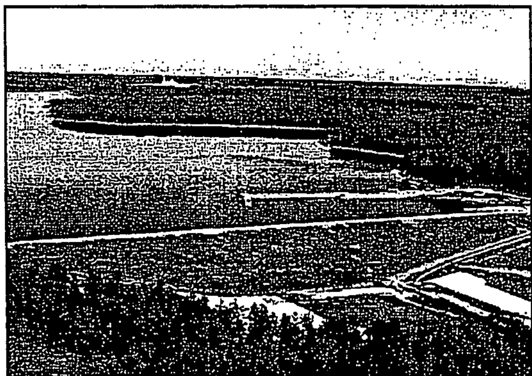
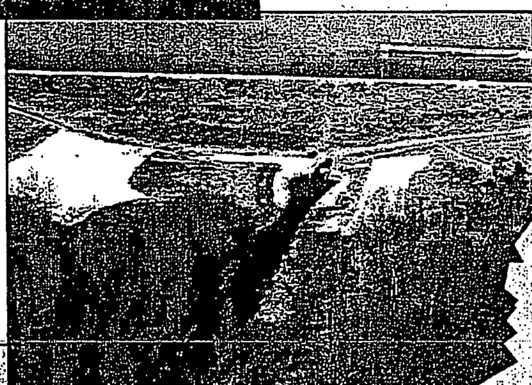
DOE/EIS-0268

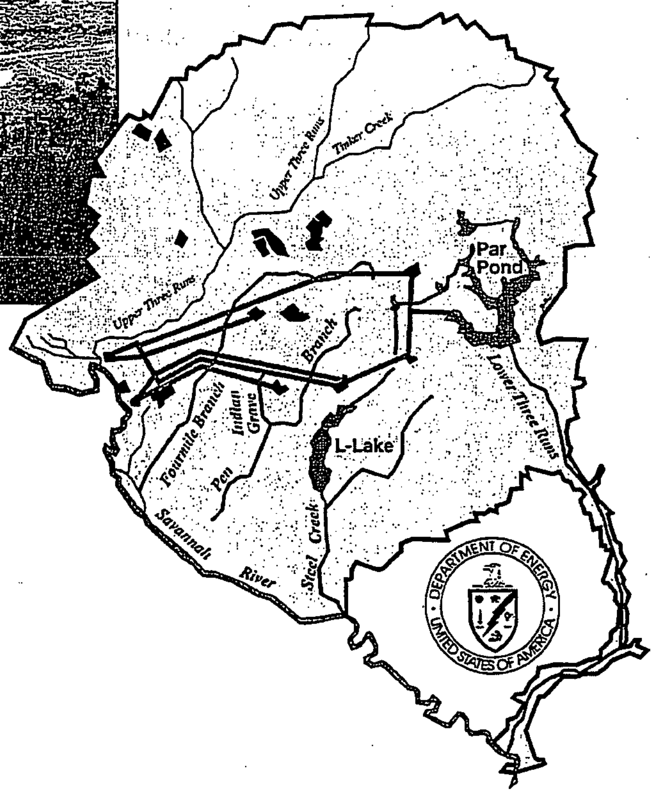
Final Environmental Impact Statement

Shutdown of the River Water System at the Savannah River Site

May 1997







Department of Energy • Savannah River Operations Office • Aiken, South Carolina

COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: Final Environmental Impact Statement, Shutdown of the River Water System at the Savannah River Site, Aiken, South Carolina (DOE/EIS-0268).

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ABSTRACT: The purpose of the DOE action evaluated in this environmental impact statement (EIS) is to shut down the Savannah River Site River Water System in order to save money; that is, to prevent further expenditure of the funds necessary to operate a system that has no current mission. In the *DOE Savannah River Strategic Plan*, DOE committed to identifying and disposing of excess infrastructure. The River Water System has been identified as potential surplus infrastructure. As its Proposed Action and Preferred Alternative, DOE proposes to shut down and maintain the River Water System and to place all or portions of the system in a standby condition that would enable restart if conditions or mission changes required system operation. Consequently, DOE prepared this draft EIS to evaluate potential environmental impacts and to assess reasonable alternatives to this action. In this document, DOE assesses the cumulative environmental impacts of shutting down the River Water System, examines the impacts of alternatives, and identifies measures available to reduce adverse impacts. Evaluations of impacts on water quality, air quality, ecological systems, land use, geologic resources, cultural resources, and the health and safety of onsite workers and the public are included in the assessment.

In addition to the Preferred Alternative, described above, and the No-Action Alternative, which consists of continuing to operate the River Water System, this EIS examines an alternative to shut down and deactivate the River Water System.

PUBLIC COMMENTS: In preparing this Final EIS, DOE considered comments received by letter and voice mail, and statements given at two public scoping meetings in North Augusta, South Carolina on December 4, 1996. TC

FOREWORD

This environmental impact statement (EIS) evaluates alternative approaches to and environmental impacts of shutting down the River Water System at the Savannah River Site (SRS). Until the end of the Cold War, the U.S. Department of Energy's (DOE's) primary mission at SRS was to produce and process nuclear materials to support national defense programs. The SRS produced nuclear materials that supported the defense, research, and medical programs of the United States. Five production reactors were constructed and operated at the site. To support these facilities, the River Water System was constructed to provide cooling water to pass through heat exchangers to absorb heat from the reactor core in each of the five reactor areas (C, K, L, P, and R). Par Pond and L-Lake are manmade reservoirs constructed in 1958 and 1984, respectively. Par Pond was built to provide additional cooling water for P- and R-Reactors, and DOE built L-Lake to dissipate heated effluent from L-Reactor. R-Reactor ceased operation in 1964; C-Reactor ceased operation in 1985; K-Reactor ceased operation in 1993; and P- and L-Reactors ceased operation in 1988. Now that all the reactors have been shut down, no operational need exists to provide cooling water except for small loads to K- and L-Reactor Areas. DOE's mission now empha- TC sizes cleanup and waste management, environmental restoration, and decontamination and decommissioning.

DOE is examining options to reduce operating cost. The *DOE Savannah River Strategic Plan* directs the SRS to find ways to reduce operating costs and to determine what site infrastructure it must maintain and what infrastructure is surplus. The River Water System has been identified as a potential surplus facility. Three alternatives to reduce the River Water System operating costs are evaluated in this EIS. In addition to the No-Action Alternative, which consists of continuing to operate the River Water System, this EIS examines one alternative (the Preferred Alternative) to shut down and maintain the River Water System in a standby condition until DOE determines that a standby condition is no longer necessary, and one alternative to shut down and deactivate the River Water System.

Assumptions and analyses in this EIS are consistent with those that are in the *Continued Operation of K-, L-, and P-Reactors EIS*, DOE/EIS-0147 (1990); *L-Reactor Operation EIS*, DOE/EIS-0108 (1984); *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site*, DOE/EA-1070 (1995); and *Savannah River Site Waste Management EIS*, DOE/EIS-0217 (1995).

DOE welcomes dialog with conservation and wildlife foundations. In a climate of decreasing funding, DOE must determine if it should continue to operate the River Water System. DOE L9-11 is willing to consider donations by private or public foundations to offset costs required to maintain the river water supply and preserve L-Lake, which is expected to recede over a 10-year period if the River Water System is shut down.

DOE published a Notice of Intent to prepare this EIS in the *Federal Register* on June 12, 1996 (61 FR 29744). The notice announced a public scoping period that ended on July 12, 1996, and solicited comments and suggestions on the scope of the EIS. DOE held scoping meetings during this period in North Augusta, South Carolina, on June 27, 1996. During the scoping period, comments were received from individuals, organizations, and government agencies. Comments received during the scoping period and DOE's responses were used to prepare an action plan that defined the scope and approach of this EIS. DOE issued the action plan in August 1996.

The action plan and reference materials cited in this EIS are available for review in the DOE Public Reading Room, located at the University of South Carolina-Aiken Campus, Gregg-Graniteville Library, 2nd Floor, University Parkway, Aiken, South Carolina [(803) 648-6851].

DOE completed the draft of this EIS in November 1996, and on November 15, 1996 the U.S. Environmental Protection Agency published a Notice of Availability of the document in the *Federal Register* (61 CFR 58548). This notice officially started the public comment period on the draft EIS, which extended through December 30, 1996. Publication of the draft EIS provided an opportunity for public comment on the nature and substance of the analyses included in the document.

DOE has considered comments it received during the comment period in preparing this final EIS. These comments were received by letter, electronic mail, and statements made at public hearings held in North Augusta, South Carolina on December 4, 1997. Comments and responses to comments are in Appendix E.

Changes from the draft EIS are indicated in this final EIS by vertical change bars in the margin. The bars are marked TC for technical changes, TE for editorial changes, or if the change was made in response to a public comment, the designated comment number as listed in Appendix E. Many of the technical changes are the result of the availability of updated information since publication of the draft EIS.

DOE prepared this EIS in accordance with the provisions of the National Environmental Policy Act (NEPA), Council on Environmental Quality regulations (40 CFR 1500-1508), and DOE NEPA Implementing Procedures (10 CFR 1021). This EIS identifies the methods used in the analyses and the sources of information. In addition, it incorporates, directly or by reference, information from other ongoing studies.

The document is structured as follows:

Chapter 1 provides background information and introduces the River Water System at the SRS.

Chapter 2 sets forth the purpose and need for DOE action.

Chapter 3 describes the alternatives DOE is considering.

Chapter 4 describes the environment at the SRS and in the surrounding area potentially affected by the alternatives addressed and provides a detailed assessment of the potential environmental impacts of the alternatives. It also assesses environmental justice, unavoidable adverse impacts, irreversible or irretrievable commitments of resources, short-term uses and long-term productivity of the human environment, and cumulative impacts.

Chapter 5 identifies regulatory requirements and evaluates their applicability to the alternatives considered.

Chapter 6 is a list of references used in Chapters 1 through 5 of this EIS.

Appendix A is an investigation of potential remedial actions for L-Lake.

Appendix B describes the ecological effects of radioactive and nonradioactive contaminants.

Appendix C provides supplemental data for occupational and public health impacts.

Appendix D describes ecological resources, including flora and fauna.

Appendix E contains copies of letters from the public comment period and DOE responses to those comments.

Appendix F describes L-Lake sediment data and the data sources.

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SUMMARY

S.1 Introduction

The U.S. Atomic Energy Commission (AEC), a U.S. Department of Energy (DOE) predecessor agency, established the Savannah River Site (SRS) in the early 1950s for the production of nuclear materials to support the national defense, research, and medical programs of the United States. The Site continued that function until the early 1990s when the end of the Cold War led the United States to reduce the size of its nuclear arsenal.

This environmental impact statement (EIS) examines the environmental impacts of shutting down a 50-mile (80-kilometer) underground concrete piping structure and pumping system that was built in the early 1950s to provide cooling water for the Site's five nuclear production reactors. The reactors are no longer in operation and the Site's mission now emphasizes cleanup and environmental restoration.

S.2 Purpose and Need for Agency Action

The AEC built the River Water System during the 1950s to provide secondary cooling water from the Savannah River to the five production reactors (C-, K-, L-, P-, and R-Reactors) at the SRS. The system pumped water from the river to the reactor areas, where the water passed through heat exchangers to absorb heat from the reactor core. The heated discharge water returned to the river by way of several onsite streams. DOE constructed two lakes on the Site, Par Pond in 1958 to provide additional cooling water for P- and R-Reactors, and L-Lake in 1984 to dissipate the thermal effluents from L-Reactor. The stream channel of Lower Three Runs was expanded, a dam built across a section of its path, and the upstream area flooded to form Par Pond. Similarly, Steel Creek channel was expanded, an earthen dam built across its path, and the upstream area flooded to form L-Lake.

As a result of the end of the Cold War, the SRS mission emphasis has shifted from operation and production to cleanup and environmental restoration. Through the *DOE Savannah River Strategic Plan* and previous versions, DOE developed guidance for meeting the expanded missions. These strategic plans direct SRS organizations to identify excess infrastructure and to develop action plans for their disposition. As a result of this process, DOE identified the River Water System as excess infrastructure, costly to operate and maintain, and with limited application for new Site missions.

Therefore, in a climate of decreasing funding, DOE must determine if it should continue to operate the River Water System, a system that has no current mission and will become more expensive to operate.

S.3 Proposed Action

DOE proposes to shut down the River Water System and to place all or portions of the system in a standby condition that would enable restart if conditions or mission changes required system operation. DOE proposes to lay up all or portions of the system. Layup means that DOE would place equipment in a protective state that minimizes degradation. DOE would maintain those portions in a standby condition (could be readied for restart). DOE could also maintain portions of the system in a state of readiness higher than a standby condition in order to quickly restore pumping capability. The cessation of river water input to L-Lake is expected to result in a gradual drawdown of the reservoir and its reversion to the pre-L-Lake conditions of Steel Creek. During the expected drawdown period (about 10 years), DOE would apply measures to ensure that it could refill L-Lake safely and would apply other measures to minimize potential adverse effects of exposed sediments, which contain contaminants, in the lakebed.

Examples of situations that could necessitate restarting the River Water System include the need to pump water into Par Pond to bring the lake back to a level greater than 195 feet (59 meters) above mean sea level. In an earlier National Environmental Policy Act (NEPA) action (DOE/EA-1070 and associated Finding of No Significant Impact, *Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site*, 1995), DOE decided to discharge a minimum flow of 10 cubic feet (0.23 cubic meter) per second to Lower Three Runs and to reduce pumping. The water level in Par Pond would fluctuate, but DOE would resume pumping if impact threshold levels were reached in water quantity or quality. Based on the extent of contamination and potential impacts to aquatic communities in the lakebed, 195 feet (59 meters) above mean sea level was established as a conservative lower limit to ensure minimal, if any, environmental impacts.

Other situations that could necessitate pumping include the need to refill L-Lake if the final outcome of the Federal Facility Agreement process recommends refilling the lake to an appropriate level, as a means of remediation. After the system is ready for restart, refilling would take approximately 4 months using two of the large river water system pumps. Following refill, a smaller pump would run continuously to maintain the lake level and downstream (Steel Creek) flow at a minimum of 10 cubic feet (0.28 cubic meter) per second.

New missions could also require restarting the River Water System. In the Record of Decision for the *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling* (DOE/EIS-0161, 60 FR 63877), DOE selected SRS as the location for an accelerator, if one is built. Using the River Water System to supply cooling water to the accelerator could be a design option. DOE would identify the duration of the standby condition in the Record of Decision.

S.4 Alternatives

DOE is considering two alternatives to the Proposed Action. The first alternative, the No-Action Alternative, is defined as the continued operation of the River Water System with a 5,000-gallon-per-minute (0.32-cubic-meter-per-second) pump with large back-up pumps being maintained. DOE would maintain the large pumps in Pumphouse 3G in operational readiness. DOE would continue to use the system to provide the following:

- Fire protection at K- and L-Reactors
- Blending flow for the L-Area Sanitary Waste Treatment Plant effluent
- A full pool water level in L-Lake of 190 feet (58 meters) above mean sea level

In addition to these uses, DOE would retain the capability to pump river water to prevent the water level in Par Pond from falling below 195 feet (59 meters) above mean sea level and to ensure Steel Creek and Lower Three Runs received minimum discharges of 10 cubic feet (0.28 cubic meter) per second.

The second alternative would be to shut down and deactivate the River Water System. DOE would shut down the system in a secure, environmentally satisfactory condition. Under this alternative, DOE would have to implement alternatives for the requirements listed above except for the maintenance of the L-Lake water level. Cessation of river water flow to L-Lake would result in the gradual recession of the lake to the original stream level of Steel Creek. Natural recharge to Steel Creek is expected to maintain an average flow of 10 cubic feet (0.28 cubic meter) per second. After drawdown, DOE would select an economical option for the earthen dam such as breaching or insuring unobstructed flow through the existing conduit.

Steel Creek is expected to maintain its natural flow, while Lower Three Runs would receive minimum discharges of 10 cubic feet (0.28 cubic meters) per second and Par Pond is expected to maintain a water level greater than 195 feet (60 meters).

S.5 Affected Environment

Located in southwest South Carolina, the SRS occupies an area of approximately 300 square miles (800 square kilometers). The Savannah River forms the Site's southwestern boundary for 27 miles (43 kilometers) on the South Carolina-Georgia border. The Site is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 20 miles (32 kilometers) south of Aiken, South Carolina, the nearest major population centers.

The SRS is on the Aiken Plateau, an area of broad flat surfaces dissected by narrow steep-sided valleys. Across the Site, elevations range from about 100 feet (30 meters) above sea level at the Savannah River to about 350 feet (107 meters) above sea level near the northern boundary. The climate is temperate with short mild winters and long humid summers. Warm, moist maritime air masses dominate the weather.

Open fields and pine and hardwood forests comprise 73 percent of the SRS; approximately 22 percent is wetlands, streams, or reservoirs (L-Lake and Par Pond). Production and support areas, roads, and utility corridors account for 5 percent of the total land area. L-Lake occupies about 1,000 acres (4 square kilometers) of the site and Par Pond about 2,640 acres (10.7 square kilometers). The Site is heavily forested with upland pine and mixed hardwoods. Since 1951, approximately 80,000 acres of former agricultural lands were planted with loblolly, longleaf, and slash pine to reduce erosion, provide forest products, and enhance wildlife habitat for white-tailed deer, wild turkey, and feral hogs, as well as the endangered red-cockaded woodpecker.

L-Lake averages 1,970 feet (600 meters) in width and extends along the Steel Creek Valley about 4.4 miles (7 kilometers) from the headwaters to the dam. Par Pond extends about 3.1 miles (5 kilometers) along the Lower Three Runs stream bed and has an average width of about 2,625 feet (800 meters). Both lakes have characteristic wetlands along the shoreline with pine and hardwood forests farther up the slope. The streams on the SRS generally flow in a southerly direction toward the Savannah River. Floodplains are characterized by bottomland hardwood forests or scrub-shrub wetlands with a variety of amphibian, reptile, wading bird, waterfowl, and terrestrial mammal populations. Water quality on the SRS is generally suitable for maintaining balanced biological communities.

Par Pond, a 2,640-acre (10.7-square-kilometer) reservoir, was created in 1958 by building an earthen dam (the Cold Dam) across the upper reaches of Lower Three Runs. It has an average depth of 20 feet (6.2 meters) and a maximum depth of 59 feet (18 meters). At normal pool, the reservoir storage volume is approximately 52,800 acre-feet (65 million cubic meters).

S.6 Environmental Consequences

This EIS evaluates alternative actions for the River Water System at the SRS. The alternatives cover the spectrum of reasonable actions from continued operation (No Action) to complete shutdown and deactivation (Shutdown and Deactivate) with no intention (and eventually no capability) to restart the system. The DOE Proposed Action and Preferred Alternative is a middle ground under which DOE would shut the system down, lay up all or portions of the system, and maintain some portions in a standby condition that would enable restart. The alternatives vary substantially in their ability to satisfy the purpose and need for DOE action, their costs to operate or maintain the system, their commitment of resources (primarily energy), and their environmental consequences. Table S-1 compares basic operational characteristics of the alternatives.

L12-05 Table S-2 summarizes and compares potential environmental impacts of the alternatives. The intent of this table is to draw from the detailed sections on affected environment and environmental impacts to present the primary impacts of the proposal and alternatives in comparative form. The following statements form the bases of the results reported in this table:

- TC DOE will operate a 5,000 gallon-per-minute (0.32 cubic-meter-per-second) pump as a way to save money and energy. In this EIS, flows and cost comparisons described under the No-Action Alternative reflect operation of the small pump.
- Under the shutdown alternatives, DOE would implement alternative sources for the river water required under No Action except that DOE would not provide water to L-Lake to maintain its water level. These requirements are reflected as an incremental impact of shutdown relative to No Action.
- Analyses indicate that L-Lake cannot maintain its normal pool level without flow augmentation from the River Water System. To ensure that impacts of the shutdown alternatives are not underestimated, DOE assumes a worst-case situation where L-Lake continues to recede until it reaches the original Steel Creek surface water profile.
- TE With the exception of capability under the Proposed Action to restart the River Water System to respond to potential future needs, impacts under the Shut Down and Deactivate Alternative are equal to those of the DOE Proposed Action and Preferred Alternative, Shut Down and Maintain.

Table S-1. Characteristics of the alternatives.

	No Action	Shut Down and Deactivate	Shut Down and Maintain	
Data	Small pump	No pumping	Jockey pump[a]	Dry layup[b]
Replacement/restart one-time cost[c]	NA[d]	NA	$820,000	$4,730,000
Time to restart	NA	NA	30 months	30 months
Cost of Operation		$200,000[e]		
System surveillance and maintenance	$1,084,000	$85,000[f]	$710,000	$85,000
L-Lake, Par Pond Dam surveillance and maintenance	520,000	$520,000[g]	520,000	520,000
Energy costs	494,000	20,000	71,000	44,000
Total annual cost	$2,098,000[h]	$625,000	$1,301,000	$649,000
Staff required[i]	7.8	1	6	1
Security (included in total costs)	Visual inspection 1/day	Visual inspection 1/day	Visual inspection 1/day	Visual inspection 1/day
Regulatory requirements	Intake canal dredging	None	Dredging[j] SCDHEC[k] permit for spoils	Dredging SCDHEC permit for spoils
Volume of water pumped	5,000-gallon-per-minute average	NA	Low flow to keep piping system pressurized	0

TC

a. The piping system would stay pressurized by operation of a very small pump called a jockey pump.
b. The piping system would be drained.
c. One-time cost to restart (high reliability).
d. NA = not applicable.
e. One-time cost to shut down.
f. One full-time equivalent person to handle minor maintenance.
g. This is an annual cost for L-Lake and Par Pond dams. After L-Lake has receded and the dam is breached, annual dam maintenance costs for L-Lake will be $0.
h. This cost does not include unexpected repair or replacement of the system.
i. Staff salary and overhead are included in system and dam maintenance cost.
j. Above costs do not include cost (if any) for re-permitting for dredging or reuse of existing spoil areas.
k. SCDHEC = South Carolina Department of Health and Environmental Control.

Table S-2. Comparison of the impacts of the alternatives for the River Water System.

Resource	No-Action Alternative	Shutdown Alternatives
Geology and Soils		
Castor Creek (tributary to Fourmile Branch) and headwaters of Steel Creek (upstream of L-Lake)	Minimal soil erosion from vegetated slopes and natural flows	Same as No-Action Alternative.
Indian Grave Branch (tributary to Pen Branch)	Minimal soil erosion from vegetated slopes carrying natural flows and river water and well water discharges from K-Area	Same as No-Action Alternative except well water would replace river water discharge.
Steel Creek and Lower Three Runs (below dams)	Minimal erosion and sedimentation rates due to controlled stream flow	Same as No-Action Alternative for Lower Three Runs and Steel Creek while L-Lake drains, after which Steel Creek flows would be variable and uncontrolled and would experience moderate erosion and sedimentation from lakebed.
L-Lake and Par Pond	Minimal erosion due to constant normal pool water elevations in L-Lake and small fluctuations in Par Pond	Minimal remobilization of soils potentially contaminated by preimpoundment activities due to gradual recession of L-Lake; same as No-Action Alternative in Par Pond.
Surface Water		
Par Pond	Par Pond ecosystem would revert to that typically found in reservoirs in Southeast due to reduction of nutrients from Savannah River; DOE could resume pumping to Par Pond if conditions warranted	Reversion to typical southeastern reservoir, as with No-Action Alternative; under Shut Down and Maintain, DOE could prepare system for operation, then restart system to pump to Par Pond; no capability to pump under Shut Down and Deactivate.
L-Lake	Water level sustained by as much as 4,800 gpm[a] of river water pumped to and discharged from L-Area	Reversion to stream conditions with potential for lakebed erosion.
L-Lake water quality	Dissolved oxygen in epilimnion seldom would fall below 5 milligrams per liter and would generally be greater than 1 milligram per liter in hypolimnion. Lowest temperatures would be around 50°F (10°C); maximum near-surface summer temperatures would be around 86°F (30°C); acidity would not be substantial; pH levels in near-surface water would seldom fall below 6.	Reduction in dissolved oxygen and temperature and increased acidity in epilimnion and hypolimnion of L-Lake until lake is drained.
TC Steel Creek	Minimal siltation due to intake structure drawing water that would be low in suspended solids from top of lake; flow of 10 cfs[b] would be sustained	The dam is expected to act as a sedimentation basin, thereby minimizing siltation below dam.
L-Area sanitary wastewater treatment plant	Blending flows would be supplied by river water pumping to L-Area	Alternate compliance method (e.g., septic tanks) would be required.

Table S-2. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
L-Area cooling water discharges	L-Area 186-Basin maintained full for fire protection and overflowing for discharges to L-Lake; well water or river water could supply 190 gpm of cooling water for compressors	Alternate supply (e.g., well water) would be required for fire protection and compressor cooling; total well water requirement would be 390 gpm; total discharge to L-Lake would be reduced by 10 gpm evaporation from the 186-Basin to approximately 380 gpm.
K-Area cooling water discharges	As much as 200 gpm pumped from system to K-Area 186-Basin for fire protection; well water would supply 210 gpm of cooling water for compressors	Alternate supply (e.g., well water) would be required for fire protection; same as No-Action Alternative for compressor cooling water; total discharge to Indian Grave Branch would be approximately 400 gpm (i.e., 200+210 less evaporation).
Groundwater		
Water table levels in L-Area	With downgradient elevation of Water Table Aquifer controlled by lake level, it would stand at 190 ft[c] above mean sea level; Water Table Aquifer elevation at L-Area Oil and Chemical Basin (one of four nearby CERCLA[d] units) would be approximately 208 ft	As L-Lake recedes, water table elevations would drop 10 ft at Steel Creek outcrop (estimated 180 ft); at L-Area Oil and Chemical Basin, water table elevations would drop approximately 4 ft (estimated 204 ft); hydraulic gradients at CERCLA units would increase resulting in a 12-percent increase in local velocities. After lake level dropped, it would take approximately 18 years for contaminated groundwater to travel from CERCLA units to Steel Creek. Therefore, there would be little, if any, effect on remedial actions for these units.
Air		
Air toxic - Mercury	0.014 microgram per cubic meter	Increased by 1.15×10^{-6} microgram per cubic meter to approximately 6 percent of regulatory standard.
Air toxic - Manganese	0.821 microgram per cubic meter	Increased by 2.6×10^{-6} microgram per cubic meter to approximately 3 percent of regulatory standard. TC
Criteria pollutant - 24-hour PM_{10} concentration at SRS boundary	SRS sources plus background = 113 micrograms per cubic meter at the SRS boundary	Increase of 16 for a total of 129 micrograms per cubic meter at the SRS boundary, which is 85.7 percent of regulatory standard.
Radionuclides - annual effective inhalation dose equivalent to maximally exposed offsite individual	Very small dose (0.02 millirem/yr)	Total dose from all pathways 6.5×10^{-3} (mrem/yr); 0.07 percent of regulatory standard. TC

Table S-2. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
Terrestrial Ecology		
L-Lake	No reduction in habitat for amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl in L-Lake	Reduction in habitat for amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl as L-Lake recedes.
	L-Lake amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl would be protected from predation	L-Lake amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl would be more vulnerable to predation as reservoir recedes.
	No increased exposure to contaminated L-Lake sediments	Animals foraging in the lakebed after drawdown would be exposed to contaminated sediments via inhalation, ingestion, and dermal contact.
Aquatic Ecology		
L-Lake	Natural changes in aquatic communities as L-Lake ages	Reservoir ecosystem replaced by small strea ecosystem.
SRS streams	Natural flows in small watersheds support few benthic organisms and fish in Indian Grave Branch	Same as No-Action Alternative.
Wetlands		
L-Lake	Natural successional changes in littoral zone plant communities	Loss of submerged and floating-leaved aquatic plants as reservoir recedes; emerger species could move downslope with lake level.
Par Pond	Changes in species composition of littoral-zone plants; acreage could be reduced	Same as No-Action Alternative.
Steel Creek	With 10 cfs flow requirement, scrub-shrub vegetation would become more prevalent in stream corridor; willow probably would predominate. Over time, hardwood species would become established in delta, replacing swamp (cypress-gum) forest with deciduous hardwood (oak-elm-sweetgum) forest.	Same as No-Action Alternative during drav down; after drawdown, natural flows woul vary, averaging 10 cfs.
Lower Three Runs	Readjustment of stream and bottomland ecosystems associated with continuation of existing flow requirements	Same as No-Action Alternative.
Threatened and Endangered Species		
Bald eagles	Bald eagles nesting at Pen Branch would continue to forage around L-Lake	Bald eagles nesting at Pen Branch would time lose primary foraging habitat (L-Lak and could leave area.

Table S-2. (continued).

Resource	No-Action Alternative	Shutdown Alternatives	
Wood storks	Foraging on SRS would continue	Wood storks could be exposed to increased levels of contaminants if L-Lake dropped rapidly and fish were trapped in small pools (primarily in spring and summer, when wood storks forage on SRS).	TC
Alligators	Alligators would continue to be present in L-Lake	L-Lake alligators would, in time, be displaced; drawdown of L-Lake could result in loss of nests, eggs, or hatchlings, depending on timing and rapidity of drawdown.	
Occupational Health			
Radiological - annual probability of fatal cancer to current involved worker (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	1.7×10^{-7}	1.7×10^{-7}	TC
Radiological - number of lifetime fatal cancers to current SRS involved workers (16 lifetime fatal cancers from all causes expected in current SRS involved worker population)[e]	5.5×10^{-5}	5.5×10^{-5}	TE
Nonradiological - annual probability of fatal cancer to current SRS involved worker (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	2.5×10^{-8}	1.4×10^{-6}	TC
Public Health			
Radiological - annual probability of fatal cancer to offsite maximally exposed individual (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	3.3×10^{-9}	3.5×10^{-9}	TC
Radiological - number of lifetime fatal cancers to offsite population (157,900 lifetime fatal cancers from all causes expected in the offsite population living within 50 miles of SRS)[e]	5.0×10^{-5}	4.9×10^{-5}	TC
Nonradiological - annual probability of fatal cancer to offsite maximally exposed individual (annual fatal risk from all causes is 3.4×10^{-3})[e]	None	7.9×10^{-9}	TC

Table S-2. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
Land Use		
Onsite	Site facilities, natural vegetation types with more than 73 percent in forest land	Same as No-Action Alternative
Adjacent land	Used mainly for forest, agricultural, and industrial purposes	Same as No-Action Alternative
Aesthetics		
TE L12-09 L-Lake	1,000-acre reservoir with wetlands along shoreline and abundance of wading birds, turtles, and some alligators	As L-Lake recedes, dried mud flats would appear for periods of time until revegetation began; could be seen by 1,800 SRS workers who pass by daily.
TC Par Pond	2,640-acre reservoir with wetlands along shoreline, pine and hardwood forests up slope; abundance of amphibians, reptiles, wading birds, and waterfowl (in winter); water level fluctuates while discharge from Par Pond is controlled.	Same as No-Action Alternative
SRS streams	Narrow streams at headwaters broadening into wide swampy deltas at Savannah River; abundant hardwood and wetland vegetation with variety of wildlife; 10 cfs in Lower Three Runs and Steel Creek downstream of dams; natural flow in Fourmile Branch and Steel Creek above L-Lake; natural flow plus small cooling water discharges to Indian Grave Branch/Pen Branch	Same as No-Action Alternative

a. gpm = gallons per minute; to convert to cubic meters per second, multiply by 0.000063088.
b. cfs = cubic feet per second; to convert to cubic meters per second, multiply by 0.028317.
c. ft = feet; to convert to meters, multiply by 0.3048.
TE d. CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
e. Based on fatal cancer incidence in general population of 235 per 1,000 and a 70-year life expectancy.

CHAPTER 1. INTRODUCTION

1.1 Background

The Savannah River Site (SRS) covers approximately 300 square miles (800 square kilometers) of land in southwestern South Carolina. The Site is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 20 miles (32 kilometers) south of Aiken, South Carolina (See Figure 1-1).

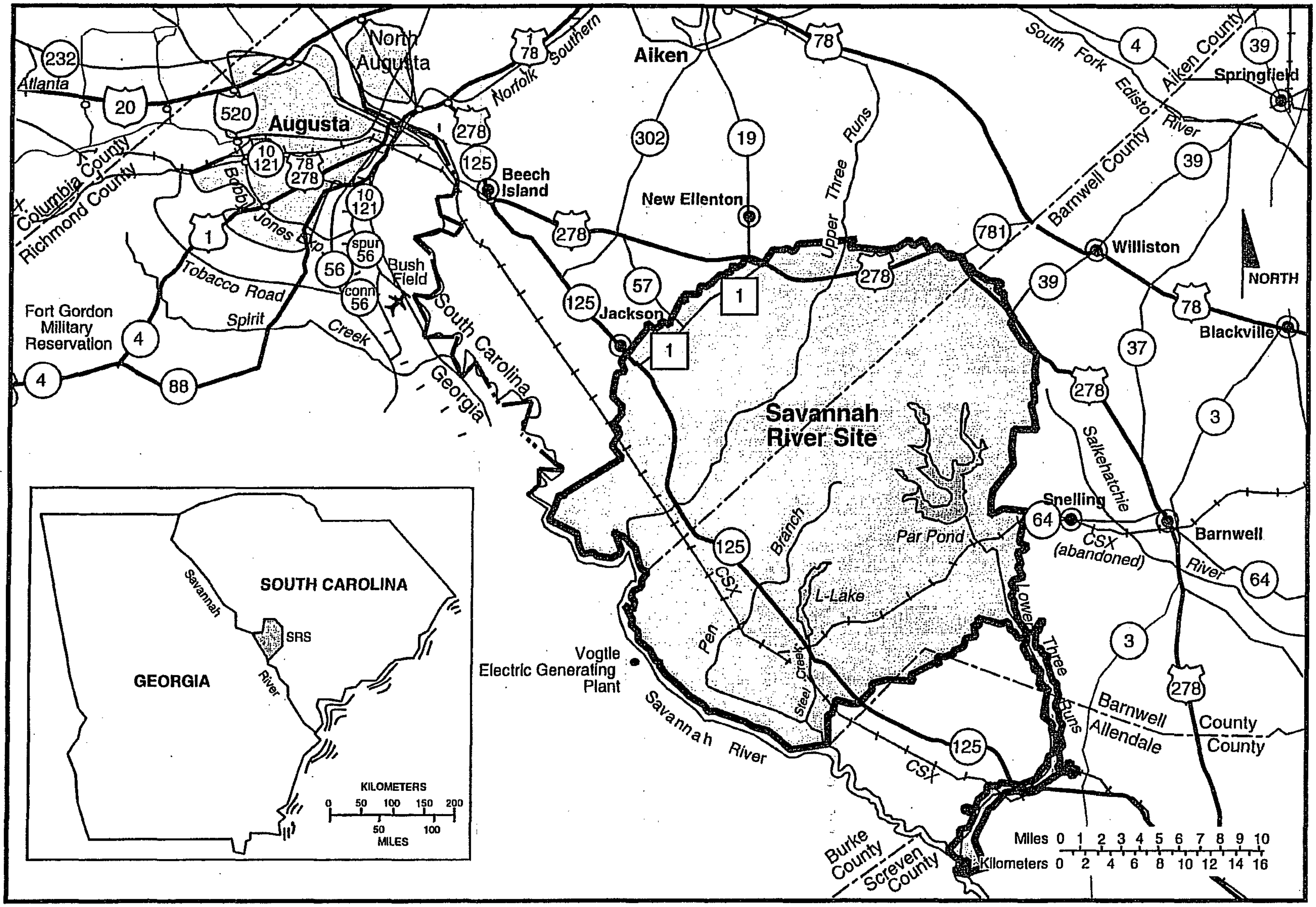
Until the end of the Cold War, the primary mission of the SRS was to produce nuclear materials that supported the defense, research, and medical programs of the United States. The end of the Cold War and the reduced size of the U.S. nuclear weapons stockpile have caused a dramatic reduction in the need for the nation to produce defense-related nuclear materials. The U.S. Department of Energy's (DOE's) mission at the SRS now emphasizes cleanup and environmental restoration.

In 1990, DOE assessed the impacts of continued operation of reactors at SRS and alternatives that would ensure the capability to produce nuclear materials for United States defense and nondefense programs (DOE 1990). With the change in mission at SRS, a *Supplement Analysis for Reactor Transition* (DOE 1994a) was prepared to determine if National Environmental Policy Act (NEPA) documentation to supplement this environmental impact statement (EIS) should be prepared to assess the impacts of reactor transition activities including associated facilities. This analysis initiated the NEPA process for the shutdown of the River Water System with the Assistant Secretary for Environmental Management directing DOE to prepare a Supplemental EIS to fully analyze the impacts of shutting down the River Water System and transition and deactivation activities. Subsequent internal scoping resulted in the recommendation to prepare a standalone EIS for this action. Sections 1.2 and 1.3 introduce the Proposed Action and alternatives, respectively.

DOE also developed the *DOE Savannah River Strategic Plan* (DOE 1996a) as guidance for meeting the changing missions. The Strategic Plan directs the SRS organizations to identify excess infrastructure (i.e., items that were once important parts of the processes with which the Site accomplished its missions) and to develop action plans for their disposition. As a result of this process, DOE identified the River Water System (Figure 1-2) as excess infrastructure.

The U.S. Atomic Energy Commission (AEC), a DOE predecessor agency, built the River Water System to provide secondary cooling water from the Savannah River to the five production reactors at the SRS (C-, K-, L-, P-, and R-Reactors). The system pumped water from the river to the reactor areas, where the water passed through heat exchangers to absorb heat from the reactor core. The heated discharge water returned to the river by way of several onsite streams. In 1958, the AEC built Par Pond by impounding Lower Three Runs to provide additional cooling water to P- and R-Reactors. In 1984, DOE built L-Lake by impounding Steel Creek to dissipate the thermal effluent from L-Reactor. As part of its 1988 decisions on alternative cooling water systems, DOE began the construction of a cooling tower to dissipate the thermal effluent from K-Reactor (53 FR 4203-4205). In response to its 1991 Record of Decision on the operation of K-, L-, and P-Reactors, DOE expedited and completed the construction of the cooling tower (56 FR 5584-5587).

The River Water System includes three pumphouses, two on the Savannah River (Pumphouses 1G and 3G) and one on Par Pond (Pumphouse 6G). Pumphouses 1G and 6G no longer operate. In addition, Pumphouse 5G and its piping comprise a separate system to support the D-Area powerhouse and are not part of this EIS. Each pumphouse contains 10 pumps;



PK64-2PC

Figure 1-1. Savannah River Site.

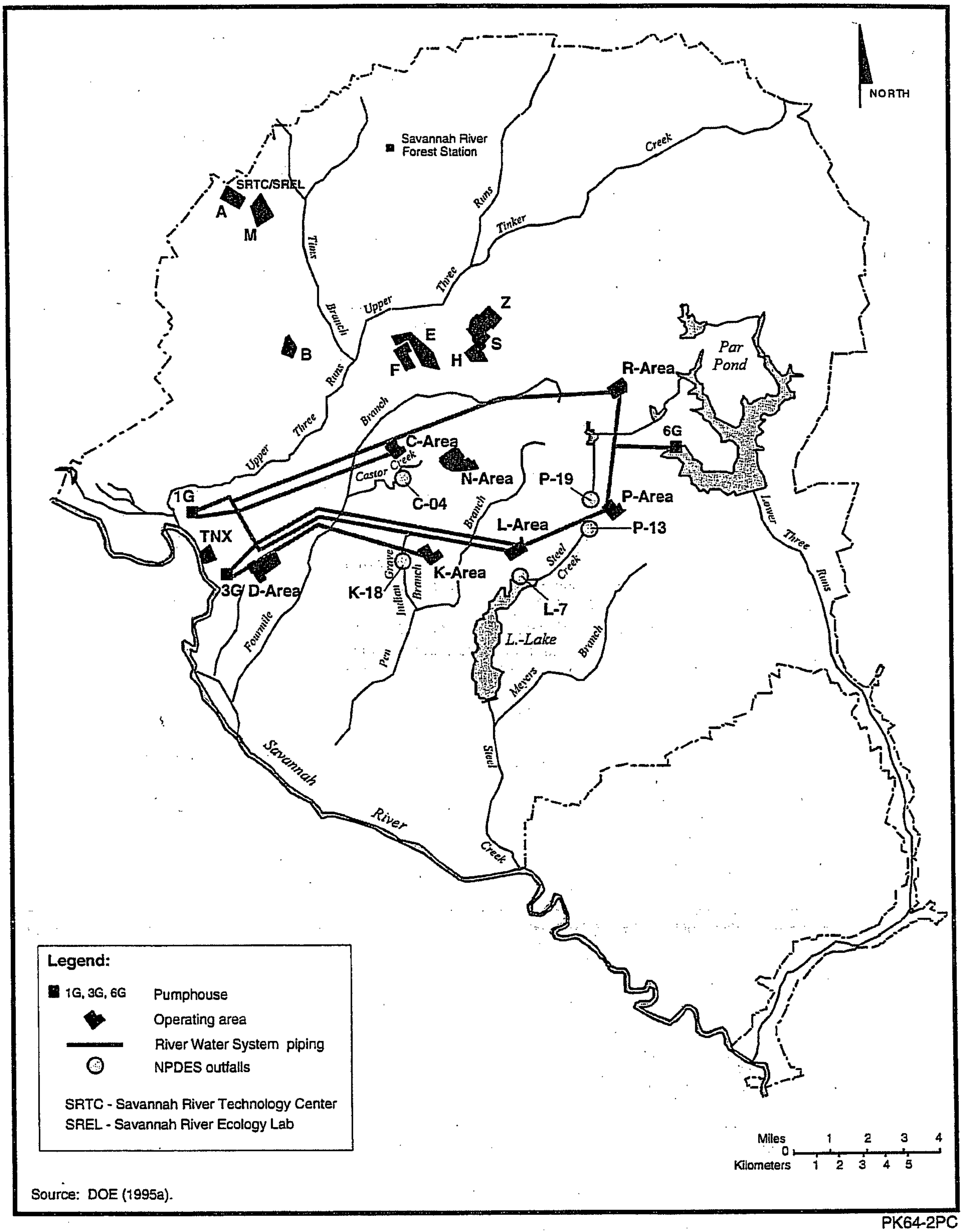


Figure 1-2. River Water System on SRS.

pump capacities vary from 24,000 gallons per minute (1.5 cubic meters per second) to 32,500 gallons per minute (2.1 cubic meters per second). Approximately 50 miles (80 kilometers) of underground concrete piping can deliver river water from the pumphouses to the reactor areas. When the reactors were operating, the River Water System delivered 174,000 gallons per minute (11.0 cubic meters per second) to each reactor area. At the time each reactor was shut down, the areas discharged their heated effluents as follows:

- From K-Reactor to Indian Grave Branch, then to Pen Branch and to the Savannah River
- From L-Reactor to L-Lake, then through the Steel Creek dam to Steel Creek and to the river
- From P-Reactor, recirculate in Par Pond, then excess through the Par Pond dam to Lower Three Runs and to the river
- From C-Reactor to Castor Creek, then to Fourmile Branch and to the river
- From R-Reactor, recirculate in Par Pond, then excess through the Par Pond dam to Lower Three Runs and to the river

Prior to the construction of L-Lake and Par Pond, the discharges from L-, P-, and R-Reactors were different from those described above. These earlier flow paths are described in Chapter 4.

Because the SRS reactors are not operating, there is no longer a need to provide secondary cooling water for the reactors with the exception of some small cooling loads in K- and L-Areas. DOE has taken several steps to save energy and money by reducing pumping. In 1993, Pumphouse 1G was placed in layup following the placement of the only remaining operable reactor (K-Reactor) in cold standby, and in 1995, Pumphouse 6G was deactivated and abandoned. As a result, the River Water System annual operation cost dropped from approximately $26 million in 1994 to $11.5 million in 1995.

In 1995, following completion of the *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a) and its associated Finding of No Significant Impact (DOE 1995b), DOE decided to discharge a minimum flow of 10 cubic feet (0.28 cubic meter) per second to Lower Three Runs and reduce pumping. The water level in Par Pond would fluctuate near its normal operating level of 200 feet (61.0 meters) above mean sea level but not go lower than 195 feet (59.4 meters). In addition, DOE decided to reduce the flow to L-Lake as long as it maintained the lake at its normal operating level of 190 feet (57.9 meters), and the flow in Steel Creek downstream of L-Lake did not fall below 10 cubic feet (0.28 cubic meter) per second. These actions were estimated to reduce annual pumping costs by $930,000 (DOE 1995a). DOE also determined that river water pumping would be required to avoid a continual drawdown of L-Lake to its original "pre-lake" (Steel Creek) condition (Jones and Lamarre 1994).

Currently DOE satisfies these and other minor system requirements by operating one of the 10 available pumps in Pumphouse 3G. This pump withdraws approximately 28,000 gallons per minute (1.8 cubic meters per second), which is approximately 23,000 gallons per minute (1.5 cubic meters per second) more water than is needed for current system uses. The river water is discharged from K- and L-Areas to Fourmile Branch, Pen Branch, L-Lake, and the headwaters of Steel Creek, respectively.

As a further energy and cost-saving initiative, DOE will operate a small 5,000-gallon-per-minute (0.32-cubic-meter-per-second) pump. The elimination of the 23,000 gallons per minute of excess water would save over $1 million in the annual cost of electricity. DOE intends to install and operate the small pump in the Spring of 1997, shortly before or shortly after issuance of this Final EIS.

Before taking this action, DOE reviewed Council on Environmental Quality (CEQ)

NEPA requirements (40 CFR 1508.4) and the DOE NEPA implementing procedures (57 FR 15122-15158) and determined that the action of installing the small pump is categorically excluded from requiring either an Environmental Assessment or an EIS. CEQ defines a categorical exclusion as an action that does not individually or cumulatively have a significant effect on the human environment.

DOE follows a detailed procedure to ensure that it identifies the appropriate level of NEPA documentation for its actions. If any of six prescreening evaluations are negative (e.g., potentially affects environmentally sensitive resources), the project sponsor is required to complete a detailed Environmental Evaluation Checklist (EEC). The EEC includes a detailed description of the project, identification of the applicable categorical exclusion (listed in the DOE NEPA implementing procedures), a NEPA checklist, and an environmental permits checklist.

DOE applied this process and determined that installation was an appropriate categorical exclusion as categorical exclusion B.5.1, Actions to conserve energy (57 FR 15122-15158).

The small pump will supply up to 4,800 gallons per minute (0.30 cubic meter per second) to L-Area to maintain its 186-Basin full (for fire protection) and overflowing to provide blending for the L-Area sanitary wastewater discharge, keep L-Lake at its normal operating level, and provide a minimum flow of 10 cubic feet (0.28 cubic meter) per second (approximately 4,500 gallons per minute) to Steel Creek. Up to 200 gallons per minute (0.013 cubic meter per second) would be pumped to K-Area to maintain its 186-Basin full for fire protection. The small pump would not pump to C- or P-Areas; this would eliminate current (November 1996) C-Area discharges to Fourmile Branch via Castor Creek and P-Area discharges to the headwaters of Steel Creek (WSRC 1995a). These flows vary but C-Area discharges averaged approximately 265 gallons per minute (0.017 cubic meter per second) during Water Year 1996 (i.e., October 1995 through September 1996). Since DOE diverted P-Area flow from Par Pond to Steel Creek, the discharge to Steel Creek (March through September 1996) has averaged 3,860 gallons per minute (0.24 cubic meter per second). In addition, flows from K-Area to Pen Branch, which have recently (July through September 1996) averaged approximately 7,400 gallons per minute (0.47 cubic meter per second) (Melendez 1996), would be reduced to no more than 400 gallons per minute (0.025 cubic meter per second), resulting from 210 gallons per minute from well-water-cooled compressors (WSRC 1996a) and 200 gallons per minute pumped from the River Water System to K-Area, less about 10 gallons per minute evaporation (WSRC 1995a). Table 1-1 compares 1996 discharge of river water to those that
L10-09 will occur under operation of the small pump
L16-03 and those that would occur if DOE shut down the River Water System.

Table 1-1. Discharges of river water to onsite streams (gallons per minute).[a]

Stream	Sept. 96	Small Pump Operation	Shutdown
Steel Creek (headwaters via P-13)	3,860	0.0	0.0
L-Lake (via L-7)	16,475	4,800	400[b]
Lower Three Runs	0.0	0.0	0.0
Fourmile Branch (via C-04 to Castor Creek)	265	0.0	0.0
Pen Branch (via K-18 to Indian Grave Branch)	7,400	400[c]	400[b]
Total Discharge (gpm)	28,000	5,200	800

L10-08

a. To convert from gallons per minute to cubic meters per second, multiply by 6.3×10^{-5}.
b. Maximum well water discharge.
c. 200 river water, 200 maximum well water discharge.

DOE has not performed maintenance on the equipment in Pumphouse 6G since its shutdown but does perform routine surveillance and maintenance on the equipment in Pumphouse 1G and the piping network. Inspections of the pipe system reveal infrequent problems that might require minor repairs and continued preventive maintenance. The consensus is that the piping is in excellent condition and is likely to experience minimal deterioration if DOE shuts down the piping system and implements a suitable layup, surveillance, and maintenance process (WSRC 1996b).

1.2 Proposed Action

DOE's Proposed Action, and its Preferred Alternative, is to shut down the River Water System and to place all or portions of the system in standby. Under this action, DOE could place portions of the system in a variety of conditions, such as shutting down and deactivating surplus portions that would not be capable of restart. Another example would be the placement of all or portions of the system in a layup condition to support potential future missions (i.e., DOE would shut the system down but preserve it so restart would be possible). In the layup condition, DOE could maintain portions of the system in a higher state of readiness, retaining the capability of restarting them in a relatively short period. Short-term cost savings would be minimal, but this condition would enable DOE to maintain a greater degree of flexibility.

Under the Preferred Alternative, DOE would have to develop and implement alternative sources to provide water for fire protection at K- and L-Reactor and implement an alternative for elimination of sanitary wastewater treatment plant discharges from L-Area. The cessation of river water input to L-Lake would result in the gradual disappearance of the lake and its reversion to the original conditions of Steel Creek. Unlike the Shut Down and Deactivate Alternative described below, the River Water System could be available to serve future DOE needs. TE

1.3 Alternatives to the Proposed Action

DOE is considering two alternatives to the Proposed Action. The first would be to continue the current operation of the River Water System (this is also the No-Action Alternative). Under this alternative, DOE would use the small pump to provide fire protection at K- and L-Reactor and blending flow for the L-Area sanitary waste treatment plant effluent. In addition, DOE would maintain the water level in L-Lake, discharge at least 10 cubic feet (0.28 cubic meter) per second from L-Lake to Steel Creek, and maintain pumps in Pumphouse 3G in operational readiness.

The second alternative would be to shut down and deactivate the River Water System. As described above for the Preferred Alternative, DOE would have to develop and implement alternative water sources, and the cessation of river water input to L-Lake would result in the gradual disappearance of the lake and its reversion to the original conditions of Steel Creek.

1.4 Associated Actions

In this evaluation of shutting down the River Water System, DOE considers a number of actions that must be implemented prior to system shutdown or continued operation with the small pump. DOE also considers potential future actions that could affect decisions on appropriate actions for the River Water System. Although this EIS does not attempt to make decisions on alternatives for such actions, it presents a perspective on how they might affect decisions on the River Water System. DOE believes that the actions described in the following paragraphs are associated with its decisions on the River Water System.

L-Lake Site Evaluation and Remedial Alternatives Study

DOE has established the process for environmental restoration activities at the SRS in accordance with the Federal Facility Agreement (FFA). The FFA is an agreement between DOE, the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC). The FFA integrates DOE responsibilities under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Chapter 5 provides detail on the requirements and compliance status of RCRA, CERCLA, and the FFA.

In accordance with the FFA, DOE prepared an internal draft site evaluation report for L-Lake that contained recommendations on whether there is a need for further investigation. Surface sediment samples collected for this evaluation and analyses to date indicate that cesium-137 is the primary contaminant of concern. In response to EPA comments on the Draft EIS, DOE has canceled plans to issue the Site Evaluation Report for regulatory review. Instead, DOE recommends further assessment of L-Lake under the FFA using the draft site evaluation as a basis for preparing the assessment.

At present, DOE has revised a preliminary (and conservative) risk-based analysis for exposure scenarios and remediation alternatives; it contains approximate costs for the remediation required to reduce risk to prespecified levels (PRC 1996; PRC 1997a,b,c). It was written to provide the decisionmaker with approximate costs that may be incurred in the future under various possible FFA (i.e., CERCLA) remedial options. Appendix A of this EIS describes the status and results of this L-Lake alternatives report and describes the process DOE uses to evaluate actually or potentially contaminated sites at the SRS.

Therefore, DOE must make a near-term (1997) operational decision on the River Water System in light of potential future remedial action at L-Lake. Because this potential remedial action is not yet ready for consideration, DOE followed recommendations published by its Office of NEPA Policy and Assistance (DOE 1993a), which indicate that DOE should treat such an action as a connected action with indirect effects. DOE described the cumulative impacts of the Proposed Action and the connected action (potential remedial actions) but would defer alternatives for the connected action until conceptual alternatives have been defined. If the remedial actions under the FFA called for the procedural and documentation requirements of NEPA, DOE would incorporate NEPA values in the FFA documents or, after consultation with stakeholders, could choose to integrate separate NEPA and FFA processes (DOE 1994a). Further, DOE would ensure that the near-term decisions on the River Water System did not limit the choice of reasonable alternative remedial actions under the FFA process (40 CFR 1506.1).

In accordance with the recommendations described above (DOE 1993a), this EIS bases the occupational and public health impacts of shutting down the River Water System on realistic exposure conditions. The EIS uses, in part, current data that are available from the remedial site evaluation for L-Lake, and this Final EIS uses an updated data set. Further, the EIS analyzes realistic exposure conditions for ecological receptors, the current facility worker (e.g., at L-Lake), the collocated worker (e.g., in L-Area), the hypothetical maximally exposed offsite individual, and the offsite population. The EIS also analyzes reasonably foreseeable future conditions. Based on the *SRS Future Use Report* (DOE 1996b), such conditions include a future facility worker (e.g., privatized industry) and public access for recreation but do not include a future resident.

CERCLA radiological analyses of human health differ from those used in the EIS; the CERCLA analyses report cancer morbidity (incidence) as the impact while the EIS estimates latent cancer fatalities. The CERCLA analysis uses ingestion, inhalation, and external exposure slope factors (PRC 1996) to estimate morbidity risk. The more traditional EIS approach calculates a committed effective dose equivalent from exposure to contaminated soil and multiplies this value by a dose-to-risk cancer mortality conversion factor from the International Commission on Radiological Protection (ICRP 1991). Further, impacts described in the EIS account for radioactive decay of the constituents over the exposure period. By not allowing for decay, the CERCLA analysis would overestimate risk.

Remedial Action Process for Onsite Streams

This action is not associated with the Proposed Action to shut down the River Water System. Rather, it is associated with operation of the small pump, which is part of the baseline in the No-Action Alternative. Steel Creek, Fourmile Branch, Pen Branch, Lower Three Runs, and Par Pond are on the RCRA/CERCLA Units List and will receive future evaluation and potential remedial actions under the requirements of the FFA. FFA Project Managers at EPA and SCDHEC have expressed concern about effects on these units due to actions on the River Water System. Basically, flows due to small pump operation under the No-Action Alternative would be less than those that occurred in 1996 in Fourmile Branch, Pen Branch, and the headwaters of Steel Creek; discharges to Lower Three Runs and Steel Creek at their dams would continue at 10 cubic feet (0.28 cubic meter) per second (4,500 gallons per minute). The extent of the reduction in Fourmile Branch, Pen Branch, and the headwaters of Steel Creek would be independent of the alternative DOE decided to implement. Onsite streams would approach natural flow conditions; operation of the small pump would keep L-Lake at its normal water level.

Water Requirements for Alternatives

Under the No-Action Alternative a combination of groundwater and river water from the small pump is required to supply the entire auxiliary equipment cooling water demand, sanitary waste water, fire protection, and maintenance of L-Lake levels. For the shutdown alternatives, DOE would need additional groundwater supplies to replace those that would be provided by the small pump under No Action. Table 1-2 presents a list of those requirements.

Air conditioning cooling water requirements for K- and L-Area are 1,510 gallons per minute (0.095 cubic meter per second) and 1,490

Table 1-2. Water requirements for No-Action and shutdown alternatives.

Purpose for water	No-Action: River Water Demand (gpm)	No-Action: Groundwater Demand (gpm)	Shutdown: Groundwater Demand (gpm)
L-Area			
186-Basin Fire Protection Water	200	0	200
Auxiliary Equipment Cooling	0	190[a]	190
Sanitary Waste Water Blending	83	0	0[b]
Lake Level and Steel Creek Flow Maintenance	4,517[c]	0	0
K-Area			
186-Basin Fire Protection Water	200	0	200
Auxiliary Equipment Cooling	0	210	210
Total	5,000	400	800

a. Although not required for the No-Action Alternative, DOE switched this cooling water requirement from river water to groundwater.
b. Replaced by septic tank and tile field in the shutdown alternatives.
c. Total outflow to L-Lake is 4,800 gpm.

gallons per minute (0.094 cubic meter per second), respectively (WSRC 1996a). The 4,800 gallons per minute (0.30 cubic meter per second) that will be pumped to L-Area by the small pump and eventually released to L-Lake is sufficient to provide all L-Area cooling water requirements.

As a cost-saving initiative, DOE eliminated the 1,300 gallons-per-minute (0.082 cubic-meter-per-second) load for air conditioning in each area by replacing the original water-cooled system with an air-cooled system. This action reduces the K- and L-Area demands to 210 gallons per minute (0.013 cubic meter per second) and 190 gallons per minute (0.012 cubic meter per second), respectively. Groundwater would be used to supply the 400-gallon-per-minute (0.025 cubic meters per second) demand for auxiliary equipment cooling. Therefore, before operation of the small pump, DOE provided well water to meet current requirements.

Small sanitary wastewater treatment plants in K-, L-, and P-Areas discharge through National Pollutant Discharge Elimination System (NPDES)-permitted outfalls to Indian Grave Branch, L-Lake, and the headwaters of Steel Creek, respectively. The associated action is to resolve compliance issues, if any, that would occur if DOE stopped pumping river water due to a decision to implement a shutdown alternative.

The P-Area sanitary wastewater plant was deactivated in November 1996, which eliminates its discharge. Because it is a package unit, it is being maintained for potential use at another location (Dukes 1997). The wastewater discharge from K-Area presents three potential concerns:

1. The elimination of river water pumping would affect permit limits due to loss of blending credit.
2. The effluent would not flow as far as the sampling point.
3. The effluent would not reach the intended receiving stream.

In relation to the first concern, calculations confirm that blending flow is not required at K-Area outfall (Huffines 1996a). DOE has also resolved the other two concerns with SCDHEC. DOE would not need to modify permit requirements or alter discharge paths if it moved the outfall to a location that would enable continuous sampling. Because there would be no discharge to the receiving stream except during storm events, DOE would address stormwater flows in the existing Stormwater General Permit (Smith 1996).

Calculations (Huffines 1996b) indicate that the effluent from the L-Area Sanitary Wastewater Treatment Plant would not meet SCDHEC standards for water quality without blending from other area effluents, such as river water flows. Under the No-Action Alternative, DOE requires 83 gallons per minute (0.0052 cubic meters per second) blending water through operation of the small pump (Huffines 1996b). Under a shutdown alternative, DOE would need an alternative method to meet SCDHEC standards for water quality. A recent DOE study presents three options (septic tanks and tile field, spray fields, and tying into the existing central system) and approximate costs for treating the L-Area sanitary wastewater (Huffines 1996b). DOE includes these possible cost impacts in Section 4.1.2 to enable a determination of the effect of those options on decisions about the River Water System.

Finally, DOE uses the 25-million-gallon (95,000-cubic-meter) 186-Basins in K- and L-Area as a long-term fire protection water supply source. In L-Area, a 4,800 gallon-per-minute (0.30 cubic-meter-per-second) overflow is maintained from the 186-Basin, which eventually discharges from NPDES permitted outfall L-07 to L-Lake. In K-Area, the 186-Basin is operated as a retention basin with no pumped withdrawal of water; however, the estimated latent water loss rate from the K-Area 186-Basin (evaporation and drain gate valve leakage) is about 110 gallons per minute (0.0069 cubic meter per second). To provide a liberal margin due to uncertainty in leakage, DOE provides 200 gallons per minute (0.013 cubic meter per second) of river water to the K-Area 186-Basin. This water loss rate would also apply to the L-Area 186-Basin if DOE selects a shutdown alternative. The capability to supply up to 400 gallons per minute (0.025 cubic meter per second) of alternative make-up water for fire protection must exist concurrent with the shutdown of the River Water System. DOE has determined that this make-up capacity could be provided by the existing K- and L-Area well water system.

Reactor 186-Basins Alternative Uses Study

In 1994, DOE studied the feasibility of using the SRS C-, L-, P-, and R-Reactor 186-Basins and 904-Retention Basins for aquacultural purposes (WSRC 1994a). This study indicated that raising hybrid striped bass or Australian crayfish would be feasible and potentially profitable alternative uses for the 186-Basins.

In March 1995 DOE advertised the availability of the reactor 186-Basins for commercial use. Several fish farming projects were solicited by the advertisement and, in one case, DOE was requested to provide assurance that secondary infrastructure would be available if investors funded use of the C-Area 186-Basin (Krist 1995). This project would require makeup water which could be supplied by river water or well water. Later that year, DOE accepted a fish farming proposal from a business partnership that would rely on make-up water supplied by the two C-Area deep wells (not the river water supply system). However, the partnership later made a business decision not to pursue the farming project and withdrew its proposal. No alternative uses of the reactor 186-Basins are currently planned by DOE.

CHAPTER 2. PURPOSE AND NEED FOR ACTION

The Federal government built the River Water System at the Savannah River Site (SRS) near Aiken, South Carolina, during the 1950s. During the time when the primary mission of the Site was to produce defense nuclear materials such as tritium for use in weapons, the mission of the River Water System was to provide cooling water to the SRS production reactors. Over the past several years, the SRS mission has changed. The mission at the SRS now emphasizes (1) the safe management of radioactive materials such as spent nuclear fuel for which it is responsible until the U.S. Department of Energy (DOE) can dispose of them safely and (2) the cleanup and environmental restoration of areas affected by more than 40 years of nuclear and industrial activity. TC

In March 1993 DOE placed K-Reactor, the last of the operating SRS production reactors, in a standby condition. In December 1995 Secretary of Energy O'Leary announced the Department's decisions on alternatives proposed for the production of tritium (60 FR 63878). Because these decisions did not involve the use of K-Reactor, DOE made an administrative decision to place it in a state of cold shutdown with no provision for future restart. In other words, from the perspective of having to supply cooling water to the reactors, there is no longer a mission for the River Water System.

In the future DOE probably will receive less funding than in past years, and so must determine the most effective and responsible use of its funds. The *DOE Savannah River Stategic Plan* (DOE 1996a) describes the changing mission, vision, and values at the SRS. In the plan, DOE commits to identify and dispose of excess infrastucture (items that once were part of the processes with which the Site accomplished its original mission but that have limited value for current Site missions). To that end, the Department has identified the River Water System as infrastructure that is both surplus and costly to operate and maintain. In 1993, for example, repairs to the Par Pond dam cost more than $10 million. Future costs will increase as equipment reliability decreases and replacement parts become more difficult to obtain. TC

Therefore, in a climate of decreasing funding for SRS missions, DOE must determine if it should continue to operate a system that has no current mission and that will become more expensive to operate as time passes. This environmental impact statement analyzes the impacts of the proposed shutdown of the River Water System. DOE proposes to perform the shutdown to save money; that is, to prevent further expenditures of funds to operate a system that has no current mission.

CHAPTER 3. PROPOSED ACTION AND ALTERNATIVES

The regulations of the Council on Environmental Quality (CEQ; 40 CFR 1500-1508) direct Federal agencies to use the process established by the National Environmental Policy Act (NEPA) to identify and assess reasonable alternatives to proposed actions that would avoid or minimize adverse effects on the quality of the human environment [40 CFR 1500.2(e)]. This chapter describes the No-Action Alternative and two other alternatives that span the range of reasonable alternatives for the shutdown of the River Water System at the Savannah River Site (SRS).

- No Action – The U.S. Department of Energy (DOE) would continue its present course of action, which it established through the NEPA process during the preparation of the environmental assessment (EA) and Finding of No Significant Impact for *Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a,b). Using the small pump described in Chapter 1, DOE would continue to pump water from the Savannah River to provide fire protection at K- and L-Reactors and blend flow into L-Area Sanitary Waste Plant effluent. In addition, DOE would pump water to L-Lake to maintain its full pool [190 feet (57.9 meters) above mean sea level]. DOE would also retain the capability to pump river water to Par Pond to prevent water levels from falling below 195 feet (59.4 meters) above mean sea level and to ensure that Steel Creek and Lower Three Runs received discharges no less than 10 cubic feet (0.28 cubic meter) per second. Section 3.1 contains a more detailed discussion of this alternative.

- Shut Down and Deactivate the River Water System – DOE would shut down and deactivate the River Water System and place it in a secure, environmentally satisfactory condition. This means that DOE could not pump river water to L-Lake, Par Pond, or to other current or future potential users of the system. Par Pond is expected to maintain a water level greater than 195 feet (59.4 meters) above mean sea level, and Lower Three Runs would receive minimum discharge of 10 cubic feet (0.28 cubic meter) per second. No surveillance or maintenance of the pump and piping system would be performed. The only water input both lakes would receive would come from natural recharge from the environment. The water level of L-Lake would fall to the original conditions of Steel Creek. Section 3.2 contains a more detailed discussion of this alternative.

- Shut Down and Maintain the River Water System – This is DOE's Proposed Action and Preferred Alternative. DOE would maintain the River Water System in a standby condition, which would include the ability to restart the system if environmental degradation/remediation or other future conditions or missions dictated such a need. With the exception of one layup scheme described in Section 3.3.2, L-Lake would subside to the original Steel Creek conditions. Par Pond would still be maintained at 195 to 200 feet (59.4 to 61.0 meters) above mean sea level, and flow in Lower Three Runs would be maintained at 10 cubic feet (0.28 cubic meter) per second. The remaining streams would receive natural flows from their respective watersheds. Section 3.3 contains a more detailed discussion of this alternative.

The information that DOE used to develop specific actions that would be involved in implementing the alternatives consisted of:

- Engineering studies that examined the effects of the shutdown of the River Water System on system structures, equipment, and piping, and the costs associated with a range of layup options

- Extensive analyses of aerial radiological surveys, radiological sampling of the sediments on the surface of the L-Lake lakebed, and deeper core sampling of the L-Lake lakebed
- Human health and ecological documentation from the early 1990s through 1996
- Studies of water and sediment chemistry, transport properties, effects of fluctuating water levels, fish communities, and vegetation
- Geological and hydrological studies of L-Lake, Par Pond, and the onsite streams conducted primarily in the 1990s
- NEPA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) documentation for Par Pond and L-Lake

DOE also recognizes that there are potential future uses of the River Water System. However, water requirements are not part of the scope or alternatives in this environmental impact statement (EIS) but would be examined in the NEPA review of the project or projects that would use the River Water System.

DOE eliminated several alternatives from the River Water System analysis as unreasonable, including options to maintain the surface of L-Lake at an intermediate level that would promote natural fluctuation. Another option was pumping of water from Par Pond through existing piping to P-Reactor and into L-Lake through Steel Creek. DOE eliminated this alternative on the basis of both cost and uncertainty that Par Pond would have sufficient supply to maintain L-Lake and Par Pond levels. These alternatives are not consistent with the need for DOE action (i.e., to reduce costs by shutting down the River Water System). Maintaining permanent water level in L-Lake would require the use of the River Water System.

DOE also eliminated an alternative that would have used the River Water System to pump to Par Pond to maintain nutrient inputs to the ecosystem and to minimize exposures to contaminated sediments. The extent of lakebed contamination in Par Pond is well documented [about two-thirds of the contaminated sediments in the lakebed are below the 189-foot (57.6-meter) level], and environmental impacts would occur if the lake level fell below 195 feet (59.4 meters) above mean sea level (DOE 1995a). However, studies and analyses conducted from 1991 to 1996 indicate that the lake would fluctuate but maintain its level well above 195 feet (59.4 meters) above mean sea level (Gladden 1996a). The continuation of pumping to Par Pond was part of the No-Action Alternative that DOE described in the Par Pond EA (DOE 1995a). In August 1995, DOE implemented the proposed action described in the EA, which evaluated the impacts as a result of natural fluctuation of the water level in Par Pond, and issued a Finding of No Significant Impact (DOE 1995b). Since January 1996, when DOE shut off the River Water System to Par Pond, the lake level has not fallen below the 199-foot (60.7-meter) level (Kirby 1996, 1997).

3.1 No-Action Alternative

As described above, the No-Action Alternative calls for DOE to continue the course of action it established as the result of an earlier NEPA evaluation, the *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a,b). The proposed action in that EA was to examine the need for continuing the operation of the River Water System by (1) developing data needed to evaluate potential environmental impacts of a further reduction or elimination of flow demands from the system and (2) evaluating the potential of reducing operating costs by allowing the water level in Par Pond to fluctuate with reduced pumping. The proposed action in the environmental assessment also included a reduction of flow rates from L-Lake to Steel Creek to natural stream flows while maintaining a full pool. In its Finding of No Significant Impact, DOE determined that, based on the information and analyses in the EA, the proposed action did not constitute a major Federal action that would significantly affect the quality of the human environment within the meaning of NEPA.

At present, the River Water System requires a staff of 7.8 full-time equivalent personnel and a visual security inspection once a day, and requires routine dredging of the intake canal from the Savannah River (Proveaux 1996). As indicated in Chapter 1, to save money (over $1 million per year) and energy, DOE will purchase a small pump [approximately 5,000 gallons per minute (0.32 cubic meter per second)] to supply the current demand for river water. As detailed in Chapter 1, DOE assumed the use of this new pump, rather than one of the existing large pumps, in the evaluation of this No-Action Alternative. DOE will provide measures to minimize current use of the River Water System. In K- and L-Areas, DOE has replaced river-water-cooled air conditioning chillers with air-cooled systems and river water with well water for cooling air compressors. TC The operation of the system using the small pump described above would entail the following annual costs (WSRC 1996c):

Item	Cost
System maintenance	$1,084,000
Dam (Par Pond and L-Lake) maintenance	520,000
Energy	494.000
Total	$2,098,000

3.1.1 L-LAKE

Under the No-Action Alternative, the River Water System would continue to pump an average of 5,000 gallons per minute (0.32 cubic meter per second) and would supply river water to K- and L-Reactors through their respective 186-Basins by way of 12 miles (19 kilometers) of underground concrete piping. In L-Area, outfall water from the reactor flows to L-Lake (WSRC 1996b). No Action in this EIS means that the River Water System would continue to pump an average of 5,000 gallons per minute (0.32 cubic meter per second) and that DOE TE would maintain L-Lake at full pool [i.e., 190 feet (57.9 meters) above mean sea level].

3.1.2 SRS STREAMS

Under the No-Action Alternative, reduced flow rates [i.e., no less than 10 cubic feet (0.28 cubic meter) per second] below the L-Lake and Par Pond dams would continue. In addition, the River Water System would continue to supply river water to loads in K- and L-Reactors. These loads include make-up water for fire protection in K- and L-Area basins and for blending of L-Area sanitary wastewater discharges. Flows from K- and L-Areas would continue to discharge to Indian Grave Branch and Pen Branch, and L-Lake and Steel Creek, respectively.

3.1.3 PAR POND

Under the No-Action Alternative, DOE would not pump river water to Par Pond, and the lake level would fluctuate near full pool [200 feet (61.0 meters) above mean sea level]. DOE has committed to a post-refill monitoring program that establishes threshold levels for the determination of impacts due to changes in hydrology (reservoir fluctuation performance), water quality, sediment contaminants, shore-zone macrophyte community, and fish populations as the reservoir water level fluctuates and the lake changes due to the lack of river water input (DOE 1995a). If any of these parameters exceeded established threshold levels, DOE would use the River Water System to pump water into the reservoir to an appropriate level greater than 195 feet (59.4 meters) above mean sea level to minimize impacts.

3.2 Shut Down and Deactivate the River Water System

This alternative would have two distinct phases: shutdown and deactivation. During the shutdown phase, DOE would perform the following activities:

- Secure River Water System facilities in C-, K-, L,- and P-Areas and the associated piping for personnel safety
- Secure Pumphouse 3G intake lines to prevent intrusion of water from the Savannah River
- Perform pumphouse cleanup activities necessary to satisfy concerns about releases of petroleum products or other chemicals that could affect the environment
- Leave the equipment in Pumphouse 3G with moving parts in the positions least susceptible to degradation
- Keep the L-Lake Dam intact with the outlet gates set to provide no less than 10 cubic feet (0.28 cubic meter) per second until the lake drained to the original natural flow of Steel Creek

The following costs would be associated with the shutdown phase (Jones 1996a; Jones 1997a; WSRC 1996b):

Item	Cost
System shutdown (one-time cost)	$200,000
Annual dam maintenance	520,000
Annual labor (one full-time equivalent person to handle minor maintenance)	85,000
Annual energy	20,000
Total annual cost	$625,000

DOE would complete the deactivation phase after the River Water System was completely through the shutdown phase and L-Lake had drained to the original condition of Steel Creek. DOE would limit surveillance or maintenance to Par Pond and would assume that no equipment would be operable in the future. After the lake recedes, DOE would either breach the dam or take other actions to ensure unobstructed flow a a cost in addition to those shown above to enable original stream flow conditions through the area with no further dam maintenance costs. This alternative would discontinue River Water System fire protection support for K- and L-Reactors. This make-up capacity would be provided by the existing K- and L-Area well water systems.

3.2.1 L-LAKE

Under the Shut Down and Deactivate Alternative, DOE would shut down the River Water System, thereby pumping no water to L-Lake. The only water the lake would receive would be through natural recharge. L-Lake would recede over approximately 10 years (Jones and Lamarre 1994), returning to the original stream flow conditions of Steel Creek. During this drawdown period, DOE would apply appropriate measures to minimize adverse effects of exposed sediments in the lakebed such as the following:

- Plant grass seed in exposed sediments to minimize the effects of erosion and exposure of contaminants in the lakebed
- Revegetate the upland areas with tree species by natural seeding and hand planting, i necessary
- Apply appropriate vegetation measures to accelerate the reversion of the lake to the original conditions of the Steel Creek floodplain
- Seed the upstream face of the dam and tie i into the embankment after the lake level drops below the top portion of the dam, which is protected by riprap

In addition, DOE would keep the outflow gates set to allow water to flow gradually to Steel Creek below the dam. During L-Lake drawdown, DOE would control the rate of drawdown to the extent possible by adjusting the outflow gates while maintaining 10 cubic feet (0.28 cubic meters) per second flow to Steel Creek. DOE would minimize drawdown of the lake during fall and winter months when the growth of stabilizing ground cover would be minimal. DOE may elect to drawdown L-Lake more quickly during the times when the receding water would expose steep banks that would be subject to erosion by wave action or when rapid natural growth of vegetation is assured.

During the period of L-Lake drawdown, DOE would take advantage of various research opportunities enabled by the transition of L-Lake from a lake system to its original stream ecosystem.

After Steel Creek reached its original flow conditions, DOE would either breach the dam or take the necessary actions to ensure continuous unobstructed flow through the existing outflow structure. The actions taken on the dam after L-Lake recedes would not occur in the near term (expected to be approximately 10 years after shutdown). Therefore, DOE considers this a connected action and does not evaluate the effects of alternative actions for the dam.

Additional actions concerning the future disposition of the dam would be subject to the appropriate level of NEPA review.

Natural Steel Creek flow is estimated to average 10 cubic feet (0.28 cubic meter) per second. This flow could not be augmented during low flow years.

3.2.2 SRS STREAMS

Under the Shut Down and Deactivate Alternative, DOE would shut down the River Water System, thereby supplying no river water to Steel Creek, Lower Three Runs, and other onsite streams. L-Lake would revert to stream conditions, but both Steel Creek and Lower Three Runs would receive flows which could support a diverse and biologically balanced fish community (WSRC 1993).

3.2.3 PAR POND

Under the Shut Down and Deactivate Alternative, DOE would not pump water to Par Pond. The only water the lake would receive would be through natural recharge. Because the River Water System would not be operating, man-made recharge would not be possible if the lake level fell below 195 feet (59.4 meters) above mean sea level.

3.3 Proposed Action - Shut Down and Maintain the River Water System

Sections 3.1 and 3.2 describe the bounds of reasonable alternatives. Under the No-Action Alternative, DOE would continue the current operation of the River Water System. Under the other bound, Shut Down and Deactivate, DOE would shut down and eventually abandon the system and would provide no surveillance and maintenance except that required to ensure safety and to avoid environmental releases of petroleum products or other chemicals. The DOE Proposed Action and Preferred Alternative, Shut Down and Maintain, is a middle ground under which DOE would shut the system down, lay up all or portions of the system, and maintain some portions in a standby condition that would enable restart.

As indicated in Section 3.2.1, the cessation of river water input to L-Lake is likely to result in a gradual drawdown of the lake and its reversion to the original conditions of Steel Creek. During the drawdown period (about 10 years), DOE would apply measures to ensure that it could refill L-Lake safely and would apply the measures described in Section 3.2.1 to minimize adverse effects of exposed sediments in the lakebed. DOE also would apply the measures described in Section 3.2.1 to control the rate of drawdown under this alternative. DOE could TC restart the system temporarily to eliminate drawdown during periods of slow regrowth. This alternative would require another water supply for fire protection. This make-up capacity would be provided by the existing K- and L-Area well water system.

A decision to implement the Proposed Action would require a corresponding decision on the type of layup that DOE would implement. For example, DOE could maintain the system in a way that enabled startup in a short period of time, or (at significantly less cost) it could shut down the system to the extent that it would take a long time to return the system to an operable condition. The following subsections contain examples of potential events that could lead to a decision to restart the River Water System if DOE selected and implemented the Proposed Action and layup schemes ranging from a high state of readiness (almost immediate startup with high annual surveillance and maintenance costs) to minimal surveillance and maintenance (requiring a long time period and significant expense to bring the system to operational readiness).

3.3.1 POTENTIAL DECISIONS TO RESTART THE RIVER WATER SYSTEM

DOE would shut down the River Water System, lay up all portions of the system, and maintain those portions in a standby condition that would enable restart. This status would continue until DOE was sure that maintenance in standby was unnecessary. DOE proposes to maintain the system because there could be future needs that require large quantities of water, making the restart of the system a feasible option. Should DOE determine in the future that it no longer desires to maintain the River Water System in a standby condition, DOE would issue a Record of Decision based on this EIS and deactivate the system.

L10-05 Three examples of restarting the River Water System are presented below. DOE does not wish to imply that it expects to actually need to restart the system for the situations presented but has selected them to cover a range of actions that maintenance in standby would support (i.e., pump to L-Lake, Par Pond, or a new facility).

3.3.1.1 <u>Pump to Par Pond</u>

L10-05 Until final CERCLA remedial actions are determined and implemented, DOE would pump river water into Par Pond to bring the lake back to an appropriate level greater than 195 feet (59.4 meters) above mean sea level if any monitored parameter exceeded established threshold levels. DOE believes that the likelihood of exceedances or the lake level falling below 195 feet (59.4 meters) is very low. DOE used 10 years of rainfall data and applied a simulation model to estimate changes in the Par Pond water level, basing its estimates on natural surface water and groundwater inflows (i.e., no pumping) and a discharge of 5,000 gallons per minute (0.32 cubic meter per second), which is slightly greater than the required 10 cubic feet (0.28 cubic meter) per second to Lower Three Runs. DOE based its determination that the 10-cubic-foot-per-second discharge rate was appropriate on discharge/habitat relationships predicted by an instream flow model and information on fish assemblage structure. DOE believes that Par Pond would not fall below the 195 foot level unless there was a catastrophic L9-07 drought that would affect water quality in other regional lakes and streams. Based on the 10-year record and the simulation model, this analysis predicted that the water level would be above 198.4 feet (60.5 meters) 75 percent of the time and the lowest level would be 196.6 feet (59.9 meters) (Gladden 1996a). Based on gage data in calendar year 1996, the lowest daily lake level was 199.21 feet (61 meters) (Kirby 1997). Nevertheless, DOE prefers to maintain the River L9-07 Water System after shutdown and, if necessary it would restart the system, pump to Par Pond, and bring the water level to an appropriate level above 195 feet (60 meters).

Under the Proposed Action, DOE could bring the water level back to an appropriate level above 195 feet (59.4 meters) above mean sea level by restarting the River Water System. This would require restart of at least one of the large system pumps. A layup option requiring a short time to resume pumping would be preferred. Otherwise, DOE would initiate system restart before a monitored parameter exceeded an established threshold level [i.e., if it observed that drought conditions would be likely to persist and the lake level was approaching the lower bounding limit of 195 feet (59.4 meters)].

3.3.1.2 Refill L-Lake

In accordance with the Federal Facility Agreement (FFA) between DOE, the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (EPA 1993a), DOE has prepared an internal draft remedial site evaluation report for L-Lake. The report contains recommendations on the need for further investigation of the lake under the FFA. In the unlikely event that the decision under the FFA process included refilling the lake to an appropriate level, DOE would then restart the River Water System to refill L-Lake. The time required to restart the system would not be critical, but this decision would require a substantial quantity of water. For example, using two 25,000-gallon-per-minute (1.6-cubic-meter-per-second) pumps to fill an empty L-Lake to its normal pool while continuing to release 10 cubic feet (0.28 cubic meter) per second to Steel Creek would take approximately 4 months. After refilling the lake, DOE would run the small pump [approximately 5,000 gallons per minute (0.32 cubic meter per second)] continuously to maintain the lake level and downstream releases.

3.3.1.3 Support New Missions

Although the current SRS mission emphasis is cleanup and environmental restoration, DOE could initiate new defense-related, industrial, or other missions that would require large quantities of water that the River Water System could provide. For example, in the Tritium Supply and Recycling Programmatic EIS, DOE evaluated an alternative which would produce tritium in an accelerator. In the associated Record of Decision, DOE announced its intention to pursue a dual track involving the two most promising tritium supply alternatives: (1) an existing or partially complete commercial reactor and (2) accelerator production of tritium. The Record of Decision also selected the SRS as the location for an accelerator, if DOE decides to build one. By 1998, DOE will select the primary source of tritium and thereafter will develop the other alternative as a backup tritium source, if feasible (60 FR 63878-63891).

DOE plans to prepare project-level EISs for these potential projects (see *Notice of Intent, Accelerator Production of Tritium at the Savannah River Site Environmental Impact Statement,* 60 FR 46787-46790). The optimum use of the River Water System, if any, would be part of the project design for an accelerator. At present, three of the plans for supplying cooling water to an accelerator involve the use of the system. The preferred plan would use the pumphouse, two replacement pumps, and an existing distribution line to get as close as possible to the project site, and then would construct a smaller pipe to carry make-up water to recirculating cooling towers at the accelerator [preliminary calculations indicate that approximately 6,000 gallons per minute (0.38 cubic meter per second) of make-up water would supply the peak demand] (WSRC 1996d). The second plan would use the existing pumphouse, pumps, and distribution system, then would construct a new, large-diameter pipe to carry water to once-through heat exchangers at the accelerator [preliminary calculations indicate that this alternative would require approximately 125,000 gallons per minute (7.9 cubic meters per second)]. The third option would use the K-Reactor cooling tower and portions of River Water System piping.

Shutting down and maintaining the River Water System could preserve its availability for such new missions as the accelerator project. The

second plan described above would necessitate a far more extensive restart mission. Nevertheless, DOE could accomplish the required upgrades and replacements over an extended
TC period of time (30 months), and the system
L2-01 would be available when the accelerator project was ready to use the cooling water supply.

TC | 3.3.2 LAYUP OPTIONS

River Water System operations personnel pre-
TE pared cost estimates for the potential shutdown and restart of the system for several combinations of restart reliability (high risk/low reliability versus low risk/high reliability), layup schemes [pipes full using the small 5,000-gallon-per-minute (0.32-cubic-meter-per-second) pump versus pipes full using a still smaller jockey pump versus dry pipe], and levels of operational readiness (restart within 1, 6, 12, and 30 months) (WSRC 1996c). From these combinations, DOE selected options that were reasonable for its Preferred Alternative, Shut Down and Maintain.

DOE eliminated high risk/low reliability because it would want assurance of restart capability if it decided to restart the system. The three layup schemes are reasonable, but they vary in cost and the operational readiness they could support. For example, the small-pump layup scheme is the only one that could support restart within 1 month; system startup under the dry pipe scheme would require 30 months. Surveillance, maintenance, and restart costs are sensitive to the level of operational readiness. High operational readiness (restart in 1 month) would provide no cost advantage over operating under the No-Action Alternative, while layup under schemes calling for restart within 30 months would save nearly $1.5 million per year.

The following bases for the analysis are important for a comparison of the layup and restart options:

- Costs presented for implementing each layup option are for comparison only. Because DOE has not developed detailed project plans for the layup and restart options, they are only preliminary estimates of probable cost. However, because DOE used a consistent set of assumptions to develop the costs for each option, they provide a reasonable basis for comparison.

- Costs are in 1996 dollars without an escalation or discount rate. The restart costs assume that the River Water System would be shut down for 3 to 5 years before DOE decided to restore or restart it. As the shutdown time lengthened, replacement costs would increase.

- TC In the base case, all layup schemes would maintain two large pumps with a combined capacity of 50,000 gallons per minute (3.2 cubic meters per second), and would permanently shut down the water line to R-Area and would not bring it back up. These layup schemes would not support the demand for the once-through heat exchangers at the accelerator, and the R-Area line is the line DOE would use for either river water alternative for the accelerator. Therefore, the base case estimates do not serve as a guide for the accelerator examples. As stated above, the optimum use of the River TC Water System, if any, would be part of the project design for the accelerator.

- As stated above, the optimum use of the River Water System, if any, would be part of the project design for the accelerator. However, DOE has estimated the additional cost for maintaining the water line to R-Area to support the preferred recirculating L1-01 L2-01 L15-01 cooling tower plan or the once-through heat exchanger plan. It has also estimated the additional cost of maintaining eight large pumps that would supply river water to the once-through heat exchangers.

- With the wet layup schemes (small 5,000 gallon-per-minute pump or jockey pump), excess water above that needed to keep the L9-02 system pressurized will be discharged to an appropriate outfall. The small pump layup scheme could maintain L-Lake at its normal operating level [190 feet (58 meters)]. Discharge from the jockey pump would be insufficient to maintain lake level. L9-02

- The analysis does not include procurement and installation costs for the jockey and small pumps. The small pump and its estimated 800-horsepower motor will be available for each layup scheme and, therefore, should not be part of this cost analysis.

Table 3-1 lists the results of the base case restart readiness/layup scheme for the low risk/high reliability options. The sections that follow the table discuss each combination.

