorial corrections are not identified. Changes that are the result of public comments are identified by the specific comment numbers that appear in Appendix M. 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." Other changes in this Final EIS are identified by an alphanumeric marginal notation (e.g., AA-1); these notations refer to comments in Appendix M (Volume 3). The responses to these comments also provide additional information and clarification. In this Final EIS, Sections 2.4, 4.4.2, and Appendix I have been extensively revised, and Sections 4.5, 5.1.3, and 5.2.8 and Appendix L have been added to provide a more detailed discussion of cooling-water alternatives and the Department of Energy's preferred alternative. Because of these revisions and additions, no vertical change lines are included for these sections.

The Environmental Assessment (EA) and the Draft EIS contained temperatures for L-Reactor secondary cooling-water discharges and for downstream Steel Creek, based on the reactor operating year-round at 2400 megawatts-thermal. The actual operating power is lower than 2400 megawatts-thermal in the summer and is higher during the other seasons. The operating power is limited by the cooling-water supply temperatures from the Savannah River. The discharge-water temperatures and the resulting temperatures downstream in Steel Creek have been calculated for the actual operating power for each season, and are reflected in this Final EIS.

The estimated remobilization of radioisotopes (primarily cesium-137) in Steel Creek will occur via three mechanisms: (1) desorptive transport, (2) transport in biota, and (3) suspended sediment-water transport. The estimates of the quantities transported via desorption and in biota have remained the same in the EA, the Draft EIS, and this Final EIS (i.e., 1.7 and 0.4 curies, respectively, during the first year). The estimates for the suspended sediment-water transport have been revised. Earlier estimates were based on a 3-day test program and assumed an average concentration of suspended solids and an initial peak transport during the first year. These estimates were 7.7 curies of cesium-137 transported via suspended sediment-water transport during the first year, 7.2 curies transported in the second year, and an annual 20-percent reduction thereafter. The revised estimates are based on a field test program, in which samples were taken at the mouth of Steel Creek during secondary cooling-water system tests over a 53-day period in the spring of 1982; these tests used ambient river water at a flow of about 6 cubic meters per second, which is about half of the full cooling-water flow from L-Reactor. These revised estimates, using the larger data base, are 2.3 curies during both the first and second years, with an annual 20-percent reduction thereafter.

The Savannah River Plant has instituted a program to reduce the amount of process wastewater from the various facilities; the particular emphasis of the program is on reducing discharges to the seepage basins in the Separations (F- and H-) Areas and the Fuel and Target Fabrication (M-) Area. Rearrangements of rinse tanks and procedures, the recycling of evaporator "overhead" water, and other changes in operational procedures have been initiated. In M-Area, for example, the discharge rate to the seepage basin has been reduced since the release of the Draft EIS from 0.85 cubic meter per minute to the present (February 1984) rate of 0.48 cubic meter per minute. By the end of 1984, this discharge is expected to decrease to about 0.05 cubic meter per minute.

Since the preparation of the Draft EIS, the rates of ground-water withdrawn from the Tuscaloosa Aquifer by SRP facilities have changed from those measured in 1982. In 1983, the sitewide pumping rate was about 27 cubic meters per minute, about 3.2 cubic meters per minute greater than in 1982. This increase is related in part to the increased use in L-Area (from 0.28 to 0.94 cubic meter per minute) and to the increased use in A- and M-Areas (from 5.0 to 6.8 cubic meters per minute); M-Area is producing fuel and targets that could be used in L-Reactor. Ground-water use in F-Area also increased.

More changes in pumping rates are expected in 1984. The M-Area ground-water remedial action project is scheduled to start in August 1984. The effluent from the air stripper will be used to augment the process-water supply used by the A-Area powerhouse; this could reduce A-Area consumption by about 1.1 cubic meters per minute. In September 1984, the F-Area powerhouse will be placed in standby. This will reduce the consumption of ground water from the Tuscaloosa Aquifer by about 1.9 cubic meters per minute.

Considering all factors, DOE has selected a once-through 1000-acre lake as its preferred cooling-water alternative. The impacts of this alternative were bracketed in the Draft EIS by the 500-acre and 1300-acre cooling ponds.

This EIS was prepared in accordance with the Council on Environmental Quality NEPA regulations (40 CFR 1500-1508) and DOE's NEPA guidelines (45 FR 20694, March 28, 1980) by DOE and by DOE's contractors under the direction of DOE. Methodologies used and scientific and other sources of information relied upon for conclusions are explicitly identified in this EIS; it is based on comprehensive environmental information drawn from over 100 publicly available documents developed over the last 30 years. In addition, available results of ongoing studies have been used.

The discussion on the need for L-Reactor is, by necessity, qualitative in nature because quantitative information on defense material requirements and production capacity is classified; detailed quantitative discussion on need is contained in a classified appendix, Appendix A. This appendix is not available for public review.

Referenced material in the EIS has been reviewed for classification and sensitivity and is available for review in the U.S. Department of Energy Public Reading Rooms: 211 York Street, N.E., Aiken, SC 29801, and 1000 Independence Ave, S.W., Washington, DC, between the hours of 8:30 a.m. and 4:30 p.m., Monday through Friday.

## SUMMARY

This section summarizes the Final Environmental Impact Statement (EIS) on the proposed restart of L-Reactor at the Savannah River Plant (SRP) in South Carolina. In preparing this Final EIS, the U.S. Department of Energy (DOE) has considered the comments that were submitted by government agencies, private organizations, and individuals during the public review period that followed publication of the Draft EIS in September 1983.

This summary also presents the principal comments on the Draft EIS grouped by category, the Department's responses, and modifications made in response to these comments. Also, as required by the Council on Environmental Quality's (CEQ) regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA), the Final EIS discusses the Department's preferred alternative.

### Contents of the EIS

In accordance with the provisions of the National Environmental Policy Act and the Department of Energy's NEPA guidelines, the Final EIS contains a description of the proposed action, which is the restart of L-Reactor as soon as practicable, and the reason for this action. The Final EIS also contains descriptions of the following major elements:

- Alternative ways to produce defense nuclear materials
- The present environment that would be affected by the restart of L-Reactor
- The environmental consequences of L-Reactor operation
- Potential ways to reduce the environmental effects of restarting L-Reactor
- The environmental effects that would arise from the increased use of existing SRP facilities due to L-Reactor restart, and the cumulative environmental effects
- Environmental monitoring and studies
- Federal and state requirements for the restart of L-Reactor, and the status of compliance with these requirements

### Purpose of this EIS

The Department of Energy, as a Federal agency, is required by the National Environmental Policy Act of 1969, as amended, to assess the potential environmental impacts of its major actions. In August 1982 the Department, seeking to comply with NEPA requirements, published an Environmental Assessment on the restart of L-Reactor and a related Finding of No Significant Impact. Following publication of this finding, a number of groups and individuals expressed their concerns about the possible environmental effects of the L-Reactor restart.

Subsequently, in November 1982, a lawsuit was filed seeking to prevent the restart of L-Reactor until an environmental impact statement had been prepared.

On July 14, 1983, the President signed the Energy and Water Development Appropriations Act, 1984, which directed the Department of Energy to prepare an EIS on L-Reactor on an "expedited" basis. On July 15, 1983, the Federal District Court of Washington, D.C., acting on the November 1982 lawsuit, directed the Department of Energy to prepare an EIS on the proposed restart of L-Reactor. Accordingly, on July 19, 1983, the Department announced that it would prepare an EIS on the proposed restart of L-Reactor to comply with the provisions of NEPA and the Energy and Water Development Appropriations Act, 1984.

The purpose of this EIS is to assess the environmental consequences of the proposed restart of L-Reactor. This Final EIS sets forth and evaluates two major kinds of activities: The first are potential ways to produce defense nuclear materials as alternatives to the restart of L-Reactor; the second are mitigation measures that could avoid, reduce, or compensate for environmental effects occurring before or after the restart. Congressional approval might be necessary for certain alternatives to the restart and for some mitigation measures.

Based on this Final EIS, the Department will prepare a Record of Decision that will state the Department's decision on the proposed restart of L-Reactor. The Record of Decision will identify all the alternatives considered, including those considered environmentally preferable, and will review the factors that were weighed in balancing the need for the restart of L-Reactor against the potential environmental effects from its operation.

## Proposed Action

Under the Atomic Energy Act of 1954, the Department of Energy is responsible for developing and maintaining the capability to produce all defense nuclear materials required for the U.S. weapons programs. To this end, the Department operates nuclear reactor production complexes at its Hanford Reservation and Savannah River Plant. The Hanford Reservation currently operates a single reactor, the N-Reactor, for both nuclear materials and steam production; the Savannah River Plant operates three reactors--C-, K-, and P-Reactors--to produce defense nuclear materials only.

The proposed action in this EIS is to restart L-Reactor as soon as practicable. L-Reactor, which is located on the Savannah River Plant, previously operated from 1955 to 1968 to produce plutonium. It is a heavy-water (deuterium oxide) moderated, special-purpose production reactor. Its secondary cooling water is supplied from the Savannah River.

The Department's preferred alternative in this Final EIS is to restart L-Reactor after the construction of a 1000-acre once-through cooling lake. This preferred alternative is different from that presented in the Draft EIS, which was the restart of L-Reactor with direct discharge of secondary cooling water to Steel Creek followed by subsequent thermal mitigation. The impacts of the 1000-acre lake were fully bracketed by the discussions in the Draft EIS of the 1300- and 500-acre impoundments. The actual acreage has been changed but the identification and nature of the impacts is essentially the same. Direct discharge is referred to as the "reference case" alternative in this Final EIS. The change in the preferred alternative was made in response to public comments and a determination by the State of South Carolina that direct discharge would not be permittable under the current National Pollutant Discharge Elimination System (NPDES) permit regulations.

To ensure that the preferred cooling-water alternative is a viable option for the decisionmaker consistent with the restart of L-Reactor as soon as practicable, the Department prepared and filed dredge and fill (404) and NPDES permit applications with the U.S. Army Corps of Engineers and the South Carolina Department of Health and Environmental Control (SCDHEC), respectively, before the completion of this Final EIS.

Need for L-Reactor

To meet the additional requirements for plutonium contained in the Nuclear Weapons Stockpile Memorandum approved by President Carter on October 24, 1980, the Department of Energy proceeded to implement the most timely and cost-effective production initiatives. These initiatives provided a substantially greater amount of plutonium but not enough to fully meet the requirements. Accordingly, the Department proposed several additional initiatives for implementation, including the restart of L-Reactor at the Savannah River Plant.

The requirements for increased defense nuclear material and the production initiatives necessary to provide the additional production capacity have been reaffirmed in subsequent Stockpile Memoranda since 1980, including a Memorandum for fiscal years 1984 through 1989 that was approved by President Reagan on February 16, 1984. This Nuclear Weapons Stockpile Memorandum--which is the most recent--defines the annual requirements for defense nuclear materials for fiscal years 1984 through 1989, the planning directives for the next 5-year period, and 5 additional years of projections for long-range planning.

In approving the Stockpile Memorandum, President Reagan emphasized the importance of meeting annual requirements and maintaining an adequate supply of defense nuclear materials by directing that: "As a matter of policy, national security requirements shall be the limiting factor in the nuclear force structure. Arbitrary constraints on nuclear materials availability shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence. Accordingly, DOE shall . . . assure the capability to meet current and projected needs for nuclear materials and . . . restart the L-Reactor at the Savannah River Plant, Aiken, S.C., as soon as possible."

The specific need for L-Reactor is supported by a quantitative analysis of the production capabilities of DOE facilities and the requirements set forth in the Nuclear Weapons Stockpile Memorandum. This information is classified in accordance with the Atomic Energy Act of 1954. A classified appendix to this EIS (Appendix A), which contains the quantitative analysis of the need for L-Reactor, has been revised in accordance with the latest approved Nuclear Weapons Stockpile Memorandum. This analysis supports the need to restart L-Reactor as soon as practicable.

During the public review period on the Draft EIS, comments were submitted on the need for additional defense nuclear materials and the quantitative analysis supporting this need. Based on these comments, the Department has provided additional information in Chapter 1 to clarify the production capabilities of selected production initiatives. The Department has not, however, modified this Final EIS to include an analysis of the need for nuclear weapons, their use, and specific nuclear weapon systems, or to include a publicly available quantitative analysis of the need for defense nuclear materials. Information on defense nuclear material requirements, inventories, production capacity, and projected effects on weapon system deployments is classified. In addition, the national policy on nuclear weapons, their deployment, and the need for increased weapons is beyond the scope of this EIS.

Production Alternatives to the Restart of L-Reactor

In accordance with NEPA regulations, the Department of Energy has examined a range of production alternatives to the restart of L-Reactor as soon as practicable. The alternatives include those that have production capabilities similar to that of L-Reactor and those that have only partial-production capabilities compared with that of L-Reactor.

The alternatives that have production capabilities that are similar to that of L-Reactor include restarting R-Reactor at the Savannah River Plant; restarting one of the K-Reactors at the Hanford Reservation in Richland, Washington; and recovering plutonium from spent fuel produced by commercial power reactors.

R-Reactor began operation in late 1953 and was placed in standby status in mid-1964 due to a decline in the need for defense nuclear materials. Since R-Reactor was placed in standby status, its systems and components have not been maintained as well as those in L-Reactor and could not be started in less than 5 years. K-West (KW) and K-East (KE) Reactors at the Hanford Reservation began operation in 1955 and were shut down in 1970 and 1971, respectively, due to a decline in the need for defense nuclear materials. The K-Reactors have been retired and are being prepared for decontamination and decommissioning. The fuel fabrication plant has been dismantled and some essential equipment has been removed. More than 5 years would be required to restore either K-Reactor for the production of plutonium.

Theoretically, weapon materials could be produced directly in existing commercial light-water reactors, or weapons-grade plutonium could be separated isotopically from high-assay plutonium in existing spent fuel from light-water reactors. However, the conversion of spent commercial reactor fuel into weapons-grade plutonium is currently prohibited by law [Atomic Energy Act of 1954, as amended, 42 USC section 2007(e)].

The alternatives that have partial-production capabilities compared to that of L-Reactor are as follows: increasing the power of the N-Reactor at the Hanford Reservation or increasing the power of operating reactors at the Savannah River Plant; reducing the plutonium-240 content of reactor-produced plutonium to allow a more rapid conversion of fuel-grade plutonium into weapons-grade material through blending; and adopting (sooner than had been scheduled) a new design for plutonium-producing fuel assemblies--known technically as the Mark-15 fuel lattice--in the SRP reactors. A quantitative analysis has shown that none of these options, or combinations of options, would provide the required amount of defense nuclear materials.

The Department has also examined a delayed L-Reactor restart in combination with the implementation of two partial-production options--the accelerated use of the Mark-15 lattice in the SRP reactors and the reduction of the plutonium-240 content of plutonium produced in N-Reactor. The Department's analysis concluded that implementing these partial-production options would require additional time and Congressional action to appropriate funds for the use of the Mark-15 lattice, which also would require more time. Furthermore, this combination of alternatives would not provide the amount of required defense nuclear materials.

As required by NEPA, the Department also considered taking no action and maintaining the L-Reactor in a ready-for-operation mode. However, no action would not meet the requirements for defense nuclear materials.

The only available production alternative that satisfies the requirements for defense nuclear materials is the restart of L-Reactor as soon as practicable.

Individuals who commented on the Draft EIS suggested accelerating several partial- and full-production initiatives, including the development of a new production reactor, the recovery of material from retired and obsolete warheads, and an accounting of any surplus production material. None of these accelerated initiatives could provide the required material in sufficient time. The recovery of material from retired and obsolete warheads as well as from production material surpluses was taken into account in the need for material contained in the Nuclear Weapons Stockpile Memoranda. After careful review of the comments, the Department did not make any major changes to the discussion of production alternatives in this Final EIS.

## Environmental Effects of the Restart of L-Reactor

This Final EIS first discusses the environmental effects of the restart of L-Reactor without the implementation of any mitigation measures (i.e., the reference case). Reasonable mitigation measures that could reduce environmental impacts are then discussed, followed by the environmental consequences of the Department's preferred alternative and those of no action.

The following sections summarize the environmental impacts of the Department's preferred alternative, including the impacts of normal operation, incremental impacts, cumulative impacts, and potential impacts from postulated accidents.

Normal operation. The Department of Energy's preferred alternative is to restart L-Reactor as soon as practicable, together with the following actions:

- Construct a 1000-acre lake before resuming L-Reactor operation, redesign the reactor outfall that carries the thermal discharge from the reactor to the lake, and operate L-Reactor in such a way that a temperature of 90°F (32.2°C) or less is maintained in about half the lake, thereby ensuring a balanced biological community. After L-Reactor is operating, the Department will conduct studies to confirm the effectiveness of the cooling lake and to decide on the need for precooling devices to allow greater operational flexibility.

- Use the L-Area seepage basin for the periodic disposal of disassembly-basin purge water, while continuing to study and evaluate moderator detritiation.

- Use batch discharge for the periodic disposal of sludge from the L-Reactor cooling-water reservoir.

- Use the existing L-Reactor confinement system.

The principal environmental effects of the preferred alternative would be the results of the construction and use of the 1000-acre lake to reduce L-Reactor thermal effects, the withdrawal of cooling water from the Savannah River, and the release of radionuclides.

Cooling lake--The 1000-acre lake would be constructed by placing an embankment across Steek Creek upstream from the Seaboard Coast Line Railroad bridge. The lake would be about 3900 feet (1200 meters) at its maximum width--with an average width of approximately 2000 feet (600 meters)--and would extend about 4 and a half miles (7 kilometers) upstream from the embankment. While the embankment was being built, the creek would flow past the work area through a temporary metal conduit. The construction of the lake would also require the relocation of electric transmission and cable rights-of-way.

Under an expedited schedule, the 1000-acre lake could be complete in 6 months at a capital cost of approximately $25 million. This major acceleration of the schedule has been made possible because of the Corps of Engineers workforce recently utilized for the construction of the Richard B. Russell Dam on Savannah River is now becoming available and because no long-lead-time equipment items are required for this alternative. Approximately 550 construction personnel, including civil engineers for design and supervision, would be required to construct the lake.

The lake would inundate 225 acres of wetlands and 775 acres of uplands in the Steel Creek corridor. An additional 100 acres of uplands would be lost due to the relocation of electric and cable rights-of-way. A total of between 735 to 1015 acres of wetlands in the Steel Creek corridor, delta, and Savannah River swamp would be impacted.

One historic mill-and-dam site that is eligible for inclusion in the National Register of Historic Places would also be inundated. A resource recovery plan for this site has been developed by the University of South Carolina Institute of Archeology and Anthropology and has been approved by the State Historic Preservation Officer and the Advisory Council on Historic Preservation. Additional historic and archeological sites might be located in the lake area. A survey is underway to identify potentially significant sites. Contingent on the survey's results, needed measures would be taken before the lake is filled.

Construction of the earthen embankment and diversion system would cause some temporary increases in suspended solids in Steel Creek. Fugitive dust and particulate emissions from construction and clearing activities would occur. These emissions, though, would be confined to relatively small areas and would be generally short-lived. Runoff and sediment from construction areas would be controlled by the use of sediment basins and other control measures such as berms, dikes, drains, and mulch.

When the construction of the lake has been completed and the lake filled, L-Reactor thermal discharges would enter through a modified discharge structure that would enhance cooling efficiency. Cooling-water discharges would be managed by altering reactor power levels to maintain a balanced biological community in the lake [i.e., about 50 percent of the lake would not exceed 90°F (32.2°C)]. The balanced biological community probably would not be established until 3 to 5 years after the lake had been filled. The projected water temperatures in the summer (5-day worst case) at the Steel Creek delta and mouth would be within 2°F (1°C) above the ambient temperature. During the winter, projected temperatures at Road A and points downstream from the embankment would be from 13° to 16°F (7°C to 9°C) above the ambient temperature. The lake concept and the management of L-Reactor discharges are expected to meet State water-quality standards.

The Department of Energy anticipates that the lake would contain a balanced biological community similar to that of Par Pond on the Savannah River Plant. Fish species from the Savannah River could enter the lake as eggs, larvae, or fry when L-Reactor is not operating. The exact balance of species that will develop cannot be predicted accurately; however, experience at Par Pond indicates that a community dominated by bass and bluegill would probably develop.

Endangered species--The flows of water from the lake during periods of L-Reactor operation would affect foraging habitat for the endangered wood stork and habitat for the American alligator.

The wood stork (Mycteria americana) was listed as an endangered species on February 28, 1984--five months after the Draft EIS for L-Reactor was completed. Studies on the wood stork were initiated in April 1983. The design of the study program together with its preliminary results were reviewed with the U.S. Fish and Wildlife Service (FWS) during an informal consultation process. Data from the wood stork program is contained in this Final EIS. A Biological Assessment of the wood stork was submitted to the FWS at the end of March 1984. The FWS is reviewing this assessment before it issues its Biological Opinion, which could include mitigation measures. The Department anticipates that after its review, the FWS will concur in the Department's conclusion that while the operation of L-Reactor could affect portions of the wood stork's SRP foraging habitat, the operation of L-Reactor and of other ongoing and planned operations would not affect the continued existence of this species.

On February 25, 1983, the FWS issued a Biological Opinion on the American alligator (Alligator mississippiensis), which concluded that the operation of L-Reactor as then proposed--direct discharge of cooling water--would not jeopardize the continued existence of this species. Since the Biological Opinion was issued, the Department has identified the 1000-acre lake as its preferred cooling-water system. An updated biological assessment that includes the 1000-acre lake was submitted to the FWS at the end of March 1984. The FWS is reviewing this updated assessment before it issues a Biological Opinion, which could include needed mitigation measures. The Department anticipates that, after its review, the FWS will concur with the Department's finding that L-Reactor operation would not have an adverse effect on the continued existence of this species.

The Department is cooperating with the Fish and Wildlife Service to develop a Habitat Evaluation Procedure (HEP) for the Steel Creek system and the 1000-acre lake. The HEP will identify the value of habitat to be gained or lost with the implementation of the preferred cooling-water alternative for use in assessing further mitigation. The Department will implement additional mitigative measures that might be identified through the HEP process; if required, it will request Congressional funding authorization and appropriation.

Cooling-water withdrawal--During L-Reactor operation, water for secondary cooling would be withdrawn from the Savannah River at a rate of about 400 cubic feet (11 cubic meters) per second. This withdrawal--amounting to less than 4 percent of the average flow and 7 percent of the 7-day, 10-year low flow of the river--would cause entrainment and impingement of fish, fish eggs, and larvae in the area of the water intake canal. Studies in 1982 and 1983 show that an estimated 3 to 6 percent of the fish eggs and larvae that pass the intake canal would be lost annually. An estimated average of 16 fish per day would be lost due to impingement during normal river flow.

Radioactive releases--The discharge of L-Reactor cooling water would transport a portion of the cesium-137 and cobalt-60 that remains in the Steel Creek channel and floodplain. The quantities of cesium-137 and cobalt-60 that would be transported from Steel Creek to the Savannah River and to the offsite Creek Plantation Swamp were estimated by monitoring their movement in Steel Creek at flows as high as 220 cubic feet (6 cubic meters) per second during cold flow testing of L-Reactor.

Because the factors that could influence such transport in the combined lake-stream system are difficult to quantify precisely, it is conservatively estimated to be no greater than that from direct discharge (i.e., 4.4 curies of cesium-137 and 0.25 curie of cobalt-60 during the first year).

In addition to the radiocesium and radiocobalt transported to the Savannah River and the adjacent swamp, other liquid and atmospheric releases of radioactivity would occur during normal operation of L-Reactor. The principal sources of these releases are the disassembly basin for irradiated fuel and target assemblies in the reactor building and the periodic purge of water from this basin to the L-Area seepage basin. Radioactivity would be released as a result of the evaporation of water containing tritium in the seepage basin, and as a result of the movement of radionuclides from the seepage basin through shallow ground water to the 1000-acre lake. This movement through the shallow ground water would allow partial decay of the radioactivity. The discharge to the seepage basin would be expected to affect only shallow ground water in the vicinity of L-Reactor; deeper ground-water formations such as the Tuscaloosa and Congaree would not be affected by radioactivity because of the geologic and hydrologic characteristics of the L-Reactor area.

Other sources of radioactivity include atmospheric effluents generated during reactor operation and releases of small process-water leaks into the cooling-water discharge.

The conservatively estimated radiological dose to the maximally exposed person living near the Savannah River Plant from all L-Reactor sources during the first year of normal operation would be 3.6 millirem, or 1/26 of that received from natural radiation sources during the same year. The average dose to the population within 50 miles (80 kilometers) of the Plant and to the Beaufort-Jasper and Port Wentworth water-consuming populations during that year would be 27.6 person-rem, or 1/3900 of the dose from natural background radiation.

Comments--Many of the comments on the Draft EIS were related to the direct discharge of cooling water, the environmental effects of such discharge, and the potential impact on ground water from the periodic discharge of disassembly-basin water to the L-Area seepage basin.

