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 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.

TC

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 center of the river.

TC

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 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.

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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.

<u>Production of less-than-3-percent plutonium-240 at SRP</u>

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.

<u>Production of less-than-6-percent plutonium-240 at N-Reactor</u>

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 cut-off 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

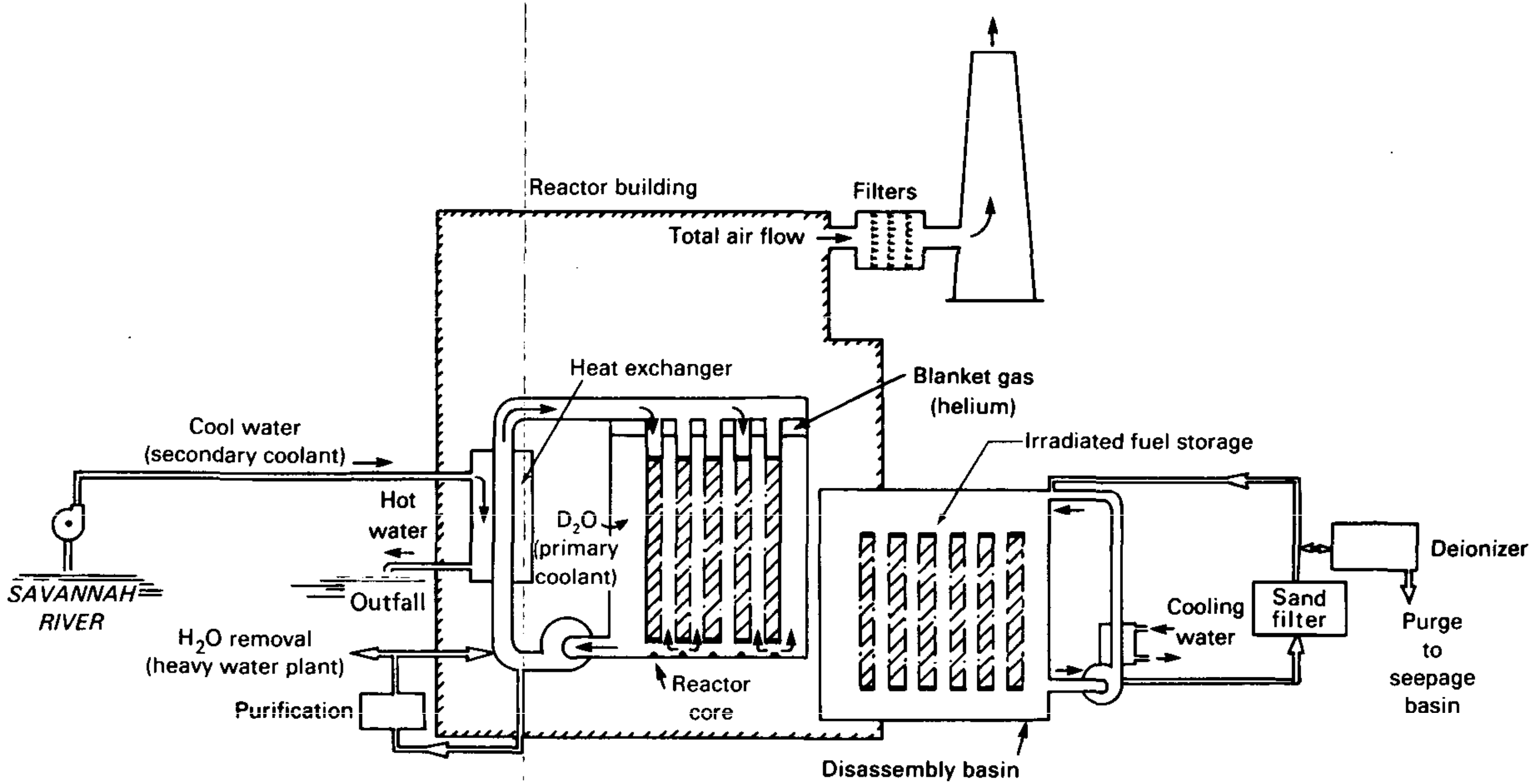
L-Reactor would be part of an integrated SRP complex for the production of defense nuclear materials, including a fuel and target fabrication plant, five reactors (three currently operating), two chemical separations plants, a heavy-water production plant (on standby except for rework), and waste-storage 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.