DOE assumes that dam maintenance, which includes both L-Lake and Par Pond dams, would be constant ($520,000 per year) for all combinations. In addition, there is a trend toward lower annual costs of layup and higher restart cost as readiness decreases (i.e., increased time to restart). If DOE did not restart the system during the layup period, the Shut Down and Deactivate Alternative would be less costly than the layup combinations listed in Table 3-1.

3.3.2.1 Restart in 1 Month

- Small Pump – Only the small-pump scheme would support a restart within 1 month. Pumping would be continuous and essentially equivalent to activities under the No-Action Alternative. Because this option would not meet the purpose and need for the shutdown action (i.e., cost savings), it is not a reasonable option for the Proposed Action to shut down the River Water System and maintain it in standby.

3.3.2.2 Restart in 6 Months

- Small Pump – The small-pump scheme to support a restart within 6 months would be equal in cost to a 1-month restart, and DOE has dismissed it as an unreasonable option for the Proposed Action.
- Jockey Pump – If DOE desired this high degree of operational readiness (restart in 6 months), it would save about $300,000 per year in electricity. A 6-month restart scheme would require a wet layup. This means the jockey pump would run continuously and the two large pumps that DOE is maintaining would run 24 hours per month to keep the system pressurized. The estimated savings in electricity would pay for the jockey pump in about 2 years of layup. Because the need to replace equipment is not likely under this intense surveillance and maintenance option, restart costs would be zero. Most restart actions would not require a startup time this fast. It would,

Table 3-1. Maintenance and restart costs of layup options - base case. TC

Time to restart	Layup scheme	Annual Costs ($ million per year): Electricity	System surveillance and maintenance	L-Lake and Par Pond dam maintenance	Total annual cost	One-time cost for restart ($ million) TC
1 month	Small pump	0.494	1.084	0.520	2.098	0.000
6 months	Small pump	0.494	1.084	0.520	2.098	0.000
	Jockey pump	0.164	1.084	0.520	1.768	0.000
12 months	Small pump	0.401	0.865	0.520	1.786	0.552
	Jockey pump	0.071	0.710	0.520	1.301	0.812
30 months	Small pump	0.401	0.865	0.520	1.786	0.560
	Jockey pump	0.071	0.710	0.520	1.301	0.820
	Dry layup	0.044	0.085	0.520	0.649	4.730

however, enable DOE to respond quickly to water needs at Par Pond.

3.3.2.3 Restart in 12 Months

As in the 6-month restart options, only wet layup schemes could support restart in 12 months. Under both schemes, continuous pumping would keep the system pressurized. However, system operations personnel would rotate the two large pumps in standby by hand and would not operate them. This option would result in lower electricity and system maintenance costs in comparison to the corresponding 6-month restart schemes, but there would also be restart costs.

- Small Pump – In relation to No Action, the small-pump scheme and 12-month startup would save about $300,000 per year but would require approximately $550,000 for restart. If DOE kept the system shut down for more than 2 years, the costs to maintain and restart would be less than the costs to operate under the No-Action Alternative. Both No Action alternative and this layup
L9-02 scheme could maintain L-Lake.
- Jockey Pump – The total annual cost for the jockey pump scheme would be approximately $485,000 less than the cost for the small pump scheme for the 1-year-to-restart case, but restart costs would be an additional $260,000. Given a reasonable period of layup the jockey pump option would have a lower cost. For example, for a 5-year layup period the total cost for layup and restart would be approximately $9.5 million ($1.786 \times 5 + 0.552$) for the small-pump scheme and approximately $7.3 million ($1.301 \times 5 + 0.812$) for the jockey pump scheme.

3.3.2.4 Restart in 30 Months

The wet pipe layup schemes and the dry pipe scheme could support restart in 30 months.

- Small-Pump – This option would have the same annual layup costs as the correspond-
TE ing 12-month restart option.
- Jockey Pump – As in the 12-month restart options, the jockey pump scheme is better than the small-pump scheme with respect to cost because the lower annual costs during layup quickly offset the higher cost to restart the system.
- Dry Layup – The characteristics of the dry pipe layup and restart scheme are low annual costs for electricity, surveillance, and maintenance but high costs for restart. Under this scheme, DOE would maintain building electricity as it would in all layup combinations but would not maintain right of way; fallen trees would be cleared but no brush would be cut. System operations personnel estimate that this scheme would require the replacement of 1 mile (1.6 kilometers) of pipe, which would account for $2 million of the $4.7 million restart cost.

DOE compared layup and restart costs for the jockey and dry pipe schemes. For layup periods of less than 6 years, the relatively low startup costs for the jockey pump scheme would make its total layup and restart costs less than those for the dry pipe scheme. For layup periods of 6 years or more, the relatively low annual costs of layup for the dry pipe scheme would dominate and its total cost of layup and restart would be less than those for the jockey pump scheme. Table 3-2 summarizes the tradeoffs between the two schemes and compares both to the cost of operation under No Action.

Table 3-2. Cumulative costs to lay up, restart (within 30 months), and operate the River Water System (layup period in years; costs in millions of dollars). TE

Layup period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Operation (No Action)	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0	23.1	25.2	27.3	29.4	31.5
Jockey pump	2.1	3.4	4.7	6.0	7.3	8.6	9.9	11.2	12.5	13.8	15.1	16.4	17.7	19.0	20.3
Dry pipe	5.4	6.0	6.7	7.3	8.0	8.6	9.3	9.9	10.6	11.2	11.9	12.5	13.2	13.8	14.5
Jockey pump savings	0.0	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	7.9	8.7	9.5	10.3	11.1
Dry pipe savings	-3.3	-1.8	-0.4	1.1	2.5	4.0	5.4	6.9	8.3	9.8	11.2	12.7	14.1	15.6	17.0

3.3.2.5 Additional Costs to Support Use of the River Water System for Accelerator Production of Tritium

As stated for base case layup options, DOE would permanently shutdown the water line to R-Area (i.e., the R-Normal Line) and would not reactivate it if the system is restarted. In its selection of a restart option, DOE would evaluate the additional cost of maintaining the R-Normal Line for a short period of time until the decision on whether or not to construct the accelerator for production of tritium is made (DOE expects to make this decision by 1998). L15-02 L1-01 L2-01

If DOE wants to ensure the capability to support the preferred recirculating cooling tower option, it would not need to change its layup options except for increased surveillance and maintenance of the R-Normal Line. The increased cost is expected to be $10,000 per year for the dry pipe scheme and $35,000 per year for the wet pipe schemes (Jones 1997b). L15-02 L1-01 L2-01

If DOE also wishes to ensure the capability to support the once-through heat-exchanger option, it would maintain eight large pumps to be available to supply the 125,000 gallons per minute once-through flow. This would increase the costs for electricity, maintenance, and restart. Table 3-3 presents the increased costs to support this option, including surveillance and maintenance of the R-Normal Line.

Table 3-3. Additional cost to maintain R-Normal Line and 125,000 gallon-per-minute pumping capacity. L15-02 L1-01 L2-01

Time to restart	Layup scheme	Annual Costs ($ million per year): Electricity	System surveillance and maintenance	L-Lake and Par Pond dam maintenance	Total annual cost	One-time cost for restart ($ million)
1 month	Small pump	0.020	0.135	0.000	0.155	0.000
6 months	Small pump	0.020	0.135	0.000	0.155	0.000
	Jockey pump	0.020	0.135	0.000	0.155	0.000
12 months	Small pump	0.020	0.140	0.000	0.160	0.806
	Jockey pump	0.020	0.135	0.000	0.155	0.896
30 months	Small pump	0.020	0.140	0.000	0.160	0.830
	Jockey pump	0.020	0.135	0.000	0.155	0.920
	Dry layup	0.006	0.040	0.000	0.046	2.368

Source: Jones (1997c).

3.3.3 ADDITIONAL COSTS FOR THE SHUTDOWN AND MAINTAIN ALTERNATIVE

DOE has considered additional costs to implement the Shutdown and Maintain Alternative. They include monitoring and restoration costs incurred by the L-Lake drawdown and an alternative to river system blending water for sanitary wastewater effluents in L-Area. These costs are as follows:

- Septic tank and tile field installation:
L9-10 $70,100; annual operation and maintenance: $120.

  Other alternatives to River Water System blending are in Section 4.1.2.

- Monitoring and restoration costs during L-Lake drawdown are estimated to average $190,000 per year for approximately 10 years.

  This cost is a preliminary estimate of probable cost. The preliminary estimates range from $125,000 per year to $300,000 per year depending on the extent of stabilization, revegetation, and monitoring. If DOE selects a shutdown alternative, it will prepare a detailed monitoring and restoration implementation plan that will enable costs to be estimated with greater accuracy.

Costs for investigation and potential remedial actions for L-Lake would be incurred regardless of the decision on the River Water System. DOE believes that the reversion of L-Lake to pre-SRS Steel Creek conditions would enhance the efficiency of the investigation and remedial action under the FFA. The costs for alternative
L9-10 remedial actions for a drained lake are presented in Appendix A and summarized in Table 3-4.

DOE believes that institutional controls to prevent residential use of the L-Lake lakebed for a period of time that allows for natural radiological decay of the contaminants to safe levels is more cost effective and reasonable than maintaining the 40-year-old River Water System and incurring the cost to maintain L-Lake water level for a long (perhaps 100 years) period of time. For the benefit of readers who do not wish to study the appendixes, costs estimates for various remedial options are presented below.

Table 3-4. Costs for various remedial options in accordance with the Federal Facility Agreement.

Remedial option	Onsite worker (risk = 10^{-4})	Onsite worker (risk = 10^{-6})	Future resident (risk = 10^{-4})	Future resident (risk = 10^{-6})
L9-10 No action	No cost	No cost	No cost	No cost
Institutional control	No cost	$10,000	$15,000	$15,000
Soil cover	No cost	$100,000	$29.7 million	$131 million
Excavation	No cost	$1.4 million	$380 million	$1.7 billion

3.4 Comparison of Environmental Impacts

This EIS evaluates alternative actions for the River Water System at the SRS. The alternatives cover the spectrum of reasonable actions from continued operation (No Action) to complete shutdown and deactivation (Shut Down and Deactivate). The DOE Proposed Action and Preferred Alternative is a middle ground under which DOE would shut the system down, lay up all or portions of the system, and maintain some portions in a standby condition that would enable restart.

The alternatives vary substantially in achieving the purpose and need for DOE action, costs to operate or maintain the system, commitment of resources, and environmental consequences.
TE Table 3-5 compares basic operational characteristics of the alternatives.

Table 3-5. Characteristics of the alternatives.

	No Action	Shut Down and Deactivate	Shut Down and Maintain	
Data	Small pump	No pumping	Jockey pump[a]	Dry layup[b]
Replacement/restart one-time cost[c]	NA[d]	NA	$820,000	$4,730,000
Time to restart	NA	NA	30 months	30 months
Cost of Operation		$200,000[e]		
System surveillance and maintenance	$1,084,000	$85,000[f]	$710,000	$85,000
L-Lake, Par Pond Dam surveillance and maintenance	520,000	$520,000[g]	520,000	520,000
Energy costs	494,000	20,000	71,000	44,000
Total annual cost	$2,098,000[h]	$625,000	$1,301,000	$649,000
Staff required[i]	7.8	1	6	1
Security (included in total costs)	Visual inspection 1/day	Visual inspection 1/day	Visual inspection 1/day	Visual inspection 1/day
Regulatory requirements	Intake canal dredging	None	Dredging[j] SCDHEC[k] permit for spoils	Dredging SCDHEC permit for spoils
Volume of water pumped	5,000-gallon-per-minute average	NA	Low flow to keep piping system pressurized	0

TC

a. The piping system would stay pressurized by operation of a very small pump called a jockey pump.
b. The piping system would be drained.
c. One-time cost to restart (high reliability).
d. NA = not applicable.
e. One-time cost to shut down.
f. One full-time equivalent person to handle minor maintenance.
g. This is an annual cost for L-Lake and Par Pond dams. After L-Lake has receded and the dam is breached, annual dam maintenance costs for L-Lake will be $0.
h. This cost does not include unexpected repair or replacement of the system.
i. Staff salary and overhead are included in system and dam maintenance cost.
j. Above costs do not include cost (if any) for re-permitting for dredging or reuse of existing spoil areas.
k. SCDHEC = South Carolina Department of Health and Environmental Control.

Table 3-6 summarizes and compares potential environmental impacts of the alternatives. The intent of this table is to draw from the detailed sections on affected environment and environmental impacts to present the primary impacts of the Proposed Action and alternatives in comparative form. The following statements form the bases of the results reported in this table: L12-05

- DOE will operate a 5,000-gallon-per-minute (0.32-cubic-meter-per-second) pump as a way to save money and energy. In this EIS, flows and cost comparisons described under the No-Action Alternative reflect operation of the small pump. TC
- Under the shutdown alternatives, DOE would implement alternative sources for the river water required under No Action except that DOE would not provide water to L-Lake to maintain its water level. These requirements are reflected as an incremental impact of shutdown relative to No Action.
- Analyses indicate that L-Lake cannot maintain its normal pool level without flow augmentation from the River Water System.

To ensure that impacts of the shutdown alternatives are not underestimated, DOE assumes a worst-case situation where L-Lake continues to recede until it reaches the original Steel Creek surface water profile.

- With the exception of capability under the Proposed Action to restart the River Water System to respond to potential future needs, impacts under the Shut Down and Deactivate Alternative are equal to those of the DOE Proposed Action and Preferred Alternative, Shut Down and Maintain.

TE

Table 3-6. Comparison of the impacts of the alternatives for the River Water System.

Resource	No-Action Alternative	Shutdown Alternatives
Geology and Soils		
Castor Creek (tributary to Fourmile Branch) and headwaters of Steel Creek (upstream of L-Lake)	Minimal soil erosion from vegetated slopes and natural flows	Same as No-Action Alternative.
Indian Grave Branch (tributary to Pen Branch)	Minimal soil erosion from vegetated slopes carrying natural flows and river water and well water discharges from K-Area	Same as No-Action Alternative except well water would replace river water discharge.
Steel Creek and Lower Three Runs (below dams)	Minimal erosion and sedimentation rates due to controlled stream flow	Same as No-Action Alternative for Lower Three Runs and Steel Creek while L-Lake drains, after which Steel Creek flows would be variable and uncontrolled and would experience moderate erosion and sedimentation from lakebed.
L-Lake and Par Pond	Minimal erosion due to constant normal pool water elevations in L-Lake and small fluctuations in Par Pond	Minimal remobilization of soils potentially contaminated by preimpoundment activities due to gradual recession of L-Lake; same as No-Action Alternative in Par Pond.
Surface Water		
Par Pond	Par Pond ecosystem would revert to that typically found in reservoirs in Southeast due to reduction of nutrients from Savannah River; DOE could resume pumping to Par Pond if conditions warranted	Reversion to typical southeastern reservoir, as with No-Action Alternative; under Shut Down and Maintain, DOE could prepare system for operation, then restart system to pump to Par Pond; no capability to pump under Shut Down and Deactivate.
L-Lake	Water level sustained by as much as 4,800 gpm[a] of river water pumped to and discharged from L-Area	Reversion to stream conditions with potential for lakebed erosion.

Table 3-6. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
L-Lake water quality	Dissolved oxygen in epilimnion seldom would fall below 5 milligrams per liter and would generally be greater than 1 milligram per liter in hypolimnion. Lowest temperatures would be around 50°F (10°C); maximum near-surface summer temperatures would be around 86°F (30°C); acidity would not be substantial; pH levels in near-surface water would seldom fall below 6.	Reduction in dissolved oxygen and temperature and increased acidity in epilimnion and hypolimnion of L-Lake until lake is drained.
Steel Creek	Minimal siltation due to intake structure drawing water that would be low in suspended solids from top of lake; flow of 10 cfs[b] would be sustained	The dam is expected to act as a sedimentation basin, thereby minimizing siltation below dam. TC
L-Area sanitary wastewater treatment plant	Blending flows would be supplied by river water pumping to L-Area	Alternate compliance method (e.g., septic tanks) would be required.
L-Area cooling water discharges	L-Area 186-Basin maintained full for fire protection and overflowing for discharges to L-Lake; well water or river water could supply 190 gpm of cooling water for compressors	Alternate supply (e.g., well water) would be required for fire protection and compressor cooling; total well water requirement would be 390 gpm; total discharge to L-Lake would be reduced by 10 gpm evaporation from the 186-Basin to approximately 380 gpm.
K-Area cooling water discharges	As much as 200 gpm pumped from system to K-Area 186-Basin for fire protection; well water would supply 210 gpm of cooling water for compressors	Alternate supply (e.g., well water) would be required for fire protection; same as No-Action Alternative for compressor cooling water; total discharge to Indian Grave Branch would be approximately 400 gpm (i.e., 200+210 less evaporation).
Groundwater		
Water table levels in L-Area	With downgradient elevation of Water Table Aquifer controlled by lake level, it would stand at 190 ft[c] above mean sea level; Water Table Aquifer elevation at L-Area Oil and Chemical Basin (one of four nearby CERCLA[d] units) would be approximately 208 ft	As L-Lake recedes, water table elevations would drop 10 ft at Steel Creek outcrop (estimated 180 ft); at L-Area Oil and Chemical Basin, water table elevations would drop approximately 4 ft (estimated 204 ft); hydraulic gradients at CERCLA units would increase resulting in a 12-percent increase in local velocities. After lake level dropped, it would take approximately 18 years for contaminated groundwater to travel from CERCLA units to Steel Creek. Therefore, there would be little, if any, effect on remedial actions for these units.
Air		
Air toxic - Mercury	0.014 microgram per cubic meter	Increased by 1.15×10^{-6} microgram per cubic meter to approximately 6 percent of regulatory standard.

Table 3-6. (continued).

	Resource	No-Action Alternative	Shutdown Alternatives
TC	Air toxic - Manganese	0.821 microgram per cubic meter	Increased by 2.6×10^{-6} microgram per cubic meter to approximately 3 percent of regulatory standard.
	Criteria pollutant - 24-hour PM_{10} concentration at SRS boundary	SRS sources plus background = 113 micrograms per cubic meter at the SRS boundary	Increase of 16 for a total of 129 micrograms per cubic meter at the SRS boundary, which is 85.7 percent of regulatory standard.
TC	Radionuclides - annual effective inhalation dose equivalent to maximally exposed offsite individual	Very small dose (0.02 millirem/yr)	Total dose from all pathways 6.5×10^{-3} (mrem/yr); 0.07 percent of regulatory standard.
	Terrestrial Ecology		
TE	L-Lake	No reduction in habitat for amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl in L-Lake	Reduction in habitat for amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl as L-Lake recedes.
		L-Lake amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl would be protected from predation	L-Lake amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl would be more vulnerable to predation as reservoir recedes.
		No increased exposure to contaminated L-Lake sediments	Animals foraging in the lakebed after drawdown would be exposed to contaminated sediments via inhalation, ingestion, and dermal contact.
	Aquatic Ecology		
	L-Lake	Natural changes in aquatic communities as L-Lake ages	Reservoir ecosystem replaced by small stream ecosystem.
	SRS streams	Natural flows in small watersheds support few benthic organisms and fish in Indian Grave Branch	Same as No-Action Alternative.
	Wetlands		
	L-Lake	Natural successional changes in littoral zone plant communities	Loss of submerged and floating-leaved aquatic plants as reservoir recedes; emergent species could move downslope with lake level.
	Par Pond	Changes in species composition of littoral-zone plants; acreage could be reduced	Same as No-Action Alternative.
TC	Steel Creek	With 10 cfs flow requirement, scrub-shrub vegetation would become more prevalent in stream corridor; willow probably would predominate. Over time, hardwood species would become established in delta, replacing swamp (cypress-gum) forest with deciduous hardwood (oak-elm-sweetgum) forest.	Same as No-Action Alternative during drawdown; after drawdown, natural flows would vary, averaging 10 cfs.

Table 3-6. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
Lower Three Runs	Readjustment of stream and bottomland ecosystems associated with continuation of existing flow requirements	Same as No-Action Alternative.
Threatened and Endangered Species		
Bald eagles	Bald eagles nesting at Pen Branch would continue to forage around L-Lake	Bald eagles nesting at Pen Branch would in time lose primary foraging habitat (L-Lake) and could leave area.
Wood storks	Foraging on SRS would continue	Wood storks could be exposed to increased levels of contaminants if L-Lake dropped rapidly and fish were trapped in small pools (primarily in spring and summer, when wood storks forage on SRS). TC
Alligators	Alligators would continue to be present in L-Lake	L-Lake alligators would, in time, be displaced; drawdown of L-Lake could result in loss of nests, eggs, or hatchlings, depending on timing and rapidity of drawdown.
Occupational Health		
Radiological - annual probability of fatal cancer to current involved worker (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	1.7×10^{-7}	1.7×10^{-7} TC
Radiological - number of lifetime fatal cancers to current SRS involved workers (16 lifetime fatal cancers from all causes expected in current SRS involved worker population)[e]	5.5×10^{-5}	5.5×10^{-5} TE
Nonradiological - annual probability of fatal cancer to current SRS involved worker (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	2.5×10^{-8}	1.4×10^{-6} TC
Public Health		
Radiological - annual probability of fatal cancer to offsite maximally exposed individual (annual fatal cancer risk from all causes is 3.4×10^{-3})[e]	3.3×10^{-9}	3.5×10^{-9} TC

Table 3-6. (continued).

Resource	No-Action Alternative	Shutdown Alternatives
TC Radiological - number of lifetime fatal cancers to offsite population (157,900 lifetime fatal cancers from all causes expected in the offsite population living within 50 miles of SRS)[e]	5.0×10^{-5}	4.9×10^{-5}
TC Nonradiological - annual probability of fatal cancer to offsite maximally exposed individual (annual fatal risk from all causes is 3.4×10^{-3})[e]	None	7.9×10^{-9}
Land Use		
Onsite	Site facilities, natural vegetation types with more than 73 percent in forest land	Same as No-Action Alternative
Adjacent land	Used mainly for forest, agricultural, and industrial purposes	Same as No-Action Alternative
Aesthetics		
TE L12-09 L-Lake	1,000-acre reservoir with wetlands along shoreline and abundance of wading birds, turtles, and some alligators	As L-Lake recedes, dried mud flats would appear for periods of time until revegetation began; could be seen by 1,800 SRS workers who pass by daily.
TC Par Pond	2,640-acre reservoir with wetlands along shoreline, pine and hardwood forests up slope; abundance of amphibians, reptiles, wading birds, and waterfowl (in winter); water level fluctuates while discharge from Par Pond is controlled.	Same as No-Action Alternative
SRS streams	Narrow streams at headwaters broadening into wide swampy deltas at Savannah River; abundant hardwood and wetland vegetation with variety of wildlife; 10 cfs in Lower Three Runs and Steel Creek downstream of dams; natural flow in Fourmile Branch and Steel Creek above L-Lake; natural flow plus small cooling water discharges to Indian Grave Branch/Pen Branch	Same as No-Action Alternative

a. gpm = gallons per minute; to convert to cubic meters per second, multiply by 0.000063088.
b. cfs = cubic feet per second; to convert to cubic meters per second, multiply by 0.028317.
c. ft = feet; to convert to meters, multiply by 0.3048.
TE d. CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
e. Based on fatal cancer incidence in general population of 235 per 1,000 and a 70-year life expectancy.

CHAPTER 4. AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

Chapter 1 of this environmental impact statement (EIS) introduces the River Water System, alternative actions related to the system, and actions connected to the Proposed Action to shut down the system and maintain it in standby; Chapter 2 describes the U.S. Department of Energy (DOE) purpose and need to implement actions on the River Water System; and Chapter 3 describes three reasonable alternative actions. This chapter describes the environment of the Savannah River Site (SRS) and the impacts of implementing the alternatives, including the Proposed Action. In addition, it provides the information and analysis for a comparison of the environmental impacts of the Proposed Action and the alternatives (see Section 3.4).

DOE determined that it could enhance the quality of the analysis and the clarity of the presentation by using an EIS format that was different from its standard format (40 CFR 1502.10). Rather than using the approach that presents the affected environment and impacts sections in separate chapters, DOE put both the affected environment and impacts in this chapter, so the description of the affected environment for a particular resource category (e.g., groundwater) precedes the description of the impacts of each alternative on that resource. Further, DOE has divided the sections by water body to emphasize the component that is most affected by implementation of the alternatives (L-Lake) and to also describe the component that has the least variability among the alternatives (Par Pond). DOE selected this order because only a few categories would be affected by the action and its alternatives, and it can describe the impacts of an alternative most easily by a comparison to the No-Action Alternative. This ordering of system components, resource categories, affected environment, and environmental impacts of each alternative is listed as follows.

Chapter 4. Affected Environment and Environmental Impacts

4.1 L-Lake

- 4.1.1 Geology and Soils
- 4.1.1.1 Affected Environment
- 4.1.1.2 Environmental Impacts
- 4.1.1.2.1 No Action
- 4.1.1.2.2 Shut Down and Deactivate
- 4.1.1.2.3 Shut Down and Maintain

Other resources categories with same subheadings include Surface Water, Groundwater, Air Resources, Ecological Resources, Land Use, Aesthetics, and Occupational and Public Health.

4.2 SRS Streams (sequence matches 4.1)

4.3 Par Pond (sequence matches 4.1)

DOE has determined that this EIS will not address in detail the following topics because the Proposed Action and alternatives would cause minimal or no impacts in these areas:

- Socioeconomics – The River Water System would require a staff from one (Shut Down and Deactivate) to 7.8 (No Action) full-time equivalent personnel. Selection of one alternative over another will not affect socioeconomic factors in the region.

- Traffic and Transportation – Onsite traffic impacts would be minimal under each alternative due to the small number of personnel involved. The operation of the River Water System would involve minimal onsite transportation of materials and waste and no offsite transportation. Alternatives are not measurably different in terms of potential impacts of transportation activities.

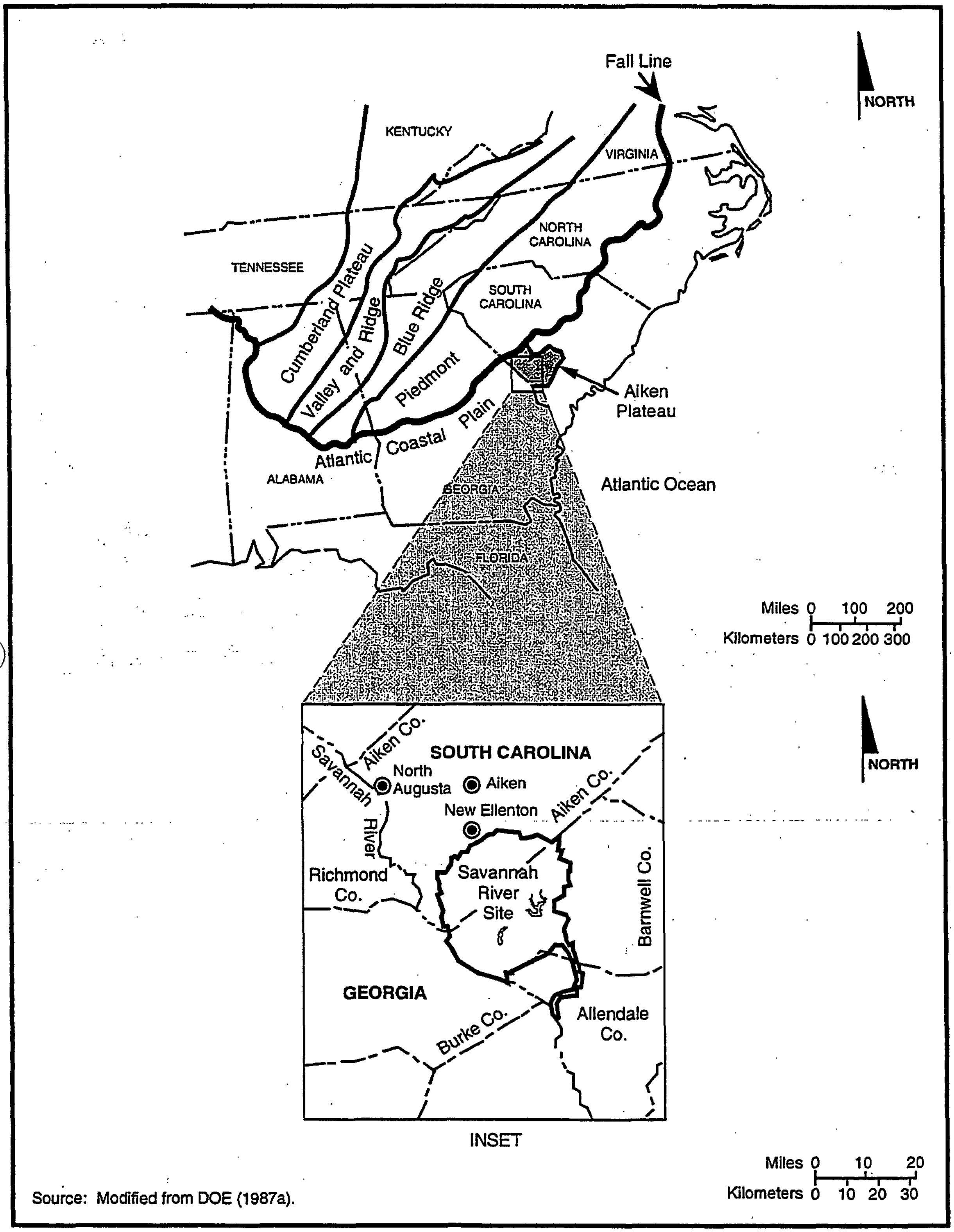


Figure 4-2. General location of the Savannah River Site and its relationship to geologic provinces of the southeastern United States.

cesium-137 activity (Du Pont 1984). The dam site material was moved to a deposit area approximately 0.25 mile (0.40 kilometer) above the dam site and within the lake area and covered with 5 feet (1.5 meters) of clean soil. During L-Lake construction, DOE cut the timber along the floodplain into manageable sizes and covered it with soil to prevent possible future floating or movement and subsequent control gate obstruction (Marter 1984). L-Lake overflight photographs show evidence of these activities.

After DOE completed the L-Lake Dam in 1985, the basin filled with rainfall, flow from the Steel Creek headwaters and watershed, and water pumped from the Savannah River and Par Pond. The impoundment reached full pool in October 1985. DOE brought L-Reactor on line and began discharging heated effluent into L-Lake in November 1985, took the reactor out of service in April 1988 for a scheduled maintenance outage (DOE 1990), and did not restart it.

Water moves from L-Lake to Steel Creek by overflow into a multigate, dual wet well intake structure, a 72-inch (183-centimeter) diameter concrete conduit embedded in the dam, and a stilling basin downstream of the dam. A system of eight gates in the intake structure regulates the reservoir level. DOE can open two intake gates 10 feet (3 meters) below the normal pool elevation and two intake gates near the bottom of the reservoir to enable water to enter the wet wells before releasing to the stilling basin. These intake gates are either fully opened or closed. Water passes through the intake tower, the wet wells, the conduit, and the stilling basin before flowing to Steel Creek. The volume of water discharged to Steel Creek is controlled by two service gates at the base of the intake tower wet wells. These gates can release flows ranging from 71 to 1,024 cubic feet per second (2.0 to 29.0 cubic meters per second). To release from 11 to 71 cubic feet per second (0.3 to 2.0 cubic meters per second), DOE opens two 18-inch (46-centimeter) diameter knife gates (Wike et al. 1994).

4.1.1 GEOLOGY AND SOILS

4.1.1.1 Affected Environment

This section describes the regional geologic setting in the vicinity of L-Lake; the description includes descriptive rock type, thickness, mineral and economic resources, and soil types. Figure 1-1 shows the location of the SRS, and Figure 4-2 shows the geologic provinces around the Site. Section 4.1.3 presents L-Lake hydrogeologic information. This EIS does not describe geologic structures such as folding and faulting because the alternatives would not affect these features.

The geology and soils of SRS are well documented (e.g., Aadland, Gellici, and Thayer 1995; WSRC 1996e). DOE has drilled a number of deep production, test, or monitoring wells near the areas potentially affected by the alternatives discussed in this EIS (Aadland, Gellici, and Thayer 1995).

Figure 4-3 is a topographic map of the area of interest between L-Lake, Par Pond, and nearby SRS streams. The geological cross-section (identified on Figure 4-3) is depicted on Figures 4-4a and 4-4b. The section extends from the northeast edge of Par Pond, to the southwest through L-Lake, and ending near Pen Branch (also see Aadland, Gellici, and Thayer 1995; WSRC 1996e). Prowell (1994) most recently describes the surface geology of the SRS region.

Geomorphology

The SRS is on the Aiken Plateau of the Atlantic Coastal Plain in west-central South Carolina, bounded by the Savannah River to the west, the Fall Line to the north, the Orangeburg Scarp to the south, and the Congaree River and Congaree Sand Hills to the east. The Aiken Plateau consists of a broad flat surface dissected by narrow steep-sided valleys. The plateau slopes from 650 feet (198 meters) above mean sea level at the Fall Line to approximately 250 feet

:ction 4.6, Unavoidable Adverse Impacts
e., erse environmental effects which
nnot be avoided should the proposal be
nplemented" (40 CFR 1502.16)]

:ction 4.7, Short-Term Uses and Long-
:rm Productivity [i.e., "the relationship
:tween short-term uses of man's environ-
ent and the maintenance and enhancement
f long-term productivity" (40 CFR
502.16)]

ection 4.8, Irreversible or Irretrievable
ommitment of Resources [i.e., "any irre-
ersible or irretrievable commitments of re-
ources which would be involved in the
roposal should it be implemented"
40 CFR 1502.16)].

:es – Because the alterna-
the Proposed Action, would
construction, there would be
: of damaging historic or ar-
ources or areas of cultural
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:s the following environ-
; that would be sitewide in
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:ulative Impacts [i.e., cu-
that result "from the in-
: of the action when added
sent, and reasonably fore-
:ions" (40 CFR 1508.7)]

- Section 4.6, Unavoidable Adverse Impacts [i.e., "adverse environmental effects which cannot be avoided should the proposal be implemented" (40 CFR 1502.16)]
- Section 4.7, Short-Term Uses and Long-Term Productivity [i.e., "the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (40 CFR 1502.16)]
- Section 4.8, Irreversible or Irretrievable Commitment of Resources [i.e., "any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented" (40 CFR 1502.16)].

4.1 L-Lake

feet million cubic meters) (USACE
).

ke flooded about 225 acres (0.9 square
neter) of wetlands and 775 acres (3 square
neters) of uplands in the Steel Creek corri-
Wike et al. 1994). During the construction
-Lake, most of the vegetation in the area
became the lakebed was cut and hauled
y or burned on the site. Two coves in the
:r half of the lake and the area above Road
ere left with standing timber to enhance fish
wildlife habitat. The shoreline was cleared
to 5 feet (1 to 1.5 meters) above maximum
l elevation and seeded for erosion control.
e than 30 reefs were built from tires, brush,
ler blocks, and log piles to improve fish
itat in shallow areas otherwise devoid of
er (Mattson et al. 1993a; Paller 1996).

from the Steel Creek floodplain at the dam
contained an estimated 0.2 curie of ce-
n-137 activity and the trees removed from
ng the floodplain contained 12 millicuries of

1,000-acre (4-square-
Figure 4-1), on the upper
c in 1984 and 1985 to re-
from L-Reactor. Before
Lake, L-Reactor effluents
Steel Creek. DOE formed
4,000-foot (1,200-meter)
Creek valley approxi-
kilometers) upstream of
e Savannah River. The
idth of approximately
s) and an average depth of
s), and extends for ap-
(7.0 kilometers) along the
m the dam to the headwa-
above SRS Road B
et al. 1994).

ntake structure maintain
l pool elevation of
bove mean sea level. The
ıbout 200 feet (61 meters)
At normal pool, the res-
is approximately 26,000

acre-feet (32 million cubic meters) (USACE 1987).

L-Lake flooded about 225 acres (0.9 square kilometer) of wetlands and 775 acres (3 square kilometers) of uplands in the Steel Creek corridor (Wike et al. 1994). During the construction of L-Lake, most of the vegetation in the area that became the lakebed was cut and hauled away or burned on the site. Two coves in the lower half of the lake and the area above Road B were left with standing timber to enhance fish and wildlife habitat. The shoreline was cleared to 3 to 5 feet (1 to 1.5 meters) above maximum pool elevation and seeded for erosion control. TC | More than 30 reefs were built from tires, brush, cinder blocks, and log piles to improve fish habitat in shallow areas otherwise devoid of cover (Mattson et al. 1993a; Paller 1996).

Soil from the Steel Creek floodplain at the dam site contained an estimated 0.2 curie of cesium-137 activity, and the trees removed from along the floodplain contained 12 millicuries of

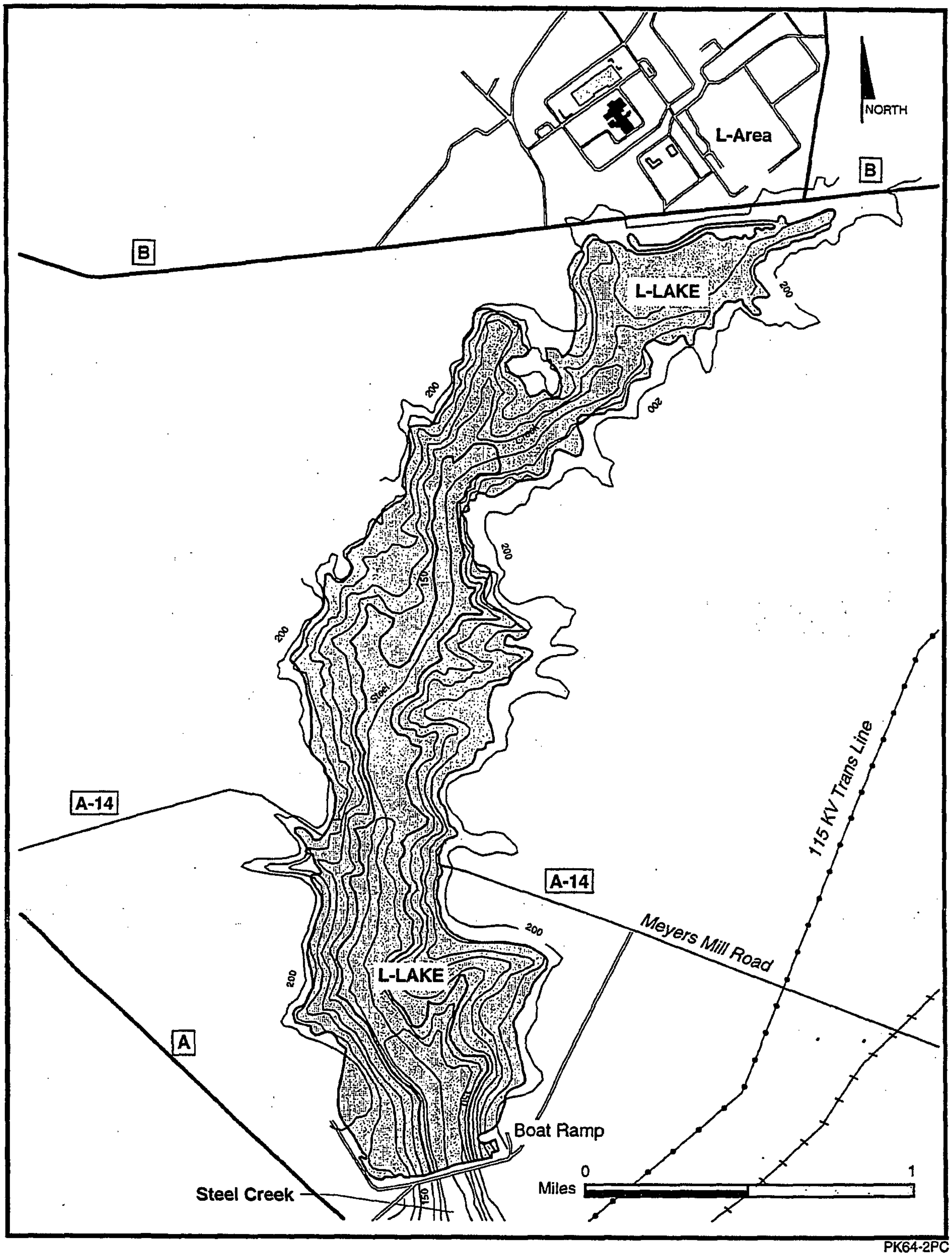

Figure 4-1. L-Lake and environs.

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esium-137 activity (Du Pont 1984). The dam ite material was moved to a deposit area approximately 0.25 mile (0.40 kilometer) above ie dam site and within the lake area and covred with 5 feet (1.5 meters) of clean soil. uring L-Lake construction, DOE cut the timer along the floodplain into manageable sizes id covered it with soil to prevent possible fure floating or movement and subsequent conol gate obstruction (Marter 1984). L-Lake verflight photographs show evidence of these tivities.

fter DOE completed the L-Lake Dam in 1985, e basin filled with rainfall, flow from the Steel reek headwaters and watershed, and water imped from the Savannah River and Par Pond. ie impoundment reached full pool in October 185. DOE brought L-Reactor on line and ben discharging heated effluent into L-Lake in ovember 1985, took the reactor out of service April 1988 for a scheduled maintenance oute (DOE 1990), and did not restart it.

ater moves from L-Lake to Steel Creek by erflow into a multigate, dual wet well intake ucture, a 72-inch (183-centimeter) diameter ncrete conduit embedded in the dam, and a lling basin downstream of the dam. A system eight gates in the intake structure regulates reservoir level. DOE can open two intake tes 10 feet (3 meters) below the normal pool vation and two intake gates near the bottom the reservoir to enable water to enter the wet lls before releasing to the stilling basin. ese intake gates are either fully opened or sed. Water passes through the intake tower, wet wells, the conduit, and the stilling basin fore flowing to Steel Creek. The volume of ter discharged to Steel Creek is controlled by service gates at the base of the intake tower t wells. These gates can release flows rang; from 71 to 1,024 cubic feet per second 0 to 29.0 cubic meters per second). To rese from 11 to 71 cubic feet per second (0.3 to cubic meters per second), DOE opens two inch (46-centimeter) diameter knife gates ike et al. 1994).

4.1.1 GEOLOGY AND SOILS

4.1.1.1 <u>Affected Environment</u>

This section describes the regional geologic setting in the vicinity of L-Lake; the description includes descriptive rock type, thickness, mineral and economic resources, and soil types. Figure 1-1 shows the location of the SRS, and Figure 4-2 shows the geologic provinces around the Site. Section 4.1.3 presents L-Lake hydrogeologic information. This EIS does not describe geologic structures such as folding and faulting because the alternatives would not affect these features.

The geology and soils of SRS are well documented (e.g., Aadland, Gellici, and Thayer 1995; WSRC 1996e). DOE has drilled a number of deep production, test, or monitoring wells near the areas potentially affected by the alternatives discussed in this EIS (Aadland, Gellici, and Thayer 1995).

Figure 4-3 is a topographic map of the area of interest between L-Lake, Par Pond, and nearby SRS streams. The geological cross-section (identified on Figure 4-3) is depicted on Figures 4-4a and 4-4b. The section extends from the northeast edge of Par Pond, to the southwest through L-Lake, and ending near Pen Branch (also see Aadland, Gellici, and Thayer 1995; WSRC 1996e). Prowell (1994) most recently describes the surface geology of the SRS region.

Geomorphology

The SRS is on the Aiken Plateau of the Atlantic Coastal Plain in west-central South Carolina, bounded by the Savannah River to the west, the Fall Line to the north, the Orangeburg Scarp to the south, and the Congaree River and Congaree Sand Hills to the east. The Aiken Plateau consists of a broad flat surface dissected by narrow steep-sided valleys. The plateau slopes from 650 feet (198 meters) above mean sea level at the Fall Line to approximately 250 feet

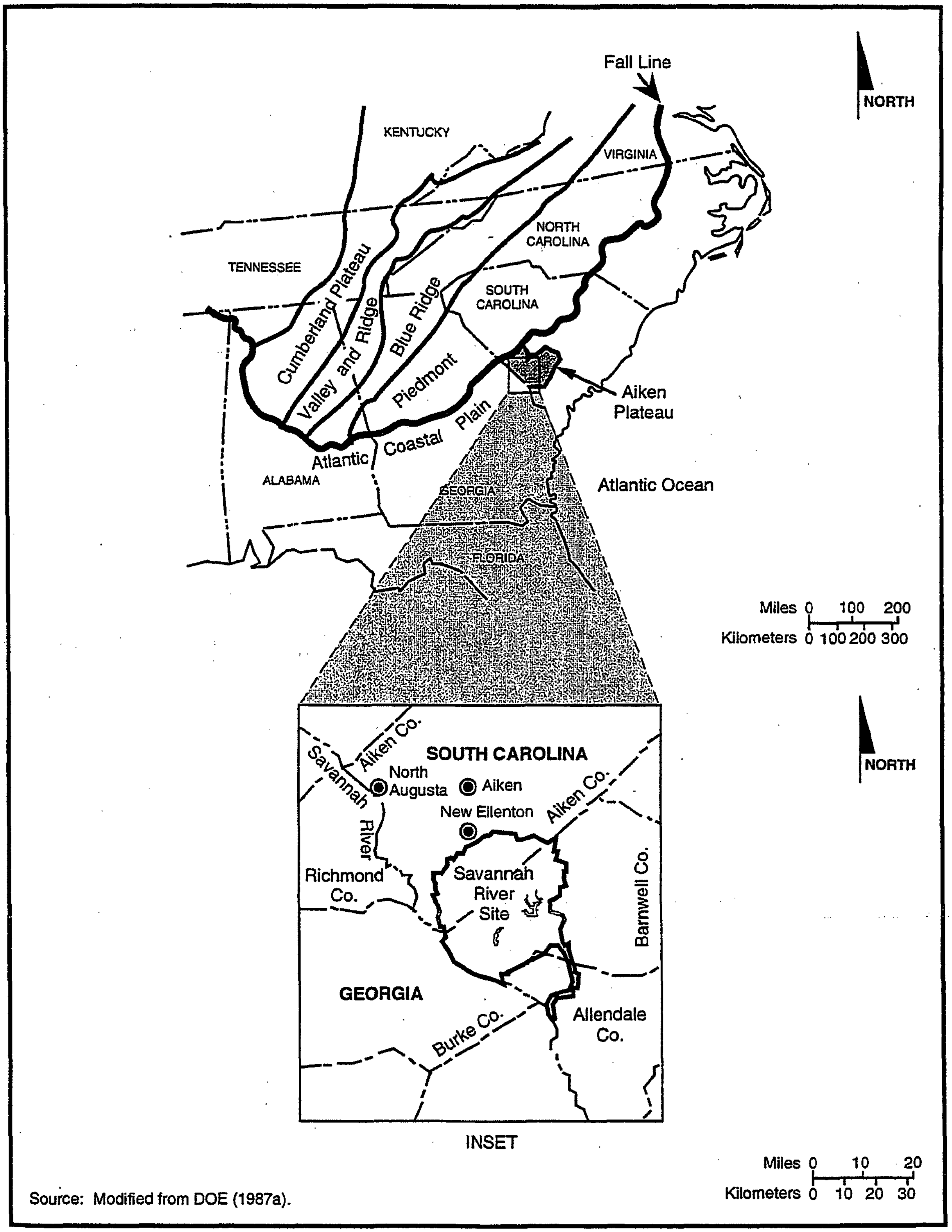
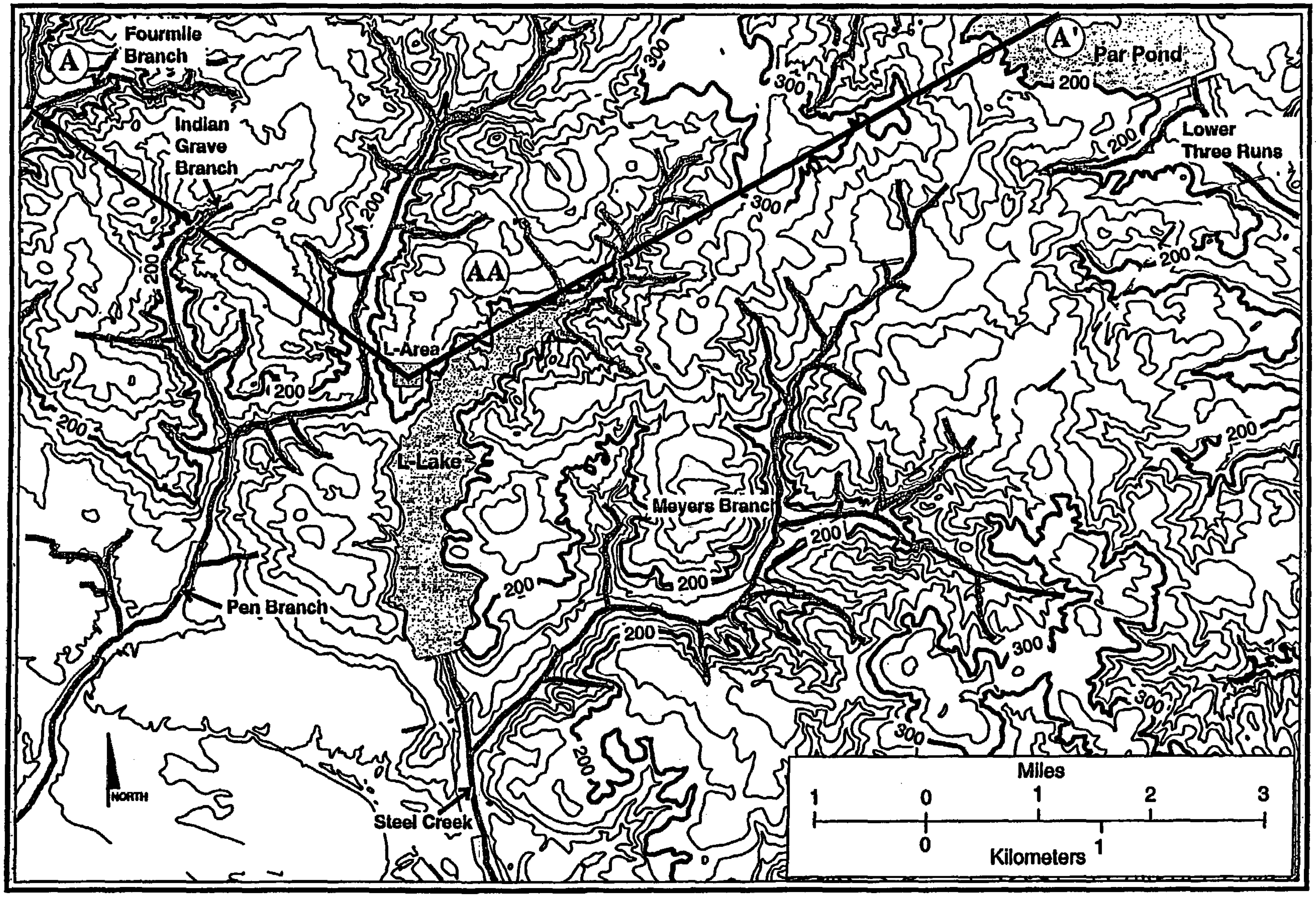


Figure 4-2. General location of the Savannah River Site and its relationship to geologic provinces of the southeastern United States.



Source: Modified from data by the Savannah River Technology Center.
Note: Contours at 20 ft. intervals

PK64-6PC

Figure 4-3. Topographic map L-Lake/Par Pond area (noting geologic cross-section).

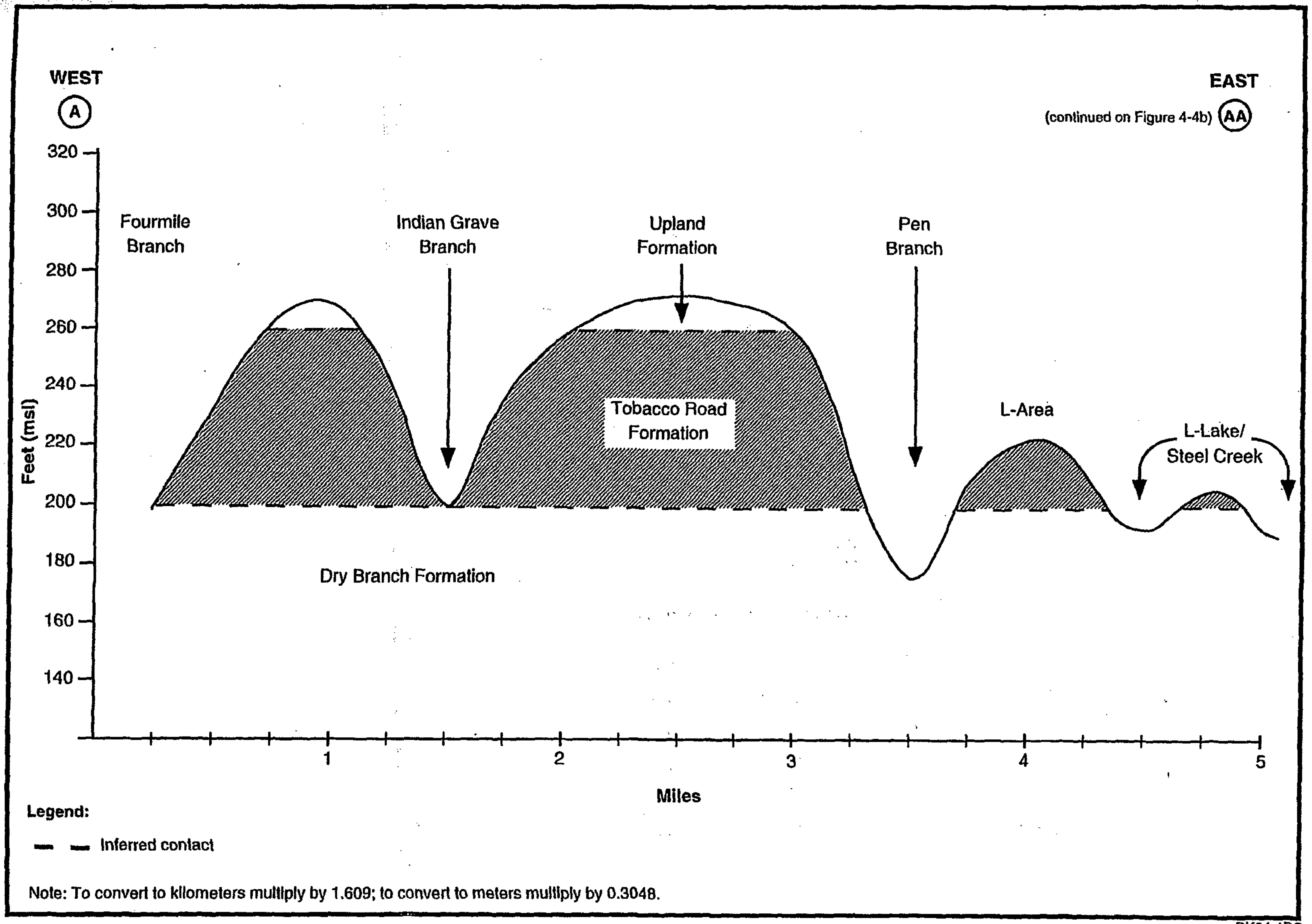


Figure 4-4a. Generalized geologic cross section from Fourmile Branch to L-Lake (west to east).

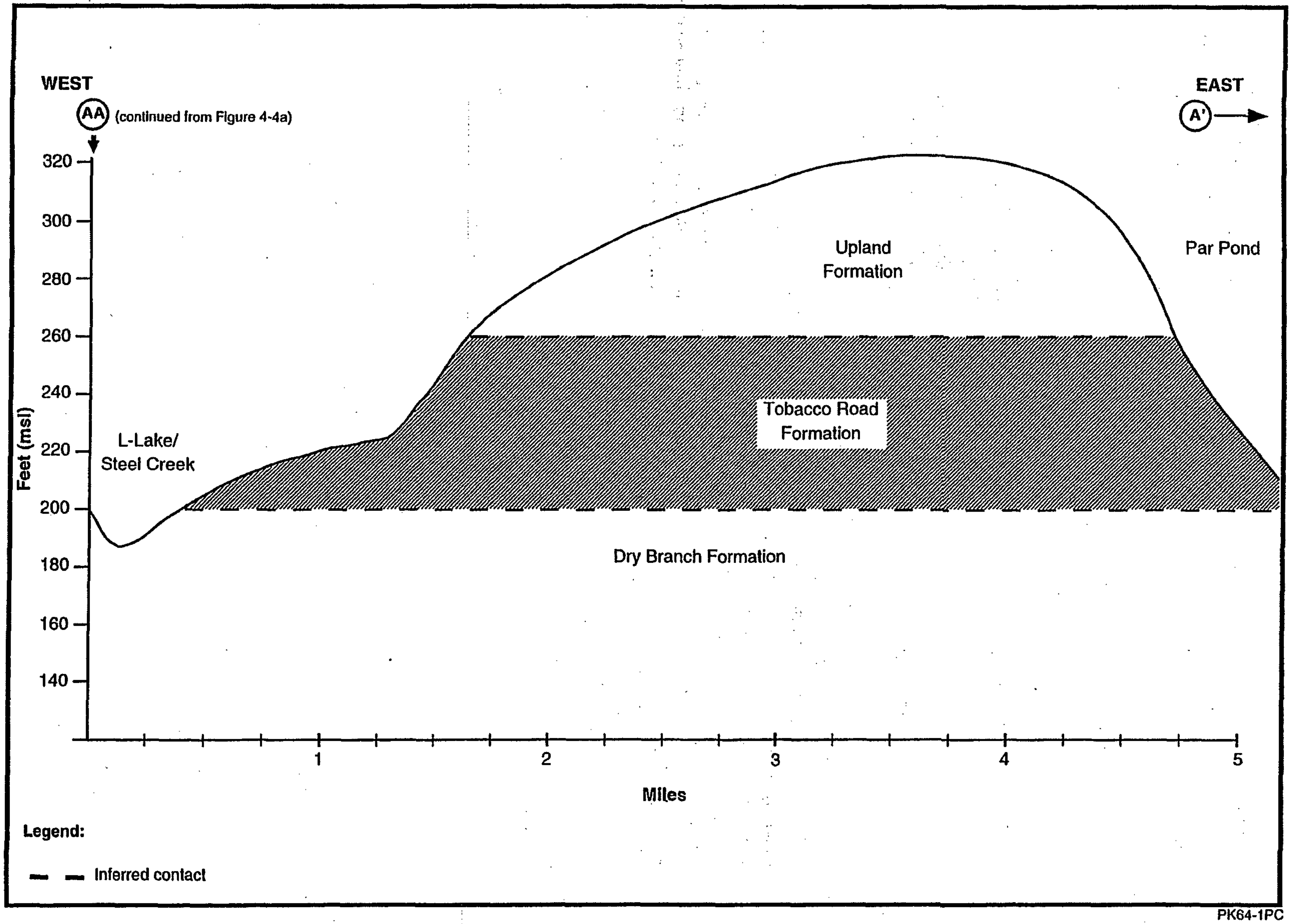


Figure 4-4b. Generalized geologic cross section from L-Lake to Par Pond (west to east).

(76 meters) above mean sea level at the southeast edge of the site (DOE 1995c). The difference in elevation across the area of interest is approximately 240 feet (73 meters); the Savannah River floodplain is about 100 feet (30 meters) above mean sea level and the hills overlooking L-Lake are about 340 feet (104 meters) above sea level. The lake is centrally located on the SRS to the southeast of L-Area and southwest of Par Pond. It is in a narrow, slightly sloping valley incised by Steel Creek.

Tectonic Provinces

L-Lake is approximately 50 miles (80 kilometers) southeast of the Fall Line, which is the geographic feature that results from the contact between the Piedmont and the Atlantic Coastal Plain physiographic provinces. The Piedmont province consists of Pre-Cambrian and Paleozoic age crystalline rocks overlain by sediments of Cretaceous and younger age. Fault-controlled basins of Triassic age, filled with younger Coastal Plain sediments, are structurally imposed on the Piedmont rocks, and similar to the classic Triassic basins of New Jersey and New England. The Dunbarton Basin, over which L-Area is situated, is an example of these oldest SRS geologic structures (WSRC 1996e,f).

Stratigraphy

Overlying the Piedmont structures is a thick sequence of sediments that comprise the Atlantic Coastal Plain. These sediments, which are the primary focus of the affected environment, include silts, sands, conglomerates, limestones, and clays of both fluvial and marine origin.

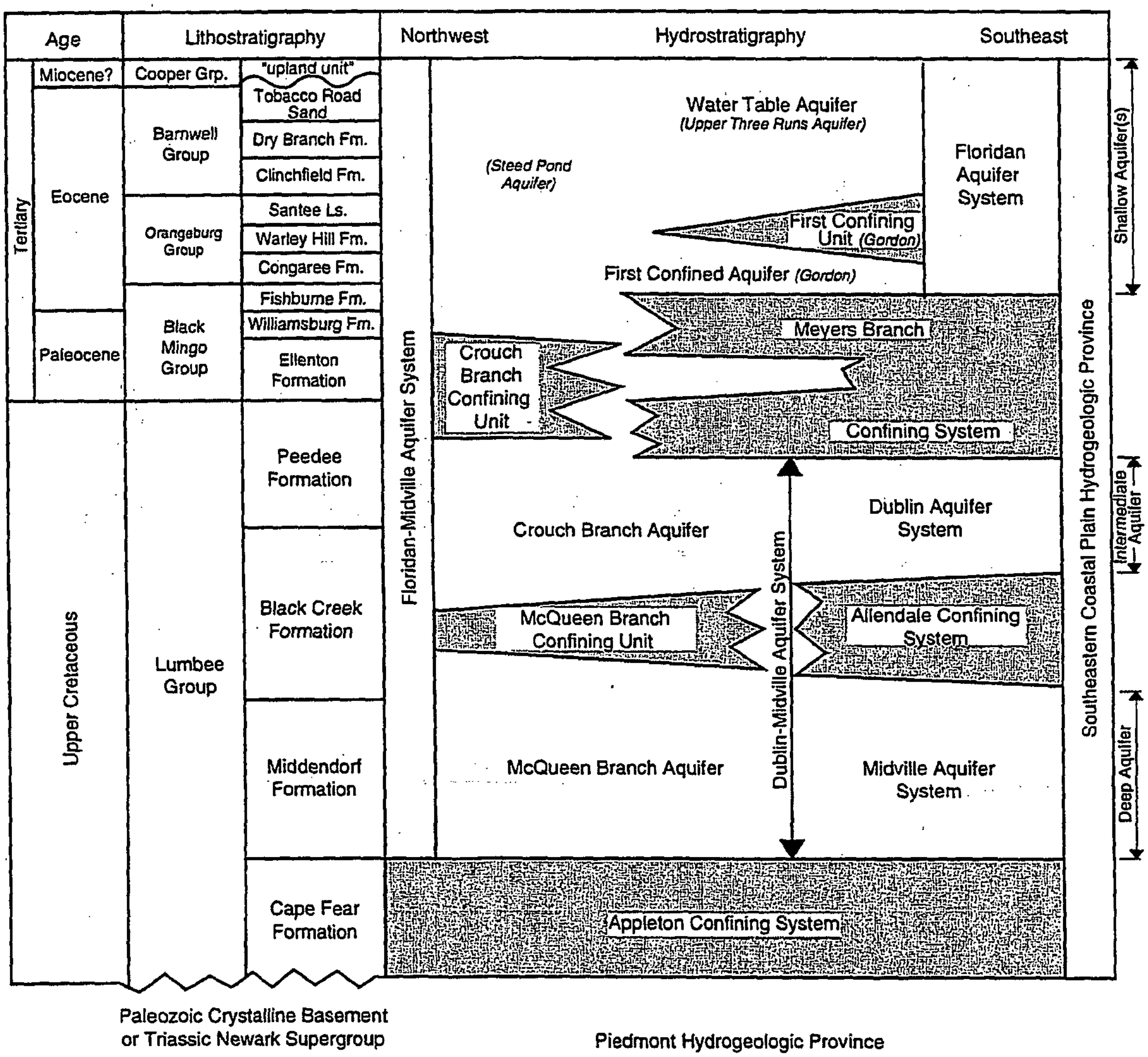
The alternatives discussed in this EIS would affect the Tertiary (Eocene and Paleocene age) sediments (Figure 4-5) of the Atlantic Coastal Plain. The depositional environment is representative of a fluvial to marine shelf (prodeltaic) during alternating transgressions and regressions of the ocean. The thickness of the Tertiary section expands from the northern part of the SRS toward the southern boundary and onward to the coast. This thick sequence of sands, silts, and clays along the northern part of the SRS grades into a carbonate (limestone) sequence in the southern part of the site. The regional dip is to the southeast, ranging from 35 to 60 feet (11 to 18 meters) per mile. There are four groups of Tertiary sediments: the Black Mingo Group (the oldest), the Orangeburg Group, the Barnwell Group, and the Cooper Group (the youngest), which is the group of interest for this assessment. The following paragraphs briefly describe the individual formations within each group (see WSRC 1996e,f; Aadland, Gellici, and Thayer 1995). TE

The following formations are part of the Black Mingo Group:

- Ellenton Formation (also known as the Lang Syne/Sawdust Landing Formations) – primarily gray to dark gray micaceous sand; the thickness ranges from 40 to 100 feet (12 to 30 meters), usually poorly sorted; occasionally contains lignite interbedded with gray clays.

- Williamsburg Formation (also known as the Snapp Member or Formation) – primarily dark gray to black silty quartz sand (coarse to medium) with clay; 50 feet (15 meters) thick along the southern portion of the SRS and pinches out at the northernmost edge of the Site.

- Fishburne Formation (also known as the Fourmile Member or Formation) – This sedimentary sequence varies in thickness from 15 to 75 feet (5 to 23 meters). It is comprised of yellow, brown, orange, and tan clayey sand.



TC | Note: Not to scale. Nomenclature in parentheses denotes alternative names for these units.

Source: Modified from DOE (1995c).

PK64-2

Figure 4-5. Comparison of lithostratigraphy and hydrostratigraphy for the Savannah River Site region.

The following formations comprise the Orangeburg Group:

- Congaree Formation – fine to coarse quartz sand sequence, highly variable in color, ranging in thickness from 25 to 60 feet (8 to 18 meters); generally well sorted; thin clay beds and pebble zones are common throughout.
- Warley Hill Formation (also known as the "Green Clay" and in the past collectively known as the Warley Hill and Caw Caw Members of the Santee Formation) – usually a glauconitic fine-grained sand and clay; in the southern part of the Site, grades to a micritic clayey limestone or limy clay (Santee Limestone); north to south thickness ranges from 0 to 20 feet (6 meters).
- Santee Formation (also known as the "Tinker Formation," "McBean Formation," or a "member of the Lisbon Formation") – includes yellow to tan clays, marls, limestones, and calcareous sands; moderately sorted; thickness ranges from 40 to 80 feet (12 to 24 meters) across the Site.

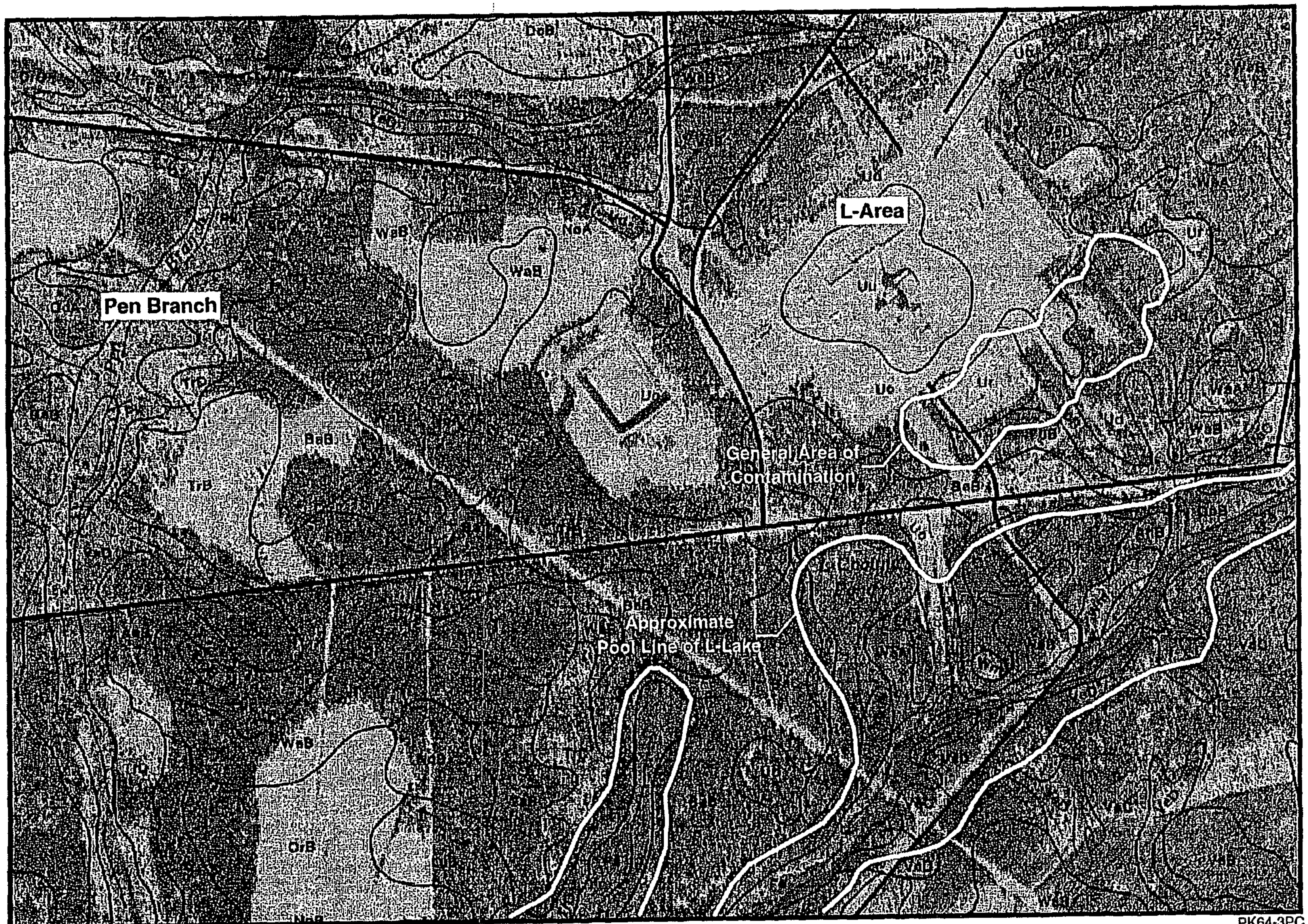
The Barnwell Group consists of the following:

- Clinchfield Formation – This formation has two members:
  - Riggins Mill Member – sand member approximately 25 feet (8 meters) thick along the southern portion of SRS and pinched out at the northernmost parts of the Site; characterized by tan to green, medium to coarse, poorly to well-sorted quartz sand; the sand in well cuttings is difficult to discern at most locations unless it occurs between the carbonate layers of the overlying Dry Branch Formation and underlying Santee Formation.
  - Utley Member – a calcareous sand or sandy limestone with tan to white color variances.
- Dry Branch Formation – This formation has three members:
  - Twiggs Clay Member (also known as the "Tan Clay") – ranges in color from tan to brown to light gray; discontinuous occurrence; reaches a thickness of only as much as 12 feet (4 meters); generally dense and compact, somewhat plastic to crumbly in places; frequent iron staining; occurs at a depth of approximately 145 feet (44 meters) mean sea level in well LCO-5 northwest of L-Lake in L-Area (WSRC 1996g).
  - Griffins Landing Member – commonly occurs as a tan or green calcareous sandy clay or a calcareous sand; thickness as much as 50 feet (15 meters).
  - Irwinton Sand Member – consists of tan to orange moderately sorted quartz sand with interbedded clays; thickness ranges from 40 to 75 feet (12 to 23 meters).
- Tobacco Road Formation (sand) – consists of red, brown, purple, tan, or orange poorly to moderately sorted quartz sand; grain size varies from fine to coarse with pebble layers common; outcrops over a large portion of the Site.

The "upland unit" (also known as the Hawthorne Formation) is of unknown age (part of the Cooper Group and possibly Miocene in age). It is a conglomerate sequence of silts, clayey sands, and pebbly sands, with a variable thickness from 60 to 70 feet (18 to 21 meters). These are the primary surface sediments, probably fluvial in origin. Facies changes can occur radically.

Soils

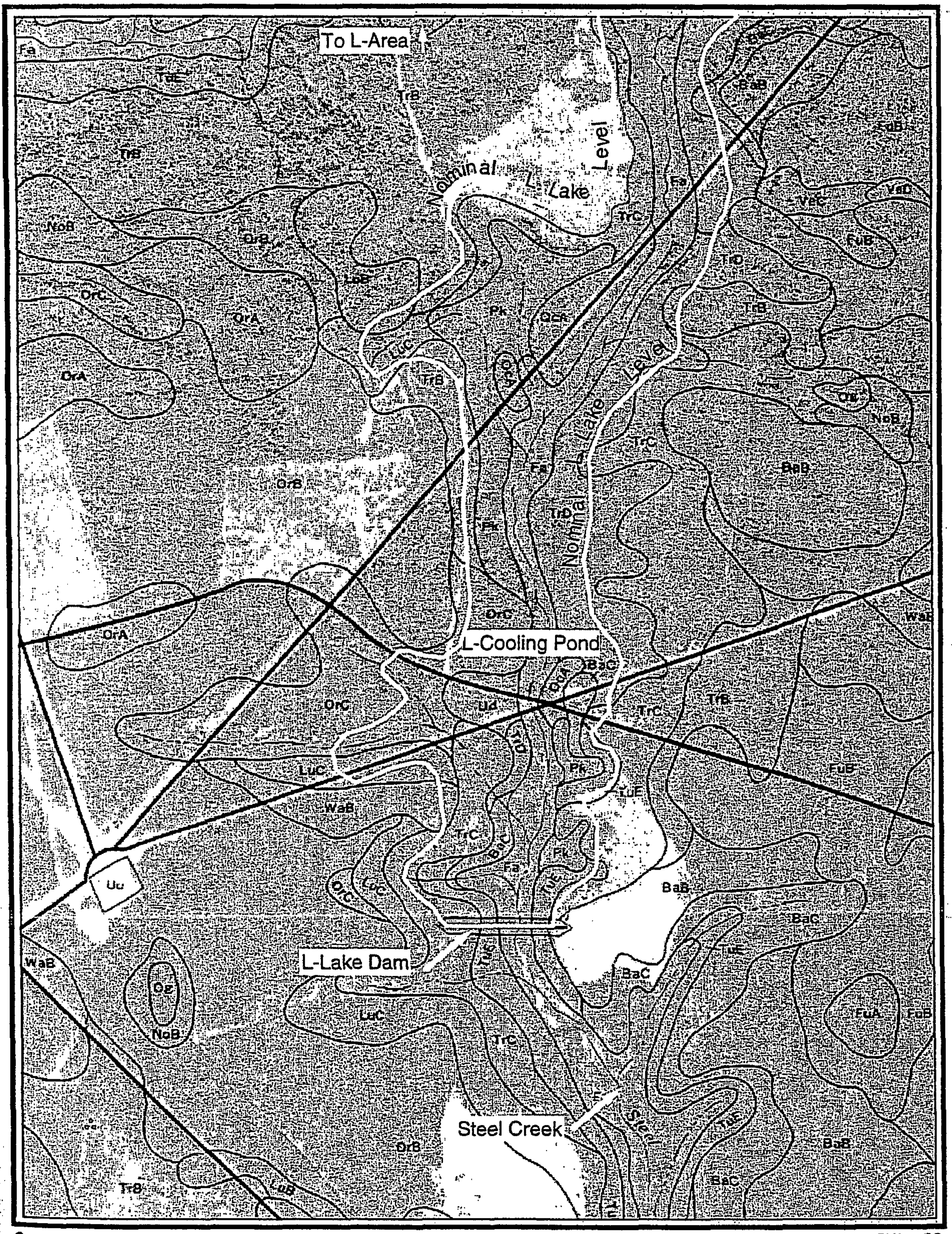
The SRS soils map (USDA 1990) shows approximately 50 mapping units. Figures 4-6 through 4-9 show the surface soils distributions for selected areas near L-Lake, L-Area, Pen Branch and Steel Creek, the southwest side of



Source: Modified from USDA (1990).

TE | Note: The more common soil mapping unit abbreviations are defined in Soils discussion of Section 4.1.1.1

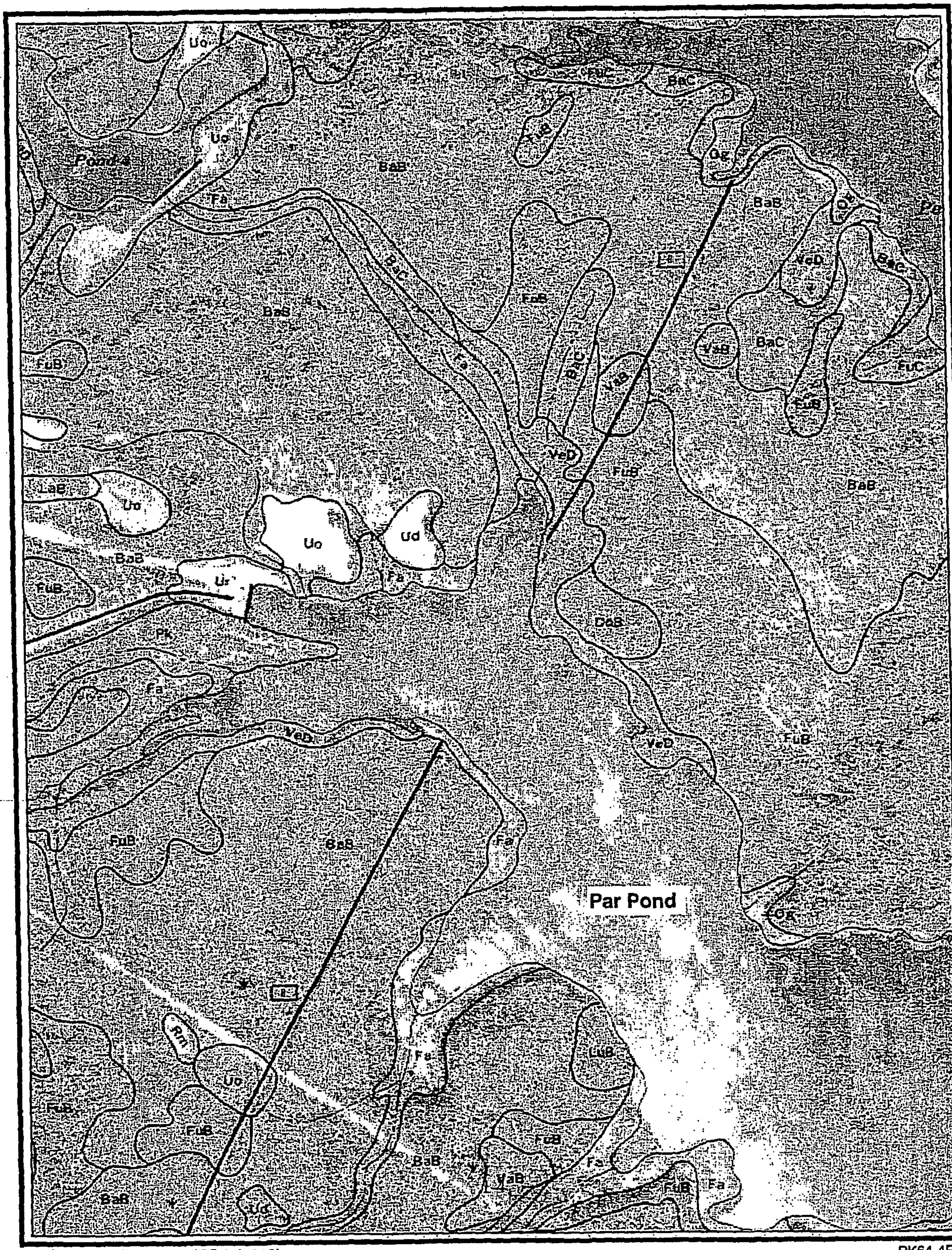
Figure 4-6. Soils Horizons - L-Lake, upper Steel Creek, and Pen Branch.



Source: Modified from USDA (1990). PK64-4PC

TE | Note: The more common soil mapping unit abbreviations are defined in Soils discussion of Section 4.2.1.1

Figure 4-7. Soils Horizons - lower Steel Creek.



Source: Modified from USDA (1990).

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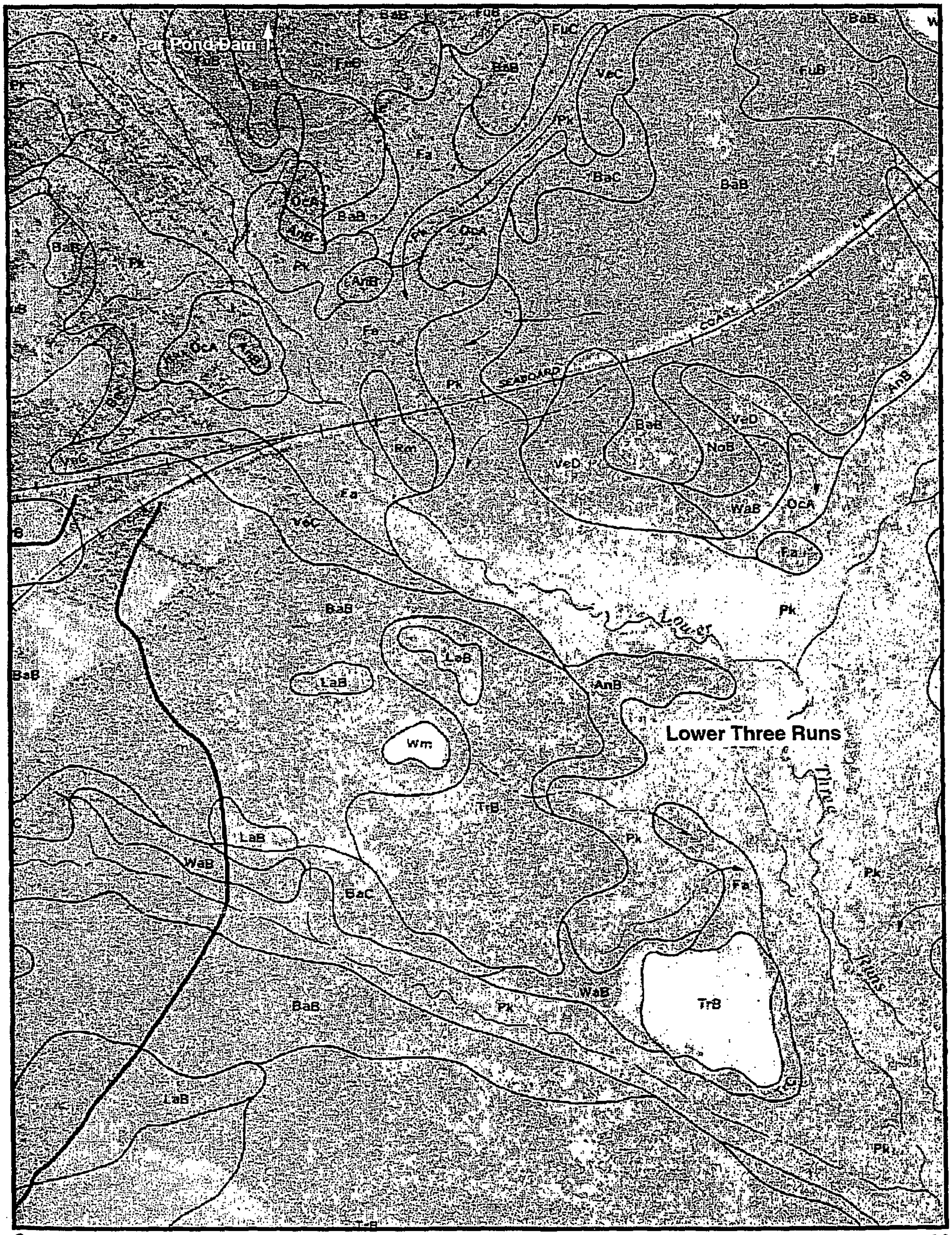
TC | Note: The more common soil mapping unit abbreviations are defined in Soils discussion of Section 4.3.1.1.2

Figure 4-8. Soils Horizons on west side of Par Pond.



Source: Modified from USDA (1990). PK64-3PC

TE Note: The more common soil mapping unit abbreviations are defined in Soils discussion of Section 4.2.1.1

Figure 4-9. Soils Horizons - Lower Three Runs (below Par Pond Dam).

Par Pond, and Lower Three Runs drainage areas. Previously disturbed soils, which are mostly well drained, come from excavated areas, borrow pits, and other areas in which major land-shaping or grading activities occurred. These soils are beside and under constructed byways (i.e., sidewalks and parking lots). Their slopes generally range from 0 to 10 percent and they have moderate erosion hazard. These disturbed soils range from a consistency of sand to clay, depending on the source of the material (DOE 1995c).

In general, undisturbed soils at the SRS consist of sandy surface layers above a subsoil of silts, sands, and clays. These gently sloping to moderately steep (0 to 10 percent) soils have a slight erosion hazard (USDA 1990). Some soils on the uplands are nearly level, and those on the bottomlands along the major streams are level. Soils in small narrow drainage valleys are steep. Most upland soils are well drained to excessively drained; well-drained soils have a thick sandy surface layer that extends to a depth of 7 feet (2 meters) or more in some areas. The soils on the bottomlands range from well drained to very poorly drained. Some soils on the abrupt slope breaks have a dense brittle subsoil (DOE 1995c; Wike et al. 1994; USDA 1990).

There are two soil associations – Vaucluse-Ailey and Fuquay-Blanton-Dothan – in the area of interest. This assessment uses preimpoundment soil descriptions (USDA 1990). If the lake receded, the exposed soils would be different due to lake sediment deposition. DOE has not yet determined those soil types; however, an ongoing study at the lake will provide site-specific soil data.

The following is a list of the more common soil mapping units (shown in Figure 4-6) in the area west of L-Lake (USDA 1990):

- Ailey sand, 2- to 6-percent slopes (AeB)
- Blanton sand, 6- to 10-percent slopes (BaC)
- Dothan sand, 2- to 6-percent slopes (DoB)
- Fuquay sand, 2- to 6-percent slopes (FuB)
- Norfolk loamy sand, 2- to 6-percent slopes (NoB)
- Udorthents, firm substratum and Udorthents, friable substratum (used during L-Area construction)
- Vaucluse -Ailey Complex, 6- to 10-percent slopes (VeC)
- Vaucluse sandy loam, 2- to 6-percent slopes (VaB)

Mineral or Economic Resources

With the exception of sand and gravel, the known economic and mineral value of the geologic resources of the SRS is limited (see DOE 1984, 1987a, 1995c).

4.1.1.2 Environmental Impacts

In general, the character and conditions of the geology and soils in the area of interest would not change radically under any alternative in the EIS. [TE] If DOE decides to shutdown the River Water system it would develop a plan to maintain the stability of the dam and the outflow to [TE] Steel Creek during and after lake drawdown. Topographic changes resulting from the various alternatives are not likely, with the exception of a potentially slight and gradual alteration in the shape of the stream valleys. Elimination of [L10-15] river water from the geologic system could not stimulate an earthquake (WSRC 1996f), would not affect economic or mineral resources, and would not induce faulting or cause noticeable geologic structures.