Comments on the discharge of cooling water dealt principally with how the direct discharge of cooling water related to the water-quality standards of the State of South Carolina. In the Draft EIS, direct discharge was examined in relation to conditions contained in the National Pollutant Discharge Elimination System (NPDES) draft permit issued by the State in August 1982. Several comments noted that subsequent drafts of the permit contained a different compliance point--from in the Savannah River to the discharge point at Steel Creek. Therefore, the direct discharge of cooling water could not comply with the State's standards.

As a result of these comments and continuing discussions with the State of South Carolina on an NPDES permit for L-Reactor, the Department has modified Section 4.1 of this Final EIS by dropping the analysis of direct discharge as it related to the NPDES draft permit issued in August 1982. In addition, Section 4.4.2, which describes cooling-water mitigation measures, includes more measures than those described in the Draft EIS and provides temperature data for assessing compliance with water-quality standards. Also, the Department has changed its preferred cooling-water alternative from direct discharge and subsequent mitigation to construction of a 1000-acre lake prior to L-Reactor restart. Several new sections have been added to discuss this preferred alternative specifically.

Some comments also questioned the analysis of potential ground-water impacts from the periodic discharge of radioactively contaminated disassembly-basin purge water to the L-Area seepage basin. Specifically, these comments questioned the basis for predicting a horizontal movement of radionuclides through shallow ground water rather than vertical movement into deeper, more important ground-water formations, and the effect on future ground-water use of the movement of radionuclides. To clarify the bases for its predictions of horizontal movement and the effect of additional ground-water use, the Department has included additional information in Chapters 3 and 4 and Appendix F.

In response to other comments, the Department has incorporated additional information in the Final EIS on continuing studies of the wood stork and on entrainment and impingement.

Incremental impacts. The restart of L-Reactor would result in incremental increases in the level of effluents and emissions and handling of materials at a number of facilities currently operating at the Savannah River Plant. These facilities include a fuel and target fabrication area (M-Area), two chemical separations areas for irradiated materials (F- and H-Area), and facilities that generate steam and handle and store high- and low-level radioactive waste.

The main environmental effects from incremental increases at these operating facilities would result from greater discharges to the seepage basins in the M-, F-, and H-Areas, and incremental increases in both ground-water withdrawal and radioactive releases.

Discharges to seepage basins--The M-Area seepage basin was placed in service in 1958 to settle out and contain uranium discharges from fuel and target production operations. Currently, very little wastewater seeps from the basin; instead, most of the water overflows the basin and seeps into the ground at Lost Lake. In the past, waste effluents included large volumes of volatile organic compounds used as metal degreasing agents. Substantial quantities of these solvents entered shallow ground water from several sources: effluent sewer leaks, the seepage basin, overflow to Lost Lake, and miscellaneous spills. In early 1982, the State of South Carolina and EPA were promptly notified that concentrations of two organic degreasers--no longer used at SRP--were detected in the Tuscaloosa Formation. On the basis of well surveys and monitoring, the contamination of the Tuscaloosa Formation is believed to have resulted from the movement of organic degreasers from shallow ground water down the annuli of wells that had defective cement grout between the sediment and the well casings.

The discharge of volatile organic compounds in process wastewaters from the M-Area operations has been reduced substantially due to recent changes in operating practices. The use of one sewer line to the M-Area seepage basin has been discontinued and another line has been repaired.

High concentrations of the organic compounds in the shallow ground water in the M-Area are being removed by both a pilot and a prototype air stripper. State and Federal agencies have reviewed the ground-water remedial action plan for the removal of the organic compounds using recovery wells and a large air stripper; this plan will be implemented in August 1984. The use of the M-Area seepage basin is scheduled to be discontinued by April 1985, when a new wastewater-treatment plant will begin processing the effluent.

Fuel and targets for loading into the L-Reactor already have been produced in the M-Area. The incremental increase in the discharge to the M-Area seepage basin due to L-Reactor represents approximately a 33-percent increase. However, by the end of 1984, the effluent volume attributable to L-Reactor incremental increases will be reduced by 80 percent. Contaminants discharged to the M-Area seepage basin due to L-Reactor and previous SRP operations prior to April 1985 are expected to be intercepted by the wells to be installed as part of the remedial action program. After April 1985, any incremental releases attributable to L-Reactor will be treated by a new wastewater treatment facility.

Since 1954 and 1955, the Savannah River Plant has discharged large volumes of nonradioactive chemicals and low levels of radioactivity to the seepage basins in the F- and H-Areas. The present discharges to the F- and H-Area seepage basins are not characterized as "hazardous" except for frequent periods of low pH and infrequent discharges of mercury and chromium. The chromium discharges result primarily from the processing of offsite fuels. Discharges to the F- and H-Area seepage basins have not resulted in contamination of the Congaree ground water or of ground water in deeper formations such as the Tuscaloosa. The green clay--a thick layer at the base of the McBean Formation--and the clays in the upper Ellenton Formation and at the base of the Congaree Formation have been effective barriers in preventing the vertical movement of contaminants in the F- and H-Areas.

Because of changes in operating practices--principally recycling--discharges to the F- and M-Area seepage basins have been reduced since 1982 by 45 percent and 7 percent, respectively.

The Department of Energy plans to request fiscal year 1986 Congressional funding for an effluent treatment facility to process the wastewater discharged to the F- and H-Area seepage basins.

Ground-water withdrawal--The L-Reactor restart would result in the withdrawal of additional ground water for operating facilities. The additional withdrawal is projected to be about 210 cubic feet (5.9 cubic meters) per minute, which would be a 7-percent increase over the withdrawal rate at SRP in 1982. This withdrawal is expected to have little impact on offsite water levels; however, increased withdrawals could cause the head differential between the Tuscaloosa and Congaree in the H-Area to become downward, and the head differential in the M-Area to become increasingly downward. These changes to the head differential are not expected to result in any contamination of aquifers such as the Tuscaloosa because of the presence of the green clay in the central portion of the Plant and the establishment of the remedial action program for the M-Area.

Ground-water protection--The Department of Energy is currently committed to several items related to ground-water monitoring and mitigation at the Savannah River Plant, including:

- Continuing and expanding the program of ground-water monitoring and studies
- Involving the State of South Carolina in onsite ground-water monitoring activities
- Taking mitigative actions to reduce pollutants released to the ground water and establishing a mutually agreed-on compliance schedule for mitigation efforts

A number of comments concern the contamination of ground water at SRP, especially from such practices as the use of seepage basins. The Department has drafted an "SRP Groundwater Protection Implementation Plan," which examines strategies and schedules for initiating mitigative actions for the cleanup of past operations that threaten to or contaminate SRP ground water, including the closing and decommissioning of seepage basins. The plan has been reviewed by State agencies and the Environmental Protection Agency. The mitigation actions ultimately adopted will be the subject of a separate NEPA review.

Radioactive releases--The resumption of L-reactor operation would also result in incremental radioactive releases from the Central Shops area, the fuel and target fabrication area, and the separations area. These incremental releases would result in a composite maximum individual dose of 0.087 millirem in the first year and 0.072 millirem during the tenth year, or less than 0.1 percent of the average dose of 93 millirem received by an individual living near the SRP site from natural sources of radiation. The maximum population dose from incremental releases is estimated to be 8.1 person-rem in the tenth year of L-Reactor operation, or about 0.007 percent of the dose to the population living within 50 miles (80 kilometers) of the Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations from natural radiation sources.

This Final EIS also discusses the potential impacts associated with incremental increases in the handling and storage of high- and low-level radioactive waste.

Comments--Comments on the Draft EIS regarding incremental impacts from the restart of L-Reactor were concerned primarily with the potential ground-water impacts from continued seepage basin use. Comments ranged from general statements that the restart of L-Reactor would increase ground-water contamination by 33 percent to several specific comments on ground-water data, analysis methodologies, and assumptions about geology and hydrology.

Comments from state and Federal agencies indicated concern about jurisdictional responsibilities under the Resource Conservation and Recovery Act, and the relationship of proposed cleanup programs to incremental increases in releases due to the restart of L-Reactor. Almost all the comments received reflected a general concern that the restart of L-Reactor should not increase any existing levels of ground-water contamination.

The Department has made several modifications in this Final EIS in response to the comments received. These include the addition of well data and recent monitoring results, additional analyses on the amount of incremental releases to seepage basins, the effects of additional ground-water withdrawal, and additional information on the present status of remedial action and ground-water protection programs.

Cumulative impacts. The cumulative impacts considered in the EIS include the effects of L-Reactor and support facility operations together with those of other SRP and major nearby facilities. Major SRP facilities include the planned Fuels Material Facility and Defense Waste Processing Facility. Other facilities near the SRP include the Vogtle Nuclear Power Plant, the Urquhart Steam Station, the Chem-Nuclear, Inc., plant, and the Barnwell Nuclear Fuel Plant.

The primary areas of cumulative environmental impact discussed in this Final EIS include socioeconomic impacts and the impacts from ground-water usage, cooling-water withdrawal and discharge, and radioactive releases.

Socioeconomics--Construction of the Fuel Materials Facilities, the Defense Waste Processing Facility, and other Savannah River Plant projects are expected to increase the labor force by 2800 persons by the end of September 1984. In addition, the restart of the L-Reactor would temporarily add about 550 personnel to construct the 1000-acre lake. The cumulative work force that might relocate to the area would total about 800 personnel. This work force, some of which has already relocated, is not expected to cause major impacts in the six-county area surrounding SRP.

Ground-water use--Cumulative ground-water consumption at the Savannah River Plant is expected to increase slightly--30 cubic feet (0.75 cubic meter) per minute--because of the operation of the Fuel Materials Facility and the Defense Waste Processing Facility. The added withdrawals will reduce the upward head differential between the Tuscaloosa and Congaree Formations in the central portion of the Savannah River Plant, and the head differential will become increasingly downward beneath the H- and M-Areas. These changes in the head differential will not affect the quality of ground water in the Tuscaloosa Aquifer because of clay barriers at the F- and H-Areas and the remedial action program at the M-Area. The cumulative SRP ground-water withdrawal impacts on offsite water levels are expected to be small.

Cooling-water discharge and withdrawal--In addition to the proposed restart of L-Reactor, other sources of thermal discharge include the currently operating reactors at the Savannah River Plant, the Vogtle Nuclear Power Plant, which will use natural-draft cooling towers, and the Urquhart Steam Station. Cumulative thermal discharges to Steel Creek from the proposed 1000-acre lake and K-Reactor are expected to be less than 7°F (4°C) above the water temperature of the Savannah River during spring and summer at the mouth of Steel Creek. No thermal blockage is expected in the Savannah River as a result of SRP and Vogtle Power Plant thermal discharges. The total cumulative withdrawal from the Savannah River for cooling water is expected to result in the entrainment of about 19 percent of the fish eggs and larvae passing the Plant intakes and the impingement of about 53 fish per day. During periods of high water, cumulative impingement could reach 104 fish per day.

Radioactive releases--The cumulative SRP radiological effects analyzed in this Final EIS include the sum of the doses from L-Reactor, its increment of the support facilities, current operation with three reactors, and the planned Fuel Materials Facility and Defense Waste Processing Facility--which are expected to become operational in the late 1980s. The radiological dose due to the Vogtle Nuclear Power Plant was included, but the dose from the Barnwell Nuclear Fuel Plant was not included because this plant is not expected to operate. The cumulative composite maximum individual dose of 3.6 millirem is 27 times less than the average dose of 93 millirem received by an individual living near the site from natural radiation. The cumulative composite population dose of 163 person-rem is about 0.15 percent of the exposure of about 109,000 person-rem from natural radiation sources to the population living within 50 miles (80 kilometers) of the Savannah River Plant and the Beaufort-Jasper and Port Wentworth drinking-water populations.

Comments--Comments on the Draft EIS cumulative impact discussion included requests that the Department (1) evaluate the cumulative effects of "nuclear development" in the Savannah River Basin, and (2) consider further the cumulative impacts to water resources. In the EIS, the Department has evaluated the potential radiological effects resulting from cumulative Savannah River Plant releases--existing and planned--as well as those from other nuclear facilities in the vicinity of the Plant. The Department has also included additional information on cumulative ground-water withdrawals and on the current status of studies concerning maintenance of Savannah River flow rates below the Clarks Hill dam.

Postulated accidents. The EIS considers a number of postulated reactor accidents that could result in the release of radioactive materials into the environment. These include credible accidents and severe hypothetical accidents that are not considered credible or probable.

The credible accidents include a major moderator spill, the melting of a single assembly during a discharge mishap, the melting of 3 percent of the core caused by a reloading error, and the melting of 1 percent of the core due to a loss-of-coolant accident. The 3-percent core melt has the highest potential consequences of the credible accidents. The estimated maximum individual whole-body radiation dose received by a person residing at the SRP boundary from this postulated accident is calculated to be 0.39 rem, with a maximum thyroid dose of 1.5 rem. Both of these doses are well below the Nuclear Regulatory Commission's site evaluation dose guidelines of 25 rem and 300 rem for the whole body and thyroid, respectively.

The EIS also discusses an accident beyond those considered credible--a postulated 10-percent core melt--to provide a perspective on the consequences of an accident having an extremely low probability but a potentially great severity. The probability for this accident is estimated to be between 1 in 1 million and 1 in 100 million per reactor-year. The consequences calculated indicate no cases of early fatalities, no cases where the maximum individual whole-body dose would exceed 1.7 rem, and no cases where the thyroid dose would exceed 11.7 rem. Again, the estimated doses from this beyond-credible accident would be well below the Nuclear Regulatory Commission's site evaluation dose guidelines established for commercial power reactors.

To provide a further perspective on the overall accident risk (defined as consequence times probability) of L-Reactor operation, this Final EIS contains a preliminary total risk curve that depicts the annual probability of an individual living at the SRP boundary receiving more than a certain dose from postulated severe accidents. The results shown in this curve were based on the Safety Analysis Report, and include a range of accidents up to low-probability, high-consequence accidents, including hypothetical 100-percent core-melt scenarios at the upper bound of the consequence spectrum.

In addition to postulated reactor accidents, the Final EIS also discusses non-nuclear hazards and such natural phenomena as earthquakes and tornadoes, the evolution of reactor safety at the Savannah River Plant and current programs to improve safety, and emergency planning.

The aspect of the accident analyses that received the most comments concerned the need for a containment building for L-Reactor, the comparability of L-Reactor to the Nuclear Regulatory Commission requirements for commercial nuclear reactor site criteria (10 CFR 100), and the presentation of a "worst-case" analysis.

For the most part, the comments on the need for a containment building were general, often only citing that commercial reactors are required to have them and that L-Reactor is not. The need for pressure containment buildings for commercial light-water reactors is based on their design and site characteristics and on the need for specific engineered safety features. Reactors of different designs and engineered safety features other than a containment building can also limit radioactive releases and be within acceptable standards for a range of postulated accidents. The Fort St. Vrain reactor, which has been licensed by the Nuclear Regulatory Commission, is an example of a commercial reactor without a containment building; its design and engineered safety features are different from those in commercial light-water reactors.

The L-Reactor has several important design features and alternative engineered safety features that must be considered in any comparison with commercial light-water reactors. For example, L-Reactor operates at much lower pressures and temperatures than commercial light-water reactors; thus, the stored energy in a postulated loss-of-coolant accident--which is of primary concern in the need for a containment building--is much less. Other important differences exist for operational limits, emergency shutdown systems, the confinement system, the type of fuel, and the distance to the nearest site boundary. These differences, considered in the analysis of credible accident events and resultant consequences, indicate that L-Reactor with its confinement system would meet the Nuclear Regulatory Commission's radiation protection site evaluation factors for a commercial reactor.

Other comments received on the need for a containment building concerned the comparability of the accident analyses for L-Reactor to the Nuclear Regulatory Commission's requirements for reactor site criteria (10 CFR 100). Specifically, commentors contended that a postulated 100-percent core-melt accident was the proper basis for assessing the safety comparability of L-Reactor to commercial reactors. They also contended that if the 100-percent core-melt accident were used as the basis, L-Reactor would not meet the Nuclear Regulatory Commission's site evaluation factors.

The requirements of 10 CFR 100 do not assume or require the assumption of a full-core (100-percent) meltdown as a basis for assessing consequences, as contended. These requirements clearly indicate analyses of ". . . accidental events, that would result in potential hazards not exceeded by those from any accident considered credible." Again, the design differences between reactors and different engineered safety features must be considered in determining "accidents considered credible." In recognition of the high-heat capacity of the Fort St. Vrain graphite-moderated reactor, for example, no fuel melting was assumed in specifying the source term for determining compliance with 10 CFR 100. Similarly, the most severe credible L-Reactor accident is a postulated criticality accident that results in a 3-percent core melt. The postulated criticality accident, rather than the loss-of-coolant accident used for commercial light-water reactors, reemphasizes the differences in the design and engineered safety systems between L-Reactor and commercial light-water reactors.

Finally, commentors contended that the Draft EIS failed to present a worst-case analysis. Specifically, they asserted that the EIS should have presented the consequences of a 100-percent core-melt accident with a concurrent failure of the active confinement system, rather than those of a 10-percent postulated core-melt accident.

The Department of Energy recognizes uncertainties inherent in its predictions of the probabilities and consequences of extremely low-probability but high-consequence accidents. The worst-case analysis required by NEPA is intended to provide the decisionmaker with information that balances the need for the action against the risk and severity of possible adverse impacts if the action proceeded in the face of uncertainty. The "uncertainty" in this instance, however, is not one that questions the severity of the consequences if this class of accident were to occur, but rather the degree of improbability of its occurrence (i.e., whether once in 10 million years or once in a billion or more years). The detailed analyses of the very-low-probability, 10-percent, core-melt accident, together with available information on the consequences and probabilities of a spectrum of more severe but even less probable accidents included in the EIS are judged to provide the decisionmaker with sufficient information for this purpose.

Summary of Environmental Effects

Table S-1 summarizes and compares the environmental consequences of the Department's preferred alternative and the no-action alternative.

Monitoring and Studies

In addition to its extensive environmental studies on L-Reactor, the Department of Energy has begun several long-range studies to determine the Savannah River Plant's overall effect on the health and environment of people who live in nearby areas. These studies are intended to identify any further improvements that can be made to SRP operations.

The Department is committed to making whatever modifications might be necessary to ensure that SRP operations do not pose an undue risk to the local environment or to public health. Representatives of Federal and state agencies are active participants in these studies. The studies initiated by the Department of Energy relate to four basic areas, which are summarized below.

Cooling water. The Department initiated a 2-year study in July 1983 to further assess the effects of SRP thermal discharges on the Savannah River ecosystem, including all major streams that flow to the river and adjacent wetlands. The study is an expansion of ongoing studies concerning the three operating reactors, steam plant operations, and the proposed operation of L-Reactor.

Participating in the study are the States of South Carolina and Georgia, the U.S. Environmental Protection Agency (Region IV), the U.S. Fish and Wildlife Service (Region IV), and the U.S. Army Corps of Engineers (South Atlantic Division).

This study is examining the environmental effects associated with cooling-water withdrawal and thermal discharges. It is assessing wetland impacts, impacts to fish populations, utilization of the SRP wetlands and streams by aquatic and semiaquatic species, including endangered species, water-quality parameters, and radionuclide and heavy-metal transport. The study is assessing spawning areas at intervals along the river and near the mouth of tributaries from Augusta downstream to the area of salt-water intrusion.

Thermal mitigation. The Department will consider alternatives to the direct discharge of cooling water for all major SRP thermal discharges from operating facilities. Among the alternative systems being evaluated are cooling towers, cooling ponds, and spray cooling systems.

Ground water. Continued efforts are being made to safeguard ground-water systems by removing contaminants from the water-table aquifer in the Fuel and Target Fabrication Area. In addition, the Department is committed to stopping all further use of the seepage basin at the fuel fabrication facility by April 1985. The "SRP Groundwater Protection Implementation Plan" will be the subject of a separate NEPA review.

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Land use and socioeconomics | 1000 acres would be required for the construction of the cooling lake and about 130 acres of land for relocating roads and right-of-ways; operating workforce of about 350 required as well as 550 temporary construction workers for lake construction. | No additional land would be required; standby workforce of about 100 will be required; approximately 330 operating jobs would be lost. |
| Archeological sites | Five sites eligible for inclusion in the National Register might be affected; a approved resource recovery plan has been developed for one historic site located within the proposed lake area; archeologic studies in the lake area are continuing and mitigative measures will be taken if significant sites are found. | Some erosional impacts are anticipated from cold flow testing to the eligible sites. |
| Cooling-water withdrawal | L-Reactor will withdraw about 400 cubic feet (11 cubic meters) per second, or about 4% of the average annual flow rate and 7% of the 7-day, 10-year low flow of the Savannah River; withdrawal will cause impingement of an additional 16 fish per day, and entrainment of about 3 to 6% of all fish eggs and larvae passing the SRP intakes when L-Reactor is operating under average conditions. | Testing and flushing of secondary cooling-water system approximately several days per month at flows up to 6.2 cubic meters per second; impingement and entrainment impacts during these test periods will be about one-half the impacts for the preferred alternative. |
| Cooling-water discharge | L-Reactor will discharge about 400 cubic feet (11 cubic meters) per second of cooling water to the 1000-acre lake; reactor power will be adjusted to assure a balanced biological community in the lake; projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 2°F (1°C) of ambient; average values of water temperatures at the mouth of Steel Creek are projected to be 82°F, 72°F, and 55°F (28°C, 22°C, and 13°C) during summer, spring, and winter, respectively; the 5-day, worst-case value during summer is projected to be 86°F (30°C) or within about 2°F (1°C) of ambient. | No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation. |

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Wetlands/ habitats | 1000-acre lake would affect between 735 and 1015 acres of wetlands/habitats in the Steel Creek corridor, delta, and Savannah River swamp, and about 875 acres of upland; cooling lake would provide a balanced biological community in the lake; delta growth would resume at about 1-2 acres per year; DOE is working with the Department of Interior on use of the Habitat Evaluation Procedure to identify further mitigation. | Minor impacts during periods of testing. |
| Aquatic impacts | Minor impacts downstream of the embankment to the delta due to flooding and siltation; spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta would not be affected except in winter when the water temperatures would be 12°F to 16°F (7° to 9°C) above ambient; cold shock effects would be minimal due to gradual heat loss after shutdown; the lake embankment would prevent access by riverine and anadromous fish to about 100 acres of Steel Creek wetlands above L-Reactor, however, the only migratory fish in this reach of Steel Creek is the American eel which can access the lake; access to Meyers Branch would not be affected by the lake. | No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation. |
| Endangered species | Increased flow from the cooling lake would affect foraging habitat for the wood stork, and the habitat for the American alligator; additional habitat for alligator would be created by the lake; consultation with FWS continuing for both species; no impacts to shortnose sturgeon. | Habitat for wood stork and American alligator could be affected intermittently during cold flow testing. No impacts to the shortnose sturgeon. |
| Water quality | Liquid effluents discharged would have chemical characteristics similar to those in the Savannah River. | No impacts. Periodic cold-water testing discharges would have chemical characteristics similar to those in the Savannah River. |

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Ground-water quality | | |
| L-Area | Disassembly-basin purge water containing principally tritium will be discharged to the L-Reactor seepage basin; shallow ground water will become contaminated by discharges that will eventually discharge to the cooling lake in about 20 years; the use of the seepage basin will allow radioactive decay; deeper groundwater sources will be protected by clay barriers; DOE will continue to study the feasibility of moderator detritiation. | No discharges to the L-Area seepage basin. |
| M-Area | Incremental discharges increased by 33 percent; by the end of 1984, incremental discharges will be reduced by 80 percent; contaminants will be intercepted by remedial action program; a new treatment facility will replace seepage basin use by April 1985. | Same as for preferred alternative except effluents from ongoing operations will continue without incremental increase due to L-Reactor. |
| F- and H-Areas | Incremental discharge to seepage basins would result in a 7 percent increase in concentration of contaminants in shallow groundwater; deeper formations would be protected by confining clay units; treatment facilities to replace seepage basins use when Congressional approval obtained. | Same as for preferred alternative except effluents from ongoing operations will continue without incremental increase due to L-Reactor. |
| Ground-water use | A total of 210 cubic feet (5.9 cubic meters) per minute will be withdrawn from the Tuscaloosa aquifer for L-Reactor and its support facilities; total ground-water withdrawal by SRP is projected to be 7% greater than in 1982. | Ground-water withdrawal of 33 cubic feet (0.94 cubic meter) per minute is required. |
| Air quality | Operational emission from K-Area would increase by 10 percent consisting primarily of $NO_x$, $SO_x$, and particulate matter; some fugitive dust emissions would occur during construction of lake; no detectable impact on local or regional air quality is expected. | No change from present operations; no detectable impact on air quality would be expected. |

Table S-1. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| *Impact* | *Preferred Alternative*[a] | *No Action*[b] |
|---|---|---|
| Solid waste | All unsalvageable domestic trash would be packaged and disposed of in SRP landfill; sanitary waste sludge would be disposed of at the SRP sludge pit; bottom ash sluiced to the K-Area ash basin would increase by 10%. | No change from present operations. |
| Radiological releases and effects | | |
| Radiocesium | About 4.4. curies of radiocesium would be transported during the first year and about 20-25 percent less each year; radiocesium releases would not exceed any applicable standards or affect public health and safety. | Small amounts would be resuspended during periodic testing and flushing. |
| Radiation dose | Maximum individual dose of 3.6 millirem in the first year, or about 26 times less than the average received by an individual living near SRP from natural radiation; total-body dose to both the 50-mile (80-kilometer) and downstream river-water-consuming populations of 36 person-rem (tenth year), or less than 0.032 percent of the dose from natural background radiation. | No radioactive releases from L-Reactor or incremental releases from support facilities. |
| Health effects | Estimated health effects in the first year about 0.003 premature cancer death and 0.006 genetic disorder; releases during the tenth year would eventually cause about 0.006 premature cancer death and 0.01 genetic disorder. | No radioactive releases from L-Reactor or incremental releases from support facilities. |
| Accidents | Accidents are highly unlikely; safety systems at SRP have been improved to further reduce the chance of an accident; small additional risks. | L-Reactor would not operate nor would there be incremental use of support facilities. |

[a]The preferred alternative is to restart L-Reactor as soon as practicable after construction of a 1000-acre lake. Impacts identified are those from the operation of L-Reactor and incremental increases at support facilities.