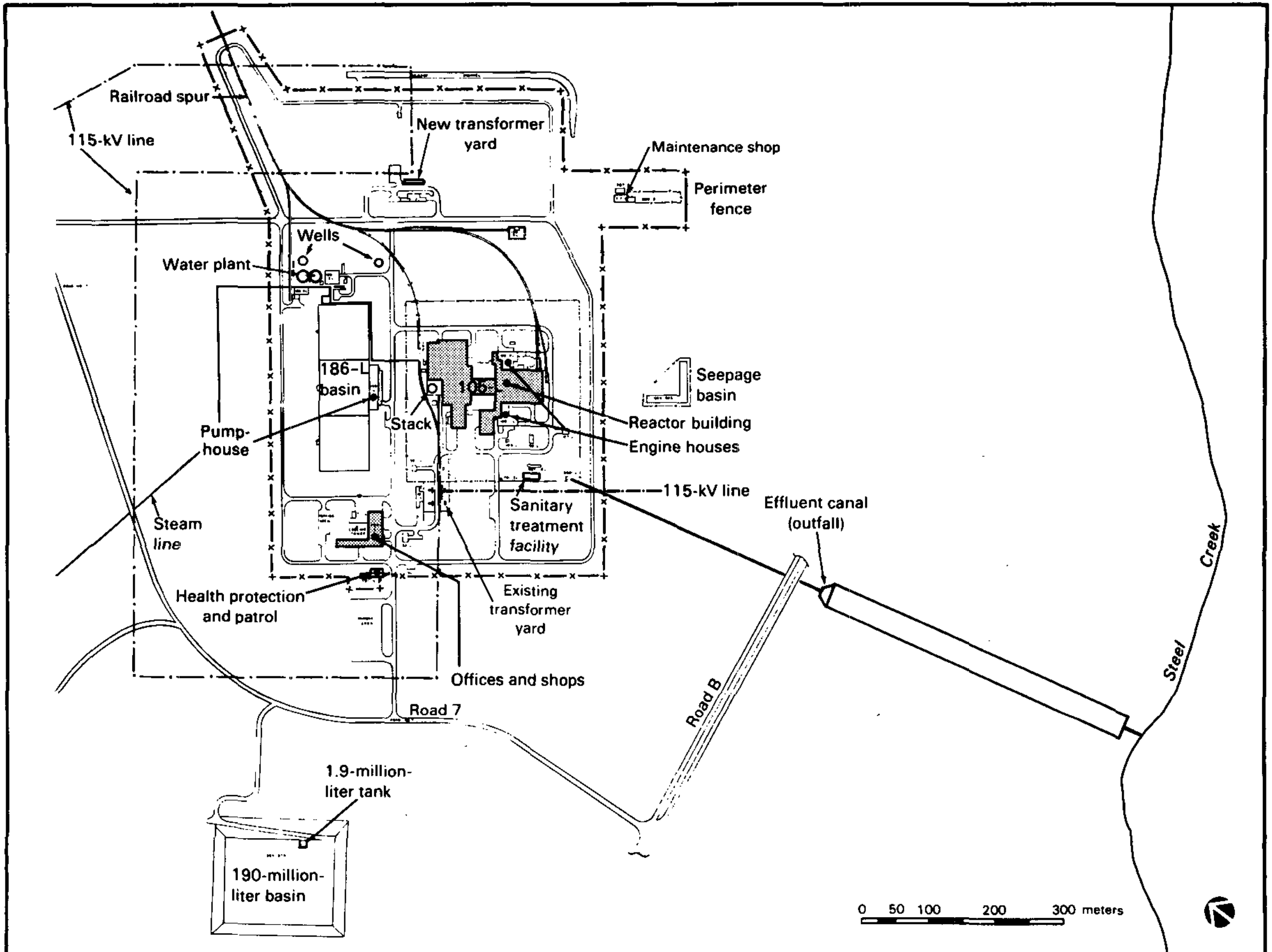


Figure 2-2. Major L-Area structures.