The overall lithologic character of sands and clays does not vary appreciably across the area of interest or the SRS and would probably remain constant under any alternative. The shut down alternatives would generally decrease the amount of stream surface water and subsequently alter the erosion rate. Impacts on groundwater are described in Sections 4.1.3, 4.2.3, and 4.3.3.

4.1.1.2.1 No Action

Maintenance of the River Water System and the lake level would not affect the geology or soils in the L-Lake area. The soils and geology in L-Area upgradient of the lake are contaminated at four Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) sites, but there is no evidence that this alternative would exacerbate contaminant migration through the soils or geologic formations. Section 4.1.3.2.1 discusses the contaminant movement in groundwater. The outfall of the River Water System from L-Area to L-Lake is downgradient of the contaminated areas and is not a mechanism for contamination. The continued outfall of L-Area water would not foster contamination of soils or geology.

4.1.1.2.2 Shut Down and Deactivate

The lowering of the pool would not compromise geologic conditions or resources. Because no changes in the stability of the geologic formations are likely, this alternative should not compromise the structural competency of the L-Lake dam.

As the lake recedes, Steel Creek would resume a course similar to the old stream channel, but within recently deposited lacustrine deposits. Reestablished stream activity could remobilize soils contaminated by preimpoundment activities. Section 4.1.2.2 describes impacts related to the reemergence of Steel Creek. DOE studies indicate that higher concentrations of cesium contamination already exist below L-Lake (DOE 1984). Soils and exposed geological strata could become contaminated downstream of L-Lake during or after exposure. Potential resuspension of contaminated sediments and their redeposition to downstream areas would result in small increments of contamination. Contaminated soil resuspension should not occur if the recession is gradual (as expected) because grasses and other vegetation would overtake the area.

4.1.1.2.3 Shut Down and Maintain

Impacts resulting from this alternative would be similar to those described in Section 4.1.1.2.2 above. Maintenance of the dam would impede the transport of upstream soils and lacustrine deposits; thereby limiting potential downstream (Steel Creek) contamination.

4.1.2 SURFACE WATER

4.1.2.1 Affected Environment

Section 4.1 contains a description of L-Lake. The intake tower for L-Lake is offset to the east of the former Steel Creek stream bed. The intake tower includes two service and emergency gates near the bottom of the lake and two regulating gates 7 feet (2 meters) below the normal pool elevation, 190 feet (58 meters). Two service gates located at the base of each collective well regulate flows to Steel Creek. This intake tower design permits water flow regimes from the upper [177 feet (54 meters) to 183 feet (56 meters)] and/or lower [115 feet (35 meters) to 119 feet (36 meters)] regions of L-Lake.

Permitted Wastewater and Stormwater Discharges to L-Lake

The South Carolina Department of Health and Environmental Control (SCDHEC) has permitted three wastewater discharge outfalls (L-07, L-07A, and L-08), the effluents of which originate from point and area sources in L-Area, to discharge to L-Lake under National Pollutant Discharge Elimination System Permit No. SC0000175. Outfall L-07 discharges Savannah River water pumped from the L-Area water storage 186-Basin, sanitary effluent from Outfall L-07A, process sewer and L-Reactor building drains wastewater, and L-Area stormwater. This effluent flows to L-Lake through the lake's influent canal. DOE has based Outfall L-07 effluent water quality limitations on maximum and average flows of 132 million gallons

(499,670 cubic meters) per day and 41.7 million gallons (157,850 cubic meters) per day, respectively; these limitations are as follows (SCDHEC 1996a):

- Total suspended solids – daily maximum: 40 milligrams per liter; monthly average: 20 milligrams per liter
- Oil and grease – daily maximum: 15 milligrams per liter; monthly average: 10 milligrams per liter
- pH – 6.0 to 8.5

Outfall L-07A is the wastewater sampling point for the L-Area sanitary wastewater treatment plant. Outfall effluent water quality limitations are based on the treatment plant capacity limited maximum flow of 35,000 gallons (133 cubic meters) per day and have been established as follows:

- Total suspended solids – weekly average: 45 milligrams per liter; monthly average: 30 milligrams per liter
- Dissolved oxygen – daily minimum: 1.0 milligram per liter
- Biochemical oxygen demand – weekly average: 45 milligrams per liter; monthly average: 30 milligrams per liter
- Fecal coliform – daily maximum: 400 per 100 milliliters; monthly average: 200 per 100 milliliters
- pH – 6.0 to 9.0

SCDHEC has not imposed effluent water quality limitations on ammonia, nitrate-nitrite (as nitrogen), or zinc primarily due to sufficient blending with other waste streams at Outfall L-07.

Outfall L-08 receives wastewater from the L-Area engine house cooling system, L-Reactor building drains, and L-Area stormwater runoff. Generation of the engine house effluent is necessary to maintain equipment operability, but does not occur because L-Reactor is shut down. DOE has based Outfall L-08 effluent water quality limitations on maximum and average flows of 2.367 million gallons (8,960 cubic meters) per day and 912,000 gallons (3,450 cubic meters) per day, respectively, and has established these limitations as follows:

- Total suspended solids – daily maximum: 40 milligrams per liter; monthly average: 20 milligrams per liter
- Oil and grease – daily maximum: 15 milligrams per liter; monthly average: 10 milligrams per liter
- pH – 6.0 to 8.5

Water Quality

Water quality comprises the physical and chemical features that define the suitability of a reservoir for a defined use. This EIS defines water quality as physical and chemical characteristics that are suitable for maintaining biologically balanced communities in L-Lake.

DOE monitored L-Lake water quality extensively from the filling of the lake in November 1985 until December 1992 as part of the L-Lake/Steel Creek Biological Monitoring Program (Kretchmer and Chimney 1993). DOE designed the monitoring program to meet environmental regulatory requirements associated with the restart of L-Reactor, primarily Section 316(a) of the Clean Water Act, which addresses thermal effects. The monitoring included field measurements, major ions, and plant nutrients; trace metals and radioactive materials were studied by DOE in 1995 and 1996.

<u>Field Measurements and Thermal Structure</u>

The monitoring program noted that vertical gradients in L-Lake water temperature caused by solar heating begin to develop in January or February and become more pronounced through the spring (Kretchmer and Chimney 1993). A more or less stable condition of thermal stratification typically exists by May. Temperatures in the mixed surface zone are highest in July or August, averaging about 80.6°F (27°C); the bottom zone, or hypolimnion, has temperatures ranging from 55.4° to 60.8°F (13° to 16°C). The zone between the mixed layer and the hypolimnion, the metalimnion, is where the change in temperature with depth is most rapid. Since 1987 the top of the metalimnion is typically between 16 and 20 feet (5 and 6 meters) deep during thermal stratification in L-Lake. Maximum temperature near the surface is about 86°F (30°C). Fall turnover usually begins in September or October and ends in November. Lowest temperature, around 50°F (10°C), usually occurs in January or February.

Thermal stratification prevents bottom waters from exchanging gases with the atmosphere, and dissolved oxygen levels in the L-Lake hypolimnion begin to decline in February or March (Kretchmer and Chimney 1993). Dissolved oxygen in the hypolimnion first fell below 1 milligram per liter in March in 1988, in May from 1989 through 1991, and in July in 1992. This progression, indicative of a slower decline in hypolimnetic oxygen concentrations during stratification, indicates that L-Lake was becoming less eutrophic. Surface-water oxygen levels were seldom below 5 milligrams per liter. The highest dissolved oxygen concentrations, 11 to 13 milligrams per liter, occurred in January, February, or March; this is mainly a function of temperature, but the highest levels were probably influenced by photosynthesizing phytoplankton near the water surface.

From 1988 to 1992, pH values in L-Lake varied from about 5 to 9; the lowest values were not associated with a particular area or season, but the highest were attributable to high rates of phytoplankton productivity in the surface-water layer, or mixing zone, from February to July (Kretchmer and Chimney 1993). Mixing zone pH levels were seldom below 6.

Mean specific conductance values in L-Lake during 1992 ranged from 58 to 73 microsiemens per centimeter (Kretchmer and Chimney 1993). These values were similar to those seen in 1991, which were 10 to 20 microsiemens per centimeter lower than 1990 levels, which were, in turn, 10 to 20 microsiemens per centimeter lower than in previous years. The highest specific conductance values were generally recorded in the hypolimnion during the fall.

DOE measured oxidation-reduction (redox) potential in L-Lake to distinguish reducing and oxidizing areas and to quantify the reducing potential. Low (strongly negative) redox potentials, which are associated with anaerobic conditions in the hypolimnion, indicate reducing conditions. Conversely, high or positive redox potentials occur in the presence of oxygen and indicate oxidizing conditions. During the L-Lake monitoring program, redox potential was positive throughout the water column except in the hypolimnion during summer stratification (Kretchmer and Chimney 1993). The lowest potential, about −250 millivolts, occurred in 1988. The hypolimnetic potentials have been less strongly negative in more recent years. The lowest redox potential in 1992 was about −130 millivolts.

Major Ions

Alkalinity concentrations ranged from 6 to 29 milligrams of calcium carbonate per liter in 1992, similar to levels observed in 1990 and 1991, but lower than those seen in the first part of the study (Kretchmer and Chimney 1993). Alkalinity values were highest in the hypolimnion, usually in the summer or fall and lowest in the winter. At 5.4 to 6.8 milligrams per liter, chloride concentrations in 1992 were similar to those in 1991, 1986, and 1987 but lower than the values observed from 1988 through 1990. Sulfate levels ranged from 2 to 8 milligrams sulfate per liter in 1992, similar to values seen in the first years of the study and in 1990 and 1991, but lower than those observed in 1988 and 1989.

Concentrations of total calcium, magnesium, and potassium declined slightly during the 7 years of study and were never higher than about 5 milligrams per liter (Kretchmer and Chimney 1993). The ranges of total sodium concentrations increased from 1986 (6 to 12 milligrams per liter) to 1989 (9 to 18 milligrams per liter) and then decreased in 1991 and 1992 (4 to 9 milligrams per liter).

Mean total aluminum concentrations measured from 1985 to 1992 were generally slightly greater than the detection limit (0.1 milligram per liter) and no higher than about 1 milligram per liter (Kretchmer and Chimney 1993). Total aluminum levels appeared to decline during the study period. Iron was present in higher concentrations in hypolimnetic samples (0.05 to 12 milligrams per liter) than in mixed layer samples (less than 0.02 to 6.9 milligrams per liter), reflecting thermal stratification and dissolution in the reducing conditions in the hypolimnion. Total manganese behaved similarly and ranged from 0.04 to 8.5 milligrams per liter in the hypolimnion and from less than 0.02 to 2.2 milligrams per liter above the hypolimnion.

TE | Nutrient Loading

Nutrient availability has declined in L-Lake since 1986; this is partly associated with the reservoir aging process. Reservoirs are often characterized by a pulse of high primary productivity (milligrams of carbon fixed per square meter per day) soon after filling due to the release of nutrients from inundated terrestrial vegetation and soils; this productivity usually decreases with time. However, L-Lake also received nutrients in the water imported from the Savannah River, which contains relatively high levels of total phosphorus and nitrogen, which created eutrophic conditions in L-Lake. Reduced nutrient loading to L-Lake began with reductions of L-Reactor power levels in 1987, and continued after DOE shut L-Reactor down in mid-1988. Annual loading rates for total phosphorus ranged from 4.6 to 6.0 milligrams of phosphorous per square meter per day from 1990 to 1992, decreasing each year (Kretchmer and Chimney 1993). Average orthophosphorus loading rates ranged from 2.6 to 3.3 milligrams of phosphorous per square meter per day for the same years. These values are well above loading levels considered dangerous for eutrophication (Wetzel 1983).

L-Lake acted as a very effective nutrient sink and retained most of the total phosphorus and orthophosphorus imported to it during the first 4 years of the study. L-Reactor effluent had mean total phosphorus concentrations ranging between 0.06 and 0.246 milligrams of phosphorous per liter from 1985 to 1989 (Wike et al. 1994). L-Lake concentrations of total phosphate and orthophosphate ranged from 0.014 to 0.864 milligrams per liter and less than 0.005 to 0.816 milligrams per liter, respectively, from 1985 through 1989. L-Lake also retained phosphorus from 1990 through 1992, but the concentrations in L-Reactor effluent were slightly lower (Kretchmer and Chimney 1993). Total phosphorus concentrations in the mixing (euphotic, in this case) zone of L-Lake appeared to decrease from 1990 to 1992 (Carson and Cichon 1993).

L-Lake also retained imported nitrogen compounds (nitrite, nitrate, and ammonia) very effectively (Wike et al. 1994). However, the lake usually exported more total Kjeldahl nitrogen than was present in the reactor effluent. Concentrations of L-Lake nitrogen compounds ranged as follows: nitrite, from less than 0.001 to 0.092 milligrams per liter; nitrate, from less than 0.001 to 0.660 milligrams per liter; and ammonia, from less than 0.01 to 2.72 milligrams per liter. Nitrate, ammonium, and total Kjeldahl nitrogen concentrations in the mixing (euphotic, in this case) zone of L-Lake appeared to decrease from 1990 to 1992 (Carson and Cichon 1993).

Trace Metals

During September 1995, eight L-Lake water samples were analyzed for the U.S. Environmental Protection Agency (EPA) target analyte list of metals (Paller 1996). Although none of the detected metals exceeded EPA acute toxicity screening values for surface waters, the detection limits for cadmium, lead, mercury, and silver were above chronic toxicity screening values (0.66 micrograms per liter, 1.32 micrograms per liter, 0.012 micrograms per liter, and 0.012 micrograms per liter, respectively). Therefore, the elimination of these metals as potential L-Lake contaminants is impossible. Both iron and beryllium were measured at concentrations that exceeded their respective EPA chronic screening values (1,000 micrograms per liter and 0.53 micrograms per liter, respectively), but these concentrations occurred in the hypolimnion during stratification. DOE concluded that radionuclides and metals in L-Lake water were not present in levels likely to be deleterious to aquatic life (Paller 1996).

Radioactive Materials

Early periods of P-Reactor and, to a lesser extent, L-Reactor operations resulted in releases of radioactive materials, primarily cesium-137, into Steel Creek where they became adsorbed on sediments in the Steel Creek floodplain that was inundated with the filling of L-Lake. During September 1995, DOE screened eight L-Lake water samples for a variety of radioactive contaminants (Paller 1996). No contaminants were present in concentrations likely to be deleterious to aquatic life, although cesium-137 and alpha-emitting radionuclides were present in measurable amounts in one of four water samples taken near the bottom of the reservoir. A fraction of cesium-137 remobilizes from sediments under anoxic conditions and this mechanism probably was responsible for the sample results.

In a 1995 study DOE took sediment core samples from eight L-Lake locations (Koch, Martin, and Friday 1996). These locations included a single, shallow (nonchannel) and seven channel sites. The mean volume-weighted cesium-137 concentration for all L-Lake core samples was 8.7 picocuries per gram and ranged as high as 103 picocuries per gram.

The analysis of the eight sediment cores from L-Lake also included semivolatiles and nonradionuclide inorganics (Koch, Martin, and Friday 1996). Inorganics were measured at concentrations below EPA Region IV screening levels with the exception of arsenic and one value for mercury. The arsenic results were below detection limits, making it impossible to definitely eliminate it as a potential contaminant. TC

4.1.2.2 Environmental Impacts

4.1.2.2.1 No Action

There would be no new or enhanced impacts to L-Lake surface water quality or use if the No-Action Alternative was selected.

4.1.2.2.2 Shut Down And Deactivate

Lake Recession

DOE performed three computer-based simulations of the fluctuations in water level for L-Lake with a constant discharge of 10 cubic feet (0.28 cubic meter) per second using the U.S. Army Corps of Engineers' hydrologic model HEC-5 with rainfall and stream flows for 1980 to 1989 (a low-flow drought period) and 1960 to 1979 (average and above average stream flow conditions). These simulations assumed that no additional water (e.g., groundwater seepage) was entering L-Lake; thus, they produced results that probably exaggerate the extent of L-Lake recession. The simulations used both precipitation-based stream flows and stream flow-based L-Lake inflows computed with U.S. Geological Service gauging station data for Upper Three Runs. As expected, all simulations predicted that L-Lake would slowly drain from its normal pool of 190 feet (58 meters) above mean sea level (a reasonable outcome considering the size of the L-Lake watershed, estimated Steel Creek inflows, and required reservoir discharge). One simulation used the historic low-flow period in conjunction with stream flow-based modeling to predict that recession to within 15 feet (4.6 meters) of the nominal dam-site Steel Creek elevation of 115 feet

(35.1 meters) would occur within about 10 years (Jones and Lamarre 1994).

DOE has analyzed the water balance of L-Lake to determine the significance of various water balance components and to estimate the overall effects of reducing the discharge from L-Lake to Steel Creek. Savannah River pumping inflow from L-Area and discharge through the dam into Steel Creek have dominated the water balance of L-Lake. The average natural inflow to L-Lake from precipitation [5.7 cubic feet (0.16 cubic meter) per second] and natural Steel Creek flow [1.4 cubic feet (0.04 cubic meter) per second] combine to about 7.1 cubic feet (0.20 cubic meter) per second. Annual average lake water losses through evaporation [4.9 cubic feet (0.14 cubic meter) per second] and groundwater percolation [1.1 cubic feet (0.03 cubic meter)] per second combine to about 6.0 cubic feet (0.17 cubic meter) per second. With a reduction in lake discharge to the base flow of 10 cubic feet (0.28 cubic meter) per second, about 4,100 gallons per minute (0.26 cubic meter per second) of additional inflow would be required to maintain the lake level. A higher estimate of groundwater percolation loss [3,200 gallons per minute (0.20 cubic meter per second)] due to uncertainty in estimating this loss parameter would increase the additional inflow needed to maintain the lake level to 6,700 gallons per minute (0.42 cubic meter per second) (del Carmen and Paller 1993a).

Siltation

Because the L-Lake watershed cannot supply enough water to compensate for natural water losses and the required discharge to Steel Creek, DOE expects continual drawdown of the lake, with minor periods of reservoir refilling during storm events. Once exposed, the lakebed would be susceptible to erosion with potentially increased levels of siltation in Steel Creek. This process could result in the downstream transport of contaminants.

L-Lake Embankment

Regardless of the extent of L-Lake recession, the L-Lake embankment and outlet works will need continued inspection and maintenance as required by the Federal Energy Regulatory Commission. These inspections will, among other things, ensure that the intake tower gates remain unobstructed to prevent a partial or complete refill of the reservoir (Jones 1996b).

The ability to withstand an extremely rare probable maximum flood [a hypothetical intense storm event releasing 28 inches (72 centimeters) of rain in 24 hours] has been included in the design bases for the embankment. The existing outlet works and natural saddle emergency spillway to Pen Branch would remain fully capable of controlling and attenuating all storm event impacts, including those resulting in the probable maximum flood, without overtopping the embankment (DOE 1984).

Pooling at the Intake Tower

The L-Lake intake tower is offset from the midline of the Steel Creek bed and the lower gates are at an approximate 15 foot (5 meter) higher elevation [130 feet (40 meters) above mean sea level] than the former Steel Creek bed [115 feet (35 meters) above mean sea level]. As a consequence, complete recession to the former Steel Creek channel would not be possible and a small pond would form upstream of the dam. This pond should act as a stilling basin and, therefore, ameliorate the siltation discussed above. However, once this pond has silted in, storm events could cause movement of the silt to reaches of Steel Creek below the dam.

L-Area Sanitary Wastewater Treatment Plant

DOE has calculated that L-Area Sanitary Wastewater Treatment Plant (SWTP) discharges from National Pollutant Discharge Elimination

System-permitted Outfall L-07A through Outfall L-07 to L-Lake would not meet the SCDHEC water quality criteria after DOE stopped pumping Savannah River water to L-Area. DOE has evaluated additional treatment plant technologies to achieve the required water quality at Outfall L-07 and found them impracticable because of extensive operation and maintenance (O&M) requirements. As a consequence, DOE evaluated an alternative (elimination of SWTP discharges to surface water) as three options:

- Option 1 – septic tank and tile field installation with estimated capital and annual O&M costs of $70,100 and $120, respectively
- Option 2 – Central Sanitary Wastewater Treatment Facility tie-in with estimated capital and annual O&M costs of $1,970,000 and $10,200, respectively
- Option 3 – spray field discharge with estimated capital and annual O&M costs of $970,000 and $88,260, respectively

After comparing the net present values of these options, DOE concluded that Option 1 would be the preferred approach if the L-Area worker population did not exceed 250 persons. If the population exceeded 250 (e.g., due to new mission assignments), DOE concluded that Option 2 would enable more efficient use of current resources and would provide the necessary treatment regardless of worker population variability (Huffines 1996b).

Water Quality

DOE anticipates an increase in suspended solids loading in L-Lake, and perhaps in its discharge, as recession occurs. This increase is likely to be temporary; as exposed sediments become vegetated, the rate of erosion would decline and eventually stabilize. The discharge of significant suspended solids from L-Lake would depend on the size and morphometry of the remaining pool, and on storm event conditions such as rainfall and wind speed. On a short-term basis, increased suspended solids concentration, which contributes to turbidity, could interfere with primary and secondary production, flocculate plankton, and reduce food availability to invertebrates and fish.

The reduction of Savannah River water input to L-Lake would result in reduced loading of nutrients. This process has been proceeding in L-Lake without apparent deleterious effects. However, the change in nutrient loading caused by water supply shutdown probably would be more severe than previous reductions. Reduced primary and secondary productivity in L-Lake is the likely result, with the reservoir shifting from a eutrophic condition to a less eutrophic, or even mesotrophic, condition.

Whether the change from eutrophic conditions would be a benefit or a problem would depend entirely on management objectives. If the objective is maximum fish production, the nutrient loading reduction would be a problem; if the objective is maximum water clarity and aesthetics, the reduction would be a benefit. To date, DOE has managed L-Lake to meet regulatory requirements while functioning as a cooling reservoir. Because a reduction in nutrient loading would not affect these objectives, the change in nutrient regime would be neutral for lake management.

In addition to lower rates of nutrient loading, the reliance on local runoff and groundwater for recharging L-Lake would result in lower concentrations of dissolved salts, or lower ionic strength. Loss of ionic strength had at least one biological effect during the Par Pond drawdown. Without the addition of Savannah River water, the relatively large influence of groundwater and natural surface inputs (having low ionic strength) to Par Pond was observed in the water chemistry of the reservoir. The specific conductance of the Par Pond surface water was reduced from near 100 microsiemens per centimeter to about 30 microsiemens per centimeter. Coincident with the new ionic strength was the enhanced bioaccumulation of cesium-137 in largemouth bass muscle tissue. This observation suggested an increased biological mobility of cesium-137 (a metabolic analog of potassium) stemming from the reduced availability of potassium (DOE 1995a).

4.1.2.2.3 Shut Down and Maintain

Refer to Section 4.1.2.2.2. This alternative would have essentially the same water flow as those described for the Shut Down and Deactivate Alternative; therefore, those impacts are likely to prevail under both alternatives.

4.1.3 GROUNDWATER

This section summarizes groundwater data available for the SRS (see Aadland, Gellici, and Thayer 1995; WSRC 1996f) and pertinent data about the areas of interest for this EIS. It describes the current knowledge base of groundwater conditions and character at the SRS and near L-Lake, including such issues as transmissivity, hydraulic conductivity, flow directions, quality, and usage.

4.1.3.1 Affected Environment

Two hydrogeological provinces underlie the SRS – the Piedmont Hydrogeologic Province, which is older, and the Southeastern Coastal Plain Hydrogeologic Province (see Figure 4-10). The Piedmont Province consists of the crystalline bedrock and consolidated sediments of the Triassic-age Dunbarton Basin. Aquifers in this province are generally not useful for domestic or industrial purposes. The Southeastern Coastal Plain Hydrogeologic Province consists of Cretaceous, Tertiary, and Quarternery age unconsolidated sands, silts, limestones, and clays, as described in Section 4.1.1.1. This province includes the formations that provide water for the SRS and the surrounding area. The Southeastern Coastal Plain Hydrogeologic Province contains the following aquifer systems for the southeast portion of the Site (youngest to oldest, see Figure 4-5); SRS-specific units are shown in parenthesis:

- Floridan aquifer system
- Meyers Branch confining system (Crouch Branch confining unit)
- Dublin aquifer system (Crouch Branch aquifer)
- Allendale confining system (McQueen Branch confining unit)
- Midville aquifer system (McQueen Branch aquifer)
- Appleton confining system (the base of the province)

Regional Hydrogeologic Setting

The Floridan aquifer system and the Meyers Branch confining system comprise approximately 550 feet (170 meters) of the nearly 2,000 feet (610 meters) of sediments that are the Southeastern Coastal Plain Hydrogeologic Province (Aadland, Gellici, and Thayer 1995). The Floridan aquifer system is the only hydrogeologic unit that the alternatives are likely to affect (see Aadland, Gellici, and Thayer 1995; WSRC 1996f). Figure 4-5 shows the correlation between the geological formations and hydrostratigraphic nomenclature.

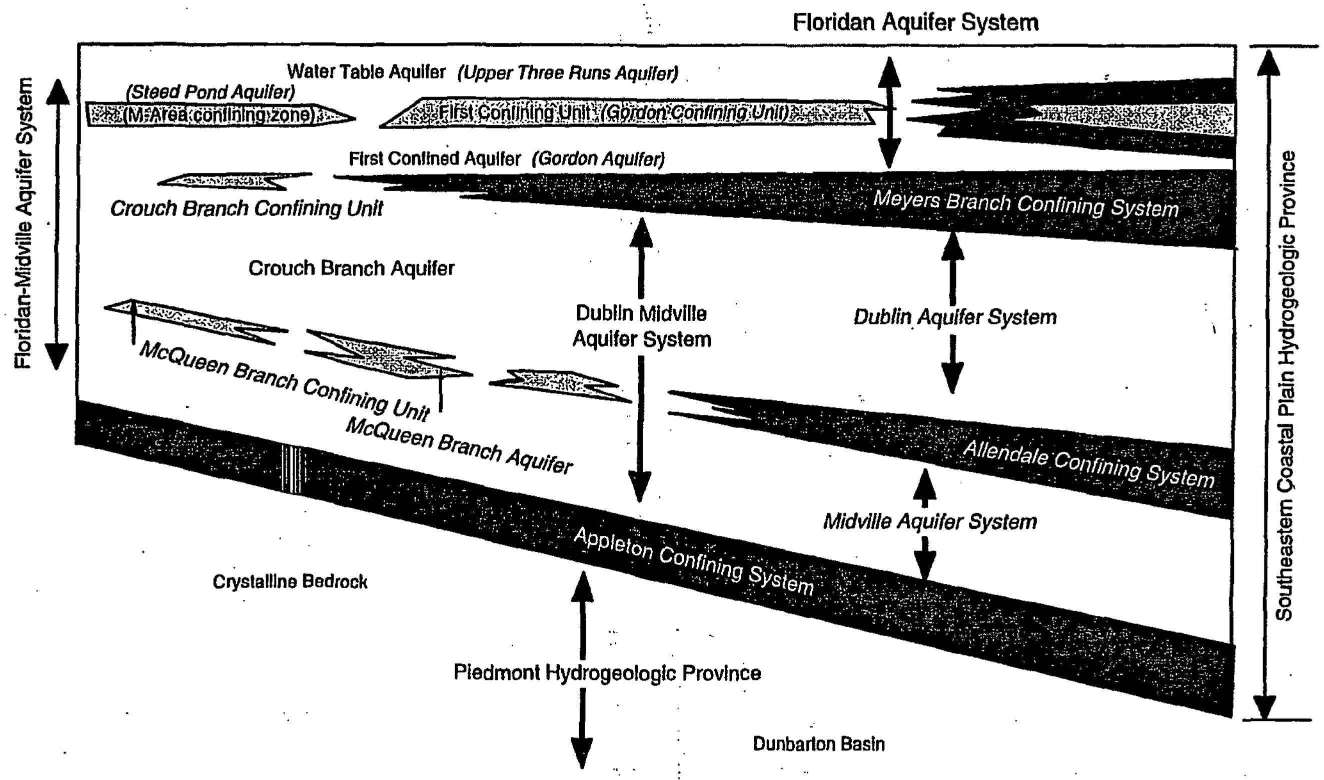
The Floridan aquifer system includes two aquifers and one confining unit:

- Water table aquifer
- First confining unit
- First confined aquifer

Aquifer Units

The water table aquifer and the first confined aquifer are the focus of the groundwater analysis in this EIS because none of the alternatives would affect the other aquifers or the confining units (see Aadland, Gellici, and Thayer 1995; WSRC 1996f).

The water table aquifer is comprised of the Tobacco Road Formation, the Dry Branch Formation, and the Clinchfield or Santee Formation. The first confining unit includes the



Source: Aadland, Gellici, and Thayer (1995).

PK64-1PC

Figure 4-10. Hydrogeologic cross-section.

Clinchfield Formation, the Santee or Tinker Formation, and possibly the Warley Hill Formation, depending on the SRS area. The first confined aquifer [also known as the Gordon aquifer (Aadland, Gellici, and Thayer 1995)] might include the Congaree, Warley Hill, Fishburne, and possibly Williamsburg Formations, depending upon the SRS area. Section 4.1.1.1 contains descriptions of these sedimentary strata. Run-on and rainfall provide recharge to these units.

Groundwater Flow

Groundwater flow rates vary from several hundred feet to a few inches per year towards the onsite streams and swamps and eventually to the Savannah River. Groundwater movement is controlled by the incision depth of streams, most of which receive a significant contribution from groundwater. In addition, groundwater flow has a downward component to deeper aquifers at inter-stream areas (e.g., at L-Area and at P-Area). In some places it flows upward to shallow aquifers closer to streams (e.g., at F- and H-Seepage Basin Areas).

L-Area is situated above a groundwater divide, flowing either to Steel Creek or a Pen Branch tributary (Figure 4-11). The contaminated sites are located between the southeast side of L-Area and the northwest side of L-Lake. The shallow groundwater on this side of L-Area flows southeast toward the lake. Figures 4-11 and 4-12 are potentiometric maps of the water table aquifer and the first confined (Gordon) aquifer, respectively (from WSRC 1996f and Aadland, Gellici, and Thayer 1995, respectively).
Tables 4-1 and 4-2 list the principal hydrogeological properties of the water table aquifer and the first confined aquifer, respectively, for the three areas of interest.

Groundwater Quality

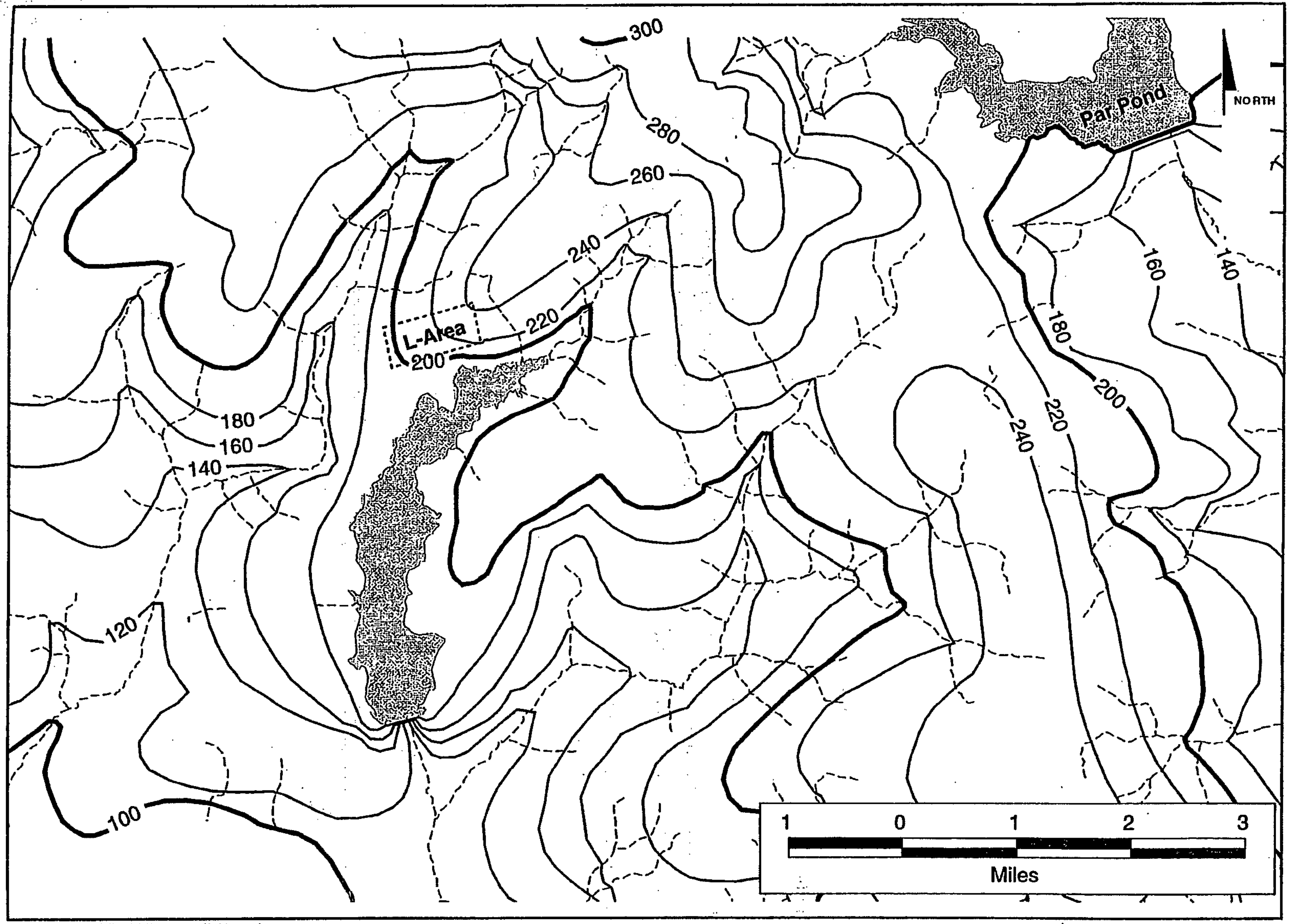
In most of South Carolina, including the SRS, the quality of the groundwater, is generally very good. The pH range for SRS groundwater is 4.9 to 7.7, and the water is generally soft. Concentrations of dissolved and suspended solids are low but iron concentrations are high in some aquifers (DOE 1995c).

The shallow aquifers at the SRS have been contaminated with tritium, metals, and industrial solvents; however, only 5 to 10 percent of the aquifer system is affected sitewide. Most of the L-Area contamination is associated with facilities where lead, radionuclides, and solvents are present in the water table aquifer (see Figure 4-13). L-Area, which is on the northwest shore of L-Lake, contains four Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) units several SRS reports have been prepared to describe its geology and soils and the related environmental issues for these areas. The water table aquifer outcrops above the current level of L-Lake but contamination from L-Area CERCLA units has not reached the point where the aquifer outcrops (WSRC 1996g). The first confined aquifer is not known to have been contaminated in any of the areas of interest for this EIS. Contaminant releases to the subsurface at SRS have not migrated offsite (DOE 1995c).

TE

Groundwater Use

In the area surrounding SRS, groundwater is used for domestic and industrial purposes. DOE identified at least 56 major municipal, industrial, and agricultural groundwater users within 20 miles (32 kilometers) of the center of SRS for a total of 36 million gallons (140,000 cubic meters) per year (DOE 1987a). Groundwater is the only source of domestic water at the SRS, with treatment required for pH and iron. Almost every major operating area has groundwater production wells. The total SRS groundwater production is 9 to 12 million gallons (34,000 to 45,000 cubic meters) per day (Arnett, Mamatey, and Spitzer 1996). On the SRS, only the deeper aquifers provide drinking water and also water for some industrial uses. Off the Site to the north, the Water Table Aquifer is the source of drinking water and other municipal purposes (DOE 1987a). Southeast of



Source: Modified Hiergesell (1996).
Note: Contours at 20 ft. intervals

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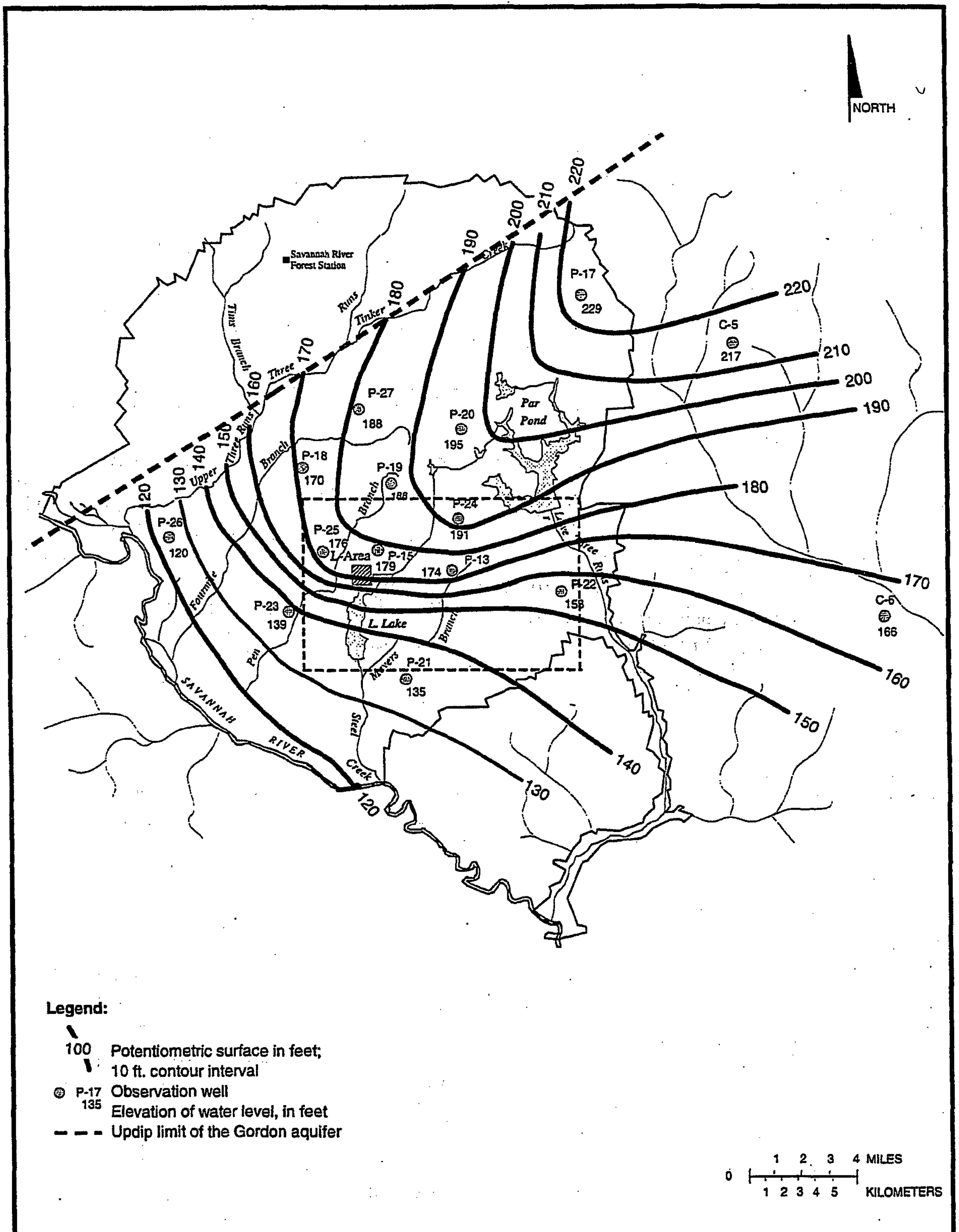
Figure 4-11. Potentiometric surface of the water table aquifer, L-Lake/Par Pond area (first quarter 1995 data).



Source: Aadland, Gellici, and Thayer (1995). PK64-1PC

Figure 4-12. Potentiometric surface of the first confined aquifer (Gordon aquifer), April-May 1992.

Table 4-1. Water table aquifer.

Property	L-Area[a]	SRS Streams and Par Pond[b]
Hydraulic conductivity	1.11 - 2.52 feet per day (0.34-0.77 meter per day)	16.4×10^{-2} - 39.37 feet per day (5.5×10^{-2} - 12.3 meters per day)
Porosity	0.20 - 0.25	0.20 - 0.25
Hydraulic gradient	0.011 - .013 foot per foot (0.0033-0.040 meter per meter)	Not reported
Transmissivity	Not reported	419.8-960.1 square feet per day (39.0 - 89.2 square meters per day)

a. Source: WSRC (1996g).
b. Source: WSRC (1996e).

Table 4-2. First confined aquifer.

Property	L-Area	SRS Streams	Par Pond
Hydraulic conductivity[a]	24 - 41 feet per day (7.32 - 12.5 meters per day)	24 - 41 feet per day (7.32 - 12.5 meters per day)	35 feet per day (10.67 meters per day)
Porosity[a]	Average - 33.5%, Range 26 - 38%	Average - 33.5%, Range 26 - 38%	Average - 33.5%, Range 26 - 38%
Transmissivity	GSA[b]: 1,292 - 2,562 square feet per day (120 - 238 square meters per day)[c]	GSA: 1,124 - 2,562 square feet per day (12,099 - 25,578 square meters per day) C-Area: 68.2 square feet per day (734 square meters per day)	Par Pond: 2,116 square feet per day (196.6 square meters per day) P-Area: 13,400 square feet per day (1,245 square meters per day)

a. Source: Aadland, Gellici, and Thayer (1995).
b. GSA = General Separations Area.
c. Source: WSRC (1996e). TE

the Site the primary drinking water aquifers are the first confined aquifer and the deeper aquifers.

The current use of groundwater at K- and L-Areas is for the industrial and domestic water supply. K- and L-Areas each have two production wells, which produce from the lower portions of the Crouch Branch aquifer and the upper portions of the McQueen aquifer. These two aquifers are not contaminated in the area of interest and are prolific water producers at the SRS (Beavers 1996).

The wells at K-Area currently meet the demands of the facility. The wells have 500-gallon-per-minute (0.032-cubic-meter-per-second) pumps but produce only 200 to 300 gallons per minute (0.013 to 0.019 cubic meter per second). The domestic water supply has been supplemented by the recent hookup to the sitewide water system. The two L-Area wells are producing at lower levels than originally designed but are meeting demands. One well is producing 200 to 300 gallons per minute with a 500-gallon-per-minute pump. The other well produces 100 gallons per minute (0.0063 cubic meter per second) on a 150-gallon-per-minute (0.0095-cubic-meter-per second) pump. The deeper aquifers at L-Area are capable of producing the water required to operate the facility if the River Water System were shut down (Beavers 1996).

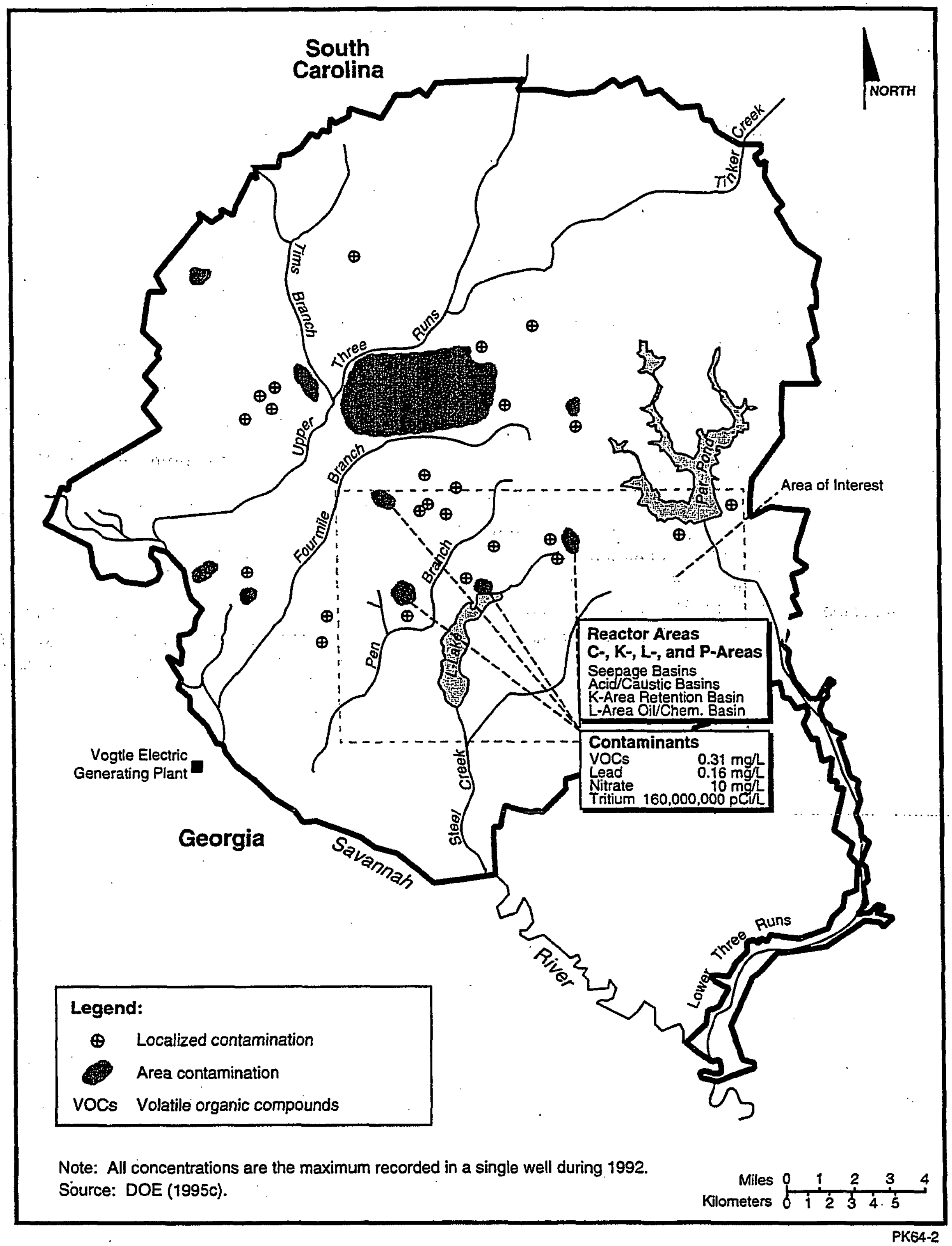


Figure 4-13. Groundwater contamination at the Savannah River Site.

4.1.3.2 Environmental Impacts

4.1.3.2.1 No Action

Under this alternative, DOE would maintain L-Lake in its current state. The water table aquifer gradient, level, and flow rate should remain constant because the L-Lake outfall would continue to discharge; therefore, the aquifer would maintain reservoir elevation. At L-Area, this alternative would not affect contaminants in this aquifer. Infiltration of water from the River Water System does not occur at L-Reactor but downgradient of L-Reactor at the L-Lake outfall and, therefore, would not mobilize contaminants in the water table aquifer. Because L-Lake and the first confined aquifer are not in direct communication at the lake, the continued operation of the River Water System would not affect groundwater conditions in the first confined aquifer.

Under the No-Action Alternative, the River Water System would provide fire protection water for K- and L-Areas. DOE would minimize the need for river water by using the existing pumps screened into the deeper aquifers (Crouch Branch and McQueen Branch) more under this alternative. However, the nature and character of these aquifers would not change. TC The net increased well water demand would be approximately 200 gallons per minute (0.013 cubic meter per second) for each area.

4.1.3.2.2 Shut Down and Deactivate

Under this alternative, DOE would allow L-Lake to drain. Because the water table aquifer conditions are currently influenced by L-Lake, groundwater gradients, levels, and flow rates probably would change. Calculations demonstrate the water table elevation at the L-Area Oil and Chemical Basin (one of four CERCLA units) would drop approximately 4 feet (1 meter), the local gradient would steepen and local velocities would increase approximately 12 percent (Halliburton NUS 1996). By lowering the level of water in the aquifer, a possible effect could be to strand contamination within the vadose zone. If, in fact, the water table aquifer is homogeneous, then contaminant migration would be accelerated by the increased velocities. An earlier study indicated that the travel time from the L-Reactor seepage basin (another one of the four CERCLA units) would be 21 years to L-Lake compared to 18 years to natural Steel Creek level (DOE 1984). TC

Removal of the water from L-Lake would have little effect on groundwater elevation, gradient, flow rates, or flow direction in the first confined aquifer, which is not in direct communication with the lake or the water table aquifer. This aquifer contains no known contamination. River Water System outfalls do not directly influence the first confined aquifer, so discontinuation of the L-Lake outfall would have no effect on this aquifer. There is a possibility that the reduction of reservoir levels could influence the downward flow into the first confined aquifer below the dam.

As compared with the No-Action Alternative, TC this alternative would cause a further increase at K- and L-Areas in the demand for groundwater from the deeper aquifers of up to 200 gallons per minute (0.013 cubic meter per second) at L12-03 each reactor area. Aquifer conditions would not change.

4.1.3.2.3 Shut Down and Maintain

The impacts discussed above for the Shut Down and Deactivate Alternative would apply to this alternative.

4.1.4 AIR RESOURCES

4.1.4.1 Affected Environment

4.1.4.1.1 Climate and Meteorology

The climate at the SRS is temperate, with short mild winters and long humid summers. Warm, moist maritime air masses affect the weather throughout the year (Hunter 1990).

Summer weather usually lasts from May through September, when the western extension of the semipermanent Atlantic subtropical "Bermuda" high-pressure system strongly influences the area. Winds are relatively light, and migratory low-pressure systems and fronts usually remain well to the north of the area. The Bermuda high is a relatively persistent feature, resulting in few breaks in the summer heat. Climatological records for the Augusta, Georgia, area indicate that during the summer months, high temperatures were greater than 90°F (32°C) on more than half of all days. The relatively hot and humid conditions often result in scattered afternoon and evening thunderstorms (Hunter 1990).

The influence of the Bermuda high begins to diminish during the fall, resulting in relatively dry weather and moderate temperatures. Fall days are frequently characterized by cool clear mornings and warm sunny afternoons (Hunter 1990).

During the winter, low-pressure systems and associated fronts frequently affect the weather of the SRS area. Conditions often alternate between warm, moist subtropical air from the Gulf of Mexico and cool, dry polar air. The Appalachian Mountains to the north and northwest of the SRS moderate the extremely cold temperatures associated with occasional outbreaks of arctic air. As a consequence, fewer than one-third of all winter days have minimum temperatures below freezing, and temperatures below 20°F (-7°C) occur infrequently. Snow and sleet occur on average less than once a year (Hunter 1990).

Outbreaks of severe thunderstorms and tornadoes occur more frequently during the spring than during the other seasons. Although spring weather is variable and relatively windy, temperatures are usually mild (Hunter 1990).

Precipitation

The annual average precipitation for the SRS is 48.2 inches (122 centimeters). Table 4-3 lists the monthly average and extreme precipitation amounts for the Site. Precipitation is fairly well distributed throughout the year. Average precipitation during the fall months (September, October, and November) is slightly less than the averages for the other seasons, accounting for about 18 percent of the average annual total. The maximum rainfall amount in a monthly period was 19.6 inches (50 centimeters) in October 1990 (Shedrow 1993). The maximum annual rainfall amount for the SRS was 73.5 inches (187 centimeters) in 1964; the record minimum annual amount was 28.8 inches (73 centimeters) in 1954 (Hunter 1990).

In Augusta, Georgia, the greatest observed rainfall for a 24-hour period was 8.6 inches (22 centimeters) in October 1990 (NOAA 1995). Hourly observations indicate that rainfall rates are usually less than 0.5 inch (1.3 centimeters) per hour, although higher rates are likely during spring and summer thunderstorms (Hunter 1990).

Occurrence of Violent Weather

The SRS area experiences an average of 55 thunderstorms per year, half of which occur during the summer months of June, July, and August (Shedrow 1993). On average, lightning flashes will strike six times per year on 0.39 square mile (1 square kilometer) of ground (Hunter 1990). Thunderstorms can generate wind speeds as high as 40 miles (64 kilometers) per hour and even stronger gusts. The highest 1-minute wind speed recorded at Bush Field in Augusta, Georgia, between 1950 and 1994 was 62 miles (100 kilometers) per hour (NOAA 1995).

Since SRS operations began, nine confirmed tornadoes have occurred on or close to the Site; eight caused light to moderate damage. The tornado of October 1, 1989, caused considerable damage to timber resources on about 1,097 acres (4.4 square kilometers) and lighter damage on about 1,497 acres (6 square kilometers) over southern and eastern areas of the Site. Estimated wind speeds for this tornado were as

Table 4-3. Monthly precipitation amounts for the Savannah River Site.[a,b,c]

Month	Average	Maximum[d]	Minimum[d]
January	4.17	10.02 (1978)	0.89 (1981)
February	4.61	7.94 (1956)	0.94 (1968)
March	5.02	10.96 (1980)	1.31 (1985)
April	3.49	8.20 (1961)	0.57 (1972)
May	4.23	10.90 (1976)	1.33 (1965)
June	4.36	10.89 (1982)	1.54 (1979)
July	5.02	11.48 (1982)	0.90 (1980)
August	4.85	12.34 (1964)	1.04 (1963)
September	3.74	8.71 (1959)	0.49 (1985)
October	2.49	10.86 (1959)	0.00 (1963)
November	2.60	6.46 (1957)	0.21 (1958)
December	3.63	9.55 (1981)	0.46 (1955)
Annual	48.21	73.47 (1964)	28.82 (1954)

a. Source: Hunter (1990).
b. Total inches, water equivalent; to convert inches to centimeters, multiply by 2.54.
c. Period of record, 1951-1987.
d. Year of occurrence given in parentheses.

high as 150 miles (240 kilometers) per hour (Shedrow 1993).

Thirty-six hurricanes caused damage in South Carolina between 1700 and 1992 (Shedrow 1993). The average frequency of occurrence of a hurricane in the state is once every 8 years; however, the observed interval between hurricanes has ranged from as short as 2 months to as long as 27 years. Eighty percent of these hurricanes have occurred in August and September (Hunter 1990).

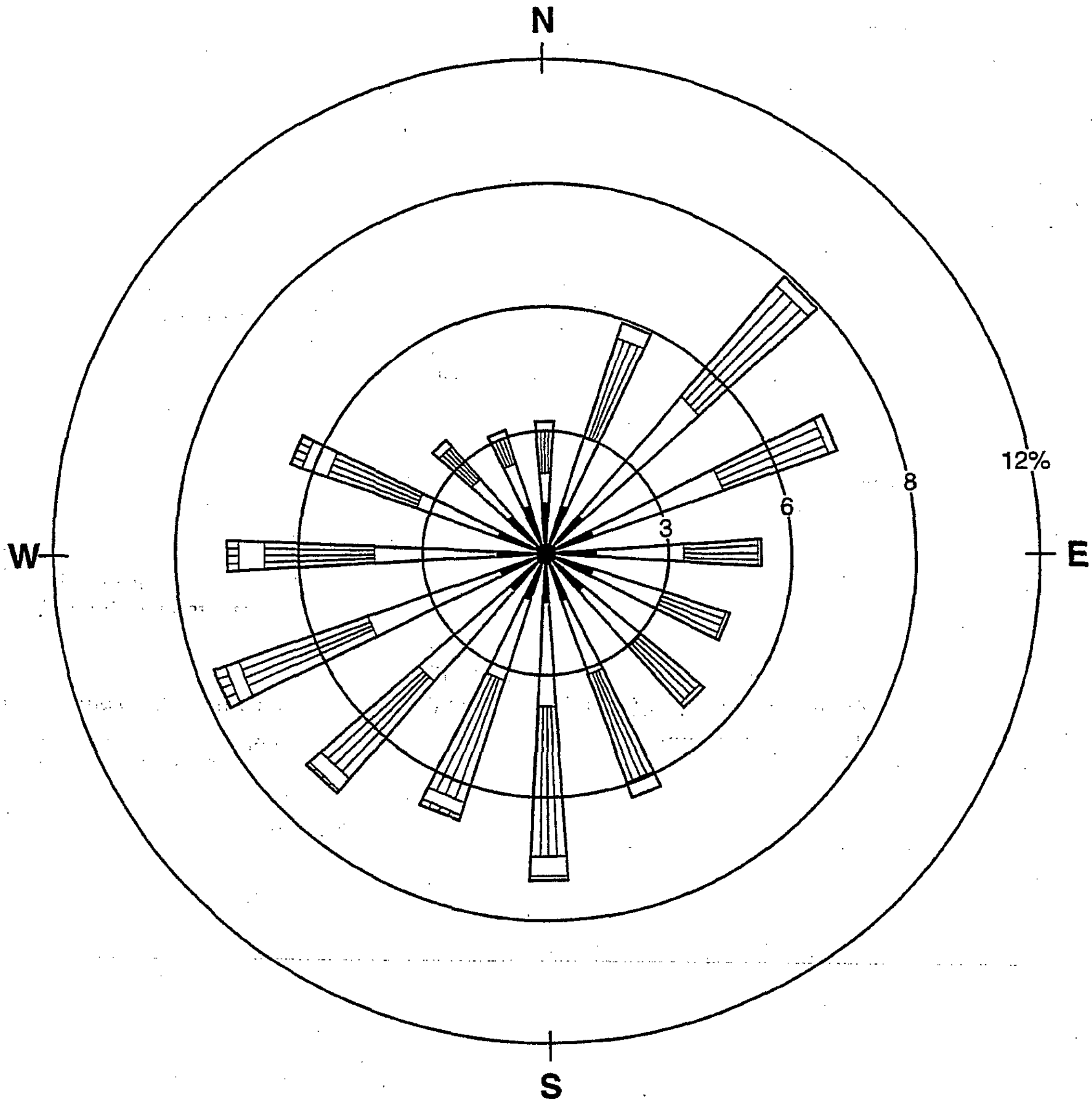
Wind Speed and Direction

Figure 4-14 shows a joint frequency summary (wind rose) of hourly averaged wind speeds and directions collected from the H-Area meteorological tower at a height of 200 feet (61 meters) during the 5-year period from 1987 through 1991. This figure indicates that the prevailing winds are from the south, southwest, west, and northeast. Winds from the south, southwest, and west occurred during about 35 percent of the monitoring period (Shedrow 1993).

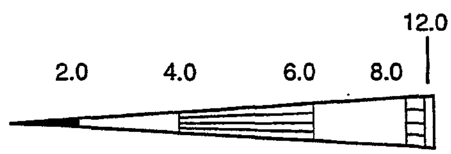
The average wind speed for the 5-year period was 8.5 miles (14 kilometers) per hour. Hourly averaged wind speeds less than 4.5 miles (7.2 kilometers) per hour occurred about 10 percent of the time. Seasonally averaged wind speeds were highest during the winter [9.2 miles (15 kilometers) per hour] and lowest during the summer [7.6 miles (12 kilometers) per hour] (Shedrow 1993).

Atmospheric Stability

The air dispersion coefficients used in modeling are determined by atmospheric stability. Air dispersion models that predict downwind ground-level concentrations of an air pollutant released from a source such as a dried lakebed are based on specific parameters such as vegetative cover, soil crusting, soil particle size, wind speed, and air dispersion coefficients.



This wind rose plot shows percent occurrence frequencies of wind direction and speed at the Savannah River Site. It is based on a composite of hourly averaged wind data from the H-Area meteorological tower for the 5-year period 1987 through 1991. Measurements were taken from 200 feet above ground. Directions indicated are *from* which the wind blows.



Wind Speed Class Boundaries
(meters/second)

Source: Arnett, Karapatakis, Mamatey (1993).

PK64-2

Figure 4-14. Wind rose for the Savannah River Site, 1987 through 1991.

The ability of the atmosphere to disperse air pollutants is frequently expressed in terms of the seven Pasquill-Gifford atmospheric turbulence (stability) classes A through G. DOE has determined occurrence frequencies for each stability class at the SRS using meteorological data collected from 1987 through 1991 at the onsite meteorological towers. Relatively turbulent atmospheric conditions that increase atmospheric dispersion, represented by the unstable classes A, B, and C, occurred approximately 56 percent of the time. Stability class D, which represents conditions that are moderately favorable for atmospheric dispersion, occurred approximately 23 percent of the time. Relatively stable conditions that minimize atmospheric dispersion, represented by classes E, F, and G, occurred about 21 percent of the time (Shedrow 1993).

4.1.4.1.2 Existing Radiological Conditions

Ambient air concentrations of radionuclides at the SRS include radionuclides of natural origins, such as radon from uranium in soils, manmade radionuclides such as fallout from nuclear weapons testing, and emissions from coal-fired and nuclear powerplants. DOE operates a 35-station atmospheric surveillance program at the SRS, with stations inside the perimeter, on the perimeter, and at distances as far as 100 miles (161 kilometers) from the Site (Arnett, Mamatey, and Spitzer 1996).

Routine SRS operations release gases and particulates that emit alpha- and beta-gamma radiation. DOE uses gross alpha and nonvolatile beta measurements as a screening method to determine the concentrations of radionuclides in the air. TE

Table 4-4 lists the average 1990 to 1995 gross alpha radioactivity and nonvolatile beta radioactivity measured at the SRS and at distances of 25 to 100 miles (40 to 161 kilometers) from the Site. The results show no significant differences between onsite locations near operating facilities and those at the site perimeter and beyond (Arnett, Mamatey, and Spitzer 1996). The 1994 results show gross alpha concentrations dropping to near the 1990 levels. The cause of the higher levels between 1991 and 1993 is unknown, but modifications to the analytical procedures are likely (Arnett, Mamatey, and Spitzer 1996).

Tritium (predominantly as water) is the only radionuclide detectable at and beyond the SRS boundary. Tritium is released from routine operations at the separations areas, and in smaller amounts from the reactor areas and D-Areas. TE

Table 4-4. Average gross alpha and gross beta measured in air (microcuries per milliliter), 1990-1995.

	Average gross alpha					
Locations	1990	1991	1992	1993	1994	1995
On Site	1.3×10^{-15}	2.5×10^{-15}	1.8×10^{-15}	1.9×10^{-15}	1.4×10^{-15}	1.5×10^{-15}
Site perimeter	1.1×10^{-15}	2.6×10^{-15}	1.8×10^{-15}	1.8×10^{-15}	1.4×10^{-15}	1.4×10^{-15}
25-mile radius	1.0×10^{-15}	2.5×10^{-15}	1.7×10^{-15}	1.8×10^{-15}	1.4×10^{-15}	1.4×10^{-15}
100-mile radius	1.3×10^{-15}	2.6×10^{-15}	1.7×10^{-15}	2.0×10^{-15}	1.8×10^{-15}	1.6×10^{-15}
	Average gross beta					
Locations	1990	1991	1992	1993	1994	1995
On Site	1.8×10^{-14}	1.8×10^{-14}	1.9×10^{-14}	1.8×10^{-14}	1.7×10^{-14}	1.8×10^{-14}
Site perimeter	1.8×10^{-14}	1.8×10^{-14}	1.9×10^{-14}	1.9×10^{-14}	1.8×10^{-14}	1.8×10^{-14}
25-mile radius	1.8×10^{-14}	1.8×10^{-14}	1.8×10^{-14}	1.8×10^{-14}	1.8×10^{-14}	1.8×10^{-14}
100-mile radius	1.9×10^{-14}	1.8×10^{-14}	1.7×10^{-14}	2.0×10^{-14}	1.8×10^{-14}	1.8×10^{-14}

The highest tritium levels occur near H-Area, but they decrease with distance from the release point. Other onsite locations (F-Area and the Burial Ground) show concentrations substantially lower than those at H-Area but greater than at the Site boundary, while boundary tritium concentrations are higher than those on the 25-mile- (40-kilometer) radius. Total 1995 atmospheric releases for tritium, cesium-137, and cobalt-60 were 96,700 curies, 0.015 curie, and 0.00006 curie, respectively. Tritium in elemental and oxide forms accounts for more than 99 percent of the radioactivity released to the atmosphere from SRS operations.

TE

The calculated dose to the maximally exposed individual from airborne releases using the CAP88 code during 1995 was 0.8 millirem, which is 0.8 percent of the EPA airborne emission standard of 10 millirem-per-year due to radioactive emissions from DOE facilities (40 CFR 61, Subpart A) (Arnett, Mamatey, and Spitzer 1996).

4.1.4.1.3 Nonradiological Ambient Air Concentrations

At present, SRS does not perform onsite ambient air quality monitoring. The State of South Carolina operates ambient air quality monitoring sites, including sites in Barnwell and Aiken Counties. These monitors classify air quality control regions of the state as either in compliance or out of compliance with National Ambient Air Quality Standards. SRS is in a designated attainment area because it complies with those standards for criteria pollutants, including sulfur dioxide, nitrogen oxides (reported as nitrogen dioxide), particulate matter [less than or equal to 10 microns in diameter (PM_{10})], carbon monoxide, ozone, and lead (SCDHEC 1996b).

The only criteria pollutant potentially affected by the actions proposed in this EIS is PM_{10} due to the resuspension of dried lakebed sediment. Calculated maximum boundary-line PM_{10} concentrations from existing SRS operations are 50.6 and 2.9 micrograms per cubic meter for a 24-hour and annual averaging time respectively (DOE 1995c). The maximum observed 24-hour and annual average PM_{10} concentrations during 1995 near the SRS were 62 and 19 micrograms per cubic meter, respectively (SCDHEC 1996b).

4.1.4.2 Environmental Impacts

4.1.4.2.1 No Action

The continued operation of the River Water System would have no additional or new impacts on the existing ambient air quality at SRS. DOE would maintain L-Lake at its current full level, and the potential for exposed sediments that could become airborne would be minimal.

As discussed in Section 4.1.2.1, the primary contaminants in L-Lake are radionuclides and metals. No organic contaminants are present in the lakebed or floodplain at levels that are close to EPA Region IV risk-based concentrations, which DOE is using as screening levels at SRS (PRC 1996). Areas of highest contamination have been found in the Steel Creek floodplain.

4.1.4.2.2 Shut Down and Deactivate

TE

The shutdown and deactivation of the River Water System would cause the level of water in L-Lake to recede as discussed in Section 4.1.2.2.2, and the lakebed could completely dry over several years. The drainage of L-Lake over several years could expose sediment covering as much as 920 acres (3.7 square kilometers) of surface area to windborne air currents (Ross 1996; Jones and Lamarre 1994). Winds could resuspend dried lake basin sediments (DOE 1996c; PRC 1996).

TC

The amount of airborne contamination resulting from the exposure of the dried lakebed to airborne currents would depend on such parameters as the types and quantities of contamination in the sediment, the size of the dried lakebed exposed to air currents, the local meteorology (the occurrence of high wind speeds and precipitation), and the amount of vegetative cover on the soil. The level of contaminants that could volatilize from L-Lake sediments would be very low and, therefore, potential environmental impacts would be negligible (DOE 1996c; PRC 1996).

DOE used the Multimedia Environmental Pollutant Assessment System (MEPAS) model (Pacific Northwest Laboratory 1995) to estimate quantities of resuspended particulates originating from the dried lakebed. DOE obtained joint frequency wind data from the Savannah River Technology Center to represent the wind speeds and directions obtained from the L-Area meteorological tower for the period from 1986 to 1991 (Simpkins 1996a). The algorithm used by MEPAS to calculate the particulate emission factor has a parameter for the frequency of disturbances on the dried lakebed. For conservatism, a factor of 30 disturbances per month was used to estimate a worst-case particulate emission rate. The annual average concentration is conservatively calculated to equal the modeled 24-hour average concentration.

Table 4-5 lists the maximum concentration in air of nonradiological constituents at the boundary of the SRS. Included in the table is a column that shows the maximum allowable concentrations established by SCDHEC (SCDHEC 1976). As can be seen from the table, the resuspension of particulate matter from L-Lake produces only minimal concentrations by comparison to the allowable concentration.

Table 4-6 lists the maximum concentration in air of the radiological constituents at the boundary of the SRS. A column also is included in the table that shows the radiation dose resulting from annual exposure to this concentration of material. This radiation dose was calculated for all potential exposure pathways (e.g., ingestion of vegetation, direct exposure to radiation) that are the result of material being suspended and transported to the site boundary. These doses are much less than the 10 millirem per year requirement in 40 CFR 61.

A net benefit to the environment would be the reduction of fugitive evaporative tritium emissions from the L-Lake surface. The maximum calculated reduction in airborne tritium concentration at the SRS boundary is 0.073 picocurie per cubic meter.

Table 4-5. Maximum ground-level concentrations of nonradiological air constituents at the Savannah River Site boundary under the Shut Down and Deactivate Alternative.

Nonradiological Constituent	Modeled maximum air concentration[a] ($\mu g/m^3$)	Maximum allowable concentration[b] ($\mu g/m^3$)
Antimony	8.6×10^{-6}	2.5
Arsenic	2.2×10^{-5}	1.0
Beryllium	2.9×10^{-6}	0.01
Cadmium	1.3×10^{-6}	0.25
Lead	1.8×10^{-5}	1.5 (calendar quarter average)
Manganese	3.8×10^{-7}	25
PM_{10}[c]	1.2	50 (annual average) 150 (24-hour average)

TC

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).
b. Source: SCDHEC (1976).
c. PM_{10} is particulate matter with a diameter of 10 microns (0.00001 m) or less.

Table 4-6. Maximum ground-level concentrations of radiological air constituents at the Savannah River Site boundary under the Shut Down and Deactivate Alternative.

Radiological Constituent	Modeled maximum air concentration[a] (pCi/m^3)	Dose from all pathways (mrem/yr)
cesium-137	7.2×10^{-6}	3.6×10^{-4}
cobalt-60	1.1×10^{-7}	1.6×10^{-6}
plutonium-239	7.9×10^{-9}	3.5×10^{-5}
promethium-146	7.9×10^{-9}	9.5×10^{-9}
uranium-233	9.6×10^{-7}	9.3×10^{-5}
thorium-229	4.5×10^{-9}	4.7×10^{-6}
radium-225	4.5×10^{-9}	1.8×10^{-7}
actinium-225	4.5×10^{-9}	3.0×10^{-8}

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).

TC

4.1.4.2.3 Shut Down and Maintain

The effects of this alternative would be the same as those described in Section 4.1.4.2.2. Impacts to the existing SRS ambient air quality would be minimal.

4.1.5 ECOLOGY

This section describes the plant and animal communities in and around L-Lake, and characterizes the potential impacts of the Proposed Action and alternatives. The Affected Environment and Environmental Impacts sections are divided into three categories based on the wildlife habitat that is present: Terrestrial Ecology, Aquatic Ecology, and Wetlands. Section 4.1.5.1 describes the affected environment by habitat type; the potential impacts of the Proposed Action and alternatives are discussed in Section 4.1.5.2.

Wetlands and potential impacts to wetlands are discussed in considerable detail in Sections 4.1.5, 4.2.5, and 4.3.5, in accordance with the requirements of 10 CFR 1022. The floodplain and wetlands assessment required by 10 CFR 1022 is included in these sections. Section 4.3.5.3 discusses threatened and endangered species separately because several, such as the bald eagle and wood stork, range widely, and thus are not restricted to a particular drainage basin or reservoir. They also warrant additional consideration because they are protected by Federal law and therefore have special status under the National Environmental Policy Act (40 CFR 1508.27).

4.1.5.1 <u>Affected Environment</u>

L-Lake contains phytoplankton, zooplankton, macroinvertebrate, and fish communities characteristic of productive southeastern reservoirs with significant nutrient inputs and long growing seasons. A variety of reptiles and amphibians also occur in and around the lake. Birds (shorebirds, wading birds, and birds of prey) and mammals forage around L-Lake and drink its water. Several thousand ducks use L-Lake in winter. Small numbers of (threatened) bald eagles, (endangered) wood storks, and (threatened) American alligators are found in the L-Lake area at certain times of the year.

4.1.5.1.1 Terrestrial Ecology

The terrain surrounding L-Lake is almost entirely upland, with the exception of a few small tributaries entering the reservoir (one from the east and two from the west), the Steel Creek headwaters draining into the north (upper) end of the lake, and the Steel Creek corridor below the L-Lake dam. These uplands are dominated by pine forests and pine plantations, which approach to within 10 meters of the shore, where wax myrtle (*Myrica certifera*) becomes dominant. Some oaks, such as water oak (*Quercus nigra*) and willow oak (*Q. phellos*) occasionally become established in the understories of the less densely populated pine stands. These more open pine stands will often also contain black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), and persimmon (*Diospyros virginiana*), as well as yellow jessamine (*Gelsemium sempervirens*), Japanese honeysuckle (*Lonicera japonica*), broomsedge (*Andropogon virginicus*), and an occasional bear-grass (*Yucca filamentosa*).

On the east side of the reservoir, the pines are mostly long-leaf (*P. palustris*) with some loblolly and slash pine. There are also a couple of small inclusions of oak-hickory forest. The long-leaf pines were planted in the early 1950s, with the exception of a few small inclusions planted in 1988 (SRFS 1997). Two small stands of loblolly towards the north end of the reservoir were established in 1941 and 1937. A third, and much larger stand (approximately 230 acres) of loblolly pines planted in 1971, is more centrally located away from the lake shore to the east. A single, approximately 150-acre (0.6 square kilometer) stand of slash pines is located along the shore at the north end of the lake and adjacent to the south side of SRS Road B. These trees were established in 1950. TC

On the west side of the reservoir, the pines are mostly slash (*Pinus elliottii*) and loblolly (*P. taeda*) and were established from 1947 to 1957 (SRFS 1997). A couple of small inclusions of loblolly pines were established in 1982. There are also two small inclusions of oak-hickory (*Quercus* spp.) forest on this side. These hardwoods tend to occur in areas of higher soil moisture.

The area on and around the dam at the south end of the lake is open and grassy and maintained in grass through regular mowing. The grasses are typical cultivated lawn grasses (e.g., fescue and rye). Below the dam, directly in the Steel Creek corridor, are wetlands dominated by sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), Nuttall oak (*Q. nuttallii*), and willow (*Salix* spp.). At elevations immediately above these wetlands are slash and long-leaf pines that were planted in the 1950s (SRFS 1997).

At the north end of the lake, on the north side of SRS Road B, is L-Area. On the west side of L-Area is an open, regularly mowed grassy area and a stand of slash pines that were planted in 1957. South of the reactor are young stands of loblollies that were established in 1989. Along the west side of the Steel Creek headwaters is an old stand of oak-hickory forest that became established in 1916 and along the shoreline is a stand of mature sweetgum and tulip poplar. The uplands on the east side of the headwaters are dominated by loblolly pines that were established in 1946 and 1953 (SRFS 1997). TC

Only two sensitive plant species occur within a half mile of the reservoir. These species are wild indigo (*Baptisia lanceolata*) and sandhill lily (*Nolina georgiana*) (SRFS 1996). Neither of these species is federally recognized as threatened or endangered and their status in the State is currently unresolved (Knox and Sharitz 1990). Both are centrally located east of the reservoir in the uplands.

Due to its location (near the Fall Line, where two physiographic provinces meet), large size [300 square miles (780 square kilometers)], climate (wet summers and mild winters), wide variety of terrestrial and aquatic habitats, and protection from public intrusion, the SRS contains diverse reptile and amphibian communities (Gibbons and Patterson 1978; Gibbons and

Semlitsch 1991). Some 36 species of snakes, 26 frogs and toads, 17 salamanders, 12 turtles, 9 lizards, and a single crocodilian (the American alligator) have been found on the SRS (Wike et al. 1994). Amphibians and reptiles in the Steel Creek corridor and delta were surveyed before the construction of L-Lake (Smith, Sharitz, and Gladden 1981, 1982). Surveys of amphibians and reptiles were also conducted along the shoreline of L-Lake from 1986 to 1989 as part of the L-Lake/Steel Creek biomonitoring program, which was designed to assess the degree to which the creation of the reservoir altered amphibian and reptile community structure (Scott, Patterson, and Giffin 1990). Table 4-7 shows the number of amphibian and reptile species collected during the pre-impoundment and post-impoundment periods.

These surveys suggest that amphibian and turtle species richness in the L-Lake area declined after Steel Creek was impounded, while lizard and snake species richness remained stable or increased (Wike et al. 1994). Three species of salamanders that were abundant in the upper Steel Creek area in 1981 and 1982, the mole salamander (*Ambystoma talpoideum*), marbled salamander (*Ambystoma opacum*), and dwarf salamander (*Eurycea quadridigitata*), were present in much lower numbers in 1989. These three species are largely terrestrial as adults, using temporary waterbodies (pools formed by heavy spring rains) for breeding and may have been displaced by the waters of L-Lake. Several frog species commonly collected in 1981 and 1982, including the southern leopard frog [*Rana utricularia (R. sphenocephala)*], green tree frog (*Hyla cinerea*), and southern cricket frog (*Acris gryllus*) were either not collected or were infrequently collected in 1989. An increase in the abundance of aquatic predators, such as largemouth bass, water snakes (*Nerodia* spp.), and cottonmouth "moccasins" (*Agkistrodon piscivorous*) after the impoundment of Steel Creek possibly led to the decline in frog populations. In addition, several turtles [e.g., the eastern mud turtle (*Kinosternon subrubrum*) and Florida cooter (*Pseudemys floridana*)] that were abundant in Steel Creek in the early 1980s either did not occur or were uncommon in the L-Lake area by the late 1980s. All three species are adapted to aquatic or semiaquatic life, so the cause of the apparent decrease in abundance is unclear.

Conversely, species richness of lizards and snakes remained relatively stable in the vicinity of L-Lake after its creation. Some of the lizard species that prefer drier habitats, such as the six-lined race runner (*Cnemidiphorus sexlineatus*), generally decreased in numbers from 1987 to 1989, but the decrease might be due to natural variability (Scott, Patterson, and Giffin 1990). Almost all snake species captured in 1981 and 1982 were collected in higher numbers in 1986 through 1989 after the reservoir was created. In addition, several other reptile species appear to

Table 4-7. Number of amphibian and reptile species collected from Steel Creek and lower reaches of L-Lake before and after the creation of L-Lake.

Group	Steel Creek 1981-1982	L-Lake 1986	L-Lake 1989
Salamanders	11	6	3
Frogs and toads	13	7	5
Turtles	8	5	2
Lizards	6	7	6
Snakes	7	10	10
Total	45	35	26

Sources: Smith, Sharitz, and Gladden (1982); Scott, Patterson, and Giffin (1990).

have benefited, or are presumed to have benefited, from the construction of L-Lake. These species include the American alligator (*Alligator mississipiensis*), snapping turtle (*Chelydra serpentina*), softshell turtle (*Apalone* spp.), and yellow-bellied slider (*Chrysemys scripta*), all of which are aquatic or semiaquatic species.

Appendix D, Table D-1 lists species of reptiles and amphibians collected from Steel Creek and L-Lake sampling locations during the 1981 to 1989 period.

Although the birds of L-Lake have not been inventoried, the Savannah River Ecology Laboratory conducted surveys of birds in the Steel Creek watershed prior to the construction of L-Lake (Smith, Sharitz, and Gladden 1981). More than 90 species were identified, including a variety of common native songbirds [Carolina wren (*Thryothorus ludovicianus*), northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottos*)], neotropical migrant songbirds [prothonotary warbler (*Protonotaria citrea*), summer tanager (*Piranga rubra*), red-eyed vireo (*Vireo olivaceus*)], birds of prey [red-tailed hawk (*Buteo jamaicensis*), barred owl (*Strix varia*)], upland game birds [northern bobwhite (*Colinus virginianus*), wild turkey (*Meleagris gallopavo*)], and wading birds [great blue heron (*Ardea herodias*) and great egret (*A. alba*)]. Three species – white-eyed vireo (*Vireo griseus*), Carolina wren, and tufted titmouse (*Parus bicolor*) – were particularly abundant in surveys in the summer of 1981 (Smith, Sharitz, and Gladden 1981). Appendix D, Table D-2 lists bird species known to occur in the Steel Creek drainage and nearby wetlands. It also includes a number of waterfowl, wading bird, and raptor species observed in the L-Lake area in more recent years by scientists involved in research and monitoring (Scott, Patterson, and Giffin 1990; Bildstein et al. 1994). TE

Large numbers of waterfowl have wintered on the SRS since the early 1950s, when public access was restricted and hunting banned (Du Pont 1987a). The lower reaches of Steel Creek attracted significant numbers of wintering waterfowl in the 1970s when effluent from L-Reactor and P-Reactor created expanses of marsh and open water in portions of the swamp bordering the Savannah River. By the mid-1980s, the Steel Creek delta and adjacent swamp forests were used extensively by foraging mallards (*Anas platyrhynchos*) and wood ducks (*Aix sponsa*) (Du Pont 1987a). Other waterfowl commonly observed in the Steel Creek delta in the 1980s included black ducks (*Anas rubripes*), blue-winged teal (*Anas discors*), and hooded mergansers (*Lophodytes cucullatus*).

The completion of L-Lake in 1985 provided additional habitat in the Steel Creek drainage for wintering waterfowl and other waterbirds. Numbers of waterfowl using L-Lake over the October to April migratory period increased from 424 in 1986-1987, to 488 in 1987-1988, to 3,143 in 1988-1989 (Scott, Patterson, and Giffin 1990). In the final year of the study, the most abundant species was the lesser scaup (*Aythya affinis*) (1,609 observed), followed by mallard (818), bufflehead (*Bucephala albeola*) (180), and ruddy duck (*Oxyura jamaicensis*) (121). Numbers of "water-dependent" birds such as coots (*Fulica americana*), cormorants (*Phalacrocorax* sp.), and grebes (*Podilymbus podiceps* and *Podiceps auritus*) using L-Lake also steadily increased over the course of the study, from 2,372 in 1986-1987, to 3,353 in 1987-1988, to 3,934 in 1988-1989 (Scott, Patterson, and Giffin 1990).

Kennamer (1994) presents data on wintering waterfowl use of SRS reservoirs from 1982 to 1994. Four diving duck species – lesser scaup, ring-necked duck (*Aythya collaris*), ruddy duck, and bufflehead – dominated aerial counts of waterfowl. In the first several years after L-Lake filled, ducks continued to use Par Pond heavily and use L-Lake very little. By 1988-1989, however, L-Lake was used by several thousand wintering waterfowl. The total number of waterfowl wintering on the SRS did not increase over this period: the increased use of L7-06 L11-08

L-Lake corresponded with a decreased use of Par Pond and its subimpoundments (Ponds B and C). In the winter of 1991-1992, during the first winter of the Par Pond drawdown, water- L7-06 fowl (particularly ring-necked ducks and lesser L11-08 scaup) showed a pronounced preference for L-Lake. This shift in usage was attributed to the decimation of the *Corbicula* (Asiatic clam) population in Par Pond caused by the rapid drawdown. *Corbicula* are an important food source for diving ducks, particularly ring-necked ducks and lesser scaup (Hoppe, Smith, and Wester 1986). In 1992-1993 and 1993-1994, waterfowl use of Par Pond increased as its water level stabilized and aquatic vegetation and TC invertebrate populations recovered. This increased use of Par Pond was accompanied by somewhat lower waterfowl use of L-Lake.

L-Lake has become an important foraging area for wading birds since its creation. Bildstein et al. (1994) compared wading bird use of L-Lake with that of Par Pond and Pond B between the fall of 1987 and the summer of 1989. Surveys conducted over this 2-year period indicated that wading bird densities were significantly higher at L-Lake than at the two older (built in 1958) reservoirs. Wading birds using L-Lake showed a preference for shallow areas where wetland plants had been planted (see "Wetlands" section that follows).

Seven species of wading birds [great blue heron, great egret, snowy egret (*Egretta thula*), little blue heron (*E. caerulea*), tricolored heron (*E. tricolor*), green-backed heron, and wood stork (*Mycteria americana*)] were observed at L-Lake, with highest abundance in summer and fall. Great blue herons and great egrets made up 96 percent of all wading birds observed in upper L-Lake and 87 percent of wading birds observed in lower L-Lake (Bildstein et al. 1994).

The relatively heavy wading bird use of L-Lake could be related to the attractiveness of the reservoir as a foraging area (Bildstein et al. 1994). L-Lake provides ideal conditions for wading birds – shallow coves with patches of emergent vegetation. This enables wading birds to stalk around the edges of the weedy patches, preying on small fish concentrated in the vegetation.

More than 20 mammal species occur in the Steel Creek area. These include three shrew species, two mole species, seven species of mice, voles, and woodrats, three squirrel species (gray squirrel, fox squirrel, and flying squirrel), gray fox (*Urocyon cinereoargenteus*), white-tailed deer (*Odocoileus virginianus*), feral swine (*Sus scrofa*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), and bobcat (*Felix rufus*) (Smith, Sharitz, and Gladden 1982). Many of these species forage in the wetlands and marshy areas around L-Lake; others occur in adjacent uplands. Appendix D, Table D-3 lists mammal species that probably occur in the bottomland hardwood forests and river swamps of the SRS, including the forested margins of L-Lake.

4.1.5.1.2 Aquatic Ecology

As a condition of National Pollutant Discharge Elimination System Permit Number SC0000175, issued in 1984, DOE monitored aquatic communities in L-Lake (and Steel Creek downstream of the L-Lake Dam) to demonstrate that heated effluent from L-Reactor did not prevent the development of a balanced biological community in the lower half of the reservoir or in Steel Creek. As a result, the water quality and aquatic communities of L-Lake were monitored intensively from January 1986 through December 1992. The results of these monitoring studies were presented in a Clean Water Act Section 316(a) Demonstration (Gladden et al. 1989), a series of biological monitoring reports (Carson and Cichon 1993; Westbury 1993; Bowen 1993a,b), several journal articles (e.g., Paller, Gladden, and Heuer 1992), and a number of monographs (e.g., Bowers 1991).

Plankton

L-Lake reached full pool for the first time in October 1985; the phytoplankton community of L-Lake was studied from January 1986 through December 1992 (Carson and Cichon 1993). During the first 2 years of study, the phytoplankton was dominated by the blue-green alga, *Microcystis aeruginosa,* under bloom conditions. The bloom ended by 1988, even though phosphorus loading from river water pumped to L-Lake remained very high. From 1987 to 1992, phytoplankton diversity increased while primary productivity and chlorophyll-*a* declined. Besides blue-green algae, important groups in terms of biovolume or numbers included the green and golden-brown algae, diatoms, cryptomonads, and dinoflagellates. Although less so in recent years, L-Lake is distinctly eutrophic in terms of chlorophyll and primary productivity levels and phytoplankton community composition.

Zooplankton were investigated in L-Lake over the same 1986-1992 period. Substantial numbers of taxa (species and genera) appeared quickly during the first year of L-Lake's existence, but taxa richness gradually declined in succeeding years, mainly from fewer protozoan and rotifer taxa (Bowen 1993b). Throughout the study protozoa, mainly ciliates, dominated the community in terms of numbers, and although densities of rotifers and crustaceans were similar to other lakes in the region, protozoan densities were atypically high in L-Lake. Eutrophic lakes are often characterized as having an important detrital component in the open water, supporting large bacterial populations. This is based on the close correlation often observed between the biomass of phytoplankton and heterotrophic bacteria (Wetzel 1983). A high density of ciliate protozoans, as found in L-Lake, is consistent with a high phytoplankton and bacterial biomass because ciliates graze bacteria.