[b]No action is defined as maintaining L-Reactor in a ready-for-operation standby mode.

Health effects. The Department is continuing health effects studies of cancer mortality rates in the areas around SRP. These studies concentrate on those types of cancer for which a proven causal relationship with radiation exposure has been demonstrated. To date, no correlations have been established between population cancers and SRP operations.

Health studies of SRP employees are also being conducted by the Occupational Epidemiology Section of the Oak Ridge Associated Universities, and by the Epidemiology Group at Los Alamos National Laboratory, both of which are DOE laboratories. The Oak Ridge morbidity and mortality studies of radiation workers and the Los Alamos studies of plutonium workers are in the early stages.

At DOE's request, the Centers for Disease Control in Atlanta has organized a review committee of independent experts to review the results of population health effects studies and occupational epidemiological studies. Epidemiologists from the States of South Carolina and Georgia are participating in this study. The Department will adopt recommendations of this panel to modify its existing studies and to conduct additional studies.

Comments on monitoring and studies in the Draft EIS consisted for the most part of those that requested "independent" oversight or review of Savannah River Plant activities, and those that were concerned with particular aspects of the annual SRP monitoring program. The Department of Energy has attempted to respond to these concerns in this Final EIS by describing the interactions that are currently taking place with state and Federal agencies, the monitoring programs being conducted by the States of South Carolina and Georgia, and its ongoing commitment to adhere to applicable regulations and standards that will ensure continued protection of the area population's health and safety.

Federal and State Environmental Requirements

Table S-2 lists the permits and other environmental approvals required for the Department's preferred alternative before L-Reactor operation can resume. It indicates the status of each requirement. Based on the comments received on the Draft EIS and the identification of a preferred cooling-water mitigation alternative, the discussion of Federal and state environmental requirements has been expanded in this Final EIS.

Table S-2. Required regulatory permits and notifications

| Activity/facility | Requirement(s) | Agency | Status |
|---|---|---|---|
| Water | | | |
| Process and sanitary-sewer outfalls | NPDES permit<br>Construction permit | South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division | Discharges permitted<br>Construction permitted |
| Domestic water supply system | Permit to construct ground-water wells, treatment and distribution systems | South Carolina Department of Health and Environmental Control, Water Supply Division | Domestic water-supply system construction permitted |
| Cooling-water discharge | 316(a) (thermal impact) study | South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division | See Appendix L |
| Cooling-water discharge, preferred alternative (1000-acre lake) | NPDES permit | South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division | Pending completion of FEIS |
| | Dredge and fill permit (Section 404) | U.S. Army Corps of Engineers | Pending completion of FEIS |
| | Certification (Section 401) | South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division | Requested by COE as part of the dredge and fill permit process |

Table S-2. Required regulatory permits and notifications (continued)

| Activity/facility | Requirement(s) | Agency | Status |
|---|---|---|---|
| Oil storage | Spill prevention, control and counter-measure plan | EPA/South Carolina Department of Health and Environmental Control | To be included in overall plan for SRP |
| Air | | | |
| L-Area emergency diesel generators | Operation permits | South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control | Permitted |
| F-, H, and M-Area process facilities | Operation permit amendments | South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control | Application under review |
| K-Area powerhouse | Operation permit | South Carolina Department of Health and Environmental Control, Bureau of Air Quality Control | New permit not required |
| Endangered species | Consultation/ biological assessment | U.S. Fish and Wildlife Service and National Marine Fisheries Service | Consultations with FWS in process; consultations with NMFS completed |
| Fish and Wildlife Coordination Act | Consultation/ consideration of fish and wildlife resources | U.S. Fish and Wildlife Service | Consultations with FWS in progress |
| Migratory Bird Treaty Act | Consultation with FWS and development of mitigation plan | U.S. Fish and Wildlife Service | Consultation with FWS in progress |

Table S-2. Required regulatory permits and notifications (continued)

| Activity/facility | Requirement(s) | Agency | Status |
|---|---|---|---|
| Anadromous Fish Conservation Act | Consultation with FWS and development of mitigation plan | U.S. Fish and Wildlife Service | Consultation with FWS in progress |
| Historic preservation | Archeological survey and assessment | South Carolina Historic Preservation Officer | 1000-acre lake will require new survey compliance, etc. |
| Floodplain/wetlands | Assessment and determination | *U.S. Department of Energy* | *To be updated based on* FEIS |
| Hazardous wastes | Resource Conservation and Recovery Act Requirements | U.S. Department of Energy/ South Carolina Department of Health and Environmental Control/U.S. Environmental Protection Agency | RCRA Program Management Plan in place |

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# 1 NEED FOR RESUMPTION OF L-REACTOR OPERATIONS AND PURPOSE OF THIS ENVIRONMENTAL IMPACT STATEMENT

The U.S. Department of Energy (DOE) operates two nuclear reactor production complexes for the purpose of producing plutonium and tritium for the nation's defense programs; these complexes are the Savannah River Plant (SRP) in South Carolina and the Hanford Reservation in Washington State. Three SRP reactors (C, K, and P) are presently operating; they produce the majority of the plutonium and all the tritium used for defense programs. At Hanford, one production reactor, the N-Reactor, is being operated in a combined mode to produce plutonium for defense programs and steam for electric power generation.

Current forecasts of nuclear material needs for defense programs indicate that these existing production complexes have insufficient capacity to meet projected plutonium requirements. To prevent shortages, especially during the next few years, DOE proposes to resume operation of L-Reactor at the Savannah River Plant as soon as practicable. This proposed action is one of a series of production initiatives being taken to increase the supply of weapons-grade plutonium to a level that will satisfy the projected requirements.

## 1.1 NEED

### 1.1.1 Defense nuclear materials

The responsibilities of DOE in the area of defense programs stem from the Atomic Energy Act of 1954, as amended. This legislation establishes the Department's responsibility to develop and maintain a capability to produce all nuclear materials required for the defense programs of the United States.

In 1980, a high-level Policy Review Committee (members included the Secretaries of State, Energy, and Defense), under the auspices of the National Security Council, was convened to assess changes needed in the nation's nuclear weapons stockpile. The committee determined that the stockpile should be increased and that additional nuclear material production capacity will be required to meet the increased requirements. Also, the committee determined that a number of new production initiatives should be started at that time. The increased requirements were defined in the fiscal year (FY) 1981-1983 Nuclear Weapons Stockpile Memorandum (NWSM), approved by President Carter on October 24, 1980.

The Nuclear Weapons Stockpile Memorandum is the document by which the President annually authorizes the production and retirement of nuclear weapons. In the memorandum, the Secretaries of Defense and Energy jointly recommend to the President the size and composition of the nuclear weapons stockpile they believe is required to defend the United States. In the development of this memorandum many factors are considered, such as the needs of the armed services; the current status of legislative actions concerning weapons systems and production capability; and the current status of material inventory, material supply from weapon retirements, material production and weapons fabrication. Included BL-19, BL-21, BY-2 in the memorandum to the President is the plan for producing the nuclear materials required to support the nuclear weapons stockpile. The Nuclear Weapons Stockpile Memorandum is forwarded to the President through the National Security Council. In accordance with the Atomic Energy Act, approval of the NWSM by the President and subsequent authorization and appropriation of funds by the Congress constitute the legal authority and mandate to DOE to produce the specified types and quantities of nuclear materials and weapons. If significant changes occur after the development of an NWSM, such as Congressional action that potentially affects material supply and demand, DOE factors the impact into its implementation of the NWSM requirements after the Department of Defense formalizes the modified requirements.

BL-19, EN-5

The increased requirements authorized in the FY 1981-1983 Nuclear Weapons Stockpile Memorandum resulted from efforts to modernize and improve stockpiled nuclear weapons, as well as to provide warheads for new weapons systems scheduled for deployment during the next decade. The program to modernize existing weapons systems involves replacing older nuclear warheads and existing delivery systems with modern, safer, and more effective warheads. Modernization, in many instances, has led to replacing older warheads that used uranium enriched in the isotope uranium-235 with new warheads that use weapons-grade plutonium.

The increased defense nuclear material requirements and the production initiatives necessary to provide the resultant additional production capacity have been reaffirmed in subsequent Stockpile Memoranda since 1980, including the FY 1984-1989 NWSM. Congress has generally supported, through authorization legislation and appropriation of funds, the initiatives necessary to produce the needed additional nuclear materials.

The current nuclear materials requirements for defense programs come from the FY 1984-1989 NWSM, approved by President Reagan on February 16, 1984. This document defines the annual requirements for defense nuclear materials for the first 5 years (FY 1984-1989), the planning directives for the next 5-year period, and 5 additional years of projections for long-range planning. In his approval of the FY 1984-1989 Nuclear Weapons Stockpile Memorandum, President Reagan emphasized the importance of meeting these annual requirements and maintaining an adequate supply of defense nuclear materials by directing that: ". . . as a matter of policy, national security requirements shall be the limiting factor in the nuclear force structure. Arbitrary constraints on nuclear material availability . . . shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence. Accordingly, DOE shall . . . assure the capability to meet current and projected needs for nuclear materials and . . . restart the L-Reactor at the Savannah River Plant, Aiken, S.C., as soon as possible."

BL-19, BL-21, EN-1

During the fall of 1983, the Departments of Energy and Defense developed the FY 1984-1989 NWSM. This NWSM incorporated the changes in proposed weapon systems that had occurred since the FY 1983-1988 NWSM was prepared, as well as the modified material inventory requirements and material supply from weapon retirements. Changes have affected the required delivery of defense nuclear materials, because Congress has delayed or did not fund certain nuclear weapons systems mentioned in the FY 1983-1988 NWSM; however, the production capacity of the implemented and proposed initiatives is still needed to meet the requirements of the FY 1984-1989 NWSM.

BL-19, BY-2, EN-5

Certain events that have occurred since the development of the FY 1984-1989 NWSM have the potential of affecting the supply and demand for defense nuclear materials; these include the Congressional action to delete DOE funding for production facilities for the warhead for the 155-mm artillery-fired atomic projectile (AFAP). This warhead (W82) was intended to replace the W48 warhead, which is currently scheduled for retirement. The impact of the Congressional action on the need for material has not yet been determined; however, its effect and that of any other subsequent events will be factored into the implementation of the FY 1984-1989 NWSM when DOD requirements are revised to reflect Congressional actions. Because the Department of Defense has indicated that the retirement schedule for the W48 warhead will depend on the deployment of the W82, the Congressional action on the W82 warhead is not anticipated to result in a major impact on the need for the restart of L-Reactor. BL-19, EN-5

### 1.1.2 Need for L-Reactor

When the call for additional nuclear material was made by the National Security Council in 1980, there was insufficient operating capacity in the existing DOE production complexes to meet the increased requirements for both tritium and weapons-grade plutonium.* As a consequence, all identifiable production options were evaluated and the most timely and cost-effective options were implemented. These implemented initiatives included

- Altering the Hanford N-Reactor operating cycle to produce weapons-grade plutonium rather than fuel-grade plutonium.
- Restarting the PUREX Separations Plant at Hanford to recover the plutonium from the spent N-Reactor fuel in storage (primarily of high Pu-240 content) and the fresh spent fuel (6-percent Pu-240). The stored N-Reactor spent fuel is being sorted such that spent fuel with lower Pu-240 content can be processed first.
- Shortening the SRP reactor operating cycles to produce 3-percent Pu-240 assay plutonium rather than 6-percent Pu-240.
- Blending higher assay Pu-240 plutonium either from DOE-owned plutonium presently in inventory or from plutonium to be recovered from the operation of the Hanford PUREX Plant with the 3-percent Pu-240 plutonium being recovered at SRP to produce weapons-grade plutonium. BL-19

*Weapons-grade plutonium is primarily Pu-239 and contains less than 6-percent Pu-240. The term "fuel-grade" plutonium is used to refer to plutonium containing greater than 6-percent Pu-240, generally 9- to 14-percent Pu-240.

Figure 1-1 shows current operations and implemented initiatives; the implemented initiatives are described below.

The N-Reactor at the Hanford Reservation in Richland, Washington, operated strictly as a plutonium production reactor from its startup in December 1962 until April 1966. Since April 1966, the byproduct steam from N-Reactor has been used to produce electrical power in the adjacent steam plant belonging to the Washington Public Power Supply System. Before 1973, N-Reactor was operated part of the time to produce 9-percent Pu-240; the rest of the time, it produced weapons-grade plutonium (6-percent Pu-240).

From 1973 to 1982, N-Reactor produced plutonium with a Pu-240 content of approximately 12 percent. In 1982, it was switched from the production of fuel-grade to the production of weapons-grade plutonium. This conversion was to 6-percent Pu-240. In the 6-percent Pu-240 production mode, the schedule requires the shutdown and discharge of approximately one-fourth of the core eight times a year (rather than only four times a year for the 12-percent Pu-240 production program). Therefore, the fuel throughput increased by a factor of two, which required operational changes in fuel fabrication, reactor charge and discharge operations, the storage of spent fuel, and reprocessing.

The PUREX Separations Plant at Hanford is a large, remotely operated and maintained nuclear fuel reprocessing plant. It contains equipment for chemically dissolving nuclear fuel, recovering uranium and plutonium from solution by the PUREX solvent extraction process, and converting the chemically purified plutonium to solid plutonium oxide for shipment. Uranium is recovered as a concentrated nitrate solution, which is converted to an oxide powder in the Hanford
BL-21 uranium oxide plant; liquid wastes are neutralized and stored in tanks.

The PUREX Separations Plant operated from 1956 to 1972, when it was placed on standby. The resumption of PUREX Plant operations was authorized and funded in FY 1981. At that time, the predicted date for the PUREX Plant to resume operation was April 1984; however, the plant was restarted 5 months ahead of schedule. The PUREX Plant itself does not produce plutonium; it separates reactor-produced plutonium from uranium and waste products. The operation of this plant will maximize the amount of weapons-grade plutonium available for defense programs by processing the lower Pu-240 material first.

The early restart of the PUREX Plant will have a minor effect on the supply of weapons-grade plutonium during the timeframe of concern for L-Reactor, because sufficient supplies of fuel-grade plutonium are available in inventory for blending; in addition, the capacity of the PUREX facility is large in comparison with the backlog of N-Reactor weapons-grade material available for processing. Furthermore, the early plant restart was factored into the material supply information in the FY 1984-1989 NWSM approved by President Reagan on February 16, 1984.

Environmental effects for resuming operation of the PUREX Plant are discussed in the Final Environmental Impact Statement for PUREX Operation (DOE/EIS-0089).

Initially, most of the material the PUREX plant will recover will be a high-assay Pu-240 (greater than 6-percent) product. The recovery rate will exceed the availability of 3-percent Pu-240 produced at SRP for blending.

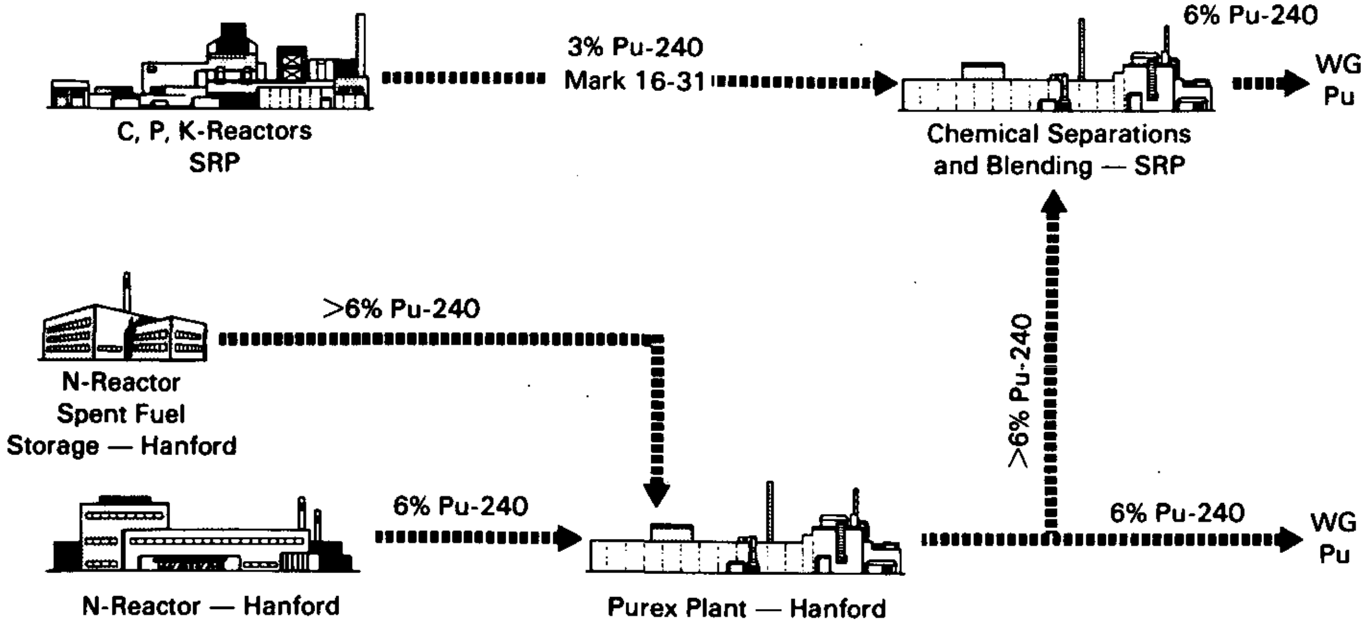



**Figure 1-1. Current and implemented initiatives to produce weapons-grade (WG) plutonium (Pu).**

Although PUREX will not always operate at full capacity during the 1980s, the available extra capacity cannot be put to any other practical use. The proposed operation of L-Reactor would accelerate the use of high-assay Pu-240 processed at PUREX because L-Reactor would produce additional 3-percent Pu-240 material for blending.

Spent fuel from N-Reactor has been accumulating in Hanford storage basins since the shutdown of the PUREX Separations Plant in 1972; this spent fuel is being reprocessed by the PUREX Plant. Although the N-Reactor has been operating with a nominal 12-percent Pu-240 content in its discharged fuel, the actual Pu-240 content varies from about 5 percent to 19 percent, depending on the fuel position within the reactor and its actual exposure. Physically sorting the fuel into batches (which started in 1983) before reprocessing allows the 6-percent Pu-240 assay fuel to be reprocessed first, thus making it available for early processing in the PUREX Plant. This plutonium is not a net gain to the system, however, because the remaining fuel-grade material produced from the
BL-21 PUREX Plant is blended at a slower rate due to its higher Pu-240 content.

Blending involves the conversion of fuel-grade plutonium to weapons-grade plutonium; this conversion occurs by mixing plutonium with less than 6-percent Pu-240 with plutonium containing greater than 6-1/2-percent Pu-240. One of the production initiatives undertaken in 1981 was to convert the SRP reactors to the production of 3-percent Pu-240. The major sources of high-assay Pu-240 for blending are spent fuel from N-Reactor and other DOE fuels containing plutonium originally processed at Hanford. The blending program was initiated with the use of existing inventories of fuel-grade plutonium.

The blending operation at SRP provides about a 50-percent increase in the amount of available weapons-grade plutonium, based on a nominal 12-percent Pu-240 content in existing spent fuel. Specific annual production rates of low-assay Pu-240 plutonium vary because tritium demand is satisfied before plutonium production at SRP, and tritium demand varies from year to year.

These implemented initiatives produce a substantially greater amount of plutonium, but not enough to fully meet the nuclear defense material requirements. To provide more plutonium production, DOE has proposed several additional initiatives for implementation; these proposed initiatives, shown in Figure 1-2, are to:

- Restart the restored L-Reactor at the Savannah River Plant.
- Use an improved fuel lattice (Mark 15) in the SRP reactors to produce significantly more plutonium than the present Mark 16-31 plutonium-producing lattice.
- Construct a special isotope separations (SIS) plant to process and convert fuel-grade plutonium into weapons-grade plutonium.

The Mark-15 homogeneous lattice has been designed to be the most efficient
BL-21 plutonium core that can be accommodated at SRP. It consists of a uniform reactor lattice using slightly enriched uranium fuel (the Mark 16-31 plutonium-producing lattice currently employed at SRP uses highly enriched and depleted

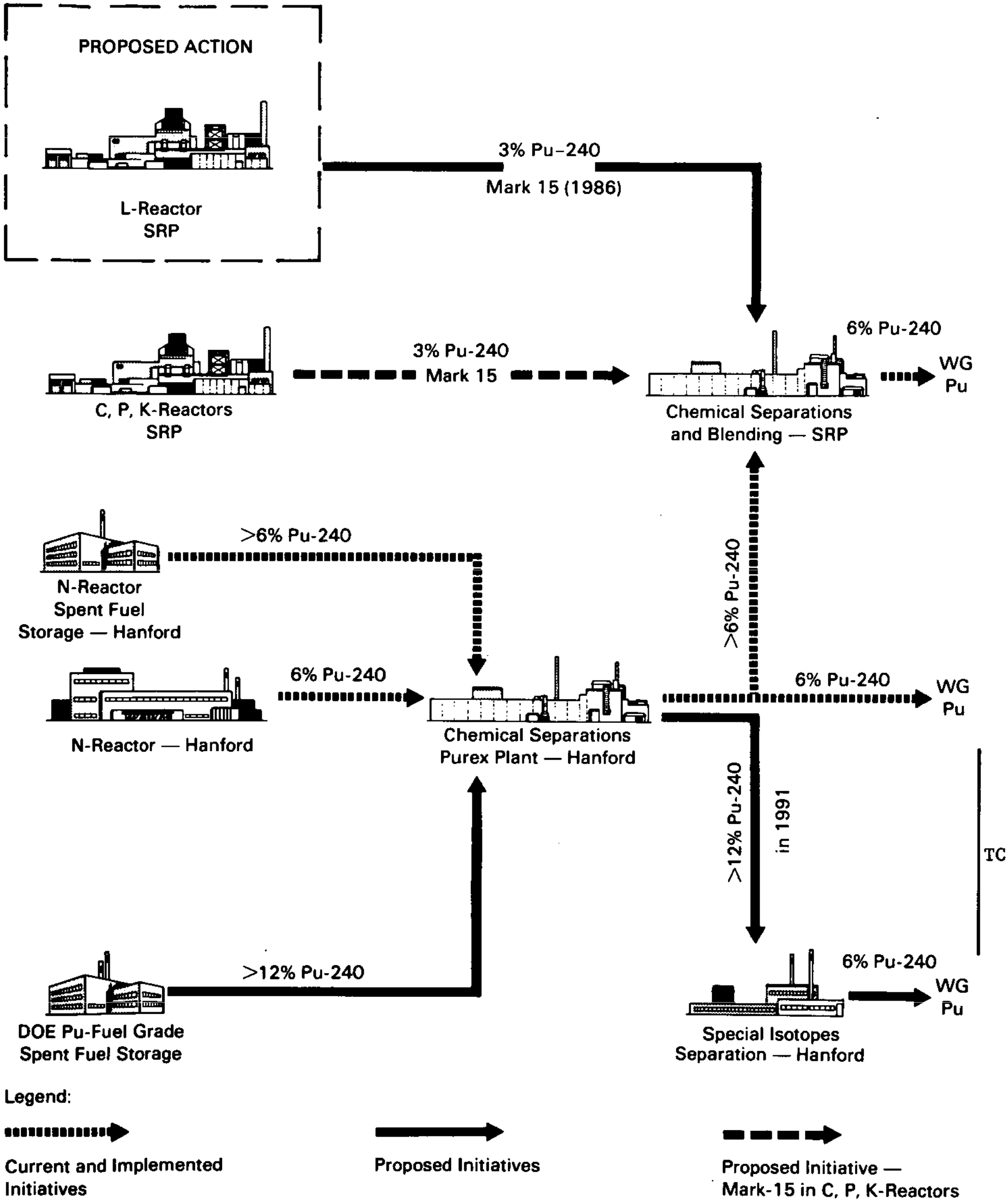



**Figure 1-2. Current, implemented and proposed initiatives to produce weapons-grade (WG) plutonium (Pu).**

uranium elements). A demonstration Mark 15 lattice was operated successfully in
BL-21 the K-Reactor at SRP in August 1983. Implementation of the Mark 15 lattice is planned for late 1986.