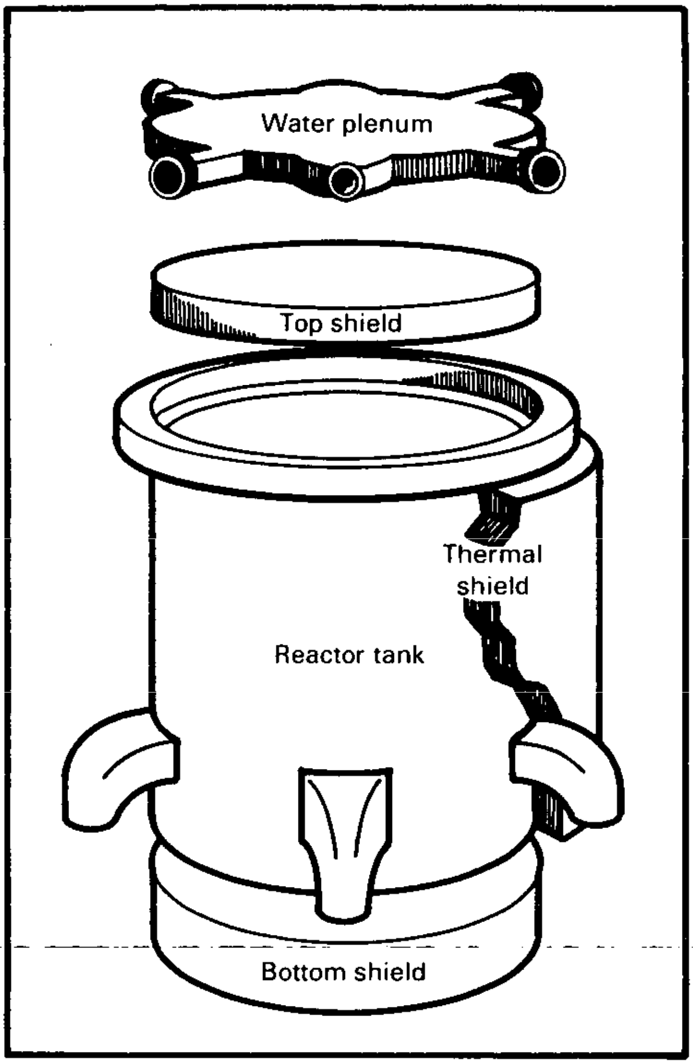


Figure 2-3. Schematic of reactor structure.

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)	TE
Secondary coolant		
Outlet temperature	Up to 80°C	
Coolant flow	11 m^3/second	

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.

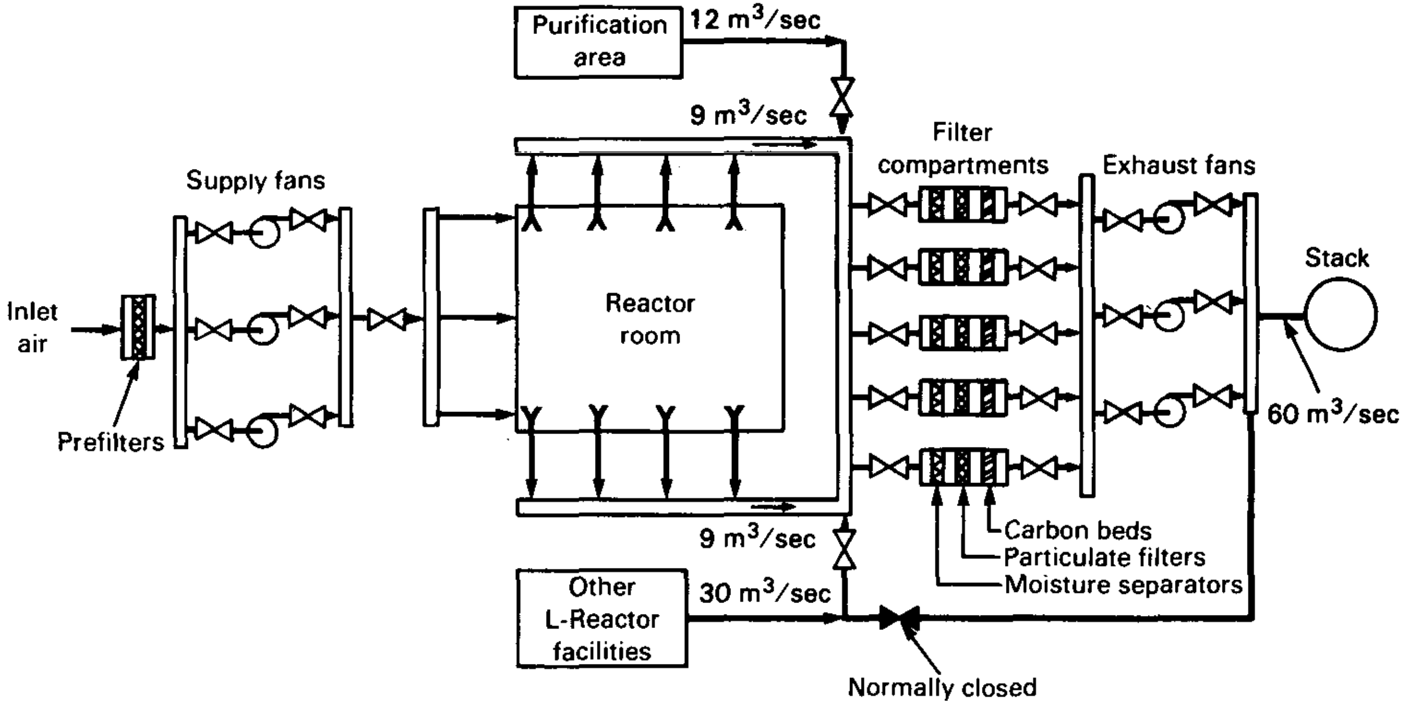


Figure 2-4. Reactor confinement system.

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 ΔT 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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