Crustacean zooplankton were small in L-Lake; all cladocerans became rare in summer and adult copepods were infrequently found (Bowen 1993b). Changes in zooplankton size corresponded with increased pressure from fish predation. Feeding by larval and juvenile fish appeared to place strong pressure on zooplankton communities in the summer, and the presence of larger cladocerans was correlated with the abundance of threadfin shad both seasonally and from year to year. Threadfin shad, which are members of the clupeid (shad and herring) family, typically feed on zooplankton in open water areas (Baker and Schmitz 1971), and were present in large numbers in L-Lake until at least 1991. Clupeids are known to alter the size structure of zooplankton communities (Brooks and Dodson 1965).

Benthic Macroinvertabrates

Specht (1996) conducted surveys of L-Lake benthic macroinvertebrates in September 1995 and compared measures of density, relative abundance, and community structure with those obtained in 1988-1989 during L-Lake biomonitoring studies. Macroinvertebrate densities at 6.6-foot (2-meter) depths were lower in 1995 than 1988-1989, while densities at 13.1-foot (4-meter) depths changed little. The relative abundance of larval chironomids of the group Chironomini declined substantially, while those of the group Tanytarsini increased. Amphipods (microcrustaceans), oligochaetes (aquatic earthworms), Turbellaria (flatworms), bivalves (especially the Asiatic clam *Corbicula fluminea*), and the phantom midge larvae (*Chaoborus punctipennis*) all increased in abundance.

Most noteworthy was the increase in amphipods, whose relative abundance was low in 1988-1989 (less than 1 percent of total at most sampling locations), but ranged from 5 to 31 percent of benthic organisms collected at the various sampling locations in 1995. Amphipods are often abundant in the vegetated littoral zones of lakes, where they feed on decaying vegetation or attached algae as juveniles and become opportunistic scavengers (omnivores) as adults (Pennak 1978; Covich and Thorp 1991).

Specht (1996) suggested that the changes in the L-Lake macroinvertebrate community were due, in part, to the establishment of aquatic macrophyte beds along the margins of the reservoir. Aquatic macrophytes stabilize the substrate (bottom sediments) of reservoirs, benefiting both benthic organisms and fish, and provide benthic macroinvertebrates with shelter and food (Boyd 1971; Minshall 1984). As a result, many benthic macroinvertebrates (e.g., aquatic insects) tend to be less abundant and less diverse on bare substrates (sand or clay) and more diverse and abundant in areas with aquatic vegetation (Minshall 1984). Specht (1996) also related changes in the L-Lake benthos community to aging of the reservoir, as early-successional species were replaced by species characteristic of a more mature ecosystem.

Fish

L-Lake was stocked with approximately 40,000 juvenile bluegill (*Lepomis macrochirus*) in the fall of 1985 and 4,000 juvenile largemouth bass (*Micropterus salmoides*) in the spring of 1986. These introductions were intended to speed the development of a balanced biological community in the lower half of the reservoir. Both species are ubiquitous in the southeastern United States, and are often stocked in farm ponds and new impoundments because they grow rapidly, feed on a variety of invertebrate and vertebrate prey, and adapt readily to a variety of lentic conditions.

DOE evaluated community structure of L-Lake fish monthly from 1986 through 1989 and quarterly during 1990 and 1991 as part of the Clean Water Act Section 316(a) study discussed above. Fish were collected by electrofishing at 20 stations in five regions of the middle and lower portions of the reservoir (Paller 1996). Supplemental sampling occurred in November and December of 1995 to determine if any obvious changes in fish community structure had occurred since 1991.

Statistical analysis of fish collections revealed patterns of community structure that corresponded with five distinct time periods. Table 4-8 lists the relative abundance of fish species that were regularly collected over the five time periods, designated Period 1, Period 2, Period 3, Period 4, and Period 5 (P1, P2, P3, P4, and P5).

During Period 1, collections were dominated by three Lepomids (redbreast sunfish, spotted sunfish, and dollar sunfish), two shiners (coastal shiner and golden shiner), and a livebearer, the eastern mosquitofish; all are native to the streams and swamps of the Atlantic Coastal Plain (Lee et al. 1980; Rohde et al. 1994).

By the end of Period 2, shiners and mosquitofish were rare in L-Lake samples, and bluegill (stocked 2 years earlier) made up 79.3 percent of all fish collected. Redbreast were still common (16.1 percent of all fish collected) but were only half as abundant as they were in Period 1. Two other native Lepomids, the spotted sunfish and the dollar sunfish, declined in abundance, unable to compete with bluegill and redbreast, which are better suited for reservoir life.

Interspecific competition probably was responsible for the change in community structure observed between Period 1 and Period 2 (Paller, Gladden, and Heuer 1992). As noted above, two species (bluegill and largemouth bass) adapted to reservoir life were stocked in L-Lake in 1985 and 1986 and rapidly out-competed the smaller-bodied (and slow-growing) insectivores (e.g., mosquitofish, shiners, and brook silversides) that were in the Steel Creek system when the stream was dammed. Moreover, these minnow-like species became prey for the expanding population of largemouth bass stocked in the spring of 1986. The juvenile largemouth bass stocked in 1986 would have been large enough to feed on mosquitofish, shiners, and silversides by their second year (1987) in the reservoir (Carlander 1977).

By Period 3, L-Lake had developed into a typical small-reservoir fish community, with large numbers of bluegill and redbreast, increasing numbers of threadfin shad, and smaller numbers

Table 4-8. Relative abundance of L-Lake fish species, 1986 through 1995.

Species		January - June 1986	July 1986 - July 1987	August 1987 - June 1989	July - December 1989	November 1995
		P1	P2	P3	P4	P5
Bluespotted sunfish	*Enneacanthus gloriosus*	0.2	<0.1	0.0	<0.1	0.0
Bluegill	*Lepomis macrochirus*	1.2	79.3	45.8	16.1	12.3
Brook silverside	*Labidesthes sicculus*	2.3	<0.1	0.1	1.1	28.5
Brown bullhead	*Ameiurus nebulosus*	0.0	<0.1	0.0	0.0	0.3
Chain pickerel	*Esox niger*	0.1	<0.1	<0.1	0.1	4.0
Coastal shiner	*Notropis petersoni*	20.9	0.7	0.1	0.1	13.3
Creek chubsucker	*Erimyzon oblongus*	0.8	<0.1	0.0	0.0	0.0
Dollar sunfish	*Lepomis marginatus*	4.4	0.2	<0.1	0.0	0.3
Flat bullhead	*Ameiurus platycephalus*	0.1	0.1	0.5	0.4	0.0
Gizzard shad	*Dorosoma cepedianum*	0.0	<0.1	0.7	0.8	1.3
Golden shiner	*Notemigonus crysoleucas*	13.7	0.4	0.1	0.4	1.9
Ironcolor shiner	*Notropis chalybaeus*	0.0	<0.1	0.0	0.0	0.0
Lake chubsucker	*Erimyzon sucetta*	0.1	<0.1	0.0	0.0	1.4
Largemouth bass	*Micropterus salmoides*	1.4	1.8	4.2	2.9	4.0
Eastern mosquitofish	*Gambusia holbrooki*	14.4	<0.1	<0.1	0.0	0.0
Northern hogsucker	*Hypentelium nigricans*	0.1	0.0	0.0	0.0	0.0
Redbreast sunfish	*Lepomis auritus*	32.3	16.1	24.3	27.1	9.8
Spotted sunfish	*Lepomis punctatus*	6.2	0.6	0.2	<0.1	1.8
Threadfin shad	*Dorosoma petenense*	0.0	<0.1	23.2	49.9	0.0
Warmouth	*Lepomis gulosus*	0.3	0.1	0.4	0.4	2.7
Yellow bullhead	*Ameiurus natalis*	0.5	0.1	0.2	0.1	0.2
Yellow perch	*Perca flavescens*	<0.1	<0.1	<0.1	0.3	17.6

Source: Paller (1996).

of largemouth bass. Many of the small stream and swamp species that were present in the watershed when the reservoir was built had become rare, among them the bluespotted sunfish, creek chubsucker, coastal shiner, dollar sunfish, spotted sunfish, and mosquitofish.

Threadfin shad was the most abundant species in Period 4 collections, with redbreast and bluegill second and third in abundance (Paller 1996). These three species comprised more than 90 percent of all fish collected. Largemouth bass made up a small percentage (2.9 percent) of fish collected, and was the only top-of-the-food-chain predator present in significant numbers.

By late 1995 (Period 5), the community structure of L-Lake fish had changed markedly. A number of the resident stream species, such as brook silverside, coastal shiner, and creek chubsucker, that had become a minor component of the fish community from 1986 through 1989 became much more common. Other species, such as yellow perch and chain pickerel, which had previously been uncommon to rare, became fairly abundant. Threadfin shad, which made up 23.2 percent of fish collected in Period 3 and 49.9 percent of fish collected in Period 4, were not collected in Period 5.

These shifts in species dominance appeared to be independent of L-Reactor operations and resultant temperature and dissolved oxygen fluctuations (Paller 1996). Several of the species (e.g., coastal shiner, spotted sunfish, dollar sunfish), whose abundance declined during years (1986-1988) when L-Reactor was operating, are adapted to life in small Coastal Plain streams where water temperature and dissolved oxygen levels show wide daily and seasonal fluctuations. Others, such as the mosquitofish and golden shiner, are extremely hardy species that are tolerant of high water temperatures and low levels of dissolved oxygen (Tomelleri and Eberle 1990; Rohde et al. 1994).

Threadfin shad, which were apparently introduced to L-Lake as eggs or larvae entrained in Savannah River water in 1986 or 1987 (Paller 1996), increased in abundance over the ensuing 2 to 3 years, taking advantage of the reservoir's healthy plankton populations. As a consequence, the fish community structure shifted by Period 4 (1989) to one dominated by threadfin shad, with relative abundance of Lepomids (notably bluegill) declining. Reduced bluegill recruitment into the population appears to have resulted from intense largemouth bass predation on juvenile Lepomids, including bluegill (Paller 1996).

As noted previously, supplemental fish sampling was conducted in late 1995 to update the first 5 years (1986 to 1991) of surveys. The change in species composition from Period 4 (1991) to Period 5 (1995) was pronounced, with several of the original stream species (e.g., coastal shiner and brook silverside) reappearing in significant numbers and threadfin shad disappearing from samples (Paller 1996). Several species that had been rare before (yellow perch and chain pickerel) became relatively abundant in Period 5.

Examination of the habitat requirements of the species that increased in abundance during Period 5 suggested possible reasons for the changes in species composition. Three of the four species that increased most (brook silversides, yellow perch, and chain pickerel) are phytophilous species that spawn over aquatic vegetation (Paller 1996). The remaining species, coastal shiner, has more general spawning requirements, but because it is small and occupies the littoral zone, it benefits from the protection from predators afforded by aquatic vegetation.

Aquatic vegetation had become well established along the shoreline of L-Lake by 1995. Much of this vegetation was originally established in 1987 as a result of artificial plantings along 12,000 feet (4,000 meters) of shoreline in the lower portions of the reservoir (Wein, Kroeger, and Pierce 1987). Approximately 40 species were planted with the objective of creating submerged/floating-leafed, emergent, and upper emergent/shrub zones (see "Wetlands" section that follows). Vegetation cover within the submerged zone of the planted areas increased from 1 percent in 1987 to 22 percent in 1989 (Westbury 1993) and continued to increase through 1991. Among the most abundant species were eelgrass (*Vallisneria americana*), lotus (*Nelumbo lutea*), and pondweed (*Potamogeton diversifolius*).

Although the expansion of aquatic vegetation throughout the littoral zone of L-Lake explains many of the fish assemblage changes associated with Period 5, it does not account for the apparent absence of threadfin shad. In addition, predation alone probably was not responsible for the decline of threadfin shad because shad were abundant during Periods 3 and 4 when largemouth bass were well established and abundant. Lack of food probably contributed to the decline of threadfin shad in L-Lake (Paller 1996). Analysis of the contents of threadfin shad gizzards in 1988 and 1989 indicated that algae comprised a large part of their diet. The standing crop of phytoplanktonic algae (as indicated by chlorophyll-*a*) remained relatively high in L-Lake through 1989 but dropped precipitously in 1990 and 1991. Microcrustaceans and rotifers, other important foods of L-Lake threadfin shad, also exhibited large declines over time and by 1990 many microcrustaceans were comparatively rare (Wike et al. 1994).

Several factors probably contributed to declines in phytoplankton and zooplankton densities in L-Lake. Threadfin shad predation contributed directly to the decline of large zooplankton in L-Lake, especially larger daphnids and copepods (Taylor, DeBiase, and Mahoney 1993). However, nutrient availability might have played a part. L-Lake received relatively high levels of total phosphorus and nitrogen in the water pumped from the Savannah River. Inputs of river water declined markedly after L-Reactor was shut down in mid-1988, reducing nutrient loading.

Entrainment and Impingement of Fishes

In early 1988, when K-, L-, and P-Reactors last operated, the maximum rate of river water withdrawal at the 1G and 3G intakes was about 380,000 gallons per minute (24 cubic meters per second) – 179,000 gallons per minute (11.3 cubic meters per second) each for once-through cooling at K-and L-Reactors, 22,000 gallons per minute (1.4 cubic meters per second) for makeup water at P-Reactor. Based on studies conducted in the 1980s, this rate of withdrawal would result in an estimated 18 million fish larvae and 9 million fish eggs entrained annually during the spring and summer spawning period. During the 1980s, clupeid (shad and herring), centrarchid (sunfish and crappie), and cyprinid (minnow and common carp) larvae were entrained most often, while eggs of two species, American shad and striped bass, were most often entrained, comprising 73 percent of all eggs drawn into river water intakes. The *Final EIS for Continued Operation of K-, L-, and P-Reactors* concluded that any impacts to fisheries from entrainment of fish eggs and larvae at SRS would be small and limited to fish populations in the immediate vicinity of the Site (DOE 1990).

Studies conducted at the 1G and 3G Pumphouse intakes in the 1980s indicated that approximately 6,000 fish were lost to impingement annually. Sunfish (bluespotted sunfish, redbreast sunfish, and warmouth) and shad (threadfin and gizzard shad) were the groups most often impinged. DOE did not attempt to assess the significance of these impingement losses, but they probably were comparatively minor (DOE 1990).

Since 1988, there has been a dramatic reduction in the rates of surface water withdrawn from the Savannah River. By 1988, all SRS production reactors had been shut down and placed under review to determine their future status (Arnett, Mamatey, and Spitzer 1995). As of 1994, four reactors were shut down permanently and the fifth, K-Reactor, was in cold standby. In June 1996, only one of the 10 pumps in the 3G Pumphouse was operating, pumping approximately 28,000 gallons per minute (1.8 cubic meters per second) for maintenance of L-Lake water levels; auxiliary equipment cooling in K-, L-, and P-Areas; fire protection in K-, L-, and P-Areas; and sanitary wastewater in K-, L-, and P-Areas.

4.1.5.1.3 Wetlands Ecology

The filling of L-Lake inundated approximately 225 acres (0.9 square kilometer) of wetlands and 775 acres (3.1 square kilometers) of uplands in the Steel Creek corridor. An additional 100 acres (0.4 square kilometer) of uplands were lost due to relocation of electric and cable rights-of-way. Between 735 and 1,015 acres (3.0 and 4.1 square kilometers) of wetlands in the Steel Creek corridor, Steel Creek delta, and the Savannah River swamp received impacts (DOE 1984).

A study conducted during the summer of 1981 documented the vegetation of the Steel Creek corridor for use in evaluating the Steel Creek ecosystem prior to the restart of L-Reactor (Smith, Sharitz, and Gladden 1981). Aerial photographs taken in 1978 and field studies conducted in 1981 were used to map the corridor. The portion of the Steel Creek corridor that was inundated by L-Lake was a forested wetland system characterized by a narrow band of alder (*Alnus* spp.) bordering the stream with other woody species such as sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubra*) occurring on the banks. As the stream corridor became broader farther south, wax myrtle (*Myrica cerifera*), willow (*Salix* spp.), and blackberry (*Rubus* spp.) dominated the floodplain community behind the alder band. The classification system used for mapping followed the Cowardin method with some modification to more accurately portray the features of this system (Smith, Sharitz, and Gladden 1981).

The area of the corridor that was later inundated by the reservoir had wetlands ranging from open water to forested. The vegetation was classified as scrub-shrub or forested wetland. The five specific mapping units identified are listed in Table 4-9.

Appendix D, Table D-4 describes the five mapping units in the portion of the Steel Creek corridor inundated by the lake.

During lake construction, approximately 1,034 acres (4.2 square kilometers) were clear cut, including 356 acres (1.4 square kilometers) of bottomland hardwood and shrub wetlands, 360 acres (1.5 square kilometers) of upland hardwoods and pine forests, and 125 acres (0.5 square kilometer) of other areas within the lake basin. Outside the lake basin an additional 193 acres (0.8 square kilometer) of mostly upland pine and hardwood forests were clear cut for power line rights-of-way and other construction-related sites (McCort, Lee, and Wein 1988). Most vegetation in the lakebed was removed or burned onsite. The shoreline was cleared 3 to 5 feet (1 to 1.5 meters) above the maximum pool elevation and seeded to control erosion. The shoreline vegetation above the cleared area was primarily planted pine (Wike et al. 1994). Trees in the floodplain of Steel Creek were not harvested because they were potentially contaminated from radioisotopes in the Steel Creek sediments. These trees and the timber in two coves in the lower half of the lake and the area above Road B were left standing as wildlife habitat (McCort, Lee, and Wein 1988; Westbury 1993).

Although DOE intended that L-Lake be used to mitigate the impacts of thermal effluent from L-Reactor on Steel Creek and the Savannah River, its use resulted in new impacts requiring mitigation (McCort, Lee, and Wein 1988). One component of the mitigation required by the regulatory agencies was the establishment of a Balanced Biological Community within L-Lake. DOE decided to accelerate the process of natural succession by planting wetland vegetation within the cooler southern end of L-Lake in an effort to establish a Balanced Biological Community more quickly. Wetlands and vegetation play important roles in nutrient cycling, sediment retention, and shoreline stabilization, and are a major factor in establishing a Balanced Biological Community. The establishment of wetland/littoral vegetation provided (1) organic matter for soil development and decomposers; (2) substrate for attached algae; (3) habitat for aquatic insects and other macroinvertebrates; and (4) cover and food for fish and wildlife (Wein, Kroeger, and Pierce 1987).

Table 4-9. Wetland community types occurring in the Steel Creek corridor.[a]

Wetland type	Mapping unit
Aquatic Bed	Open water
Scrub-shrub - Broad-leaved deciduous	*Alnus serrulata*
Forested - Broad-leaved deciduous	*Salix* sp.
Forested - Broad-leaved deciduous	*Alnus serrulata-Myrica cerifera*
Forested - Broad-leaved deciduous	*Liquidambar styraciflua-Acer rubrum-Salix* sp.

a. Source: Smith, Sharitz, and Gladden (1981).

Establishment of wetland vegetation along the shoreline of L-Lake occurred through natural colonization and planting of aquatic macrophytes. Shortly after L-Lake filled in October 1985, aquatic macrophytes became established on the cleared shoreline (Wike et al. 1994). Between January and July 1987, an extensive vegetation transplanting program managed by the Savannah River Ecology Laboratory accelerated the colonization of the L-Lake littoral zone by aquatic macrophytes and wetland plants. DOE invited a panel of experts in the areas of wetland ecology and restoration to the Savannah River Site. The panel developed a management plan for establishing an appropriate wetland plant community, which recommended that Par Pond serve as the primary source of plant material because its vegetation was adapted to elevated water temperatures, it was close to L-Lake, and the species found in it were representative of natural wetland species in the region.

The panel also proposed the establishment of zones of vegetation to represent species patterns found in Par Pond and natural lakes in the region. The zones were differentiated by species composition and defined by water level. The upper emergent-shrub zone, formed by trees, shrubs, and some emergents lies above the waterline up to 3 feet (1 meter) above mean high water and can flood periodically. The emergent zone consists of erect plant species that occur mostly in shallow water at depths of less than 1 foot (0.3 meter). The third zone consists of submersed and floating-leaved plant species that occur in deeper water. Approximately 12,000 feet (4,000 meters) of the shoreline at the southern end of L-Lake were planted with 100,000 individual plants representing more than 40 species. Perennial herbaceous plants were excavated by hand from Par Pond, but trees, one emergent herb (*Sagittaria latifolia*), and seed of some grasses were obtained from commercial sources. Species that were planted are listed in Appendix D, Table D-5. Major limitations to successful vegetation establishment were identified at the outset. These included steep slopes, fluctuating water levels, and low nutrient substrates [Wein, Kroeger, and Pierce 1987; additional details concerning planting densities, methods, and techniques are provided in Kroeger (1990) and USACE (1995)].

Kroeger (1990) and Westbury (1993) provide the most recent published data pertaining to wetland vegetative cover at L-Lake. During the summers of 1987, 1988, and 1989, the Savannah River Ecology Laboratory surveyed the vegetation in planted and unplanted areas to monitor the establishment and survival of plants in the submersed/floating-leaved, emergent, and upper emergent/shrub zones of L-Lake (Kroeger 1990). Of the nine species planted in the submersed and floating-leaved zone, American lotus (*Nelumbo lutea)* and water celery (*Vallisneria americana)* were the only surviving species in 1989. Wave action and low initial planting numbers were cited as reasons for the disappearance of some species. In 1989, 38 percent of the plots surveyed contained vegetation and mean cover per plot had increased to 22 percent. The rapid colonization of empty plots by *V. americana* and *N. lutea* along with cattails (*Typha latifolia*) moving from the emergent zone into the submersed and floating-leaved zone were cited as factors. No submersed or floating-leaved plants occurred in the unplanted areas, and most plots were unvegetated (Wike et al. 1994).

Approximately 30 species were planted in the emergent zone, and by 1989 most were still surviving. By 1989, 84 percent of the plots sampled had vegetation, and mean cover per plot was 40 percent. Within the planted areas, increases in *Eleocharis* spp., *T. latifolia*, *Hydrocotyle umbellata*, *V. americana*, and the *Panicum/Sacciolepis* group of grasses accounted for the increases. *N. lutea* and *V. americana* moved into the emergent zone from the submersed and floating-leaved zone and became important components of the emergent zone. In the unplanted areas, 85 percent of the plots remained unvegetated from 1987 to 1989. Plots with vegetation had low species diversity (Wike et al. 1994).

All species planted in the upper emergent/shrub zone in 1987 were present in 1989. Most (84.4 percent) of the plots had vegetation, primarily terrestrial species during the period from 1987 to 1989. Mean cover per plot in planted areas was 55 percent in 1989. Changes in species from 1987 to 1989 included major growth of willow (*Salix nigra*) shoots, decreases in relative frequency and cover of shoreline grasses, an increase in frequency and cover of *Panicum/Sacciolepis*, and a decrease in frequency and cover of *T. latifolia*. *S. nigra*, and the *Panicum/Sacciolepsis* grasses were the most important species in this vegetation zone. The emergents, *Juncus effusus*, *Polygonum* spp., *Sagittaria latifolia*, and *T. latifolia*, were also important species in this zone. In unplanted areas, facultative emergent and terrestrial species were the most important components. No *Juncus*, *Polygonum* spp., or *Panicum/Sacciolepsis* were found. *S. nigra* had a higher frequency in the unplanted areas than in the planted areas (Wike et al. 1994).

Discussions of changes in species composition and abundance in the unplanted areas of the littoral zone of L-Lake can also be found in the reports produced under the Biological Monitoring Program for L-Lake and Steel Creek, which was part of the project to ensure the establishment of a Balanced Biological Community. Data covering the period from November 1985 through December 1987 are discussed in Gladden et al. (1989). Westbury (1993) summarizes the results of 7 years of data covering the January 1986 through December 1992 period.

In the first 5 years (1986 through 1990) after the creation of L-Lake, plant community development was limited to emergent aquatic macrophytes and wetland plants near the shoreline. In 1991 and 1992, submersed and floating-leaved macrophytes such as *V. americana* and *Potamogeton diversifolius* greatly increased in abundance. Appendix D, Table D-6 lists the plant taxa mapped in the study plots in descending order of their whole lake (four study plots) annual mean areal coverage. The species-specific annual mean areal cover (square meters per hectare) and frequency are based on 16 samples (four stations × four seasons) (Westbury 1993).

TC

A seed bank study at L-Lake (Collins and Wein 1995) detected the presence of a total of 136 different taxa (see Appendix D Table D-7). Thirty-three percent were well represented while 35-46 percent of taxa occurred only once. Collins and Wein found that shallow water [less than 13 inches (33 centimeters) deep] and the shoreline above waterline had more germinable seeds and a greater number of taxa than water deeper than 13 inches. The study concluded that periodic drawdown, may enhance seed bank and vegetation development in a reservoir such as L-Lake by redistributing seeds with the changing waterline and by allowing input of seeds of facultative wetland species (Collins and Wein 1995).

A recent mapping effort by Savannah River Ecology Laboratory mapped areal coverage and estimated acreage for three vegetation classes: submersed aquatic, floating-leaved, and emergent vegetation (Wein 1996). Aerial photographs taken in March 1996 were used to map the submersed aquatic vegetation. The floating-leaved and emergent vegetation were mapped using Global Positioning System data collected during the summer of 1996. Table 4-10 lists the classes of vegetation and area of coverage for each. The dominant species in the submersed aquatic class were *V. americana*, *P. diversifolius*, and *Myriophyllum aquaticum*. *N. lutea* was the predominant floating-leaved wetland species. The emergent class of vegetation was dominated by *T. latifolia*, *P. hemitomon*, *Eleocharis quadrangulata*, and *Hydrocotyle umbellata*.

ɔle 4-10. Aquatic macrophyte coverage of L-Lake, 1996.[a]

Class name	Area in acres (square kilometers)	Percentage
Open water	969 (4.0)	88.8
Submersed	76 (0.3)	7.0
Floating-leaved	19 (<0.1)	1.7
Emergent	27 (0.1)	2.5
Total	1,091 (4.4)	100.0

Source: Wein (1996).

.5.2 Environmental Impacts

.5.2.1 No Action

restrial Ecology

; No-Action Alternative would have little or effect on semiaquatic and terrestrial animals t forage around L-Lake and drink its water. ɜre would be normal cycles of abundance .sed by disease outbreaks, predator-prey in-ıctions, and variation in the availability of d and other resources.

uatic Ecology

der the No-Action Alternative, DOE would ıtinue to maintain L-Lake at its current level ipproximately 190 feet (58 meters) and pro-e make-up water for the K-Reactor 186-sins. Over time, however, the reservoir could ome less productive as a result of normal ervoir aging processes. As primary produc-ty decreases, there would be an attendant line in zooplankton production, fish produc-ı, and fish growth. Most reservoirs experi-e declines in primary and secondary ductivity 5 to 10 years after filling, then ch trophic equilibrium with relatively stable ıatic communities that show typical seasonal ctuations in abundance and biomass. Sum-r is typically the period of peak productivity l late winter the period of lowest productiv-. The productivity of L-Lake has been maintained by the continuous pumping of nutri-ents to the reservoir along with large volumes of Savannah River water. In time, L-Lake would become a more typical, moderately productive coastal plain reservoir. TE

Under this alternative, DOE would continue to withdraw approximately 5,000 gallons per mi-nute (0.3 cubic meter per second) of Savannah River water. This is 1.3 percent of the rate of river water withdrawal in the mid-1980s [up to 380,000 gallons per minute (24 cubic meters per second)] when millions of larval fish were en-trained and thousands of adult fish were im-pinged annually. Based on studies conducted from 1983 through 1985, a withdrawal of 380,000 gallons per minute (24 cubic meters per second) results in an average loss of approxi-mately 17,600,000 fish larvae and 9,300,000 fish eggs during the February-July spawning season (DOE 1990). Assuming entrainment losses were proportional to the rate of river wa-ter withdrawal, an estimated 234,000 larval fish and 117,000 fish eggs would be lost each spawning season under the No-Action Alterna-tive. Because use of the smaller (5,000-gallon-per-minute) pump greatly reduces the approach velocities at the intake structure, impingement losses would be negligible, limited to small numbers of fish already weakened by disease, stress, cold shock, or some other debilitating factor(s).

Wetlands Ecology

Under the No-Action Alternative, wetland vegetation along the shoreline of L-Lake would show subtle changes in community structure (i.e., species dominance) caused by year-to-year variation in rainfall, runoff, and other natural influences. There probably would be continued expansion of littoral wetlands, partic-ularly in the southeast region of the reservoir.

4.1.5.2.2 Shut Down and Deactivate

Terrestrial Ecology

This alternative would affect semiaquatic and terrestrial animals that depend on L-Lake for critical habitat needs such as breeding and nesting areas, food, and water. The amount of shoreline, which is an ecological edge or "ecotone," would shrink as the reservoir recedes. There would be less habitat available for amphibians, reptiles, semiaquatic mammals (muskrats, beavers, raccoons), and wading birds. Small mammals and upland game birds would be forced to venture farther from shoreline cover to drink and forage around reservoir edges and would be more exposed to predators. As the lake recedes, many animals may be forced to disperse from the area, expending energy and becoming more vulnerable to predation.

TC

Based on the behavior of wintering waterfowl in 1991-1992, when Par Pond was first drawn down, diving ducks (particularly ring-necked ducks and lesser scaup) that have traditionally wintered on L-Lake could be forced to move to Par Pond, the nearest body of water that offers food and protection from hunters. Depending on the amount of available food in Par Pond, these "displaced" diving ducks would either over-winter on Par Pond or would be forced to leave the Savannah River Site in search of suitable wintering habitat. In 1991-1992, Par Pond diving ducks moved to L-Lake in response to the Par Pond drawdown, but the combined pressure of feeding ducks from both reservoirs quickly depleted L-Lake's supply of *Corbicula* (Kennamer 1994). Most diving ducks ultimately left the Savannah River Site. This suggests that diving ducks that have traditionally wintered on L-Lake could be forced to disperse to Par Pond or offsite reservoirs if L-Lake's water level drops dramatically in the late fall or winter, particularly if large numbers of *Corbicula*, which are concentrated in shallow, near-shore areas, are killed.

TE

If the Shutdown and Deactivate Alternative is implemented, animals would be exposed to contaminants in sediments and could accumulate contaminants via incidental ingestion (contaminated soil ingested along with vegetation and prey items), inhalation of contaminated airborne soil (or dust), and ingestion of contaminated vegetation growing in the newly exposed lakebed. Potential risks from exposures to contaminants are evaluated in more detail in Section 4.3.5.3 and Appendix B.

Aquatic Ecology

The Shut Down and Deactivate Alternative would result in the creation of a much smaller reservoir or a stream meandering through the old lakebed. Hydrological models predict that L-Lake would slowly recede if water was not pumped to the reservoir because the watershed could not supply sufficient water to compensate for natural losses and the required releases to Steel Creek (del Carmen and Paller 1993a). After 10 to 50 years as the lake drained, the aquatic component of the L-Lake ecosystem would shift from a plankton-based system (in which energy flowed by photosynthetic activity from phytoplankton to zooplankton to planktivorous fish to carnivorous fish) to a detritus-based system (in which energy is transferred from nonliving organic matter to detritus-feeding organisms and their predators).

The L-Lake watershed would supply much lower levels of nutrients to L-Lake than water pumped from the Savannah River. Lower rates of nutrient loading usually result in less productivity, improved water clarity, and less zooplankton, phytoplankton, macroinvertebrate, d fish biomass. Similar effects would occur the periphyton and consumers utilizing this source in littoral areas. Indirect effects, such shifts in species composition brought about nutrient limitation, could change predator-luced effects in species composition of prey d, in turn, prey food resources. For example, creased predation or competition due to lim-d nutrients could lower threadfin shad densi-s (assuming this species recovered from its cline), releasing zooplankton from predation essure. This could result in more efficient azing of the phytoplankton by large-bodied oplankton, enhancing water clarity and the owth of phytoplankton species able to avoid azing. Prediction of the nature and extent of s potential indirect effect is not possible, nor it necessarily a deleterious effect, viewing the stem as a whole.

rviving aquatic communities would be re-ced in terms of numbers (abundance), diver-y (species richness), and productivity (plant d animal biomass produced per unit time). ie degree to which these aquatic communities ould be reduced would largely be a function of ce level, although other factors (such as tim-g and speed of lake recession) could be impor-nt.

number of researchers have documented re-onses of reservoir macroinvertebrate com-unities to water level drawdowns (Wegener, illiams, and McCall 1974; Benson and Hud-n 1975; Marshall 1978). Benthic organisms e affected directly and indirectly by water vel changes. Direct effects include exposure extremes of heat and cold. Depending on the ration of the drawdown and weather condi-ons (temperature, relative humidity, and cloud ver) benthic organisms may be killed or may rvive by burrowing into soft substrates. Indi-ct effects of drawdown include dessication of gae and aquatic vascular plants that supply nthic organisms with food and shelter. Ex-osed periphyton may be killed in a matter of ys, while exposed vascular plants may live for veral months, depending on temperature and infall.

The most obvious impact of lake level draw-down on macroinvertebrates would be reductions in population size due to loss of habitat. The extent of these reductions in population size would depend on the area and type of habitat affected. For example, macrophytes offer a more complex habitat than bare substrates and support a more diverse and abundant macroinvertebrate fauna. If water levels recede below the macrophyte beds, there would be large losses among benthic populations that use macrophytes as habitat. Smaller losses of macroinvertebrates would be expected from the exposure of bare substrate habitat or substrate covered with algae (periphyton). Losses of benthic organisms would be reduced if lake levels were to recede slowly, allowing aquatic macrophytes to become established in the new littoral zone.

The impacts of rapid drawdowns may be exacerbated by the effects of erosion. When reservoir drawdowns are gradual, wetland and upland plants are more likely to become established on the exposed lakebed, minimizing erosion and sedimentation. When drawdowns are more rapid and pronounced, erosion is more apt to occur because more lakebed is exposed and bare sediments are exposed to the elements for longer periods. In these instances, silt and sediment could be carried downgradient by runoff to settle out in the shallows. Silt can interfere with food collection and respiration of benthic organisms and can smother eggs and larvae.

When Par Pond was drawn down in 1991, a large proportion of the littoral macroinvertebrate benthos was destroyed (DOE 1995a). Mussels and clams were particularly hard hit. The introduced clam *Corbicula fluminea*, which is widespread in L-Lake, is incapable of long downslope migrations (Folsom 1983). When exposed to air, most *Corbicula* die within a few days. Survival is dependent upon temperature and humidity, with clams surviving an average of 27 days at 20°C and high humidity and only 7 days at 30°C and low humidity (Folsom 1983). Large clams can survive longer than small clams, and burrowing in mud can increase survival time.

Because *Corbicula* tend to be concentrated in shallow, well-oxygenated (littoral) areas (Folsom 1983) and are unable to move downslope in response to rapidly-changing water levels, they would likely be devastated by a sudden or prolonged reservoir drawdown. This could have short-term impacts on fish and waterfowl that feed heavily on *Corbicula.* Because of the species' high reproductive potential, stable water levels in the spring or fall could produce a rapid population expansion. Thus, cycles of increased and decreased abundance of *Corbicula* as the reservoir recedes probably would occur until dissolved oxygen levels became limiting.

DOE might also be able to predict changes in benthic invertebrate community structure that would accompany lower water levels in L-Lake. Wegener, Williams, and McCall (1974) examined benthic macroinvertebrate populations of a Florida lake before, during, and after an extreme drawdown that exposed 50 percent of the lake bottom. Standing crops of profundal benthos, which remained under water during the drawdown, were slightly reduced during the drawdown but increased after the lake was refilled. Densities of oligochaetes and certain larval dipterans were stable or increased, while densities of mayflies (Ephemeridae and Baetidae) decreased. The littoral-zone benthos showed a similar trend, with a complete loss of macroinvertebrates during the drawdown, and densities of oligochaetes, chironomids, and mayflies of the family Baetidae increasing after the lake refilled. Marshall (1978) found that oligochaetes became relatively more abundant in years with low water levels in Lake McIlwaine, while chironomids increased in abundance following flooding.

These differences could be due to the manner in which different macroinvertebrate groups colonize (or recolonize) new areas. Oligochaetes are usually more abundant in deeper waters and may have the advantage of already being established when water levels recede. On the other hand, chironomids have winged adults, allowing them to rapidly colonize new habitat, such as newly flooded areas. Therefore an increase in the relative abundance of oligochaetes may be expected for L-Lake during the drawdown, particularly if dissolved oxygen levels are low. Many oligochaetes possess anatomical and behavioral adaptations that aid in oxygen uptake and transport (Brinkhurst and Gelder 1991).

As the water level drops, fish habitat would be reduced and exposed littoral zone vegetation, which would provide fish with critical spawning habitat, food, and cover, would die. If lake levels eventually stabilize at or fluctuate around a lower level, a reservoir (or pond) fish community would likely develop, although numbers and diversity of fish probably would be reduced. If the reservoir empties, the reservoir fish community would be eliminated, probably through fish kills in the final stages of the drawdown when fish are forced into small areas and stressed by overcrowding, low dissolved oxygen levels, and temperature extremes.

In time, a stream channel would become established in the lakebed, and streamside vegetation would slow erosion. Accumulated sediment in the stream would be washed downstream by heavy rains and floods. After many years, a stream ecosystem similar to other small, blackwater streams in the area would develop. Based on the investigations of fish community structure conducted by Paller (1994) and others, a relatively simple fish community comprised of small, schooling insectivores (shiners and chubs), small sunfish, and catfish (madtoms and bullheads) probably would develop over time. Depending on sediment loads, rainfall, and the success of the revegetation efforts planned for the exposed lakebed, this could take years or decades.

Under this alternative, no river water would be withdrawn at the 3G Pumphouse. This would completely eliminate entrainment and impingement and could have a small positive impact on ish populations in the immediate vicinity of the RS pumphouses and intakes.

Vetlands Ecology

Natural wetlands in the sandhills of the Upper Coastal Plain of South Carolina have evolved vith widely fluctuating water levels. The two est examples are the bottomland hardwood wamps along the Savannah River and its ributaries and Carolina bays. Water levels in he bottomland hardwood swamps fluctuate on n annual cycle, with levels declining during the pring and summer and rising during the winter. Short-term fluctuations such as floods in the pring and long-term fluctuations such as lroughts that extend over several growing seaons produce some variation in the "normal" nnual cycle (Sharitz, Irwin, and Christy 1974). Water levels in Carolina bays show similar cycles. A bay might be dry for years, and a period of above-normal rainfall will create standing vater and saturated soils.

The L-Lake reservoir level simulation completed in 1994 (Jones and Lamarre 1994) modeled the reservoir level over two different time periods with different precipitation assumptions (1969 through 1980 with normal rainfall; and 1980 through 1990 with drought conditions). Two models, a precipitation-based (rainfall, unoff) model and a streamflow-based model, were used. Assuming a sustained and constant ninimum release rate of 10 cubic feet per second (0.28 cubic meter per second) into Steel Creek and no groundwater recharge or discharge, the model shows that the lake cannot sustain full pool. However, in only one simulaion did the lake completely empty.

Using 1980-1990 (drought years) data and the streamflow-based approach, modeling indicated hat the reservoir would drop 70 feet (21.3 meers) over a 10-year period and empty completely (Jones and Lamarre 1994). The simulation showed that the lake would drop 34 feet (10.4 meters) over a 10-year period using data from drought years and employing the precipitation-based approach. The streamflow-based simulation showed that the lake would drop 15 feet (4.6 meters) over a 10-year period during years with normal rainfall (1969-1980 data).

Modeling also indicated that the lake level would drop slowly during the summer months and stabilize or even rise during the winter months. This reflects the fact that the models are based on stream flow and precipitation in the region. These cycles of drying and flooding are typical of bottomland hardwood swamps on the SRS and in the southeast.

The drought of the late 1980s allowed upland species such as loblolly pine and facultative wetland species such as sweetgum to invade Carolina bays on the SRS as their waters receded over a 3- or 4-year period. When the bays refilled in the early 1990s, the water TC drowned out the upland species and allowed wetland species such as buttonbush and maidencane to regain their dominance (Pechmann et al. 1993).

Based on historic data and the models, the reservoir would probably recede during the growing season. As the lake level slowly recedes, wetland plants growing in the emergent zone probably would move downslope with the water. Seed in the shoreline and shallow-water areas would germinate when exposed, and a dense growth of wetland and upland species would L11-10 quickly cover the sediments (Collins and Wein L11-14 1995). This occurred in Lost Lake (near M-Area) following the waste site remediation and restoration in early 1991. In the fall of 1991, successful naturally invading species at Lost Lake included *Eleocharis acicularis*, *Eupatorium* sp., *Typha latifiolia*, *Polygonum* sp., *Panicum dichotomiflorum*, *Setaria* sp., and *Cephalanthus occidentalis* (Wike et al. 1994). After the drawdown of Par Pond in 1991, similar reinvasion of the newly exposed shoreline was observed in August 1992 (Mackey and Riley 1996).

As L-Lake recedes, the submersed and floating-leaved aquatics probably would desiccate and die as they become stranded. During high rainfall years, some littoral-zone wetland plants would survive in shallow water over the summer but probably would die during the next drought cycle. As the waters of the reservoir recede, this cycle of drying and dessication (during years in which the reservoir drops several feet or more), the reestablishment and even expansion (during wet years in which the reservoir drops a foot or less), and drying and dessication would repeat until the reservoir reaches equilibrium or empties. As noted above, the annual drop in lake elevation could range from 1.5 feet to 7.0 feet (0.5 to 2.1 meters) per year (Jones and Lamarre 1994).

Wetlands surrounding L-Lake would convert to uplands (through natural succession) as the lake levels drop. Wetland species such as red maple and sweetgum would continue to grow as the shoreline recedes, but upland species would, in time, assert their dominance.

Lowering the reservoir levels slowly would mitigate impacts to wetlands and to the animals that inhabit the wetlands along the shore. Erosion should be minimal during most years along much of the shoreline but could be a problem along the steeper section between elevations at 170 feet (52 meters) and 190 feet (58 meters) on the northeast shore, particularly in drought years.

L05-01 L06-03 L08-01 L13-02 L13-06

As noted in Section 3.2.1, DOE would apply appropriate measures to revegetate the bare lakebed and attempt to reestablish the ecosystem that existed before the creation of the reservoir. These measures would include fertilizing and seeding bare areas to prevent erosion and could include a variety of other soil conservation measures, such as silt fences, sediment barriers, and fabric blankets, which promote seed growth as well as control erosion. These erosion control measures would be part of a larger effort to restore the stream ecosystem and associated floodplain forest that existed before SRS operations dramatically altered this ecosystem.

TC

DOE is currently drafting a plan for restoration of the upper portion of Steel Creek and its floodplain forest in consultation with soil scientists, ecologists, and foresters at the Savannah River Forest Station and Westinghouse Savannah River Company Savannah River Technology Center.

If DOE selects the Proposed Action, the Record of Decision for the EIS would contain a commitment to prepare a Mitigation Action Plan, as well as a more detailed implementation plan that provides a step-by-step guide to restoring the plant communities of the riparian corridor and floodplain that were lost when L-Lake was created. In addition to the soil stabilization measures discussed earlier, this plan would include provisions for planting and/or transplanting trees and shrubs that are likely to survive and propagate in the Steel Creek floodplain. The Mitigation Action Plan would also contain monitoring requirements to ensure the success of the restoration. The lack of woody vegetation in the bare lakebed (and the shallow water table) would simplify the reforestation effort and ensure a high degree of success because there would be no other trees competing for water, nutrients, and space.

4.1.5.2.3 Shut Down and Maintain

Impacts of the Proposed Action would be the same as the Shut Down and Deactivate Alternative, except that if the River Water System was restarted and flows to L-Lake were increased, water levels could rise and inundate the shoreline. If the water level rises rapidly, the upland vegetation would die after a period of inundation. Wetland species would recolonize the shoreline when the rate of filling slowed and the lake level stabilized.

4.1.6 LAND USE

4.1.6.1 Affected Environment

Located in southwestern South Carolina, the SRS occupies an area of approximately 300 square miles (800 square kilometers). The

Savannah River forms the Site's southwestern boundary for 27 miles (43 kilometers) on the South Carolina-Georgia border. The SRS is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 19 miles (31 kilometers) south of Aiken, South Carolina, the nearest major population centers.

With the exception of Site facilities, land cover consists of a wide variety of natural vegetation types, with more than 90 percent in forest land. Land adjacent to the Site is used mainly for forest, agricultural, and industrial purposes; industrial uses include a commercial two-unit nuclear powerplant, a regional low-level radioactive waste repository, and a wide variety of conventional industries.

Open fields and pine and hardwood forests comprise 73 percent of the Site; approximately 22 percent is wetlands, streams, and two reservoirs (L-Lake and Par Pond); production and support areas, roads, and utility corridors account for 5 percent of the total land area (DOE 1993b). L-Lake occupies about 1,000 acres (4.0 square kilometers) of the site (Bowen 1993a). The SRS includes several production, production support, service, research and development, and waste management areas. The U.S. Forest Service (under an interagency agreement with DOE) harvests about 1,800 acres (7.3 square kilometers) of timber from SRS each year (DOE 1993b).

DOE has set aside approximately 14,085 acres (57 square kilometers) of the SRS exclusively for nondestructive environmental research in accordance with its designation of the Site as a National Environmental Research Park. Research in the set-aside areas is coordinated by the University of Georgia's Savannah River Ecology Laboratory (DOE 1993b). The SRS has been proposed but not yet approved as a Congressionally designated National Environmental Research Park. Under that proposal, lands of the SRS would be under Federal control in perpetuity (Shearer 1996).

In January 1994, DOE began a process to seek internal and external stakeholder recommendations on future uses of lands and facilities at each of its sites. Each DOE field office was to obtain stakeholder-preferred future use recommendations. At the SRS, DOE formed the Future Use Project Team, which is comprised of representatives of local stakeholder groups such as the SRS Citizens Advisory Board, SRS Land Use Technical Committee, and Citizens for Environmental Justice. DOE used a variety of public involvement approaches, including public meetings, to arrive at stakeholder-preferred future use options.

In January 1996, DOE published the *SRS Future Use Project Report* (DOE 1996b), which summarizes stakeholder-preferred future use recommendations that DOE uses as it considers ongoing and future mission needs, technical capabilities, legal requirements, and funding throughout future planning and decisionmaking activities. In the report, the Future Use Project Team made the following recommendations:

- SRS boundaries should remain unchanged, and the land should remain under the ownership of the Federal government, consistent with the Site's designation as the first National Environmental Research Park.
- Residential uses of SRS land should be prohibited.
- If DOE or the Federal government decides to sell any SRS land, DOE should seek legislation to permit former landowners (as of 1950 to 1952) or their descendants to have the first option to buy back the land they owned.
- SRS land should be available for multiple uses (e.g., industry, ecological research, natural resource management, research and technology demonstration, recreation, and public education) where appropriate and nonconflicting, but not for residential use.

- Some SRS land should continue to be available for nuclear and non-nuclear industrial uses, and commercial industrialization should be an option.

- Industrial and environmental research and technology development and transfer should be expanded.

- Natural resource management should be pursued where possible, with biodiversity the primary goal.

- Recreational opportunities should be increased as appropriate.

- Future use planning should consider the full range of worker, public, and environmental risks, benefits, and costs associated with remediation.

The 1995 *Land-Use Baseline Report, Savannah River Site* (WSRC 1995b) does not project any other future mission for L-Lake. Appendix A contains more information on the environmental restoration implications of the proposed action in this EIS.

It was suggested by EPA in its comments on DOE's *Waste Management Activities for Groundwater Protection* EIS that DOE continue to use a 100-year institutional control period for guiding future SRS projects that have Site specific actions (DOE 1987a).

At present, there are no proposed privatization plans requiring the use of L-Lake or site-use permits for other than its current use (Hill 1996). Ten scientists and technicians conduct monitoring and research on L-Lake each week, and about three tour groups visit L-Lake each week (Marcy 1996). Research studies include effects of radioactive effluents and metals on aquatic macrophytes, fish, and other vertebrates (Janecek 1996). Otherwise, the use of L-Lake is restricted.

4.1.6.2 Land Use Impacts

4.1.6.2.1 No Action

Activities associated with the No-Action Alternative would not affect current uses of L-Lake. DOE has not identified the lake as an area for possible future missions. DOE would use the Future Use Project recommendations and the actions described in Section 4.1.6.1 to determine future uses for the lake.

4.1.6.2.2 Shut Down and Deactivate

Under this alternative, L-Lake would recede over approximately 10 years, returning to the stream flow conditions of Steel Creek. During this period, the research and monitoring described in Section 4.1.6.1 would continue. However, as the receding water exposed potentially contaminated sediments (see Section 4.1.8.2), the type and frequency of monitoring would differ from current operations. Appendix A describes environmental restoration implications and ongoing investigations associated with the cleanup of an exposed contaminated lakebed. Additional L-Lake research opportunities would become available, for example, studying how a biological community adjusts to stresses associated with the return of Steel Creek to original conditions.

4.1.6.2.3 Shut Down and Maintain

The impacts from this alternative would be the same as those from the Shut Down and Deactivate Alternative, except DOE could restart the River Water System if necessary. Section 3.3.1 discusses possible reasons DOE would restart the system.

AESTHETICS

.1 Affected Environment

lominant aesthetic settings in the vicinity tS are agricultural land and forest, with ed residential and industrial areas. The res and most of the large facilities are in the :or portions of the Site (see Figure 1-2). use of the distance to the SRS boundary, ig terrain, normally hazy atmospheric itions, and heavy vegetation, L-Lake is not le from off the Site or from roads with c access.

ands are more prevalent along the east side Lake; lotus is the dominant surface plant in er water habitats at the outer edges of the il beds (Jensen et al. 1992). Wading birds ften observed foraging in lake shallows, urtles are abundant, sunning on stumps and Section 4.1.5 describes the flora and fauna e L-Lake area. Figure 4-15 shows ke/Steel Creek from the north side of Road oking upstream. Figure 4-16 shows L-Lake the boat ramp on the west side of the lake rd the southeast. Figure 4-17 is a view to orth of L-Lake from the road across the at the south end of the lake.

ent users and those who regularly view ke include 1,790 vehicles a day that travel or west across the north end of the lake on l B, three SRS tour groups a week, and t 10 scientists and technicians who conduct itoring and or research on the lake. The is restricted from other uses (Marcy 1996).

.2 Aesthetic Impacts

.2.1 No Action

er the No-Action Alternative, DOE would inue to pump water from the Savannah r through the River Water System to ike and would maintain it at full pool. The ietic setting of the lake would not change here would be no impacts.

4.1.7.2.2 Shut Down and Deactivate

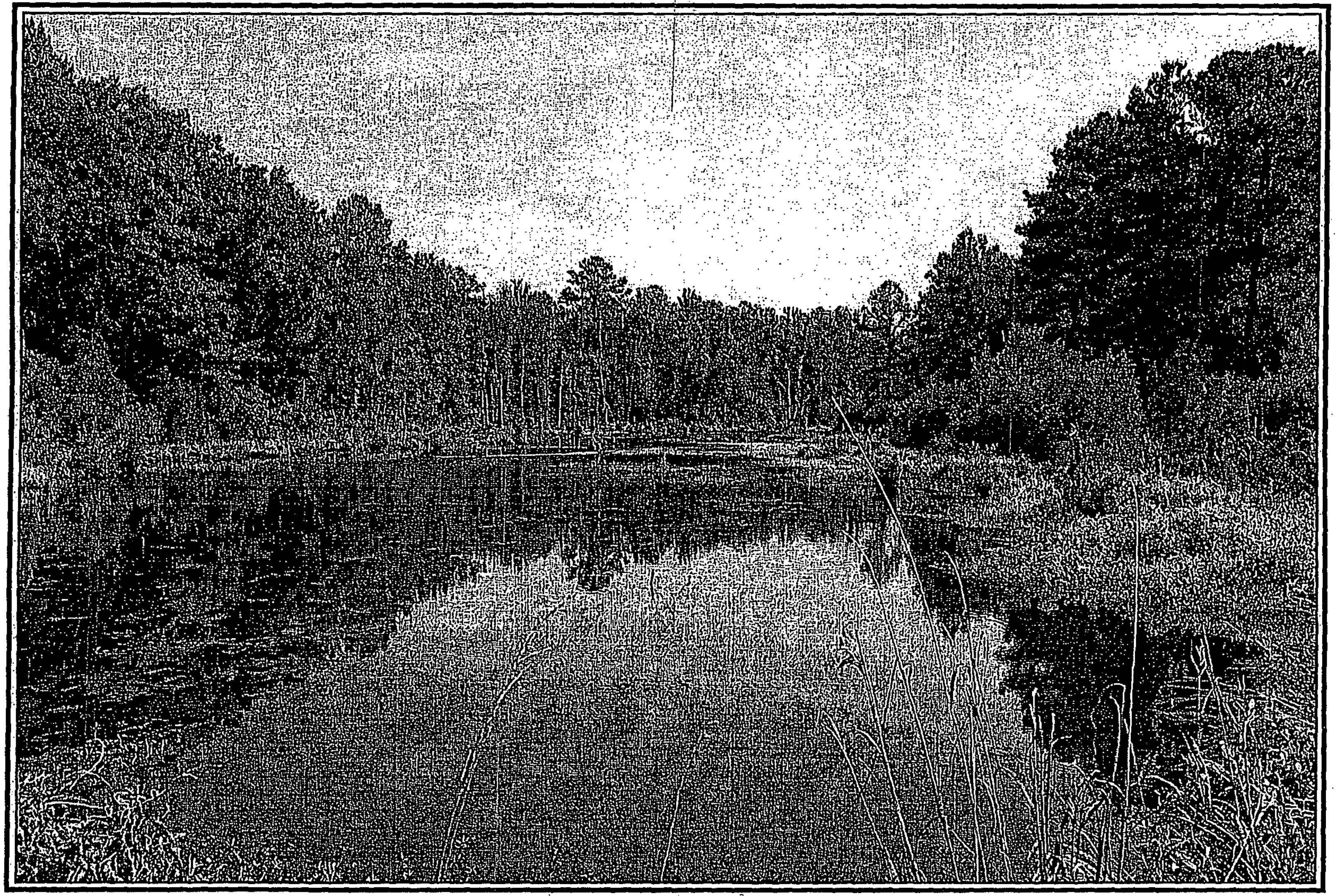
Under this alternative, DOE would shut down the River Water System, thereby pumping no water to L-Lake. The only water the lake would receive would come from natural recharge from the environment. The lake would recede over approximately 10 years to the original Steel Creek channel.

Figure 4-18 shows L-Lake at partial pool to illustrate how it would look as it recedes. As the lake recedes, there would be a loss of wildlife habitat and vegetation. Dried mud flats would be exposed until revegetation began, and there could be intermittent odor problems. However, based on the 1991 through 1995 Par Pond drawdown, plants would invade the newly exposed shoreline fairly rapidly. Grasses, sedges, and rushes colonized the bare Par Pond lakebed (Wike et al. 1994), and some old field species also became established. Figures 4-19 and 4-20 are artists' rendering of how the lake would appear as it recedes and revegetation of the exposed lakebed begins. TE

During the drawdown period, DOE would apply the following measures to minimize adverse effects of exposed sediments in the lakebed; these measures would also help to rebuild natural resources and minimize aesthetic impacts:

- Plant grass seed on exposed sediments to minimize effects of erosion and exposure of contaminants in the lakebed
- Apply other appropriate vegetation measures to accelerate the reversion of the lake to the original conditions of Steel Creek
- Seed the upstream face of the dam after the lake level dropped below the top portions of the dam, which are protected by riprap

The effects of these landscape changes cannot be quantified. Aesthetics is a subjective factor, dependent on individual perception and opportunity. In essence, it depends on whether a

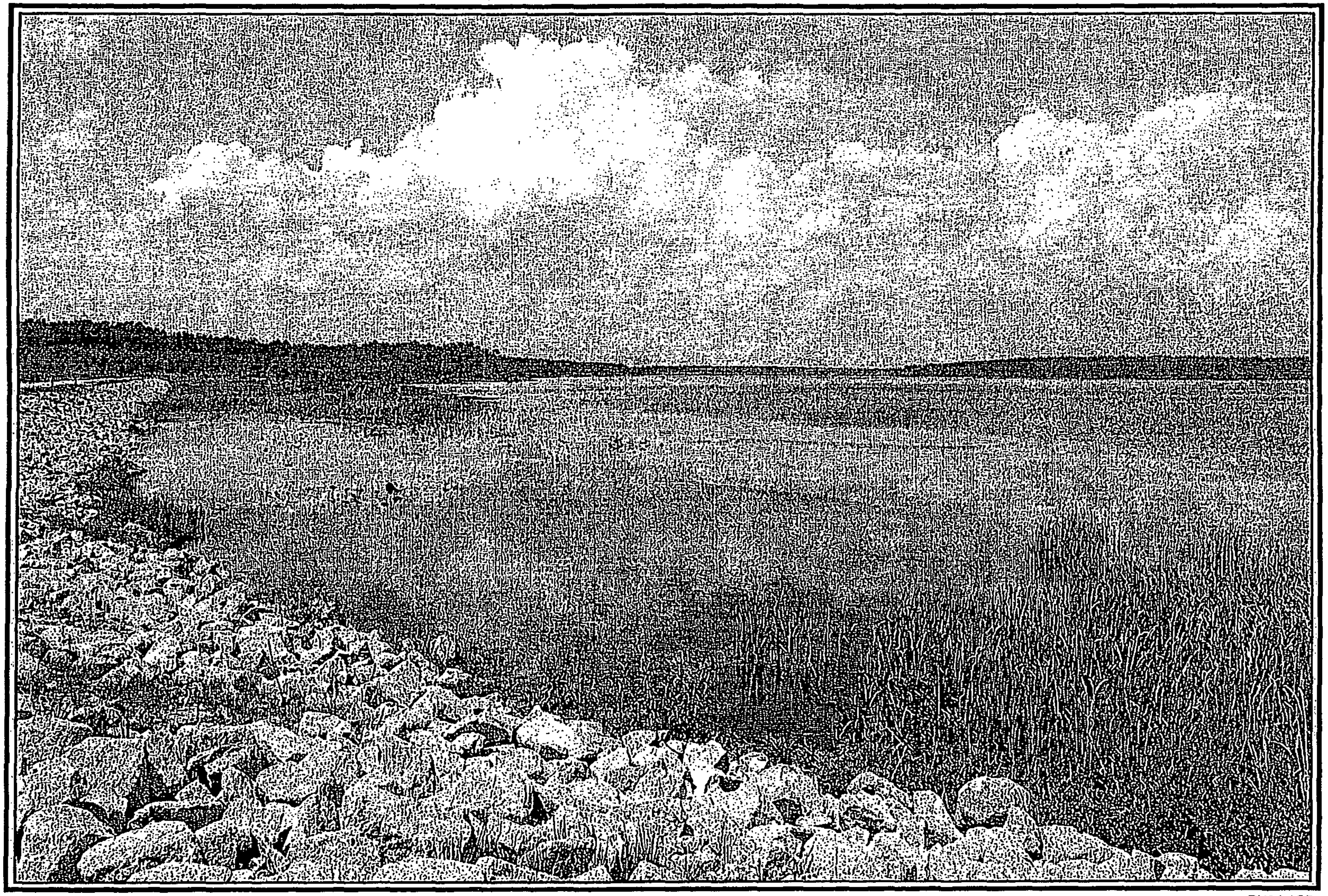


PK64-1CD

Figure 4-15. View of L-Lake/Steel Creek from north side of Road B.

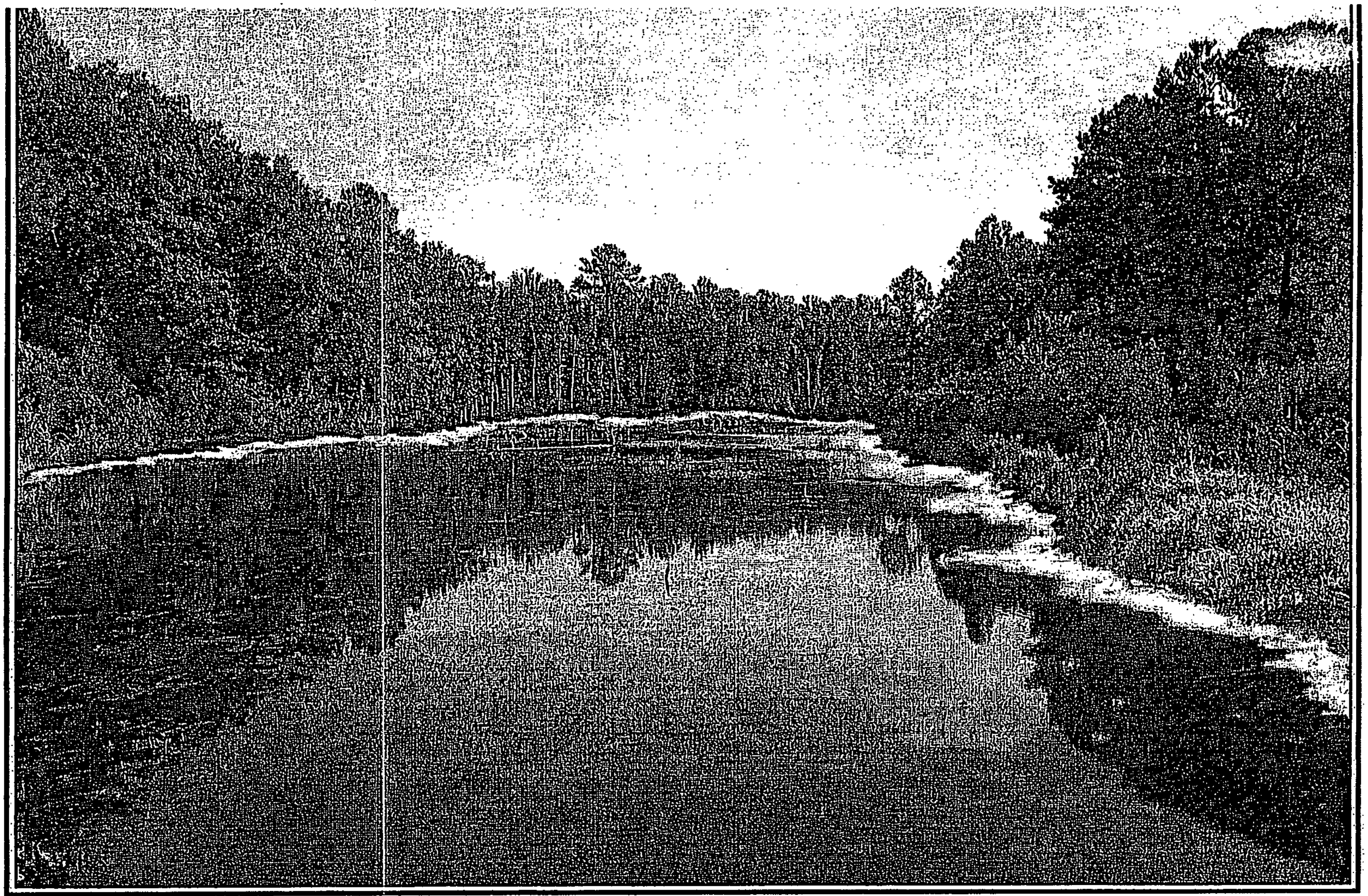
PK64-1CD

Figure 4-16. View of L-Lake from boat ramp on west side of L-Lake.



PK64-1CD

Figure 4-17. View of L-Lake from road across the dam at south end of lake.



PK64-1CD

Figure 4-18. Artist's rendering of L-Lake/Steel Creek from Road B at partial pool.

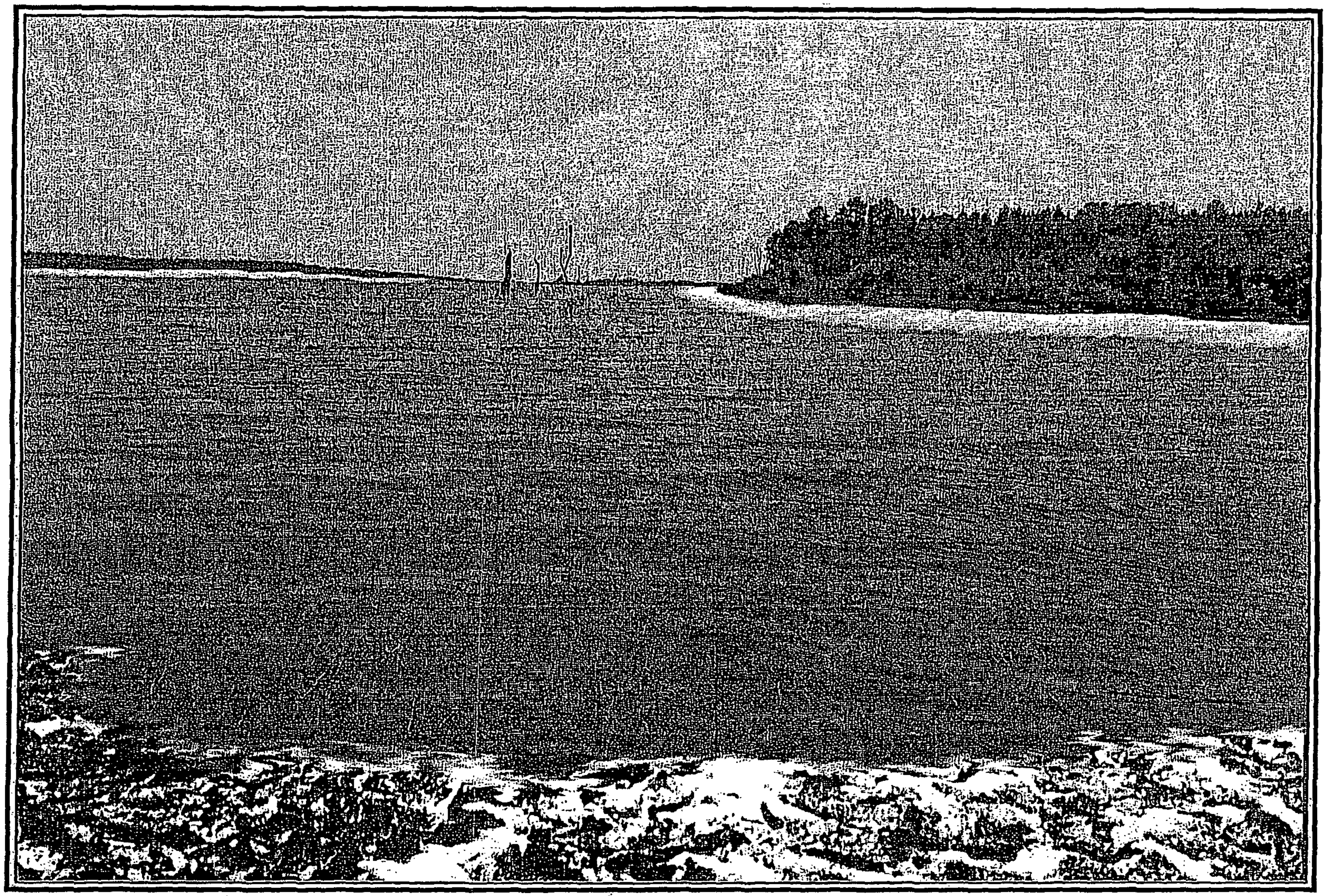


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Figure 4-19. Artist's rendering of receding L-Lake from boat ramp.

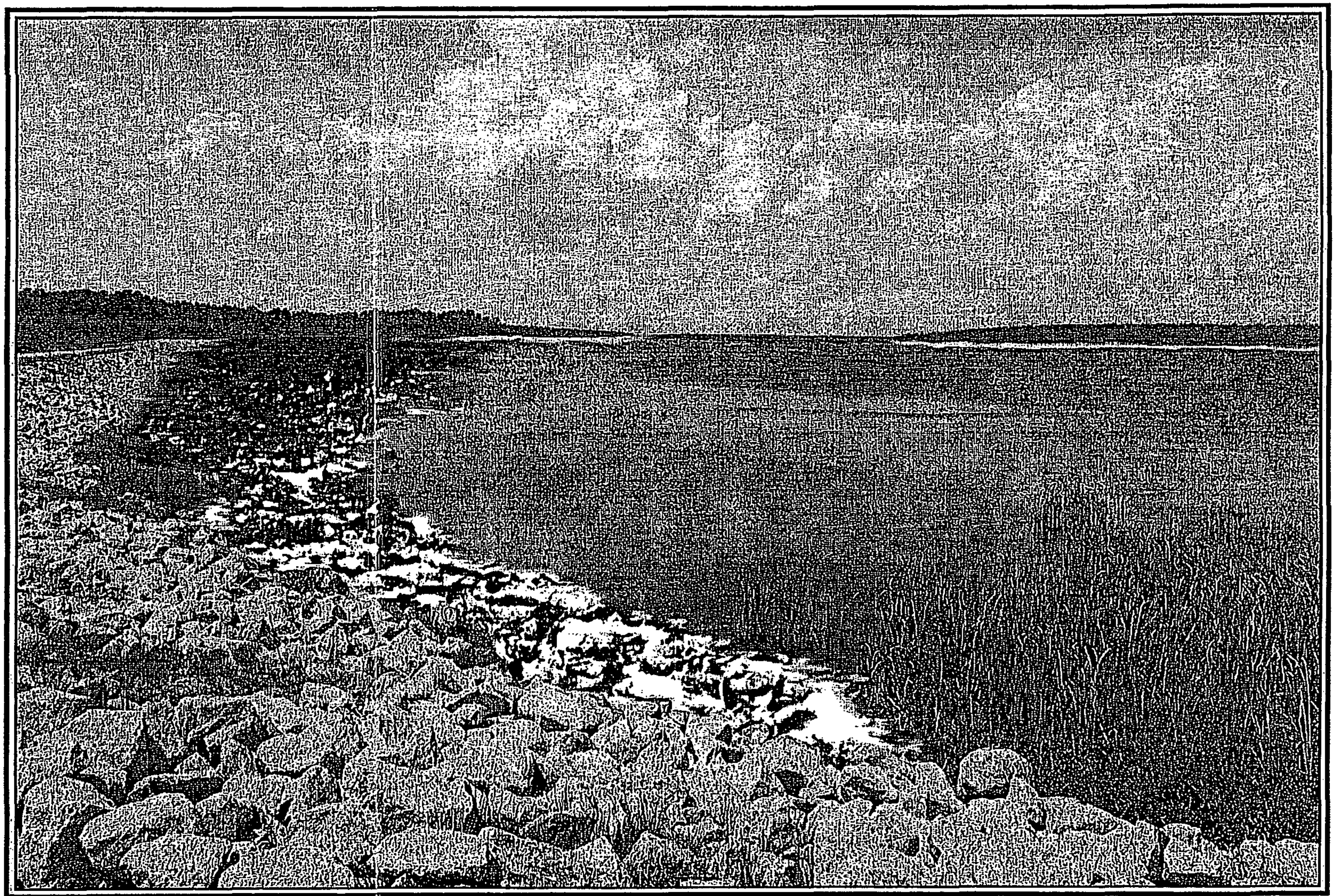

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Figure 4-20. Artist's rendering of receding L-Lake from top of the dam.

particular object or scene would affect the individuals viewing it. The nearly 1,800 persons who pass by L-Lake each day are SRS workers accustomed to changes in the Site landscape who might not consider these changes significant, assuming they perceive SRS as strictly an industrial complex.

4.1.7.2.3 Shut Down and Maintain

The consequences of this alternative would be the same as those for the Shut Down and Deactivate Alternative, except DOE could restart the River Water System if necessary. Section 3.3.1 contains possible reasons for restarting the system.

4.1.8 OCCUPATIONAL AND PUBLIC HEALTH

4.1.8.1 Affected Environment

4.1.8.1.1 Public Health

A release of radioactivity to the environment from a nuclear facility is an important issue for both SRS workers and the public. However, the environment contains many sources of ionizing radiation, and it is important to understand all such sources to which people are routinely exposed.

Sources of Environmental Radiation

Environmental radiation consists of natural background radiation from cosmic, terrestrial, and internal body sources; radiation from medical diagnostic and therapeutic practices; radiation from weapons test fallout; radiation from consumer and industrial products; and radiation from nuclear facilities. All radiation doses mentioned in this EIS are effective dose equivalents (i.e., organ doses are weighted for biological effect to yield equivalent whole-body doses) unless specifically identified otherwise (e.g., absorbed dose, thyroid dose, bone dose).

Releases of radioactivity to the environment from the SRS account for less than 0.1 percent of the total annual average environmental radiation dose to individuals within 50 miles (80 kilometers) of SRS (Arnett, Mamatey, and Spitzer 1996).

Natural background radiation contributes about 82 percent of the annual average dose of 360 millirem received by an average member of the population within 50 miles (80 kilometers) of SRS (Figure 4-21). Based on national averages, medical exposure accounts for an additional 15 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for about 3 percent of the total dose (DOE 1995c).

External radiation from natural sources comes from cosmic rays and emissions from natural radioactive materials in the ground. The radiation dose to the individual from external radiation varies with the exposure location and altitude.

Internal radiation from natural terrestrial sources consists primarily of potassium-40, carbon-14, rubidium-87, and daughter products of radium-226 that people consume in food grown with fertilizers containing these radionuclides. The estimated average internal radiation exposure in the U.S. from natural radioactivity (primarily indoor radon daughter products) is 240 millirem per year.

Medical radiation is the largest source of man-made radiation to which the population of the U.S. is exposed. The average dose to an individual from medical and dental X-rays, prorated over the entire population, is 39 millirem per year (DOE 1995c). In addition, radiopharmaceuticals administered to patients for diagnostic and therapeutic purposes account for an average annual dose of 14 millirem prorated over the population. Thus, the average medical radiation dose in the U.S. population is about 53 millirem per year. Prorating the dose over the population determines an average dose that, when multiplied by the population size, produces an estimate of population exposure; it does not mean that every member of the population receives a radiation exposure from these sources.

In 1980 the estimated average annual dose from fallout from nuclear weapons tests was 4.6 millirem (0.9 millirem from external gamma radiation and 3.7 millirem from ingested radioactivity). Because atmospheric nuclear weapons tests have not occurred since 1980, the average annual dose from fallout is now less than 1 millirem. This decline is due principally to radioactive decay.

A variety of consumer and industrial products yield ionizing radiation or contain radioactive materials and, therefore, result in radiation exposure to the general population. These sources include televisions, luminous dial watches, airport X-ray inspection systems, smoke detectors, tobacco products, fossil fuels, and building materials. The estimated average annual dose for the U.S. population from these sources is 10 millirem per year (DOE 1995c). About one-third of this dose is from external exposure to naturally occurring radionuclides in building materials.

People who travel by aircraft receive additional exposure from cosmic radiation because at high altitudes the atmosphere provides less shielding from this source of radiation. The average annual airline passenger dose, prorated over the entire U.S. population, amounts to 1 millirem (DOE 1995c).

Radiation Levels in the Vicinity of SRS

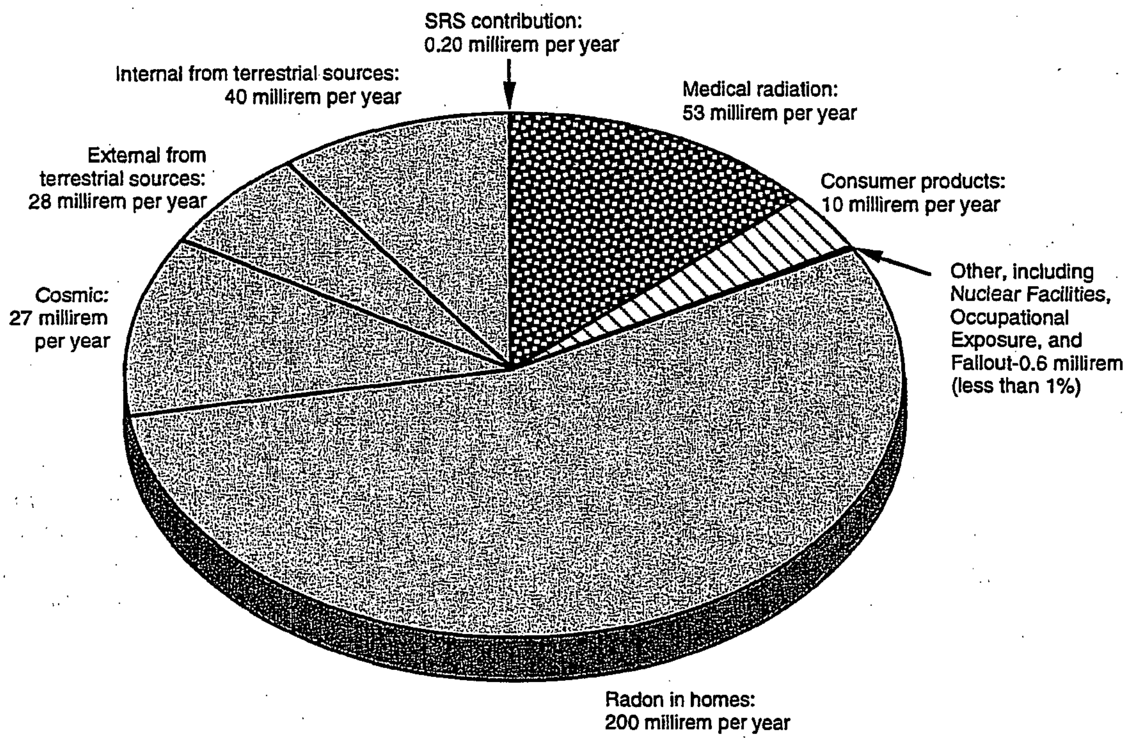
Figure 4-21 summarizes the major sources of exposure for the population within 50 miles (80 kilometers) of SRS and for populations in Beaufort and Jasper Counties, South Carolina, and Chatham County, Georgia, that drink water from the Savannah River. Many factors, such as natural background dose and medical dose, are independent of SRS.

Atmospheric testing of nuclear weapons deposited approximately 25,600,000 curies of cesium-137 on the earth's surface (DOE 1995c). About 104 millicuries of cesium-137 per square kilometer were deposited in the latitude band that includes South Carolina (30°N to 40°N). The total resulting deposition was 2,850 curies on the 10,580 square miles (27,400 square kilometers) of the Savannah River watershed and 80 curies on SRS. The cesium-137 attached to soil particles and has slowly moved from the watershed. Results from routine health protection monitoring programs indicate that since 1963 about 1 percent of the 2,850 curies of cesium-137 deposited on the total Savannah River watershed has been transported down the river (DOE 1995c).

Onsite monitoring shows an average of 50 millicuries of cesium-137 per square kilometer (1976 to 1982 average) in the upper 2 inches (5 centimeters) of the soil column; this is half the original amount. Some of the cesium has moved down in the soil column, and some has moved in surface water to the Savannah River.

Other nuclear facilities within 50 miles (80 kilometers) of the SRS include a low-level waste burial facility operated by Chem-Nuclear Systems, Inc., near the eastern Site boundary, and Georgia Power Company's Vogtle Electric Generating Plant, located directly across the Savannah River from the Site. In addition, Carolina Metals, Inc., which is northwest of Boiling Springs in Barnwell County, South Carolina, processes depleted uranium. The Chem-Nuclear facility, which began operating in 1971, releases essentially no radioactivity to the environment (DOE 1995c), and the population dose from normal operations is very small. The 50-mile- (80-kilometer-) radius population receives an immeasurably small radiation dose from the transportation of low-level radioactive waste to the burial site. Plant Vogtle began commercial operation in 1987, and its releases to date have been far below DOE guidance levels and Nuclear Regulatory Commission regulatory requirements (DOE 1995c).

In 1995 releases of radioactive material to the environment from SRS operations resulted in a Site boundary maximum dose from all pathways



Notes: The major contributor to the annual average individual dose in the United States, including residents of the Central Savannah River Area, is naturally occurring radiation (about 300 millirem). During 1995, SRS operations potentially contributed a maximum individual dose of 0.20 millirem, which is less than 0.1 percent of the 360 millirem total annual average dose (natural plus manmade sources of radiation).

Legend:

Natural Background

PK64-2

Figure 4-21. Major sources of radiation exposure in the vicinity of Savannah River Site.

from atmospheric releases of 0.06 millirem per year (in the west-southwest sector), and a maximum dose from releases into water of 0.14 millirem per year, for a maximum total annual dose at the SRS boundary of 0.20 millirem. The maximum dose to downstream consumers of Savannah River water, to users of the Beaufort-Jasper public water supply, was 0.05 millirem per year (Arnett, Mamatey, and Spitzer 1996).

In 1996 the population within 50 miles (80 kilometers) of SRS was 672,122 (Simpkins 1996b). The collective effective dose equivalent to this population in 1995 was 3.5 person-rem from atmospheric releases. Table 4-11 lists the population distribution for the 50-mile (80-kilometer) population. The 1990 population of 65,000 people using water from Port Wentworth (Savannah), Georgia, and from Beaufort and Jasper Counties, South Carolina received a collective dose equivalent of 1.6 person-rem (Arnett, Mamatey, and Spitzer 1996).

DOE conducts controlled deer and hog hunts annually at SRS to control their populations. Field measurements performed on each animal before its release to the hunter determine the levels of cesium-137 present in the animal. Laboratory analyses verify field measurements and dose calculations estimate the dose to the hypothetical maximally exposed individual among the hunters. In 1995 this hypothetical hunter harvested three animals during the hunts. The estimated dose to this hunter was based on the cesium-137 measurements of the deer and hog muscle taken from these animals and the conservative assumption that the hunter consumed all edible portions of these animals [156 pounds (70.8 kilograms) of meat]. The estimated dose was 30 millirem (Arnett, Mamatey, and Spitzer 1996), which represents 30 percent of the DOE annual limit of 100 millirem (DOE Order 5400.5).

Table 4-11. Population distribution in 1996 within 50-mile (80-kilometer) radius of Savannah River Site.[a]

Direction	Miles[b] 0-5	5-10	10-20	20-30	30-40	40-50	Total
N	0	28	5,765	10,853	5,492	13,235	35,373
NNE	0	6	1,430	2,238	4,819	15,572	24,065
NE	0	1	3,191	3,172	5,712	11,053	23,129
ENE	0	29	3,387	4,858	5,786	44,195	58,255
E	0	168	7,308	5,748	9,554	4,698	27,476
ESE	0	39	1,686	2,093	2,938	3,526	10,282
SE	0	28	592	7,055	7,248	9,297	24,220
SSE	0	43	423	833	1,469	2,752	5,520
S	0	1	603	1,442	7,861	3,615	13,522
SSW	0	2	972	2,175	4,533	3,191	10,873
SW	0	18	1,023	2,428	2,825	2,883	9,177
WSW	0	65	1,195	7,707	2,478	6,306	17,751
W	0	59	3,591	8,604	8,666	7,349	28,269
WNW	0	486	3,621	115,805	54,542	12,520	186,974
NW	0	293	6,393	95,284	28,808	3,279	134,057
NNW	0	393	19,535	29,437	7,225	6,589	63,179
Total	0	1,659	60,715	299,732	159,956	150,060	672,122

a. Source: Simpkins (1996b).
b. To convert miles to kilometers, multiply by 1.6093.

In 1995 DOE assumed that the hypothetical maximally exposed individual fisherman ate 42 pounds (19 kilograms) of fish per year. The estimated dose to the fisherman, based on consumption of fish taken only from the mouth of Steel Creek on SRS, was 1.20 millirem (Arnett, Mamatey, and Spitzer 1996), or 1.2 percent of the DOE annual limit.

Gamma radiation levels, including natural background, terrestrial, and cosmic radiation measured at 179 locations around the SRS boundary during 1995, yielded a maximum dose rate of 106 millirem per year (Arnett, Mamatey, and Spitzer 1996). This level is typical of normal background gamma levels in the general area (100 millirem per year measured in Girard, Georgia, in 1995). The maximum gamma radiation level measured on the Site (N-Area) was 275 millirem per year (Arnett, Mamatey, and Spitzer 1996).

DOE provides detailed summaries of releases to the air and water from the SRS in a series of annual environmental reports (e.g., Arnett, Mamatey, and Spitzer 1996). Each of these reports summarizes radiological and nonradiological monitoring and the results of analyses of environmental samples. These reports also summarize the results of the extensive groundwater monitoring at SRS, which uses more than 1,600 wells to detect and monitor both radioactive and nonradioactive contaminants in the groundwater and drinking water in and around process operations, burial grounds, and seepage basins.

Radiation Levels in C-, K-, L-, P-, and R-Areas

Table 4-12 lists gamma radiation levels measured in C-, K-, L-, P-, and R-Areas in 1994. These values can be compared to the average dose rate of 35 millirem per year measured at the SRS boundary. This difference is attributable to differences in geologic composition and to facility operations.

Analyses of soil samples from uncultivated areas measure the amount of particulate radioactivity deposited from the atmosphere. Table 4-13 lists maximum measurements of radionuclides in the soil in 1995 for C-, K-, L-, P-, and R-Areas, the SRS boundary, and background [100-mile (160-kilometer)] monitoring locations. Elevated concentrations of strontium-90 and plutonium-239 measured around F- and H-Areas reflect releases from these areas.

Radiation Levels and Metals in L-Lake

TC

To support this EIS, DOE conducted a 2-year, full-scale contaminant study to develop a complete and defensible list of contaminants in L-Lake. The sampling locations chosen were biased toward areas of suspect contamination such as the original stream channel. In the following discussion, L-Lake includes both the lake itself and the original creek bed beneath the lake. Under the Proposed Action, Steel Creek would reestablish itself as a flowing stream.

Table 4-12. External radiation levels (milliroentgen per year) at Savannah River Site facilities.[a,b]

Location	Average	Maximum
C-Area	78	80
K-Area	79	93
L-Area	80	87
P-Area	80	88
R-Area	79	84

a. Source: Arnett, Mamatey, and Spitzer (1996).
b. One milliroentgen is approximately 1 millirem.

Table 4-13. Maximum measurements of radionuclides in soil for 1995 [picocuries per gram; 0 to 3 inches (0 to 8 centimeters) depth].[a] TE

Location	Strontium-90	Cesium-137	Plutonium-238	Plutonium-239
C-Area	0.00343	0.974	0.0881	0.616
K-Area	0.00290	1.01	0.0286	0.0923
L-Area	0.00300	0.152	0.0533	0.166
P-Area	0.00152	0.110	0.00144	0.0036
R-Area	0.00083	(b)	(b)	(b)
Site boundary	0.00185	0.424	0.00190	0.0149
Background [100-mile (160-kilometer radius)]	0.00741	0.355	0.000578	0.00681

TC

a. Source: Arnett, Mamatey, and Spitzer (1996).
b. Activity is below the lower level of detection.