Since 1972, the N-Reactor at Hanford has produced fuel-grade plutonium of high-assay Pu-240 for use in reactor studies and other DOE programs. Also, DOE has other fuel-grade plutonium stocks [e.g., Fast Flux Test Facility (FFTF)] that can be processed and fuel-grade plutonium that can be recovered in the PUREX Plant. Processing some of these spent fuels will require a shear-leach head-end addition to the PUREX Plant.

CX-4 The Department of Energy is currently proceeding with the development of the special isotope separation (SIS) process as a method to convert fuel-grade plutonium into weapons-grade plutonium. This process has been demonstrated only in the laboratory. The FY 1984-1989 NWSM is based on a scale-up to a full-production facility by 1991. This plant could be used for the isotopic purification of existing fuel-grade plutonium produced from past operation of the N-Reactor and from spent FFTF fuel.

An alternative considered for production of defense nuclear materials after 1985 (the far-term) is the construction and operation of a New Production
AB-8 Reactor (NPR). The estimated time from the authorization of an NPR to its startup is about 10 years. Thus, an NPR could not contribute to material production until 1995 at the earliest, much too late to help offset the near-term need for defense nuclear materials.

The proposed restart of the L-Reactor at the Savannah River Plant, originally scheduled for October 1983, is the subject of this environmental impact statement. All the initiatives discussed above, including L-Reactor restart, are needed as soon as practicable to meet the increased defense nuclear material requirements. Any delays will directly affect the needed supply of defense
BL-19, EN-10 nuclear materials for our Nation's nuclear force structure.

The President emphasized the importance of the timely restart of L-Reactor to increase the supply of nuclear material in his approval of the FY 1984-1989 Nuclear Weapons Stockpile Memorandum, on February 16, 1984, as follows: ". . . DOE shall . . . restart the L-Reactor at the Savannah River Plant, Aiken, South Carolina, as soon as possible."

This discussion on the need for L-Reactor is, by necessity, qualitative and limited because quantitative information on defense material requirements, inventories, production capacity, and projected material shortages or adverse impacts on weapons-system deployments is classified. A quantitative discussion of the need for restarting L-Reactor, including the impacts of delaying the restart, is provided for the DOE decisionmaker in a classified appendix (Appendix A).

## 1.2 PURPOSE

The purpose of this environmental impact statement is to analyze the potential environmental consequences of the proposed resumption of L-Reactor operation and its alternatives in compliance with Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended, and the Energy and Water Development Appropriations Act, 1984. Also, on July 15, 1983, the U.S. District Court, acting on a November 1982 lawsuit, directed the DOE to prepare and publish an environmental impact statement as soon as possible on the proposed operation of L-Reactor.

The proposed action is to resume operation of L-Reactor as soon as practicable. The Department of Energy's preferred alternative is to operate L-Reactor after construction of a 1000-acre once-through cooling lake. TC

An environmental assessment on the L-Reactor restart was issued earlier in August 1982 (DOE, 1982a). This EIS describes production options considered (Chapter 2) and the affected SRP environment (Chapter 3), and assesses the potential environmental consequences of the resumption of L-Reactor operation and describes potential mitigation alternatives (Chapter 4).

Chapter 5 addresses incremental effects from other SRP facilities that would occur due to the resumption of L-Reactor operation and potential cumulative effects with nearby nuclear facilities.

Chapter 6 describes programs to study and monitor effluents from the SRP facility and to assess the ecological health of the SRP environment. Chapter 7 summarizes Federal and State of South Carolina requirements that apply to the proposed resumption of L-Reactor operation. Chapter 8 describes the unavoidable/irreversible impacts of L-Reactor operation.

Two EISs that address SRP waste-management operations and that are relevant in understanding potential environmental effects of the resumption of L-Reactor operation have been published in the last 6 years. The Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina (ERDA, 1977) describes the waste-management operations of the Savannah River Plant and analyzes their actual and potential environmental effects. The Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina (DOE, 1982b) describes the disposal strategy and the construction and operation of facilities at the Savannah River Plant to immobilize defense high-level radioactive wastes and analyzes the potential environmental effects.

The "SRP Ground-Water Protection Implementation Plan" will be the subject of a separate NEPA review. This review will cover such topics as seepage-basin decommissioning, cleanup levels, costs, schedules, and the need for institutional controls.

## REFERENCES


DOE (U.S. Department of Energy), 1982a. Environmental Assessment, L-Reactor Operation, Savannah River Plant, Aiken, South Carolina, DOE-EA-0195, Washington, D.C.

DOE (U.S. Department of Energy), 1982b. Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina, DOE/EIS-0082.

ERDA (U.S. Energy Research and Development Administration), 1977. Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina, ERDA-1537.

# 2 PRODUCTION OPTIONS AND PROPOSED ACTION

This chapter describes the production options considered by the Department of Energy (DOE) to meet the established requirements for defense nuclear materials. Section 2.1 describes the production options to the restart of L-Reactor. Section 2.2 describes the proposed action; Section 2.3 describes the no-action alternative, which would keep the restored L-Reactor in a ready-for-operation standby mode. The summary to this chapter is contained in Section 2.4, which describes the preferred cooling-water mitigation measure within the proposed action. TC

Section 4.4 describes mitigation, as opposed to production, alternatives. Each cooling-water mitigation alternative encompasses two options: mitigation before restart and mitigation implemented after the reactor has operated for a period of time. Each mitigation alternative is associated with an inherent delay in production; the length of each delay depends on the particular alternative selected. As with production options, any delay in restarting L-Reactor to implement a mitigation option entails a loss of needed production that cannot be fully compensated.

This discussion on production options to L-Reactor is, by necessity, qualitative and limited because quantitative information on defense material requirements, inventories, production capacity, and projected material shortages or adverse impacts on weapons-system deployments are classified. A quantitative discussion of the need for restarting L-Reactor, including the impacts of delaying the restart, is provided for the DOE decisionmaker in a classified appendix (Appendix A).

## 2.1 PRODUCTION OPTIONS TO L-REACTOR

The production options to L-Reactor consist of those that have production capacities similar to those for L-Reactor and those that have only partial capacities when compared to L-Reactor. The production options described below can be categorized as either "full" or "partial"; they are described in the following sections.

The following full-production options were assessed:

- Restarting R-Reactor at the Savannah River Plant
- Restarting one of the K-Reactors at the Hanford Reservation TC
- Processing commercial reactor spent fuel

The following partial-production options were also assessed:

- Increased power in the operating SRP reactors

- Increased power in the N-Reactor at Hanford

- Production of less-than-3-percent plutonium-240 in the operating SRP reactors

TC

- Production of less-than-6-percent plutonium-240 at the N-Reactor
- Accelerated use of the Mark-15 fuel lattice in the operating SRP reactors
- Combinations of partial-production options

### 2.1.1 Full-production options

Possible full-production options have been analyzed. Existing production reactors were considered, as was the use of spent fuel from commercial power reactors. The options that have capacities similar to those for L-Reactor include the restart of either R-Reactor at the Savannah River Plant (SRP) or one of the K-Reactors at the Hanford Reservation, and recovery of plutonium from commercial power-reactor spent fuel.

#### 2.1.1.1 *Restart of R- or K-Reactor*

Restart R-Reactor at the Savannah River Plant, South Carolina

R-Reactor began operation in late 1953 and was placed in standby status in mid-1964 due to a decline in the need for defense nuclear materials. Since R-Reactor was placed in standby status, its systems and components have not been maintained as well as those in L-Reactor. Because no heating or ventilation was provided since its placement in standby, extensive deterioration is evident throughout R-Reactor. In addition, many R-Reactor components have been removed for use in operating SRP reactors (Turcotte, Palmiotto, and Mackey, 1983).

R-Reactor would require more extensive restoration than L-Reactor. An estimated minimum of 5 years would be required for its restoration to a safe and reliable operating condition; it would also require substantially higher costs for renovation than L-Reactor. Although a restored R-Reactor would have a comparable production rate to L-Reactor, its restart is not considered a reasonable production option to L-Reactor because of timing considerations.

Restart of K-Reactors at the Hanford Reservation, Washington

K-West (KW) and K-East (KE) Reactors at the DOE Hanford Reservation began operation in 1955 and were shut down in 1970 and 1971, respectively, due to a decline in the need for defense nuclear materials. The K-Reactors have been retired and are being prepared for decontamination and decommissioning. The fuel fabrication plant has been dismantled and some essential equipment has been removed. More than 5 years would be required to restore either K-Reactor for the production of plutonium (Turcotte, Palmiotto, and Mackey, 1983).

Because these reactors have been retired and are being prepared for decommissioning, they cannot contribute to the production of plutonium to meet present and near-term needs; therefore, the restart of either K-Reactor is not considered a reasonable production option to the restart of L-Reactor.

2.1.1.2 Commercial reactor spent fuel

Theoretically, weapon materials could be produced directly in existing commercial light-water reactors, or weapons-grade plutonium could be isotopically separated from high-assay plutonium in existing spent fuel from light-water reactors. However, conversion of spent commercial reactor fuel into weapons-grade plutonium is currently prohibited by law [Atomic Energy Act of 1954, as amended, 42 USC section 2077(e)]. The legislative removal of this prohibition is not considered a reasonable alternative to the restart of L-Reactor as a source of weapons-grade plutonium. This policy determination was passed by Congress in December 1982 which reaffirmed the position of strict separation of nuclear defense and commercial activities established by the Atomic Energy Act in 1954. BY-2

### 2.1.2 Partial-production options

The partial-production options would provide only a portion of the required defense nuclear materials if L-Reactor either was not restarted or was delayed beyond its current schedule for restart. These partial production options include increasing the power of N-Reactor at the Hanford Reservation and/or the operating SRP reactors; production of less-than-6-percent plutonium-240 at N-Reactor and/or less-than-3-percent plutonium-240 at operating SRP reactors for blending with fuel-grade plutonium; and the accelerated use of the Mark-15 lattice at the operating SRP reactors.

2.1.2.1 Increased power in operating reactors

A possible production option to the restart of L-Reactor that would partially attain the needed levels of defense nuclear materials would be to increase the power of N-Reactor at Hanford and/or the three operating reactors at the Savannah River Plant.

SRP reactors

An increase in power levels (on the order of 15 percent per reactor) and production might be achievable in SRP reactors. These reactor power gains could be achieved by installing larger heat exchangers in the reactor buildings to increase heat transfer, by increasing primary ($D_2O$) and secondary ($H_2O$) coolant flows, and by increasing reactor-blanket-gas pressure. Such changes would require rebuilding the reactor hydraulic systems (Macafee, 1983a).

Although rebuilding the hydraulic systems to increase reactor power is feasible from an engineering standpoint, increased power might not be feasible from a safety standpoint. Whereas safety considerations for the current scope of operations are well defined, safety and operation beyond the range of experience would have to be proven. The following areas would have to be evaluated and show positive results for the more extreme operating conditions to be viable:

- The ability of the reactor safety systems and confinement system to cope with postulated accidents at increased power

- The capability of reactor piping system components to withstand increased cooling and process water flows

- The reliability of reactor components at higher temperatures and pressures

If proven feasible, the necessary modifications to increase power in the SRP reactors would take about 5 years to implement. In addition, during modifications, an estimated 1 year of reactor operating time would be required to modify each reactor for operation of the higher power level; this lost production time would also affect the blending initiative because there would be a reduced amount of 3-percent plutonium-240 for blending.

Because of the large uncertainty of this option, coupled with the length of time for implementation, safety concerns, and loss of near-term production, increasing the power of SRP reactors is not a reasonable production option to the restart of L-Reactor.

N-Reactor at Hanford

The power level of the N-Reactor (currently operating at 4000 megawatts-thermal) at the Hanford Reservation could potentially be increased by 10 percent. The net annual plutonium production increase would be less than 10 TC percent over current levels because of production inefficiencies from increased charge/discharge of fuel and because of the downtime required to make plant modifications. The power level increase could be accomplished by increasing reactor coolant flow rates and/or temperature levels. The additional heat produced by N-Reactor would be discharged to the Columbia River through steam dump condensers.

Increased N-Reactor power levels might be feasible from an engineering design perspective. Minor improvements to the reactor instrumentation, confinement, emergency core cooling, and auxiliary systems would be required to provide the necessary operational latitude at the higher power level. Even though N-Reactor has operated as high as 4800 megawatts-thermal during a plutonium/tritium coproduction mode of operation in 1966 and 1967, the increased flow rates and temperature would be beyond the safety limits developed for current operating conditions. Before N-Reactor could be operated at the higher power level, the following safety considerations would require further evaluation to ensure satisfactory results:

- The ability of the safety systems to cope successfully with postulated accidents at elevated temperature and flow rate conditions

- The ability of critical system components to operate reliably at increased temperature and flow rates

- The ability of reactor fuel design to withstand postulated accidents at increased power levels

In addition to these considerations, the service life of N-Reactor is governed by distortion of the graphite moderator, which is directly proportional to the integrated neutron exposure to the graphite and to the graphite temperature. Because of these radiation-induced effects in the graphite moderator, the life of N-Reactor at the present power level is not expected to extend beyond the mid-1990s. Increasing the power level would decrease the service life of N-Reactor; a 10-percent power increase would reduce the expected reactor service life by about 1 year.

Environmental data, calculations, and analysis show no significant adverse radiological impacts from current or projected future operation of N-Reactor and TC its Fuel Fabrication Facility. Current environmental impacts of the operation of N-Reactor and its Fuel Fabrication Facility are due primarily to airborne radiological releases, radiological and chemical releases to the soil, and thermal impacts of cooling water. The calculated, whole-body population dose received by the approximately 340,000 people living within an 80-kilometer radius during 1982 was 4 person-rem from N-Reactor and the Fuel Fabrication operation. This was less than 0.012 percent of the doses due to naturally occurring radiation in the environment (PNL, 1983). TC

On the average, about 200 curies of radionuclides (almost entirely tritium) are released annually to the Columbia River near N-Reactor. A few chemical effluents are also discharged to the N-Reactor and Fuel Fabrication area soils. Those chemicals make up a minor part of the process water discharged to the ground and are either entrained in the soil column or discharged to the Columbia River in compliance with an NPDES Permit.

The remaining waste heat is dissipated to the environment directly in cooling water discharged to the Columbia River. N-Reactor steam is exported to the Washington Public Power Supply System generating plant, where the residual heat is discharged to the river. At 4000 megawatts-thermal, approximately 700 megawatts-thermal are discharged through a 260-centimeter outfall line to the TC center of the river.

To achieve a 10-percent increase in the power level of N-Reactor, an increase of about 10 percent in the cooling-water flow would be necessary. In past studies, however, impingement of aquatic organisms at the N-Reactor intake structure has been very low, so the increased cooling-water flow rate would TC result in negligible additional entrainment and impingement of aquatic organisms. The thermal discharge to the Columbia River from the discharge of cooling water would also be increased. The dominant environmental impact of a 10-percent increase in reactor power would be an increase in the thermal discharge to the Columbia River. Other impacts would include increased chemical emissions from the Fuel Fabrication Facility. Nonradioactive and radioactive releases to the environment would be expected to be increased slightly over existing release levels, but would be well within applicable control limits. TC

DOE policy is to keep N-Reactor operating as long as possible because it is the nation's only backup to the Savannah River Plant for the production of defense nuclear material.

### 2.1.2.2 Decreased plutonium-240 content

Another production option that would partially attain the production levels of L-Reactor would be to further reduce the plutonium-240 content of plutonium produced in existing reactors. This would allow a more rapid conversion of fuel-grade plutonium into weapons-grade material through blending. The decrease in plutonium-240 content could be achieved by the production of less-than-3-percent plutonium-240 at SRP operating reactors or less-than-6-percent plutonium-240 at N-Reactor at Hanford.

-21, -6 Plutonium-240 content is an undesirable product created through neutron capture of plutonium-239; its production is directly proportional to the plutonium-239 produced in the target material and the exposure time during reactor operation. A lower percentage plutonium-240 content in the plutonium product can be achieved by shortening the reactor exposure cycles. This necessitates shutting down the reactor more frequently for changing out target and/or fuel elements. However, shutting down the reactors more frequently increases reactor down time and reduces the overall amount of plutonium product that can be produced on an annual basis.

Production of less-than-3-percent plutonium-240 at SRP

TC The production of less-than-3-percent (2-percent) plutonium-240 at the SRP reactors is not effective in increasing production due to the excessively high throughput and increased reactor downtime. The loss of production due to reactor downtime is not compensated by the production of less-than-3-percent plutonium and blending. Therefore, this is not considered a reasonable production option to the restart of L-Reactor.

Production of less-than-6-percent plutonium-240 at N-Reactor

The production of less-than-6-percent (5-percent) plutonium-240 at the Hanford Reservation's N-Reactor can be accomplished with the current fuel design by shortening the reactor fuel cycles and/or by increasing the number of fuel assemblies discharged per cycle (ERDA, 1977).

BT-6 The incremental environmental effects that would be expected from the production of less-than-6-percent plutonium-240 at the N-Reactor include those associated with increased manufacturing operations at the Hanford fuel fabrication facility. The production of the additional fuel assemblies for production of less-than-6-percent plutonium-240 would result in an approximate 20-percent increase in radiological and nonradiological releases to the environment from that facility. These releases include airborne uranium emissions from the cutoff saw exhaust, $NO_x$ releases from the chemical bay stack, and process chemicals discharged to the 300-Area process trenches and the 183-H solar evaporation basin. Although the quantities of these materials discharged annually would increase, the average effluent concentrations during operation would remain the same.

The production of less-than-6-percent plutonium-240 would result in additional fuel processing at the Hanford PUREX reprocessing facility. There would be an increase in the radiological and nonradiological releases to the environment of approximately 2 percent per year, depending on the backlog of material processed at PUREX. The releases would include some gaseous fission products (krypton-85, carbon-14, iodine-129, and tritium), oxides of nitrogen, and tritiated water. The quantities of materials discharged annually would increase slightly; however, the average effluent concentrations during operation would remain the same. All releases from the N-Reactor fuel manufacturing facility and the PUREX operation are expected to be within applicable control limits. BT-6

2.1.2.3 Accelerated use of Mark-15 fuel lattice

Currently, SRP reactors use the Mark 16-31 lattice for plutonium production. A Mark-15 lattice design has been developed for the SRP reactors to increase the efficiency of plutonium production. A demonstration of the Mark-15 lattice design was performed in August and September of 1983 to verify its design and operability. Similar, although less efficient, uniform lattices have been used in earlier SRP reactor operations.

Once funding is appropriated for the Mark-15 lattice, the front end of this fuel cycle must be established. This includes obtaining slightly enriched uranium from DOE gaseous diffusion plants, converting the slightly enriched uranium to uranium billets, and fabricating the billets into the Mark-15 lattice at the SRP. Presently, the materials for the Mark 16-31 lattice (highly enriched uranium and natural uranium) are obtained from available inventories. BL-21

The conversion from the Mark 16-31 lattice to the Mark-15 lattice is presently planned for funding in FY 1985 and for implementation in late 1986. Under an accelerated program, a supplemental FY 1984 appropriation could be requested of Congress for implementation in early 1986. If promptly enacted, this would accelerate the use of Mark-15 lattice by about 6 months. BL-21

The environmental effects of using the Mark-15 fuel lattice design are expected to be similar to those from current operations. Emissions of nitrogen oxide ($NO_x$) from the fuel manufacturing area are expected to increase by an estimated 12 tons annually, increasing $NO_x$ emissions from the fuel manufacturing area operations by 50 percent and increasing annual SRP $NO_x$ emissions by 0.24 percent. The site boundary concentrations of $NO_x$ would be well below the ambient air quality standard (Sires, 1983).

Cooling-water discharges from the reactor areas are expected to increase Savannah River temperatures by less than 0.2°C from that due to current operations. Negligible increases in fission product gas releases, atmospheric tritium releases, and carbon-14 releases will occur resulting in 0.1-percent, 1-percent, and 0.4-percent increases, respectively, in current offsite doses. The volume of liquid radioactive effluents released to the F-Area seepage basin is expected to double, but would not exceed seepage basin capacity. The H-Area seepage basin would not be affected. Occupational exposures associated with the

TE use of Mark-15 lattices are expected to remain the same as those for the current lattice design (Sires, 1983).

2.1.2.4 Combinations of partial-production options

The partial-production options that could be considered for implementation include the production of less-than-6-percent plutonium-240 at the Hanford Reservation's N-Reactor, increased power at the N-Reactor, and the accelerated use of the Mark-15 lattice at operating SRP reactors. Various combinations of these three partial-production options have been evaluated with respect to their total capabilities to produce the required defense nuclear materials. Due to the throughput limitations in the fuel fabrication facility at Hanford, the production of less-than-6-percent plutonium-240 and increased power at the N-Reactor are mutually exclusive. The production of less-than-6-percent plutonium-240 would produce greater quantities of material than increased power at the N-Reactor; therefore, the potential combination of partial-production options providing the greatest material production would be the accelerated use of the Mark-15 lattice at the SRP reactors and the production of less-than-6-percent plutonium at the N-Reactor. None of these options, or combinations of options,
EW-1 can provide the needed defense nuclear materials requirements nor can they fully compensate for the loss of this material that would be produced by L-Reactor.

2.1.3 Delayed L-Reactor operation

If implementation of a mitigative measure, as discussed in Section 4.4, requires a delay in the scheduled restart of L-Reactor, the potential combination of two partial options could be considered (i.e., the accelerated use of the Mark-15 lattice at SRP operating reactors and the production of less-than-6-percent plutonium-240 at the Hanford Reservation's N-Reactor). The immediate enactment by Congress of an FY 1984 supplemental appropriation would be required to permit the acceleration of the use of the Mark-15 lattice in the SRP operating reactors. The accelerated use of the Mark-15 lattice, in combination with the production of 5-percent plutonium-240 at N-Reactor, would not, however, provide the amount of needed defense nuclear materials that could be produced by L-Reactor.

## 2.2 PROPOSED ACTION--RESTART OF L-REACTOR

The only available alternative that would satisfy the need for defense nuclear materials established in the FY 1984-89 NWSM is the resumption of L-Reactor operation as soon as practicable. L-Reactor operated from 1954 until 1968, when a decreasing demand for special nuclear materials resulted in its being placed in standby status. It has now been upgraded and restored to be physically ready to resume operation. Operations would use the same techniques used by the three reactors (C, K, and P) currently in operation at the Savannah River Plant. Effluent control, environmental protection improvements, and safety improvements that have been incorporated into the other operating SRP reactors since 1968 have been included during the upgrade of L-Reactor.

### 2.2.1 SRP process description

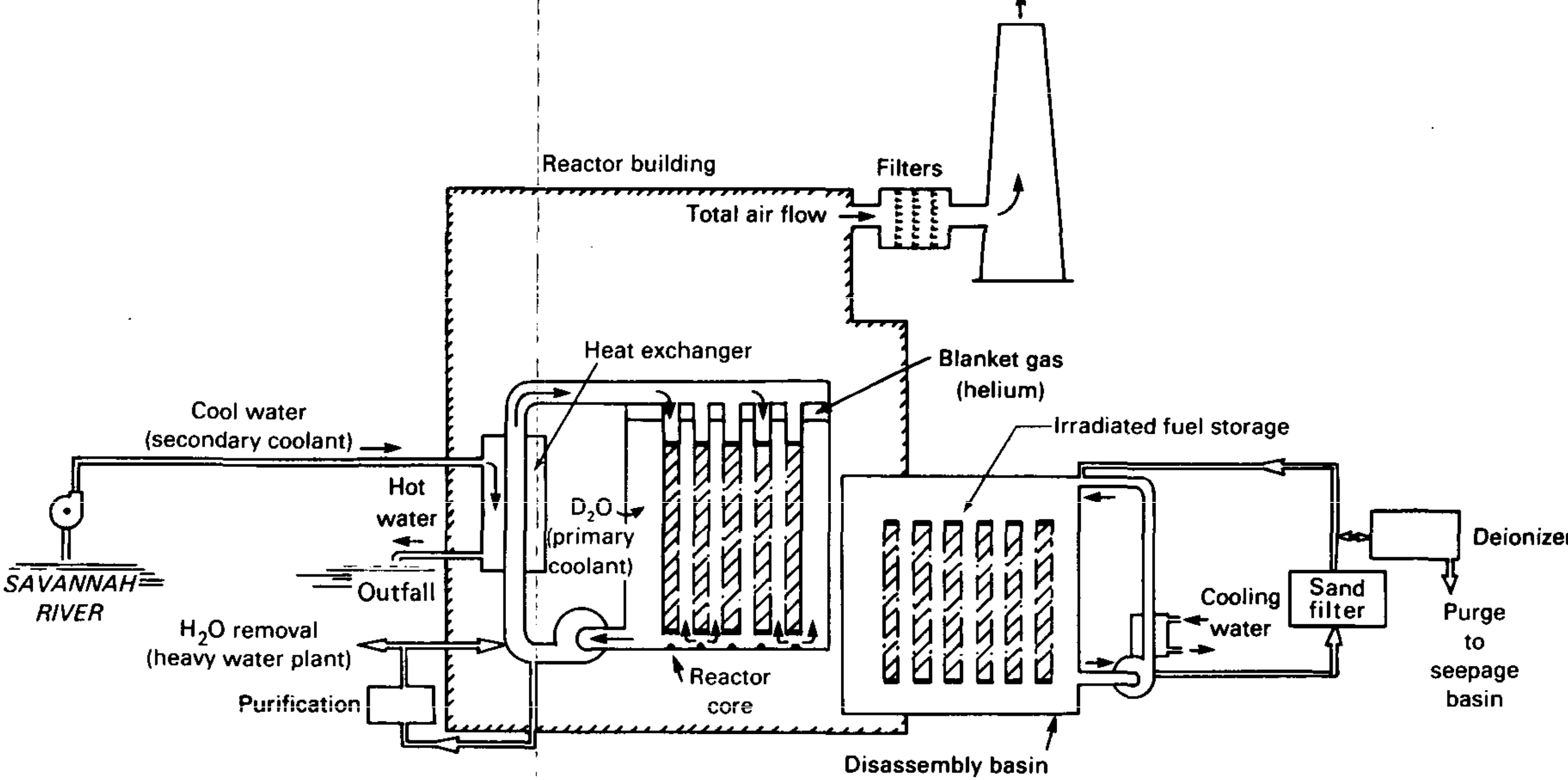
L-Reactor would be part of an integrated SRP complex for the production of defense nuclear materials, including a fuel and target fabrication plant, five reactors (three currently operating), two chemical separations plants, a heavy-water production plant (on standby except for rework), and waste-storage facilities. This complex includes fabrication of fuel and target materials into elements and assemblies for loading into the reactors; irradiation in the reactors; separation of transuranic elements, tritium, and residual uranium from waste byproducts; heavy-water recovery and purification; and waste processing and storage. The Defense Waste Processing Facility (DWPF), now under construction, will immobilize high-level wastes currently stored in underground tanks.