However, for the purpose of this risk assessment, it is assumed that the entire creek bed would become exposed. As a result, no credit is taken for the shielding that this water would provide. Appendix F provides a more comprehensive description of the sampling program. Table 4-14 provides an average of all samples that screened above EPA risk-based guidelines. This method provides a conservative approach toward risk determination.

DOE in 1995 collected sediment cores from shallow and deep water locations in L-Lake. The 0- to 1-foot (31-centimeter) segments of these samples were analyzed for radioactive and nonradioactive constituents and the results were validated (Koch, Martin, and Friday 1996). In 1996 DOE collected additional surface soil and sediment cores from the submerged portions of the L-Lake basin. These samples were also analyzed for radioactive and nonradioactive constituents and the results validated (Dunn, Gladden, and Martin 1996; Dunn, Koch, and Martin 1996). To further reduce the number of potential constituents of concern, the validated nonradiological constituents results were then screened using the EPA Region 3 screening criteria (Dunn and Martin 1997). Similarly, the validated radiological constituent results were screened with the Westinghouse Savannah River Company Risk Based Activity screening criteria (Dunn and Martin 1997). TC

Table 4-14 lists the average concentrations of radionuclides and metals meeting the screening criteria for the samples taken in 1995 and 1996. DOE used these data for input to the Multimedia Environmental Pollutant Assessment System (MEPAS) computer code (Droppo et al. 1995) for impact analysis by spatially averaging these values over the entire lakebed. These values were also used for evaluations presented in Appendixes A and B. TC

Figure 4-22 presents a cesium-137 isodose contour of L-Lake.

Water samples from L-Lake were analyzed to determine concentrations of radionuclides and metals. Table 4-15 lists the results of these analyses.

4.1.8.1.2 Occupational Health

The major goal of the SRS Health Protection Program is to keep the exposure of workers to radiation and radioactive material within safe limits and, within those limits, as low as reasonably achievable. An effective radiation protection program must minimize doses to individual workers and the collective dose to all workers in a given work group.

Table 4-14. Average concentration and inventory of radionuclides and metals in L-Lake sediments.[a]

Contaminant	Concentration	Inventory
Radionuclides	(pCi/g)	(curies)
Cesium-137	5.8	11.6
Cobalt-60	0.09	1.8×10^{-1}
Plutonium-239/240	3.0×10^{-2}	5.9×10^{-2}
Promethium-146	1.4×10^{-2}	2.7×10^{-2}
Uranium-233/234	0.77	1.54
Metals	(µg/kg)	(grams)
Antimony	6.9×10^{3}	1.4×10^{7}
Arsenic	1.8×10^{4}	3.5×10^{7}
Beryllium	2.3×10^{2}	4.6×10^{6}
Cadmium	1.0×10^{3}	2.0×10^{6}
Lead	1.4×10^{4}	2.9×10^{7}
Manganese	3.0×10^{2}	6.1×10^{5}
Thallium	1.9×10^{4}	3.9×10^{7}

a. Source: Dunn and Martin (1997).

TC

Sources of Radiation Exposure to Workers at SRS

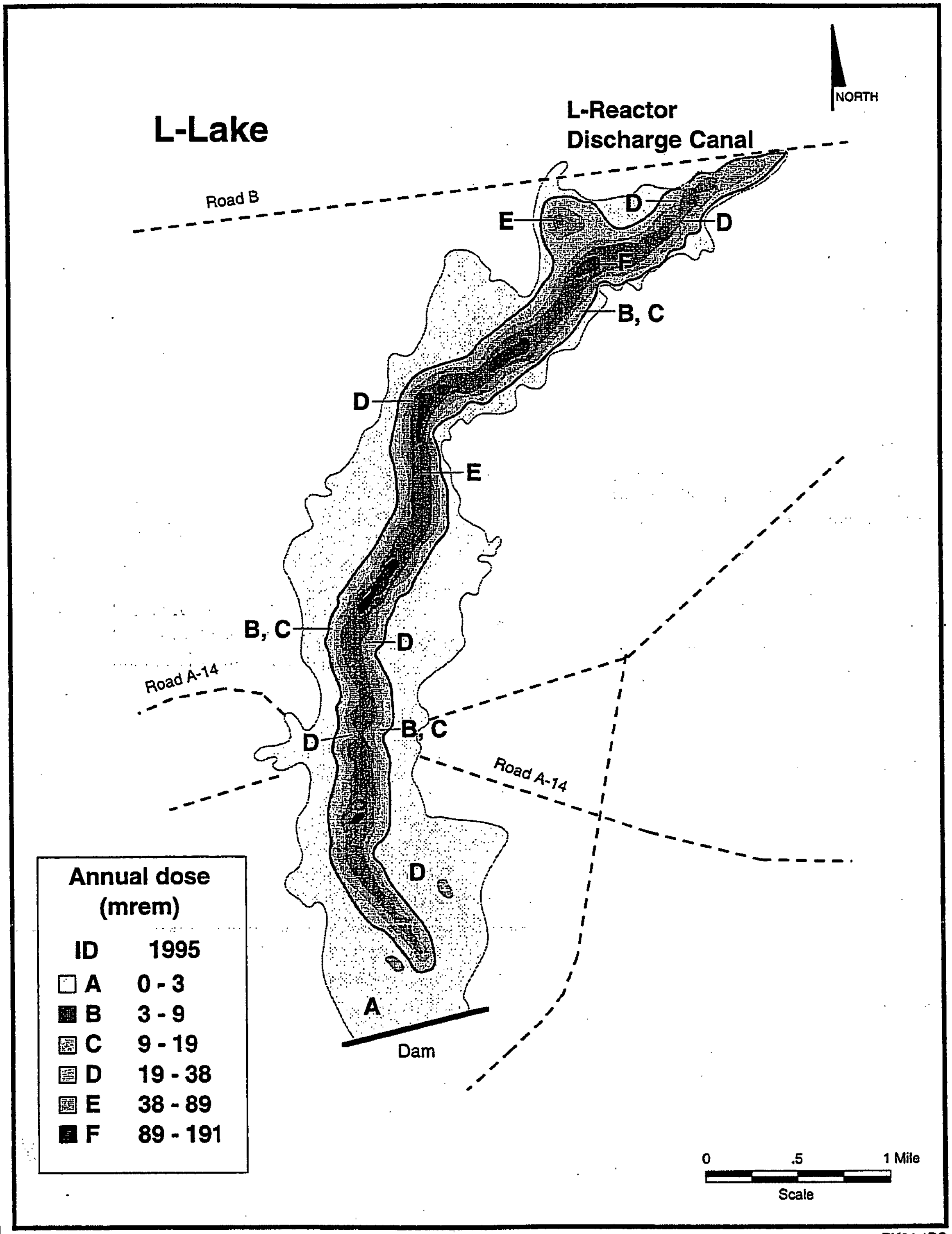
Worker dose comes from exposure to external radiation or from internal exposure when radioactive material enters the body. In most SRS facilities, the predominant source of worker exposure is from external radiation. In the SRS facilities that process tritium, the predominant source of exposure is the internal dose from tritium that workers have inhaled or absorbed into internal body fluids. On rare occasions, other radionuclides can contribute to internal dose if workers have accidentally inhaled or ingested them.

External exposure comes primarily from gamma radiation emitted from radioactive material in storage containers or process systems (tanks and pipes). Neutron radiation, which few special radionuclides emit, also contributes to worker external radiation in a few facilities. Beta radiation, a form of external radiation, has a smaller impact than gamma and neutron radiation because it has lower penetrating energy and, therefore, produces a dose only to the skin rather than to internal organs. Alpha radiation from external sources is nonpenetrating and produces no external exposure.

Internal exposure occurs when radioactive material is inhaled, ingested, or absorbed through the skin. Once the radioactive material is inside the body, low-energy beta and nonpenetrating alpha radiation emitted by the radioactive material in proximity to organ tissue can produce a dose to that tissue. If this same radioactive material were outside the body, the low penetrating ability of the radiation would prevent it from reaching the critical organs. To determine health hazards, organ dose can be converted to effective dose equivalents. The mode of exposure (internal versus external) is irrelevant when comparing effective dose equivalents.

SRS Worker Dose

The purpose of the radiation protection program is to minimize doses from external and internal exposure; it must consider both individual and collective doses. DOE could reduce individual worker dose to very low levels by using many workers to perform extremely small portions of the work task. However, frequent changing of



Source: WSRC (1995c).

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Figure 4-22. Cesium-137 conservative 1995 isodose contours.

Table 4-15. Average surface water concentrations of radionuclides and metals in L-Lake.[a]

Contaminant	Concentration
Radionuclides	(pCi/ml)
Tritium	10.0
Metals	(μg/ml)
Barium	1.1×10^{-2}
Manganese	2.5×10^{-2}
Magnesium	1.2
Vanadium	4.6×10^{-4}
Beryllium	3.9×10^{-4}

a. Sources: Simpkins (1996c); Paller (1996).

workers would be inefficient and would result in a higher total dose received by all workers than if DOE used fewer workers and each worker received a slightly higher dose.

Worker doses at the SRS have consistently been well below the DOE worker exposure limits. Administrative exposure guidelines are set at a fraction of the exposure limits to help ensure doses are as low as reasonably achievable. For example, the current DOE worker exposure limit is 5 rem per year, and the SRS administrative exposure guideline was 0.7 rem per year in 1996 (WSRC 1995d). Table 4-16 lists maximum and average individual doses and SRS collective doses from 1988 through 1995.

Worker Radiological Risk

To compare the alternatives, this EIS quantifies risks associated with very small chronic exposures. These calculated risks are reasonably conservative estimates of actual risks included in a range that could include zero. In addition, because of the large uncertainties that exist in the dose-effect relationship, the Health Physics Society recently recommended against quantifying risks due to radiation exposures comparable to those calculated in this EIS [i.e., doses (in addition to background) less than 5 rem in a year or less than 10 rem in a lifetime] (HPS 1996). These uncertainties are due, in part, to the fact that epidemiological studies have been unable to demonstrate that these adverse health effects have occurred in individuals exposed to small doses (less than 10 rem) over a period of many years (chronic exposures) and the fact that the extent to which cellular repair mechanisms reduce the likelihood of cancers is unknown. Therefore, the radiological risks reported in this EIS should be used only for relative comparisons between alternatives and should not be interpreted as absolute or actual risks.

TC In the United States, 23.4 percent of human deaths each year are caused by some form of cancer (CDC 1996). Any population of 5,000 people is likely to contract approximately 1,200 fatal cancers from nonoccupational causes during their lifetimes, depending on the age and sex distribution. Workers who are exposed to radiation have an additional risk of 0.0004 latent fatal cancer per person-rem of radiation exposure (DOE 1995c).

In 1995, 5,157 SRS workers received a measurable dose of radiation amounting to 256 person-rem (Table 4-16). Therefore, this group could TE experience as much as 0.1 (0.0004×256) additional cancer death due to their 1995 occupational radiation exposure. Continued operation of the SRS could result in as much as 0.1 additional cancer death each year of operation, assuming future annual worker exposure continues at the 1995 level. In other words, for each 10 years of operation, there could be one additional death from cancer among the work force that receives a measurable dose at the 1995 level.

Table 4-16. Savannah River Site annual individual and collective radiation doses, 1988-1995.[a]

Year	Individual dose (rem) Maximum	Individual dose (rem) Average[b]	SRS collective dose (person-rem)
1988	2.040	0.070	864
1989	1.645	0.056	754
1990	1.470	0.056	661
1991	1.025	0.038	392
1992	1.360	0.049	316
1993	0.878	0.051	263
1994	0.957	0.024	314
1995	1.341	0.019	256

a. Adapted from: DOE (1995c), WSRC (1994b), Kvartek (1995, 1996).
b. The average dose is calculated only for workers who received a measurable dose during the year.

4.1.8.2 Environmental Impacts

This section discusses radiological and nonradiological exposures from L-Lake due to normal operations under the alternatives and subsequent impacts to the public and workers. This analysis shows that the health effects (specifically latent cancer fatalities and hazard indexes) associated with the alternatives would be small, and would be small in relation to those normally expected in the worker and regional area population groups from other causes.

The principal potential human health effect from exposure to low levels of radiation is cancer. Human health effects from exposure to chemicals can be toxic (e.g., nervous system disorders) or cancer. This analysis expresses radiological carcinogenic effects as the number of fatal cancers for populations and the maximum probability of death of a maximally exposed individual.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the exposed population and genetic effects in subsequent generations. To enable comparisons with fatal cancer risk, the International Commission of Radiological Protection (ICRP 1991) suggested the use of detriment weighting factors that consider the curability rate of nonfatal cancers and the reduced quality of life associated with nonfatal cancer and heredity effects. The commission recommended probability coefficients (risk factors) for the general public of 0.0001 per person-rem for nonfatal cancers and 0.00013 per person-rem for hereditary effects. Both of these values are approximately a factor of 4 lower than the risk factors for fatal cancer. Therefore, this EIS presents estimated effects of radiation only in terms of latent cancer fatalities, because that is the major health effect from exposure to radiation.

For nonradiological carcinogenic health effects, risks are estimated as the incremental probability of an individual developing cancer (either fatal or nonfatal) over a lifetime as a result of exposure to the potential carcinogen. The overall potential for cancer posed by exposure to multiple chemicals is calculated by summing the chemical-specific cancer risks to determine a total individual lifetime cancer risk.

The potential for nonradiological noncarcinogenic health effects is evaluated by comparing an exposure level over a specified period with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is called a hazard quotient (EPA 1989). The noncancer hazard quotient assumes that there is a level of exposure below which even sensitive populations would be unlikely to experience adverse health effects. If the exposure level exceeded this threshold, there could be concern for potential noncancer effects.

To assess the overall potential for noncarcinogenic effects posed by more than one chemical, a hazard index approach is used (EPA 1989). This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures. The hazard index, therefore, is described as the sum of the hazard quotients. If the hazard index exceeds 1, there could be concern for potential health effects.

DOE used the MEPAS computer code (Droppo et al. 1995), a multipathway risk model developed by Pacific Northwest Laboratory, to assess the impacts of the No-Action, Shut Down and Deactivate, and Shut Down and Maintain Alternatives. The MEPAS code transports contaminants from a contaminated area to potential human receptors through various transport pathways (groundwater, surface water, soils, food, etc.). Human receptors receive both chemical and radiation doses through exposure or intake routes (ingestion, dermal contact, inhalation, etc.) and number of exposure pathways (drinking water, leafy vegetables, meat, etc.). MEPAS reports impacts for radiological exposures in terms of dose (rem) and cancer risk. For chemical exposures, it can report impacts as cancer risks or hazard index.

Because future use scenarios for the SRS include the use of Site lands for recreational activities (DOE 1996b), health impacts that could result from recreational use by members of the public are analyzed in this EIS. In addition, DOE has specified that future use scenarios of SRS land should include a full range of worker activities (PRC 1996). Therefore, this EIS includes potential impacts associated with these future and current land use worker scenarios. The following sections provide details of these scenarios.

Figures 4-23 and 4-24 show the pathways evaluated in this EIS for members of the public and workers, respectively. This EIS reports only impacts that would result from alternative actions that represent changes (incremental impacts) in relation to impacts from routine (baseline impacts) operation of the SRS (baseline impacts as presented in Section 4.1.8.1). However, the EIS estimates impacts that exist in the baseline case and are likely to change due to alternative activities, to enable the calculation of incremental changes for each alternative. Most of these impacts would be so small they could not be measured accurately and, therefore, must be calculated. Examples of these small impacts would include risks associated with exposure to volatilized tritium through inhalation and to mercury through dermal absorption resulting from contact with contaminated sediments.

4.1.8.2.1 No Action

The No-Action Alternative assumes L-Lake would remain at full pool [190 feet (58 meters) above mean sea level] and contaminated sediments would remain saturated and, therefore, would not become resuspended and available for transport to another location or inhalation. However, this analysis assumes that tritium would volatilize from the surface of the lake and become available for inhalation and absorption under current and future land use scenarios by members of the public and involved and uninvolved workers. Workers could also be exposed to contaminants in the surface water.

Public Health Impacts

The current land use scenario assumes that volatilized airborne tritium based on a 42-inch (1-meter)-per-year evaporation rate (del Carmen and Paller 1993a) would be transported off the SRS and become available for inhalation and ingestion by the offsite population living within

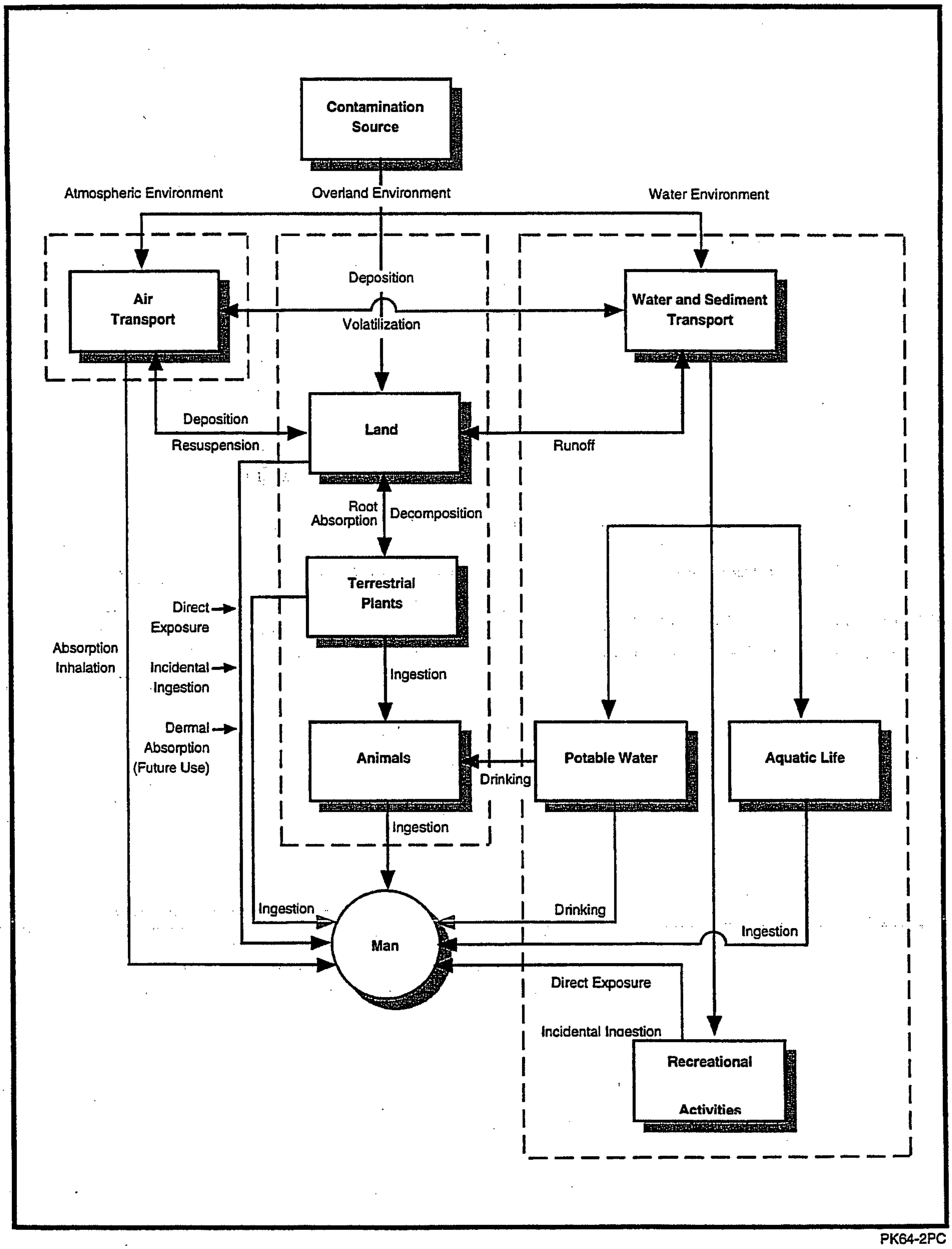


Figure 4-23. Public exposure pathways.

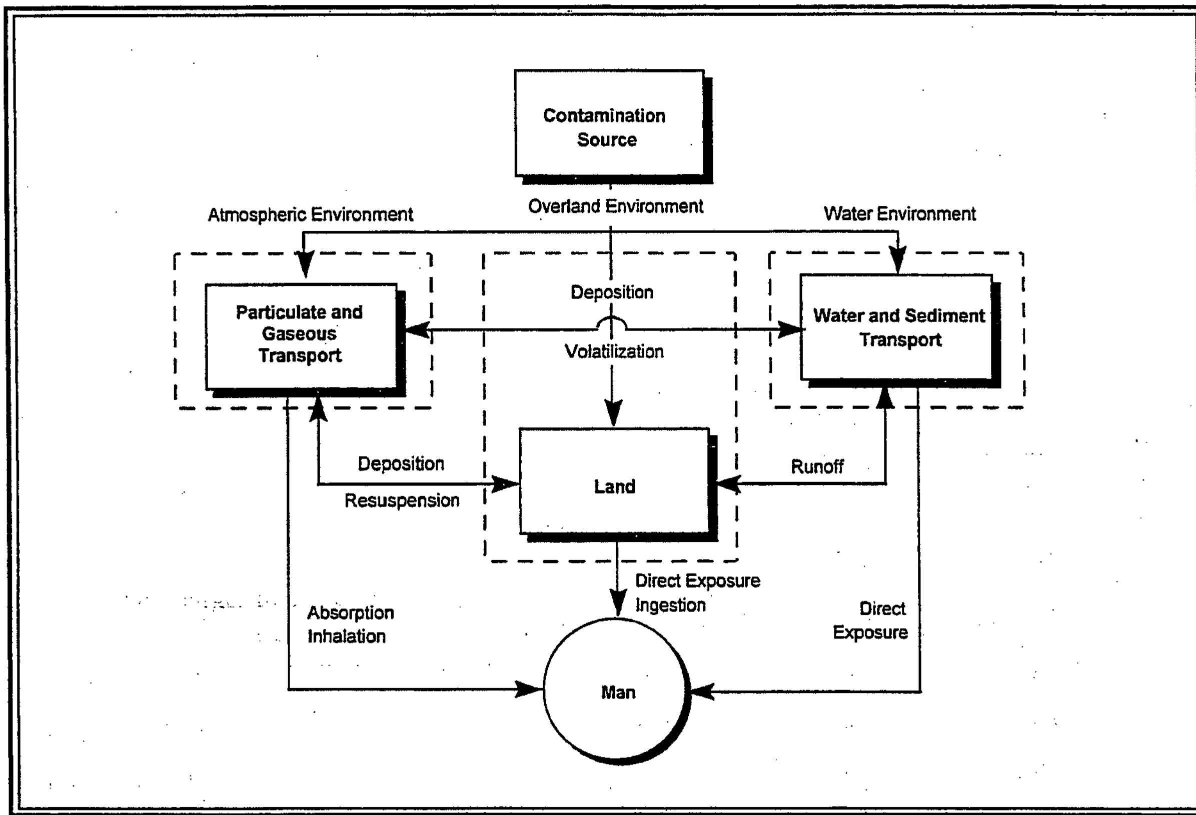


Figure 4-24. Worker exposure pathways.

50 miles (80 kilometers) of the Site. In addition, the future use scenario evaluates inhalation and absorption pathways resulting from recreational use of L-Lake (Figure 4-23) for other TE| constituents of concern listed in Table 4-15.

Radiological Impacts

Estimates of health effects associated with the No-Action Alternative on the public require the calculation of radiological doses to individuals and population groups. Estimates of latent cancer fatalities are calculated using the conversion factor of 0.0005 latent cancer fatality per rem for the general population (DOE 1995c). This factor is slightly higher than that for workers because infants and children are part of the general population.

Effects are estimated for the population group consisting of the 672,122 people living within 50 miles (80 kilometers) of SRS (Simpkins 1996b) and for the maximally exposed individual within this group. For this assessment, DOE assumed that the population would remain constant over the 70-year period of analysis. This assumption is justified because (1) current estimates indicate that the population will increase by less than 15 percent during this period (DOE 1995c), (2) there are uncertainties in the determination of year-to-year population distributions, and (3) although the absolute impacts would increase proportionately with population growth, the relative impact comparison between alternatives would not be affected.

The MEPAS code converts airborne radiological releases to doses. This code calculates the dose to a hypothetical maximally exposed individual at the SRS boundary (located in the southern compass sector for releases from L-Lake) and the collective dose to the population within a 50-mile (80-kilometer) radius. The current land use scenario under the No-

Action Alternative evaluates only the tritium volatilization and atmospheric pathways. The future use scenario, in addition to atmospheric pathways, includes pathways resulting from recreational use of L-Lake (Figure 4-23), which includes incidental ingestion of shoreline sediments and surface water, dermal contact with shoreline sediment and surface water, external direct exposure from shoreline sediments and surface water, and consumption of fish taken from the lake.

Table 4-17 lists the calculated atmospheric doses. For the current land use scenario, the annual doses (0.00015 millirem to the offsite maximally exposed individual and 0.0014 person-rem to the offsite population) would be small fractions of the dose from total SRS airborne releases in 1995 [0.06 millirem to the offsite maximally exposed individual and 3.5 person-rem to the population within 50 miles (80 kilometers) of SRS (Arnett, Mamatey, and Spitzer 1996)]. These doses from 1995 operations were well within the EPA requirements (40 CFR 161; DOE Order 5400.5), which restrict the annual dose limit to the offsite maximally exposed individual of 10 millirem from all airborne releases.

Using the fatal-cancer-per-rem dose factor provided above, DOE calculated the probability of the maximally exposed individual developing a fatal cancer and the numbers of fatal cancers that could occur in the regional population for the current land use scenario under the No-Action Alternative (Table 4-17). The probability of the maximally exposed individual dying of cancer as a result of 70 years of exposure to radiation under the No-Action Alternative is 1.3×10^{-9} or slightly more than 1 in a billion. Radiological doses and resulting health effects (number of fatal cancers) that could occur in the regional population of 672,122 people for this same exposure period would be 1.2×10^{-5}.

About 23.4 percent of deaths in the U.S. population are attributable to cancer from all causes; accordingly, the probability of an individual dying of cancer is 0.234, or approximately 1 in 4. In a population of 672,122 people [the number of people living within 50 miles (80 kilometers) of SRS], the number of people likely to die of cancer would be 157,000. Similarly, the annual risk of fatal cancer in the general population can be estimated (assuming a 70-year life expectancy) to be 3.3×10^{-3} per year. Thus, the incidence of radiation-induced fatal cancers associated with the No-Action Alternative (see Table 4-17) would be much smaller than the incidence of cancers from all causes. TC

For the future land use scenario, the calculated annual dose and resulting cancer risk (0.38 millirem to the maximally exposed individual and a 1.9×10^{-7} risk of latent fatal cancer) would be higher than for the current land use scenario because members of the public would be able to come into direct contact with the contaminated surface water of L-Lake. However, this risk would be a small fraction of the natural incidence of cancer from all causes.

Nonradiological Impacts

Table 4-18 lists the hazard index and cancer risk associated with the No-Action Alternative for members of the public. For the current land use scenario, hazard indexes are not calculated because the analysis assumes no releases of nonradiological constituents from L-Lake. However, the hazard index and cancer risk are calculated for the future land use scenario, which assumes that members of the public would use L-Lake for recreational activities. Under this scenario, exposure pathways would include incidental ingestion of shoreline sediments and surface water, dermal contact with shoreline sediment and surface water, and consumption of fish taken from the lake. TE

As listed in Table 4-18, the calculated hazard index (6.2×10^{-2}) for the maximally exposed individual under the future land use scenario would be less than one. TE

Table 4-17. Radiological doses associated with the No-Action Alternative and resulting health effects to the public.[a]

Receptor(s)[b]	Individual Dose (millirem): Atmospheric releases	Individual Dose (millirem): Aqueous releases	Individual Dose (millirem): Total	Individual: Probability of fatal cancer	Population Dose (person-rem)[c]: Atmospheric releases	Population Dose (person-rem)[c]: Aqueous releases	Population Dose (person-rem)[c]: Total	Population: Number of fatal cancers
Offsite maximally exposed individual (current use)								
Annual	1.5×10^{-4}	NC[d]	1.5×10^{-4}	7.5×10^{-11}	NA[e]	NA	NA	NA
Lifetime[f]	2.6×10^{-3}	NC	2.6×10^{-3}	1.3×10^{-9}	NA	NA	NA	NA
Offsite maximally exposed individual (future use)								
Annual[g]	3.8×10^{-1}	NC	3.8×10^{-1}	1.9×10^{-7}	NA	NA	NA	NA
Lifetime[f]	1.3×10^{1}	NC	1.3×10^{1}	6.5×10^{-6}	NA	NA	NA	NA
Population								
Annual	NA	NA	NA	NA	1.4×10^{-3}	NC	1.4×10^{-3}	6.8×10^{-7}
Lifetime[f]	NA	NA	NA	NA	2.4×10^{-2}	NC	2.4×10^{-2}	1.2×10^{-5}

a. See Tables C-1 and C-2 in Appendix C.
b. The doses to the public from total SRS operations in 1995 were 0.20 millirem to the offsite maximally exposed individual (0.06 millirem from airborne releases and 0.14 millirem from aqueous releases) and 5.1 person-rem to the regional population (3.5 person-rem from airborne releases and 1.7 person-rem from aqueous releases). Source: Arnett, Mamatey, and Spitzer (1996).
c. For atmospheric releases, the dose is to the population within 50 miles (80 kilometers) of SRS. For aqueous releases, the dose is to the people using the Savannah River from the SRS to the Atlantic Ocean.
d. NC = not calculated; aqueous releases do not change with respect to baseline values.
e. NA = not applicable.
f. Based on 70 years of exposure; doses are corrected for radioactive decay.
g. Assumes future recreational use of L-Lake.

Table 4-18. Nonradiological hazard index associated with the No-Action Alternative for members of the public.[a]

Receptor	Annual (lifetime)[b] latent cancer risk[c]	Hazard index
Offsite maximally exposed individual (Future use)[d]	3.1×10^{-7} (2.1×10^{-5})	6.2×10^{-2}

a. See Table C-3 in Appendix C.
b. Based on 70 years of exposure.
c. Resulting from exposure to beryllium in surface water.
d. Assumes future recreational use of L-Lake.

The lifetime risk of fatal cancer due to exposure to beryllium in the surface water of L-Lake is 2.1×10^{-5}. This is a small fraction of the normal incidence of fatal cancers (0.234) in the exposed population from all causes.

Occupational Health

Radiological Impacts

Estimated doses and the resulting impacts to involved workers are based on a review of exposures resulting from the No-Action Alternative. For the current land use scenario, the involved worker is assumed to be a researcher who spends 6 hours per week (Hamm 1996), 15 weeks per year in the vicinity of L-Lake. The current worker is assumed to have a 5-year career exposure period (Hamm 1996). During the time spent around L-Lake, the worker's arms and hands are in contact with shoreline sediments. Other exposure pathways evaluated include incidental ingestion of shoreline sediments and direct radiation exposure to sediments (Figure 4-24). To evaluate shoreline sediment exposure pathways, the MEPAS computer code calculated the concentration of radionuclides in L-Lake shoreline sediments based on ambient water concentrations of the radionuclides (Table 4-15). This method will estimate the incremental impacts (above baseline) resulting from exposure to shoreline sediments that are exposed while L-Lake is maintained at full pool under the No-Action Alternative. The future land use scenario assumes the same exposure pathways as the current land use scenario, except the worker would spend 2,000 hours per year (8 hours per day for 250 days a year) in the vicinity of L-Lake. The future worker is assumed to have a 25-year career exposure period.

An evaluation (Appendix C) determined the hypothetical maximally exposed uninvolved worker is in L-Area [approximately 2 miles (3.2 kilometers) from the release point (center of L-Lake)]. This individual is assumed to be exposed for 40 hours a week. Population doses were calculated for the uninvolved workers in this area based on a population of 251 workers (Simpkins 1996c). Doses were estimated for the inhalation, ground contamination, and plume immersion exposure pathways. Table 4-19 lists incremental worker doses (the increase in dose due to activities under the No-Action Alternative). DOE regulations (10 CFR 835) require that annual doses to individual workers not exceed 5 rem per year. DOE requires that exposure to the maximally exposed involved worker at the SRS does not exceed 0.7 rem per year administratively (WSRC 1995d).

From these radiological doses, estimates of latent cancer fatalities were calculated using the conversion factor for workers of 0.0004 latent cancer fatality per rem (ICRP 1991). Based on this factor, the probability that the average involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation under the No-Action Alternative and current land use scenario would be 2.0×10^{-11}. For the total involved workforce, the collective radiation dose

Table 4-19. Worker radiological doses associated with the No-Action Alternative and resulting health effects.[a]

Receptor(s)	Individual		All workers	
	Dose (rem)	Probability of fatal cancer	Dose (person-rem)	Number of fatal cancers
Involved worker[b] (current use)				
Annual[c]	5.0×10^{-8}	2.0×10^{-11}	3.5×10^{-6}[d]	1.4×10^{-9}
Lifetime[e]	2.2×10^{-7}	8.7×10^{-11}	1.5×10^{-5}	6.1×10^{-9}
Involved worker (future use)[b]				
Annual[c]	1.1×10^{-6}	4.4×10^{-10}	7.7×10^{-5}	3.1×10^{-8}
Lifetime[e]	1.5×10^{-5}	5.9×10^{-9}	1.0×10^{-3}	4.1×10^{-7}
Uninvolved worker[f]				
Annual[c]	2.0×10^{-8}	7.8×10^{-12}	4.9×10^{-6}	2.0×10^{-9}
Lifetime[e]	2.6×10^{-7}	1.1×10^{-10}	6.6×10^{-5}	2.6×10^{-8}

a. See Tables C-4, C-5, and C-6 in Appendix C.
b. The estimated number of involved workers would be 70.
c. Annual individual worker doses can be compared to the regulatory dose limit of 5 rem (10 CFR 835) and the SRS administrative exposure guideline of 0.7 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. Based on a total of 13,651 monitored workers (Kvartek 1996), the 1995 average dose for Site workers who received a measurable dose was 0.019 rem (See Table 4-16).
d. Total for all involved workers; 1995 SRS total for all workers was 256 person-rem (see Table 4-16).
e. Based on 5 years of exposure for current workers and 25 years of exposure for future and uninvolved workers. Doses are corrected for radioactive decay.
f. L-Area. Total uninvolved workers estimated to be 251 [Source: Simpkins (1996c)].

could produce up to 1.4×10^{-9} additional fatal cancer as the result of a single year's exposure; over a 5-year career, the involved workers could have 6.1×10^{-9} additional fatal cancer as a result of exposure.

Under the future land use scenario, the probability that the average involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation under the No-Action Alternative would be 4.4×10^{-10}. For the total involved workforce, the collective radiation dose could produce up to 3.1×10^{-8} additional fatal cancer as the result of a single year's exposure; over a 25-year career, the involved workers could have 4.1×10^{-7} additional fatal cancer as a result of exposure.

The annual probability of an individual uninvolved worker developing a fatal cancer as a result of the estimated exposure would be 7.8×10^{-12}. For the total uninvolved workforce, the collective radiation dose could produce up to an additional 2.0×10^{-9} fatal cancer as the result of a single year's exposure; over a 25-year career, the uninvolved worker could have an additional 1.1×10^{-10} risk of developing a fatal cancer and 2.6×10^{-8} additional fatal cancer in the workforce.

The calculated numbers of fatal cancers due to worker exposure to radiation can be compared to the number of fatal cancers that would normally be likely among the workers during their lifetimes. Population statistics indicate that, of the U.S. population that died in 1994, 23.4 percent died of cancer (CDC 1996). If this percentage of deaths from cancer remains constant, 23.4 percent of the U.S. population will develop a fatal cancer during their lifetime. Therefore, in the group of 70 involved workers, about 16 normally would be likely to die of cancer.

The probability of developing a radiation-induced fatal cancer associated with the No-Action Alternative would be much less than the probability of developing a fatal cancer from other causes. The impacts from the alternatives discussed in this EIS would be a small fraction of the incidence of fatal cancer from all causes.

Nonradiological Impacts

DOE calculated nonradiological health impacts (hazard index and cancer risk) for the current and future land use involved worker. The exposure pathways and exposure times would be the same as those discussed previously. The hazard index for the uninvolved worker was not calculated because under the No-Action Alternative, chemical constituents are not assumed to be released to the atmosphere; therefore atmospheric exposure pathways would not exist for this individual. Table 4-20 lists the results; the calculated hazard index for the maximally exposed involved worker under the current and future land use scenarios would be a small fraction of 1. Therefore, these individuals would be not be likely to experience adverse health effects.

4.1.8.2.2 Shut Down and Deactivate

This alternative assumes that L-Lake would recede to the original Steel Creek stream channel, thereby exposing contaminated sediment. These sediments would dry, become resuspended in the atmosphere, and be available for inhalation by onsite workers and the offsite population within 50 miles (80 kilometers) of SRS. In addition, soil erosion would be likely, which would cause sediments to become entrained in storm water and appear in Steel Creek and the Savannah River. However, the recession of the lake would remove the tritium volatilization pathway discussed above from consideration. The following sections describe the specific pathways evaluated for each receptor.

Public Health

Radiological Impacts

To estimate the health effects associated with the Shut Down and Deactivate Alternative on the public, radiological doses were calculated only to the maximally exposed individual and population groups for the current land-use scenario only. Because L-Lake would recede to the original stream channel, the future recreational land use scenario would not exist.

Table 4-20. Worker nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Receptor(s)	Annual (lifetime)[b] latent cancer risk	Hazard index
Involved worker (current use)	9.1×10^{-9} (4.5×10^{-8})	2.1×10^{-4}
Involved worker (future use)	1.3×10^{-8} (3.1×10^{-7})	4.8×10^{-5}
Uninvolved worker[c]	NC[d]	NC

a. See Tables C-7 and C-8 in Appendix C.
b. Based on 5 years of exposure for current worker and 25 years of exposure for future and uninvolved workers.
c. L-Area.
d. NC = not calculated; nonradiological constituents are not released under the No-Action Alternative.

For the Shut Down and Deactivate Alternative, in addition to the 672,122 people living within 50 miles (80 kilometers) of SRS who would be exposed through the atmospheric pathways, doses from aqueous releases were calculated for the 65,000 people (Arnett, Mamatey, and Spitzer 1996) who use the Savannah River for drinking water (Port Wentworth, Georgia, and Beaufort and Jasper Counties, South Carolina) and who would be exposed to releases to the River. As discussed previously for atmospheric releases from L-Lake, the maximally exposed individual would be at the Site boundary in the southernmost compass sector. However, for aqueous releases, this individual is assumed to drink untreated water from the River at a location just south of the SRS boundary and, conservatively, to be the same maximally exposed individual from atmospheric releases.

As with atmospheric pathways, the MEPAS code calculated doses and impacts from waterborne releases. This code calculated the dose to a hypothetical maximally exposed individual along the Savannah River just downstream of SRS, and to the population using the River from SRS to the Atlantic Ocean. Fish ingestion, water ingestion, shoreline sediment ingestion, and recreational exposure pathways were included in the calculation for the maximally exposed individual. Downstream population doses were calculated from the ingestion of water from the Savannah River.

As for the atmospheric assessments, the population was assumed to remain constant over the 70-year period of analysis.

Table 4-21 lists calculated doses resulting from releases to air and water under the Shut Down and Deactivate Alternative. The annual doses (4.2×10^{-4} millirem to the offsite maximally exposed individual and 4.6×10^{-4} person-rem to the offsite population) would be small fractions of the doses from total SRS releases to water in 1995 [0.20 millirem to the maximally exposed member of the public and 5.1 person-rem to the population (Arnett, Mamatey, and Spitzer 1996)].

Table 4-21 also lists the annual and lifetime probability of the maximally exposed individual developing a fatal cancer and the numbers of fatal cancers that could occur in the regional population under the Shut Down and Deactivate Alternative. The probability of the maximally exposed individual dying of cancer as a result of 70 years of exposure to radiation is 9.7×10^{-9}; the number of additional fatal cancers in the regional population for this same exposure period would be 1.0×10^{-5}.

Nonradiological Impacts

Table 4-22 lists the hazard indexes associated with the Shut Down and Deactivate Alternative. Hazard quotients were calculated for atmospheric and aqueous exposure pathways for the current land use scenario.

As listed in Table 4-22, the calculated total hazard index for the maximally exposed individual is a small fraction of one. Therefore, this individual would not be likely to experience adverse health effects. In addition, the lifetime cancer risk to the maximally exposed individual would be 5.6×10^{-7}.

Occupational Health

Radiological Impacts

DOE estimated doses to involved and uninvolved workers for the Shut Down and Deactivate Alternative using the exposure assumptions discussed above with the additional pathway resulting from inhalation of resuspended, dried sediments. The doses and resulting impacts (although still very small) have increased over the No-Action Alternative due to the exposed sediments.

The incremental worker doses (the increase in dose due to activities under the No-Action Alternative) are listed in Table 4-23. These doses

Table 4-21. Radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects to the public.[a]

	No-Action Alternative				Shut Down and Deactivate Alternative			
	Dose[c]				Dose[c]			
Receptor(s)[b]	Atmospheric releases	Aqueous releases	Total	Probability[d] or number of fatal cancers	Atmospheric releases	Aqueous releases	Total	Probability[d] or number of fatal cancers
Offsite maximally exposed individual								
Annual (millirem)	1.5×10^{-4}	NC[e]	1.5×10^{-4}	7.5×10^{-11}	4.0×10^{-4}	1.4×10^{-5}	4.2×10^{-4}	2.1×10^{-10}
Lifetime[f] (millirem)	2.6×10^{-3}	NC	2.6×10^{-3}	1.3×10^{-9}	1.9×10^{-2}	6.7×10^{-4}	1.9×10^{-2}	9.7×10^{-9}
Population								
Annual (person-rem)	1.4×10^{-3}	NC	1.4×10^{-3}	6.8×10^{-7}	4.2×10^{-4}	3.5×10^{-5}	4.6×10^{-4}	2.3×10^{-7}
Lifetime[f] (person-rem)	2.4×10^{-2}	NC	2.4×10^{-2}	1.2×10^{-5}	1.9×10^{-2}	2.3×10^{-3}	2.1×10^{-2}	1.0×10^{-5}

a. See Tables C-9, C-10, C-11, and C-12 in Appendix C.
b. The doses to the public from total SRS operations in 1995 were 0.20 millirem to the offsite maximally exposed individual (0.06 millirem from airborne releases and 0.14 millirem from aqueous releases) and 5.1 person-rem to the regional population (3.5 person-rem from airborne releases and 1.6 person-rem from aqueous releases). Source: Arnett, Mamatey, and Spitzer (1996).
c. For atmospheric releases, the dose is to the population within 50 miles (80 kilometers) of SRS. For aqueous releases, the dose is to the people using the Savannah River from SRS to the Atlantic Ocean.
d. For the offsite maximally exposed individual, probability of a latent fatal cancer; for the population, number of fatal cancers.
e. NC = not calculated for no action.
f. Based on 70 years of exposure. Doses are corrected for decay.

Table 4-22. Nonradiological hazard index and cancer risks associated with the Shut Down and Deactivate Alternative for members of the public.[a]

	No-Action Alternative		Shut Down and Deactivate Alternative			
Receptor(s)	Hazard index[b]	Annual (lifetime)[c] latent cancer risk[d]	Atmospheric release hazard index	Aqueous release hazard index	Total hazard index	Annual (lifetime)[c] latent cancer risk[e]
Offsite maximally exposed individual	6.2×10^{-2}	3.1×10^{-7} (2.1×10^{-5})	6.9×10^{-3}	2.1×10^{-1}	2.2×10^{-1}	8.0×10^{-9} (5.6×10^{-7})

a. Supplemental information is provided in Tables C-13 and C-14 in Appendix C.
b. Future land use scenario.
c. Assumes 70 years of exposure.
d. Resulting from exposure to beryllium in surface water.
e. Resulting from exposure to cadmium, arsenic, and beryllium in contaminated sediments.

represent a small fraction of the DOE limit (10 CFR 835) that require that annual doses to individual workers not exceed 5 rem per year as well as a small fraction of the SRS administrative limit of 0.7 rem per year (WSRC 1995d).

The probability that the average involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation under the Shut Down and Deactivate Alternative and current land use scenario would be 9.7×10^{-8}. For the total involved workforce, the collective radiation dose could produce up to 6.8×10^{-6} additional fatal cancer as the result of a single year's exposure; over the worker's 5-year career, the involved worker population could have 3.2×10^{-5} additional fatal cancer as a result of exposure.

Under the future land use scenario, the probability that the average involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation would be 1.6×10^{-5}. For the total involved workforce, the collective radiation dose could produce up to 1.1×10^{-3} additional fatal cancer as the result of a single year's exposure; over the worker's 25-year career, the involved worker population could have 2.1×10^{-2} additional fatal cancer as a result of exposure.

The probability of any individual uninvolved worker developing a fatal cancer as a result of a single year of exposure would be 5.7×10^{-10}. For the total uninvolved workforce, the collective radiation dose could produce up to an additional 1.4×10^{-7} fatal cancer as the result of a single year's exposure; over the worker's 25-year career, the uninvolved worker population could have an additional 3.5×10^{-6} additional fatal cancers.

Nonradiological Health

Nonradiological health impacts (hazard index) were calculated for the current and future land use scenarios for the involved worker. The exposure pathways and exposure times would be the same as those discussed previously. Table 4-24 lists the results. As listed, the calculated hazard indexes for the maximally exposed involved worker under the current and future land use scenarios (1.1×10^{-2} and 2.1×10^{-1}, respectively) would be a small fraction of one. Therefore, these individuals would be not be likely to experience adverse health effects.

Table 4-23. Worker radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

	No-Action Alternative		Shutdown and Deactivate Alternative	
Receptor(s)	Dose (rem)	Probability[b] or number of fatal cancers	Dose (rem)	Probability[b] or number of fatal cancers
Involved worker (current use)				
Annual[c]	5.0×10^{-8}	2.0×10^{-11}	2.4×10^{-4}	9.7×10^{-8}
Lifetime[d]	2.2×10^{-7}	8.7×10^{-11}	1.1×10^{-3}	4.5×10^{-7}
All involved workers[e] (current use)				
Annual[c] (person-rem)	3.5×10^{-6}	1.4×10^{-9}	1.7×10^{-2}	6.8×10^{-6}
Lifetime[d] (person-rem)	1.5×10^{-5}	6.1×10^{-9}	7.9×10^{-2}	3.2×10^{-5}
Involved worker (future use)				
Annual[c]	1.1×10^{-6}	4.4×10^{-10}	4.1×10^{-2}	1.6×10^{-5}
Lifetime[d]	1.5×10^{-5}	5.9×10^{-9}	7.5×10^{-1}	3.0×10^{-4}
All involved workers[e] (future use)				
Annual[c] (person-rem)	7.7×10^{-5}	3.1×10^{-8}	$2.9 \times 10^{+0}$	1.1×10^{-3}
Lifetime[d] (person-rem)	1.0×10^{-3}	4.1×10^{-7}	5.2×10^{1}	2.1×10^{-2}
Uninvolved worker[f]				
Annual[c]	2.0×10^{-8}	7.8×10^{-12}	1.5×10^{-6}	5.8×10^{-10}
Lifetime[d]	2.6×10^{-7}	1.1×10^{-10}	3.4×10^{-5}	1.4×10^{-8}
All uninvolved workers[g]				
Annual[c] (person-rem)	4.9×10^{-6}	2.0×10^{-9}	3.7×10^{-4}	1.5×10^{-7}
Lifetime[d] (person-rem)	6.6×10^{-5}	2.6×10^{-8}	8.6×10^{-3}	3.4×10^{-6}

a. Supplemental information provided in Tables C-15, C-16, and C-17 in Appendix C.
b. For the offsite maximally exposed individual, probability of a latent fatal cancer; for the population, number of fatal cancers.
c. Annual individual worker doses can be compared with the regulatory dose limit of 5 rem (10 CFR 835) and with the SRS administrative exposure guideline of 0.7 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. The 1995 average dose for all Site workers who received a measurable dose was 256 rem (See Table 4-16).
d. Based on 5 years of exposure for current workers and 25 years of exposure for future and uninvolved workers. Doses are corrected for radioactive decay.
e. The estimated number of involved workers is 70.
f. L-Area.
g. L-Area the estimated number of all uninvolved workers is 251 (Source: Simpkins 1996c).

Table 4-24. Worker nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

	No-Action Alternative		Shutdown and Deactivate Alternative	
Receptor(s)	Annual (lifetime)[b] latent cancer risk[c]	Hazard index	Annual (lifetime)[b] latent cancer risk[d]	Hazard index
Involved worker (current use)	9.1×10^{-9} (4.5×10^{-8})	2.1×10^{-4}	6.6×10^{-8} (3.3×10^{-7})	1.1×10^{-2}
Involved worker (future use)	1.3×10^{-8} (3.1×10^{-7})	4.8×10^{-5}	1.2×10^{-6} (2.9×10^{-5})	2.1×10^{-1}
Uninvolved worker[e]	NC[f]	NC	1.4×10^{-9} (3.6×10^{-8})	1.1×10^{-4}

a. See Tables C-20 and C-21 in Appendix C.
b. Based on 5 years of exposure to the current worker and 25 years of exposure for future and uninvolved workers.
c. Due to exposure to beryllium in surface water.
d. Due to exposure to airborne cadmium, arsenic, and beryllium.
e. L-Area.
f. NC = not calculated; nonradiological constituents are not released under the No-Action Alternative.

For the uninvolved worker assumed to be in L-Area, the calculated hazard index of 1.1×10^{-4} would be a small fraction of 1 and, therefore, this individual would be not be likely to experience adverse health effects. The probability of the uninvolved worker developing a fatal cancer due to a lifetime of exposure would be 3.6×10^{-8}.

TC

4.1.8.2.3 Shut Down and Maintain

For the Shut Down and Maintain Alternative, the water level in L-Lake would be likely to recede to the original Steel Creek stream channel in a similar manner as that described for the Shut Down and Deactivate Alternative. Therefore, the impacts to workers and member of the public under Shut Down and Maintain would be the same as the impacts under Shut Down and Deactivate.

4.2 SRS Streams

Five major tributaries of the Savannah River drain the SRS and eventually flow into the Savannah River (Figure 4-25). The five main stream systems that originate on, or flow through, the SRS before flowing into the Savannah River are Upper Three Runs, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs. A sixth stream, Pen Branch, joins Steel Creek in the Savannah River floodplain swamp.

Upper Three Runs, a relatively deep, fast-flowing blackwater stream, is 24 miles (39 kilometers) long with a 211 square-mile (545 square-kilometer) drainage basin, some of which lies outside the SRS boundary. Beaver Dam Creek is a small, 3-mile- (5-kilometer-) long stream that receives thermal effluent from the D-Area coal-fired powerplant. Fourmile Branch [15 miles (24 kilometers) long; 22 square-mile (57 square-kilometer) drainage basin] received thermal effluent from C-Reactor from 1955 to 1985. Pen Branch [15 miles (24 kilometers) long; 21 square-mile (55 square-kilometer) drainage basin] intermittently received thermal effluent from K-Reactor from 1954 to 1988. Steel Creek [9 miles (15 kilometers) long; 35 square-mile (91 square-kilometer) drainage basin] intermittently received thermal effluent from P- and L-Reactors from 1954 to 1964, and from L-Reactor only from 1964 to 1968. Lower Three Runs is 24 miles (38 kilometers) long with a 178 square-mile (460 square-kilometer) drainage basin; it received thermal effluent from R-Reactor from 1953 until 1958, when its upper reaches were impounded to form Par Pond. These values represent the total area of the drainage basins (Wike et al. 1994).

Before the creation of the two cooling reservoirs (Par Pond in 1958; L-Lake in 1985), water temperatures in Steel Creek and Lower Three Runs ranged from 158°F (70°C) at the reactor outfalls to 104°F (40°C) where the streams entered the Savannah River swamp (Bennett and McFarlane 1983). Water temperatures higher than 104°F (40°C) exclude virtually all species of freshwater fish (Coutant 1977) and greatly reduce species number, abundance, and production of aquatic insects (Wiederholm 1984). In addition to thermal stresses, these streams were subjected to high flows that produced erosion upstream and sedimentation downstream, further altering the community structure of aquatic plants, aquatic macroinvertebrates, and fish. Plant and animal communities in Lower Three Runs recovered when DOE built Par Pond which received heated effluent from P- and R-Reactors. Similarly, biological communities in Steel Creek began to recover when DOE placed L-Reactor on standby in 1968.

Each stream has a floodplain characterized by bottomland hardwood forests or scrub-shrub wetlands in varying stages of succession. Dominant species include red maple (*Acer rubrum*), box elder (*A. negundo*), bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), sweetgum (*Liquidambar styraciflua*), and black willow (*Salix nigra*). The Savannah River floodplain swamp covers about 12,148 acres (49 square kilometers) of the Site. Most of the old-growth timber was cut in the swamp in the late 1800s. At present, the swamp forest consists of second-growth bald cypress, black gum (*Nyssa sylvatica*), and other hardwood species (Workman and McLeod 1990).

4.2.1 GEOLOGY AND SOILS

4.2.1.1 Affected Environment

This section describes the character of the geology and soils along SRS streams. The alternatives for the proposed action could affect four streams: Pen Branch, Fourmile Branch, Steel Creek, and Lower Three Runs. Pen Branch, Fourmile Branch, and Steel Creek would be affected by the elimination of river water discharges to these streams.

TC

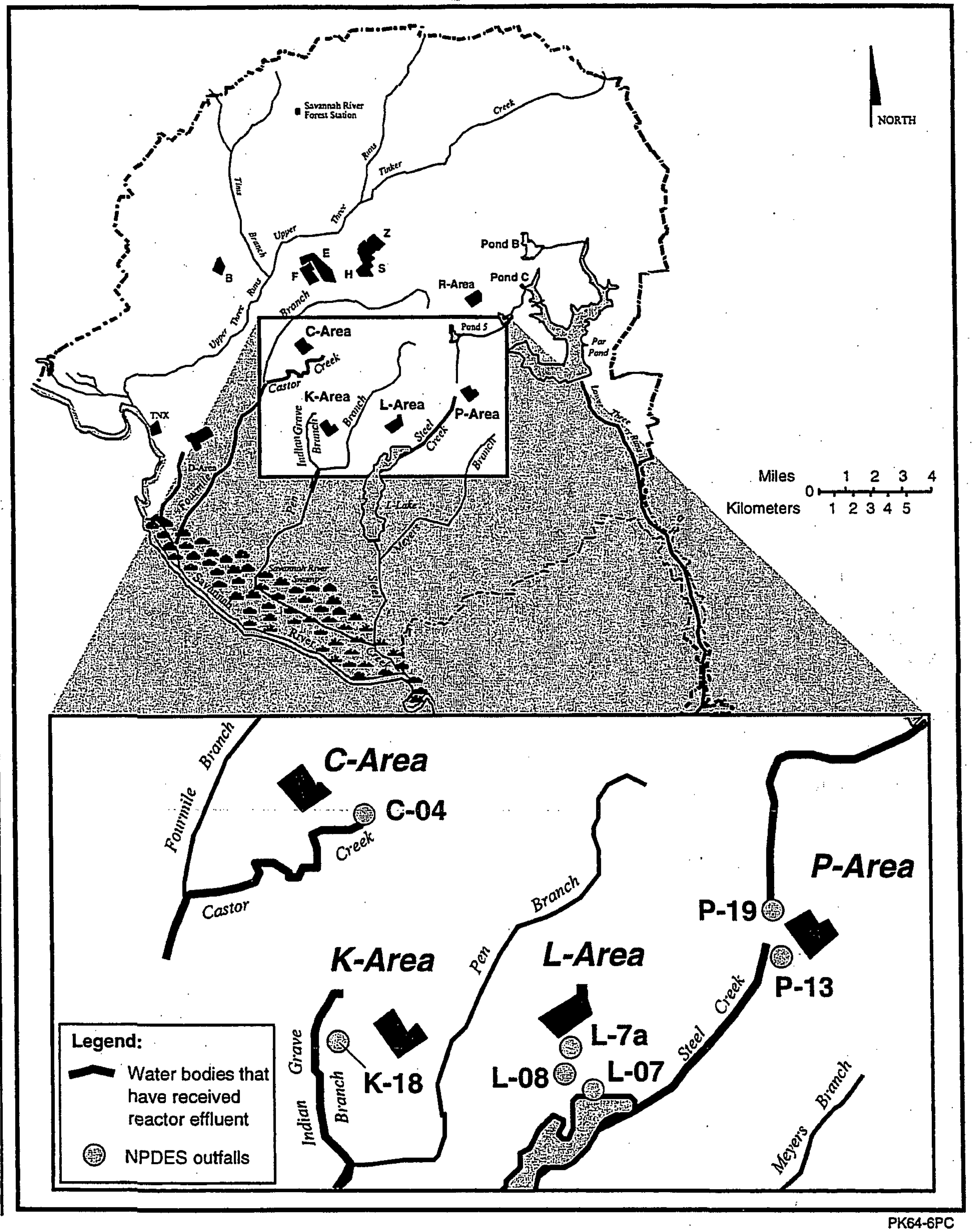


Figure 4-25. Surface water features at the Savannah River site showing water bodies that have received reactor effluent.

Stratigraphy

The geologic units near or intersecting the SRS streams are as follows (Prowell 1994):

- Pen Branch – The Tobacco Road and Dry Branch Formations are exposed in the stream valley.
- Fourmile Branch – The Tobacco Road and Dry Branch Formations are exposed in the stream valley.
- Lower Three Runs – The Tobacco Road and Dry Branch Formations are exposed in the watersheds.
- Steel Creek – The Tobacco Road Formation outcrops along most of the lower end of L-Lake; the Dry Branch Formation outcrops upstream of the lake and downstream of the dam.

Soils

The more common soil mapping units near SRS streams are listed below and illustrated in Figures 4-7, 4-8, and 4-9 (USDA 1990). TE

- Blanton sand, 0-6 percent slopes (BaB)
- Blanton sand, 6-10 percent slopes (BaC)
- Pickney sand, frequently flooded (Pk)
- Troup sand, 0-6 percent slopes (TrB)
- Troup sand, 10-15 percent slopes (TrD)
- Troup sand, 15-25 percent slopes (TuE)

4.2.1.2 <u>Environmental Impacts</u>

4.2.1.2.1 No Action

There would be no effects from this alternative on Pen Branch, Fourmile Branch, or Lower Three Runs soils or geology. The current rate of erosion or accretion of soils by stream action in Steel Creek below the dam would continue, and there would be no effect on the geology related to this watershed.

4.2.1.2.2 Shut Down and Deactivate

This alternative would affect the soils and geology in the streams because the shut down of the River Water System would discontinue outfall discharges; the presence or absence of water would alter the presence and probably the type of nearby soils (i.e., erosion or accretion). TC Stream conditions downstream of the dam would not change because DOE would regulate the flow rate from the dam as the lake recedes, after which the stream would return to its pre-lake flow rate [estimated to average 10 cubic feet (0.28 cubic meter) per second] (del Carmen and Paller 1993a). In the part of the watershed currently covered by the lake, soil erosion would initially increase along the sides of the Steel Creek stream valley. This erosion should decrease as vegetation reclaims the slopes. Although the area would revegetate naturally, DOE would encourage revegetation by seeding.

There would be no effects on Lower Three Runs. The Par Pond water level would remain near full pool due to groundwater discharge to the reservoir and thereby maintaining the level of discharge into the stream. TE

4.2.1.2.3 Shut Down and Maintain

The impacts discussed above for the Shut Down and Deactivate Alternative would apply to this alternative.

4.2.2 SURFACE WATER

4.2.2.1 <u>Affected Environment</u>

The streams that received heated effluents from the River Water System are Fourmile Branch via Castor Creek, Pen Branch via Indian Grave Branch, Steel Creek, and Lower Three Runs (see Figure 4-25). Section 4.2 describes these streams and their watersheds. L10-09

In August 1995 DOE prepared an environmental assessment (EA; DOE 1995a) that addressed the impact of reducing the flow from L-Lake to

Steel Creek to 10 cubic feet (0.28 cubic meter) per second, which was its historic flow level. The EA concluded that reducing Steel Creek to this level would recreate stream conditions that existed before the impoundment of L-Lake. DOE later issued a Finding of No Significant Impact (DOE 1995b).

L10-09 Discharges to site streams from the River Water System during September 1996 are presented in Table 4-25 (Melendez 1996). The concentration of contaminants in affected streams would increase due to removal of these discharges. Tritium does not present a major contribution to risk under the alternatives in this EIS. Further more, none of the alternatives presented in this EIS would increase the risk of tritium release offsite. However, tritium is a primary sitewide constituent of concern with regard to the maximum exposed offsite individual and the onsite exposed worker. Tritium concentrations in the affected streams were measured in September 1996 (Fledderman 1997). Table 4-26 presents this information and corresponding stream flows as well as the prediction tritium concentrations under No Action and the shutdown alternatives. Human health and ecological impacts associated with increased tritium concentrations are discussed in Section 4.2.8 and Appendix B, respectively.

TE **Table 4-25.** Discharges to onsite streams (cubic feet per second).

Stream	September 1996	No Action	Shutdown
Steel Creek (headwaters via P-13)	8.6	0	0
L-Lake (via L-07)	36.7	10.7	0.9[a]
Lower Three Runs	0	0	0
Fourmile Branch (via C-004 to Castor Creek)	0.6	0	0
Pen Branch (via K-18 to Indian Grave Branch)	16.5	0.9[b]	0.9[a]
Total Discharge	62.4	11.6	1.8

L10-09

a. Maximum well water discharge.
b. Includes 0.45 cubic feet per second river water and 0.45 cubic feet per second maximum well water.

TE **Table 4-26.** Total flows and tritium concentrations in onsite streams.

	Total downstream of confluence (cfs)			Tritium concentration (pCi/ml)		
Stream	September 1996	No Action	Shutdown	September 1996	No Action	Shutdown
Steel Creek (above Road B)	4.96	3	3	NA[a]	NA	NA
Steel Creek (below L-Lake)	44.5	10	10	10.65	47.4	47.4
Steel Creek at Road A (includes Meyers Branch)	69	34.5	34.5	6.87	13.7	13.7
Lower Three Runs (below Par Pond)	22.3	10	10[b]	1	2.2	2.2
Fourmile Branch at Road A-12.2	19.9	19.3	19.3	227	234	234
Pen Branch at Road A-13.2	34.4	18.8	18.8[c]	62.8	115	115

L10-09

a. NA = Not available.
b. Minimum release for no action and shutdown.
c. Discharges and base flow from Indian Grave Branch is included.

Indian Grave Branch/Pen Branch

Pen Branch follows a southwesterly path from its headwaters about 2 miles (3.2 kilometers) northeast of K-Area to the Savannah River swamp (Figure 4-25). After entering the swamp, the creek flows parallel to the river for about 5 miles (8 kilometers) before it enters and mixes with the waters of Steel Creek about 0.2 mile (0.3 kilometer) from the mouth of that stream. In its headwaters, Pen Branch is a largely undisturbed blackwater stream, similar to the headwater reaches of Fourmile Branch. Indian Grave Branch is a tributary of Pen Branch. | TE

Effluents Contribution – Until K-Reactor shutdown in 1988, Indian Grave Branch received thermal effluent from K-Reactor. With reactor discharge, the natural flow of about 10 cubic feet (0.28 cubic meter) per second increased to about 400 cubic feet (11.3 cubic meters) per second. At present, Indian Grave Branch receives nonthermal effluents (i.e., nonprocess cooling water, ash basin effluent waters, powerhouse waste water, and sanitary waste water) from K-Area and sanitary effluent from the Central Shops Area (Wike et al. 1994).

Flow – From July through September 1996, the average discharge from the K-11 (K-Reactor) outfall to Indian Grave Branch was 16.6 cubic feet (0.47 cubic meter) per second (Melendez 1996). Stream discharge in Indian Grave Branch upstream from the discharge canal averaged 1.35 cubic feet (0.04 cubic meter) per second during Water Year 1994 (Wike et al. 1994). Flow in Pen Branch upstream of the confluence with Indian Grave Branch averaged 7.7 cubic feet (0.22 cubic meter) per second from 1983 through 1991 (Table 4-27). During Water Years 1994 and 1995 the discharges in Pen Branch at Road A-13.2 (Figure 4-26) averaged 50.9 cubic feet (1.4 cubic meters) per second and 55.8 cubic feet (1.6 cubic meters) per second respectively (Wike et al. 1994; USGS 1996). | TE

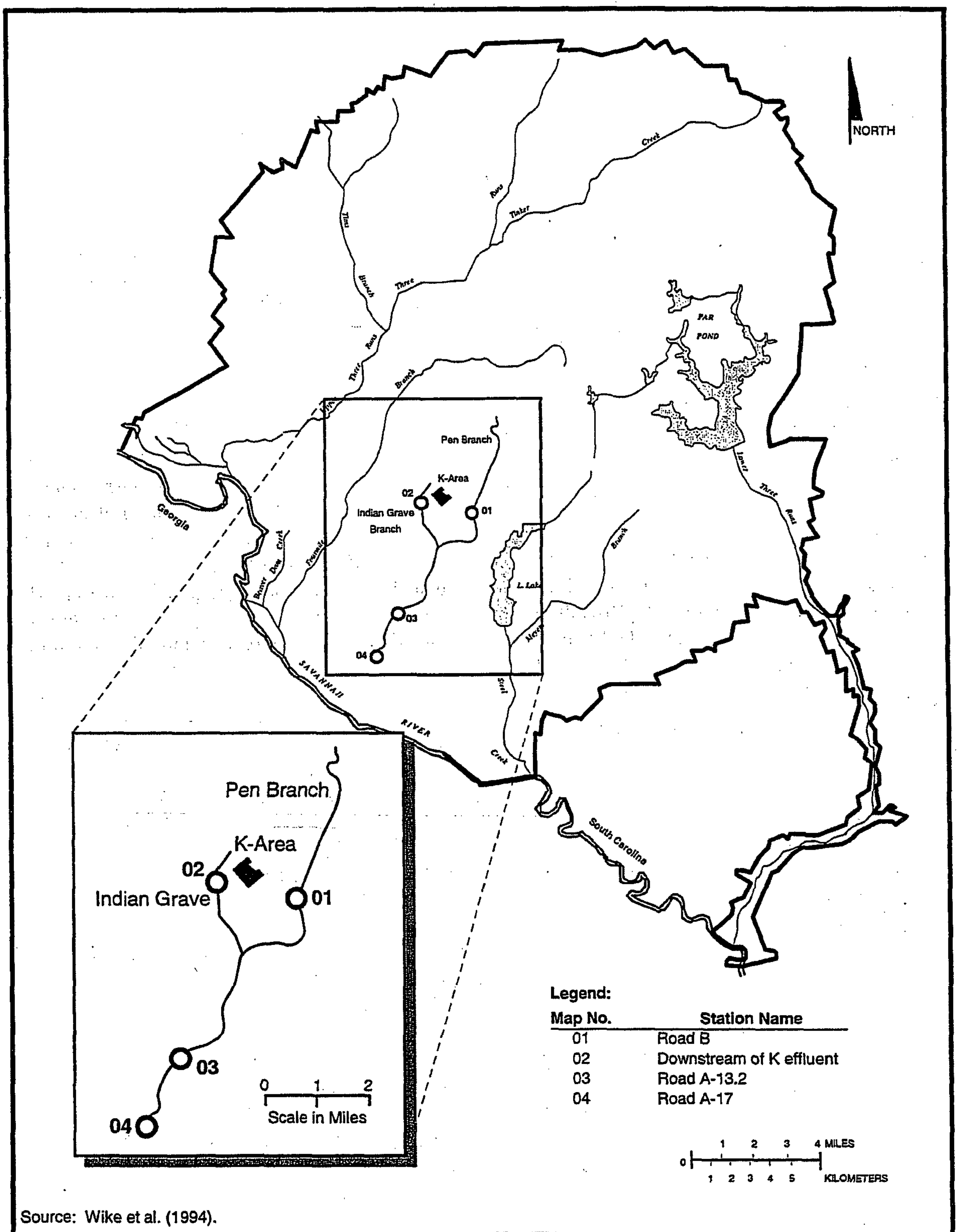
Water Temperature – During reactor operation, mean temperatures [93° to 118°F (33.5° to 48.1°C)] (Wike et al. 1994) in thermal portions of Pen Branch ranged from 64° to 91°F (18 to 33°C) above those of the upstream nonthermal waters (Table 4-28). The temperatures at the thermal sites fluctuated more widely than those of the nonthermal sites because of the reactor cycle. The shutdown of K-Reactor in 1987 resulted in a decrease in temperatures in the Pen Branch System to an average of 72°F (22°C) (Wike et al. 1994). | TE

Dissolved Oxygen – Dissolved oxygen concentrations in natural waters are inversely related to water temperature, as reflected in the data obtained during the 1987 Comprehensive Cooling Water Study. The mean dissolved oxygen concentrations in the thermal waters were much lower (5.3 to 7.5 milligrams per liter or 87 to 90 percent saturation) than those at the nonthermal site. The mean dissolved oxygen concentration was 8.12 milligrams per liter at the Pen Branch nonthermal site (Table 4-29; Wike et al. 1994). Because there has been no thermal input to the Pen Branch system for 5 years, the mean dissolved oxygen concentration of 8.5 milligrams per liter at Road A-17 is now similar to the concentrations measured at the nonthermal site during the Comprehensive Cooling Water Study (Wike et al. 1994). | TE | TE

Table 4-27. Flow summary for Pen Branch (cubic feet per second).[a,b] | TE

Station name	Period of record	Range: Mean	Low	High	7Q10	7-day low flow
Road B	1983-1991	7.7	0.2	372	0.36	0.22
Road A-13.2	1976-1991	273[c]	20	760[c]	25.4	22

a. Source: Wike et al. (1994).
b. To convert cubic feet to cubic meters, multiply by 0.028317.
c. High flows are the flows of reactor cooling water discharge.



Source: Wike et al. (1994).

PK64-2PC

Figure 4-26. Flow measurement sampling stations for Pen Branch.

Table 4-28. Pen Branch field data (CCWS).[a,b] | TE

Location	Water temperature (°C)	pH	Stream maximum depth (cm)[c]	Stream velocity (cm/sec)
01 Pen Branch at Road B				
Mean	15.2	6.93	75	48
Range	1.4-24.0	5.10-9.00	40-164	9-140
Samples	46	46	28	40
02 Indian Grave Branch downstream of K-Reactor effluent				
Mean	48.1	7.42	100	183
Range	7.6-68.0	5.90-8.70	31-143	45-260
Samples	46	46	34	
03 Pen Branch at Road A-13.2				
Mean	42.6	7.42	119	124
Range	7.1-60.0	5.60-8.59	91-127	7-180
Samples	45	44	28	39
04 Pen Branch at Road A-17				
Mean	33.5	8.11	29	15
Range	7.90-46.3	5.70-9.25	23-41	-15-140
Samples	46	45	21	39

a. Source: Wike et al. (1994).
b. CCWS = Comprehensive Cooling Water Study.
c. To convert centimeters to inches, multiply by 0.3937.

Castor Creek/Fourmile Branch

Fourmile Branch receives effluents from F-, H-, and C-Areas (Figure 4-27). Before DOE placed C-Reactor in standby in 1985, heated Savannah River water discharged from C-Reactor to Fourmile Branch via Castor Creek (Wike et al. 1994).

Flow – At present, C-Area receives only a small amount of river water, from valve leakage that ultimately discharges to Fourmile Branch (Gladden 1996b). During Water Year 1996, this discharge (at C-003) averaged 0.59 cubic foot (0.017 cubic meter) per second (Melendez 1996). Upstream from the confluence of the C-Area discharge with Fourmile Branch at monitoring station A-7 (see Figure 4-27), the Fourmile Branch discharge averaged 14.7 cubic feet (0.42 cubic meter) per second in Water Year 1994 (Wike et al. 1994) and 21.3 cubic feet (0.6 cubic meter) per second in Water Year 1995 (USGS 1996). Similar flows have been observed in past years; the average discharge at Road A-7 for 1972 to 1991 was 17.8 cubic feet (0.50 cubic meter) per second (Table 4-30). | TE

Temperature – Since the shutdown of C-Reactor, temperatures in Fourmile Branch at Road A ranged from 43° to 88°F (6.2° to 31°C) and averaged 65°F (18.5°C). The wide temperature fluctuations reflect seasonal differences. Temperatures upstream, at Road A-7, reflect a similar range [43° to 79°F (6.4° to 26°C)] and

TE | **Table 4-29.** Pen Branch physical characteristics and general chemistry (CCWS).[a,b]

Location	Dissolved oxygen (mg/l)	Specific conductance (μmhos/cm)[c]	Turbidity (NTU)	Total suspended solids (mg/l)
01 Pen Branch at Road B				
Mean	8.12	45.6	10.6	9.63
Range	5.80-12.3	28.2-75.0	3.10-52.2	0.25-72.4
Samples	46	38	43	45
02 Indian Grave Branch downstream of K-Reactor effluent				
Mean	5.32	74.6	21.4	10.0
Range	2.70-11.5	50.7-90.1	7.30-61.5	0.25-43.2
Samples	45	36	43	45
04 Pen Branch at Road A-17				
Mean	7.53	71.9	14.6	4.63
Range	5.50-12.3	47.7-98.3	3.8-57.4	0.25-36.7
Samples	45	38	43	45

a. Source: Wike et al. (1994).
b. CCWS = Comprehensive Cooling Water Study.
c. To convert centimeters to inches, multiply by 0.3937.

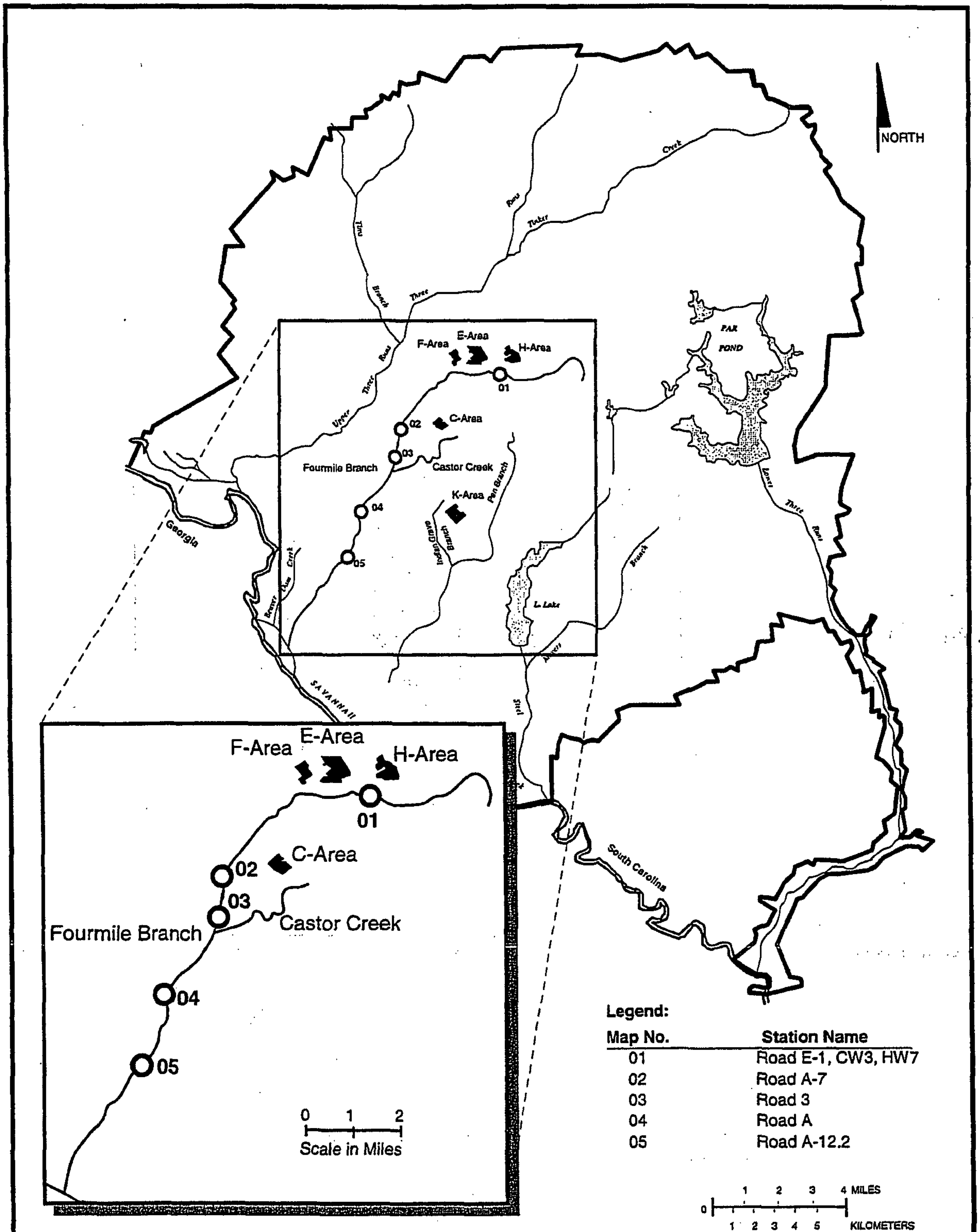
TE | an average of 63°F (17°C) (see Table 4-31; Wike et al. 1994).

Dissolved Oxygen – From 1987 to 1991, dissolved oxygen concentrations in Fourmile Branch at Road A-7 ranged from 5.0 to TE | 12.0 milligrams per liter (Table 4-32). Concentrations of dissolved oxygen are directly related to water temperature and the wide ranges listed are the result of seasonal temperature fluctuations (Wike et al. 1994).

Steel Creek

The headwaters of Steel Creek originate near P-Reactor (Figure 4-25). Flow from the outfall of the L-Lake Dam travels about 3 miles (5 kilometers) through the Steel Creek corridor before entering the Savannah River Swamp and then another 2 miles (3.2 kilometers) before entering the Savannah River. At present, the headwaters of Steel Creek (at P-Area) receive treated effluent from the P-Area sanitary water treatment facility combined with river water overflow from the P-Area 186-Basin (Wike et al. 1994). Since DOE diverted P-Area flow from Par Pond to Steel Creek, this discharge (March through September 1996) has averaged 8.6 cubic feet (0.24 cubic meter) per second (Melendez 1996).

DOE began an extensive water quality monitoring study, the L-Lake/Steel Creek Biological Monitoring Program, after the construction of L-Lake. This study assessed various components of the Steel Creek system and identified changes due to the operation of L-Reactor or discharges from L-Lake. DOE placed sampling stations throughout the Steel Creek corridor, marsh, swamp, and channel (Figure 4-28). TE | Table 4-33 lists the range of values for 34 water quality parameters for Steel Creek from November 1985 to December 1991 (Wike et al. 1994). In addition, sampling at Road A is part of routine SRS monitoring.



Source: Wike et al. (1994).

PK64-2PC

Figure 4-27. Flow measurement and water quality sampling stations on Fourmile Branch.

TE | **Table 4-30.** Flow summary for Fourmile Branch (cubic feet per second).[a,b]

Station	Period of record	Range				
		Mean	Low	High	7Q10	7-day low flow
Road A-7	1972-1991	17.8	2.7	830	4.9	3.2
Road A-12.2	1976-1991	208	6.7	1200	11.1	7.6

a. Source: Wike et al. (1994).
b. To convert cubic feet to cubic meters, multiply by 0.028317.

TE | **Table 4-31.** Fourmile Branch field data.[a]

Sampling location	Water temperature (°C)	pH	Stream maximum depth (cm)[b]	Stream velocity (cm/sec)
<u>01 Fourmile Branch at Road E-1</u>	(CCWS)[c]			
Mean	16.8		48	73
Range	1.3-28.5	5.10-8.10	19-199	7-250
Samples	46		33	41
<u>02 Fourmile Branch at Road A-7</u>	(1987-1991)			
Mean	17	(d)		
Range	6.4-26	5.4-8.1	NA[e]	NA
Samples	60			
<u>03 Fourmile Branch at Road 3</u>	(CCWS)			
Mean	16.9		147	9
Range	0.1-27.0	5.30-8.30	121-193	1-45
Samples	46		36	37
<u>04 Fourmile Branch at Road A</u>	(1987-1991)			
Mean	18.5			
Range	6.2-31	3.1-8.5		
Samples	60		NA	NA
<u>05 Fourmile Branch at Road A-12.2</u>	(CCWS)			
Mean	39.4			73
Range	9.6-52.0	5.90-9.05	NA	14-100
Samples	46			41

a. Source: Wike et al. (1994).
b. To convert centimeters to inches, multiply by 0.3937.
c. CCWS = Comprehensive Cooling Water Study.
d. Blank spaces = Mean not calculated due to insufficient data in report.
e. NA = Not analyzed.

Table 4-32. Fourmile Branch physical characteristics and general chemistry.[a] | TE

Location	Dissolved oxygen (mg/l)	Specific conductance (μmhos/cm)	Turbidity (NTU)	Total suspended solids (mg/l)
01 Fourmile Branch at Road E-1	(CCWS)[b]			
Mean	6.79	24.3	10.1	13.8
Range	2.30-11.6	12.5-40.7	1.3-60	0.25-270
Samples	46	38	43	45
02 Fourmile Branch at Road A-7	(1987-1991)			
Mean	8.4	56.5	8.2	5.1
Range	5.0-12	0.15-112	1.0-42	0.0-27
Samples	60	60	60	60
03 Fourmile Branch at Road 3	(CCWS)			
Mean	7.81	70.0	20.8	7.82
Range	5.20-12.40	31.5-96.9	0.3-394.0	0.25-152.10
Samples	46	38	43	44
04 Fourmile Branch at Road A	(1987-1991)			
Mean	7.9	44.3	5.2	3.1
Range	6.5-12	11-103	1.0-23	1.0-47
Samples	60	60	60	60
05 Fourmile Branch at Road A-12.2	(CCWS)			
Mean	5.99	87.0	18.5	9.31
Range	3.50-11.8	59.3-108.2	4.3-118.0	0.25-109.70
Samples	46	45	43	45

a. Source: Wike et al. (1994).
b. CCWS = Comprehensive Cooling Water Study.

Flow – During Water Year 1996, the mean flow at Road A was 59.2 cubic feet (1.7 cubic meters) per second (Melendez 1996). The mean flow for 1985 to 1991 was 185 cubic feet (5.2 cubic meters) per second (Table 4-34). The mean flow at the L-Lake outfall for Water Year 1996 was 41.5 cubic feet (1.2 cubic meters) per second (Melendez 1996). | TE

As previously discussed in this section, DOE prepared an EA in 1995 (DOE 1995a) that addressed the impact of reducing the flow from L-Lake to Steel Creek to 10 cubic feet (0.28 cubic meter) per second. The EA concluded that reducing the Steel Creek flows would result in the reestablishment of stream conditions that existed before the creation of SRS.

Steel Creek flows below the L-Lake dam have averaged 41.5 cubic feet (1.17 cubic meters) per second (Water Year 1996) during a period when one river water pump operated continuously, pumping approximately 28,000 gallons per minute (1.8 cubic meters per second) to the reactor areas (Melendez 1996). The surplus water from the reactor areas (overflow from 186-Basins) discharged to L-Lake, along with flows from

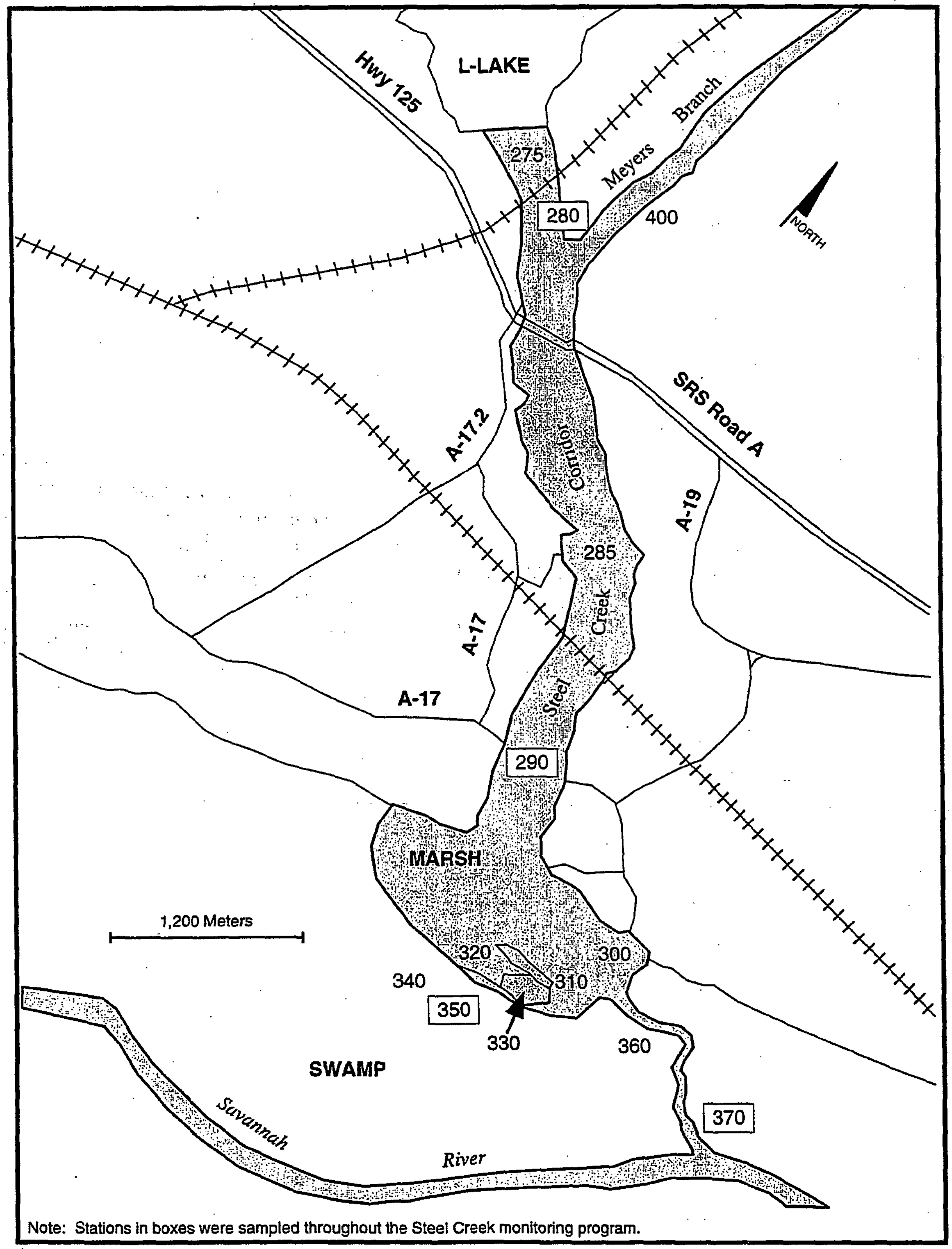


Figure 4-28. Locations of Steel Creek water quality sampling stations as indicated by station numbers 275-370.