The SRP fabrication plant manufactures fuel and target elements to be irradiated in the production reactors. Currently, its major products are extruded enriched-uranium, aluminum-clad fuel; aluminum-clad depleted-uranium metal targets; and lithium-aluminum control rods and targets.

Each reactor building houses one production reactor and its supporting operational and safety systems. The reactor buildings incorporate heavy concrete shielding to protect personnel from radiation and a confinement system to minimize atmospheric radioactivity releases. The reactors use heavy water ($D_2O$) as a neutron moderator and as a recirculating primary coolant to remove the heat generated by the nuclear fission process. The recirculating $D_2O$ coolant is, in turn, cooled in heat exchangers by water pumped from the Savannah River and Par Pond, a 10.7-square-kilometer impoundment. Figure 2-1 shows the reactor process system. The reactors produce plutonium by the absorption of neutrons in the uranium-238 isotope. Rechargeable fuel and target assemblies all are clad with aluminum. These fuel and target assemblies are discharged from the reactors after a specified exposure period and stored in a water-filled disassembly basin to permit decay of short-lived radiation products.

The chemical separations plants dissolve the irradiated fuel and target materials in nitric acid. A solvent extraction process then yields (1) solutions of plutonium, uranium, or neptunium and (2) a high-heat liquid waste, containing the nonvolatile fission products. After the product solutions are decontaminated sufficiently from the fission products, further processing is performed in unshielded areas, where plutonium is converted from solution to solid form for shipment.

Heavy water for use as the reactor moderator was separated from river water at the heavy-water facility (now in standby except for rework) by a hydrogen sulfide extraction process and then purified by distillation.




TC

**Figure 2-1. Reactor process systems.**

The liquid radioactive wastes produced from the chemical processing of irradiated fuel and targets are partially concentrated and stored in large underground tanks. The DWPF will immobilize the wastes from these tanks in borosilicate glass disposal forms (DOE, 1982). These solidified wastes will be stored onsite until their final disposal in a Federal repository, which is scheduled to be available in 1998 (cf: Nuclear Waste Policy Act of 1982). Low-level radioactive solid wastes produced at Savannah River Plant are disposed of in a centrally located burial ground.

The proposed restart of L-Reactor will increase the production rate at the fuel and target fabrication facility and at the chemical separations facilities by about one-third. These facilities originally were designed to support five reactors; with the restart of L-Reactor, four reactors will be operating. Thus, the L-Reactor restart is not expected to cause major operational changes in these facilities. Operation of the DWPF by 1990 will eliminate the need for new waste tanks to accommodate the liquid waste generated from the processing of nuclear material as a result of L-Reactor operations.

### 2.2.2 L-Reactor description

#### 2.2.2.1 Site

L-Reactor is located on a 0.33-square-kilometer controlled area, about 5 kilometers south of SRP's geographical center, and about 9 kilometers northwest of the closest SRP boundary. The site, an upland area between Steel Creek and Pen Branch, has a level to gently rolling topography and is about 76 meters above mean sea level. The facilities closest to L-Reactor include K- and P-Reactors, which are approximately 4 kilometers to the west and 5 kilometers east-northeast, respectively. |TC |TC

#### 2.2.2.2 Schedule

Upgrading and restoration of L-Reactor has been completed. Testing of all reactor systems has been ongoing as work on each system is completed. The reactor has been charged with heavy-water moderator and fuel and target assemblies. Testing with a full flow of cooling water will be performed for approximately 1 week before restart. |TC

#### 2.2.2.3 Operating work force

In anticipation of L-Reactor operation, about 350 people have been hired for training in reactor operation and maintenance. These people will be assigned throughout the SRP labor force so L-Reactor and the other reactors will be operated primarily by experienced personnel. All reactor operators and supervisors are specially trained and formally qualified.

2.2.2.4 Buildings

Figure 2-2 shows the location of the major structures in L-Area, which include the following:

- 105-L building. Houses the reactor and associated support systems; a fuel and target receiving, assembly, testing, and storage area; a pool for the storage and disassembly of irradiated fuel and target elements; and facilities for the purification of heavy-water moderator/coolant.

- 186-L basin. Receives and stores heat-exchanger cooling water pumped from the Savannah River. Has a 95-million-liter capacity.

- 190-million-liter basin. Contains a 1.9-million-liter tank and collects cooling water discharged in the event of an accident.

- Office and shop buildings.

- Other support facilities. Includes two transformer yards, sanitary treatment facility, water treatment plant, radiological health protection, and security areas.

2.2.2.5 Reactor systems

Reactor vessel and reactor lattice

The L-Reactor vessel is a cylinder about 4.5 meters high and 5 meters in diameter made of 1/2-inch Type 304 stainless steel plate. Coolant enters through six nozzles at the top of the reactor into a plenum, flows down coolant channels in the fuel and target assemblies, and discharges into the bulk moderator. It leaves through six nozzles at the bottom of the reactor vessel (Figure 2-3). A gas plenum and top radiation shield are located under the inlet water plenum. Under the reactor vessel, a radiation shield containing 600 monitor pins provides flow and temperature monitoring for each fuel and target position. The vessel is surrounded by a 50-centimeter-thick water-filled thermal shield, and a 1.5-meter-thick concrete biological shield (Du Pont, 1982).

CU-3 Ward et al. (1980) studied the effects of neutron irradiation on the stainless-steel SRP reactor vessels and concluded that the vessels have experienced no significant deleterious effects. Furthermore, no deleterious metallurgical effects are expected in the future because neutron fluence has been accumulating very slowly since operations with lithium-blanketed charges began in 1968.

The reactor contains positions for 600 fuel and target assemblies; other principal positions in the reactor lattice are used for control rod housings, spargers, and gas port pressure-relief tubes. Interspersed among the principal lattice positions are 162 secondary positions, which can be occupied by safety and/or instrument rods. In addition to the downflow coolant for the fuel and target, upflow coolant is provided for the control assemblies and for the bulk moderator.

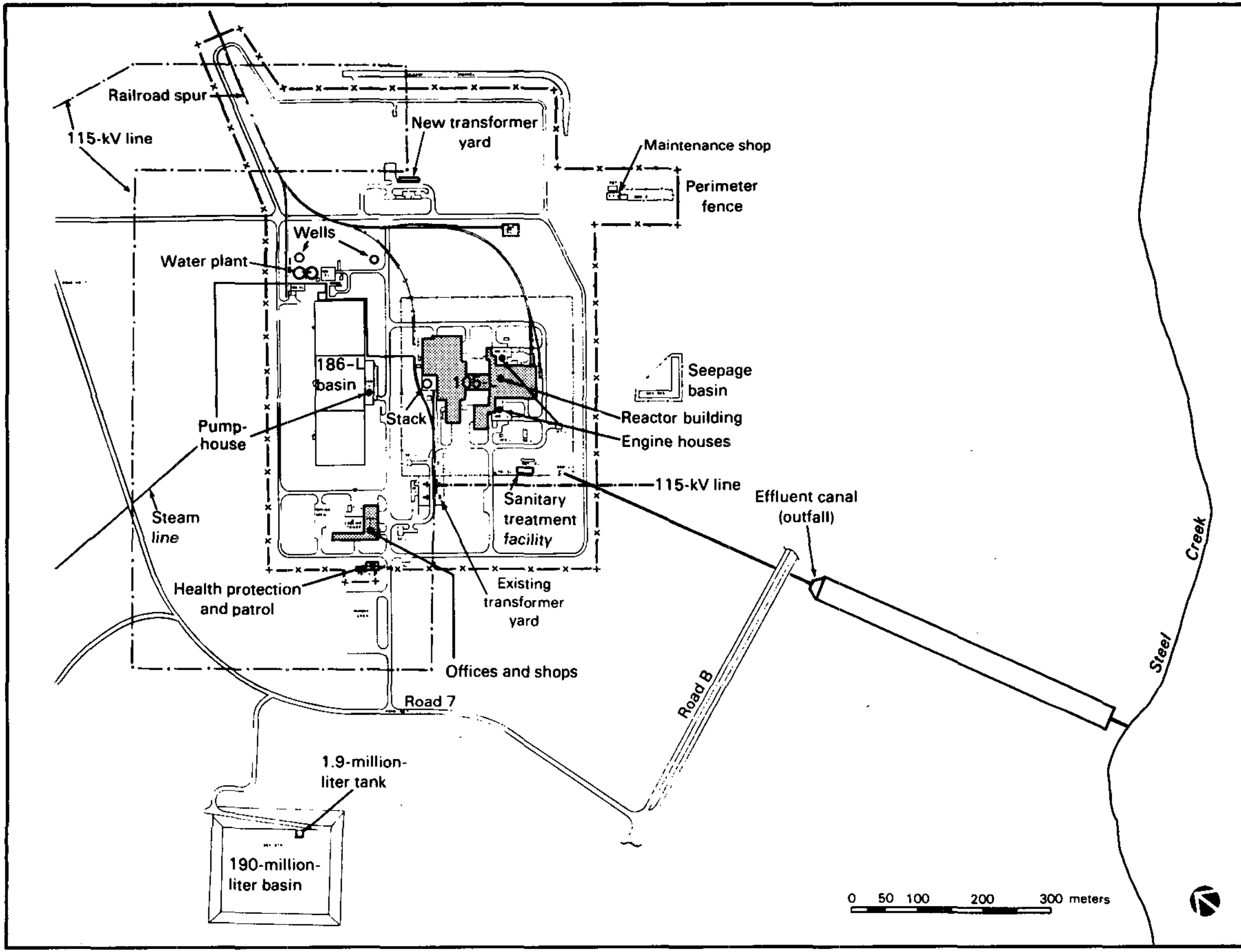



Figure 2-2. Major L-Area structures.

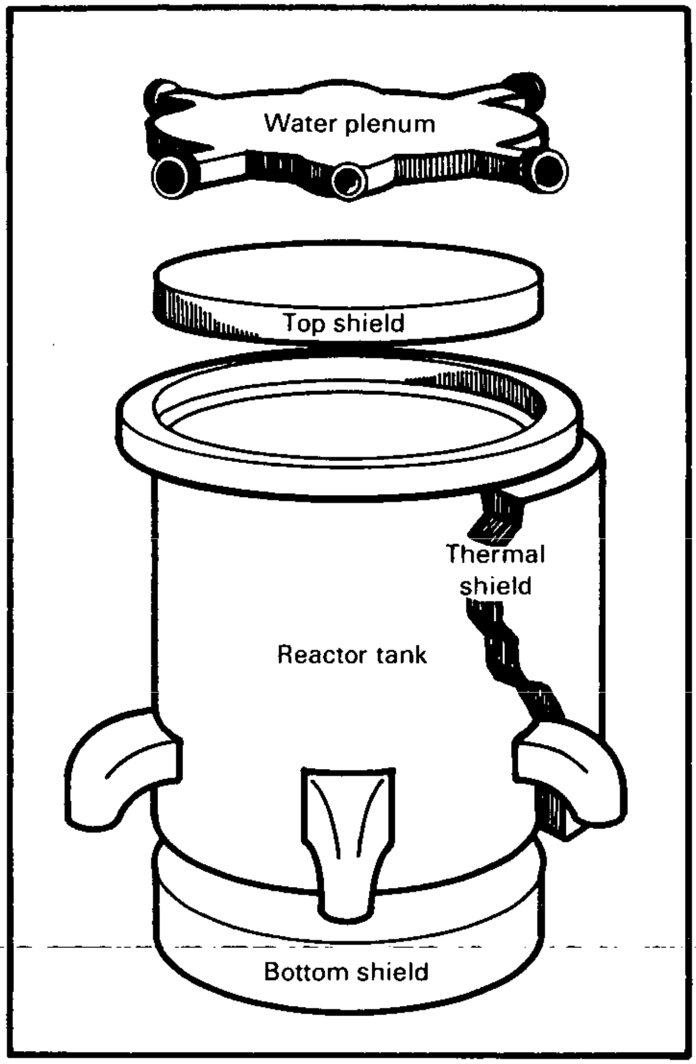



**Figure 2-3. Schematic of reactor structure.**

Neutron flux in the reactor is controlled by neutron-absorbing rods in 61 positions; each position contains seven individually motor-driven control rods. These control rods can be moved in gangs (groups) for simultaneous positioning, or individually in sequence. Two half-length rods in each position control the vertical flux distribution; full-length rods control overall power and the radial flux distribution.

Process monitoring and reactor control is accomplished from a central control room. The reactor can be controlled manually by an operator or automatically by an online computer.

Table 2-1 lists average values of the operating parameters for a typical L-Reactor charge.

Table 2-1. Typical L-Reactor operating parameters

| Parameters | Value |
|---|---|
| Lattice--Mark 16-31 | |
| Fuel | Enriched uranium |
| Target | Depleted uranium |
| Power | 2350 megawatts thermal |
| Primary coolant | |
| Fuel temperature | 113°C |
| Target temperature | 85°C - 110°C |
| Coolant flow | 8780 liters/second |
| Pressure | 34,000 pascals gauge (5 psig) |
| Secondary coolant | |
| Outlet temperature | Up to 80°C |
| Coolant flow | 11 $m^3$/second |

| TE

Primary coolant system

Heavy water ($D_2O$) serves as both a neutron moderator and primary coolant to remove heat from the nuclear fission process. The heavy water is circulated through the reactor by six parallel pumping systems. In each system, about 1600 liters per second are pumped from one of six outlet nozzles at the bottom of the reactor, through two parallel heat exchangers, and into one of six inlet nozzles in the water plenum above the reactor. All components of the $D_2O$ system, except the pump seals, are made of stainless steel. The L-Reactor produces no electric power, which allows it to operate without the high temperatures and pressures needed in power reactors.

Each of the six circulating systems contains a double-suction, double-volute centrifugal pump rated at 1600 liters per second at a total pressure head of 128 meters of water. Each circulating pump is driven by a 2500-kilowatt, squirrel-cage alternating-current (a.c.) induction motor drawing 125 amperes at full load. Pumps and motors are separated into groups of three in two pump rooms and two motor rooms. Each motor also drives a 2.7-metric-ton flywheel that stores enough energy to continue pumping heavy water for about 4 minutes if there is a loss of a.c. power. Power for the a.c. motors is supplied from either of two substations.

Backup pumping capacity for heavy-water circulation is provided by six direct-current (d.c.) motors; they are normally online when the a.c. motors are operating. If a.c. power fails, each d.c. motor will drive a pump to provide about 25 percent of the normal flow, enough to remove residual heat from the shutdown reactor. Each d.c. motor is connected directly to its own online diesel generator; two generators are kept in reserve.

Limits on pD (the heavy-water equivalent of pH), conductivity, and impurity levels of the heavy water are maintained to control the corrosion of aluminum and stainless steel and to reduce the decomposition of the heavy water. Sustained reactor operations at Savannah River Plant have demonstrated that the corrosion rate of aluminum components and the associated problems of high radioactivity and turbidity in the process systems can be reduced substantially by controlling pD. To minimize aluminum corrosion, nitric acid is added to the heavy water through a pump suction line to maintain a heavy-water pD of about 5.2. Because some of the acid is neutralized as the process water flows through the purification deionizers (causing the pD to increase), periodic injections of nitric acid are necessary.

Secondary coolant system

Each of the six heavy-water pumping systems contains two parallel, single-pass heat exchangers to transfer heat from the heavy water (primary coolant) to secondary cooling water drawn from the Savannah River and discharged to Steel Creek, where it flows back to the Savannah River. Water is taken from the Savannah River at two pumphouses and delivered to the L-Area cooling-water reservoir (186-Basin) with flows at approximately 11 cubic meters per second. An alternate tie-line provides an emergency supply of cooling water from the river to the reservoir if the primary line from the river fails. Without a supply of water from the river, the reservoir can cool the reactor in the shutdown mode for 1 to 2 weeks by recirculation.

A pumphouse adjacent to the reservoir delivers water to the reactor building. If pumphouse power is lost, the options available to deliver water to the reactor building include (1) gravity flow from the reservoir through the pumphouse, (2) gravity flow from the reservoir to the emergency pumps in the reactor building via a bypass line, (3) forced flow from the river pumphouses using a pipeline that bypasses the reservoir and delivers cooling water directly to the reactor building, (4) recirculation of reservoir water with the emergency pumps, and (5) recirculation of disassembly-basin water with the emergency pumps.

The effluent cooling water flows from the reactor building to the effluent sump. As much as 0.70 cubic meters per second can be recirculated. Normally, the water overflows a weir in this sump and flows to Steel Creek.

Core reloading

New fuel is received and stored in the reactor assembly area. Racks and hangers maintain adequate spacing for criticality control; an additional safety margin for assemblies containing fuel is provided by storage in racks constructed of material that contains boron, a neutron absorber. Moderating materials are strictly controlled in the assembly area to prevent criticality. Procedural controls limit the type and amount of material in process at any time.

The equipment for core reloading includes an inlet conveyor, a charge machine, a discharge machine, and a deposit-and-exit conveyor. The charge and discharge machines are similar, and each can perform most of the functions of the other; however, only the discharge machine can provide heavy- or light-water cooling to an irradiated assembly. Both machines travel on tracks on two parallel ledges that are part of the reactor-room wall; power for their operation is provided through cables along the ledges.

Reloading operations are conducted from a control room adjacent to the reactor control room. The charge and discharge machines can be operated manually or automatically via an automatic tape-control system. Graphic displays on the control console track the location and operation of the machines.

## Fuel discharge and storage

Fuel and target assemblies are discharged from the reactor by the discharge machine. Four sources of water are available on the discharge machine to cool an assembly during the discharge operation--primary $D_2O$, primary $H_2O$, secondary $D_2O$, and secondary $H_2O$. The primary and secondary sources supply water through different paths to the assembly. Cooling starts automatically when an irradiated assembly is completely withdrawn from the reactor; it can also be maintained if an assembly sticks during withdrawal.

For each type of assembly, an upper limit is specified for heat-generation rate at the time of discharge; discharge of an assembly does not start until the heat-generation rate of the assembly has decayed to this upper limit.

The deposit-and-exit conveyor, located in a water-filled canal connecting the reactor room and the disassembly basin, receives an assembly from the discharge machine and carries it under the reactor room wall to a water-filled disassembly basin for temporary storage.

Irradiated assemblies are stored in the disassembly basin to allow radionuclides and heat to decay to a level low enough for shipment to the separations facilities. The assemblies are cooled by natural convection; hangers allow this cooling while maintaining adequate spacing for criticality control. The basin water also provides shielding of radiation from the assemblies. Procedural controls and instrumentation prevent shipment of insufficiently cooled assemblies.

## Blanket-gas system

The blanket-gas system, which uses helium (an inert gas), is the initial barrier to the release of radioactive gases from the reactor. This system has three primary functions: (1) to dilute deuterium and oxygen evolved from the moderator (due to radiolysis) to a nonflammable concentration, (2) to recombine the deuterium and oxygen constituents of the gases evolved to heavy water, and (3) to maintain the pressure in the moderator (pressurize the gas plenum of the reactor to about 34,000 pascals gauge (5 psig) and thus increase the heavy-water saturation temperature). Helium is used as the blanket gas because it neither reacts with moderator decomposition products nor absorbs neutrons to produce radioactive gases.

During operation, gases evolve from the reactor and enter the gas plenum. From the plenum, the gases are routed to catalytic recombiners and spray separators where the deuterium and oxygen are recombined and most of the entrained heavy water is removed from the helium and returned to the reactor. The helium is then returned to the gas plenum.

Activity-confinement system

During reactor operation, the process areas are maintained at a pressure lower than the pressure of the external atmosphere to ensure that all air from the process areas is exhausted through the activity-confinement system (Du Pont, 1982). As shown in Figure 2-4, the air from these areas is exhausted through a set of confinement filters before it is released to the 61-meter stack.

Three large centrifugal fans exhaust the air from the process areas. Two of these fans normally are online, but only one is necessary to maintain the negative pressure. Fan motors can be powered by two electric sources:

1. Normal building power, from at least two substations
2. Emergency building power, from diesel generators

In addition, each has a backup motor; the backup motors for any two of the fans can be powered simultaneously by automatically starting diesel generators.

Exhaust filters remove moisture, particulates, and halogens. The filter banks are enclosed in five separate compartments, three to five of which are online during operation. Each compartment can be isolated for maintenance and/or testing; each contains filter banks, in the following order of air-flow treatment:

1. Moisture separators--designed to remove about 99 percent of entrained water (spherical particles measuring 1 to 5 microns) to protect against significant blinding of the particulate filters.

2. Particulate filters--designed to retain more than 99 percent of all particulates with diameters of 0.3 micron or larger.

3. Activated carbon beds--impregnated carbon designed to retain halogen activity.

Liquid-radwaste system

The chemical purity of the moderator is maintained to minimize heavy-water radiolysis and to minimize the corrosion rate of aluminum and stainless steel in the reactor; in addition, moderator impurities absorb neutrons that otherwise would be utilized in the production of nuclear materials. The neutron activation of moderator impurities and corrosion products, along with any fission products released by fuel failures, contributes to the overall activity level in the moderator.

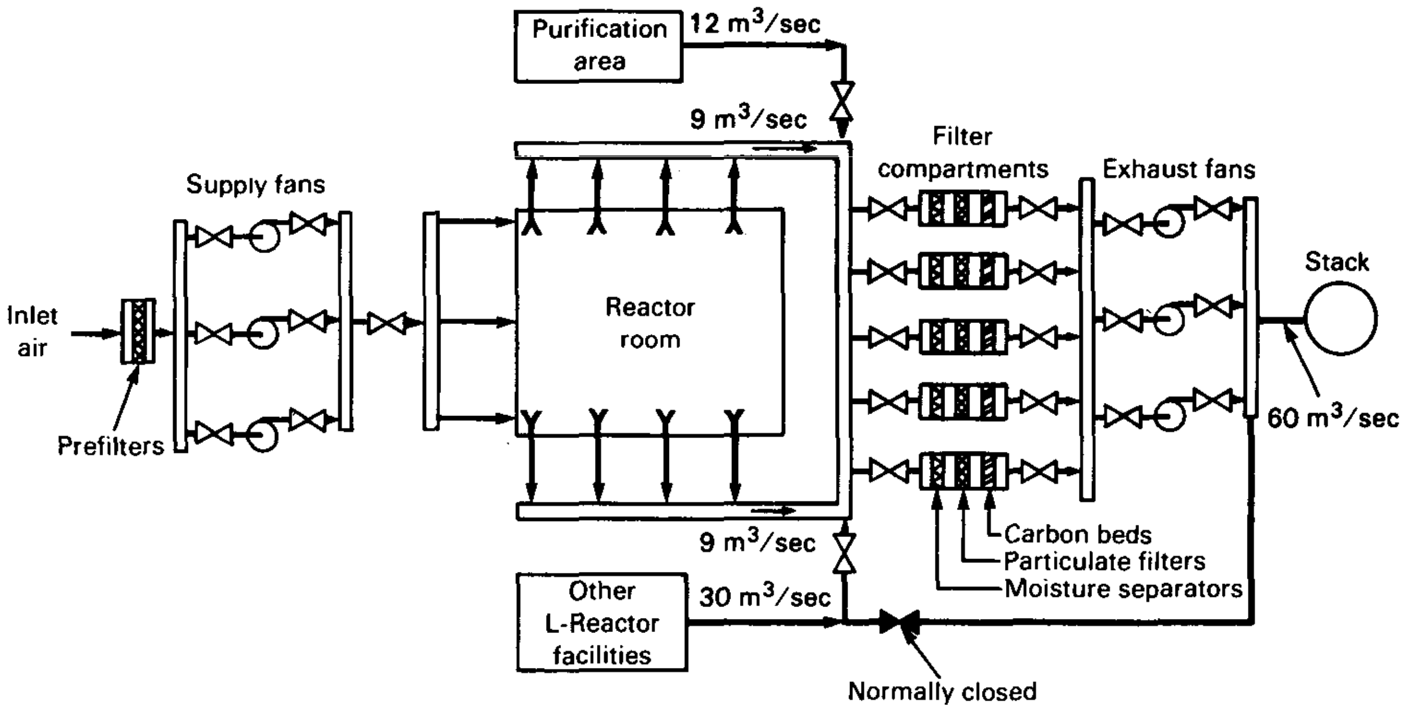



**Figure 2-4. Reactor confinement system.**

The moderator is continuously purified by circulation of a side stream to a purification area to be deionized and filtered. Most of this side stream is returned to the reactor; a small amount is distilled to remove light water ($H_2O$).

The purification system circulates about 1.9 liters per second through a pre-filter, a deionizer, and an after-filter. The deionizer contains deuterized cation and anion exchange resin. The filters retain particles larger than 10 microns in diameter.

The filters and deionizers are located in a shielded cell area. Radioactive impurities are concentrated in disposable filter and deionizer units. Vessels containing spent deionizer are remotely loaded into heavily shielded casks for transport to a facility for the eventual recovery of deuterium oxide. After processing, these vessels are sent to the burial ground for disposal.

Part of the reactor side stream is diverted to the distillation area for removal of light water.

An evaporator system removes particulate matter from deuterium oxide from the distillation column reboiler purge. No facilities are currently available to remove tritium from the reactor moderator. When the deuterium oxide distillation columns are emptied for maintenance or repair, the water is either collected in a tank to be reused or drummed to be reworked at the heavy-water production plant.

Target and spent-fuel assemblies removed from the reactor are rinsed in the discharge machine. The rinse water is collected by the discharge machine-water pan and sent to the 2270-liter rinse collection tank. Rinse water is drummed and reworked.

Some radioactivity is transferred from the irradiated assemblies to the water in the disassembly basin, even after rinsing. Periodic purging of the basin water is necessary to reduce the radiation exposure to operating personnel from the accumulation of tritium. During the purging operation, water from the basin is passed through two deionizer beds in series, and monitored before it is discharged to a low-level radioactive seepage basin. This process reduces the release of any radioactivity other than tritium to the seepage basin. The spent resin from the deionizer beds is regenerated in the chemical separations areas, and the spent regenerant is concentrated and stored in high-level radioactive waste tanks in the separations areas.

Two sand filters maintain the clarity of the disassembly-basin water. Particulate matter in the basin water tends to agglomerate and adsorb radioisotopes. When the basin water passes through the sand filters, the particulate burden is reduced. The filtration rate can vary from 32 to 95 liters per second, depending on the initial fluid clarity and the demand for treatment. When the differential pressure across the filter beds indicates the need, a filter can be isolated and backflushed. Backflushed radioactive material is transferred to the chemical separations area for concentration and storage in high-level radioactive waste tanks.

Solid radwaste

Contamination from induced activity accounts for most low-level solid waste. Work clothing, plastic sheeting, and kraft paper also become contaminated when they are used for occupational protection. Such material comprises most of the low-level waste; irreparable valves, pipe sections, pumps, instruments, and aluminum and stainless-steel reactor components also constitute such waste. Solid waste is packaged for disposal in the SRP burial ground.

2.2.2.6 Reactor shutdown systems

L-Reactor will have the same defenses against reactivity transients that other SRP reactors have. These defenses include flow and temperature sensors for each fuel assembly, which are monitored by redundant computers. The computers will rapidly detect any reactivity transient that might begin and will cause the normal control rod system to insert to safely terminate the transient--the first line of defense. If the control rod system fails to terminate the transient, the computers will activate the safety rod drop system that will shut down the reactor within about 1 second--the second line of defense. If the safety rods do not rapidly shut down the reactor, the computers will automatically activate the injection of liquid "poison" into the reactor moderator/coolant to accomplish the same safe shutdown--the third line of defense.

Scram systems

Scram circuits monitor reactor operating variables and will cause safety and control rods to be inserted into the reactor if abnormal conditions exist. The scram instruments for a particular variable (e.g., neutron flux, coolant pressure) are set to produce a scram at the operating limit imposed for safe operation. A reactor scram at the setpoint will prevent damage to the fuel, the reactor, or the confinement system.

Supplementary safety system

The supplementary safety system (SSS) is fully independent, acting as a backup shutdown system. The SSS can be actuated manually; it is actuated automatically if safety rods fail to shut down the reactor. When the system is activated, gadolinium nitrate, an efficient neutron absorber, is injected into the moderator. The SSS is designed such that the reactor can be maintained in a subcritical mode even if all safety and control rods are in the fully withdrawn condition. The system has redundant tanks, piping, and valves.

Automatic backup shutdown-safety computer (ABS-S/C).

The ABS-S/C actuates the SSS if safety rods fail to shut down the reactor quickly following a scram signal. It uses logic programmed into the two redundant safety computers. The ABS-S/C should prevent damage to the reactor structure for all postulated transients.

Automatic backup shutdown-gang temperature monitor

The gang temperature monitor (GTM) automatically actuates the SSS if temperatures in selected monitored positions exceed prescribed limits.

2.2.2.7 Engineered safety systems

Emergency cooling system (ECS)

The ECS removes decay heat following a reactor shutdown by adding light water directly to the reactor core if heavy-water coolant or circulation is lost. Four sources of light water are available; two have to be online for full-power reactor operation:

1. A diesel-driven booster pump that supplies $H_2O$ from the 95-million-liter 186-L basin

2. A 107-centimeter diameter header pressurized by five pumps drawing $H_2O$ from the 95-million-liter basin

3. An additional 107-centimeter header pressurized by five pumps

4. A pipeline from the river pumphouse direct to the reactor, pressurized by the river water pumps

The ECS can be actuated manually, or automatically by falling liquid levels in the reactor tank. When the ECS is actuated, the diesel-driven booster pump starts, and valves are automatically opened or closed to couple the reactor system with the primary sources of light water. If the booster pump does not start, the other sources of emergency cooling are sufficient to cool the reactor.

Water removal and storage

If the heavy-water system ruptures, heavy and light emergency cooling water would flow to sump pumps in the basement of the reactor building. Water from the sump is pumped first to a 225,000-liter underground tank; the flow then goes to a 1.9-million-liter tank in the 190-million-liter emergency earthen basin. Some of the water on the 0-foot-level process room floor would drain directly to the 1.9-million-liter tank. If this tank should become full, the additional water would flow into the emergency basin. The 1.9-million-liter tank is vented to the activity confinement system in the reactor building.

Remote control station

A remote control station for all four reactors, located 18 kilometers from L-Area, is manned full time. The station is a data display and control facility for reactors; it can provide remote control of reactor cooling and activity confinement systems for a shutdown reactor if the control room in the reactor building cannot be occupied.

The Power Department operators who normally work in the remote control station are trained to perform routine data acquisition tasks, to check abnormal condition indications, and, in certain circumstances, to initiate incident action and request staffing of the station by Reactor Department supervisors. These supervisors perform all other control actions after they staff the station.

Data and control signals are transmitted through underground electrical cables that link the remote control station with each reactor area.

Approximately 90 indications of the status of equipment (such as on, off, open, and closed) are displayed on the remote control station panel for each reactor area. Any change of equipment status will cause an audible alarm and a flashing light to indicate the piece of equipment involved. These alarms are divided into categories that indicate the severity or importance of the event. Category I and II alarms indicate that a reactor incident either exists or is possible. All other alarms fall under Category III. In addition to the status-of-equipment indications, the values of approximately 50 process variables can be displayed on the remote control station panel for each reactor area.

If the remote control station receives a Category I or II alarm, the Power Department operator attempts to communicate with the reactor control room personnel in the affected area; if the operator cannot establish communication, he or she executes an "enable" control function for remote control operation. This action causes visible and audible signals in the reactor control room to alert EN-30
the operators there that an enable function has been requested. The reactor operating crew then must execute a "disable" function; if this is not done, the enable function is granted automatically and remote control capability is established. If the Power Department operator in the remote control station observes the indication that the enable function has been granted, he or she trips the incident switch and requests staffing of the remote control station with Reactor Department supervisors by communicating with the unaffected reactor areas. The reactor operator takes immediate actions to place the reactor in a safe condition before the transfer of control to the remote control station. The Power Department operator then begins recording data that will be useful in analyzing the incident situation. The operator follows written procedures for all these actions.

When Reactor Department supervisors arrive at the remote control station, they examine the data, alarm indications, etc., and then follow procedures to analyze and control the incident (e.g., increase fuel cooling, minimize $D_2O$ leakage, minimize pump and motor room flooding, adjust ventilation dampers) to minimize any activity release from the reactor building and reactor area.

Power Department operators also report Category III alarms and any other situation that is abnormal to the affected area. They also routinely display and record process data to ensure the operability of the systems. Functional checks of key equipment are made periodically to ensure the operability of the remote control equipment.

2.2.2.8 Support systems

Electric power

Normal supply. Electric power from the SRP power grid is supplied to the L-Area by two independent 115-kilovolt transmission lines. In the event of a power failure, a supervisory control cable running along these lines enables the power dispatcher to monitor and switch equipment on the plant grid. Three 30,000-kilovolt-ampere transformers in the L-Area are connected to the 115-kilovolt grid. Each transformer can carry the L-Area load.

Emergency supply. Two 1000-kilowatt a.c. generators supply emergency power to the reactor building. Eight 103-kilowatt d.c. generators supply power to the process pump motors that maintain the heavy-water cooling flow to the reactor if the normal a.c. power fails; normally, six of these generators are operated at all times, and the remaining two are on standby. Four other diesel generators are located throughout the L-Area to provide backup power for ventilation fans, lights, and other equipment. Reactor shutdown systems, including scram circuits, safety and control rod drives, and the Supplementary Safety System, are also backed up by online batteries.

Steam

Steam is supplied to the L-Reactor facility for process service and ventilation heat. An interarea pipeline supplies steam from the K-Area powerhouse.

Potable water

Potable water is supplied to the L-Area from two deepwells producing from the Tuscaloosa Formation. This is also the source for clarified service water, filtered water, and domestic and fire-control water. The water is processed in a treatment plant before use.

Sanitary sewage

Sanitary sewage is processed by a secondary treatment plant using an extended aeration-activated sludge process. The plant is large enough to meet the demands placed on it during normal operations by the L-Area workforce. Chlorinated discharges from the treatment plant are sent to the process sewer, which discharges to Steel Creek. Sludge from the treatment plant is trucked to an existing sludge pit near the Central Shops area.

## 2.2.3 Process and effluent monitoring

All gaseous radioactive releases through the L-Area stack are monitored continuously. Stack effluent tritium is monitored by two ion chambers in parallel flowpaths. A continuous sampling technique with daily quantitative analysis is also used. All other air and water samples are monitored routinely and quantitative release records are kept. An above-normal activity level is investigated to locate the source so the condition can be corrected. The secondary cooling water discharged from the reactor heat exchangers is monitored continuously to detect any radioactivity leakage from the primary coolant.

Nonradiological samples are collected in accordance with the National Pollutant Discharge Elimination System (NPDES) permit (Section 6.2.1).

## 2.3 NO-ACTION ALTERNATIVE

L-Reactor has been maintained on standby since 1968. The no-action alternative is defined as the continued maintenance of the L-Reactor facility in the current ready-for-operation standby mode, which includes testing of flows as high as 6.1 cubic meters per second (the maximum flow recorded prior to June 28, 1983). This is consistent with the restarting definition given in the Energy and Water Development Appropriations Act, 1984:

> For purposes of this paragraph the term "restarting" shall mean any activity related to the operation of the L-Reactor that would achieve criticality, generate fission products within the reactor, discharge cooling water from nuclear operations directly or indirectly into Steel Creek, or result in cooling system testing discharges which exceed the volume, frequency and duration of test discharges conducted prior to June 28, 1983.

If L-Reactor is to be maintained in this standby mode, any improvements made to the other SRP reactors will also be made to L-Reactor. The adoption of this alternative would not meet the established need for nuclear material for national defense purposes described in Appendix A (classified). The no-action alternative, therefore, is not responsive to the Presidential mandate.

Maintaining L-Reactor in a standby mode would have the following environmental impacts (Turcotte, Palmiotto, and Mackey, 1983):

- Water would be withdrawn from the Savannah River on a periodic basis for hydraulic testing and flushing of cooling systems.
- Nonthermal effluents would be discharged to the Savannah River via Steel Creek during hydraulic testing and flushing.
- Sanitary wastes from the secondary treatment facility would be discharged to Steel Creek.
- Nonradiological atmospheric emissions would continue as present from the K-Area power plant to supply L-Area with steam.
- Unsalvageable domestic trash would be disposed of in the SRP landfill.
- The L-Reactor workforce would be maintained at the ready-for-operation standby mode (approximately 100 people).

## 2.4 SUMMARY OF ALTERNATIVES*

This section summarizes the L-Reactor alternatives and the mitigation alternatives considered in Chapter 4 of this EIS.

### 2.4.1 Mitigation alternatives

Section 4.4 describes the L-Reactor mitigation alternatives for safety systems, cooling water, disassembly-basin water disposal, and 186-basin sludge removal.

#### 2.4.1.1 Safety system alternatives

L-Reactor, like the other SRP operating reactors, is equipped with a confinement system to treat radioactive releases due to routine operation and potential accident situations. Alternative systems to further reduce such releases, especially during accident situations, were evaluated and compared, as listed in Table 2-2. Due to the expected low risk of L-Reactor operation, the high cost/benefit ratio, and the long lead time for the installation of alternatives, DOE has identified the existing confinement system as its preferred safety system alternative.

#### 2.4.1.2 Cooling-water alternatives

Thirty-three alternative cooling water systems are evaluated in Section 4.4.2. These alternatives can be grouped into five major categories--once-through cooling lake, recirculating cooling lake, once-through cooling tower, recirculating cooling tower, and direct discharge. This section summarizes the engineering and environmental evaluations for the most favorable alternative for each of these categories. This approach enables the reader to evaluate and compare a range of reasonable alternatives, thus defining the issues and providing a clear basis for choice among alternatives. The criteria used in selecting the most representative alternatives are the ability to meet South Carolina water-quality standards, production considerations, schedule, environmental factors, and cost. The ability to expedite the schedule was also considered for these alternatives, as was the degree that reactor operation must be modified to meet State of South Carolina water-quality standards.

Table 2-3 compares engineering and environmental factors for the five alternative cooling-water systems (i.e., once-through 1000-acre lake, recirculating 1300-acre lake, once-through 2.8°C approach temperature cooling tower, a recirculating 2.8°C approach temperature cooling tower with treatment of blowdown, and direct discharge). While the cooling tower would cause fewer

*Because Section 2.4 is new, it does not require vertical change bars.

Table 2-2. Comparison of safety system alternatives (primarily confinement/containment options)

| System | Technical feasibility | Estimated costs ($MM)[a] Capital[b] | Production Loss[c] | Total | Benefit person-rem averted[d] (3% melt) | Cost/benefit[e] ($ per person-rem averted) | Timing (months to complete) |
|---|---|---|---|---|---|---|---|
| Existing confinement system | Demonstrated and proven | Installed | None | Installed | -- | Reference | Installed |
| Remote storage system | Not demonstrated | 250 | 25 | 275 | 445 | 620,000 | 24 |
| Low temperature adsorption system | Not demonstrated | 90 | 50 | 140 | 460 | 300,000 | 36 |
| Tall stack | Demonstrated | 50 | 15 | 65 | 175 | 370,000 | 15 |
| Internal containment | Questionable | 250 | 150 | 400 | 455 | 880,000 | 48 |
| Leaktight dome | Questionable | 850 | 50 | 900 | 450 | 2,000,000 | 36 |

[a]MM - millions of dollars.

[b]Rough estimates escalated to 3Q FY 1988 construction midpoint.

[c]Rough cost of production lost during construction at $150,000 per reactor-day.

[d]Assumes hypothetical accident (3-percent melt) occurs. Dose within 80-kilometer radius from reactor (2500 megawatts accident). 50 percent meteorology. Benefit = (dose with existing confinement system - dose with alternative system) = person-rem averted.

[e]The expected cost/benefit considering the probability of the accident is at least one million times greater than the values listed here.

Table 2-3. Comparison of cooling-water alternatives

| Evaluation factors | Once-through cooling lake (1000 acres) | Recirculating cooling lake (1300 acres) | Once-through cooling towers (2.8°C approach) | Recirculating cooling tower (2.8°C approach and treatment of blowdown) | Direct discharge |
|---|---|---|---|---|---|
| Schedule for implementation | 36-month construction schedule could be accelerated to complete lake in one construction season (6 months). | 40-month construction schedule could be accelerated to complete lake, but would take longer (two construction seasons, i.e., about 18 months) than 1000-acre due to construction of recirculating system, road relocation, and additional embankments. | 27-month construction schedule might be accelerated to complete the cooling tower in slightly more than 1 year. | 27-month construction schedule; cannot be accelerated because of long-lead-time procurement of pumps. | Would not require any additional time for implementation. |
| Preliminary cost capital (million $) | 25 | 73 | 50-55 | 75 | 0 |
| Operating (million $/ year) | 3.4 | 2.9 | 5.5 | 3.2 | 3.4 |
| Thermal compliance | Would meet South Carolina water-quality standards with changes in operating power levels. | Would meet South Carolina water-quality standards with changes in operating power levels. | Would meet South Carolina 32.2°C standard but variance would be required from $\Delta T$ of 2.8°C requirement. | Would meet South Carolina water-quality standards. | Would require reclassification of Steel Creek to be permittable. |

Table 2-3. Comparison of cooling-water alternatives (continued)

| Evaluation factors | Once-through cooling lake (1000 acres) | Recirculating cooling lake (1300 acres) | Once-through cooling towers (2.8°C approach) | Recirculating cooling tower (2.8°C approach and treatment of blowdown) | Direct discharge |
|---|---|---|---|---|---|
| Modification to operation | Power reduction would be necessary between late spring and early fall to maintain balanced biological community in lake. Average annual 14% power reduction. Amenable to installation of precoolers (~$10M capital) that would allow an increase in power efficiency. | 4% inherent operating power loss. Greater than 14% power loss to maintain a balanced biological community. | Operating power of 100%; infrequent periods (once in 4.5 years) might require some reductions. | Higher temperature of recirculating cooling water would cause a reduction in operating power levels; averages 6.5% power reduction. | Operating power of 100%. |
| <u>Environmental Factors</u> | | | | | |
| Thermal effects | Balanced biological community in the lake. Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects downstream from embankment. | Same as for once-through 1000-acre lake. | Steel Creek corridor, delta, and Savannah River swamp protected from thermal effects. | No effects expected. | Steel Creek corridor, delta, and Savannah River swamp to be thermally impacted. Zone of passage to remain in the Savannah River. Also, there is a serious thermal shock effect. |

Table 2-3. Comparison of cooling-water alternatives (continued)

| Evaluation factors | Once-through cooling lake (1000 acres) | Recirculating cooling lake (1300 acres) | Once-through cooling towers (2.8°C approach) | Recirculating cooling tower (2.8°C approach and treatment of blowdown) | Direct discharge |
|---|---|---|---|---|---|
| Discharge flow effects | 11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment. | About 0.5 cubic meter per second to be discharged below embankment. Erosion and wetland impacts downstream of embankment very small. | 11.0 cubic meters per second. Erosion and delta growth would be greater than the 1000-acre lake due to erosion over longer reach of Steel Creek. | About 0.6 cubic meter per second; erosion and wetlands impacts downstream of embankment very small. | 11 cubic meters per second to be discharged. Flow will impact downstream wetlands and will cause increased streambank erosion and delta growth below embankment. |
| Habitat impacts | 735 to 1015 acres of wetlands would be affected by inundation or flow effects. 775 acres of uplands inundated. | 240 acres of wetlands and 1060 acres of uplands would be inundated. | 635 to 915 acres of wetlands would be effected by inundation and flow effects. | Slight impacts to wetlands. | Direct discharge will eliminate between 730 to 1000 acres of wetlands in the Steel Creek corridor, delta, and Savannah River swamp. |
| Water withdrawal | About 11 cubic meters to be withdrawn from the Savannah River. | About 1.8 cubic meters per second to be withdrawn from the Savannah River. | Same as 1000-acre once-through lake. | About 1.4 cubic meters per second to be withdrawn from the Savannah River. | Same as 1000-acre once-through lake. |
| Entrainment/ impingement | Water withdrawal will cause impingement of an additional 16 fish per day and entrainment of 3 to 6% of fish eggs and larvae passing SRP intakes. | Water withdrawal will cause impingement of less than 3 fish per day and entrainment of 0.5 to 2% of fish eggs and larvae passing SRP intakes. | Same as 1000-acre once-through lake. | Slightly less than recirculating cooling lake. | Same as 1000-acre once-through lake. |

Table 2-3. Comparison of cooling-water alternatives (continued)

| Evaluation factors | Once-through cooling lake (1000 acres) | Recirculating cooling lake (1300 acres) | Once-through cooling towers (2.8°C approach) | Recirculating cooling tower (2.8°C approach and treatment of blowdown) | Direct discharge |
|---|---|---|---|---|---|
| Endangered species | Habitat for American alligator and wood stork to be affected. Consultations with U.S. Fish and Wildlife Service in progress. | Habitat for American alligator affected; foraging habitat for wood stork not affected. | Same as 1000-acre once-through lake. | No impacts to endangered species. | Same as 1000-acre once-through lake. |
| Radiocesium remobilization | Radiocesium releases primarily related to flow. Maximum release to be no more than 4.4 curies in first year. Release within applicable standards. | Radiocesium releases would be smaller due to reduction in the amount of water discharged. Maximum release would be about 0.8 curie in the first year. | Radiocesium release would be smaller than for 1000-acre once-through lake and direct discharge. Maximum release would be 3.3 curies in the first year. | Same as 1300-acre recirculating cooling lake. | Radiocesium releases due to both hot water and flow effects. Maximum release to be about 4.4 curies in first year. Release within applicable standards. |
| Archeological sites | Four sites would be protected by monitoring and mitigation. One site to be flooded; recovery plan approved. Further surveys identified 10 potentially significant sites; mitigative measures to be taken as appropriate. | Same as 1000-acre once-through lake. | Five sites would be protected by monitoring and mitigation. | No archeological sites would be impacted. | Same as once-through cooling towers. |

environmental effects, the Department of Energy has identified the once-through 1000-acre lake as its preferred cooling-water alternative, because it would:

1. Meet all State and Federal regulatory and environmental requirements, eliminating thermal impacts on the river, swamp, and unimpounded stream, while providing a productive balanced biological community in the lake

2. Provide the earliest reactor startup and the maximum plutonium deliveries of any environmentally acceptable cooling-water alternative that would meet regulatory requirements

3. Have the lowest costs of any environmentally acceptable cooling-water alternative that would meet regulatory requirements

4. Be amenable to backfitting with precooler systems, if needed, which could improve reactor operational flexibility and the production capability

The 1000-acre lake's expected environmental effects were bracketed by the cooling-water alternatives analyzed in the Draft EIS (i.e., a once-through 500-acre lake, a 1300-acre recirculating lake, and modified reactor power operation).

### 2.4.1.3 Disposal of disassembly-basin purge water

The disassembly-basin water is treated by ion exchange and sand filter/clarifier systems to remove radionuclides and to maintain water clarity. The disassembly-basin water is purged periodically to maintain an acceptable tritium concentration in the room air so the occupational exposure can be kept as low as reasonably achievable. The amounts of tritium entering the atmosphere and liquid pathways as a result of (1) discharge to the seepage basin, (2) discharge to Steel Creek, and (3) evaporation are listed in Table 2-4. These releases are predicted to occur after the tenth year of L-Reactor operation. During the first year, about one-tenth of these amounts will be released. Small amounts of radionuclides other than tritium will also be released to Steel Creek due to disassembly-basin purges.

Table 2-5 lists offsite doses from tritium and other radionuclides. Doses to the maximum individual from seepage-basin disposal are about half of those from a direct discharge to Steel Creek and twice those expected from the use of an evaporator. Estimated population doses from an evaporator are slightly lower than those from either discharge to the seepage basin or a direct discharge to Steel Creek. However, these differences are small.