Table 4-33. Water quality data (range of values) for Steel Creek (November 1985-December 1991).[a] | TE

	Steel Creek (1985-1986)		Steel Creek (1987-1991)	
Parameter	Corridor	Swamp/Delta	Corridor	Swamp/Delta
Temperature (°C)	10.9-29.9	7.6-27.7	6.6-29.3	1.3-28.9
Dissolved oxygen (mg/l)	4.9-11.1	0.6-11.4	4.7-13.0	1.9-12.5
pH	5.4-6.2	4.8-7.3	5.3-8.5	5.0-7.7
Conductance (μS/cm)	41-97	22-135	18-126	23-114
Total dissolved solids (mg/l)	29-74	7-84	27-83	23-91
Total suspended solids (mg/l)	<1-204	4-40	1-59	<1-148
Total organic carbon (mg/l)	4-12	3-13	1-8	1-19
Dissolved organic carbon (mg/l)	4-9	3-12	2-10	1-17
Total inorganic carbon (mg/l)	2-8	1-13	2-6	2-10
Alkalinity (mg/l)	6.4-23.7	1.8-50.0	9-23	7-37
Ortho-phosphate (mg/l)	<5-87	<5-51	<5-136	5-67
Total phosphate (mg/l)	18-343	8-154	19-180	19-494
Nitrite (mg/l)	1-20	<1-5	<1-82	1-13
Nitrate (mg/l)	<10-402	<10-582	<10-611	<10-366
Ammonia (mg/l)	11-764	<10-190	<10-1,080	<10-157
Total inorganic nitrogen (mg/l)	27-808	21-664	17-1,119	<10-407
Silica (mg/l)	3.2-10.7	1.2-13.3	0.8-9.7	0.6-19.1
Total aluminum (mg/l)	<100-991	<100-1,210	<100-1,216	<100-449
Dissolved aluminum (mg/l)	<100-905	<100-1,270	<100-202	<100-240
Total calcium (mg/l)	2.6-4.4	2.7-11.5	311-4.8	2.6-7.8
Dissolved calcium (mg/l)	2.8-5.8	2.4-11.1	1.1-4.8	1.9-7.8
Total iron (mg/l)	0.1-3.8	0.3-7.4	0.1-1.2	0.2-4.3
Dissolved iron (mg/l)	<0.1-3.2	0.1-0.7	<0.1-1.1	<0.1-2.7
Total magnesium (mg/l)	0.74-1.94	0.64-2.66	0.77-1.40	0.78-1.87
Dissolved magnesium (mg/l)	0.70-2.01	0.62-2.59	0.87-1.46	0.84-1.83
Total manganese (mg/l)	<20-563	<20-3,590	<20-310	<20-4,173
Dissolved manganese (mg/l)	<20-466	<20-3,590	<20-311	<20-4,067
Total potassium (mg/l)	1.06-1.98	0.45-4.12	0.87-1.92	0.79-4.28
Dissolved potassium (mg/l)	1.00-1.94	0.38-3.35	0.24-1.96	0.54-4.45
Total sodium (mg/l)	4.0-13.1	6.0-14.6	4.1-13.5	5.1-13.1
Dissolved sodium (mg/l)	3.7-12.1	6.0-14.8	6.9-13.6	5.4-13.3
Chloride (mg/l)	7-8	6-10	4.0-11	3-12
Hydrogen sulfide (mg/l)	<0.1	<0.1	<0.1	<0.1
Sulfate (mg/l)	3-11	1-12	1-9	1-12

a. Source: Wike et al. (1994).

TE | **Table 4-34.** Flow summary for Steel Creek (cubic feet per second).[a,b]

Station	Period of record	Range				
		Mean	Low	High	7Q10	7-day low flow
Road A at SRS	1985-1991	185	7.7	500	12.9	11.6

a. Source: Wike et al. (1994).
b. To convert cubic feet to cubic meters, multiply by 0.028317.

P-Area and natural inflows from the Steel Creek watershed.

Temperature – Since the construction of L-Lake, Steel Creek water temperatures measured at the Road A monitoring station have been similar to preconstruction conditions, ranging from 45° to 86°F (7.1° to 30°C), with expected seasonal fluctuations, and an average of 66°F (19°C). Similar temperatures occurred throughout the Steel Creek corridor (Wike et al. 1994). The mean temperature at the L-Lake outfall during 1992 was 66°F (19°C), the minimum was 49°F (9°C), and the maximum was 84°F (29°C) (Wike et al. 1994). These readings were similar to values recorded in previous years (1990 and 1991).

pH measurements – The pH of Steel Creek at Road A ranged from 5.6 to 8.3 during the period from 1987 to 1991. Before the construction of L-Lake, pH measurements were comparable, ranging from 6 to 8 (Wike et al. 1994). The 1992 mean (6.5), minimum (5.7), and maximum (7.9) pH values at the L-Lake outfall were similar to the values for 1990 and 1991 (Wike et al. 1994).

Dissolved Oxygen – Dissolved oxygen concentrations at the Steel Creek Road A station from 1987 to 1991 ranged from 5 to 12 milligrams per liter (Wike et al. 1994). In the Steel Creek swamp, dissolved oxygen concentrations as low as 0.6 milligram per liter were recorded. Dissolved oxygen measurements for 1992 were a minimum of 7.4 milligrams per liter, a mean of 9.5 milligram per liter, and a maximum of 12.4 milligrams per liter (Wike et al. 1994). These readings were similar to measurements from previous years (Wike et al. 1994). Seasonal fluctuations occur because the solubility of oxygen in fresh water is inversely proportional to the temperature.

Total Suspended Solids and Turbidity – Mean total suspended solids (TSS) and turbidity levels in Steel Creek at Road A were 5.3 milligrams per liter and 3.7 NTU, respectively, from 1987 to 1991 (Wike et al. 1994). These levels were within the ranges measured before the construction of L-Lake.

On several occasions (November and December 1985, May and September 1986, February 1987, July 1988, and February 1989), TSS levels at Steel Creek corridor stations between the dam and the delta were considerably above normal, TE | as high as 204 milligrams per liter (Table 4-33). These concentrations might have been related to high TSS levels in L-Lake discharge waters, the increased discharge volume from L-Lake, or storm events that eroded the bank and increased sediment transport at a particular station. Mean TSS values did not exceed 5 milligrams per liter during 1992. Baseline TSS levels in Steel Creek were similar to levels in Meyers Branch, a tributary to Steel Creek (Wike et al. 1994).

Major Anions and Cations – Alkalinity concentrations in Steel Creek at Road A ranged from 1 to 21 milligrams of calcium carbonate per liter from 1987 to 1991. Mean chloride and sulfate concentrations measured from 1987 to 1991 at Road A were 6.7 and 6.9 milligrams per liter, respectively (Wike et al. 1994).

From 1987 to 1991 calcium concentrations at Road A ranged from 1.9 to 3.8 milligrams per liter and sodium concentrations ranged from 5.4 to 11.0 milligrams per liter (Wike et al. 1994).

Magnesium concentrations ranged from 0.89 to 1.4 milligrams per liter.

From 1987 to 1991 aluminum ranged from less than 0.01 to 0.16 milligram per liter, iron ranged from less than 0.02 to 0.26 milligram per liter, and manganese ranged from less than 0.01 to 0.17 milligram per liter at Road A (Wike et al. 1994).

Nutrients – Total phosphorus is the only form of phosphorus measured as part of the routine water quality monitoring program. From 1987 to 1991 the mean total phosphorus concentrations in Steel Creek at Road A was 0.032 milligram per liter, and the range was less than 0.01 to 0.36 milligram per liter (Wike et al. 1994). Similar ranges occurred in the corridor and swamp.

Organic nitrogen, ammonia, and nitrate are measured as part of the routine water quality monitoring program in Steel Creek at Road A. The means for these forms of nitrogen were as follows: organic nitrogen - 0.37 milligram per liter; ammonia - 0.076 milligram per liter; and nitrate - 1.00 milligram per liter (Wike et al. 1994).

Priority Pollutants – A special study to determine the levels of volatile, acid, and base/neutral organics in Steel Creek determined that concentrations of all 88 tested organics were below detection limits at both the Road B and Road A sampling locations (Wike et al. 1994).

Pesticides, Herbicides, and PCBs – Water samples are collected annually from Steel Creek at Road A as part of the routine water quality monitoring program and analyzed for pesticides, herbicides, and PCBs. From 1987 to 1991 no analytes were detected in Steel Creek (Wike et al. 1994).

Steel Creek Chemical Assessment

Water quality values during the Steel Creek Biological Monitoring Program were similar to the range of values reported for other regional lotic systems, and typical of southeastern waters in general (Wike et al. 1994).

During parts of the study, downstream gradients were observed between corridor Stations 275 and 290 (Figure 4-28) for temperature; dissolved oxygen; pH; total organic and inorganic carbon; ortho- and total phosphorus; nitrite-nitrogen, nitrate-nitrogen, and ammonia-nitrogen; total inorganic nitrogen; silica; total aluminum; total and dissolved iron; total and dissolved sodium; chloride; total and dissolved magnesium; total and dissolved potassium; and total and dissolved calcium. These differences were attributed to such natural conditions as cooling, metabolic activity of stream organisms, or chemical reactions (Wike et al. 1994).

Pre- and postimpoundment data for 1985 to 1989 indicated that increases in temperature, conductivity, total phosphorus, nitrate-nitrogen, ammonia-nitrogen, total and dissolved sodium, and chloride, and decreases in pH have occurred in relation to preimpoundment conditions documented during the Comprehensive Cooling Water Study. These changes reflected differences between releases of water from L-Lake (dominated by Savannah River water) and the natural drainage of the Steel Creek basin (Wike et al. 1994).

Lower Three Runs

From the Par Pond Dam, Lower Three Runs flows about 15 miles (24 kilometers) before it enters the Savannah River (Wike et al. 1994).

Water Quality – Lower Three Runs is a nonthermal stream with water temperatures that vary seasonally, but usually remain below 31°C (88°F) (Wike et al. 1994). Tables 4-35 and 4-36 list water quality data, and Figure 4-29 shows the locations of sampling stations. The greatest pH range among the Lower Three Runs sampling locations (5.5 to 8.8) occurred at Road B (just below the dam). The lowest dissolved oxygen concentration (2.4 milligrams per liter) was also at Road B; downstream dissolved TE

TE | **Table 4-35.** Lower Three Runs field data.[a]

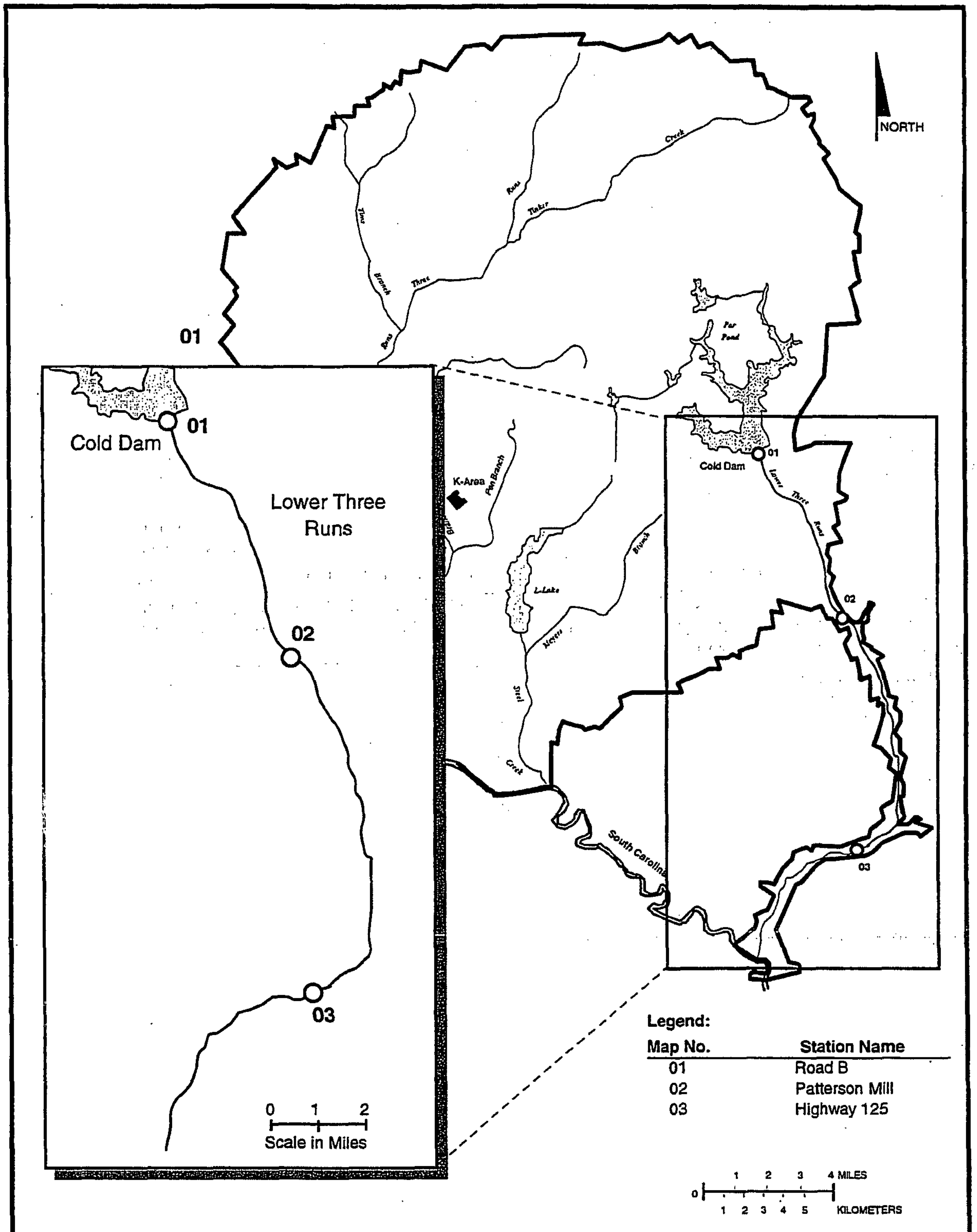
Sampling location	Water temperature (°C)	pH	Stream maximum depth (cm)[b]	Stream velocity (cm/sec)
01 Fourmile Branch at Road B	(CCWS)[c]			
Mean	19.3	6.94	41	34
Range	7.0-31.0	5.50-8.80	21-89	4-120
Samples	46	46	28	38
02 Lower Three Runs at Patterson Mill	(CCWS)			
Mean	16.2	7.17	69	19
Range	1.5-25.0	5.90-8.50	48-117	4-60
Samples	46	46	30	39
02 Lower Three Runs at Patterson Mill	(1987-1991)			
Mean	18	(d)		
Range	7.7-29.0	5.9-7.4	NA[e]	NA
Samples	60	60		
03 Lower Three Runs at US Highway 125	(CCWS)			
Mean	16.0	7.17	222	11
Range	1.5-24.7	6.10-8.40	195-283	2-50
Samples	60	46	19	39

a. Source: Wike et al. (1994).
b. To convert centimeters to inches, multiply by 0.3937.
c. CCWS = Comprehensive Cooling Water Study.
d. Blank spaces - Mean not calculated due to insufficient data in report.
e. NA = Not analyzed.

TE | **Table 4-36.** Lower Three Runs physical characteristics and general chemistry.[a]

Sampling location	Dissolved oxygen (mg/l)	Specific conductance (µmhos/cm)	Turbidity (NTU)	Total suspended solids (mg/l)
01 Lower Three Runs at Road B	(CCWS)[b]			
Mean	7.06	74.1	6.1	4.11
Range	2.40-10.2	56.9-134.8	1.2-37.0	0.25-28.4
Samples	46	38	43	44
02 Lower Three Runs at Patterson Mill	(CCWS)			
Mean	7.51	86.3	3.5	5.40
Range	5.20-11.9	46.6-125.4	1.1-13.5	0.25-69.2
Samples	46	38	43	44
02 Lower Three Runs at Patterson Mill	(1987-1991)			
Mean	8.0	75	2.8	4.9
Range	5.8-11	13-140	0.94-38	1-34
Samples	60	60	60	60
03 Lower Three Runs at US Highway 125	(CCWS)			
Mean	7.30	82.5	6.3	4.43
Range	4.60-13.0	38.9-119.2	1.4-50.0	0.25-27.2
Samples	46	38	43	45

a. Source: Wike et al. (1994).
b. CCWS = Comprehensive Cooling Water Study.



Source: Wike et al. (1994).

PK64-2PC

Figure 4-29. Flow measurement and water chemistry sampling stations for Lower Three Runs.

oxygen concentrations were all greater than 4.5 milligrams per liter.

Lower Three Runs Flow – During Water Year 1996, the mean flow in Lower Three Runs below Par Pond was 28.0 cubic feet (0.80 cubic meter) per second (Melendez 1996). Flows were seasonal with the winter and spring months (October to March) having the highest average flows, 38.0 cubic feet (1.1 cubic meters) per second. The average flow from April to September was 17.0 cubic feet (0.5 cubic meter) per second. Average flow at Road B based on the period of record ending in 1991 was 36.5 cubic feet (1.0 cubic meter) per second. TE Table 4-37 presents flows at the next downstream station, Patterson Mill, which are about a twofold increase from those at Road B (Wike et al. 1994).

4.2.2.2 Environmental Impacts

4.2.2.2.1 No Action

Under the No-Action Alternative, DOE would continue to operate a small 5,000-gallon-per-minute (0.3-cubic-meter-per-second) pump to maintain L-Lake levels. The minimum flows from L-Lake into Steel Creek would be approximately 10 cubic feet (0.28 cubic meter) per second. Lower Three Runs would continue to receive 10 cubic feet per second. Under No Action, only natural flows from the headwaters of Steel Creek and Fourmile Branch would occur. The following paragraphs discuss the impacts of reduced or absent river water flows to each of these stream systems.

4.2.2.2.2 Shut Down and Deactivate

DOE expects no impacts to Indian Grave Branch/Pen Branch, Fourmile Branch, or Lower Three Runs beyond those described for the No-Action Alternative (Section 4.2.2.2.1). If L-Lake emptied, Steel Creek would receive natural base flows, which would vary but are likely to average 10 cubic feet (0.28 cubic meter) per second at the dam location.

Under this alternative, the L-Lake water level would recede to that of the original stream, and there would be a potential for an occasional discharge of sediments accumulated upstream of the dam. Such a discharge would depend on the amount of water impounded at the discharge structure and the possibility for impoundment sediment in the area of the outlet structure. Depending on the depth of the water at the structure, sediment deposited in the area could be resuspended and transported to Steel Creek below the dam during high water flow periods and storm events. The amount of sediment impounded in the area would depend on the effectiveness of revegetation and other erosion control measures implemented during lake drawdown. The addition of suspended solids to the stream during stormwater events is a potential ecological impact, as discussed in Section 4.2.5.

TE **Table 4-37.** Flow summary for Lower Three Runs (cubic feet per second).[a,b]

	Station name	Period of record	Mean	Range		7Q10	7-day low flow
				Low	High		
TC	Patterson Mill	1974-1991	85	13	743	15.6	15.1

a. Source: Wike et al. (1994).
b. To convert cubic feet to cubic meters, multiply by 0.028371.

4.2.2.2.3 Shut Down and Maintain

This alternative would produce the same impacts as the Shut Down and Deactivate Alternative, but a restart of the River Water System could increase flows to the streams.

4.2.3 GROUNDWATER

This section describes groundwater conditions in the vicinity of potentially affected SRS streams (Steel Creek, Pen Branch, Fourmile Branch, and Lower Three Runs).

4.2.3.1 Affected Environment

Hydrogeologic Setting

In general on the SRS, the water table aquifer and the first confined aquifer recharge to the streams that incise them. The water table aquifer discharges to both Steel Creek and Pen Branch tributaries. The groundwater flow to Steel Creek and L-Lake from the L-Area is toward the southeast. The groundwater flow to Pen Branch from L-Area is to the northwest. Although groundwater discharges to L-Lake in its upstream portions, lake water at the L-Lake dam recharges the water table aquifer. The net flux of groundwater in the first confined aquifer is believed to originate from L-Lake and the water table aquifer (del Carmen and Paller 1993b). Further downstream, the aquifers resume discharge to the stream in a southerly direction. Below the Par Pond Dam, the water table aquifer and first confined aquifer discharge to the Lower Three Runs stream valley. Hydraulic properties for the aquifers are not available for specific stream areas. Therefore, Tables 4-1 and 4-2 list general sitewide data.

4.2.3.2 Environmental Impacts

4.2.3.2.1 No Action

DOE anticipates no changes in current conditions for the water table aquifer or the first confined aquifer because the lake level would be maintained.

4.2.3.2.2 Shut Down and Deactivate

Water Table Aquifer

The current outfall from L-Area would be eliminated and L-Lake levels would lower. Because L-Lake discharges to the water table aquifer below the dam and into Steel Creek, groundwater gradients, levels, and flow rates of the aquifer would decrease over the near term but would eventually return to the natural hydrogeologic state. Groundwater properties would remain stable downstream from the dam.

Fourmile Branch and headwaters of Steel Creek would not receive outfall discharges from the River Water System. The water table aquifer at Lower Three Runs would not be affected because its source of water is not directly related to the River Water System.

First Confined Aquifer

Because none of the SRS streams and their outfalls currently or directly affect the properties of this aquifer, shutting down the River Water System would not have an effect.

4.2.3.2.3 Shut Down and Maintain

The impacts described in Section 4.2.3.2.2 would also apply to this alternative.

4.2.4 AIR RESOURCES

4.2.4.1 Affected Environment

The climate, meteorology, and ambient air quality for the SRS streams are equivalent to those for the SRS, which is discussed in Section 4.1.4.1. DOE assumes that joint wind frequency data from the L-Area tower and meteorological and climatological data from other SRS locations would be applicable to the streams.

4.2.4.2 Environmental Impacts

4.2.4.2.1 No Action

The continued operation of the River Water System would have no new impacts on the existing ambient air quality at the SRS. The water flow in the streams derived from pumping water from the Savannah River does not contribute additional air contaminants to the surrounding environment. Vegetative regrowth would mitigate potential exposure of dried sediment to winds due to natural fluctuations in stream flows.

4.2.4.2.2 Shut Down and Deactivate

The shutdown and deactivation of the River Water System would enable the receiving streams to return to a natural base flow; the small change in stream flows would not likely expose an appreciable amount of sediments. The potential for resuspension of contaminated sediment due to exposure to windborne currents would be minimal, and no impacts to ambient air quality would be likely.

DOE does not expect the vaporization of organics from dried sediment because an analysis of Steel Creek channel sediments indicates that no organic contaminants are present at levels close to EPA risk-based concentrations, which DOE used as screening levels at the SRS (DOE 1996c).

TE | As discussed in Section 4.1.5.2.2, the reduction in streamflow is not likely to result in exposed sediments. Vegetative cover would minimize the resuspension of contaminated soils.

4.2.4.2.3 Shut Down and Maintain

The shutdown and maintenance of the River Water System would have no impacts on the ambient air quality, as discussed in Section 4.2.4.2.2.

4.2.5 ECOLOGY

4.2.5.1 Affected Environment

4.2.5.1.1 Terrestrial Ecology

The *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a) evaluated the potential impacts to fish and wildlife of 10-cubic-foot-per-second (0.28-cubic-meter-per-second) flows in Steel Creek and Lower Three Runs. The environmental assessment concluded that impacts to downstream biotic resources would be small. Because the assessment evaluated potential impacts of 10-cubic-foot-per-second flows in these streams to terrestrial biota, this section does not discuss terrestrial wildlife.

Wike et al. (1994) summarizes existing ecological information on the major stream drainages of the SRS, including Fourmile Branch and Pen Branch/Indian Grave Branch. This includes limited information on the plant communities and terrestrial wildlife that occur along these streams. Because the Proposed Action would not affect terrestrial wildlife in the Fourmile Branch and Pen Branch areas, this section does not include detailed descriptions of terrestrial wildlife communities in these areas.

4.2.5.1.2 Aquatic Ecology

Fourmile Branch

The Fourmile Branch watershed includes a number of SRS facilities: C-Area (reactor), F- and H-Areas (separations), Defense Waste Processing Facility, and the Solid Waste Disposal Facility. Before C-Reactor was placed on standby in 1985, heated effluent was discharged into Fourmile Branch via Castor Creek. Flows in Fourmile Branch approached 400 cubic feet per second (11.3 cubic meters per second) when

C-Reactor was operating. Water temperatures exceeded 140°F (60°C) in Fourmile Branch downstream of its confluence with Castor Creek (Wike et al. 1994). In its lower reaches, Fourmile Branch broadens and flows through a delta created by the deposition of stream sediments.

Pen Branch and Indian Grave Branch

Pen Branch rises in the approximate center of the SRS and flows southwest to enter the Savannah River swamp. In its headwaters, Pen Branch is a small, largely undisturbed blackwater stream. Until K-Reactor was shut down in 1988, Indian Grave Branch received thermal effluent from K-Reactor. With K-Reactor operating, the natural flow of 10 cubic feet per second (0.28 cubic meter per second) increased to 400 cubic feet per second (11.3 cubic meters per second). Since 1988, the Pen Branch/Indian Grave system has received only nonthermal effluents (i.e., cooling water from auxiliary systems, ash basin runoff, sanitary waste water) from K-Area and sanitary effluent from the Central Shops Area (Wike et al. 1994).

The macroinvertebrate communities of Pen Branch were surveyed from 1983 to 1985 when K-Reactor was discharging heated effluent to Pen Branch, and in 1988 and 1989 after the K-Reactor shutdown (Wike et al. 1994). Prior to the shutdown of K-Reactor, portions of Pen Branch directly downstream from the reactor outfall contained few benthic macroinvertebrate taxa, while areas further removed from the outfall (such as the Savannah River swamp) had a more diverse benthic macroinvertebrate community. The macroinvertebrates in thermally-impacted areas were generally pollution-tolerant forms (e.g., chironomids, nematodes, and oligochaetes) capable of surviving high temperatures and low oxygen levels. After the shutdown of L-Reactor, macroinvertebrate communities began to recover, with densities and taxa richness generally higher (86 taxa collected in 1988-1989 versus 51 taxa in 1984-1985). The benthos continued to be dominated by pollution-tolerant groups (e.g., chironomids and black flies) after L-Reactor was shut down.

Aho et al. (1986) investigated the community structure of fishes in Pen Branch, Meyers Branch, and Steel Creek in 1984 and 1985 as part of the Comprehensive Cooling Water Study. Steel Creek had the highest species diversity, with slightly lower values for Pen Branch and Meyers Branch. Within each stream, diversity was highest at downstream sites.

Upper reaches of Pen Branch were characterized by low species richness (11 species collected) and diversity: six species [mud sunfish (*Acantharchus pomotis*), dollar sunfish (*Lepomis marginatus*), chubsucker (*Erimyzon* spp.), redfin pickerel (*Esox americanus*), brown bullhead (*Ameiurus nebulosus*), and pirate perch (*Aphredoderus sayanus*)] made up more than 91 percent of all fish collected (Aho et al. 1986). Lower reaches of Pen Branch contained more species (27), a higher percentage of which were small-bodied species [e.g., yellowfin shiner (*Notropis lutipinnis*), madtoms (*Noturus* spp.), and darters (*Percina* and *Etheostoma* spp.)] that are normally associated with blackwater streams of the Coastal Plain.

After K-Reactor was shutdown in April 1988, fish rapidly recolonized Pen Branch and Indian Grave Branch (Wike et al. 1994). Yellowfin shiners, bluehead chubs (*Nocomis leptocephalus*), and pirate perch were the most common species in the upper reaches of the stream. Largemouth bass (*Micropterus salmoides*), lake chubsucker (*Erimyzon sucetta*), redear sunfish (*Lepomis microlophus*, and redbreast sunfish (*L. auritus*) were most abundant in the middle reaches. Brook silversides (*Labidesthes sicculus*), coastal shiners (*Notropis petersoni*), spotted sunfish (*Lepomis punctatus*), and lake chubsuckers were most common in the delta. Indian Grave Branch collections were dominated by four species: spotted sucker (22.2 percent of total), coastal shiner (18.5 percent), lake chubsucker (14.8 percent), and redbreast sunfish (14.8 percent).

Steel Creek

Steel Creek originates near P-Reactor and flows southwest for about 2 miles (3 kilometers) before entering the headwaters of L-Lake. From the L-Lake Dam, Steel Creek flows south approximately 4 miles (6 kilometers) before entering the Savannah River swamp, and moves another 2 miles (3 kilometers) through the swamp before emptying into the Savannah River. Steel Creek began receiving thermal effluent from P- and L-Reactors in 1954. By 1961, the reactors were releasing a total of 850 cubic feet (24 cubic meters) per second of heated effluent into Steel Creek (Wike et al. 1994). In 1964, all P-Reactor effluent was diverted to Par Pond, and in 1968 L-Reactor was placed on standby. From 1968 to early 1985, Steel Creek recovered from the effects of SRS operations. The upper reaches of Steel Creek were impounded in 1985 to create L-Lake (see Section 4.1).

The abundance and distribution of benthic macroinvertebrates in the Steel Creek corridor, marsh/swamp, and lower channel region were evaluated from January 1986 through December 1991 (Wike et al. 1994). The macroinvertebrate communities in the Steel Creek corridor downstream of L-Lake were strongly influenced by seston inputs from L-Lake, and as a result contained high densities of filter feeding organisms (e.g., blackflies and net-spinning caddisflies). The macroinvertebrates of the lower reaches of the stream (delta and swamp) appeared to be less affected by releases from L-Lake. Amphipods, oligochaetes, caddisflies, isopods, gastropods, mayflies, and chironomids were all abundant in this portion of the stream.

Aho et al. (1986) investigated the community structure of fishes in Steel Creek, Pen Branch, and Meyers Branch in 1984 and 1985 as part of the Comprehensive Cooling Water Study. Steel Creek had the highest species diversity, with slightly lower values for Pen Branch and Meyers Branch. Within each stream, diversity was highest at downstream sites.

Upper reaches of Steel Creek were characterized by relatively-high species richness (29 species collected), while downstream portions of Steel Creek were characterized by high measures of species richness (43 species) and diversity (Aho et al. 1986). Upper reaches of Steel Creek were dominated by yellowfin shiners (54 percent of total), bluehead chubs (14 percent), northern hog sucker (*Hypentelium nigricans*) (11 percent), and redbreast sunfish (7 percent). Dusky shiners (*Notropis cummingsae*), spotted sunfish, pirate perch, yellowfin shiners, and tessellated darters (*Etheostoma olmstedi*) were collected most often in lower reaches of the stream. A number of species normally associated with river-swamp habitats contributed to the high diversity in lower Steel Creek.

Additional studies of Steel Creek fish were conducted after the restart of L-Reactor in 1985 (Wike et al. 1994). The fish community of the Steel Creek corridor was directly influenced by discharge of water from L-Lake to Steel Creek. Resulting increases in current velocity, stream width, and stream depth led to the displacement of small, minnow-like species typically found in headwater streams on the SRS (minnows and chubs) and the establishment of other species [e.g., bluegill (*Lepomis macrochirus*)] normally not found in high numbers in these small streams. After L-Reactor was shut down in 1988, fish were generally less abundant in Steel Creek as a result of a reduction in available habitat (Steel Creek became narrower and shallower). Sunfish and largemouth bass made up a larger proportion of the catch than in previous years.

Fish assemblages in the Steel Creek marsh and swamp were less obviously affected by the restart of L-Reactor in 1985 and subsequent shutdown of the reactor in 1988 (Wike et al. 1994). There was an apparent increase in the abundance of redbreast and bluegill after the restart of L-Reactor, and a reduction in abundance of brook silverside. Bluegill apparently emigrated from L-Lake to Steel Creek as larvae and juveniles. By 1988, a reproducing population of bluegill had become established in the Steel Creek marsh/swamp. Bluegill, which weren't collected in the Steel Creek marsh prior to 1986, made up 4.3 percent of fish collected in 1988. Spotted sunfish and largemouth bass were common in the marsh/swamp area of Steel Creek before (1983-1985), during (1986-1987), and after (1988) operation of L-Reactor.

Lower Three Runs

From the Par Pond Dam, Lower Three Runs flows about 24 miles (40 kilometers) before it enters the Savannah River. Before Par Pond was completed in 1958, heated effluent from R-Reactor [approximately 212 cubic feet per second (6 cubic meters per second)] was discharged to Lower Three Runs via Joyce Branch (Du Pont 1987b). In 1964 R-Reactor was shut down and heated discharge from P-Reactor was diverted from Steel Creek to Par Pond (Du Pont 1987b). P-Reactor was shut down in 1988. Historically, SRS operations caused large fluctuations in discharge immediately downstream of the Par Pond Dam, but groundwater and tributary inflows dampened these fluctuations several miles downstream (Wike et al. 1994).

4.2.5.1.3 Wetland Ecology

Steel Creek

Steel Creek and its main tributary, Meyers Branch, drain approximately 35 square miles (91 square kilometers) of the Aiken Plateau and flow to the Savannah River. The dam across Steel Creek creating L-Lake is approximately 3 miles (5 kilometers) upstream of the Steel Creek delta (Westbury 1993). | TC

Information characterizing the wetland vegetation of the Steel Creek corridor before the establishment of the SRS is not available, but Welbourne (1958) documents species present in and around the Steel Creek area during 1956 and 1957. Appendix D, Table D-8 lists these species. Upper Three Runs, a relatively undisturbed blackwater stream on the SRS, can illustrate the likely wetland vegetation of the Steel Creek corridor before the development of the SRS. Trees adjacent to the stream include tulip poplar, beech, sweetgum, willow oak, swamp chestnut oak, water oak, sycamore, and loblolly pine. Dogwood, red buckeye and American holly are also abundant. Tag alder is common along sandy stream margins. Macrophytes in wet sites with open canopies include eelgrass (*V. americana*), pondweed (*Potamogeton epihydrous*), and bulrush (*Scirpus subterminalis*). Golden club (*Orontium aquaticum*), wapato (*S. latifolia*), water primrose (*Ludwigia* spp.), and knotweed (*Polygonum* spp.) occur on small floodplains (Workman and McLeod 1990). | TC

The Savannah River Swamp System, of which Steel Creek and its delta are a part, consists of a variety of habitats that support several vegetation community types. The undisturbed wooded areas in the swamp contain four distinct communities: black oak-ironwood (*Quercus nigra-Carpinus caroliniana*), laurel oak-deciduous holly (*Quercus laurifolia-Ilex decidua*), water tupelo-ash (*Nyssa aquatica-Fraxinus pennsylvanica*), and bald cypress-blackgum (*Taxodium distichum-Nyssa aquatica*). Dominants are primarily determined by the depth and frequency of flooding (Smith, Sharitz, and Gladden 1981).

Steel Creek received reactor effluents from 1954 to 1968. Table 4-38 lists reactor-area discharges to Steel Creek by time period and source. Steel Creek received thermal effluents from both P- and L-Reactors between 1954 and 1963 and then from L-Reactor alone until 1968 (DOE 1984). Reactor effluent water released to SRS streams was commonly hotter than 158° F (70°C), and in Steel Creek reached a peak discharge of 850 cubic feet (24 cubic meters) per second in 1961 (Wike et al. 1994). | TE

Discharges before 1968 produced elevated water levels, increased water temperatures, substrate erosion, and deposition of scoured sediments throughout much of the Steel Creek system. The stream, floodplain, and associated wetlands were either destroyed or severely

TE | **Table 4-38.** Reactor-area discharges to Steel Creek.[a]

Years	Discharge (cubic meters per second)[b]		
	P-Reactor	L-Reactor	Total
1954 to 1958	5.6	5.7	11.3
1958 to early 1961	9.3	9.3	18.6
Mid-1961	11.3	11.3	22.6
Late 1961 to late 1963	9.3	11.3	20.6
November 1963 to February 1968	0.4[a]	11.3	11.7
February 1968 to 1980	0.4[a]	0.0	0.4
1981 to 1984	0.5[a]	0.002[c]	0.5

a. Source: DOE (1984).
b. To convert cubic meters to cubic feet, multiply by 35.31.
c. Flow from sanitary and domestic sources from L-Area at ambient temperature. During cold-water testing, the flow has approached 6.2 cubic meters per second.

altered by resultant above-normal water levels, silt deposition, and elevated water temperatures TE | (Westbury 1993). Table 4-39 compares stream characteristics before and after Steel Creek received heated discharges from L- and P-Reactors.

Between 1951 and 1972, the stream channel width increased more than three times due to effluent scour (DOE 1984). A pattern of upstream erosion and downstream delta formation resulted from the interaction of the stream corridor gradients and the increased stream discharges. A broad, flat delta formed where Steel Creek flowed into the Savannah River swamp.

The elevation of the delta area was higher than the adjacent natural swamp as a result of reactor-associated sediment buildup, organic matter accumulation, and greater entrapment of sediment afforded by the vegetation (Smith, Sharitz, and Gladden 1981).

Effects on the vegetation in the Steel Creek corridor and delta varied with species sensitivity to the stresses of the thermal effluent discharges. A high incidence of tree death occurred in areas of the Savannah River swamp where the thermally impacted streams entered the swamp. For example, the areal extent of the tree kill in the Steel Creek delta exceeded 247.1 acres (1.0 square kilometer) in 1966. However, vegetation in the swamp was not eliminated; areas such as sandbars, stumps, and logs elevated above the water continued to support diverse plant communities (Smith, Sharitz, and Gladden 1981).

TE | **Table 4-39.** Steel Creek stream characteristics.[a,b]

Date	Width (meters)[c]	Average depth (meter)	Flow rate (cubic meter per second)[d]	Temperature (°C)
May 1951	5.1	0.30	0.59[e]	16.1
June 1972	16.5	0.37	0.79	24.6

a. Source: DOE (1984).
b. Based on measurements taken at Road A.
c. To convert meters to feet, multiply by 3.281.
d. To convert cubic meters to cubic feet, multiply by 35.31.
e. July 1951 determination.

With the cessation of reactor discharges to Steel Creek in 1968, much of the previously impacted floodplain corridor underwent revegetation to scrub-shrub and young bottomland hardwood forested wetlands between 1968 and 1981 (Du Pont 1987c). More than 85 species of plants representing 50 families were identified in Steel Creek corridor (see Appendix D, Table D-9) during a study in the summer of 1981 (Smith, Sharitz, and Gladden 1981). Section 4.1.5 describes the characteristic vegetation of the northern portion of the Steel Creek corridor and the portion inundated by L-Lake. Below the site of the future L-Lake Dam, the corridor was similar to the portion inundated by the lake. Wax myrtle, willow, and blackberry dominated the floodplain community behind a band of alder bordering the stream. The lower portion of the stream was a broad flat floodplain with braided stream channels, with a low persistent herb community intermixed with shrub thickets. Table 4-40 lists the wetland community types occurring in the Steel Creek corridor below the dam site (before dam construction). The classification system used for mapping followed the Cowardin method with some modification to more accurately portray the features of this system (Smith, Sharitz, and Gladden 1981). Appendix D, Table D-4 describes the mapping units in the lower portion of the Steel Creek corridor. TE

Studies of the Steel Creek delta between 1968 and 1981 showed the plant communities undergoing early successional invasion by marsh and scrub-shrub wetland species. The initial flora of the emergent sandbars was dominated by the rush-like annual *Fimbristylis autumnalis*, water primrose (*Ludwigia leptocarpa*), primrose willow (*L. decurrens*), sedges (*Cyperus* spp.), and the annual *Echinochloa walteri* (Du Pont 1987c). There was limited recovery of the forest in areas adjacent to the delta. In the summer of 1981, the Steel Creek delta was characterized by heterogeneous vegetation with 124 species representing 66 families (see Appendix D, Table D-10) (Smith, Sharitz, and Gladden 1981). The deltaic fan rapidly colonized and supported successional willow forest, buttonbush shrub communities, and herbaceous wetlands dominated by cutgrass (*Leersia* sp.). A deeper-water zone peripheral to the delta was characterized by scattered trees that were remnants of the original swamp forest, as well as stumps bearing shrubs, and submerged and nonpersistent aquatic herbs. The surrounding swamp forest communities that were less affected by reactor operations were characterized by closed canopies. These areas are dominated by cypress and tupelo in deeper water and by oaks and other bottomland hardwoods on the ridges and higher elevations. TE

Table 4-40. Wetland community types occurring in the Steel Creek corridor below L-Lake dam.[a] TE

Wetland community type	Mapping unit
Emergent	Persistent - *Leersia* spp.
Emergent	Nonpersistent - *Polygonum lapathifolium*
Scrub-shrub - Broad-leaved deciduous	*Cephalanthus occidentalis-Salix nigra*
Scrub-shrub - Broad-leaved deciduous	*Alnus serrulata*
Forested - Broad-leaved deciduous	*Salix* sp.
Forested - Broad-leaved deciduous	*Alnus serrulata-Myrica cerifera*
Forested - Broad-leaved deciduous	*Liquidambar styraciflua-Acer rubrum-Salix* sp.
Forested - Mixed deciduous	*Taxodium distichum-Nyssa sylvatica* var. *biflora*

a. Source: Smith, Sharitz, and Gladden (1981).

TE | Table 4-41 lists the wetland community types occurring in the Steel Creek delta. The classification system used for mapping followed the Cowardin method with some modification to portray more accurately the features of this system (Smith, Sharitz, and Gladden 1981). Appendix D, Table D-10 describes the mapping units in the Steel Creek delta (Smith, Sharitz, and Gladden 1981).

During the construction and filling of L-Lake from 1984 to 1985, the stream flow in Steel Creek at Road A ranged from 7 to 500 cubic feet (0.2 to 14.2 cubic meters) per second and averaged 261 cubic feet (7.4 cubic meters) per second. The restart of L-Reactor resulted in several changes in the Steel Creek floodplain. Water temperatures at the Steel Creek corridor sites were not greatly elevated when the reactor was in operation, so thermal impacts on floodplain vegetation were minimal. The changes were the result of an altered hydrologic regime and increased flows in the stream. Nearly 10 times the volume of water carried before reactor restart was discharged into the Steel Creek system during reactor operations. This increased flow altered the patterns of erosion and deposition in the channels and floodplain and caused extensive inundation of areas that had been relatively dry before the resumption of reactor operations (Westbury 1993). During this period, portions of the hardwood forest canopy opened and herbaceous vegetation invaded the areas where light penetrated to the forest floor (DOE 1990).

L-Reactor ceased operation in 1988; however, the L-Reactor Operations EIS (DOE 1984) had committed that, during reactor outages, DOE would maintain flow in Steel Creek at Road A at a rate of about 106 cubic feet (3.0 cubic meters) per second during the spring spawning season, and during the remainder of the year at a rate of about 53 cubic feet (1.5 cubic meter) per second during reactor outage (Wike et al. 1994). These flows were higher than normal Steel Creek flows to eliminate the potential for dewatering the stream through the fish spawning season during a reactor outage.

A recent mapping effort by the Savannah River Ecology Laboratory mapped aerial coverage of the Steel Creek corridor and delta (Wein 1996). Three vegetation classes were identified: TE | marsh, scrub-shrub, and hardwood. Table 4-42 lists the classes of vegetation and area of coverage for each. The dominant species in the marsh class were *Leersia* spp. and *S. latifolia.* Willow and buttonbush were the predominant scrub-shrub species. The hardwood class was predominated by a young developing stand of bald cypress, tupelo, and ash.

TE | **Table 4-41.** Wetland community types occurring in the Steel Creek delta.[a]

Wetland community type	Mapping unit
Aquatic Bed	Rooted Vascular - *Myriophyllum brasiliense*
Emergent	Persistent - *Leersia* spp.
Emergent	Nonpersistent - *Hydrolea quadrivalvis*
Scrub-shrub - Broad-leaved deciduous	*Cephalanthus occidentalis-Salix nigra*
Mixed Scrub-shrub - Nonpersistent emergent	*Cephalanthus occidentalis/Polygonum lapathifolium*
Forested - Broad-leaved deciduous	*Salix nigra*
Forested - Broad-leaved deciduous	*Quercus lyrata-Carya aquatica-Nyssa aquatica*
Forested - Broad-leaved deciduous	*Quercus laurifolia*
Forested - Mixed deciduous	*Taxodium distichum-Nyssa aquatica*
Forested - Mixed deciduous	*Taxodium distichum-Cephalanthus occidentalis*

a. Source Smith, Sharitz, and Gladden (1981).

Table 4-42. Aquatic macrophyte coverage of the Steel Creek corridor and delta, 1996.[a] | TE

Class name	Area in acres (square kilometers)[b]
Water	106.3 (0.43)
Marsh	48.3 (0.20)
Shrub/Scrub	20.7 (0.08)
Hardwood	1,185.1 (4.80)
Totals	1,360.4 (5.51)

a. Source: Wein (1996).
b. To get square miles, multiply by 0.3861.

Lower Three Runs

Before 1958, heated effluent from R-Reactor discharged directly to Lower Three Runs through Joyce Branch. Lower Three Runs flows about 19 miles (31 kilometers) from the Par Pond Dam to the Savannah River. As a consequence of receiving cooling water effluent from R-Reactor (1953 to 1958) and the subsequent modification of stream flows after 1958 caused by the Par Pond Dam, the ecology of the stream has changed significantly since the early 1950s. In particular, the nature of the riparian habitats and associated floodplain wetlands along Lower Three Runs have changed.

For the most part, wetlands along Lower Three Runs downstream of Par Pond are bottomland-hardwood swamps associated with the floodplain (DOE 1990). Bottomland hardwoods on the SRS are typical of the mixed hardwood forests in low wet areas of the southeastern Coastal Plain (Workman and McLeod 1990). Common tree species in these areas are those that survive where flooding is of limited depth and normally restricted to the late winter and early spring when the plants are dormant (Whipple, Wellman, and Good 1981). Tree species of this type include several species of oaks (*Quercus* spp.), sweet-gum (*Liquidambar styraciflua*), cottonwood (*Populus heterophylla*), American elm (*Ulmus americana*), sycamore (*Platanus occidentalis*), and red maple (*Acer rubrum*). In addition, some scrub-shrub and other emergent wetlands are present in the main channel and tributaries of Lower Three Runs. Although most influenced by Par Pond releases, these bottomland areas have also been affected by beaver activity (DOE 1990). Some cypress-tupelo (*Taxodium* spp.-*Nyssa aquatica*) areas are located near the confluence of Lower Three Runs and the Savannah River.

4.2.5.2 Environmental Impacts

4.2.5.2.1 No Action

Aquatic Ecology

Under the No-Action Alternative, DOE would maintain flows in Steel Creek and Lower Three Runs at approximately 10 cubic feet (0.28 cubic meter) per second, which would approximate historic (pre-1951) base flows in Steel Creek in the area below L-Lake and represent minimum flow rates protective of aquatic life in Lower Three Runs (del Carmen and Paller 1993b). River water would no longer be pumped to Indian Grave Branch through K-Area or to Fourmile Branch through C-Reactor (see Section 4.2.2.1).

Fourmile Branch

Under the No-Action Alternative, river water would no longer be pumped to C-Area. At present, a small amount of river water discharges to Fourmile Branch as a result of valve leakage. Because this discharge represents a small fraction of the normal stream flow, no impacts are likely from its discontinuation.

Steel Creek

DOE committed in the Final EIS on L-Reactor Operations (DOE 1984) to maintain year-round minimum flows of 53 cubic feet (1.5 cubic meters) per second in Steel Creek below the L-Lake Dam. Because this requirement was based on the full reactor cooling water flow of 388 cubic feet (11 cubic meters) per second and L-Reactor was permanently shut down in 1988, the 53 cubic feet (1.5 cubic meters) per second minimum flow requirement was eliminated in 1994 (DOE 1995a).

DOE evaluated the potential impacts of reducing flows from L-Lake to Steel Creek by almost 80 percent, from 53 cubic feet (1.5 cubic meters) per second to 10 cubic feet (0.28 cubic meter) per second (DOE 1995a). To determine minimal flows that would preserve the ecological integrity of Steel Creek, a hydrological and ecological study of the Steel Creek watershed and its fisheries resources concluded that a flow of 10 cubic feet per second (0.28 cubic meter per second) would approximate the historic (pre-SRS) Steel Creek flow, and would result in the reestablishment of an aquatic community similar to the one that existed in Steel Creek before the creation of L-Lake (del Carmen and Paller 1993a).

DOE predicted a 10-cubic-foot- (0.28-cubic-meter-) per-second flow would favor fish species native to first- and second-order streams on the SRS (DOE 1995a). These would include many small schooling species (e.g., shiners) that feed on insects and a few small bottom-feeding species (e.g., madtoms) (Paller 1994). Because DOE expected a balanced biological community to develop under these conditions, it concluded that there would be no significant impacts (DOE 1995b).

DOE did not discuss possible impacts to other stream organisms, such as macroinvertebrates, but implied that the proposed reduction in Steel Creek flows would in time result in the development of a benthic community typical of first- and second-order Coastal Plain streams with more normal temperature and flow regimes (DOE 1995a). The benthic communities that developed from 1954 to 1968, when Steel Creek received massive volumes of heated effluent, and from 1985 to 1988, when Steel Creek received large volumes of L-Reactor cooling water, were atypical.

After the restart of L-Reactor in 1985, there were pronounced changes in the community structure of Steel Creek benthic macroinvertebrates and fish (Mason and Bowen 1993; Mattson et al. 1993b). These alterations in community structure were attributed to increased flows and sediment loads rather than increased heat loading from reactor operation. After July 1988 when L-Reactor was shut down, stream flows were considerably lower as a result of greatly reduced reservoir releases to Steel Creek. Fish abundance and diversity declined in the Steel Creek corridor and marsh/delta after the flow reduction. Changes in community structure of benthic macroinvertebrates were more subtle, but there appeared to be reductions in the abundance and diversity of these organisms as well.

Because DOE has described impacts of 10-cubic-foot (0.28-cubic-meter)-per-second flows to Steel Creek aquatic biota (DOE 1995a), this EIS does not discuss them further.

Lower Three Runs

Del Carmen and Paller (1993b) conducted an instream flow study on Lower Three Runs to determine the minimum discharge rate that would support a balanced biological community downstream of the Par Pond Dam. They concluded that a base flow of approximately 10 cubic feet (0.28 cubic meter) per second would result in the establishment of a balanced biological community, with a fish community typical of first- and second-order Coastal Plain streams in South Carolina (del Carmen and Paller 1993b). As noted above, this would be a stream fish community containing more small-bodied insectivores (shiners, chubs, and madtoms) and fewer large-bodied carnivores and omnivores (suckers, sunfish, and largemouth bass) than before. Because DOE has described impacts of 10-cubic-foot-per-second flows to Lower Three Runs aquatic biota (DOE 1995a), this EIS does not discuss them further.

Indian Grave/Pen Branch

Under the No-Action Alternative, DOE would continue to pump 4,800 gallons per minute (0.30 cubic meter per second) of river water to L-Lake to maintain the normal operating level of 190 feet (58.0 meters) and would continue to pump up to 200 gallons per minute (0.013 cubic meter per second) to K-Area for fire protection. An additional 200 gallons per minute of well water would be supplied to K-Area for compressor cooling. As a result, Pen Branch would continue to receive as much as 400 gallons per minute (0.025 cubic meter per second) of river water and well water from K-Area.

Flow in Pen Branch upstream of the confluence with Indian Grave averaged 7.7 cubic feet (0.22 cubic meter) per second over the 1983-1991 period (Wike et al. 1994). Under the No-Action Alternative, DOE would continue to discharge approximately 400 gallons per minute (0.89 cubic feet; 0.025 cubic meter) per second of river and well water to Pen Branch, augmenting the base flow of approximately 7.7 cubic feet per second.

Under the No-Action Alternative, Indian Grave Branch would probably support small numbers of shiners, chubs, pirate perch and darters; these minnow-like species are often found in first-order SRS streams (Aho et al. 1986; Wike et al. 1994). Flows in Pen Branch downstream of its confluence with Indian Grave Branch would probably be sufficient to support a more diverse fish community, with shiners, chubs, pirate perch, chubsuckers, small sunfish, and catfish (madtoms and bullheads). Projected flows in both Indian Grave Branch and Pen Branch would approximate natural flows, and aquatic communities would, over time, become more like the communities that existed prior to the operation of SRS production reactors.

Wetland Ecology

Steel Creek

Under the No-Action Alternative, DOE would ensure that Steel Creek received a minimum flow of 10 cubic feet (0.28 meter) per second. This flow was evaluated in the *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a). DOE concluded that no significant impacts to wetlands in Steel Creek were likely as a result of a return to the historic flow rate (DOE 1995b).

A stream flow of 10 cubic feet (0.28 cubic meter) per second could result in fewer extreme flooding events and fewer years with high annual floods. As a consequence, a narrowing of the riparian wetlands could occur downstream of the dam. Frequency, depth, and duration of flooding affect forest composition and vegetation patterns in bottomlands such as those found along the Steel Creek corridor (Workman and McLeod 1990). Plant species generally occur along a moisture gradient in these areas. Since flooding would be less frequent and less extreme under the 10-cubic-foot-per-second discharge scenario than in previous years, a denser understory could develop along with greater diversity in the herbaceous layer (Wike et al. 1994).

At present, most of the aquatic macrophyte coverage in the stream corridor and delta is in open water and marsh (Wein 1996). A return to the lower historic flow probably would result in shallower water and, therefore, a decrease in open water and marsh habitat. Tree species likely to invade the area include willow (*Salix spp.*), loblolly pine, sweetgum, cottonwood, cypress, and tupelo. An increase in scrub-shrub vegetation along the narrower stream corridor could occur. This trend was observed in surveys conducted in the stream corridor between the cessation of cooler water discharges in Steel Creek in the late 1960s and the construction of L-Lake and the restart of L-Reactor in the mid- L11-18

1980s (Wike et al. 1994). For the most part, grasses and similar emergent species dominated in 1982 after 15 years of successional revegetation. Woody vegetation could reinvade after a return to the historic flow and could be dominated by willow (*Salix* spp.), as observed in the early 1980s.

As mentioned above, sediment accumulations raised part of the delta, resulting in lower water depths and favoring scrub-shrub invasion and establishment. If hardwood species became reestablished in the deltaic fan, it probably would eventually resemble deciduous bottomland forest rather than the original swamp forest (Wike et al. 1994). The lower water level and less severe flooding events could lead to the invasion of such woody species as sweetgum (*Liquidambar styraciflua*), laurel oak (*Quercus laurifolia*), water oak (*Quercus nigra*), ironwood (*Carprinus caroliniana*), winged elm (*Ulmus alata*), and water elm (*Planera aquatica*), which thrive in that environment. In addition, willows (*Salix* spp.) and buttonbush (*Cephalanthus occidentalis*) tend to dominate higher, drier areas of deltas on SRS, as do herbaceous plants such as sedges (*Carex* spp.), rushes (*Juncus* spp.), and water primrose (*Ludwigia* spp.) (Workman and McLeod 1990).

<u>Lower Three Runs</u>

Under the No-Action Alternative, DOE would ensure that Lower Three Runs received a minimum discharge of 10 cubic feet (0.28 cubic meter) per second. An in-steam flow study in Lower Three Runs Creek to determine the discharge rate from Par Pond that would both protect downstream natural resources and allow for the reduction of river water pumping to Par Pond concluded that a minimum flow of about 10 cubic feet (0.28 cubic meter) per second in the reach of Lower Three Runs below the Par Pond Dam would be sufficient to support a balanced fish community typical of a first/second order Coastal Plain stream (del Carmen and Paller 1993b). The *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995a) evaluated the flow rate of 10 cubic feet (0.28 cubic meter) per second.

The 10-cubic-foot (0.28-cubic-meter)-per-second minimum flow would be roughly one-third of the mean historic flow (for 1974 to 1982 and 1987 to 1991) downstream of the Par Pond Dam of 36.5 cubic feet (1.0 cubic meter) per second (Wike et al. 1994). Although a stream flow of 10 cubic feet per second would support a balanced aquatic community, impacts to riparian wetlands could occur because this flow was below historic levels. The 10-cubic-foot-per-second flow probably would result in a narrowing of the Lower Three Runs stream corridor and floodplain compared to recent conditions. This flow below the Par Pond Dam would have less of an additive effect with runoff and groundwater discharge into Lower Three Runs (i.e., less total surface water) and would result in fewer extreme flooding events and fewer years with annual floods. As a consequence, a narrowing of the riparian wetlands would occur (McLeod 1996). This would be most noticeable in areas just downstream of the dam, where the flow rate is heavily influenced by releases from Par Pond.

Frequency, depth, and duration of flooding affect forest composition and vegetation patterns in bottomlands such as those along Lower Three Runs (Workman and McLeod 1990). Plant species generally occur along a moisture gradient in these areas. Because flows would be lower under the 10-cubic-foot (0.28-cubic-meter)-per-second discharge scenario and flooding would be less frequent than under historic conditions, a denser understory could develop along with greater diversity in the herbaceous layer. Over time, tree species such as white oak (*Quercus alba*), black oak (*Quercus velutina*), and mockernut hickory (*Carya tomentosa*) that are characteristic of drier, less frequently flooded areas could predominate (Whipple, Wellman, and Good 1981). Decades could pass before these changes in dominant tree species occurred (McLeod 1996).

An SRS Set-Aside Area, the Boiling Springs Natural Area, is approximately 7 miles (11 kilometers) downstream of the Par Pond Dam. Set-asides are undisturbed natural areas on the SRS that are protected to promote biological diversity and provide control data to evaluate the impacts of development (McFarlane 1988). The Boiling Springs Natural Area is an excellent example of an SRS bottomland hardwood community. Impacts to this area from the 10-cubic-foot (0.28-cubic-meter)-per-second flow and less frequent flooding probably would be minimal because this stretch of Lower Three Runs receives significant inputs from groundwater and runoff and is less dependent on Par Pond discharge. The cypress-tupelo wetlands near the confluence with the Savannah River would probably be unaffected by the 10-cubic-foot-per-second release from Par Pond because they are more than 17 miles (27 kilometers) from the reservoir and are much more strongly influenced by Savannah River flows and flooding.

4.2.5.2.2 Shutdown and Deactivate

Terrestrial, wetland, and aquatic impacts under this alternative would be identical to those described for the No-Action Alternative.

4.2.5.2.3 Shutdown and Maintain

Terrestrial, wetland, and aquatic impacts under this alternative would be identical to those described for the No-Action Alternative.

4.2.6 LAND USE

4.2.6.1 Affected Environment

Fourmile Branch, Pen Branch/Indian Grave Branch, Steel Creek, and Lower Three Runs flow through the SRS in a generally southerly direction and empty into the Savannah River. The streams are narrow at their headwaters, broadening into wide swampy deltas where they empty into the Savannah River. Section 4.2 provides a more detailed description of the flora and fauna along their paths.

DOE monitors the waters of these streams regularly for chemical, metal, physical, and biological properties and radioactive effluents; the monitoring frequency varies with the location and sample type. Sampling stations are upstream and downstream, including offsite portions of the streams. Hunting and fishing along onsite streams are prohibited; the number and frequency of people participating in offsite fishing and hunting are unknown.

As described in Section 4.1.6.1, DOE has a system in place to assist in making a decision about the future of SRS land and facilities. That section also contains information on the Future Use Project Team and its recommendations for SRS future use, the land and surroundings on the Site, and the current status of the National Environmental Research Park.

DOE has not identified any future mission or use, other than research and monitoring, for the SRS streams (Hill 1996).

4.2.6.2 Land Use Impacts

4.2.6.2.1 No Action

Under the No-Action Alternative, current uses of the streams would not change; their status would be the same as that described in Section 4.2.6.1. DOE would make decisions on future uses in accordance with Future Use Project recommendations and other avenues.

4.2.6.2.2 Shut Down and Deactivate

Activities associated with this alternative would not affect current or future uses of the streams. In relation to water quantity and quality, this alternative should not affect offsite downstream users of the streams; and DOE would maintain flow through natural recharge at 10 cubic feet (0.28 cubic meter) per second.

4.2.6.2.3 Shut Down and Maintain

As described above, activities associated with this alternative would not affect current or future uses of the streams. DOE would maintain the stream water quantity and quality. Section 3.3 discusses reasons for restarting the River Water System.

4.2.7 AESTHETICS

4.2.7.1 Affected Environment

Most of the streams on the SRS flow through or originate in the Upper Coastal Plain and are tributaries of the Savannah River, which flows through the Lower Coastal Plain. The topographical relief of this area is slight with narrow flat-bottomed valleys and rolling areas between stream valleys. Fourmile Branch, Pen Branch/Indian Grave Branch, Steel Creek, and Lower Three Runs flow through the Site in a generally southerly direction toward the river. The streams are narrow at their headwaters, broadening into wide swampy deltas where they empty into the river. Section 4.2.5 describes the flora and fauna of the streams. Figure 4-30 shows Lower Three Runs from just below the Par Pond Dam on Road B. Figure 4-31 shows Steel Creek from just below the dam on L-Lake. At the time the photograph was taken on July 31, 1996, flow was 30 cubic feet (0.9 cubic meter) per second (USGS 1996).

The only stream users are SRS personnel engaged in chemical, physical, and biological monitoring; frequency of use varies depending on location and sample type. There are sampling stations along the entire length of these streams, including offsite locations. Hunting and fishing along the streams on the Site is strictly prohibited; the number and frequency of offsite users are unknown.

4.2.7.2 Aesthetic Impacts

4.2.7.2.1 No Action

Under the No-Action Alternative, DOE would continue to pump water from the Savannah River through the River Water System to the K- and L-Area 186 basins which would discharge to Indian Grave Branch and L-Lake. The aesthetic settings of the streams would not change and there would be no visual impacts.

4.2.7.2.2 Shut Down and Deactivate

Under this alternative, DOE would shut down the River Water System, thereby supplying no water to Steel Creek, Lower Three Runs, and the other onsite streams. L-Lake would recede and could return to its original stream conditions; both Steel Creek and Lower Three Runs would receive average flows of approximately 10 cubic feet (0.28 cubic meter) per second, which could support biological communities similar to those that existed prior to the creation of the lake. Because the Steel Creek channel would continue to flow through the L-Lake bed and, because the stream would be associated with a receding lake, this alternative would adversely affect stream aesthetics. Figure 4-15 shows Steel Creek (where it broadens into L-Lake) as the lake begins to recede. This alternative would not affect the other streams.

4.2.7.2.3 Shut Down and Maintain

Aesthetic impacts under this alternative would be the same as those noted for the Shut Down and Deactivate Alternative, except DOE could restart the River Water System if necessary. Section 3.3 contains possible reasons for restarting the system.

4.2.8 OCCUPATIONAL AND PUBLIC HEALTH

4.2.8.1 Affected Environment

4.2.8.1.1 Public Health

DOE collects water samples from the Savannah River and SRS streams on a continual basis throughout the year to determine the effects of the Site's effluents on the river water. In addition, SRS stream sampling locations monitor below the process areas to detect and quantify radioactivity levels in liquid effluents being TE | transported to the river. Table 4-43 lists radio-

PK64-1CD

Figure 4-30. View of Lower Three Runs from just below the dam on Road B.

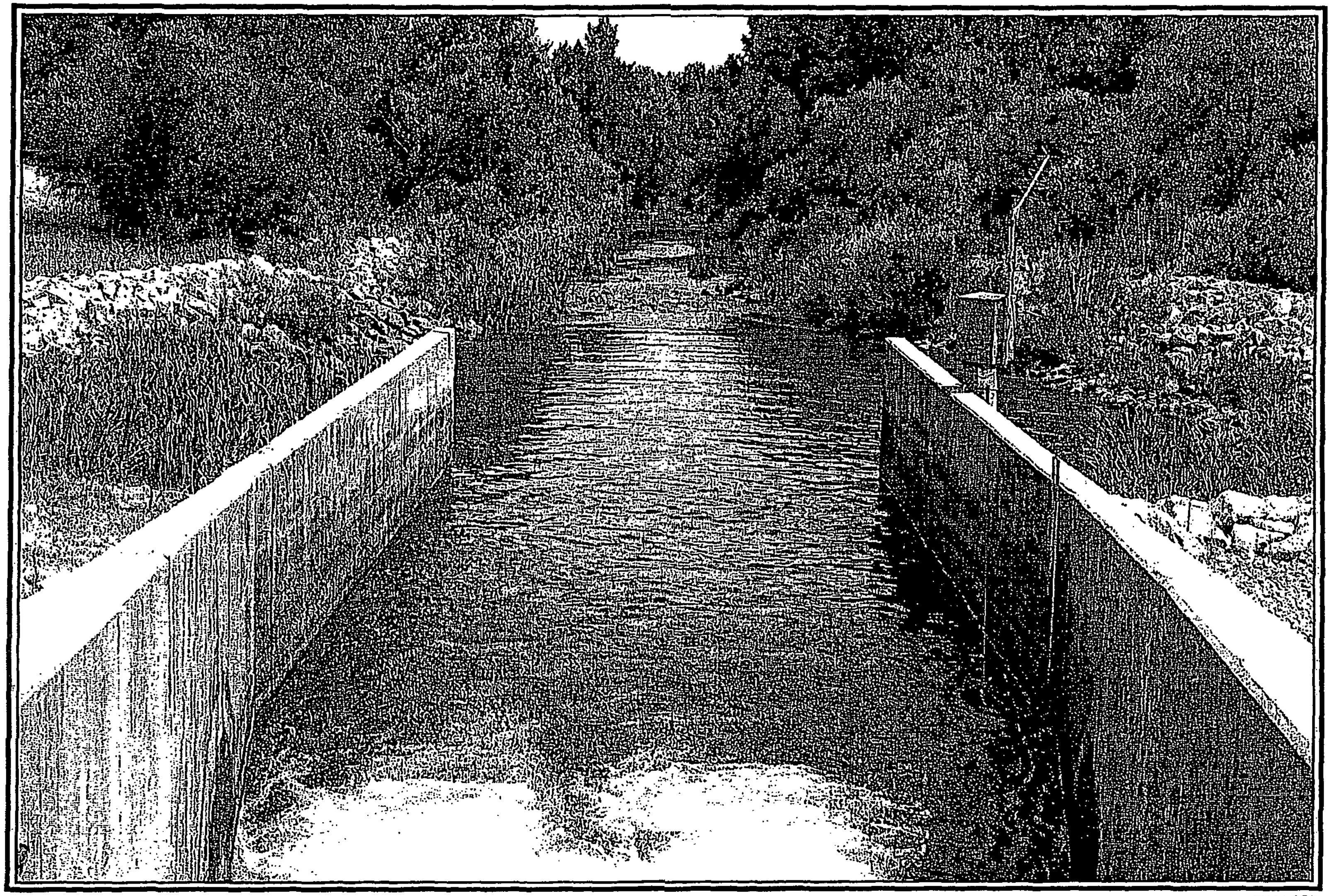


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Figure 4-31. View of Steel Creek from below the dam at L-Lake.

Table 4-43. Average water concentrations of radioactivity in the Savannah River and Savannah River Site streams for 1995 (microcuries per milliliter).[a] TE

Location	Alpha	Gross beta	Tritium
Savannah River			
River Mile 120	8.20×10^{-11}	1.98×10^{-9}	1.28×10^{-6}
River Mile 140	1.96×10^{-10}	2.33×10^{-9}	1.54×10^{-6}
River Mile 150	1.42×10^{-10}	1.98×10^{-9}	1.74×10^{-6}
Vogtle discharge	1.73×10^{-10}	1.94×10^{-9}	7.90×10^{-6}
River Mile 160	8.30×10^{-11}	2.19×10^{-9}	2.09×10^{-7}
Edisto River (offsite control)	7.67×10^{-10}	1.58×10^{-9}	2.22×10^{-7}
SRS Streams			
Tims Branch	1.47×10^{-9}	2.39×10^{-9}	9.66×10^{-7}
Upper Three Runs	1.30×10^{-9}	1.27×10^{-9}	2.21×10^{-6}
Fourmile Creek	2.81×10^{-10}	1.03×10^{-8}	2.28×10^{-4}
Pen Branch	1.07×10^{-10}	1.25×10^{-9}	6.89×10^{-5}
Steel Creek	8.40×10^{-11}	1.62×10^{-9}	6.97×10^{-6}
Lower Three Runs	3.25×10^{-10}	1.84×10^{-9}	9.88×10^{-7}
Upper Three Runs (site control)	2.12×10^{-9}	1.59×10^{-9}	5.08×10^{-7}

a. Source: Arnett, Mamatey, and Spitzer (1996).

activity measurements from selected locations along the river and SRS streams.

Sediment samples have been analyzed (Arnett, Mamatey, and Spitzer 1996) to measure the movement, deposition, and accumulation of long-lived radionuclides in SRS stream beds and in the Savannah River bed. Because of the continuous deposition and remobilization occurring in the stream and river beds, significant year-to-year differences might be evident, but the data obtained can indicate long-term environmental trends. Sediment samples are collected annually from the River and SRS streams. DOE obtains samples from the top 8 inches (3.2 centimeters) of sediment in areas where fine sediment accumulates and most of the radionuclides concentrate. Table 4-44 lists the results of sediment analyses for 1995 at selected locations on the River and SRS streams. The highest activities were observed in samples from Steel Creek and Pen Branch.

Table 4-44. Measurements of radionuclides in the Savannah River and Savannah River Site stream sediments for 1995 (picocuries per gram).[a] TE

Location	Cobalt-60	Strontium-90	Cesium-137	Plutonium-238	Plutonium-239
Savannah River					
Below Fourmile Branch	(b)	0.00670	0.788	0.000612	0.00289
Below Little Hell Landing	(b)	0.00094	1.49	0.00109	0.00586
Highway 301	(b)	(b)	0.203	0.00130	0.00823
Lower Three Runs mouth	(b)	0.00068	1.43	0.00282	0.00505
Demier's Landing (control)	(b)	0.00083	0.262	(b)	0.001260
SRS Streams					
Fourmile at Road A-7	(b)	0.417	0.954	0.000558	(b)
Pen Branch discharge at swamp	(b)	0.0063	1.39	0.00145	0.0141
Steel Creek at Road B	(b)	0.0077	0.356	0.00136	0.00949
Lower Three Runs mouth	(b)	(b)	(b)	(b)	(b)
Lower Three Runs mouth (control)	(b)	(b)	(b)	(b)	(b)

a. Source: Arnett, Mamatey, and Spitzer (1996).
b. Activity is below the lower level of detection.

4.2.8.1.2 Radioactive Releases of Cesium-137 to Onsite Streams

Since 1954, approximately 563 curies of cesium-137 were generated from reactor operations and released to onsite streams (Cummins, Hetrick, and Martin 1991). Table 4-45 shows the source, receiving stream, and amount of these releases. The following section provides information on the estimated inventory and distribution of cesium-137 remaining in Steel Creek.

4.2.8.1.3 Radiation Levels in Steel Creek

From 1955 to 1973, the SRS released approximately 284 curies of cesium-137 to Steel Creek (DOE 1984). A sharp decrease in the release of cesium-137 occurred during the early 1970s when DOE fitted all reactors with sand filters, demineralized the basin water before release, removed leaking fuel elements from the reactor basin to a safe storage area, and finally discontinued the practice of direct discharge of disassembly basin water to Site streams. The estimated inventory (decay corrected to 1996) of cesium-137 remaining in Steel Creek was 58 curies – 7 curies upstream from L-Reactor, 26 curies between L-Reactor and the Steel Creek delta, 18 curies in the Steel Creek delta, and 7 curies between the delta and the SRS boundary (PRC 1996).

The SRS discharged an estimated 27 curies (15 from L-Reactor and 12 from P-Reactor) of cobalt-60 to Steel Creek (DOE 1984). Most of the cobalt-60 (which has a half-life of 5.26 years) has been eliminated through radioactive decay; however, an estimated 0.5 curie remains in either Steel Creek or L-Lake, or has moved to the Savannah River in a manner similar to that described for cesium.

After their discharge to Steel Creek, the cesium-137 and cobalt-60 became associated primarily with the silts and clays in the 11.2-mile (18.0-kilometer) Steel Creek system before reaching the Savannah River. The sediments and associated radionuclides have been subjected to accumulation in L-Lake and to continued resuspension, transport, and deposition according to the flow regime in the creek above and below L-Lake. Aerial radiological surveys (e.g., EG&G 1992) conducted since 1974 indicate that the radionuclides have remained channeled in a zone that correlates with the historic stream channel and floodplain for Steel Creek.

4.2.8.2 Environmental Impacts

As previously discussed in Section 4.2.2.1, tritium levels in Steel Creek, Lower Three Runs,
L10-09 Fourmile Branch, and Pen Branch are expected to increase under the No Action Alternative from the 1996 levels due to removal of the

TE **Table 4-45.** Releases of cesium-137 to onsite streams from reactor operations.[a]

Source	Receiving stream	Release (curies)
C-Area	Castor Creek[b]	33
K-Area	Indian Grave Branch[c]	24
L- and P-Areas	Steel Creek	284
R-Area	Lower Three Runs[d]	222
Total		563

a. Source: Cummins, Hetrick, and Martin (1991).
b. A tributary of Fourmile Branch.
c. A tributary of Pen Branch.
d. Total release to Par Pond, R-Reactor Canals, and Lower Three Runs.

River Water System discharges. These incremental increases in tritium levels are presented in Table 4-26. As shown by the values in this table, Pen Branch would be expected to have the largest incremental increase in tritium levels (52.2 pCi/ml). In addition, for Steel Creek under the Shut Down and Deactivate and Shut Down and Maintain Alternatives, an increase in contaminated sediments is likely during periods of heavy rainfall. Therefore, for these alternatives the sediment loss has been calculated based on stabilized steady state condition and added to the flow in Steel Creek in the form of increased contaminant concentrations in shoreline sediments and surface water. The following sections describe the impacts of these increased contaminant concentrations. L10-09

4.2.8.2.1 No Action

Public Health

Radiological and nonradiological impacts from atmospheric and liquid releases to members of the public under the No-Action Alternative would not change appreciably from the baseline impacts described in Section 4.1.8.1.1. This is true for atmospheric releases because although additional sediments in the stream beds may be uncovered and allowed to dry and be dispersed by the wind, these sediments typically have relatively low concentrations of contaminants (DOE 1984) and would not affect the total airborne release appreciably. Similarly, although concentrations for some contaminants (tritium) would increase in the affected streams, the total release of these contaminants would remain constant. Therefore, incremental changes in impacts under the No-Action Alternative would be very small and this EIS does not calculate them. TC

Occupational Health

Under the No-Action Alternative, the increased tritium concentrations would have an incremental risk to the involved workers due to increased exposure to tritium through incidental ingestion of sediment and dermal contact. The resulting dose and risk values are presented in Table 4-46. Doses to the uninvolved workers would not change appreciably because volatilization of tritium from the streams would remain essentially constant from the baseline conditions. TC

4.2.8.2.2 Shut Down and Deactivate

For the Shut Down and Deactivate Alternative, DOE would discontinue pumping to the reactor areas and flows (in SRS streams that currently receive flows from the River Water System) would revert to natural levels. Because most contaminants reside in the upper regions of the stream floodplains, the alternatives would not expose additional sediments. However, additional sediment would be lost from the L-Lake bed during periods of heavy rainfall. The following paragraphs describe the impacts of this sediment loading on Steel Creek.

Public Health

Radiological and nonradiological impacts resulting from atmospheric and liquid releases would be essentially unchanged from those for the No-Action Alternative with the exception of increased sediment loading in Steel Creek. The impacts of this increased sediment loading are described in Section 4.1.8.2.2 (aqueous releases in Table 4-21). TE The remaining incremental doses and impacts to members of the public would be very small and this EIS does not calculate them.

TE | **Table 4-46.** Worker radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Receptor	No-Action Alternative		Shut Down and Deactivate Alternative	
	Dose (rem)	Probability or number of fatal cancers[b]	Dose (rem)	Probability or number of fatal cancers[b]
Average involved worker (current use)				
Annual[c]	4.9×10^{-10}	2.0×10^{-13}	4.5×10^{-8}	1.8×10^{-11}
Lifetime[d]	6.6×10^{-9}	2.6×10^{-12}	2.0×10^{-7}	8.1×10^{-11}
All involved workers[e] (current use)				
Annual[c] (person-rem)	3.4×10^{-8}	1.4×10^{-11}	3.1×10^{-6}	1.3×10^{-9}
Lifetime[d] (person-rem)	4.6×10^{-7}	1.8×10^{-10}	1.4×10^{-5}	5.7×10^{-9}
L10-09 Average involved worker (future use)				
Annual[c]	1.1×10^{-8}	4.3×10^{-12}	9.7×10^{-7}	3.9×10^{-10}
Lifetime[d]	1.5×10^{-7}	5.8×10^{-11}	1.6×10^{-5}	6.4×10^{-9}
All involved workers[e] (future use)				
Annual[c] (person-rem)	7.6×10^{-7}	3.0×10^{-10}	6.8×10^{-5}	2.7×10^{-8}
Lifetime[d] (person-rem)	1.0×10^{-5}	4.1×10^{-9}	1.1×10^{-3}	4.5×10^{-7}
Uninvolved worker[f]	No impact			

a. Supplemental information provided in Tables C-25, C-26, C-31, and C-32 in Appendix C.
b. For the exposed individual worker, probability of a latent fatal cancer; for the worker population, number of fatal cancers.
c. Annual individual worker doses can be compared with the regulatory dose limit of 5 rem (10 CFR 835) and with the SRS administrative exposure guideline of 0.8 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. The TE | 1995 average dose for all site workers who received a measurable dose was 0.019 rem (see Table 4-16).
d. Based on 5 years of exposure for current workers and 25 years of exposure for future workers; doses are corrected for radioactive decay.
e. Estimated to be 70 workers.
f. L-Area.

Occupational Health

Additional sediments from L-Lake would appear in Steel Creek during periods of heavy rainfall. This increased sediment loading would result in increased concentrations in the surface water and eventually higher concentrations in shoreline sediments in the Steel Creek corridor and delta. These higher concentrations would result in increased exposure to constituents that would result in incremental impacts from direct exposure (e.g., dermal exposure) pathways. The following paragraphs describe these impacts.

Radiological Health

Radiological doses and resulting impacts associated with the Shut Down and Deactivate Alternative would be due to sediment losses from TE | the L-Lake bed. Table 4-46 lists these doses and resulting impacts. As listed, the probability that the average involved worker would develop a fatal cancer sometime as the result of a single year's exposure to radiation under the current land use scenario would be 1.8×10^{-11}. For the total involved workforce, the collective radiation dose could produce up to 1.3×10^{-9} additional fatal cancer as the result of a single year's exposure; over a 5-year career, the involved workers could have 5.7×10^{-9} additional fatal cancer as a result of exposure. TE

Under the future land use scenario, the probability that the average involved worker would develop a fatal cancer at some time as the result of a single year's exposure to radiation would be 3.9×10^{-10}. For the total involved workforce, the collective radiation dose could produce up to 2.7×10^{-8} additional fatal cancer as the result of a single year's exposure; over a 25-year career, an involved worker could have 4.5×10^{-7} additional fatal cancer as a result of exposure. TC

Nonradiological Health

Nonradiological health impacts (hazard index and cancer risk) were calculated under the current and future land use scenarios for the involved worker. The exposure pathways and exposure times would be the same as those discussed in Section 4.1.8. Table 4-47 lists the results. TE As listed, the calculated hazard indexes for the maximally exposed involved worker under the current and future land use scenarios (8.6×10^{-5} and 1.8×10^{-3}, respectively) would TC be a small fraction of 1. Therefore, there is a very low probability that these individuals would experience adverse health effects.

4.2.8.2.3 Shut Down and Maintain

For the Shut Down and Maintain Alternative, DOE would discontinue pumping to the reactor areas and flow would revert to natural levels in SRS streams as described for the Shut Down and Deactivate Alternative. Therefore, the impacts to workers and members of the public under Shut Down and Maintain would be the same as the impacts under Shut Down and Deactivate.

Table 4-47. Worker nonradiological, noncarcinogenic hazard indexes and cancer risk associated with the Shut Down and Deactivate Alternative.[a] TE

Receptor	Total hazard index	Annual (lifetime) latent cancer risk[b]
Involved worker (current use)	8.6×10^{-5}	7.9×10^{-12} (3.9×10^{-11})
Involved worker (future use)	1.8×10^{-3}	1.5×10^{-10} (3.6×10^{-9})
Uninvolved worker[c]	No impact	No impact

TC

a. Supplemental information is provided in Tables C-33 and C-34 in Appendix C.
b. Resulting from exposure to beryllium and arsenic in sediments.
c. Steel Creek bed remains saturated and therefore no atmospheric releases to L-Area.

4.3 Par Pond

Par Pond, a 2,640-acre (10.7-square-kilometer) reservoir (Figure 4-32), was created in 1958 by building an earthen dam (the Cold Dam) across the upper reaches of Lower Three Runs (Wike et al. 1994). It has an average depth of 20 feet (6.2 meters) and a maximum depth of 59 feet (18 meters) (Du Pont 1987b). At full pool, the reservoir storage volume is approximately 52,800 acre-feet (65 million cubic meters).

From August 1958 to October 1961, Par Pond received thermal effluent only from R-Reactor. Heated effluent was discharged to the Middle Arm of Par Pond through precooler Pond C. From November 1961 to June 1964, both P- and R-Reactors discharged heated effluent to Par Pond: R-Reactor to the North Arm via precooler Pond B, and P-Reactor to the Middle Arm via a series of precooler ponds and Pond C (Du Pont 1987b). In July 1964 the Atomic Energy Commission suspended operations of R-Reactor and placed it on standby. After 1964, Par Pond received thermal effluent only from P-Reactor, and Pond B never again received heated discharge.

TE Pumphouse No. 6 (see Figure 4-32) in the west arm (Intake Arm) of Par Pond allowed recirculation of water from Par Pond to P-Area where it mixed (in the 186-Basins) with makeup water pumped from the Savannah River. During reactor operations, recirculating water flowed through the reactor heat exchangers, where it reached temperatures of approximately 158°F (70°C), and discharged through a series of precooler ponds and canals into Pond C (Du Pont 1987b). Heated cooling water from Pond C passed through a concrete culvert below an earthen dam (Hot Dam) from the bottom of Pond C into Par Pond. Water lost from the Par Pond system due to evaporation and seepage was replaced by makeup water pumped from the River. Other than the addition of the makeup water and the overflow and seepage to Lower Three Runs via the Cold Dam, Par Pond operated as a closed loop system. At present, no river water is pumped to Par Pond. Rainfall and inflows from the watershed and groundwater maintain reservoir levels above 195 feet (59.4 meters).

Simple replacement time for the total volume of water in Par Pond by rainfall and runoff from 1962 to 1977 averaged 704 days (Du Pont 1987b). However, reactor operations reduced actual replacement time to 68 days. The shorter replacement time caused increased mixing in the lake and resulted in a more homogeneous distribution of nutrients and plankton than would have occurred without pumping activities.

The natural morphometry of southern portions of Par Pond was altered by earth-moving activities during the creation of the impoundment, which resulted in level areas near the pumphouse (the Intake Arm) and noticeably steep slopes on the east side of the reservoir near the Hot Dam (Du Pont 1987b). The construction activities did not significantly change the North Arm, which as a result is more riverine and shallow.

Pond B is a 200-acre (0.8 square-kilometer) reservoir 2 miles (3 kilometers) northwest of Par Pond (see Figure 4-25). From 1961 to 1964, Pond B was the precooler pond for R-Reactor cooling water effluent. After the R-Reactor shutdown in 1964, Pond B had significantly lower concentrations of total phosphorus, nitrate, silica, potassium, magnesium, calcium, sodium, chloride, inorganic carbon, and total dissolved solids in the euphotic zone than Par Pond (Du Pont 1987b). The higher solids and nutrient levels in Par Pond were attributed to the higher levels of nutrients and suspended solids in Savannah River makeup water entering Par Pond.

Releases from R-Reactor in the form of process leaks, purges, and makeup cooling water contaminated Par Pond with low levels of radioactive materials, primarily cesium-137. Releases

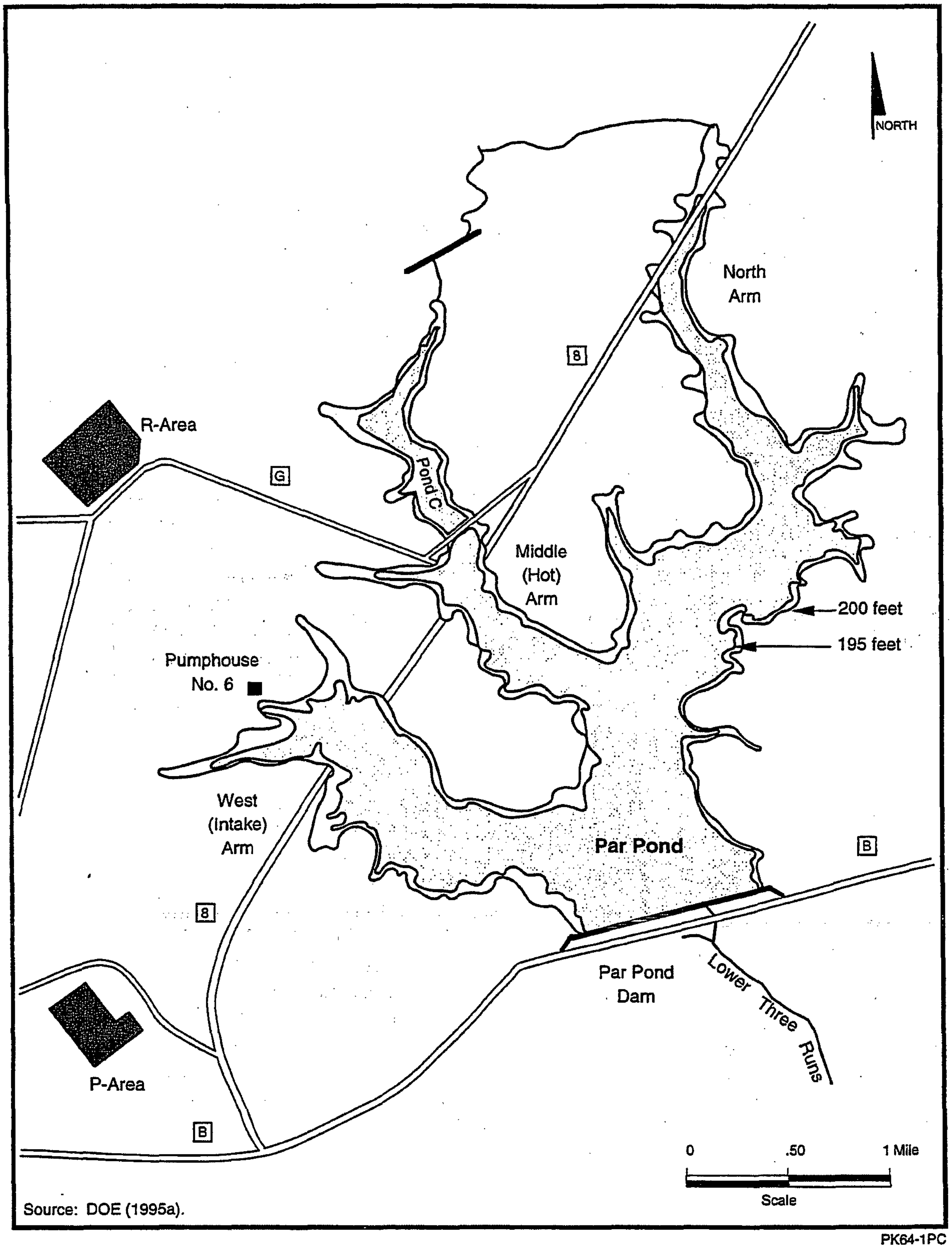

Figure 4-32. Par Pond and environs showing full pool contour of 200 feet above mean sea level and the 195 foot contour.

(except tritium) stopped after the shutdown of R-Reactor in 1964. Most of the cesium-137 in Par Pond lies in the upper 1 foot (0.3 meter) of fine sediments, and is concentrated in the area of the original stream corridor. An estimated 43 curies of cesium-137 remain, two-thirds of which occur below the 190-foot (58-meter) contour (DOE 1995a).

Elevated levels of mercury were found in Par Pond bottom sediments in the 1960s. An estimated 40 pounds (18 kilograms) of mercury were in Par Pond water, sediments, and biota in the early 1970s (Newman and Messier 1994), approximately half of which DOE assumed to have come from Savannah River water and half from natural sources (i.e., soils inundated when the reservoir was filled). The sources of mercury in the river water were industrial and manufacturing operations upstream of the SRS that discharged mercury-laden wastes to the River. With the implementation of the Clean Water Act and National Pollutant Discharge Elimination System regulations in the mid-1970s, these industries dramatically reduced levels of pollutants in their permitted discharges. Levels of mercury entering SRS waterbodies with river water showed a corresponding decline (Newman and Messier 1994).

An inspection of the Par Pond Dam in March 1991, led to the discovery of a small depression in the downstream face of the dam (DOE 1995a). DOE ordered a structural study of the dam and subsequently initiated a precautionary drawdown of the reservoir. During the June to September 1991 period, Par Pond was lowered from 200 feet (61.0 meters) to 181 feet (55.2 meters) above mean sea level, reducing its volume by approximately two-thirds (DOE 1995a). The drawdown exposed some 1,340 acres (5 square kilometers) of lakebed, roughly half the normal surface area of the reservoir (Marcy et al. 1994). In 1995 after dam repairs were completed, the reservoir was refilled under a Comprehensive Environmental Response, Compensation, and Liability Act interim action to reduce risks to human health and the environment from contaminants in exposed sediments.

The Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site (DOE 1995a) described the impacts of the 1991 to 1995 drawdown of Par Pond and the expected impacts of allowing the surface-water level of Par Pond to fluctuate from a full pool of approximately 200 feet (61.0 meters) to 195 feet (59.4 meters). This document determined that there would be three basic impacts: (1) instability in the littoral zone of the reservoir, (2) exposure of up to 500 acres (2 square kilometers) of contaminated sediments in the lakebed at the 195-foot (59.4-meter) elevation, and (3) loss of nutrient inputs to the reservoir. However, in a Finding of No Significant Impact (DOE 1995b), DOE concluded that the proposed action (a component of which was the natural fluctuation of the water level in Par Pond) was not a major Federal action "significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act."

4.3.1 GEOLOGY AND SOILS

4.3.1.1 Affected Environment

This section identifies the geologic and soil features of the Par Pond area that the alternatives described in this EIS could affect. Section 4.1.1 describes the regional geology and soils.

TE

4.3.1.1.1 Stratigraphy

By analyzing the geologic map of the site, it can be determined that the Tobacco Road Formation outcrops along approximately 60 percent of the western side of Par Pond and the Dry Branch Formation outcrops along the upper reaches of the lake. Section 4.1.1.1 describes these formations that could be affected (Prowell 1994). TE/TC

4.3.1.1.2 Soils

The following soils occur commonly in the area west of Par Pond (see Figure 4-9) (USDA 1990):

- Blanton sand, 0 to 6 percent slopes (BaB)
- Fluvaquents, frequently flooded (Fa)
- Fuquay sand, 2 to 6 percent slopes (FuB)

4.3.1.2 Environmental Impacts

4.3.1.2.1 No Action

The erosion or deposition of soil and surface formations is likely to continue at the current rates. P-Reactor area is not operational. No contamination of geology or soils at Par Pond would occur since there is no active outfall.

4.3.1.2.2 Shut Down and Deactivate

If DOE deactivated the River Water System, Par Pond would no longer have the capability to receive river water. Soils are already known to be contaminated at Par Pond. DOE believes natural fluctuations will maintain lake levels above 195 feet (59.4 meters) above mean sea level through recharge by groundwater. Without the River Water System, DOE would not be able to refill Par Pond.

4.3.1.2.3 Shut Down and Maintain

The impacts discussed above for the Shut Down and Deactivate Alternative would apply to this alternative. However, if Par Pond levels fell below the 195-foot (59.4-meter) level, DOE could restart the River Water System to refill the lake.

4.3.2 SURFACE WATER

4.3.2.1 Affected Environment

Par Pond was a cooling water reservoir for P- and R-Reactors until 1964, when DOE shut R-Reactor down (Wilde 1985). It continued to receive heated cooling water until 1988, when DOE shut P-Reactor down (Paller and Wike 1996a).

4.3.2.1.1 Water Quality

Because watershed contributions to Par Pond (through rainfall and natural drainage) are considerably lower in nutrients than water pumped from the Savannah River, the addition of water to Par Pond through the River Water System resulted in nutrient enrichment. On the basis of its water chemistry and biological community characteristics, Par Pond is an oligotrophic to mesotrophic lake (reservoir).

A comprehensive biological monitoring program conducted from November 1985 to December 1992 investigated the L-Lake/Steel Creek System. During the latter part of this study, from 1990 to 1992, DOE used one sampling location on Par Pond, near the dam, for data comparison. The 1990-1992 water quality data from this location reflect post-reactor operation conditions, as listed in Table 4-48 (Wike et al. 1994).

In 1991 the water level of Par Pond was reduced from its historic level of 200 feet (61 meters) above mean sea level to 181 feet (55.2 meters) above mean sea level because of a defect in the Par Pond Dam. The drawdown began in June 1991 and the water level reached 181 feet by September 1991. DOE repaired the dam and refilled Par Pond to its previous level in early 1995. Par Pond was extensively studied before, during, and after the drawdown, resulting in the generation of considerable information on contaminant levels in the ecosystem and ecological changes resulting from the drawdown.

In February 1995 DOE began biweekly sampling to monitor changes in water chemistry during the refilling of Par Pond to its full pool, approximately 200 feet (61 meters) above mean sea level. The sampling program measures and monitors parameters and constituents that could quickly indicate impending anoxia (oxygen depletion) or eutrophication (nutrient enrichment).

TE | **Table 4-48.** Water quality parameters for Par Pond near the dam (January 1990-December 1991).

Item	Mean	Range	Number of samples
Water temperature (°C)	18.1	8.5-31	96
pH	6.33	5.54-7.25	84
Dissolved oxygen (mg/l)	6.01	0.02-11.6	96
Specific conductance (μmhos/cm)	70.0	46-126	96
Total suspended solids (mg/l)	2.02	0-10	96
Alkalinity (mg $CaCO_3$/l)	14.6	6.73-40.3	96
Chloride (mg/l)	5.73	3.25-8.0	28
Sulfate (mg/l)	4.62	3.6-7.8	28
Total calcium (mg/l)	3.42	2.44-4.72	28
Total magnesium (mg/l)	0.84	0.593-1.04	28
Total sodium (mg/l)	6.15	3.07-9.05	28
Total potassium (mg/l)	1.04	0.54-1.38	28
Total aluminum (mg/l)	0.032	0.006-0.109	28
Total iron (mg/l)	0.517	0.015-3.63	28
Total manganese (mg/l)	0.251	0.006-137	28
Total phosphorus (mg/l)	0.032	0.008-0.28	1,000
Ortho-phosphate (mg/l)	0.007	0-0.238	999
Total Kjeldhal Nitrogen (mg/l)	0.302	0-1.03	1,000
Ammonia (mg N/l)	0.046	0-0.891	1,000
Nitrite (mg N/l)	0.003	0-0.026	1,000
Nitrate (mg N/l)	0.073	0-0.385	999

Results of the sampling through September 1995 indicated that dissolved oxygen and nutrient concentrations generally remained within the range expected for southeastern reservoirs (Koch, Martin, and Westbury 1996).

In September 1995 DOE collected sediment and water samples as part of a study that included an investigation of contaminant levels in Par Pond sediments and water, and how the drawdown and refill affected contaminant levels. The sediment sample analyses included total mercury, while the water sample analyses included total mercury and EPA target analyte list metals (Paller and Wike 1996a).

Mercury, a toxic metal, was present in detectable concentrations at 20 percent of the sample sites; elevated levels of mercury have accumulated in sediments from pumping water from the Savannah River. The average concentration, 39 parts per billion, was below the EPA Region IV sediment screening value (130 parts per billion; EPA 1995). However, the highest mercury concentration, 323 parts per billion, exceeded the EPA Region IV screening value for mercury in sediments. The highest mercury concentrations occurred in deeper portions of Par Pond.

In addition, surface sediment samples were collected in Par Pond to assess the potential ecological effects of contaminants in Par Pond sediments (Paller and Wike 1996b). Although the maximum detected value exceeded the EPA Region IV screening level, the average concentration (77 parts per billion) did not.

None of the metals measured in Par Pond water samples exceeded EPA Region IV acute toxicity screening values for surface waters (EPA 1995). However, the detection limits for beryllium, cadmium, lead, mercury, and silver were not low enough to ensure that these metals were below EPA Region IV surface-water chronic toxicity screening values.

Data collected before and after the Par Pond drawdown and refill suggest the refill had little effect on contaminant levels in the aquatic ecosystem. There was no evidence of long-term resuspension of contaminants in the water or of extensive redistribution of contaminants as a result of sediment movements [although localized downslope movements of contaminants on the exposed shoreline during the drawdown remain a possibility (Paller and Wike 1996a)].

4.3.2.1.2 Water Quantities

Par Pond has a mean depth of approximately 20 feet (6.2 meters), a maximum depth of approximately 59 feet (18 meters) near the dam, a shoreline length of approximately 33 miles (53 kilometers), and a storage volume of approximately 52,800 acre-feet (65 million cubic meters) at an elevation of approximately 200 feet (61 meters) above mean sea level (Wilde 1985).

4.3.2.1.3 Water Usage

In January 1996 DOE stopped pumping river water to Par Pond to enable water levels to fluctuate naturally between a full pool of approximately 200 feet (61 meters) and 195 feet (59.4 meters) above mean sea level. DOE accomplished this by diverting flows from National Pollutant Discharge Elimination System Outfall P-19, which normally discharges to Par Pond, to NPDES Outfall P-13, which discharges to the headwaters of Steel Creek above L-Lake. TC The current primary effluents to Outfall P-19 are the P-Area 186-basin overflow (pumped river water), nonprocess cooling water, building drains, and stormwater.

Although DOE discontinued reactor operations in 1988, it pumped river water through Outfall P-19 to Par Pond until January 1996 (except during the Par Pond dam repairs) at 7 to 10 cubic feet (0.2 to 0.3 cubic meter) per second to maintain historic water levels. Since January 1996, the water level has fluctuated naturally and has not decreased below 199 feet (60.7 meters) (Sidey 1996). Initial modeling exercises indicated that, without river water contributions, levels in Par Pond would fluctuate seasonally with rainfall, runoff, and evaporation, with pool levels ranging from 197 to 199 feet (60.1 to 60.7 meters) above mean sea level (DOE 1995a); however, these exercises had some uncertainty due to assumptions they made about the groundwater system at Par Pond. Due to a lack of information of the hydrologic system in the area, the analysis assumed for modeling purposes that net groundwater flow into the pond was zero (i.e., flow in equals flow out).

Subsequently, DOE conducted a water balance study of the Par Pond hydrologic system to estimate the rate of groundwater flow to Par Pond. The results of the study suggest that Par Pond gains water from the groundwater system in its upper reaches but loses water to the groundwater system near the dam. The rate of groundwater flow from the water table aquifer into Par Pond was 13 cubic feet (0.37 cubic meter) per second. The rate of flow from Par Pond to the water table aquifer near the dam was 7 cubic feet (0.2 cubic meter) per second. This results in a net groundwater flow of 6 cubic feet (0.2 cubic meter) per second from the aquifer to Par Pond. Table 4-49 lists the water budget components that represent actual flows in or out of Par Pond (Hiergesell and Dixon 1996). TE

Table 4-49. Inflow and outflow terms (cubic feet per second).[a,b]

TE

Inflow Terms	
Water budget component	Long-term average flux rate
Precipitation over Par Pond	13
Surface runoff entering Par Pond	11
Groundwater seepage into Par Pond	13
Long-term average canal inflow to Par Pond	23
Total	60
Outflow Terms	
Water budget component	Long-term average flux rate
Evapotranspiration from Par Pond	13
Seepage loss to groundwater	7
Spillway discharge	40
Total	60

a. Source: Hiergesell and Dixon (1996).
b. To convert cubic feet to cubic meters, multiply by 0.02832.

Using the water balance results, data on Par Pond water levels with 5,000 gallons per minute (0.32 cubic meters per second) continuous release and a full pool of 200 feet (61 meters) above mean sea level indicate that the reservoir remains above 197 feet (60.2 meters) above mean sea level more than 95 percent of the time, based on the revised model predictions (Gladden 1996a).

4.3.2.2 Environmental Impacts

4.3.2.2.1 No Action

There would be no impacts to Par Pond surface water resources if DOE decided to implement the No-Action Alternative. The SRS ceased river water inputs to Par Pond in January 1996 and allowed the water level to fluctuate naturally from its current actual full pool level of approximately 200 feet (61 meters) above mean sea level. DOE allows the water level to fluctuate from a full pool of approximately 200 feet to 195 feet (59.4 meters). Although the Par Pond water level has not decreased below 199 feet (60.7 meters) since January 1996, it could fluctuate by as much as several feet in response to seasonal changes in rainfall and evaporation. Considerable research on the effects of fluctuating water levels in reservoirs indicates that fluctuations are not harmful and might even be beneficial if they are not extreme and match the fluctuations generally characteristic of a normal hydrological cycle (i.e., high in spring and low in late fall and early winter). Fluctuations in the Par Pond water level would follow natural patterns. Under this alternative, DOE would maintain the capability to resume river water inputs to Par Pond if water levels dropped below 195 feet (59.4 meters).

The cessation of river water inputs has resulted in the reduction of nutrients entering Par Pond from the Savannah River. The reservoir is likely to change from a moderately productive state to a water body that more closely resembles typical southeastern reservoirs that do not experience substantial nutrient input (DOE 1995a).

4.3.2.2.2 Shut Down and Deactivate

Surface-water impacts under this alternative would be the same as those discussed for No Action except DOE would lose the capability to restart the river water pumps and refill Par Pond to an appropriate level if one of the monitored indicator values (e.g., a water quality parameter or a biotic index) exceeded established threshold levels.

4.3.2.2.3 Shut Down and Maintain

Surface-water impacts to Par Pond under this alternative would be the same as those discussed for No Action.

4.3.3 GROUNDWATER

This section describes the site-specific groundwater conditions near the Par Pond aquifers.

4.3.3.1 Affected Environment

Aquifer Units

Section 4.1.3 discusses the regional hydrogeology. The water table aquifer discharges along the edges of Par Pond (Hiergesell 1996). Based on a review of Well No. P24 on cross sections (Aadland, Gellici, and Thayer 1995), the first confined aquifer occurs at approximately 100 feet (30 meters) above mean sea level and approximately 100 feet below the mean reservoir water elevation.

Groundwater Flow

The water table aquifer flows away from P-Area (west to east) (see Figure 4-12) and discharges to the west side of Par Pond. Specific hydraulic properties for the water table aquifer are limited in the Par Pond area, so Table 4-1 uses sitewide hydraulic properties of the water table aquifer. According to the pontentiometric surface map of the first confined aquifer (Figure 4-12), groundwater flows in a south/ southeast direction below and away from Par Pond. Data on the hydraulic properties of the first confined aquifer in the Par Pond area are also limited and sitewide data are used here as well (Table 4-2). Water from Par Pond recharges both aquifers below the dam. Therefore, water in Par Pond does not directly affect the first confined aquifer. According to assumptions used in Hiergesell (1996), there is a leakage from Par Pond through the water table aquifer and into the first confined aquifer. Based on a review of hydrostratigraphic cross sections and maps (Aadland, Gellici, and Thayer 1995), groundwater is apparently not connected (i.e., a groundwater mound exists between lakes) between Par Pond and L-Lake aquifers. | TE

Groundwater Quality and Usage

The quality of groundwater has been adversely impacted in P- and R-Areas west of Par Pond (WSRC 1996e). However, the extent of that impact is not fully known and is under investigation. The SRS does not use the water table aquifer or first confined aquifer in the area of Par Pond. | TE

4.3.3.2 Environmental Impacts

4.3.3.2.1 No Action

Currently, Par Pond receives no River Water System outfall discharges. Therefore, the River Water System has no current effect on either aquifer in the vicinity of Par Pond. By continuing the operation of the River Water System, DOE does not anticipate any future effects on either aquifer at Par Pond.

4.3.3.2.2 Shut Down and Deactivate

The outfall from the River Water System does not currently contribute to the groundwater in either aquifer at Par Pond. Therefore, the groundwater flow rates, flow direction, and water quality in both aquifers would not be affected by a shutdown alternative. The overall groundwater contribution to the lake elevation would remain essentially constant, and there would be no change in the current groundwater contribution from Par Pond to the water table aquifer and the first confined aquifer in Lower Three Runs.

4.3.3.2.3 Shut Down and Maintain

The impacts described in Section 4.3.3.2.2 would also apply to this alternative.

4.3.4 AIR RESOURCES

4.3.4.1 Affected Environment

DOE assumes that the climate, meteorology, and ambient air quality for Par Pond are equivalent to those for the SRS, which are discussed in Section 4.1.4.1.

4.3.4.2 Environmental Impacts

4.3.4.2.1 No Action

DOE is allowing the level of water in Par Pond to fluctuate, as discussed in Section 4.3.2.2.2. The estimated lowest water elevation for Par Pond is 197 feet (60 meters) above mean sea level, which could expose up to 340 acres (1.4 square kilometers) of sediment (Gladden, Paller, and Mackey 1995). Winds could cause the exposed sediment to become resuspended as airborne particulates.

DOE used the MEPAS model to estimate quantities of resuspended particulates originating from exposed sediment (Droppo et al. 1995), incorporating joint frequency wind data from the L-Area wind tower for the period from 1986 to 1991 (Simpkins 1996a). Data from the L-Area tower is representative of Par Pond due to its proximity. The algorithm used by MEPAS to calculate the particulate emission factor has a parameter for the frequency of disturbances to the dried shoreline sediment. For conservatism, a factor of 30 disturbances per month was used by DOE to estimate a worst-case particulate emission rate. By using a factor of 30 disturbances per month, the 24-hour period of interest is modeled.

Table 4-50 lists the maximum concentration in air of nonradiological constituents at the boundary of the SRS. Included in the table is a column that shows the maximum allowable concentrations established by the South Carolina Department of Health and Environmental Control (SCDHEC 1976). As can be seen from the table, the resuspension of particulate matter from Par Pond produces only minimal concentrations by comparison to the allowable concentration.

Table 4-50. Maximum ground-level concentrations of nonradiological air constituents at the SRS boundary under the No-Action Alternative.

Nonradiological constituent	Modeled maximum air concentration[a] (µg/m^3)	Maximum allowable concentration[b] (µg/m^3)
Manganese	2.5×10^{-6}	1.0
Mercury	1.2×10^{-6}	0.25
PM_{10}[c]	15	50 (annual average) 150 (24-hour average)

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).
b. Source: SCDHEC (1976).
c. PM_{10} is particulate matter with a diameter of 10 microns (0.00001 m) or less.

The estimated airborne maximum SRS boundary-line concentrations of radionuclides resulting from the resuspension of dried lakebed sediments would be 1.63×10^{-4} and 6.0×10^{-7} picocurie per cubic meter for cesium-137 and cobalt-60, respectively. These concentrations represent a radiological dose (from all pathways originating with air dispersion) of 6.5×10^{-3} millirem per year and 9.8×10^{-6} millirem per year, respectively. Both of these doses, as well as the sum of the doses, are much less than the 10 millirem requirement of 40 CFR 61 and would not contribute any appreciable dose the normal site emissions from the SRS.

TC

4.3.4.2.2 Shut Down and Deactivate

The effects of this alternative would be the same as those described in Section 4.3.4.2.1. Impacts to the existing SRS ambient air quality would be minimal.

4.3.4.2.3 Shut Down and Maintain

The effects of this alternative would be the same as those described in Section 4.3.4.2.1. Impacts to the existing SRS ambient air quality would be minimal.

4.3.4.3 Combined Impacts of L-Lake, SRS Streams, and Par Pond

4.3.4.3.1 No Action

The continued operation of the River Water System would have minimal impact on the existing ambient air quality at the SRS. DOE would maintain L-Lake and the streams at their current levels, and the potential for exposed sediments to become airborne would be minimal. Section 4.1.4.1 discusses releases of tritium due to the presence of L-Lake. DOE expects Par Pond to fluctuate naturally between a full pool level and a modeled low of 196 feet (58.8 meters) above mean sea level (Gladden 1996a), which could expose as much as 340 acres (1.4 square kilometers) of sediment (Gladden, Paller, and Mackey 1995). Section 4.3.4.2.1 discusses potential impacts to ambient air quality due to this natural fluctuation.

TC

The primary contaminants in L-Lake, Par Pond, and the streams would be radionuclides and metals. No organic contaminants would be present in the lakebed or the floodplain at levels that are close to EPA Region IV risk-based concentrations, which DOE is using as screening levels at SRS (DOE 1996c).

TC

There would be minimal impacts to the ambient air quality as a result of the continued operation of the River Water System.

4.3.4.3.2 Shut Down and Deactivate

The shutdown and deactivation of the River Water System could cause the level of water in L-Lake to recede as discussed in Section 4.1.2.2.2 and become completely dry over a period of several years. In addition, Par Pond could recede from its current level to an estimated lowest water elevation of 196 feet (58.8 meters) above mean sea level, which would expose as much as 340 acres (1.4 square kilometers) of sediment (Gladden, Paller, and Mackey 1995).

TC

For streams, the flows would return to natural base levels. As discussed in Section 4.1.6.2.2, the reductions in stream flow are not likely to result in exposed sediment. Sediment that is covered with water or vegetation could not become suspended by air currents and, therefore, no impacts are likely.

Table 4-51 lists the maximum concentration in air of nonradiological constituents at the boundary of the SRS. Included in the table is a column that shows the maximum allowable concentrations established by the South Carolina Department of Health and Environmental Control (SCDHEC 1976). As can be seen from the table, the resuspension of particulate matter from L-Lake and Par Pond is well below the allowable concentration.

TC

Table 4-51. Maximum ground-level concentrations of nonradiological air constituents at the Savannah River Site boundary under the Shut Down and Deactivate Alternative.

Nonradiological constituent	Modeled maximum air concentration[a] ($\mu g/m^3$)	Maximum allowable concentration[b] ($\mu g/m^3$)
Antimony	8.6×10^{-6}	2.5
Arsenic	2.2×10^{-5}	1.0
Beryllium	2.9×10^{-6}	0.01
Cadmium	1.3×10^{-6}	0.25
Lead	1.8×10^{-5}	1.5 (calendar quarter average)
Manganese	2.6×10^{-6}	25
Mercury	1.2×10^{-6}	0.25
PM_{10}[c]	16	50 (annual average) 150 (24-hour average)

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).
b. Source: SCDHEC (1976).
c. PM_{10} is particulate matter with a diameter of 10 microns (0.00001 m) or less.

TC

Table 4-52 lists the maximum concentration in air of the radiological constituents at the boundary of the SRS. A column also is included in the table that shows the radiation dose resulting from annual exposure to this concentration of material. This radiation dose was calculated for all potential exposure pathways (e.g., ingestion of vegetation, direct exposure to radiation) that are the result of material being suspended and transported to the site boundary. These doses are much less than the 10 millirem per year requirement in 40 CFR 61.

TC

A benefit to the environment would be the reduction of fugitive evaporative tritium emissions from the L-Lake surface water. The maximum calculated reduction in airborne tritium concentration would be 0.073 picocurie per cubic meter.

The combined effects of the shutdown and deactivation of the River Water System would have minimal impact on the ambient air quality at SRS.

4.3.4.3.3 Shut Down and Maintain

The combined effects of this alternative would be the same as those described in Section 4.3.4.3.2. Increases in concentrations of PM_{10}, air toxics, and radionuclides would be within both State and Federal regulatory guidelines.

4.3.5 ECOLOGY

The *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek below L-Lake at the Savannah River Site* (DOE 1995a) describes the impacts of the 1991-1995 drawdown of Par Pond and the expected impacts of allowing the surface water level of Par Pond to fluctuate naturally from a full pool of approximately 200 feet (61 meters) to 195 feet (59.4 meters). The alternatives considered in this EIS would allow Par Pond to fluctuate naturally. They differ only to the extent that DOE would maintain the operability of the River Water System. The actions considered in this EIS, in relation to Par Pond, have undergone a thorough NEPA review.

Table 4-52. Maximum ground-level concentrations of radiological air constituents at the SRS boundary under the Shut Down and Deactivate Alternative.

Radiological constituent	Modeled maximum air concentration[a] (pCi/m^3)	Dose from all pathways (mrem/yr)
cesium-137	1.6×10^{-4}	6.5×10^{-3}
cobalt-60	6.1×10^{-7}	1.0×10^{-5}
plutonium-239	3.7×10^{-8}	3.5×10^{-5}
promethium-146	7.9×10^{-9}	9.5×10^{-9}
uranium-233	9.6×10^{-7}	9.3×10^{-5}
thorium-229	4.5×10^{-9}	4.7×10^{-6}
radium-225	4.5×10^{-9}	1.8×10^{-7}
actinium-225	4.5×10^{-9}	3.0×10^{-8}

TC

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).

4.3.5.1 Affected Environment

4.3.5.1.1 Terrestrial Ecology

Gibbons and Semlitsch (1991) provide information on the distribution and abundance of SRS amphibians and reptiles, including those occurring in the Par Pond area. Wike et al. (1994) contains useful information on the birds of the SRS, with special emphasis on waterfowl and threatened and endangered species (the red-cockaded woodpecker, bald eagle, and wood stork). Section 4.3.5.3 of this EIS describes these threatened and endangered species and their relative abundance and distribution on the SRS. Cothran et al. (1991) contains information on SRS mammals, including those of the Par Pond system. Gibbons et al. (1986) presents useful information on the distribution and abundance of semiaquatic mammals (e.g., the muskrat and beaver) in the Par Pond area.

A number of researchers (Brisbin, Geiger, and Smith 1973; Kennamer, McCreedy, and Brisbin 1993; Colwell, Kennamer, and Brisbin 1995; Peters, Brisbin, and Kennamer 1995) have investigated patterns of radiocesium contamination in Par Pond and Pond B and evaluated the uptake and retention of cesium-137 in birds [wood ducks (*Aix sponsa*), coots (*Fulica americana*), mourning doves (*Zenaida macroura*), and domestic chickens (*Gallus gallus*)] foraging and nesting in the Par Pond area. These studies concluded that while the birds' bodies often contained elevated levels of cesium-137, these levels are "...below those expected to affect hatchability or any other aspect of the breeding biology of these birds" (Kennamer, McCreedy, and Brisbin 1993) and "...do not indicate any present health hazard to the general public who may use them for food" (Brisbin, Geiger, and Smith 1973). Moreover, these species (all of which, except the chicken, are migratory) rapidly lose accumulated radiocesium when they move to uncontaminated areas due to their small body sizes and high basal metabolic rates. Total elimination time of a given body burden of cesium-137 may be as little as 12 to 15 days in the mourning dove and 30 days in the larger wood duck (Kennamer et al. 1997). L7-04 L7-05

Burger et al. (1996) examined concentrations of metals (mercury, lead, cadmium, selenium, manganese, and chromium) in tissues of mourning doves that foraged on herbaceous vegetation growing in the Par Pond lakebed in L7-04 L7-05

1992 and 1993. Doves from Par Pond had significantly higher levels of selenium and manganese in muscle tissue than doves from control sites outside SRS. For all metals, however,
L7-04 concentrations in doves from Par Pond and
L7-05 control sites were generally within the lower range of those reported in the literature, suggesting that those metals do not pose a health problem to the doves or to animals (including humans) who might consume them.

Aerial surveys of the Par Pond system conducted from 1981 to 1985 revealed that 20 waterfowl species spent some portion of the fall-winter period in the Par Pond system (Wike et al. 1994). Over the 4-year period, waterfowl use of the Par Pond system increased, while midwinter numbers declined in South Carolina and the Atlantic flyway. Lesser scaup (*Aytha affinis*) were most numerous, followed by ring-necked ducks (*A. Collaris*), ruddy ducks (*Oxyura jamaicensis*), and buffleheads (*Bucephala albeola*). Three of the four species showed a preference for areas unaffected by reactor operations, while ruddy ducks were frequently observed in areas receiving heated effluent from P-Reactor. Recent surveys conducted by Savannah River Ecology Laboratory scientists suggest that waterfowl use of Par Pond has remained high.

The drawdown of Par Pond decimated many beds of mussels and clams that were stranded when the reservoir waters receded (DOE 1995a). Although many freshwater mollusks can survive for several months by burrowing in mud or moist soils (Pennak 1978), they cannot survive longer periods out of water, from which they derive food and oxygen. The loss of mussels and clams resulted in reduced use of Par Pond by waterfowl in the winter of 1991-1992 (DOE 1995a). Several duck species that traditionally winter on Par Pond (e.g., ring-necked ducks and bufflehead) feed on plant material and mollusks in areas where emergent vegetation is growing, particularly when preferred plant foods (such as wild celery, smartweed, widgeon grass, waterlily, buttonbush, and pondweed) are not abundant (Sprunt and Chamberlain 1970; Hoppe, Smith, and Wester 1986). Other species, such as lesser scaup and ruddy ducks, feed on small invertebrates (snails, clams, and mussels) in deeper Par Pond waters (Hoppe, Smith, and Wester 1986; Bergan and Smith 1989).

The drawdown appeared to have little lasting effect on adult alligators, but the loss of cover appeared to have reduced alligator nesting success and juvenile survival. The drawdown had no noticeable effect on bald eagle use of Par Pond. As in years past, Par Pond was used extensively by foraging and roosting bald eagles. The rapid drawdown of Par Pond in 1991 stranded fish in shallow pools, making them easy prey for wading birds, including the endangered wood stork. As a result, there was a marked increase in the number of wood storks foraging around the margins of Par Pond (DOE 1995a). Surveys of Par Pond in 1992, 1993, 1994, and 1995 indicated that wood stork use of Par Pond had returned to normal, with storks observed occasionally foraging in the area.

4.3.5.1.2 Aquatic Ecology

The aquatic ecology of Par Pond was studied intensively from January 1984 through June 1985 as part of a Clean Water Act Section 316(a) thermal effects demonstration. It supported a diverse phytoplankton community; green algae had the most taxonomic representation, followed by the diatoms and blue-green algae (Chimney, Cody, and Starkel 1985). In terms of density, diatoms were the most abundant algal group. In terms of primary productivity, chlorophyll-*a* concentrations, and algal community composition, Par Pond was similar to other lakes in the southeastern United States.

Protozoans and rotifers were the numerical dominants of the zooplankton community, with protozoans more abundant in the winter and spring, and rotifers in the summer (Chimney, Cody, and Starkel 1985). Larger-bodied cladocerans and copepods were most abundant in the summer, indicating a lack of strong pressure from fish predation. As with the phytoplankton, the zooplankton community in Par Pond was similar to other southeastern systems.

Par Pond received additional zooplankton study as part of the last 3 years (1990 through 1992) of the Clean Water Act Section 316(a) thermal effects demonstration for L-Lake (Gladden et al. 1989; Bowen 1993a). It is difficult to infer changes in the Par Pond community between 1985 and 1990 from the presentation of data in Bowen (1993a), but protozoan densities varied widely from 1990 to 1992; they were often similar and sometimes higher than the protozoan densities in L-Lake.

Fish populations were temporarily affected by the Par Pond drawdown, which reduced spawning and nursery habitat for many species and increased predation on small forage species [e.g., brook silverside (*Labidesthes sicculus*), golden shiner (*Notemigonus crysoleucas*), and *Notropis* species] and young-of-the-year sunfish that use littoral zone macrophyte beds for escape cover.

4.3.5.1.3 Wetlands Ecology

The creation of Par Pond in 1958 flooded several thousand acres (several square kilometers) of upland habitat and riparian wetlands. Stable water levels in Par Pond during the first 33 years of its existence (1958 to 1991) allowed wetland vegetation communities to develop along the shore. However, extensive beds of macrophytes along the shoreline did not develop until the mid-1970s (Wike et al. 1994). These beds essentially stabilized by the early 1980s. A study of wetland vegetation at Par Pond in the mid-1980s characterized the wetlands of Par Pond as comprised of three classes: aquatic bed (floating-leaves species), emergent (herbs, mosses, and ferns), and scrub-shrub (shrubs and trees). Most of the wetland communities around the lake represented moderately late-successional stages (i.e., mature vegetation communities) with low species diversity. Most areas were dominated by only a few species of perennial plants, with few annual species. Aquatic bed regions were dominated by lotus (*Nelumbo lutea*), waterlily (*Nymphaea odorata*), and watershield (*Brasenia schreberi*); emergent wetlands were dominated by cattail (*Typha* spp.) and maidencane (*Panicum hemitomon*); and the scrub-shrub areas were dominated by willows (*Salix* spp.), sweet gale (*Myrica* spp.), and maples (*Acer* spp.) (Grace 1985). L11-19

In March 1991 DOE discovered a depression on the downstream slope of the Par Pond dam (Cold Dam). While determining whether repairs were needed, DOE lowered the lake level approximately 19 feet (5.8 meters) for safety reasons. As a result, both the emergent and nonemergent littoral wetland vegetation were exposed to drying conditions, and extensive macrophyte losses occurred. Surveys conducted in August 1992 indicated that some reinvasion was occurring on the newly exposed shoreline. For the most part, grasses, sedges, and rushes were the dominant forms, and some old-field species had also taken root (Wike et al. 1994).

Par Pond was restored to full pool in spring 1995, and has remained at full pool since refill, fluctuating only slightly. Periodic surveys of the shoreline aquatic communities have been conducted since the reservoir was refilled. Shoreline aquatic vegetation is undergoing rapid redevelopment. Maidencane, the current dominant emergent species, has become less abundant in deeper water since the water level rose. Several other species that dominated wetland areas of Par Pond before the drawdown are increasing in abundance, including lotus, waterlily, watershield, and spike rush (*Eleocharis equisetoides*). Cattails are also scattered throughout most of Par Pond, and long beds are forming in the Middle Arm. Lotus expanded in 1996 into areas formerly dominated by cattails. In addition, woody species, including loblolly pine (*Pinus taeda*), willow, and red maple, that colonized the reservoir's edge during the drawdown, are declining in abundance since the refill, although there is a band of willow and red maple around the margins of the lake (Mackey and Riley 1996).

4.3.5.2 Environmental Impacts

4.3.5.2.1 No Action

Terrestrial Ecology

The Par Pond environmental assessment (DOE 1995a) predicted that a "substantial and productive" aquatic macrophyte community would become established when Par Pond was allowed to fluctuate naturally; however, this new macrophyte community probably would be less extensive and less diverse, similar to macrophyte communities in other southeastern flood-control and hydroelectric power reservoirs with seasonal water level fluctuations. Instability in the littoral zone would result in reduced macroinvertebrate productivity, which in turn would reduce the value of the littoral zone as a foraging area for reptiles, waterfowl, shorebirds, and mammals.

The environmental assessment also predicted that the number of waterfowl using Par Pond would increase (in relation to the 1991-1995 drawdown period) if DOE allowed the lake to fluctuate naturally, but would be smaller than the numbers of birds that used the reservoir when the water was at full pool (199 to 200 feet above mean sea level). This predicted reduction in waterfowl use of Par Pond was based on the facts that (1) the reservoir would be smaller, providing proportionally less preferred shallow-water habitat; (2) the total acreage of aquatic macrophytes that provide waterfowl with food and cover would be smaller; and (3) the production of benthic organisms, including aquatic insect larvae and mollusks that are important foods for diving ducks, would be reduced by the instability of the littoral zone.

The environmental assessment suggested that fluctuating water levels would not be disruptive to normal movement and behavior of adult alligators, but the loss of shoreline stability and cover could affect reproductive success and juvenile survival. These impacts probably would lessen over the next several years as shoreline macrophyte communities become reestablished.

Fluctuating water levels would have little or no effect on bald eagles, although the environmental assessment noted that a slight increase in radiocesium and mercury intake could occur as a result of higher levels of contaminants in Par Pond ecological receptors (e.g., small mammals and fish) that are prey for eagles. There is no evidence that allowing Par Pond to fluctuate naturally would create conditions attractive to wood storks, because water level changes would be gradual, allowing most fish to move downslope with receding waters. As a result, wood storks would not be exposed to higher than normal concentrations of contaminants in water, sediments, and fish. Section 4.3.5.3 contains a comprehensive assessment of potential impacts to threatened and endangered species of shutting down the River Water System.

Aquatic Ecology

The environmental assessment (DOE 1995a) noted that Par Pond had received continuous infusions of nutrients for more than 30 years and predicted that a reduction in nutrient inputs would result in the development of aquatic communities (i.e., plankton and fish) that more closely resemble those of typical southeastern reservoirs that do not receive substantial nutrient inputs. The environmental assessment pointed out that a reduction in one nutrient, potassium, could lead to increased levels of cesium-137 in aquatic organisms. In the absence of potassium, aquatic organisms readily take up cesium, which cells accept as potassium because of its chemical similarity.

The environmental assessment predicted that fish populations would be reduced by fluctuating water levels and reduced nutrient inputs when pumping of river water was discontinued. Fluctuating water levels could hinder the reproduction of species (e.g., yellow perch and chain pickerel) that spawn in shallow, weedy areas, and would be particularly harmful if reservoir levels dropped precipitously during sensitive periods (e.g., soon after eggs are deposited in beds in shallow water).

Wetland Ecology

The No-Action Alternative would allow the water level in Par Pond to fluctuate naturally from a full pool of approximately 200 feet (61 meters) to 195 feet (59.4 meters) above mean sea level. This could expose as much as 340 acres (1.4 square kilometers) of sediment (DOE 1995a). However, the level is likely to remain at approximately 196 feet (59.7 meters) about 65 percent of the time, which would expose only about 115 acres (0.5 square kilometers) of sediment. Thus, some changes are likely to occur in contrast to the relatively stable and biologically productive nature of the ecosystem and littoral wetland areas that existed during the initial 33 years of Par Pond's existence. Specifically, a reduction of and instability in the littoral zone and related communities are likely to occur. The 1991 drawdown removed approximately 50 percent of the reservoir's surface area, much of which was shallow wetlands that provided habitat and foraging resources for a variety of fish and wildlife. Because impacts on the littoral-zone plant communities from natural fluctuation are not likely to be as extensive as those during the drawdown, the communities over time would resemble those in most seasonally fluctuating impoundments in the Southeast.

A recent study estimated areas of aquatic vegetation, essentially wetland vegetation, that would develop at various water levels for Par Pond; an estimated 800 acres (3.2 square kilometers) of aquatic macrophytes would be present at 199.2 feet (59.8 meters) and about 600 acres (2.4 square kilometers) at 195 feet (59.4 meters) (Narumalani 1993). Both the acreage and species composition of the aquatic macrophyte community would be affected, but impacts would be smaller, and a substantial and productive macrophyte community would develop at lower ranges of fluctuation. The species composition would differ from the one that developed during the stable water level regime. Reservoir water levels are often manipulated to control aquatic plant communities, and the results vary depending on the timing and length of drawdown and the geographic area (Cooke et al. 1986). These fluctuations can both decrease and increase the abundance of certain species; for example, cattail and bulrush (*Scirpus cyperinus*) can benefit from lower water levels because they require bare mudflats as a seedbed (Lantz et al. 1964).

Many wetland vegetation species can survive and even thrive with heavily fluctuating water levels; as a result, relative tolerance to the water-level fluctuations that could occur would determine future community dominance patterns at Par Pond (Mackey and Riley 1996). Maidencane in Carolina Bays on the SRS survived water levels as high as 4 feet (1.2 meters) via stem elongation, and occupied as much as 30 percent of plots of this species in depths to 5.6 feet (1.7 meters) (Kirkman and Sharitz 1993). The rate of refilling in Par Pond did not exceed the rates of maidencane stem growth and elongation around the newly exposed shoreline (Mackey and Riley 1996). For these reasons, maidencane could become a dominant species in Par Pond, although wave action in deeper water could inhibit continued growth and survival of this macrophyte in more steeply sloped areas. Cattail beds would also expand and, as mentioned above, spike rush is appearing in beds in areas almost identical to those observed in predrawdown studies. Lotus, also dominant before the drawdown, is likely to continue to remain dominant in intermediate and deeper waters up to depths of 6.5 to 10 feet (2 to 3 meters). It could also replace maidencane in deeper water areas (Mackey and Riley 1996).

Grace (1985) observed that the lack of appreciable water-level fluctuation in Par Pond may have created stagnant sediments in some of the back regions of Par Pond coves, causing them to be almost devoid of vegetation. Fluctuations in the water level would aerate these sediments and could expedite degradation of waste products. For example, oxygenating these stagnant areas could reduce the effect of certain substances, such as ammonia and hydrogen sulfide, that are naturally present in these kinds of backwater areas and can be highly toxic to aquatic organisms (Rand and Petrocelli 1985).

Rapid recovery of aquatic macrophytes has occurred at Par Pond, especially in predrawdown wetland areas, following almost 4 years of a 19-foot (5.8-meter) drawdown that resulted in the destruction of macrophyte beds and exposure of seed banks. Given the relatively low predicted extremes of water-level fluctuation expected, impacts to wetland vegetation could occur but would be limited to a maximum reduction of 200 acres (0.8 square kilometer) and related changes in relative abundance of wetland plant species around the lake margins.

4.3.5.2.2 Shut Down and Deactivate

DOE expects impacts from this alternative to be similar to those from the No-Action Alternative.

4.3.5.2.3 Shut Down and Maintain

DOE expects impacts from this alternative to be similar to those from the No-Action Alternative.

4.3.5.3 Threatened and Endangered Species

Savannah River Site Proposed, Threatened, Endangered, and Sensitive Plants and Animals (SRFS 1994) describes Federally listed threatened, endangered, and candidate plant and animal species that occur or might occur on the SRS. At present, the SRS monitors and protects these species and has active management programs for the wood stork, red-cockaded woodpecker, and smooth coneflower. Table 4-53 presents Federally listed species. TE

4.3.5.3.1 Affected Environment

Smooth coneflower (*Echinacea laevigata*)

The smooth purple coneflower occurs in the southeastern United States in open frequently disturbed (burned or mowed) areas such as highway roadsides and transmission line rights-of-way that receive ample sunlight (FWS 1995). Two smooth coneflower populations have been identified on the SRS: (1) off Burma Road approximately 2 miles (3 kilometers) southwest of F-Area, and (2) on a 115-kilovolt transmission line that intersects Road 9 approximately 1 mile (1.6 kilometers) east of L-Lake. Neither population is in an area that activities associated with the Proposed Action would affect. Therefore, this EIS will not discuss this species further.

Table 4-53. Threatened and endangered plant and animal species of the Savannah River Site.

Common name (scientific name)	Status
Animals	
Bald eagle (*Haliaeetus leucocephalus*)	T[a]
Wood stork (*Mycteria americana*)	E[b]
Red-cockaded woodpecker (*Picoides borealis*)	E
American alligator (*Alligator mississippiensis*)	T/SA[c]
Shortnose sturgeon (*Acipenser brevirostrum*)	E
Plants	
Smooth coneflower (*Echinacea laevigata*)	E

a. T = Federally threatened species.
b. E = Federally endangered species.
c. T/SA = Threatened due to Similarity of Appearance to the endangered American crocodile.

Red-cockaded woodpecker (*Picoides borealis*)

The red-cockaded woodpecker occurs in the open pine woodlands of the Coastal Plain, where it lives in small groups of two to nine birds called "clans" (Hooper, Robinson, and Jackson 1980; FWS 1985). Each clan consists of a mated pair, their current year's offspring, and "helpers," male offspring from previous years (FWS 1985). This species is unique in that it requires mature pine trees (greater than 60 years old), often with red heart (fungus) disease, in which to nest. Nest cavities often require years to complete and once constructed are often maintained for the life of the tree through successive generations of birds. The clan roosts and nests in a group of cavity trees called a colony, that can include as many as a dozen trees and often occupy a roughly circular area 1,500 to 2,500 feet (460 to 760 meters) in diameter (Hooper, Robinson, and Jackson 1980). The territory of the birds ranges from 98 to more than 247 acres (0.4 to 1 square kilometer), depending on habitat quality, and the total area used by a clan can be as large as 988 acres (4 square kilometers) (Hooper, Robinson, and Jackson 1980). The larvae of wood-boring insects, grubs, and beetles form the bulk of this woodpecker's food.

Bald Eagle (*Haliaeetus leucocephalus*)

The bald eagle is a permanent breeding resident of South Carolina, arriving in the fall (October to November), nesting in midwinter (December to January), and migrating north to New England and Canada in midsummer after young have fledged (Sprunt and Chamberlain 1970). Numbers of eagles in South Carolina have risen steadily since the 1970s as a result of the national ban on certain organochlorine pesticides (e.g., DDT), the protection afforded the species by the Endangered Species Act, and the construction of several large reservoirs in the Coastal Plain and Piedmont of South Carolina (Mayer, Hoppe, and Kennamer 1985, 1986; Bryan et al. 1996). Eagles fledged near the coast now are able to disperse inland to areas they previously did not inhabit such as the reservoirs built in the 1970s on the Savannah River and Broad River drainages. In 1978 only 15 nesting pairs of bald eagles were observed in South Carolina. By 1996 there were more than 100 nesting pairs in the State (Hart et al. 1996). The rate of increase in breeding territories (nesting pairs) appears to be greater in reservoir habitat in South Carolina than in nonreservoir (riverine and estuarine) habitats (Bryan et al. 1996).

Bald eagles in the southeastern United States generally nest at the boundary of a wooded area and an open area in a tall pine or cypress tree that affords a wide view of the surrounding countryside (Kale 1978). Nest trees are often the tallest in a particular forest stand, and are within 2 miles (3 kilometers) of water (Stalmaster 1987; FWS 1989).

Bald eagles in South Carolina eat fish almost exclusively but will feed on wounded waterfowl, wading birds, small mammals, and carrion, such as dead fish and road kills (Sprunt and Chamberlain 1970; Hart et al. 1996; LeMaster 1996). Bald eagles on the SRS have been observed feeding on largemouth bass, coots, buffleheads (small diving ducks), gray squirrels, and other small mammals (Hart et al. 1996).

Bald eagles were first reported on the SRS in 1959 when three were observed on Par Pond (Wike et al. 1994). Par Pond continued to be the center of eagle activity on the SRS until 1985, when DOE built L-Lake. In October 1985 L-Lake was completed and within 1 month an eagle was reported over that lake (Mayer, Hoppe, and Kennamer 1986). L-Lake now provides important foraging habitat for eagles that nest on Pen Branch, approximately 1 mile (1.6 kilometers) west of L-Lake (LeMaster 1996).

Bald eagle use of L-Lake has increased since 1987 (when the Savannah River Ecology Laboratory began surveys), with the highest number of sightings occurring in the fall and winter of 1992-1993 (Bryan et al. 1996). Eagle use of Par Pond over the same period has remained at a constant but fairly low level. In the winters of 1991-1992 and 1992-1993, when Par Pond was drawn down for repairs, bald eagles were frequently observed foraging in the area (Bryan et al. 1996). After the reservoir was refilled, bald eagles were seen less frequently in the Par Pond area.

There are three eagle nests on the Savannah River Site. The Eagle Bay nest, discovered in 1986, is in a live bald cypress tree in a beaver pond approximately 0.9 mile (1.5 kilometers) southwest of the Par Pond dam. The Pen Branch nest, discovered in 1990, is in a loblolly pine tree approximately 1 mile (1.6 kilometers) west of L-Lake. The recently discovered G Road nest is approximately 0.25 mile (0.4 kilometer) east of Par Pond (LeMaster 1996).

Eagles have nested intermittently at the Eagle Bay location since 1986, with wind storms twice destroying nests and once, in 1989, killing an eagle nestling (Hart et al. 1996). Chicks hatched at the Pen Branch nest every year from 1990 to 1996. To date, no young have been observed at the G Road nest.

Wood Stork (*Mycteria americana*)

Wood storks, large wading birds with wing spans of up to 5.5 feet (1.7 meters) occur throughout Florida, Georgia, and coastal South Carolina. They feed through a highly specialized process called tactolocation that involves wading (sometimes shuffling to intentionally disturb prey) in shallow pools with their bills opened slightly and submerged as far as the external nares. When a stork touches fish or other prey (e.g., snakes, crayfish) with its bill, it snaps its bill shut, capturing the prey. This feeding technique allows wood storks to forage in muddy or turbid water where birds that hunt visually cannot feed. To feed efficiently, storks forage in ponds where prey concentrate. This is especially important during the breeding season, because food requirements are greatest when adults are nesting or caring for young (Sprunt and Chamberlain 1970; Kale 1978).

Wood storks are colonial nesters. They build large nests in trees, usually over standing water. Nest heights range from a few meters above water in mangrove swamps to the tops of the tallest cypress trees. They breed during the dry season when evaporation in shallow ponds concentrates aquatic prey (Kale 1978; Ehrlich, Dobkin, and Wheye 1988). From northern Florida to South Carolina, wood storks breed from March to August.

The population of wood storks in the United States decreased from an estimated 20,000 pairs in 1930 to just under 5,000 pairs in 1980 (Coulter 1989). Habitat degradation and the loss of foraging habitat, which led to the population decline, ultimately resulted in the species being listed as Endangered under the Endangered Species Act in 1984 (Coulter, McCort, and Bryan 1987; Stokes and Stokes 1996). Restoration efforts have been moderately successful. The U.S. population has increased from 5,000 breeding pairs in 1980 to 8,000 breeding pairs in 1996 (Bryan 1996).

The most northern and inland wood stork colony, the Birdsville Colony, is in a 2.1-square-mile (5.7-square-kilometer) cypress swamp near Millen in Georgia. This wood stork colony is the breeding area of most storks observed foraging on the SRS. The SRS is approximately 28 miles (45 kilometers) from the Birdsville colony, a distance well within the 37- to 43-mile (60- to 70-kilometer) radius that wood storks can travel during daily feeding flights (Du Pont 1987d).

Wood storks forage in shallow, open water areas where prey concentrations are high enough to ensure successful feeding. Ideal feeding conditions usually occur in sheltered bodies of water where depths range from 2 to 6 inches (5 to 15 centimeters), and where the water column is relatively free of aquatic vegetation (Coulter and Bryan 1993). Before 1986, most wood stork foraging activity on the SRS was concentrated in the Savannah River swamps and associated stream deltas (Beaver Dam Creek, Fourmile Branch, Pen Branch, and Steel Creek) (Du Pont 1987d).

At the time of the L-Reactor restart, DOE agreed to create new wood stork foraging areas near the SRS, mitigating an anticipated loss of foraging habitat in the Steel Creek delta. Kathwood Lake, consisting of four ponds [35 acres (0.14 square kilometer)], was built at the National Audubon Society's Silver Bluff Plantation Sanctuary in the spring of 1986, filled with water to a depth of 6-12 inches (15 to 30 centimeters), and stocked with bluegill, brown bullhead, and sterile grass carp (Coulter, McCort, and Bryan 1987). Bluegill and brown bullhead were selected because they were the preferred prey of wood storks in the wild; sterile grass carp were stocked to control aquatic vegetation. Kathwood Lake is approximately 19 miles (30 kilometers) northwest of the Steel Creek delta and 28 miles (45 kilometers) northeast of the Birdsville Colony.

By 1986 significant numbers of foraging wood storks were using Kathwood Lake. The maximum number of wood storks observed per day increased from 97 in 1986 to 250 in 1990 (Coulter 1993). The ponds have been highly successful in fulfilling their intended purpose.

Wood stork use of Par Pond and L-Lake has been intermittent and at fairly low levels in most years. After the Par Pond drawdown in the summer of 1991, the reservoir was monitored weekly for wood stork use. Wood storks used portions of the reservoir, particularly the North Arm, as foraging areas fairly consistently from late July through mid-October 1991. As many as 84 storks were observed in a single survey. No storks have been observed foraging in the Par Pond area since 1992 (LeMaster 1996).

Craig's Pond and Sarracenia Bay, two Carolina bays east of the North Arm of Par Pond were used by foraging wood storks in 1993 and 1996. Eagle Bay, just south of the Par Pond Dam, was also used by foraging storks in 1993 (LeMaster 1996).

The only documented wood stork use of L-Lake from 1987 to 1993 was a single stork observed foraging in lower L-Lake on September 24, 1987. The Savannah River Ecology Laboratory has conducted weekly aerial surveys of L-Lake during the nesting season since 1993. No storks have been observed during these surveys (LeMaster 1996).

Storks have been observed foraging and roosting in several wetlands near L-Lake. Peat Bay and an adjacent wetland next to the railroad tracks (both south of L-Lake and SC Highway 125) have been used by storks each year since 1993, with as many as 100 storks observed in a single survey. SRS personnel documented stork use of two additional nearby wetlands, Steel Creek Bay and an unnamed seasonal wetland near Robbins Station, as foraging habitat in 1995 (LeMaster 1996).

Wood stork use of the Savannah River swamp decreased steadily over the 1983-1990 period (Coulter 1993). This was attributed to high water levels in areas (such as Fourmile Branch) influenced by reactor operations and the dense growth of aquatic vegetation in other areas (such as Steel Creek) that no longer received large volumes of cooling water from reactor operations.

Over the last several years, wood storks have occasionally been observed foraging in the deltas of Fourmile Branch and Pen Branch. Most stork sightings in this area have occurred in the open cypress-gum river swamp that lies between these two deltas (LeMaster 1996).

American alligator (*Alligator mississippiensis*)

The American alligator, hunted almost to extinction by the middle of the 20th century, is now a common resident of the big river swamps, bayous, lakes, and marshes of Florida, the Gulf Coast, and the south Atlantic Coastal Plain (Conant and Collins 1991). The Fish and

Wildlife Service reclassified the alligator, previously listed as threatened in South Carolina, as "Threatened (due to Similarity of Appearance)" in June 1987 (52 FR 21059-21064). It was reclassified because populations in the southeast were flourishing as a result of successful state-run restoration programs and the species was no longer at risk. However, the Service maintained that some level of Federal protection was necessary to ensure against excessive taking of alligators and to protect the much-rarer (endangered) American crocodile (*Crocodylus acutus*); one concern was that enforcement personnel would not be able to distinguish between the processed hides of the two species.

In sanctuaries, refuges, and other areas where they are protected, alligators can grow to 16 feet (4.9 meters) long and weigh as much as 600 pounds (273 kilograms) (Mount 1975; Van Meter 1987; Conant and Collins 1991). The largest alligator ever captured on the SRS was 12.5 feet (3.8 meters) long (Gibbons and Semlitsch 1991). In captivity, alligators can live as long as 50 years; in the wild 30 to 35 years is probably the maximum lifespan (Van Meter 1987). Both sexes reach maturity at a length of about 6 feet (1.8 meters), when they are 8 to 12 years old, depending on the quality of the habitat.

Alligators occur in a variety of SRS habitats including river swamps, small streams, abandoned farm ponds, Carolina bays, and two large impoundments, Par Pond and L-Lake (Du Pont 1987d). Their abundance on the SRS is the direct result of more than 40 years of protection afforded the population by the secure SRS boundary (Gibbons and Semlitsch 1991). Par Pond contains the largest concentration of alligators on the SRS, more than 200 animals (LeMaster 1996). Alligators were plentiful in downstream portions of Steel Creek when it received heated effluent and are now commonly observed in and around L-Lake (Du Pont 1987d; LeMaster 1996). No population estimates are available for L-Lake.

Beaver Dam Creek, which receives heated effluent from the D-Area coal-fired power plant, supports a moderately large, self-sustaining population of alligators that consists of small numbers of adults and larger numbers of juveniles and subadults (Murphy 1981; Wike et al. 1994). Fourmile Branch contains small numbers of alligators in its lower reaches and delta, most of which are probably immigrants (juveniles and subadults) from nearby Beaver Dam Creek. High stream flows and temperatures from K-Reactor operations made most of Pen Branch unsuitable for alligators until 1988, but there are indications that alligators are recolonizing the lower reaches of the stream (Wike et al. 1994).

Steel Creek apparently supported a large alligator population in the early 1950s before the operation of the SRS reactors (Murphy 1981), but contained few alligators in its upper reaches during the years it received thermal effluent. Alligator numbers are still low in the Steel Creek drainage, with most animals found in the delta or in the vicinity of beaver ponds adjacent to the stream. Lower Three Runs has historically supported a reproducing population of alligators, most of which are concentrated in an area below the Par Pond dam where they are protected from human encroachment (Murphy 1981; Wike et al. 1994).

Before 1958 when Par Pond was built, alligators were uncommon on the SRS and were concentrated in the Lower Three Runs drainage (Murphy 1981). The SRS alligator population grew rapidly after Par Pond was filled, and by 1974 an estimated 109 alligators were in the reservoir, 60 of which were adults.

The number of alligators inhabiting Par Pond more than doubled from 1974 to 1988, from 109 to 266 animals (Brandt 1991). The size and age structure of the population in 1988 [a high proportion of young animals less than 6 feet (1.8 meters) long] indicated an expanding population. Brandt (1991) characterized the population as "quite healthy" and suggested that the number of alligators would increase until the carrying capacity (estimated to be around 500 individuals) was reached (Brandt 1991).

After Par Pond was drawn down (July-September 1991) Savannah River Ecology Laboratory scientists conducted studies to assess the effect of the drawdown on Par Pond alligators. Brisbin et al. (1992) reported that female alligators continued to guard nests even after the water had receded and all nests were more than 300 feet (100 meters) from the new shoreline. Brisbin et al. (1992) theorized that few hatchlings survived, noting that wading bird use of the area was heavy and that the young alligators were exposed to these and other predators (largemouth bass and other alligators) because of the lack of cover. There was also strong evidence for violent territorial encounters between adults that had left Par Pond and moved to other areas in search of better conditions (Brisbin et al. 1992).

Data from six alligator nests studied in the summer of 1994 during the Par Pond drawdown indicated that clutch sizes were reduced by 10.9 percent compared to pre-drawdown periods (Brisbin et al. in press). Body condition of hatchlings (based on length-weight relationships) was also lower. Nest predation appeared to have been reduced during drawdown, however, suggesting that negative reproductive impacts of the drawdown were to some extent compensated for by increased survival. When the reservoir was refilled in late-summer of 1994, flooding caused the destruction of one of six nests studied and caused an overall loss of 30.6 percent of eggs produced (Brisbin et al. in press). There was no evidence that females responded to rising water by making additions or alterations to their nests. Impacts to nests from rising water levels appeared to be a function of location and topography.

Savannah River Ecology Laboratory scientists recently completed a study that compared body burdens of mercury in alligators from Par Pond with alligators from the Florida Everglades (Yanochko et al. in press). Concentrations of mercury in kidney, muscle, and dermal scutes were lower in Par Pond alligators than Everglades alligators. There were no differences in mercury levels in tissues of animals collected before and after the Par Pond drawdown. The average concentration of mercury (4.1 milligram per kilogram) in muscle tissue of Par Pond alligators was higher than advisory levels established by the State of Florida (0.5 milligram per kilogram) or the U.S. Food and Drug Administration (1.0 milligram per kilogram) as safe for human consumption.

In January 1996, a large male alligator measuring more than 3.9 meters (13 feet) long was found dead in Par Pond (Brisbin 1997). Decomposition of the carcass made it impossible to determine the cause of death, but samples of muscle, kidney, and liver tissue were analyzed for mercury residues. Mercury content of these tissues, expressed on a wet weight basis, averaged 3.5 milligram per kilogram for muscle, 33.6 milligram per kilogram for kidney, and 158.9 milligram per kilogram for liver (Brisbin 1997). The reason for these unusually high levels of mercury is unknown, but long-lived species such as the alligator tend to accumulate more mercury than other groups, such as amphibians and fish, that have much shorter life spans. Mercury concentrations in tissues of individual animals within a population may vary dramatically with differences in age, body size, diet, metabolic rate, sex, state of sexual maturity, condition, habitat preference, and time of year. The alligator found in Par Pond was at least 22 years old, and may have been considerably older.

Shortnose sturgeon (*Acipenser brevirostrum*)

The shortnose sturgeon is an anadromous fish that spawns in large Atlantic coastal rivers from New Brunswick, Canada, to north Florida (Scott and Crossman 1973). A species of commercial importance around the turn of the century, the shortnose sturgeon is now listed by the National Marine Fisheries Service as an endangered species. The decline of the species has been attributed to the impoundment of rivers, water pollution, and overfishing; recruitment rates appear to be too low to replenish depleted populations (Heidt and Gilbert 1978).

Shortnose sturgeon grow slowly, reach sexual maturity relatively late in life, and live as long as 30 years (Scott and Crossman 1973). Fish from southern populations can grow faster and mature earlier than those from northern populations (Heidt and Gilbert 1978). Spawning occurs in, or adjacent to, deep areas of rivers with significant currents [1 to 4 feet (0.3 to 1.2 meters) per second] during spring when water temperatures warm to 48 to 59°F (9 to 15°C) (Crance 1986; Rulifson, Huish, and Thoeson 1982). Adults apparently return to natal streams to spawn at 2- to 5-year intervals (Rulifson, Huish, and Thoeson 1982). Eggs are heavier than water and adhesive after fertilization, sinking quickly and adhering to sticks, stones, gravel, and rubble on the stream bottom (Crance 1986). The interaction of water temperature, current velocity, and substrate type apparently determines suitability of spawning habitat as well as hatching success. Very few larvae and juveniles have been collected, so little is known of their distribution and movement (Rulifson, Huish, and Thoeson 1982).

Before 1982 shortnose sturgeon were not known to occur in the middle reaches of the Savannah River. However, 12 shortnose sturgeon larvae were collected near SRS in a 4-year (1982 through 1985) DOE study of ichthyoplankton abundance and entrainment in reactor cooling water systems (DOE 1987b). When shortnose sturgeon were first collected in 1982 and 1983, DOE notified the National Marine Fisheries Service as required under Section 7 of the Endangered Species Act of 1973 (Muska and Mathews 1983). A subsequent biological assessment evaluated the potential impact of SRS operations on shortnose sturgeon. The assessment concluded that "existing and proposed operations (specifically L-Reactor) of the Savannah River Plant will not affect the continued existence of the shortnose sturgeon in the Savannah River" (Muska and Mathews 1983). This conclusion was based on the facts that (1) shortnose sturgeon spawned upriver and downriver of the SRS; (2) passage up and downstream was not blocked by thermal effluents; (3) shortnose sturgeon did not spawn or forage in SRS streams and swamps that received thermal discharges; (4) entrainment was unlikely because shortnose sturgeon eggs are demersal, adhesive, and negatively buoyant; and (5) impingement of healthy juvenile and adult shortnose sturgeon on cooling water system screening devices is highly unlikely given their strong swimming ability. The National Marine Fisheries Service concurred with the DOE determination that SRS operations did not threaten the Savannah River population of shortnose sturgeon (Du Pont 1985).

A South Carolina Wildlife and Marine Resources Division (now South Carolina Department of National Resources) study of seasonal movement and spawning habitat preferences of Savannah River shortnose sturgeon found two probable spawning sites, one upstream of SRS at river mile 177-179 (river kilometer 285-288) and the other downstream of the Site at river mile 115-121 (river kilometer 185-195) (Hall, Smith, and Lamprecht 1991). The *Comprehensive Cooling Water Study* (Du Pont 1985) suggested that shortnose sturgeon spawned as far upstream as the first migratory obstruction, the New Savannah Bluff Lock and Dam. The South Caroline Wildlife and Marine Resources Division study appears to support this theory.

4.3.5.3.2 Environmental Impacts

Red-cockaded woodpecker

<u>No Action</u>

Although there are two inactive red-cockaded woodpecker colonies within a mile (1.6 kilometers) of L-Lake (Colony 61 to the west, in the vicinity of Substation Number 3 and Colony 62 to the east, near the intersection of Roads B-4 and B-5), there are no active colonies within several miles of the reservoir. Therefore, none of the activities associated with the No-Action Alternative at L-Lake would affect this woodpecker. Receding water levels would not have an effect on birds foraging, roosting, and nesting in open pine woods miles away from the reservoir.

Although there are several inactive red-cockaded woodpecker colonies and foraging areas within 660 feet (200 meters) of the North Arm of Par Pond (Colonies 64, 65, and 70), there are no active colonies within several miles of the reservoir. None of the activities associated with the No-Action Alternative at Par Pond would affect red-cockaded woodpeckers. Fluctuating Par Pond water levels should have no effect on birds foraging, roosting, and nesting in open pine woods miles away from the reservoir.

There are two inactive red-cockaded woodpecker colonies (Colonies 7 and 71) just west of Steel Creek and several active red-cockaded woodpecker colonies and foraging areas on bluffs and dry ridges to the west of Lower Three Runs in the area of the triangle formed by Round Tree Road, Patterson Mill Road, and Road A-18. None of the activities associated with the No-Action Alternative would affect red-cockaded woodpeckers foraging, roosting, or nesting in the vicinity of SRS streams.

Shut Down and Deactivate

Under this alternative, L-Lake would recede and DOE would not pump river water to Par Pond even if its level were to unexpectedly fall below 195 feet (59.4 meters). Neither circumstance would affect red-cockaded woodpeckers. Stream flows associated with this alternative would have no effect on birds that forage, roost, and nest exclusively in mature pine stands well outside of the floodplain.

Shut Down and Maintain

This alternative would have no impact on red-cockaded woodpeckers.

Bald Eagle

No Action

Under the No-Action Alternative, DOE would continue to maintain L-Lake at its current level of approximately 190 feet (58 meters). This action would not affect bald eagles nesting on Pen Branch or foraging in the L-Lake area.

Under the No-Action Alternative, Par Pond would fluctuate naturally from about 195 feet (59.4 meters) to 200 feet (61 meters). Shoreline instability could reduce the amount of wetland vegetation around the margins of the reservoir and limit the production of macroinvertebrates. Reduction in aquatic macrophyte coverage or density would reduce the amount of cover for forage fish, while reduced production of invertebrates could affect food resources of fish and certain mammals. If fish production or growth were affected, the prey base of the bald eagles could suffer (LeMaster 1996). Based on observations of bald eagles during the 1991 to 1995 Par Pond drawdown (DOE 1995a; Hart et al. 1996), when DOE lowered the reservoir as much as 19 feet (5.8 meters), impacts to eagles from the relatively small fluctuation that would occur under the No-Action Alternative would be minimal to nonexistent.

Shut Down and Deactivate

Under this alternative, DOE researched the effect on eagles from exposure to contaminated water, sediment, and prey items (mostly fish). TE

Hart et al. (1996) evaluated potential effects to bald eagles foraging in and around Par Pond and L-Lake from exposure to radiological (chiefly cesium-137) and nonradiological (mercury) contaminants. The analysis indicated that the radiation dose to Par Pond eagles from food and drinking water was approximately 0.0026 rad per day, well below the dose range of 0.1 to 1.0 rad per day that is considered protective of wildlife (IAEA 1992; Eisler 1994; Appendix B).

The average mercury concentration in Par Pond bass was 0.94 milligram per kilogram [parts per million (ppm)] over the 1988 to 1994 period (Table 4-54), below dietary levels that have caused acute effects (mortality) in some birds (Hart et al. 1996). The average mercury concentration in L-Lake bass over a shorter time period were slightly higher, 1.17 parts per million (Table 4-54). Mercury concentrations of this magnitude in fish would not have an acute effect on eagles feeding on them (Hart et al. 1996) but could cause subtle, sub-lethal effects (LeMaster 1996). Eisler (1987) recommended total mercury concentrations in food items of "sensitive" avian species not exceed 0.10 parts per million and suggested that a concentration as low as 0.05 parts per million could adversely affect reproduction. The historic reproductive success of eagles nesting at the Eagle Bay nest suggests that if sublethal effects are occurring, they are not affecting reproduction in a measurable way (Hart et al. 1996). Appendix B presents a more detailed evaluation of potential risks to bald eagles from exposure to cesium-137 and mercury in surface waters, sediments, and fish of Par Pond and L-Lake.

Lower water levels and reduced littoral vegetation in reservoirs could make prey more available to wading birds and other avian predators (e.g., eagles and ospreys) by forcing small fish out of protective vegetative cover (Bildstein et al. 1994). Lower reservoir levels could benefit eagles by reducing the amount of energy they expend foraging, but could be detrimental to eagles if prey were so easily captured that birds "gorged" and consistently ingested larger quantities of contaminated fish than normal. Bald eagles are known to gorge when food supplies are unusually abundant (e.g., on spawned-out salmon in the Pacific Northwest). However, they generally stop feeding when their crops and stomach(s) are full (Stalmaster 1987) and might fast for several days afterwards. Consequently, there is no reason to believe that eagles would eat unusually large quantities of contaminated fish. They probably would eat until satiated and then rest, conserving energy normally spent foraging. Implementing this alternative could result in the complete emptying of L-Lake in as few as 10 years (Jones and Lamarre 1994). L-Lake could be reduced to

Table 4-54. Mercury concentrations ppm in largemouth bass (parts per million).

Location	Years	Minimum	Mean	Maximum	N
Clarks Hill Lake[a]	1988-91	<0.10	0.37	1.51	8
Savannah River above SRS[a]	1988-93	0.16	0.44[b]	1.23	21
Savannah River at SRS[a]	1988-92	<0.10	0.75	1.61	31
Par Pond[a]	1988-94	0.11	0.94	3.2	52
Par Pond[c]	1991-93	0.05	NA[d]	1.9	300
Par Pond[e]	1995	NA	0.67	3.18	38
Lower Three Runs[a]	1988-93	0.25	1.15	2.2	35
L-Lake[a]	1992-94	0.43	1.17	2.87	15
L-Lake[f]	1995	NA	0.43	1.07	49
Savannah River below SRS[a]	1989-94	<0.01	0.60[g]	1.40	42

a. From SRS Annual Environmental Reports ("flesh" was analyzed).
b. Based on n=18 because some means not listed.
c. From Jagoe, Grasman, and Youngblood (1994); muscle was analyzed.
d. NA = Not available.
e. From Paller and Wike (1996a); whole fish were analyzed.
f. From Paller (1996); whole fish were analyzed.
g. Based on n=41.

a small ponded area at the head of the L-Lake dam. This would effectively eliminate the most important foraging habitat for the Pen Branch nest pair (LeMaster 1996). If L-Lake emptied, the closest large bodies of water providing suitable foraging habitat would be Par Pond and the Savannah River, both about 6 miles (10 kilometers) away (Hart et al. 1996). These locations are approximately 1.2 miles (2 kilometers) beyond the normal foraging range of bald eagles (Hart et al. 1996). Although eagles nesting on Pen Branch could adapt to the change by foraging in other areas or by feeding more heavily on birds, small mammals, and carrion, they probably would not continue to nest near L-Lake (LeMaster 1996).

Shut Down and Maintain

This alternative would produce the same kinds of impacts described for the Shut Down and Deactivate Alternative.

Wood Stork

No Action

Under the No-Action Alternative, wood stork use of L-Lake and Par Pond would continue to be infrequent because neither reservoir provides much suitable foraging habitat. Wood stork use of SRS streams and associated delta areas would not be likely to change. Impacts to wood storks under this alternative would be unlikely.

Shut Down and Deactivate

Under the Shut Down and Deactivate Alternative, L-Lake could drop as much as 70 feet (21 meters) in 10 years, and Par Pond could conceivably drop to a level of 195 feet (59.4 meters). Stork use of L-Lake under this alternative would depend on the rate at which the reservoir receded and on the topography of the reservoir bottom. A gradual drop in water level would reduce the likelihood of stork use of L-Lake. Natural or manmade depressions on the reservoir bottom could entrap fish as the water level recedes. Fish stranded in these pools could attract storks, particularly in late summer. Storks are generally observed in the region from May through September, with most SRS sightings in July and August (LeMaster 1996).

Wood stork use of Par Pond would probably occur only during a very severe summer drought or succession of dry years, when water levels could drop to a level where fish were forced from the shelter of the macrophyte belt along the shore of the reservoir. Mercury levels in stork prey in Par Pond are at a level of concern at present and could increase in a fluctuating environment. However, the Par Pond water level has not fluctuated more than a foot since DOE refilled the reservoir in March 1995. Overall, the water level last year has remained fairly constant even though a commitment to supply 10 cubic feet (0.28 cubic meter) per second to Lower Three Runs has been met and the average rainfall in the area was below normal (LeMaster 1996).

Fish in both reservoir systems contain detectable levels of mercury. DOE assumed that approximately half of this mercury came from Savannah River water and half from natural sources (i.e., soils inundated when reservoirs were filled). Potential stork prey [fish less than 5 inches (13 centimeters) in length] collected from these reservoirs typically contain levels of mercury greater than 0.05 part per million (LeMaster 1996). Eisler (1987) recommended that total mercury concentrations in food items of "sensitive" avian species not exceed 0.10 part per million and suggested that a concentration as low as 0.05 part per million could adversely affect reproduction. In a study of wading birds in southern Florida species whose prey consisted of larger fish contained four times higher levels of mercury in the liver than those that consumed smaller fish or crustaceans, and suggested that declining numbers of nesting wading birds in southern Florida were due, in part, to mercury contamination of their food supply (LeMaster 1996). Although wood storks were not included in that study, they fall in the same trophic category – wading birds that consume larger fish (LeMaster 1996).

Mercury in reservoir sediments, whether from river inputs or atmospheric deposition, would typically be an inorganic form. However, mercury accumulated by aquatic organisms, and therefore potentially consumed by storks, is primarily a more toxic form, methyl mercury. The process controlling the transformation from inorganic species to methyl mercury is therefore key to the accumulation of mercury by aquatic organisms. Previous studies have suggested that methylation is enhanced in flooded soils (LeMaster 1996). Thus, fluctuating water levels in Par Pond could lead to increasing bioavailability of methyl mercury to aquatic organisms inhabiting those two systems (LeMaster 1996).

Appendix B presents a more detailed evaluation of potential risks to wood storks from exposure to mercury in surface waters, sediments, and fish of Par Pond and L-Lake.

Shut Down and Maintain

Impacts from this alternative would be similar to those described for the Shut Down and Deactivate Alternative.

American Alligator

No Action

Under this alternative, there would be no impacts to L-Lake alligators because water levels would not fluctuate appreciably. Under normal circumstances, Par Pond would fluctuate between 195 feet (59.4 meters) and 200 feet (61 meters). Water level changes of this magnitude should have no direct impact on alligators. Fluctuating water levels in Par Pond could affect the prey base for Par Pond alligators as described above (reduced production of forage fish; reduced growth of fish higher in the food chain). However, prey (food) is not a limiting factor for the Par Pond alligator population (LeMaster 1996).

Shut Down and Deactivate

Under this alternative, L-Lake could empty in 10 to 50 years, displacing alligators in the reservoir. If the drawdown is rapid (70 feet in 10 years as predicted by the most extreme of the four scenarios modeled) L-Lake alligators could be forced to move to other wetland habitats on the SRS. This could lead to (1) total reproductive failure in some years, caused by nest destruction, egg loss, or intense predation on hatchlings; (2) an increased incidence of violent intraspecific encounters, as L-Lake alligators were forced into established territories of adults in other areas; and (3) an increased likelihood of fatal encounters with humans and automobiles.

Based on recent Par Pond studies (Brisbin et al. in press), however, female alligators would probably not abandon established nests in response to the drawdown, and would continue to nest around L-Lake until food resources become limited or crowding forces subdominant animals to disperse to other SRS wetlands. Male alligators would be more likely to leave the L-Lake area because they have much larger home ranges than females and tend to move more within their home ranges (Van Meter 1987). Immature alligators, which actively roam over a larger area than adults (Van Meter 1987) and are not attached to breeding territories, would also be expected to disperse to other areas when competition for food or space becomes more intense. The lagoons near SC Highway 125 and the Steel Creek delta may provide suitable habitat for some of these displaced alligators (LeMaster 1996). Impacts to individual alligators in SRS streams would be minimal because most of these animals are associated with beaver ponds or other bodies of water that offer basic habitat requirements (relatively deep water, food, and cover).

Shut Down and Maintain

Impacts from this alternative would be similar to those described for the Shut Down and Deactivate Alternative.

Shortnose sturgeon

No Action

Shortnose sturgeon have never been collected or observed in any of the tributaries of the Savannah River that drain the SRS. The reduction in pumping to Fourmile Branch and Pen Branch/Indian Grave Branch under the No-Action Alternative should have no discernible impact on the Savannah River and its fish populations, including the shortnose sturgeon.

Small numbers of shortnose sturgeon larvae (12 larvae over a 4-year period) were entrained at the SRS river water intakes from 1982 through 1985, when pumping rates approached 400,000 gallons per minute (25.2 cubic meters per second) (DOE 1987b). Under the No-Action Alternative, DOE would withdraw 5,000 gallons per minute (0.32 cubic meter per second) from the Savannah River to maintain the water level of L-Lake and supply smaller amounts of water to the reactor areas for equipment cooling and fire protection. Some shortnose sturgeon larvae could be entrained, but the numbers would be a small fraction of those entrained in the 1960s, 1970s, and 1980s when pumping rates were as much as 80 times higher.

DOE would withdraw approximately 5,000 gallons per minute (0.32 cubic meter per second) of river water to maintain the level of L-Lake, which is less than 0.2 percent of the average Savannah River discharge 2.9 million gallons per minute (183 cubic meters per second) reported for the severe drought years of 1985 through 1988 (DOE 1990). The February-to-April spawning period historically has been a time of high river discharge. The actual percentage of river water withdrawn would undoubtedly be lower during this period. Given (1) the small volume of water withdrawal planned, (2) the preferred deep-water spawning habitat of shortnose sturgeon, and (3) the demersal nature of shortnose sturgeon eggs and larvae, the likelihood of a significant number of shortnose sturgeon eggs and larvae being entrained by the 5,000-gallon-per-minute pump seems remote. | TE

Shut Down and Deactivate

Under this alternative, DOE would not pump Savannah River water to maintain the level of L-Lake and Par Pond if its level fell below 195 feet (59.4 meters). As a result, no shortnose sturgeon eggs or larvae could be entrained.

Shut Down and Maintain

Under this alternative, there would be no routine pumping of river water to maintain L-Lake or Par Pond water levels. No shortnose sturgeon eggs or larvae could be entrained unless river water pumps were restarted.

4.3.6 LAND USE

4.3.6.1 Affected Environment

Section 4.1.6.1 describes the land and surroundings on the SRS. It also summarizes Future Use Project Team recommendations for the future use of the land and facilities on the Site and the current status of the SRS as a National Environmental Research Park. DOE has not identified any future mission or other uses, other than research and monitoring, for Par Pond (Hill 1996).

DOE monitors Par Pond regularly for chemical, metal, physical, and biological properties, water level, and radioactive effluents; the monitoring frequency varies with the location and sample type. Approximately 10 scientists and technicians per week conduct monitoring or research on the lake (Marcy 1996). Par Pond is restricted from other uses.

4.3.6.2 Land Use Impacts

4.3.6.2.1 No Action

Under the No-Action Alternative, DOE would not change the current uses of Par Pond; the lake status would be the same as that described in Section 4.3.6.1. DOE would make decisions on future uses in accordance with Future Use Project recommendations.

4.3.6.2.2 Shut Down and Deactivate

Activities associated with this alternative would not affect current or future uses of Par Pond. DOE anticipates no changes and no impacts to the lake. In January 1996, DOE discontinued pumping river water to Par Pond to enable water levels to fluctuate naturally (DOE 1995a,b). Since then, the lake level has not fallen below the 199-foot (60.7-meter) level (Kirby 1996).

4.3.6.2.3 Shut Down and Maintain

The impacts under this alternative would be the same as those for the Shut Down and Deactivate Alternative, except DOE could restart the River Water System if necessary. Section 3.3 discusses possible reasons for a restart of the system.

4.3.7 AESTHETICS

4.3.7.1 Affected Environment

The dominant aesthetic settings in the vicinity of SRS are agricultural land and forest, with limited residential and industrial areas. The reactors and most of the large facilities are in the interior portions of the Site (see Figure 1-2). Because of the distance to the SRS boundary, the rolling terrain, normally hazy atmospheric conditions, and heavy vegetation, Par Pond is not visible from off the Site or from roads with public access.

With the exception of the dam area, Par Pond characteristically has wetlands along the shoreline with pine and hardwood forests farther up the slope. Marsh or shallow water vegetation such as cattails inhabit cove areas, while deeper areas provide habitat for open-water species such as water lilies and lotus (Jensen et al. 1992). Figure 4-33 shows Par Pond from Road 8 looking north.

Current users and those who would regularly view Par Pond (about 10 scientists and technicians per week) conduct research and monitoring for chemical, metal, physical and biological properties, water level and radioactive effluents; the frequency of use varies depending on the sample type. Par Pond is restricted from other uses (Marcy 1996).

4.3.7.2 Aesthetic Impacts

4.3.7.2.1 No Action

Under the No-Action Alternative, the aesthetic setting of Par Pond would not change and there would be no impacts.

4.3.7.2.2 Shut Down and Deactivate

Activities associated with this alternative should not affect the current or future aesthetic setting of Par Pond. In January 1996 DOE shut off the River Water System to Par Pond to allow water levels to fluctuate naturally (DOE 1995a,b). Since then, the lake level has not fallen below the 199-foot (60.7-meter) level (Kirby 1996). Figure 4-34 shows Par Pond at the 195-foot (59.4-meter) pool elevation; some of the shoreline is exposed in the background. This photograph was taken in 1991 during the lake drawdown.

In the unlikely event that the lake level dropped below 195 feet (59.4 meters), aesthetic impacts could occur (depending on how far down the lake level dropped and for how long). There would be some loss of vegetation and wildlife habitat. Tree stumps would be exposed, dried mud flats would appear for periods of time until revegetation began, and there could be intermittent odor problems. Figure 4-35 is a 1991 photograph of Par Pond at the 181-foot (55.2-meter) pool elevation showing the exposed shoreline and wetlands in the background. If the lake level fell below 195 feet, DOE would apply measures to minimize adverse effects of exposed sediments in the lakebed; these measures would also help to minimize the aesthetic impacts. TE

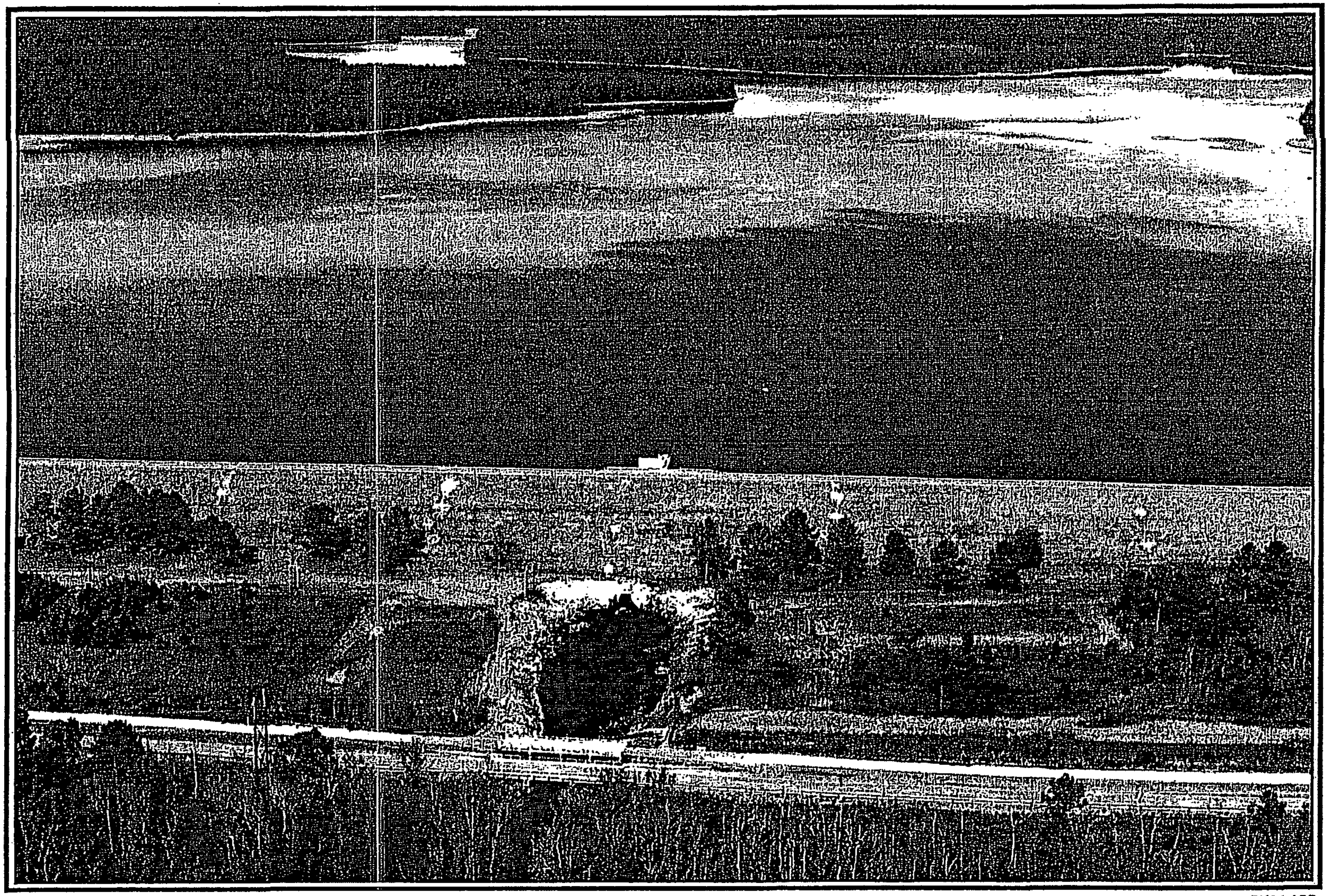

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Figure 4-33. View of Par Pond looking north.