There is little difference in cost between a discharge to the seepage basin and a direct discharge to Steel Creek; the cost of either method is small. Considering only operating costs, the cost-benefit ratio for installing an evaporator system is $42,000 per person-rem avoided in the offsite population doses; this is a costly alternative. The cost-benefit ratio for detritiation of the moderator is even greater per person-rem avoided (Section 4.4.5). Thus, DOE selected discharge to the seepage basin as its preferred alternative; at the

Table 2-4. Tritium releases from disassembly-basin water disposal alternatives--tenth year

| Release pathway | Tritium releases (Ci) With seepage basin | Direct to Steel Creek | Evaporation |
|---|---|---|---|
| Atmosphere | 3,200 | -- | 11,000 |
| Steel Creek | 6,000 | 11,000 | -- |

Table 2-5. Offsite doses from disassembly-basin water disposal alternatives--tenth year

| Exposure pathway | With seepage basin | Direct to Steel Creek | Evaporator |
|---|---|---|---|
| MAXIMUM INDIVIDUAL (CHILD) DOSE (mrem/yr) | | | |
| Atmosphere[a] | 0.013 | -- | 0.044 |
| Liquid[b] | 0.074 | 0.15 | -- |
| Total | 0.087 | 0.15 | 0.044 |
| POPULATION DOSE (person-rem/yr) | | | |
| Atmosphere[a] | | | |
| 80-kilometer radius | 0.5 | -- | 1.9 |
| Liquid[b] | 8.6 | 15.9 | -- |
| Total | 9.1 | 15.9 | 1.9 |

[a]Tritium only released by atmospheric pathway.
[b]Radionuclides other than tritium also enter liquid exposure pathway.

same time, research and development activities for detritiation are continuing for a potential general application at the Savannah River Plant.

#### 2.4.1.4 186-Basin sludge disposal

Savannah River water is held in a 95-million-liter reservoir (186-basin) before it passes through the L-Reactor heat exchangers. Suspended solids contained in the river water settle out in the 186-basin and require removal to minimize the growth of the Asiatic clam, Corbicula, and blockage effects on the reactor heat exchangers. Four alternatives were considered for removal of the sludge: (1) batch discharge to Steel Creek, (2) land application, (3) borrow pit application, (4) continuous sediment suspension.

None of the alternatives would have an impact on L-Reactor restart following a scheduled extended shutdown. The "batch discharge to Steel Creek" and "continuous sediment suspension" alternatives would have no land use requirements, but could contribute to delta growth in the Savannah River swamp or filling of the cooling lake. The "borrow pit application" alternative would be limited to the number and capacity of retired borrow pits on the SRP.

The "batch discharge to Steel Creek" alternative would not require funds for construction activities; the other three alternatives would require funds for construction, equipment procurement, maintenance, and additional operating expenses. Thus, DOE has selected the batch discharge to Steel Creek as its preferred alternative. Batch discharge is presently allowed by the National Pollutant Discharge Elimination System (NPDES) permit issued to SRP by the South Carolina Department of Health and Environmental Control. This permit requires the conduct of a 1-year study to determine the potential environmental effects of batch discharge.

### 2.4.2 L-Reactor alternatives

TC The proposed action is to resume L-Reactor operation as soon as practicable to produce needed defense material (i.e., plutonium). No reasonable full production options have been identified to the restart of L-Reactor. In addition, no partial-production options or combination of options have been identified that can provide the needed defense nuclear materials requirements or that can fully compensate for the loss of the material that would be produced by L-Reactor. The Department of Energy's preferred alternative is to operate L-Reactor after the construction of a 1000-acre lake to cool the reactor thermal discharges to meet the water-quality standards of the State of South Carolina. The Department of Energy has changed the preferred alternative it presented in the Draft EIS (i.e., to operate L-Reactor with direct discharge to Steel Creek with subsequent mitigation) due to public comments and discussions with the South Carolina Department of Health and Environmental Control.

Table 2-6 compares the impacts for the preferred alternative, as described in Chapter 4, and those for the no-action alternative. The no-action alternative would not satisfy the established needs for defense nuclear materials.

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Cost | Increased capital costs of $25 million. Operating costs would be 3.4 million per year for the 1000-acre lake. | Direct costs of $10-12 million per year for maintenance. There would be no operating costs. |
| Fuel fabrication | Less than 33% increase in throughput, emissions, and effluents. | No change from present operations. |
| Chemical processing | Less than 33% increase in throughput, emissions, and effluents. | No change from present operations. |
| Waste management | Less than 33% increase in amount of waste processed and stored; operation of the DWPF by 1990 will eliminate need for new waste tanks to accommodate the liquid waste generated from the processing of nuclear material as a result of L-Reactor operation. | No change from present operations. |
| Land use and socioeconomics | An additional 1000 acres for the lake plus additional land during construction to support earthmoving and other construction activities. SRP workforce about 350 for L-Reactor; additional 550 temporary construction workers. | No additional land would be required; standby workforce of about 100 will be required; approximately 330 jobs would be lost. |
| Archeological sites | Four sites eligible for inclusion in the National Register might be affected; a resource recovery plan has been developed by the University of South Carolina Institute of Archeology and Anthropology for one historic site (38 BR 288), located within the proposed lake area. This mitigation plan has been approved by the SHPO and ACHP, which concurred that this plan will result in no adverse impacts to National Register properties. No sites considered eligible for the National Register have been located in association with embankment construction; archeologic studies in the lake area are continuing. It is expected that some significant sites associated with the Ashely Plantation might be found that will be in the lake. | Some erosion impacts are anticipated from cold-flow testing to the eligible sites. |

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Cooling-water system withdrawal | L-Reactor will withdraw about 11 cubic meters per second, or about 4% of the average annual flow rate and 7% of the 7-day, 10-year low flow of the Savannah River. Withdrawal will cause impingement of an additional 16 fish per day, and entrainment of about 3 to 6% of all fish eggs and larvae passing the SRP intakes when L-Reactor is operating under average conditions. | Testing and flushing of secondary cooling-water system approximately several days per month at flows up to 6.2 cubic meters per second; impingement and entrainment impacts during these test periods will be about one-half the impacts for the reference case. |
| Ground-water withdrawal | A total of 5.9 cubic meters per minute will be withdrawn from the Tuscaloosa aquifer for L-Reactor and the increment by its support facilities. Total ground-water withdrawal by SRP with L-Reactor operating is projected to be 7% greater than in 1982. Some ground-water recharge in surficial formations due to lake. | Ground-water withdrawal of 0.94 cubic meter per minute is required. |
| Ground-water quality | Ground-water quality in the Barnwell and McBean formations will be contaminated by releases from L-Reactor and its support facilities in the Separations Area (as much as a 33% increase from support facilities) to seepage basins. Contamination will flow to Steel and Four Mile Creeks. Radiological impacts are summarized in this table under "Radiation Risk to Public." Concentrations of nonradioactive contaminants in creek waters will be similar to concentrations in the Savannah River, except for lower pH and greater concentrations of nitrite and nitrate. The L-Reactor contribution to the M-Area seepage basin is expected to be 33% of the total (current) discharge. The ground-water remedial action project will be initiated in August 1984 with a capacity of three times the current | No release of radioactivity to the L-Reactor seepage basin, and no incremental increase in contaminants to the ground water in the Separations Area, or the M-Area. |

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Ground-water quality (continued) | discharges to the basin. This project, consisting of nine recovery wells and an air stripper, will intercept seepage from the basin where it reaches the water table in 10 to 17 years. The use of seepage basins at SRP is being considered on a sitewide basis. Use of the M-Area seepage basin will be discontinued by April 1985, when the discharges will be treated by a process wastewater-treatment plant. | |
| Air quality | Operational emissions would consist primarily of $NO_x$, $SO_x$, and particulate matter. L-Area power house was dismantled during standby period. Emissions from K-Area would increase by 10% to supply steam to L-Reactor. Some fugitive dust emissions during construction of embankment. No detectable impact on local or regional air quality is expected. | No change from present operations. No detectable impact on air quality would be expected. |
| Solid waste | All unsalvageable domestic trash would be packaged and disposed of in SRP landfill. Sanitary waste sludge would be disposed of at the SRP sludge pit. Bottom ash sluiced to the K-Area ash basin would increase by 10%. | No change from present operations (i.e., amounts of less than 10% of hose for L-Reactor operation would be disposed of in SRP landfill; sanitary waste sludge would be disposed of at the SRP sludge pit). |
| Thermal discharge to Steel Creek | L-Reactor will discharge about 11 cubic meters per second of cooling water to the 1000-acre lake. Fluctuating reactor power will assure a balanced biological community in the lake (i.e., maintain 32.2°C or less for about 50 percent of the lake). Conditions in Steel Creek below the embankment would not present any adverse impacts concerning access to, and the spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta, except perhaps in winter, when the water | No thermal discharges to Steel Creek; however, minor impacts during periods of testing would occur due to flooding and siltation. |

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Thermal discharge to Steel Creek (continued) | temperatures would be 7° to 9°C above ambient. These warmer temperatures could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in gradual heat loss in this area, which would minimize any cold shock effects. Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 1°C of ambient. The 1000 acres inundated by the lake will include 225 acres of wetland and 775 acres of upland. The flow rate would adversely impact 215 to 335 acres of wetland in the Savannah River swamp that provide foraging habitat for mallard and wood duck. The embankment and cooling lake would prevent access by riverine and anadromous fish to about 100 acres of wetlands along Steel Creek above L-Reactor. However, the only migratory fish in this reach of Steel Creek would be the American eel, which can access the lake. Access to Meyers Branch would not be affected by the lake. | |
| Thermal discharge to Savannah River | Average values of water temperatures at the mouth of Steel Creek are projected to be 28°C, 22°C, and 13°C during summer, spring, and winter, respectively. The 5-day, worst-case value during summer is projected to be 30°C or within about 1°C of ambient. There will be a zone of passage for the movement of fish up and down the river past SRP. | No thermal discharges to the Savannah River; therefore, no change in the present thermal plumes in the river. |
| Endangered species | Increased flow from the cooling lake would affect foraging habitat for the wood stork, and the habitat for the American alligator; additional habitat for alligator would be created by the lake; consultation with FWS continuing | Habitat for wood stork and American alligator could be affected intermittently during cold flow testing. No impacts to the shortnose sturgeon. |

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Endangered species (continued) | for both species; no impacts to shortnose sturgeon. | |
| Surface-water quality | Approximately 10% increase in discharges to K-Reactor area ash basins; sanitary wastes discharges to the lake after secondary treatment; liquid effluents discharged to Savannah River via the lake would have chemical characteristics similar to those of the river. | Some continuous nonthermal low flow and periodic nonthermal high flow releases to Steel Creek; liquid effluents would be within NPDES permit requirements. |
| Radiation risks to public | | |
| Routine operations | About 81,000 Ci of radioactivity, primarily tritium, would be released annually to the atmosphere from L-Reactor; about 7,900 Ci annually would be released directly and indirectly through a seepage basin and ground water flow path to surface streams and then to the Savannah River. The maximum individual dose would be about 0.60 millirem in the tenth year of operation; the dose to the population would be about 25.6 person-rem. Expected population doses would be about 0.02% of natural background. | No releases of radioactivity from L-Reactor. |
| Accidents | Accidents are highly unlikely; safety systems have been improved to further reduce the chance of an accident. Small additional risk due to possible embankment failure. | Extremely unlikely. |
| Radiocesium transport | About 4.4 Ci of radiocesium could be resuspended and transported from Steel Creek to the swamp and to the Savannah River and its floodplain 20-25% less each year thereafter. During the first year, radiocesium concentrations due to the restart of L-Reactor, after complete mixing in the river, would be about 0.5 pCi/liter, assuming average flow | Small amounts remobilized during periodic testing/flushing of secondary cooling system; maximum individual dose from this release would be 0.01 millirem per day of testing. |

Table 2-6. Comparison of impacts for the preferred alternative and the no-action alternative (continued)

| Impact | Preferred Alternative[a] | No Action[b] |
|---|---|---|
| Radiocesium transport (continued) | conditions. The maximum individual dose from this release is calculated to be about 3.5 millirem for the first year, decreasing to about 0.3 millirem in the tenth year of operation. Of the 4.4 Ci of radiocesium remobilized, 0.9 Ci could be deposited in a 1235-acre offsite swamp. The deposition rate will decrease to about 0.08 Ci in the tenth year. | |

[a]Preferred alternative--operate L-Reactor after construction of 1000-acre lake.
[b]No action--maintain L-Reactor in a ready-for-operation standby mode.

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# 3 AFFECTED ENVIRONMENT

This chapter describes the environment that will be affected by the resumption of L-Reactor operations. Major emphasis is placed on areas that past operations have shown to have the greatest potential for being affected. Much of this material was covered in the Environmental Assessment, L-Reactor Operation (DOE, 1982a).

## 3.1 GEOGRAPHY

### 3.1.1 Site location

The Savannah River Plant (SRP), including the L-Reactor, is located in southwestern South Carolina. The plant occupies an almost circular area of approximately 780 square kilometers, bounded on its southwestern side by the Savannah River, which is also the Georgia-South Carolina border. Figure 3-1 presents the site location in relation to major population centers, the closest being Augusta, Georgia, and Aiken and Barnwell, South Carolina.

The locations of various facilities of the Savannah River Plant are shown in Figure 3-2. The L-Reactor site is located in the south-central portion of the SRP, about 5 kilometers from South Carolina Highway 125 and 9 kilometers from the nearest plant boundary. Three small South Carolina towns, Snelling (population 111), Jackson (population 1771), and New Ellenton (population 2628), and the City of Barnwell (population 5572) lie within 25 kilometers of L-Reactor. Chem-Nuclear Systems, Inc., and the Barnwell Nuclear Fuel Plant (currently not expected to operate), which is owned by Allied-General Nuclear Services, are about 25 kilometers east of L-Reactor; the Vogtle Nuclear Power Plant is approximately 15 kilometers to the west-southwest.

### 3.1.2 Site description and land use

The Atomic Energy Commission, a predecessor agency to the U.S. Department of Energy (DOE), selected the location of Savannah River Plant in November 1950, after studying more than 100 potential sites. Criteria used in the selection of the site included the low population density, the accessibility of a large cooling water supply, and the low frequency of floods and destructive storms (DOE, 1980). The construction of SRP facilities began in February 1951, and eventually involved more than $1 billion in expenditures with a peak construction force of 38,500 workers.

The Savannah River Plant is a controlled area with public access limited to through traffic on South Carolina Highway 125 (SRP Road A), U.S. Highway 278, and SRP Road 1; the Seaboard Coast Line Railroad; approved tour groups; forest management activities; controlled hunting; and environmental studies. Access to Savannah River Plant is also permitted for organized deer hunts, which began in 1965 to help control the deer population.

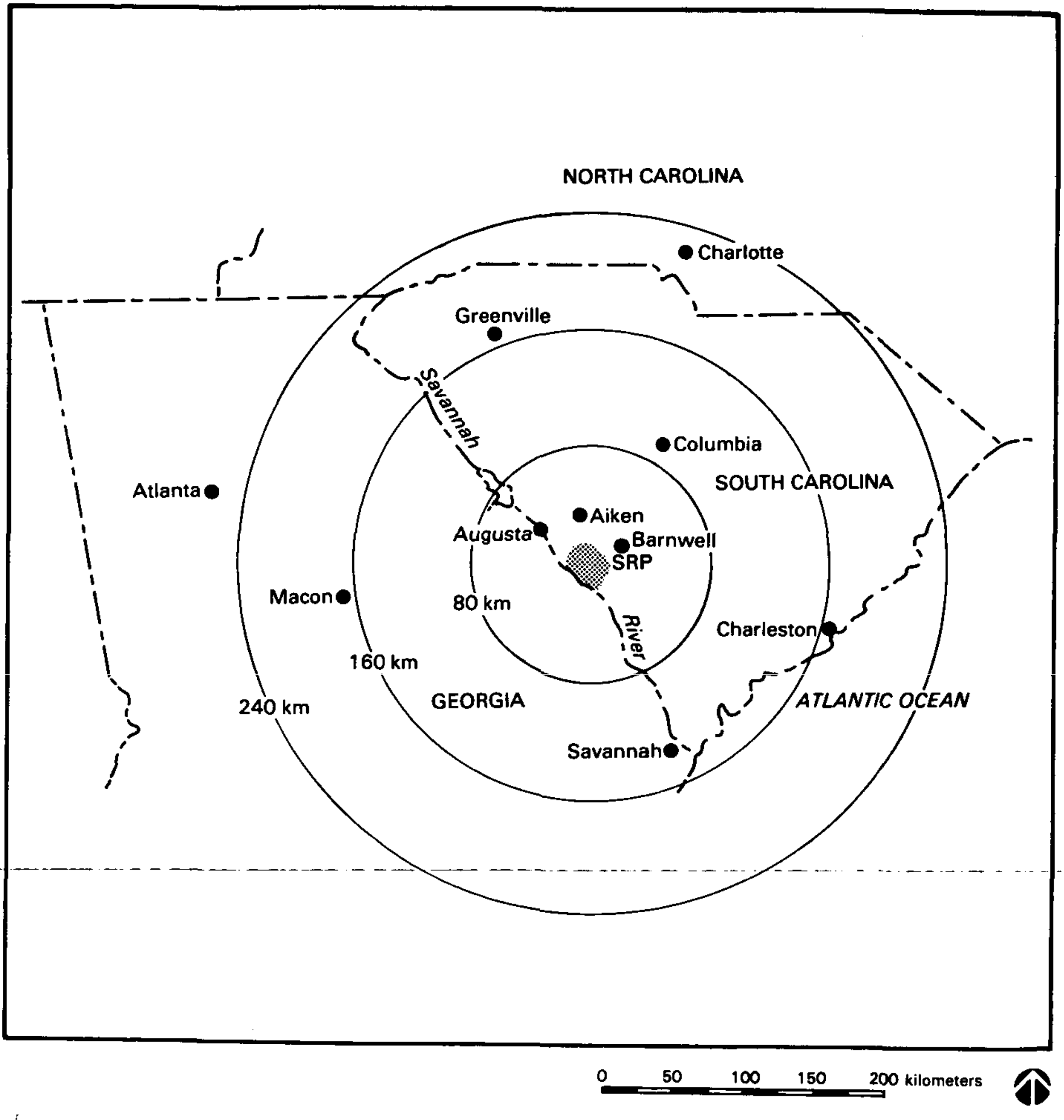
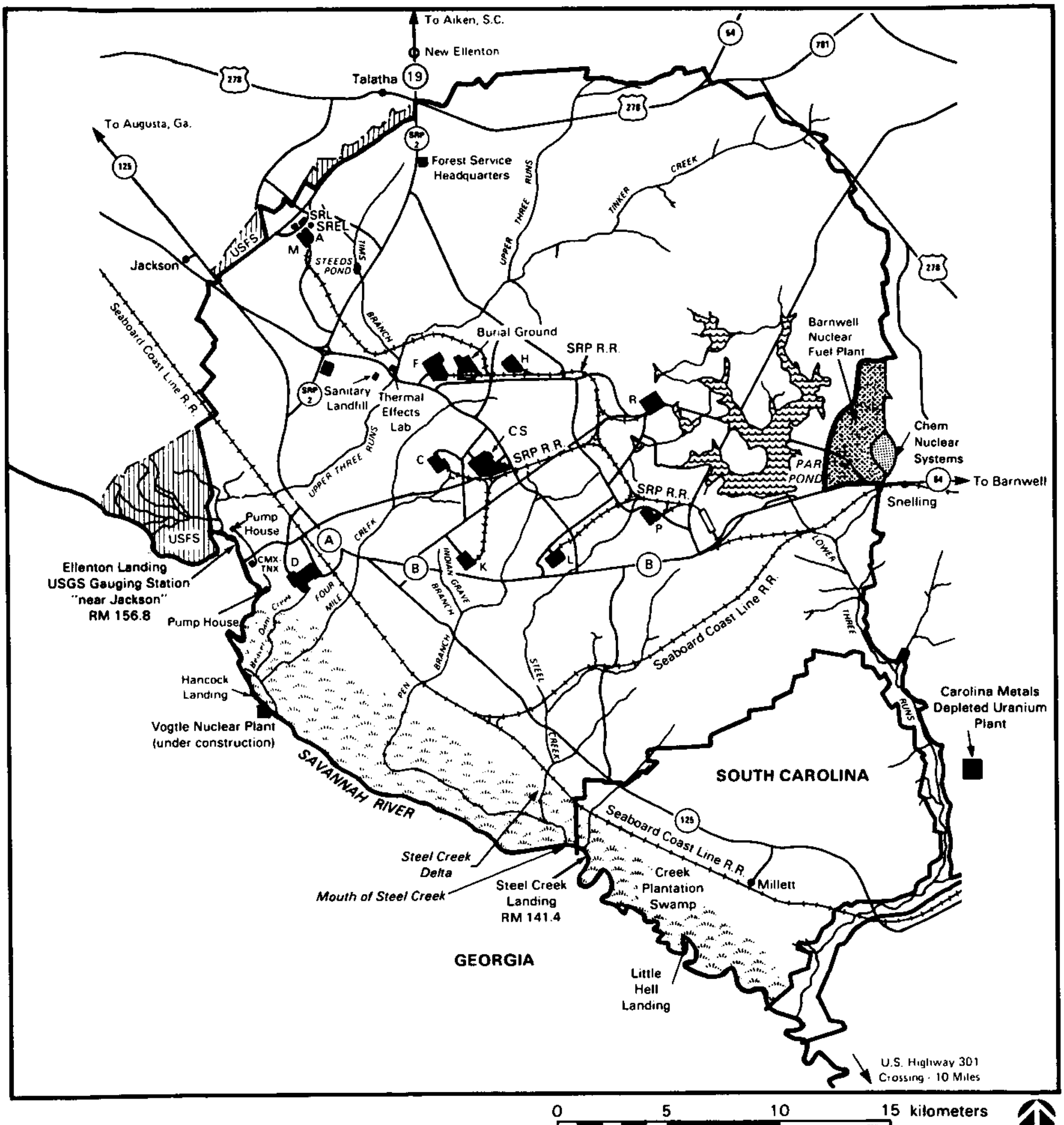



**Figure 3-1. SRP location in relation to surrounding population centers.**




Legend:

- C, K, R, L, P  Reactor Areas (C, P, K are operating)
- F, H  Separations Areas
- M  Fuel and Target Fabrication
- D  Heavy Water Production
- A  Savannah River Laboratory and Administration Area
- CS  Central Shop
- RM  River Mile

Road A = Highway 125

**Figure 3-2. Savannah River Plant site.**

The SRP facilities include five nuclear production reactors (three currently operating), two chemical separations areas, a fuel and target fabrication facility, a heavy-water production facility (on standby except for rework), and various supporting facilities (Figure 3-2). Onsite waste-disposal facilities include tank farms near the chemical separations areas for storage of high-level waste and a 195-acre burial ground for low-level radioactive waste. Construction is underway on the Fuel Materials Facility (F-Area) and the Defense Waste Processing Facility (north of H-Area).

The Savannah River Plant is located in the Aiken Plateau physiographic division of the Coastal Plain of South Carolina. Due to the plant's proximity to the Piedmont region, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 104 meters above mean sea level. This area is underlain by the Tuscaloosa aquifer, which supplies well water to several operating areas of the Savannah River Plant, including L-Reactor. Par Pond is a man-made cooling impoundment; cooling water from the operating reactors is discharged either to this impoundment (P-Reactor at present and R-Reactor before it was placed on standby) or to one of the SRP streams (C-Reactor to Four Mile Creek and K-Reactor to Pen Branch at present and L-Reactor to Steel Creek before it was placed on standby), all of which drain to the Savannah River.

K- and P-Reactors are approximately 4 kilometers to the west and east-northeast of L-Reactor, respectively. C-Reactor is about 7 kilometers northwest of L-Reactor, and R-Reactor is 8 kilometers northeast of L-Reactor.

### 3.1.3 Historic and archeological resources

In 1982, 62 sites in the study area (Section 3.2.2) were listed in the National Register of Historic Places (see Appendix E). Richmond County had the largest number of sites (26), most of which are in the City of Augusta. Approximately 20 more National Register sites are in Aiken and Allendale Counties. Fifteen of the 62 sites are within 15 kilometers of the Savannah River Plant.

During January and February 1981, a survey was conducted of the Steel Creek terrace and floodplain system below L-Reactor for archeological resources and sites that might qualify for inclusion in the National Register of Historic Places (Hanson et al., 1982). The area of Steel Creek surveyed was 13 kilometers long and 300 meters wide. Archeologists traversed the first and second terraces of the creek system, inspecting 4-square-meter plots every 5 meters along the creek. Sites found were divided into three groups--those significant (i.e., eligible for nomination to the National Register of Historic Places), those potentially significant, and those not significant.

The survey identified 18 historic and archeological sites along Steel Creek below L-Reactor. One archeological site, located at the confluence of Steel Creek and Meyers Branch, was considered significant in terms of National Register criteria. It could yield important data on relatively uninterrupted prehistoric occupation that began in the Early Archaic Period (9500-7500 B.C.) and continued through the Mississippian Period (A.D. 1000-1700). In July 1982, the DOE requested the concurrence of the Keeper of the National Register on this site's eligibility for nomination to the National Register. The Keeper concurred in this site's eligibility.

Seven other sites were also considered potentially significant in terms of National Register criteria. Three of these sites occur beyond the area of potential effects from increased water levels in Steel Creek due to L-Reactor operation. The remaining four sites include three mill dams that date to the early nineteenth century and an historic roadway across the Steel Creek floodplain. In July 1982, the DOE requested the concurrence of the Keeper of the National Register regarding the eligibility of these sites for nomination to the National Register. The Keeper of the National Register concurred in the eligibility of these four sites for inclusion in the National Register. A monitoring and erosion protection plan has been implemented for all sites eligible for inclusion in the National Register. TC

The remaining 10 sites were not considered significant in terms of National Register criteria. These are archeological sites, dating possibly as far back as 6000 B.C., that are lacking in integrity or are too limited in content to permit the acquisition of additional data. They were not considered eligible for nomination to the National Register.

Figure 3-3 shows the location of the five sites that have been determined to be eligible for inclusion in the National Register.

In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register of Historic Places.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). TC

## 3.2 SOCIOECONOMIC AND COMMUNITY CHARACTERISTICS

A comprehensive characterization of socioeconomic and community characteristics around the Savannah River Plant was undertaken for the DOE in 1981. Additional information on the topics presented in this section can be found in the Socioeconomic Baseline Characterization for the Savannah River Plant Area, 1981 (ORNL, 1981) and the Final Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina (DOE, 1982b).

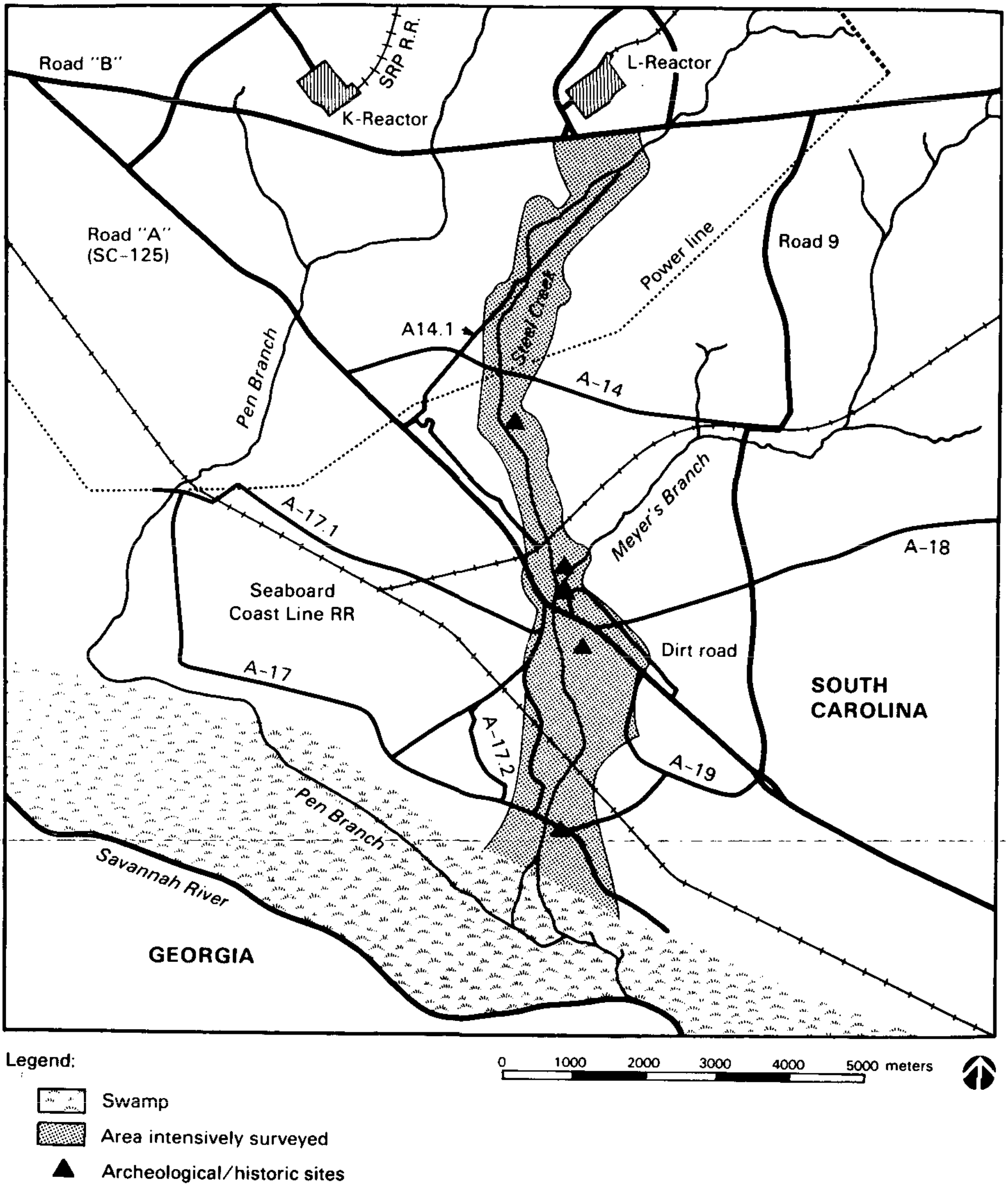



**Figure 3-3. General map of archeological survey area and sites listed in the *National Register of Historic Places.***

### 3.2.1 Past impacts of Savannah River Plant

The socioeconomic impacts of the Savannah River Plant (SRP) on 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 peak construction workforce of 38,500 was onsite. Populations of the nearby towns increased, and the number of trailer courts and new homes increased rapidly. These early days and the changes induced by plant construction are described in In the Shadow of a Defense Plant (Chapin et al., 1954).

The primary socioeconomic impact of the Savannah River Plant since the completion of initial construction has been the large number of permanent jobs created. The permanent operating and construction force has averaged 7500, ranging from a low of 6000 in the 1960s to the current 9200 (December 1982). About 97 percent of this total are employed by E. I. du Pont de Nemours and Company and its subcontractors; the remainder are employed by the U.S. Department of Energy (221), the University of Georgia (55), and the U.S. Forest Service (22).

The greatest impact of the Savannah River Plant has been on Aiken County, especially the City of Aiken, and the small towns immediately around the SRP site, as listed in the SRP worker distribution pattern in Table 3-1. 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 Aiken County.

### 3.2.2 Study area

Approximately 97 percent of SRP employees reside in a 13-county area surrounding the Savannah River Plant. Of these 13 counties, 9 are in South Carolina and 4 are in Georgia. The greatest percentage of employees now reside in the six-county area of Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina, and Columbia and Richmond Counties in Georgia (Figure 3-4). Together these six counties house approximately 89 percent of the total SRP workforce. Because any new L-Reactor operating employees will reside in a distribution similar to that listed in Table 3-1, these six counties were chosen as the study area for the assessment of potential socioeconomic and community effects.

### 3.2.3 Demography

#### 3.2.3.1 Study area population

Table 3-2 lists the 1980 populations in the study area for counties and places of more than 1000 persons. The largest cities in the study area are Augusta in Georgia, and Aiken, North Augusta, and Barnwell in South Carolina. Of the 31 incorporated communities in the study area, 16 have populations under 1000 persons, and 11 have populations between 1000 and 5000 persons. Aiken, Columbia, and Richmond Counties, which comprise the Augusta Standard Metropolitan Statistical Area (SMSA), have a total population of about 327,400; however,

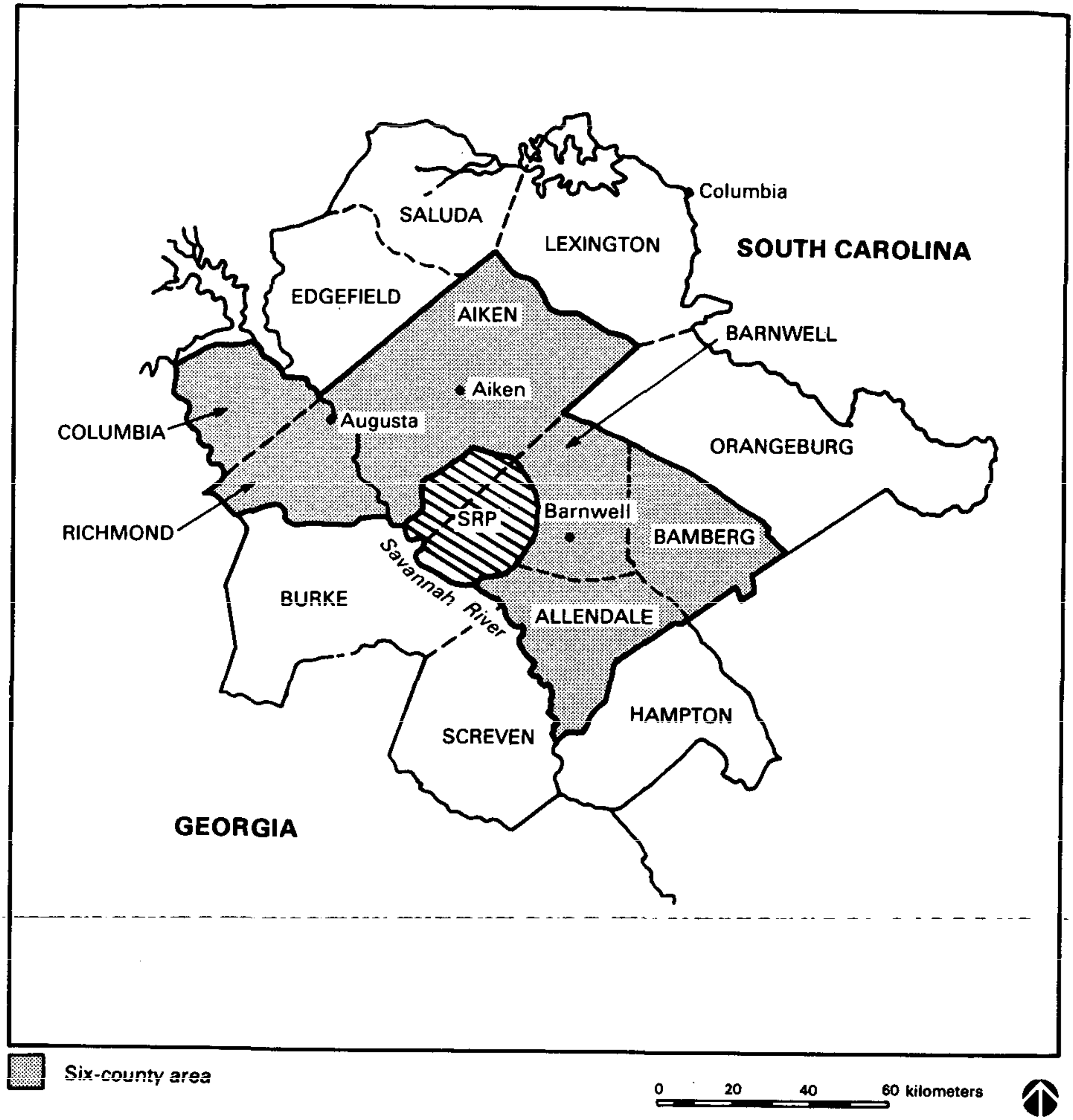



**Figure 3-4. Counties in SRP area.**

Table 3-1. Distribution of SRP employees by place of residence

| Location of residence | Percent of SRP labor force |
|---|---|
| South Carolina | 80.0 |
| Aiken County | 58.8 |
| Allendale County | 1.8 |
| Bamberg County | 2.0 |
| Barnwell County | 8.8 |
| Edgefield County | 1.1 |
| Hampton County | 1.2 |
| Lexington County | 1.6 |
| Orangeburg County | 1.7 |
| Saluda County | 1.0 |
| Other counties | 2.0 |
| Georgia | 19.9 |
| Columbia County | 3.1 |
| Richmond County | 14.8 |
| Burke County | 0.3 |
| Screven County | 0.8 |
| Other counties | 0.9 |
| Other states | 0.1 |
| Total | 100.0 |

most of this population resides outside cities or towns. About two-thirds of the total six-county population resides in rural or unincorporated areas.

Over the last three decades, the rate of population growth has varied dramatically from county to county. From 1950 to 1980, the counties comprising the Augusta SMSA experienced a positive growth rate; the combined average annual rate was about 3 percent. The most significant population increases occurred in Columbia County, which experienced an average growth rate between 1960 and 1980 of about 10 percent per year. The rural counties--Allendale, Bamberg, and Barnwell--experienced population declines between 1950 and 1970; reversals of this decline occurred between 1970 and 1980 when population increases for these counties ranged from 9 to 16 percent. The population growth rate experienced in the study area during the last two decades was about equal to that experienced in the southern United States and slightly less than the growth rate experienced in the South Atlantic Region (Bureau of the Census, 1983).

Population densities in the study area ranged from a low in 1980 of 10 persons per square kilometer in Allendale County to a high of 215 persons per square kilometer in Richmond County. The 1980 average population density of about 47 persons per square kilometer for the study area is less than the 53.5 persons per square kilometer for the South Atlantic Region of the United States (Bureau of the Census, 1983).

Table 3-2. 1980 population for counties and places of 1000 persons or greater[a]

| Location | 1980 population |
|---|---|
| Aiken County, South Carolina | 105,625 |
| City of Aiken | 14,978 |
| Town of Jackson | 1,771 |
| City of North Augusta | 13,593 |
| City of New Ellenton | 2,628 |
| Allendale County, South Carolina | 10,700 |
| Town of Allendale | 4,400 |
| Town of Fairfax | 2,154 |
| Bamberg County, South Carolina | 18,118 |
| Town of Bamberg | 3,672 |
| City of Denmark | 4,434 |
| Barnwell County, South Carolina | 19,868 |
| City of Barnwell | 5,572 |
| Town of Blackville | 2,840 |
| Town of Williston | 3,173 |
| Columbia County, Georgia | 40,118 |
| City of Grovetown | 3,384 |
| City of Harlem | 1,485 |
| Richmond County, Georgia | 181,629 |
| City of Augusta | 47,532 |
| Town of Hephzibah | 1,452 |
| Study area total | 376,058 |

[a]Adapted from the Bureau of the Census (1982a,b).

During the last 30 years, the population in the study area has tended to be slightly younger than the national average, despite a slight increase in the median age between 1970 and 1978. The birth rates in the six-county area have also tended to be somewhat higher than the national average.

### 3.2.3.2 Regional population

In 1980 the estimated population in the 80-kilometer area around the Savannah River Plant was approximately 563,300 persons. The year 2000 population in this area is estimated at 852,000 persons. This estimate was calculated utilizing the 1970-to-1980 growth rate of each county in the 80-kilometer area, assuming these growth rates would continue in the future. For counties that experienced a negative population growth rate between 1970 and 1980, the calculation assumed that no continued population decline would occur. This total county population estimate for the year 2000 is approximately 12 percent higher than the estimates prepared by the States, based on a comparison with projections prepared by Georgia and South Carolina.

#### 3.2.3.3 Transient population

The transient population within 16 kilometers of the L-Reactor consists of the SRP workforce; a total of 8864 personnel (July 1983) at the Vogtle Nuclear Power Plant, which is currently under construction; and about 300 personnel working for Chem-Nuclear Systems, Inc. The Barnwell Nuclear Fuel Plant, which is owned by Allied General Nuclear Services, is expected to maintain only a guard force.

The SRP workforce is expected to increase due to construction of the proposed Defense Waste Processing Facility and other ongoing activities. Therefore, in the mid-1980s, the SRP workforce could be near 12,600, decreasing to about 8500-9000 personnel in the mid-1990s.

Recreational hunting and camping account for about 10,000 visitor-days within a 24-kilometer radius of L-Reactor. Travelers crossing Savannah River Plant on U.S. Route 278 and South Carolina Highway 125 and on the Seaboard Coast Line Railroad add about 20,800 person-days to the 16-kilometer transient population (Du Pont, 1982a).

There are no schools, military reservations, hospitals, prisons, or airports within the 16-kilometer radius from L-Reactor.

### 3.2.4 Land use

In the study area near Savannah River Plant, less than 5 percent of the existing land-use pattern is devoted to urban and built-up uses. Most land uses of these types are in and around the Cities of Augusta, Georgia, and Aiken, South Carolina. Agriculture accounts for about 24 percent of total land use; forests, wetlands, water bodies, and unclassified lands that are predominantly rural account for about 70 percent of total land use.

All the counties in the study area except Allendale have zoning ordinances, and all except Bamberg have approved land-use plans. Of the land-use controls most commonly used by communities (i.e., zoning, subdivision regulations, land-use plans, building codes, and mobile home/trailer park regulations), 22 of the 31 incorporated jurisdictions in the study area have at least one type of regulation.

Less than 5 percent of the total SRP land area, including the L-Reactor site, is used by facilities engaged in the production of defense nuclear materials. Reservoirs and ponds comprise approximately 3000 acres on the SRP site. The remainder is composed of natural vegetation and pine plantations that are managed by the U.S. Forest Service under a cooperative agreement with DOE.

### 3.2.5 Public services and facilities

There are nine public school systems in the study area. County-wide school districts are located in each county except Bamberg, which has two districts, and Barnwell, which has three. In 1980, all school districts, except Allendale, reported available classroom space to accommodate a total of 8600 new students. The Aiken and Richmond County school districts reported the greatest capacity, with space for about 3600 and 2600 new students, respectively.

Of the 120 public water systems in the study area, 30 county and municipal systems serve about 75 percent of the population. The other 90 systems are generally smaller and serve individual subdivisions, trailer parks, or commercial and industrial enterprises. All but four of the municipal and county water systems--the Cities of Aiken, Augusta, and North Augusta, and Columbia County--obtain their water from deep wells. For those municipal and county water systems that use ground water as their supply, restrictions in system capabilities are primarily due to storage and treatment capacity rather than availability of ground water.

Most municipal and county wastewater-treatment systems have the capacity to treat additional sewage. Selected rural municipalities in Allendale, Bamberg, and Barnwell Counties and the City of Augusta in Richmond County have experienced problems in treatment-plant capacities. Programs to upgrade facilities are under way or planned in most of these areas.

### 3.2.6 Housing

Since 1970, the largest increases in the number of housing units have occurred in Columbia, Aiken, and Richmond Counties. Columbia County has grown the fastest, nearly doubling its number of housing units. Between 1970 and 1980, Aiken and Richmond Counties each experienced about a 36-percent increase in the number of housing units. In Aiken County, half of this increase resulted from the high growth rate in the number of mobile homes.

Vacancy rates for owner-occupied housing units for Richmond and Columbia Counties in 1980 were 4 and 3 percent, respectively, while vacancy rates for the South Carolina counties in the study area ranged from a low of 1 percent in Barnwell County to a high of 1.5 percent in Aiken County. Vacancy rates for rental units were the highest in Richmond County (15 percent), while the remaining counties ranged between 7 to 12 percent.

### 3.2.7 Economy

Nonfarm employment in the study area is concentrated in the manufacturing industries. Manufacturing constitutes the largest employment category in each county except Richmond County. Significant percentages of employment in retail and wholesale trade establishments also exist in Allendale and Richmond Counties.

Agriculture and agricultural employment is an important element in the economy of each county. In 1978, Allendale County had the highest average value of products sold per farm--about $58,500--while Columbia County had the lowest average--about $10,000.

Employment levels in the study area have increased in recent decades as both the total labor force and participation rates have increased. Per capita incomes in Aiken and Richmond Counties were the highest in the study area, and in 1974 ranked in the top 50 percent of the national averages. Most of the other counties, however, ranked in the bottom 11 percent of the national averages.

The substantial contribution of Savannah River Plant to the rise in the standard of living in the study area has been a major socioeconomic benefit. The FY 1983 operating budget is $864 million with the FY 1984 budget expected to be about $1.1 billion. In FY 1983, $370 million will be paid as direct wages and salaries. Local purchases are expected to be approximately $20 million. Of the total FY 1982 purchases of $247 million, about $10 million was spent with disadvantaged businesses and $100 million was spent with small businesses.

In the six-county area, 39 local jurisdictions exercise the right to levy taxes. These jurisdictions include six counties, five school districts, and 28 cities and towns. Property taxes (real and personal) accounted for approximately 17 percent of total local revenues in 1979, while state and Federal funds accounted for 11 and 8 percent, respectively. Local expenditures on transportation and public works constituted 27 percent of total expenditures in 1979; another 21 percent was expended for public safety.

## 3.3 GEOLOGY AND SEISMOLOGY

### 3.3.1 Geology

#### 3.3.1.1 Geologic setting

The SRP is located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain of South Carolina (Cooke, 1936; Du Pont, 1980a). Figure 3-5 shows that the topography in the vicinity of the L-Reactor site at Savannah River Plant is characterized by interfluvial areas with narrow, steep-sided valleys. The relief in the region of the L-Reactor site measures about 20 meters.

The L-Reactor site is about 40 kilometers southeast of the fall line (Davis, 1902) that separates the Atlantic Coastal Plain physiographic province from the Piedmont physiographic province of the Appalachian region (Appendix F, Figure F-1). Crystalline rocks of Precambrian and Paleozoic age underlie the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age. Sediment-filled basins of Triassic and Jurassic age (exact age is uncertain) occur within the crystalline basement throughout the coastal plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of Savannah River Plant.

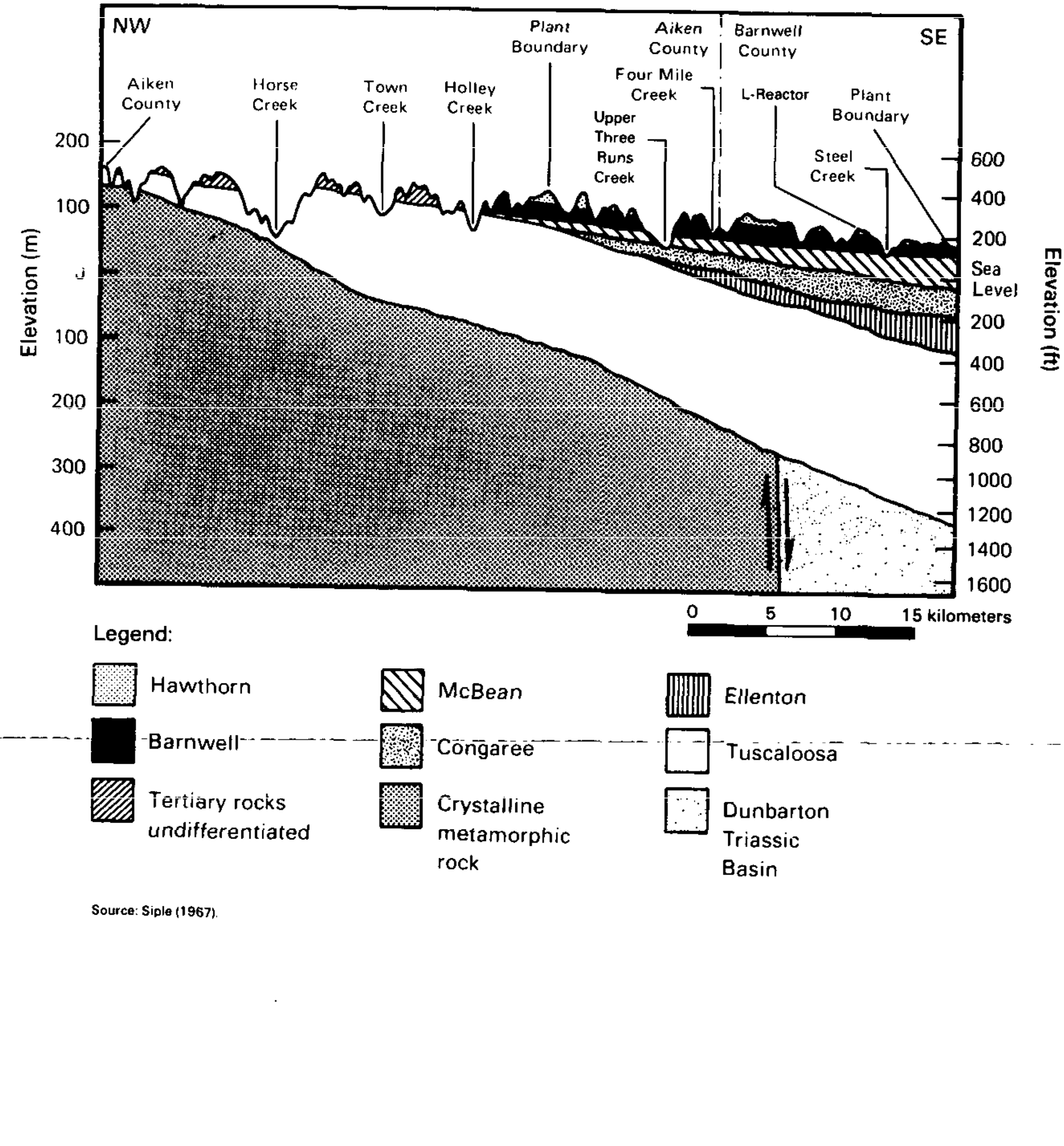



**Figure 3-5. Generalized northwest to southeast geologic profile across the *Savannah River Plant*.**