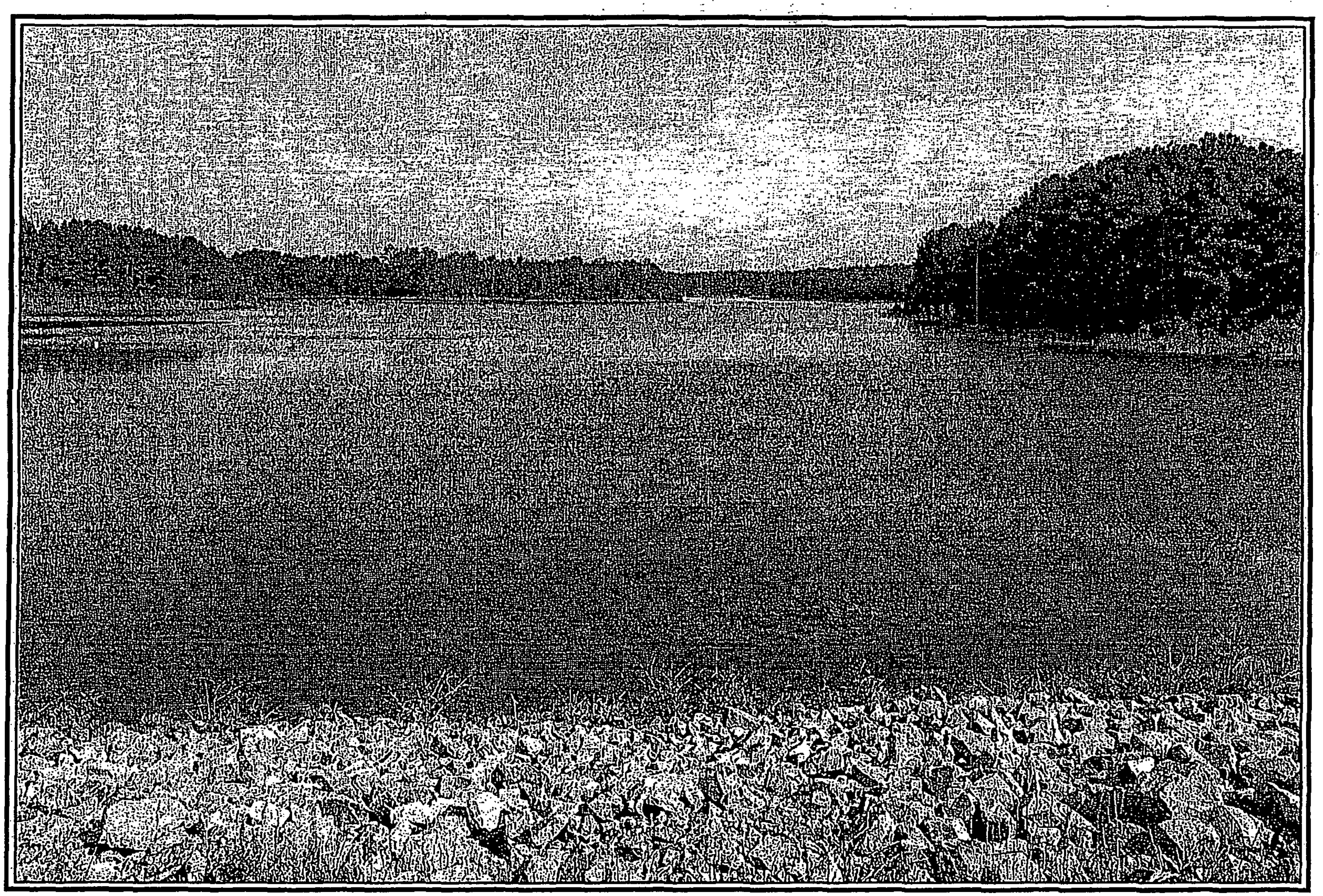

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Figure 4-34. View of Par Pond at full pool.

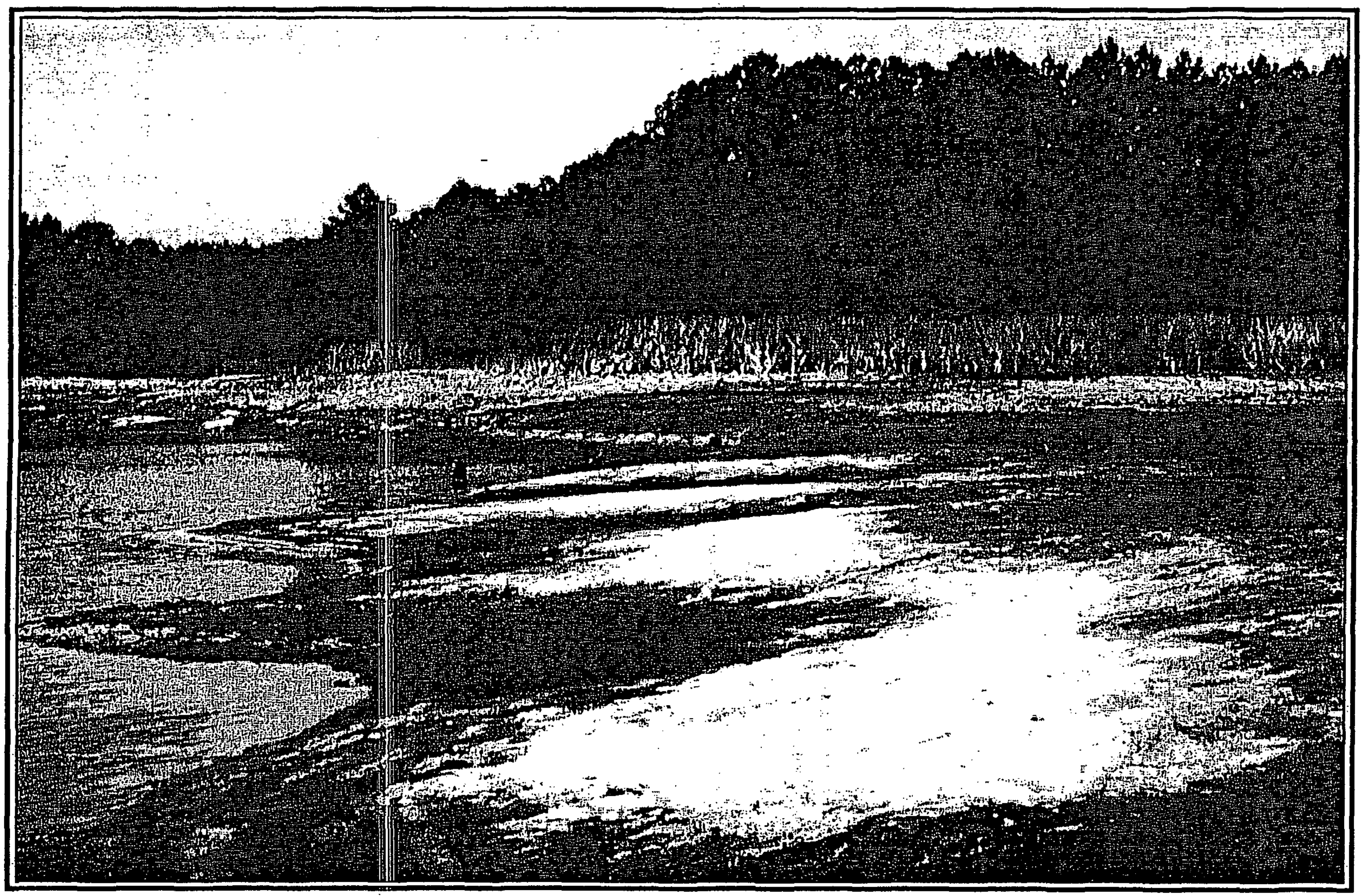

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Figure 4-35. View of Par Pond at reduced water level (181 feet).

4.3.7.2.3 Shut Down and Maintain

Aesthetic impacts under this alternative would be the same as those noted for the Shut Down and Deactivate Alternative, except DOE could restart the River Water System if necessary. Section 3.3 contains possible reasons for restarting the system.

4.3.8 OCCUPATIONAL AND PUBLIC HEALTH

4.3.8.1 Affected Environment

Releases from R-Reactor in the form of process leaks, purges, and makeup cooling water have contaminated Par Pond with low levels of radioactive materials, primarily cesium-137 [originally 222 curies in Par Pond, the R-Reactor canals, and Lower Three Runs (DOE 1995a)]. All radiological releases except tritium stopped after the shutdown of R-Reactor in 1965. Most of the cesium-137 resides in the upper 1 foot (0.3 meter) of fine sediments, in the original stream corridors. Because its half-life is 30 years, more than half of the cesium-137 associated with Par Pond has decayed since the releases occurred [currently about 43 curies remain in Par Pond, more than two-thirds below the 190-foot (57-meter) level]. Elevated levels of mercury have accumulated in sediments from water pumped from the Savannah River (DOE 1995c).

In 1995 DOE completed an environmental assessment that enabled the cessation of pumping from the River Water System to Par Pond. Until that time, DOE had maintained the water level in Par Pond at full pool [approximately 199.2 feet (59.7 meters)] with the addition of flow from the River Water System. DOE stopped the pumping to reduce operating costs and, as a result, Par Pond water levels fluctuate naturally, depending only on rainfall and groundwater recharge. As a result, the surface-water level of Par Pond is likely to fluctuate naturally from a full pool of approximately 199.2 feet (60.7 meters) to 196 feet (59.7 meters) exposing about 340 acres (1.4 square kilometers) of sediment (Figure 4-36) (DOE 1995a).

DOE collected samples from the exposed sediments of Par Pond in early 1995, shortly before refilling the reservoir after the drawdown. The sampling was confined to elevations between 190 and 200 feet (58 and 61 meters) above mean sea level, which included sediments likely to be exposed when the water level can fluctuate naturally, as expected under the alternatives. The sediments were analyzed for a number of radionuclides and metals. Some of the soil samples were analyzed for organic contaminants, none of which were detected above EPA or Canadian screening criteria for contaminants in terrestrial soils (Paller and Wike 1996b).

DOE detected a number of radionuclides in the Par Pond sediments, but only cesium-137 occurred consistently and at levels well in excess of levels at the control sites. The geometric mean concentration of cesium-137 was 7.2 picocuries per gram; the maximum was 56.7 picocuries per gram (Paller and Wike 1996b).

DOE detected mercury in exposed dry sediments in concentrations high enough to be of possible concern. Mercury concentrations were characterized by a geometric mean and maximum levels of 62 and 485 micrograms per kilogram, respectively.

4.3.8.2 Environmental Impacts

The 1995 environmental assessment (DOE 1995a) estimated human health impacts from a natural fluctuation in Par Pond. However, DOE calculated these impacts in accordance with guidance provided by the EPA (EPA 1989), and limited them to individuals working and living (residential scenario) close to contaminated sediments. The impacts, therefore, represent a conservative upper bound of risk probability.

Impacts calculated for this EIS are based on more realistic exposure parameters (e.g., people are assumed to not live close to contaminated

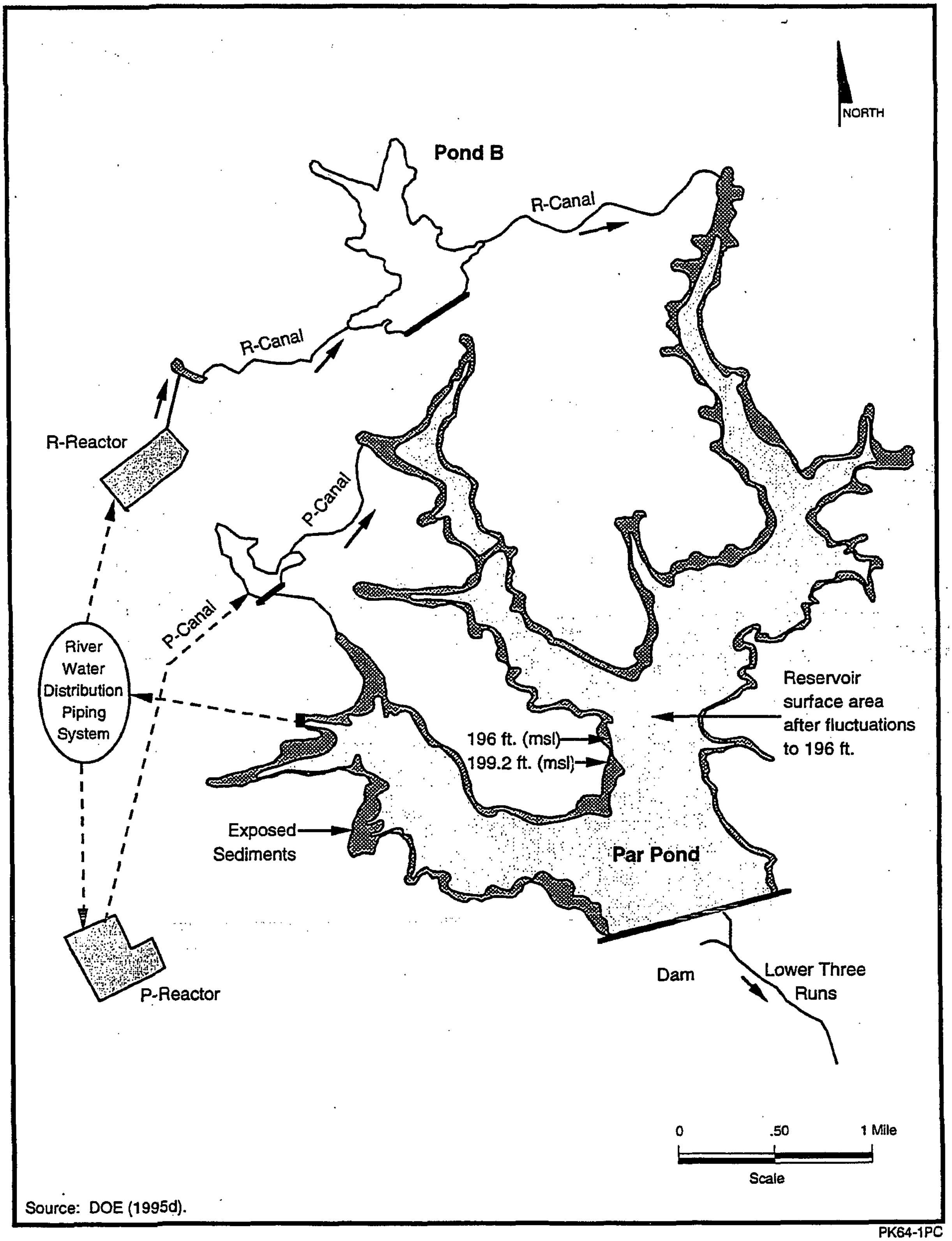

Figure 4-36. Exposed sediment areas in Par Pond at the 58.8-meter (196-foot) level and the P- and R-Reactor river water distribution system.

sediments). In addition, this EIS projects impacts to remote receptors (e.g., uninvolved workers, offsite maximally exposed individual) with the use of analytical computer codes [MEPAS (Droppo et al. 1995)] to estimate environmental transport. Finally, risk probabilities calculated for the environmental assessment relate only to the incidence (morbidity) of cancer resulting from exposures to radionuclides, whereas this EIS estimates the probability of latent fatal cancers (mortality) resulting from exposure to radiological constituents as well as hazard indexes and cancer morbidity resulting from exposures to nonradiological constituents.

4.3.8.2.1 No Action

For the No-Action Alternative, the surface water level of Par Pond would fluctuate naturally from full pool of approximately 200 feet (61 meters) to 196 feet (59.7 meters), exposing about 340 acres (1.4 square kilometers) of sediment (Figure 4-36) (DOE 1995a). The level would remain at about 198.4 feet (59.7 meters) 75 percent of the time (Gladden 1996a), exposing only about 114 acres (0.5 square kilometer) of sediment. These sediments would dry and become resuspended in the atmosphere, available for inhalation by onsite workers and the offsite population within 50 miles (80 kilometers) of the SRS. In addition, the contaminated sediments would provide direct pathways for current and future land use scenarios to the involved workers.

To provide a realistic and not overly conservative analysis, concentrations (Paller 1996) were averaged over the average exposed areas (Gladden 1996c) of dry sediment to use as input parameters to the MEPAS computer code.
TE | Table 4-55 lists spatially averaged concentrations and the resulting inventory from this evaluation.

Although tritium is present in Par Pond surface waters [1.0 picocurie per milliliter (Simpkins 1996c)], this EIS does not evaluate volatilization, atmospheric transport, and exposure through inhalation of this radioisotope for Par Pond because incremental changes in impacts would be extremely small in comparison to the other impacts evaluated. This is because the quantity of tritium volatilized from the surface water is directly proportional to the total area of surface water exposed to the atmosphere, and this area has changed only slightly from baseline conditions due to previous NEPA actions.

Due to the elevated levels of mercury and cesium-137 identified in Par Pond sediments, DOE does not anticipate that future land use scenarios would include recreational use by members of the public without some level of remediation. Because DOE does not know the required degree of remediation, it cannot calculate potential impacts from future land use by members of the public. However, the future land use scenario for onsite industrial workers assumes no remediation.

Public Health Impacts

Radiological Impacts

To estimate the health effects associated with the No-Action Alternative on the public, radiological doses for the current land use scenario were calculated to the maximally exposed individuals and population groups. For Par Pond, only atmospheric releases from exposed sediments were evaluated because incremental changes to water releases through the dam would be very small. Therefore, this EIS does not calculate doses and resulting impacts from liquid releases for members of the public.

TE | Table 4-56 lists calculated doses resulting from atmospheric releases under the current land use scenario. The annual doses (6.5×10^{-6} rem to the offsite maximally exposed individual and 2.3×10^{-3} person-rem to the offsite population) would be small fractions of the doses from total SRS releases in 1995 [0.20 millirem to the maximally exposed member of the public and 5.1 person-rem to the population (Arnett, Mamatey, and Spitzer 1996)].

Table 4-55. Average concentrations and inventory of radionuclides and metals in Par Pond sediments.[a] | TE

Radionuclides	Concentration (pCi/g)	Inventory (curies)
Cesium-137	10.9	2.41
Cobalt-60	0.04	0.0088
Metals	(ug/kg)	(grams)
Mercury	76.9	1.70×10^4
Thallium	4.1	9.05×10^2
Manganese	169	3.73×10^4

a. Source: Paller and Wike (1996a).\

Table 4-56. Radiological doses and resulting impacts associated with the No-Action Alternative and resulting health effects to the public.[a]

Receptor(s)[b]	Individual: Total dose (rem)	Individual: Probability of fatal cancer	Population: Total dose (person-rem)	Population: Number of fatal cancers
Offsite maximally exposed individual				
Annual	6.5×10^{-6}	3.3×10^{-9}	NA[c]	NA
Lifetime[d]	2.3×10^{-4}	1.1×10^{-7}	NA	NA
Population				
Annual	NA	NA	2.3×10^{-3}	1.1×10^{-6}
Lifetime[d]	NA	NA	7.6×10^{-2}	3.8×10^{-5}

a. Supplemental information provided in Tables C-35 and C-36 in Appendix C.
b. The doses to the public from total SRS operations in 1995 were 0.20 millirem to the offsite maximally exposed individual (0.06 millirem from airborne releases and 0.14 millirem from aqueous releases) and 5.1 person-rem to the regional population (3.5 person-rem from airborne releases and 1.6 person-rem from aqueous releases); Source: Arnett, Mamatey, and Spritzer (1996).
c. NA = not applicable.
d. Based on 70 years of exposure; doses are corrected for radioactive decay.

Nonradiological Impacts

Table 4-57 lists the hazard index associated with the No-Action Alternative. The calculated hazard index for the maximally exposed individual would be a small fraction of 1 and, therefore, this individual would not experience adverse health effects. | TE

Occupational Health

Radiological Impacts

Doses to involved and uninvolved workers were estimated for the No-Action Alternative using the exposure assumptions discussed in Section 4.1.8.2.2. Table 4-58 lists the incremental | TE

Table 4-57. Nonradiological, noncarcinogenic hazard index associated with the No-Action Alternative for members of the public.[a]

Receptor	Total hazard index
Offsite maximally exposed individual	1.5×10^{-4}

a. Supplemental information is provided in Table C-37 in Appendix C.

Table 4-58. Worker radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual		All workers	
Receptor(s)	Dose (rem)	Probability of fatal cancer	Dose (person-rem)	Number of fatal cancers
Involved worker[b] (current use)				
Annual[c]	4.2×10^{-4}	1.7×10^{-7}	2.9×10^{-2}	1.2×10^{-5}
Lifetime[d]	2.0×10^{-3}	7.9×10^{-7}	1.4×10^{-1}	5.5×10^{-5}
Involved worker[e] (future use)				
Annual[c]	2.3×10^{-2}	9.4×10^{-6}	1.6	6.5×10^{-4}
TC Lifetime[d]	4.4×10^{-1}	1.8×10^{-4}	3.1×10^{1}	1.2×10^{-2}
Uninvolved worker[f]				
Annual[c]	7.7×10^{-8}	3.1×10^{-11}	8.1×10^{-6}	3.2×10^{-9}
Lifetime[d]	1.4×10^{-6}	5.8×10^{-10}	1.5×10^{-4}	6.1×10^{-8}

a. Supplemental information provided in Tables C-38, C-39, and C-40 in Appendix C.
b. Estimated to be 70 workers.
c. Annual individual worker doses can be compared with the regulatory dose limit of 5 rem (10 CFR 835) and with the SRS administrative exposure guideline of 0.7 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. Based on a total of 13,651 monitored workers (Kvartek 1996), the 1995 average dose for all site workers who received a measurable dose was 0.019 rem (See Table 4-15).
d. Based on 5 years of exposure for current workers and 25 years of exposure for future and uninvolved workers; doses are corrected for radioactive decay.
e. Estimated to be 70 workers.
f. L-Area; total uninvolved workers estimated to be 251 [Source: Simpkins (1996c)].

worker doses [the increase in dose due to activities prior to the Par Pond environmental assessment (DOE 1995a)]. These doses represent a small fraction of the DOE limit (10 CFR 835), which requires that annual doses to individual workers not exceed 5 rem per year, and a small fraction of the SRS administrative limit of 0.7 rem per year (WSRC 1995d).

Nonradiological Health

Nonradiological health impacts (hazard index) were calculated under the current and future land use scenarios for the involved worker. The exposure pathways and exposure times would be the same as those discussed in Section TE 4.1.8.2.1. Table 4-59 lists the results; the

Table 4-59. Worker nonradiological hazard indexes associated with the No-Action Alternative.[a]

Receptor(s)	Total hazard index
Involved worker (current use)	3.1×10^{-5}
Involved worker (future use)	5.6×10^{-4}
Uninvolved worker[b]	1.5×10^{-8}

a. Supplemental information is provided in Tables C-41, C-42, and C-43 in Appendix C.
b. L-Area.

calculated hazard indexes for the maximally exposed involved worker under the current and future land use scenarios would be a small fraction of 1. Therefore, these individuals would not experience adverse health effects.

For the uninvolved worker, assumed to be in L-Area, the calculated hazard index would be a very small fraction of 1 and, therefore, this individual would not experience adverse health effects.

4.3.8.2.2 Shut Down and Deactivate

For the Shut Down and Deactivate Alternative, Par Pond would maintain the same water levels as those described under the No-Action Alternative. Therefore, impacts to workers and members of the public under Shut Down and Deactivate would be the same as those under No Action.

4.3.8.2.3 Shut Down and Maintain

For the Shut Down and Maintain Alternative, Par Pond would maintain the same water levels as those described under the No-Action Alternative. Therefore, impacts to workers and members of the public under Shut Down and Maintain would be the same as those under No Action.

4.3.8.3 Combined Impacts

This EIS presents human health impacts from three separate sources: L-Lake, SRS streams, and Par Pond. Because some population groups would be affected by releases from more than one of these sources at the same time, DOE has combined these effects, where appropriate, to estimate the combined impacts. For example, offsite and uninvolved worker populations would be affected simultaneously from L-Lake and Par Pond atmospheric releases (Figure 4-37 shows release points). However, DOE did not add the impacts from remote facilities to involved worker impacts because it assumes they are separate work groups. The following sections discuss the assumptions used to estimate the combined impacts of these and other releases under each alternative.

4.3.8.3.1 No Action

Public Health Impacts

As described in Section 4.2.8.2.1, DOE did not calculate public health impacts associated with the No-Action Alternative for SRS streams. Therefore, the combined radiological and nonradiological impacts for members of the public under the No-Action Alternative would consist of the combination of the impacts listed in Tables 4-17, 4-18, 4-56, and 4-57. The following paragraphs describe impacts to the combined maximally exposed individual. | TE

Radiological Impacts

Table 4-60 lists combined doses and resulting impacts to individuals and population groups for the No-Action Alternative. Under the current land use scenario, the maximally exposed individual was determined by normalizing atmospheric releases from L-Lake (tritium) and Par Pond to a center-of-Site reference and then | TE

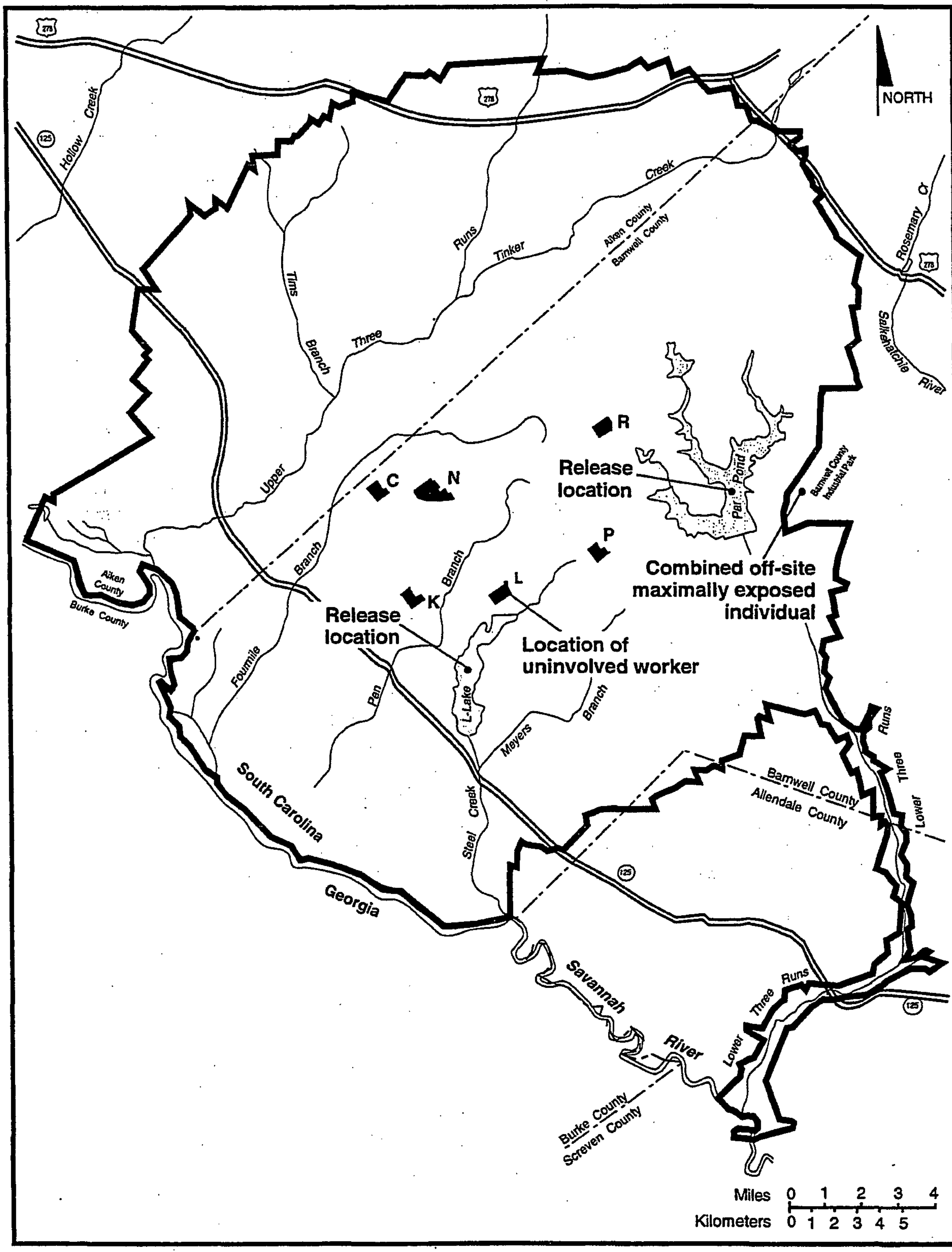

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Figure 4-37. Atmospheric release locations.

Table 4-60. Combined radiological doses and resulting impacts associated with the No-Action Alternative and resulting health effects to the public.[a]

Receptor(s)[b]	Individual		Population	
	Total dose (millirem)	Probability of fatal cancer	Total dose (person-rem)	Number of fatal cancers
Offsite maximally exposed individual (current use)				
Annual	6.6×10^{-3}	3.3×10^{-9}	NA[c]	NA
Lifetime[d]	2.3×10^{-1}	1.1×10^{-7}	NA	NA
Offsite maximally exposed individual (future use)[e]				
Annual	3.8×10^{-1}	1.9×10^{-7}	NA[c]	NA
Lifetime[d]	1.3×10^{1}	6.6×10^{-6}	NA	NA
Population				
Annual	NA	NA	3.6×10^{-3}	1.8×10^{-6}
Lifetime[d]	NA	NA	1.0×10^{-1}	5.0×10^{-5}

a. Supplemental information provided in Tables 44, 45, and 46 in Appendix C.
b. The doses to the public from total SRS operations in 1995 were 0.20 millirem to the offsite maximally exposed individual (0.06 millirem from airborne releases and 0.14 millirem from aqueous releases) and 5.1 person-rem to the regional population (3.5 person-rem from airborne releases and 1.6 person-rem from aqueous releases). Source: Arnett, Mamatey, and Spitzer (1996).
c. NA = not applicable.
d. Based on 70 years of exposure; doses are corrected for radioactive decay.
e. Assumes future recreational use of L-Lake.

adding the resulting impacts from each source facility. The combined maximally exposed individual was determined to reside in the east sector at the Site boundary.

For the future land use scenario, which assumes that only L-Lake would have future recreational use by members of the public, DOE determined the combined maximally exposed individual impacts by adding the future land use impacts for L-Lake with the current land use impacts for Par Pond.

The combined impacts to offsite populations were determined by adding the population doses and resulting impacts listed in Tables 4-17 and 4-56.

TE

Table 4-60 lists combined annual doses resulting from releases under the current land use scenario. The annual doses (6.6×10^{-3} millirem to the offsite maximally exposed individual and 3.6×10^{-3} person-rem to the offsite population) would be small fractions of the doses from total SRS releases to in 1995 [0.20 millirem to the maximally exposed member of the public and 5.1 person-rem to the population (Arnett, Mamatey, and Spitzer 1996)].

Under the future land use scenario, the annual dose (0.38 millirem) to the maximally exposed individual would be higher than under the current land use scenario but the resulting probability of developing a fatal cancer (1.9×10^{-7}) would still a be small fraction of the natural incidence of cancer from all causes. The annual population dose (3.6×10^{-3} person-rem) under future land use scenarios would remain unchanged from the current land use scenario. The offsite population receiving this dose for 70 years would be likely to develop 5.0×10^{-5} additional cancers. This is a small fraction of the number of cancers that would be expected in the same period of time from all causes (157,900) in the SRS 50-mile (80-kilometer) population.

Nonradiological Impacts

Table 4-61 presents the combined hazard index for the maximally exposed individual under the current and future land use scenarios. For the current land use scenario, the maximally exposed individual is exposed only from atmospheric releases from exposed sediments of Par Pond. This hazard index (1.5×10^{-4}) was listed in Table 4-57. For the future land use scenario, the hazard index resulting from the future use of L-Lake (Table 4-18) would be added to the current use hazard index for Par Pond. As listed in Table 4-61, the combined hazard index would be less than 1. The cancer risk associated with exposure to beryllium in the surface water of L-Lake (3.1×10^{-7}) represents a small fraction of the natural incidence of cancer from all causes.

Occupational Impacts

To determine combined impacts to involved workers, DOE assumed that the impacts resulting from work around L-Lake would not be additive to those resulting from work around Par Pond because the involved workers for each source facility would represent a separate work group.

Radiological Impacts

Based on these assumptions, the combined impacts listed in Table 4-62 for the involved worker represent the greater of the doses and resulting impacts listed in Tables 4-19 and 4-58.

To estimate the combined impact for the uninvolved workers in L-Area, appropriate values from Tables 4-19 and 4-58 were summed.

As listed in Table 4-62, the combined probability that the involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation under the No-Action Alternative and current land use scenario would be 1.7×10^{-7}. For the total involved workforce, the collective radiation dose could produce up to 1.2×10^{-5} additional fatal cancer as the result of a single year's exposure; over a 5-year career, the involved worker could have 5.5×10^{-5} additional fatal cancer as a result of exposure.

Under the future land use scenario, the combined probability that the average involved worker would develop a fatal cancer sometime during his lifetime as the result of a single year's exposure to radiation under the No-Action Alternative would be 9.4×10^{-6}, or approximately 1 in 100,000. For the total involved workforce, the collective radiation dose could produce up to 6.5×10^{-4} additional fatal cancer as the result of a single year's exposure; over a 25-year career, the involved workers could have 1.2×10^{-2} additional fatal cancer as a result of exposure.

The combined probability of any individual uninvolved worker developing a fatal cancer as a result of the estimated exposure would be 1.6×10^{-11}. For the total uninvolved workforce, the collective radiation dose could produce up to

Table 4-61. Combined nonradiological hazard indexes and cancer risk associated with the No-Action Alternative for members of the public.[a]

Receptor(s)[b]	Total hazard index	Annual (lifetime) latent cancer risk[c]
Offsite maximally exposed individual (current use)	1.5×10^{-4}	0
Offsite maximally exposed individual (future use)[d]	6.2×10^{-2}	3.1×10^{-7} (2.1×10^{-5})

a. See Tables C-47 and C-48 in Appendix C.
b. Includes direct exposure pathways.
c. Resulting from exposure to beryllium in L-Lake surface water.
d. Assumes future recreational use of L-Lake.

Table 4-62. Combined worker radiological doses and resulting impacts associated with the No-Action Alternative.[a] TE

Receptor(s)[b]	Individual		All workers	
	Dose (rem)	Probability of fatal cancer	Dose (person-rem)	Number of fatal cancers
Involved worker[b] (current use)				
Annual[c]	4.2×10^{-4}	1.7×10^{-7}	2.9×10^{-2}	1.2×10^{-5}
Lifetime[d]	2.0×10^{-3}	7.9×10^{-7}	1.4×10^{-1}	5.5×10^{-5}
Involved worker[b] (future use)				
Annual[c]	2.3×10^{-2}	9.4×10^{-6}	1.6[e]	6.5×10^{-4}
Lifetime[d]	4.4×10^{-1}	1.8×10^{-4}	3.1×10^{1}	1.2×10^{-2}
Uninvolved worker[f]				
Annual[c]	4.0×10^{-8}	1.6×10^{-11}	1.0×10^{-5}	4.0×10^{-9}
Lifetime[d]	6.5×10^{-7}	2.6×10^{-10}	1.6×10^{-4}	6.5×10^{-8}

TC

a. Supplemental information provided in Tables C-49 through C-54 in Appendix C.
b. Estimated to be 70 workers.
c. Annual individual worker doses can be compared with the regulatory dose limit of 5 rem (10 CFR 835) and with the SRS administrative exposure guideline of 0.7 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. Based on a total of 13,651 monitored workers (Kvartek 1996), the 1995 average dose for all site workers who received a measurable dose was 0.019 rem (see Table 4-15). TE
d. Based on 5 years of exposure for current workers and 25 years of exposure for future and uninvolved workers; doses are corrected for radioactive decay.
e. Total for all involved workers; 1995 total for all workers was 256 person-rem (see Table 4-15). TE
f. L-Area; estimated to be 251 workers [Source: Simpkins (1996c)].

an additional 4.0×10^{-9} fatal cancer as the result (TC) of a single year's exposure; over a 25-year career, the uninvolved workers could have 6.5×10^{-8} additional fatal cancer. (TC) This is a small fraction of the natural incidence of cancer from all causes and would be, therefore, a minimal impact.

Nonradiological Impacts

The combined nonradiological health impacts (hazard index) and cancer risks were calculate for the current and future land use scenarios for the involved worker. The exposure pathways and exposure times would be the same as those discussed in Section 4.1.8.2.1. Table 4-63 lists (TE) the results; the calculated hazard indexes for the maximally exposed involved worker under the current and future land use scenarios would be a small fraction of 1. Therefore, these individuals would not experience adverse health effects. In addition, the cancer risk to the maximally exposed involved worker would be a small fraction of the natural incidence of cancer from all causes.

For the uninvolved worker assumed to be in L-Area, the combined hazard index of 1.5×10^{-8} is a very small fraction of 1 and, therefore, this individual would not experience adverse health effects attributable to exposure pathways after L-Lake dewatering.

4.3.8.3.2 Shut Down and Deactivate

This alternative would remove two sources of exposure from consideration: exposures due to tritium releases from L-Lake would stop because the lake would recede to the original Steel Creek corridor, and exposures due to future recreational use of L-Lake. In addition, although impacts from Par Pond would remain essentially

TE | **Table 4-63.** Combined worker nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Receptor(s)[b]	Total hazard index	Annual (lifetime) latent cancer risk
Involved worker (current use)	2.1×10^{-4}	9.1×10^{-9} (4.5×10^{-8})
Involved worker (future use)	5.6×10^{-4}	1.3×10^{-8} (3.1×10^{-7})
Uninvolved worker[c]	1.5×10^{-8}	NA[d] (NA)

a. Supplemental information is provided in Tables C-55, C-56, and C-57 in Appendix C.
b. Nonradiological carcinogens are not released to the atmosphere.
c. L-Area.
d. NA = not applicable.

unchanged from those for the No-Action Alternative, the exposure of dry sediments in the L-Lake bed would create a new set of exposure pathways. The combined public and occupational health impacts are described in the following sections.

As described in Section 4.2.8.2.2, DOE did not calculate radiological and nonradiological public health impacts resulting from activities associated with SRS streams under the Shut Down and Deactivate Alternative. Therefore, as with the No-Action Alternative, public health impacts under this alternative would consist of a combination of impacts listed in Tables 4-21, TE | 4-22, 4-56, and 4-57. These impacts were combined to determine the location and resulting impacts to the combined maximally exposed individual, and population doses were summed.

Public Health Impacts

Radiological Impacts

TE | Table 4-64 lists the combined doses and resulting impacts to individuals and population groups for the Shut Down and Deactivate Alternative. The maximally exposed individual was determined by normalizing atmospheric releases from L-Lake and Par Pond to a center-of-Site reference and adding resulting impacts from each source facility. The combined maximally exposed individual would reside in the east sector at the Site boundary.

The combined impacts to offsite populations were determined by adding the population doses and resulting impacts listed in Tables 4-21 and 4-56.

TE

As listed in Table 4-64, the annual doses (6.9×10^{-3} millirem to the offsite maximally exposed individual and 2.7×10^{-3} person-rem to the offsite population) would be small fractions of the doses from total SRS releases to in 1995 [0.20 millirem to the maximally exposed member of the public and 5.1 person-rem to the population (Arnett, Mamatey, and Spitzer 1996)]. These doses would result in cancer probabilities much smaller than the natural probabilities of developing cancer from all causes.

Nonradiological Impacts

Under the Shut Down and Deactivate Alternative, the maximally exposed individual would be exposed to atmospheric releases from exposed sediments of L-Lake and Par Pond and liquid releases from sediment runoff from L-Lake. DOE determined the combined hazard index by adding the hazard index resulting

Table 4-64. Combined radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects to the public.[a] TE

Receptor(s)[b]	No Action: Total dose	No Action: Probability[c] or number of fatal cancer	Shut Down and Deactivate: Total dose	Shut Down and Deactivate: Probability[c] or number of fatal cancer
Offsite maximally exposed individual				
Annual (millirem)	6.6×10^{-3}	3.3×10^{-9}	6.9×10^{-3}	3.5×10^{-9}
Lifetime[d] (millirem)	2.3×10^{-1}	1.1×10^{-7}	2.4×10^{-1}	1.2×10^{-7}
Population				
Annual (person-rem)	3.6×10^{-3}	1.8×10^{-6}	2.7×10^{-3}	1.4×10^{-6}
Lifetime[d] (person-rem)	1.0×10^{-1}	5.0×10^{-5}	9.7×10^{-2}	4.9×10^{-5}

TC

a. Supplemental information provided in Tables C-58 and C-59 in Appendix C.
b. The doses to the public from total SRS operations in 1995 were 0.20 millirem to the offsite maximally exposed individual (0.06 millirem from airborne releases and 0.14 millirem from aqueous releases) and 5.1 person-rem to the regional population (3.5 person-rem from airborne releases and 1.6 person-rem from aqueous releases). Source: Arnett, Mamatey, and Spitzer (1996).
c. For the offsite maximally exposed individual, probability of a latent fatal cancer; for the population, number of fatal cancers.
d. Based on 70 years of exposure; doses are corrected for decay.

from L-Lake (Table 4-22) to the hazard index for Par Pond (Table 4-57). As listed in Table 4-65, the combined hazard index is a small fraction of 1 and, therefore, the exposed individual would not experience any adverse health effects. In addition, the combined cancer risk would represent a small faction of the natural incidence of cancer from all causes.

Occupational Health Impacts

For the Shut Down and Deactivate Alternative, DOE calculated occupational exposures to radiological and nonradiological constituents for L-Lake (see Tables 4-23 and 4-24), SRS streams (Tables 4-46 and 4-47), and Par Pond (Tables 4-58 and 4-59). To determine combined impacts to involved workers, DOE assumed that the impacts resulting from work around one facility would not be additive to those resulting from work around other facilities because the involved workers for each source facility would represent a separate work group. TE

Radiological Impacts

Based on these assumptions, the combined impacts listed in Table 4-66 for the involved worker represent the greater of the doses and resulting impacts presented in Tables 4-23, 4-46, and 4-58. DOE determined the combined impacts for the uninvolved workers in L-Area by adding the appropriate values from Tables 4-23 and 4-58 (uninvolved workers would not be impacted by SRS streams). TE

As listed in Table 4-66, the combined probability that the involved worker would develop a fatal cancer at some time as the result of a single year's exposure to radiation under the Shut Down and Deactivate Alternative and current land use scenario would be 1.7×10^{-7}, or approximately 2 in 10 million. For the total involved workforce, the collective radiation dose could produce up to 1.2×10^{-5} additional fatal cancer as the result of a single year's exposure; TE

Table 4-65. Combined nonradiological hazard index and cancer risks associated with the Shut Down and Deactivate Alternative for members of the public.[a]

	No Action	Shut Down and Deactivate	
Receptor(s)	Hazard index	Hazard index	Annual (lifetime) latent cancer risk[b]
Offsite maximally exposed individual	1.5×10^{-4}	2.2×10^{-1}	8.0×10^{-9} (5.6×10^{-7})

a. Supplemental information is provided in Table C-60 in Appendix C.
b. Resulting from inhalation of chromium and beryllium in contaminated sediments.

TE **Table 4-66.** Combined worker radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

	No Action Alternative		Shutdown and Deactivate Alternative	
Receptor(s)	Dose	Probability[b] or number of fatal cancer	Dose	Probability[b] or number of fatal cancer
Involved worker (current use)				
Annual[c] (rem)	4.2×10^{-4}	1.7×10^{-7}	4.2×10^{-4}	1.7×10^{-7}
Lifetime[d] (rem)	2.0×10^{-3}	7.9×10^{-7}	2.0×10^{-3}	7.9×10^{-7}
All involved workers[e] (current use)				
Annual[c] (person-rem)	2.9×10^{-2}	1.2×10^{-5}	2.9×10^{-2}	1.2×10^{-5}
Lifetime[d] (person-rem)	1.4×10^{-1}	5.5×10^{-5}	1.4×10^{-1}	5.5×10^{-5}
Involved workers (future use)				
Annual[c] (rem)	2.3×10^{-2}	9.4×10^{-6}	4.1×10^{-2}	1.6×10^{-5}
Lifetime[d] (rem)	4.4×10^{-1}	1.8×10^{-4}	7.5×10^{-1}	3.0×10^{-4}
TC All involved workers[e] (future use)				
Annual[c] (person-rem)	1.6	6.5×10^{-4}	2.9	1.1×10^{-3}
Lifetime[d] (person-rem)	3.1×10^{1}	1.2×10^{-2}	5.2×10^{1}	2.1×10^{-2}
Uninvolved workers[f]				
Annual[c] (rem)	4.0×10^{-8}	1.6×10^{-11}	1.5×10^{-6}	5.9×10^{-10}
Lifetime[d] (rem)	6.5×10^{-7}	2.6×10^{-10}	3.5×10^{-5}	1.4×10^{-8}
All uninvolved workers[g]				
Annual[c] (person-rem)	1.0×10^{-5}	4.0×10^{-9}	3.7×10^{-4}	1.5×10^{-7}
Lifetime[d] (person-rem)	1.6×10^{-4}	6.5×10^{-8}	8.7×10^{-3}	3.5×10^{-6}

a. Supplemental information provided in Tables C-61 through C-66 in Appendix C.
b. For the offsite maximally exposed individual, probability of a latent fatal cancer; for the population, number of fatal cancers.
c. Annual individual worker doses can be compared with the regulatory dose limit of 5 rem (10 CFR 835) and with the SRS administrative exposure guideline of 0.8 rem. Operational procedures ensure that the dose to the maximally exposed worker will remain as far below the regulatory dose limit as is reasonably achievable. The TE 1995 average dose for all site workers who received a measurable dose was 256 rem (see Table 4-16).
d. Based on 5 years of exposure for current workers and 25 years of exposure for future and uninvolved workers; doses are corrected for radioactive decay.
e. Estimated to be 70 workers.
f. L-Area.
g. L-Area estimated to be 251 workers [Source: Simpkins (1996c)].

over a 5-year career, the involved workers could have 5.5×10^{-5} additional fatal cancer as a result of exposure.

Under the future land use scenario, the combined probability that the involved worker would develop a fatal cancer at some time as the result of a single year's exposure to radiation under the Shut Down and Deactivate Alternative would be 1.6×10^{-5}, or approximately 1 in 100,000. For the total involved workforce, the collective radiation dose could produce up to 1.1×10^{-3} additional fatal cancer as the result of a single year's exposure; over a 25-year career, the involved workers could have 0.021 additional fatal cancer as a result of exposure. | TC

The combined annual probability of any individual uninvolved worker developing a fatal cancer as a result of the estimated exposure would be 5.9×10^{-10}. For the total uninvolved workforce, the collective radiation dose could produce up to an additional 1.5×10^{-7} fatal cancer as the result of a single year's exposure; over a 25-year career, the uninvolved workers could have an additional 3.5×10^{-6} fatal cancer as a result of exposure. These impacts would be a small fraction of the natural incidence of cancer from all causes. | TC

Nonradiological Impacts

DOE calculated the combined nonradiological health impacts (hazard index) and cancer risks under the current and future land use scenarios for the involved worker. Table 4-67 lists these impacts and risks. The calculated hazard index for the maximally exposed involved worker under the current and future land use scenarios would be a small fraction of 1. Therefore, these individuals would not experience adverse health effects. In addition, the cancer risk to the maximally exposed involved worker would be a small fraction of the natural incidence of cancer from all causes and, therefore, the impact would be minimal. | TE

For the uninvolved worker assumed to be in L-Area, the combined hazard index would be a very small fraction of 1 and, therefore, this individual would not experience adverse health effects.

4.3.8.3.3 Shut Down and Maintain

For the Shut Down and Maintain Alternative combined impacts would be the same as described in Section 4.3.8.3.2, Shut Down and Deactivate.

Table 4-67. Combined worker nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a] | TE

Receptor(s)	No Action: Total hazard index	No Action: Annual (lifetime) latent cancer risk	Shut Down and Deactivate: Total hazard index	Shut Down and Deactivate: Annual (lifetime) latent cancer risk
Involved worker (current use)	2.1×10^{-4}	9.1×10^{-9} (4.5×10^{-8})	1.1×10^{-2}	6.6×10^{-8} (3.3×10^{-7})
Involved worker (future use)	5.6×10^{-4}	1.3×10^{-8} (3.1×10^{-7})	2.1×10^{-1}	1.2×10^{-6} (2.9×10^{-5})
Uninvolved worker[c]	1.5×10^{-8}	NA[b] (NA)	1.1×10^{-4}	1.4×10^{-9} (3.6×10^{-8})

TC

a. Supplemental information is provided in Tables C-67, C-68, and C-69 in Appendix C.
b. NA = Not applicable. Nonradiological carcinogens are not released to atmosphere.
c. L-Area.

4.4 Environmental Justice

4.4.1 AFFECTED ENVIRONMENT: COMMUNITY CHARACTERISTICS

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. Executive Order 12898 also directs the Administrator of the Environmental Protection Agency to convene an interagency Federal Working Group on Environmental Justice. One task of the Interagency Working Group is to provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority and low-income populations. (Note: This EIS refers to minority populations as people of color.) The Working Group has not yet issued this guidance, although it has developed draft definitions (EPA 1996), which DOE has used in this EIS analysis. Further, in coordination with the Interagency Working Group, DOE is developing internal guidance for implementing the Executive Order.

Implementation of the Proposed Action or alternatives could result in offsite health impacts due to airborne and water-borne contaminants. For air releases, DOE based its standard population dose analyses on a 50-mile (80-kilometer) radius because reasonably foreseeable dose levels beyond that distance would be negligible. For liquid releases, the region of interest includes areas that draw drinking water from the River (Beaufort and Jasper Counties in South Carolina and Port Wentworth in Georgia). Combining these areas, the analysis included data (U.S. Bureau of the Census 1990a,b) for populations in all census tracts that have at least 20 percent of their area in the 50-mile (80-kilometer) radius and all tracts from Beaufort and Jasper Counties in South Carolina and Effingham and Chatham Counties in Georgia, which are downstream of the Site. DOE used data from each census tract in this combined region to identify the racial composition of communities and the number of persons characterized by the U.S. Bureau of the Census as living in poverty. The combined region contains 247 census tracts, 99 in South Carolina and 148 in Georgia.

TE | Tables 4-68 and 4-69 list racial and economic characteristics, respectively, of the population in TE | the combined region. Table 4-68 indicates a total population of more than 993,000 in the area; of that population, approximately 618,000 (62.2 percent) are white. Within the population of people of color, approximately 94 percent are African American. The remainder of the population of people of color consists of small percentages of Asian, Hispanic, and Native American persons. Figure 4-38 shows the distribution of people of color by census tract areas in the SRS region.

TE | **Table 4-68.** General racial characteristics of population in the Savannah River Site region of interest.[a]

State	Total population	White	People of color	African American	Hispanic	Asian	Native American	Other	Percent people of color[b]
South Carolina	418,685	267,639	151,046	144,147	3,899	1,734	911	355	36.08%
Georgia	574.982	350.233	224.749	208.017	7.245	7.463	1.546	478	39.09%
Total	993,667	617,872	375,795	352,164	11,144	9,197	2,457	833	37.82%

a. Source: U.S. Bureau of the Census (1990a).
b. People of color population divided by total population.

Table 4-69. General poverty characteristics of population in the Savannah River Site region of interest.[a] | TE

Area	Total population	Persons living in poverty[b]	Percent living in poverty
South Carolina	418,685	72,345	17.28%
Georgia	574,982	96,672	16.81%
Total	993,667	169,017	17.01%

a. Source: U.S. Bureau of the Census (1990b).
b. Families with income less than the statistical poverty threshold, which in 1990 was 1989 income of $8,076 for a family of two.

Executive Order 12898 does not define minority populations. One approach is to identify communities that contain a simple majority of people of color (greater than or equal to 50 percent of the total community population). A second approach suggested by the Interagency Working Group defines communities of people of color as those that have higher-than-average (over the region of interest) percentages of minority persons (EPA 1996). For this analysis, DOE has adopted the second, more expansive, approach to identify people-of-color communities. DOE uses two shading patterns in Figure 4-38 to indicate census tracts where (1) people of color constitute 50 percent or more of the total population in the census tract, or (2) people of color constitute between 35 percent and 50 percent of the total population in the tract.

The combined region has 80 tracts (32.4 percent) where populations of people of color constitute 50 percent or more of the total population of the tract. In an additional 50 tracts (20.2 percent), people of color constitute between 35 and 50 percent of the population. These tracts are well distributed throughout the region, although there are more of them toward the south and in the immediate vicinities of Augusta and Savannah, Georgia.

Low-income communities are defined as those in which 25 percent or more of the population is characterized as living in poverty (EPA 1993b). The U.S. Bureau of the Census defines persons in poverty as those whose income is less than a "statistical poverty threshold." This threshold is a weighted average based on family size and the age of the persons in the family. The baseline threshold for the 1990 census was a 1989 income of $8,076 for a family of two.

Table 4-69 indicates that in the SRS region, more than 169,000 persons (about 17.0 percent of the total population) are characterized as living in poverty. In Figure 4-39, shaded census tracts identify low-income communities. In the region, 72 tracts (29.1 percent) are low-income communities, which are distributed throughout the region of interest, but primarily to the south and west of the SRS. | TE

4.4.2 ENVIRONMENTAL JUSTICE ASSESSMENT

This EIS evaluates if communities of people of color or low income could be recipients of disproportionately high and adverse human health and environmental impacts. Even though DOE expects little or no adverse health impacts from any of the alternatives, it analyzed if there would be "disproportionately high and adverse human health or environmental effects [of these alternatives] on minority populations or low-income populations" (Executive Order 12898). Figures 4-38 and 4-39 show communities of people of color and low income by census tract. This section discusses predicted average radiation doses received by individuals in those communities and compares them to the predicted per capita doses that could be received in the other communities in the 50-mile (80-kilometer) region. This section also discusses impacts of doses that could be received

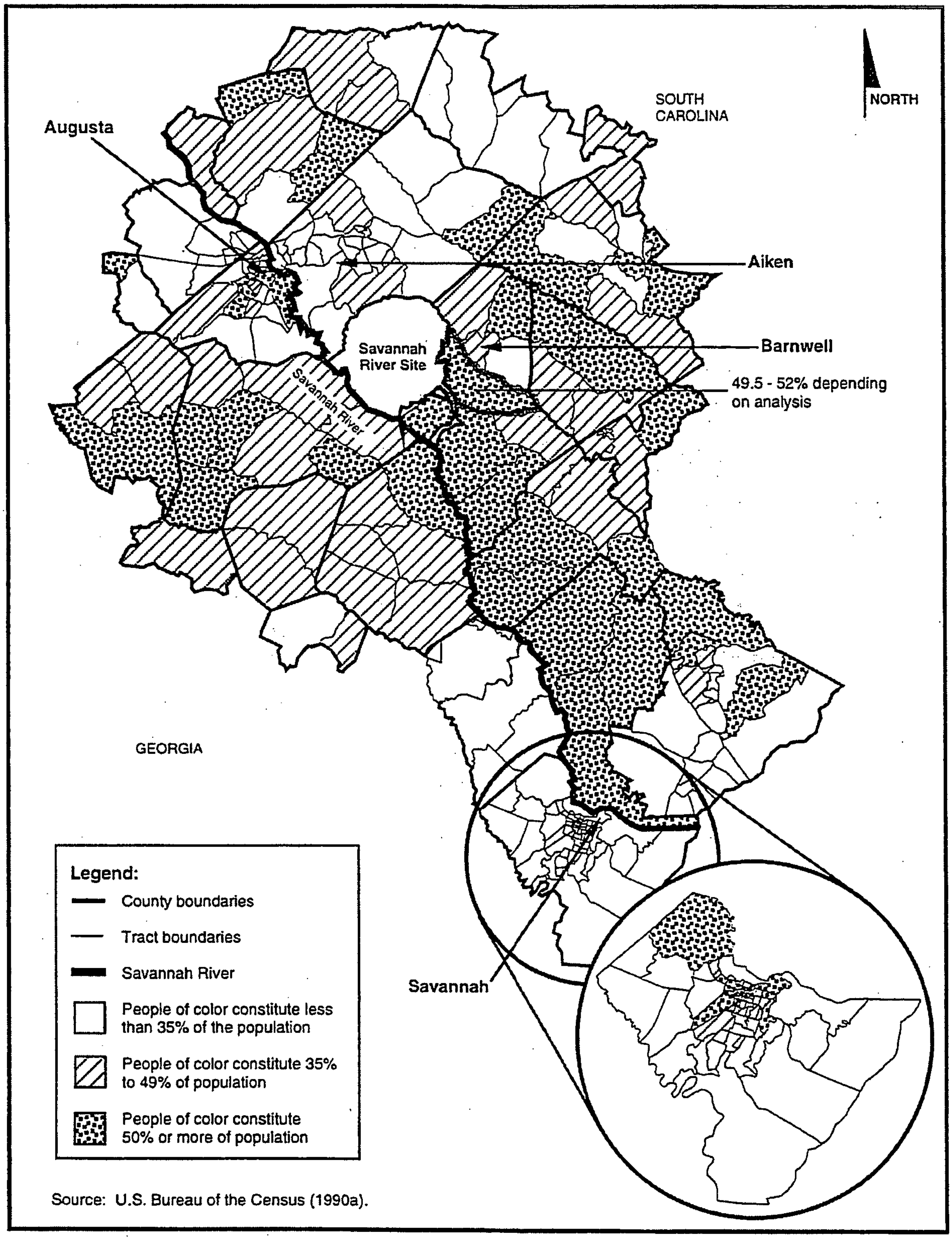


Figure 4-38. Distribution of people of color by census tract in the Savannah River Site region of analysis.

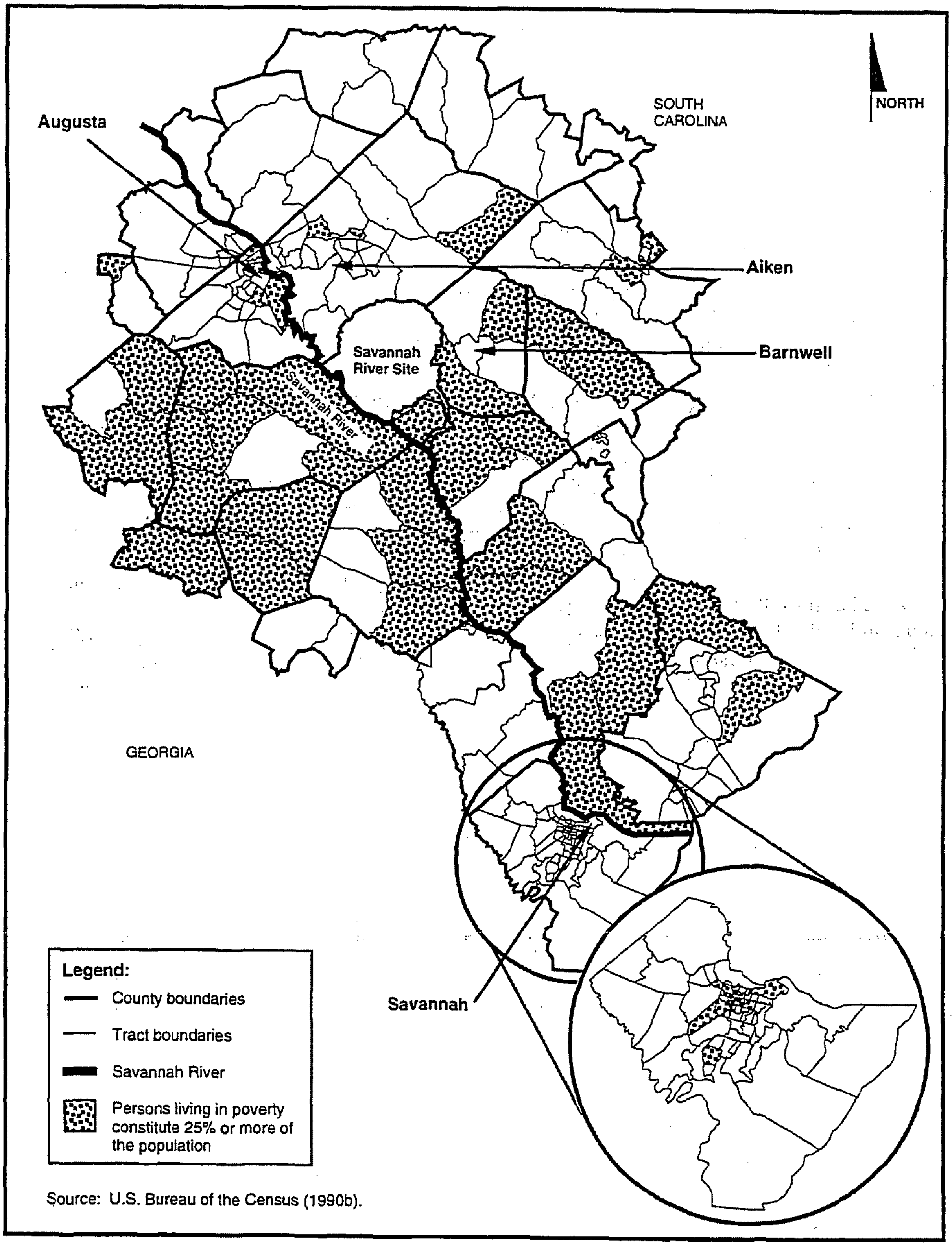


Figure 4-39. Distribution of low-income census tract in the Savannah River Site region of analysis.

in the downstream communities from liquid effluents from all alternatives, and potential impacts from nonradiological pollutants.

Figure 4-40 shows a wheel with 22.5-degree sectors and concentric rings from 10 to 50 miles (16 to 80 kilometers) at 10-mile (16-kilometer) intervals. DOE calculated a fraction of the total population dose for each sector (Table 4-70), laid the sector wheel over the census tract map, and assigned each tract to a sector. If a tract fell in more than one sector, the analysis assigned it to the sector with the largest value.

DOE analyzed the impacts by comparing the per capita dose received by each type of community to the other types of communities in a defined region. To eliminate the possibility that impacts to a low-population community close to the SRS with a high dose per person would be diluted and masked by including it with a high-population community farther from SRS, the analysis made comparisons within a series of concentric circles, the radii of which increase in 10-mile (16-kilometer) increments. To determine the radiation dose received per person in each type of community, DOE multiplied the number of people in each tract by that tract's dose value to obtain a total population dose for each tract, and then summed the population doses for each type of community over each concentric circle and divided them by the total community population to obtain a community per capita dose for each circular area.

As discussed in Section 4.3.8.3, no adverse health effects are likely to occur in any offsite community, including minority and low-income communities. The following analyses provide details of the distribution of impacts only for the Shut Down and Deactivate Alternative (Section 4.4.2.2), which would have the greatest offsite total population dose.

4.4.2.1 No Action

Because the total offsite population dose under this alternative would be less than that for either of the other alternatives, the impacts among communities would be less than those for the other alternatives. The distribution of these small impacts among communities for the No-Action Alternative would be similar to the distribution of impacts for the Shut Down and Deactivate Alternative, which is discussed in Section 4.4.2.2. Impacts would be neither highly adverse nor disproportionate and would present no environmental justice concerns.

4.4.2.2 Shut Down and Deactivate

Figure 4-41 and Table 4-71 show the per capita distribution of the total population dose (2.40×10^{-3} person-rem) for this alternative in types of communities within the 50-mile (80-kilometer) region. As shown in Figure 4-41, the analysis indicates that atmospheric releases would not be highly disproportionate among communities of people of color (population equal to or greater than 35 percent of the total population) or low income (equal to or greater than 25 percent of the total population) in the 50-mile region; that is, in a horizontal comparison of Figure 4-41 the per capita doses would not vary greatly among community types.

Section 4.1.8.2.2 discusses predicted potential doses to the offsite maximally exposed individual and the downstream population from exposure to water resources. Those doses reflect people using the Savannah River for drinking water, sports, and food (fish). Because the identified communities in the areas downstream from SRS are well distributed and the potential impacts would be so small, there would be neither highly adverse nor disproportionate impacts among people of color or low-income communities.

The distribution of carcinogenic and criteria pollutant emissions would be essentially identical to those presented for airborne radiological emissions because the distribution pathways would be the same. As a result, people of color or low-income communities would not be disproportionately affected by nonradiological emissions from any of the alternatives. Because nonradiological pollutant emissions would have

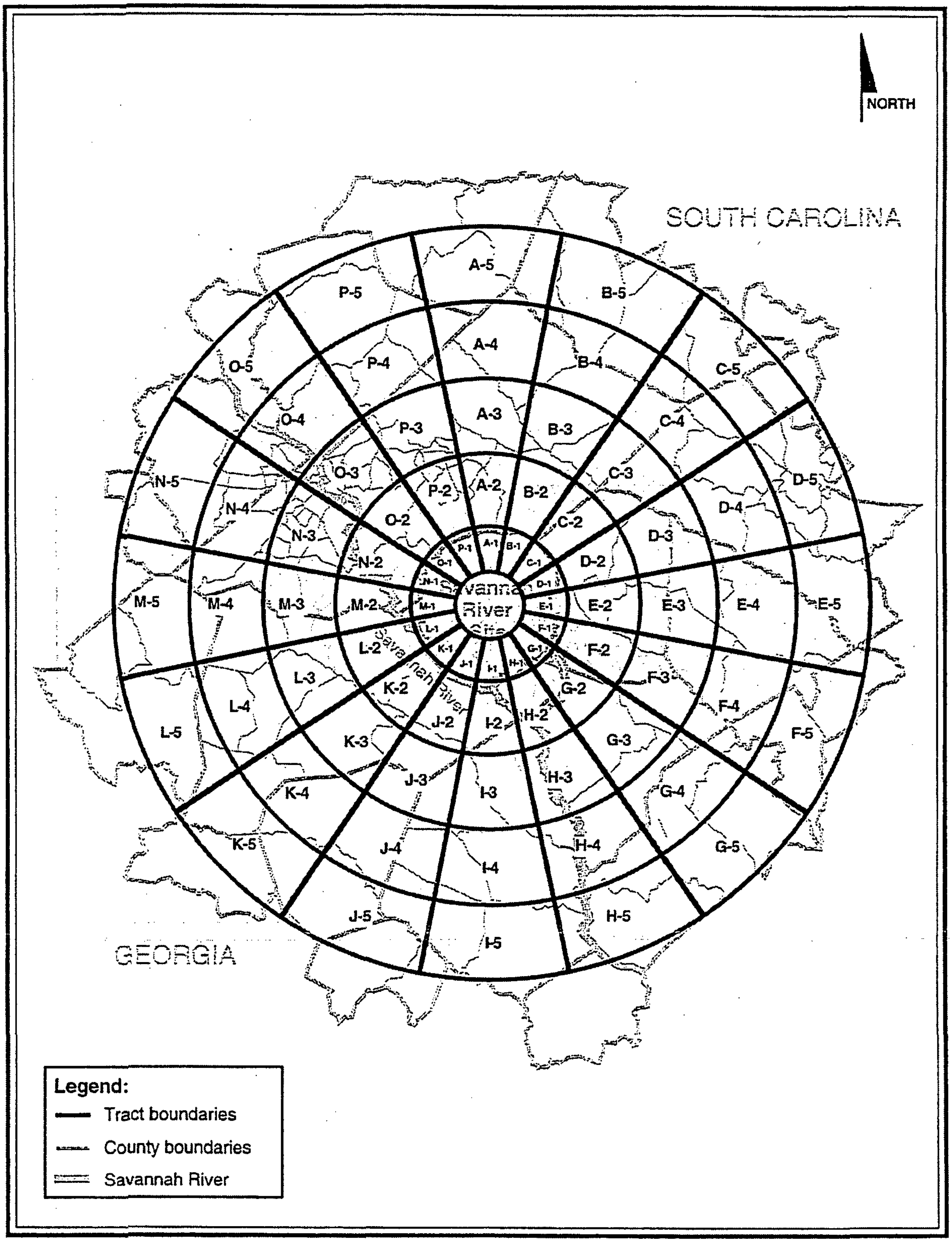
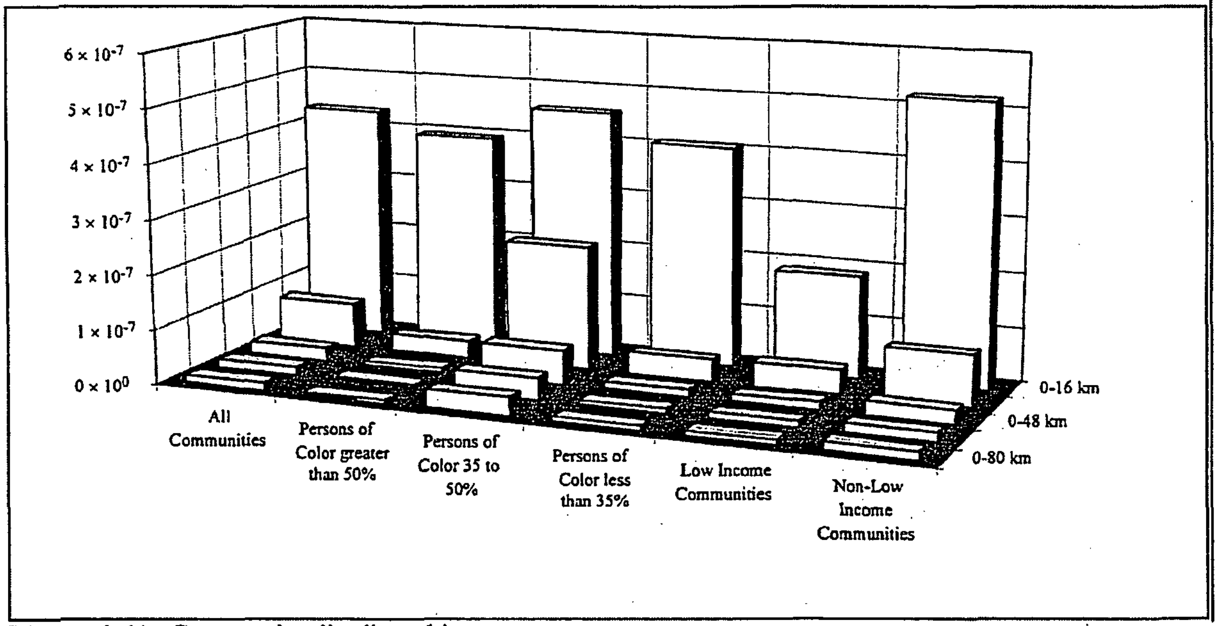


Figure 4-40. Annular sectors around the Savannah River Site.

Table 4-70. Annular sector factors for local dose evaluations.

Sector[a]	Fraction of total population dose in sector[b]					Fraction of total population dose received by average person in sector[b]				
	1 (5-10 miles)	2 (10-20 miles)	3 (20-30 miles)	4 (30-40 miles)	5 (40-50 miles)	1 (5-10 miles)	2 (10-20 miles)	3 (20-30 miles)	4 (30-40 miles)	5 (40-50 miles)
A (N)	1.44×10^{-4}	4.18×10^{-3}	8.96×10^{-4}	9.96×10^{-5}	6.90×10^{-5}	5.13×10^{-6}	7.26×10^{-7}	8.26×10^{-8}	1.81×10^{-8}	5.22×10^{-9}
B (NNE)	5.76×10^{-5}	1.86×10^{-3}	2.98×10^{-4}	1.23×10^{-4}	1.03×10^{-4}	9.59×10^{-6}	1.30×10^{-6}	1.33×10^{-7}	2.54×10^{-8}	6.64×10^{-9}
C (NE)	2.14×10^{-5}	1.02×10^{-2}	7.60×10^{-4}	1.94×10^{-4}	7.50×10^{-5}	2.14×10^{-5}	3.18×10^{-6}	2.40×10^{-7}	3.39×10^{-8}	6.78×10^{-9}
D (ENE)	2.65×10^{-3}	2.86×10^{-2}	2.22×10^{-3}	3.23×10^{-4}	5.27×10^{-4}	9.14×10^{-5}	8.46×10^{-6}	4.57×10^{-7}	5.58×10^{-8}	1.19×10^{-8}
E (E)	7.31×10^{-1}	6.59×10^{-2}	2.16×10^{-3}	4.16×10^{-4}	4.50×10^{-5}	4.35×10^{-3}	9.01×10^{-6}	3.76×10^{-7}	4.35×10^{-8}	9.59×10^{-9}
F (ESE)	7.71×10^{-3}	9.47×10^{-3}	5.91×10^{-4}	1.06×10^{-4}	2.83×10^{-5}	1.98×10^{-4}	5.61×10^{-6}	2.82×10^{-7}	3.62×10^{-8}	8.03×10^{-9}
G (SE)	3.86×10^{-3}	2.83×10^{-3}	2.09×10^{-3}	2.54×10^{-4}	7.08×10^{-5}	1.38×10^{-4}	4.78×10^{-6}	2.96×10^{-7}	3.51×10^{-8}	7.62×10^{-9}
H (SSE)	8.94×10^{-3}	2.87×10^{-3}	3.03×10^{-4}	3.71×10^{-4}	2.15×10^{-5}	2.08×10^{-4}	6.78×10^{-6}	3.64×10^{-7}	2.53×10^{-7}	7.81×10^{-9}
I (S)	6.58×10^{-4}	5.73×10^{-3}	6.84×10^{-4}	3.92×10^{-4}	3.48×10^{-5}	6.58×10^{-4}	9.51×10^{-6}	4.74×10^{-7}	4.98×10^{-8}	9.62×10^{-9}
J (SSW)	7.75×10^{-4}	1.17×10^{-2}	1.43×10^{-3}	3.35×10^{-4}	4.68×10^{-5}	3.88×10^{-4}	1.21×10^{-5}	6.56×10^{-7}	7.39×10^{-8}	1.47×10^{-8}
K (SW)	3.10×10^{-3}	8.08×10^{-3}	1.05×10^{-3}	1.51×10^{-4}	3.22×10^{-5}	1.72×10^{-4}	7.90×10^{-6}	4.31×10^{-7}	5.34×10^{-8}	1.12×10^{-8}
L (WSW)	3.31×10^{-3}	5.80×10^{-3}	2.56×10^{-3}	1.18×10^{-4}	6.93×10^{-5}	5.09×10^{-5}	4.86×10^{-6}	3.32×10^{-7}	4.77×10^{-8}	1.10×10^{-8}
M (W)	1.32×10^{-3}	8.18×10^{-3}	1.98×10^{-3}	3.15×10^{-4}	6.54×10^{-5}	2.25×10^{-5}	2.28×10^{-6}	2.30×10^{-7}	3.64×10^{-8}	8.89×10^{-9}
N (WNW)	3.42×10^{-3}	3.05×10^{-3}	1.55×10^{-2}	1.26×10^{-3}	7.41×10^{-5}	7.04×10^{-6}	8.41×10^{-7}	1.34×10^{-7}	2.31×10^{-8}	5.92×10^{-9}
O (NW)	1.44×10^{-3}	4.25×10^{-3}	6.07×10^{-3}	3.54×10^{-4}	1.10×10^{-5}	4.92×10^{-6}	6.65×10^{-7}	6.37×10^{-8}	1.23×10^{-8}	3.34×10^{-9}
P (NNW)	1.58×10^{-3}	1.06×10^{-2}	1.84×10^{-3}	9.28×10^{-5}	2.39×10^{-5}	4.01×10^{-6}	5.45×10^{-7}	6.25×10^{-8}	1.28×10^{-8}	3.62×10^{-9}

a. Sector letter is letter shown in Figure 4-40. Letter in parentheses after the sector letter indicates the compass direction of the sector (from SRS center).
b. To convert miles to kilometers, multiply by 1.6093.



TC

Figure 4-41. Community distributed impacts.

only minimal impacts for any alternative, and would not be disproportionately distributed among different types of communities, no environmental justice concerns would be related to these pollutants for any alternative.

4.4.2.3 Shut Down and Maintain

The distribution of impacts among communities for the Shut Down and Maintain Alternative would be the same as those for the Shut Down and Deactivate Alternative, and the impacts would be neither highly adverse nor disproportionate.

Table 4-71. Estimated per capita annual dose for identified communities in 80-kilometer region. TC

	Persons of color				Low income	
Distance	For all communities	Greater than 50 percent of population	35 percent to 50 percent of population	Less than 35 percent of population	Low income communities	Non-low income communities
0-16 km	4.33×10^{-7}	3.94×10^{-7}	4.57×10^{-7}	4.07×10^{-7}	1.86×10^{-7}	5.2×10^{-7}
0-32 km	8.09×10^{-8}	3.1×10^{-8}	2.26×10^{-7}	4.07×10^{-8}	4.4×10^{-8}	9.34×10^{-8}
0-48 km	2.22×10^{-8}	5.75×10^{-9}	6.22×10^{-8}	1.37×10^{-8}	1.4×10^{-8}	2.45×10^{-8}
0-64 km	1.48×10^{-8}	4.67×10^{-9}	4.01×10^{-8}	8.31×10^{-9}	1×10^{-8}	1.6×10^{-8}
0-80 km	1.31×10^{-8}	3.95×10^{-9}	3.3×10^{-8}	7.84×10^{-9}	8.62×10^{-9}	1.43×10^{-8}

TC

a. Per capita dose based on a population dose of 0.002588 person-rem.
b. To convert miles to kilometers, multiply by 1.6093.

4.5 Cumulative Impacts

This section presents cumulative impacts from the Proposed Action on the River Water System when it is added to impacts from past, present, and reasonably foreseeable onsite activities and impacts of nearby offsite industrial facilities. A cumulative impact is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable activities regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collective significant actions taking place over a period of time" (40 CFR 1508.7).

Associated actions are another component of this cumulative impacts section. This analysis considers associated actions that could not or would not proceed unless other actions were taken previously or simultaneously. Impacts associated with these actions are considered collectively with the direct impacts of the Proposed Action coupled with the impacts of past, present, and reasonably foreseeable activities.

This analysis assesses cumulative impacts for the Shut Down and Deactivate Alternative because the No-Action Alternative would have minimal effects (i.e., ongoing transitions due to limited discharges from the River Water System) and impacts generally would not vary between the two shutdown alternatives. Potential impacts under the Shut Down and Deactivate Alternative would be the worst case scenario because DOE could not restart the system. Under the Shut Down and Maintain Alternative, DOE preserves the capability to pump water from the River Water System if conditions or mission changes require system operation (e.g., recover from unlikely drawdown of Par Pond).

This section discusses cumulative impacts for air resources and public and occupational health. Impacts in other resource areas (e.g., geologic resources, surface and groundwater resources, aesthetic resources, and land use) are not included because the impacts of the Proposed Action would be small, and their potential contribution to cumulative impacts would be negligible. Sections 4.1.5, 4.2.5, and 4.3.5 on ecological resources have captured the cumulative effects and, therefore, are not repeated in this section. The baseline aspects of each component (terrestrial resources, aquatic resources, wetlands, and threatened and endangered species) are covered in the affected environment sections, and the incremental impact of the actions under each alternative are added to that baseline to define the cumulative impact. In the analysis DOE considers impacts identified in Sections 4.3.4.3 (combined atmospheric impacts) and 4.3.8.3 (combined occupational and public health impacts) coupled with emissions from existing and planned facilities or activities and background concentrations. This analysis includes the following facilities or activities:

- Existing facilities and activities:
  - Savannah River Technology Center
  - F- and H-Area Separations Facility
  - Replacement Tritium Facility
  - F/H-Area Effluent Treatment Facility
- Future facilities and activities:
  - Proposed facilities and actions associated with SRS waste management
  - Proposed facilities and actions associated with interim management of nuclear materials
  - Proposed facilities and actions associated with stabilization of plutonium solutions
  - Proposed facilities and actions associated with the Defense Waste Processing Facility
  - Proposed facilities and actions associated with SRS spent nuclear fuel

- Offsite facilities:
  - Vogtle Electric Generating Plant

4.5.1 ASSOCIATED ACTIONS

DOE has identified five closely related actions that could be associated with those being considered in this EIS.

- L-Lake Site Evaluation
- Remedial Action Process for Onsite Streams
- K- and L-Area Auxiliary Equipment Cooling
- Wastewater Discharges to Onsite Streams
- K- and L-Area Fire Protection Services

L-Lake Site Evaluation

An internal draft L-Lake remedial site evaluation has resulted in a DOE recommendation for further investigation of the lake under the FFA. Because actions being considered by DOE in this EIS could accelerate the emergence of potential hazards being evaluated under the FFA, DOE believes that the identification and selection of potential remediation strategies for L-Lake is associated with the Proposed Action in this EIS.

Remedial Action Process for Onsite Streams

Par Pond, Steel Creek, Fourmile Branch, Pen Branch, and Lower Three Runs are on the RCRA/CERCLA Units List and will receive future evaluation and potential remedial actions under the requirements of the FFA. The extent of flow reduction in these streams is the same under both shutdown alternatives being evaluated in this EIS; such a reduction could accelerate the emergence of potential hazards being evaluated under the FFA. Accordingly, DOE believes that the identification and selection of potential remediation strategies for the site streams is an associated action and a potential impact if it implements the Proposed Action. DOE believes the FFA actions on L-Lake and onsite streams and the actions in this EIS are related because FFA activities in total could initiate NEPA documentation. The form of documentation would probably follow the preferred strategy of integrating NEPA values in the regulatory documents (DOE 1994b).

K- and L-Area Auxiliary Equipment Cooling

If the Proposed Action or either of its alternatives is implemented, auxiliary equipment (chilled water and compressed air systems) in the K- and L-Areas will lose their cooling water supply. As a cost saving initiative, DOE replaced the water-cooled chilled water system with an air-cooled system and switched compressed air system cooling loads to well water systems in both areas. Also, about 210 gallons per minute (0.013 cubic meter per second) and 190 gallons per minute (0.012 cubic meter per second) of well water are supplied to the compressed air systems in the K- and L-Areas, respectively. Therefore, before operation of the small pump, DOE has provided well water to meet current equipment cooling water requirements.

Wastewater Discharges to Onsite Streams

If DOE implements the Proposed Action, it has determined that sanitary wastewater from L-Area would not meet SCDHEC water quality criteria without blending from other area sources. Reliable blending water sources do not exist and consequently DOE must select an alternative wastewater treatment option for L Area (Section 4.1.2 discusses this alternative's options). Therefore, DOE believes that the selection and installation of a new sanitary wastewater treatment method in L-Area is an associated action, having cost impacts only. DOE would implement the least costly environmentally satisfactory option, which is a septic tank and tile field.

K- and L-Area Fire Protection Services

DOE will continue to use the 25-million-gallon (1,600-cubic-meter) 186-Basins in the K- and L-Areas as the long-term fire protection water supply sources in those areas. If the River Water System is shut down, approximately 200 gallons per minute (0.013 cubic meter per second) of water would be added to each 186-Basin to ensure that the required reserve capacity is maintained. This make-up capacity would be provided by the existing K- and L-Area well water system. Piping alignments to the well water systems in both areas to supply the 186-Basins are associated actions, the impacts of which would be bounded by historic well water withdrawal rates. DOE believes that auxiliary equipment cooling replacement of river water blending for L-Area sanitary wastewater and K- and L-Area fire protection services are associated actions because the Proposed Action would not proceed until it implemented these actions.

4.5.2 AIR RESOURCES

Section 4.3.4.3 describes potential total maximum ground-level concentrations at the SRS boundary resulting from resuspended dried lakebed sediments from L-Lake and Par Pond. Table 4-72 lists the cumulative maximum SRS boundary line ground-level concentrations for air toxics (antimony, arsenic, beryllium, cadmium, lead, manganese, and mercury) and the criteria pollutant (PM_{10}) that could be released from dried lakebed sediments. This table also summarizes the combined releases associated with Par Pond and L-Lake, emissions from existing SRS facilities, background concentrations, and emissions expected from future activities. These data demonstrate that total modeled concentrations of nonradiological air pollutants from the SRS, including those from the River Water System shutdown, would be below regulatory standards.

Similarly, the concentrations of radioactive constituents would be very low. The combined airborne maximum-boundary line concentrations of cesium-137 and cobalt-60 from L-Lake and Par Pond would be 1.6×10^{-4} and 6.1×10^{-7} picocuries per liter, respectively. The cumulative impacts in terms of annual dose equivalents and health effects is discussed in the following section.

4.5.3 PUBLIC AND OCCUPATIONAL HEALTH

Sections 4.1.8 and 4.3.8 describe potential radiological releases from contaminated sediments of L-Lake and Par Pond, respectively. Table 4-73 lists the radiological doses to the hypothetical maximally exposed individual and the offsite population for the public and workers due to the exposures resulting from current and future SRS activities, including shutdown of the River Water System, and from offsite sources. The cumulative dose could result in an additional latent cancer fatality risk of 9.6×10^{-7} per year to that individual and a total of 0.033 additional cancer fatality per year to the 80-kilometer (50-mile) population from releases of radioactivity. The shutdown of the River Water System would account for approximately 0.4 percent of these effects. The cumulative impact could result in 0.31 additional latent cancer fatality to onsite workers; the shutdown of the River Water System would account for a negligible percentage (0.004 percent) of these health effects.

4.6 Unavoidable Adverse Impacts

The shutdown of the River Water System at the Savannah River Site would result in some adverse impacts to the environment. The impact assessment in this EIS identifies potential adverse impacts; the following paragraphs discuss those that would be unavoidable.

The recession of L-Lake associated with the shutdown alternatives would generate transient and minor air impacts as a result of minimal increases in the concentration of particulate matter less than 10 microns in diameter (PM_{10}) and slight increases in air toxics (including manganese, chromium, mercury, and beryllium).

These impacts coupled with those from existing operations and background values would still

Table 4-72. Cumulative maximum Savannah River Site boundary line ground-level concentrations for PM_{10} and air toxics (in micrograms per cubic meter of air).

Pollutant	Averaging time	Concentrations of existing sources[a]	Background concentrations[b]	Increase concentration: Shut Down and Deactivate[c]	Increase concentration: Waste Management[d]	Increase concentration: Plutonium Solutions[d]	Increase concentration: Spent Nuclear Fuel[d]	Increase concentration: Interim Management Nuclear Material[d]	Regulatory standards[e]	Percent of standard (%)
Particulate matter less than 10 microns in diameter	24 hours	51	62	16	5	0.2	0.4	(f)	150	90
	Annual	3	19	16	0.1	0.005	0.01	(f)	50	76
Antimony	24 hours	NA[c]	NA	8.6×10^{-6}	NA	NA	NA	NA	2.5	<0.01
Arsenic	24 hours	NA[f]	NA	2.2×10^{-5}	NA	NA	NA	NA	1.0	<0.01
Beryllium	24 hours	NA[f]	NA	2.9×10^{-6}	NA	NA	NA	NA	0.01	0.03
Cadmium	24 hours	NA[f]	NA	1.3×10^{-6}	NA	NA	NA	NA	0.25	<0.01
Lead	Quarterly	4.0×10^{-4}	0.03	1.8×10^{-5}	NA	NA	NA	NA	1.5	0.02
Mercury	24 hours	0.014	NA	1.2×10^{-6}	NA	NA	NA	NA	0.25	5.6
Manganese	24 hours	0.821	NA	2.6×10^{-6}	NA	NA	NA	NA	25	3.3

TC

a. Modeled concentrations based on maximum potential emissions from metals and actual emissions for PM_{10} from existing SRS sources (DOE 1995a).
b. Source: SCDHEC (1996b).
c. Calculated annual and 24-hour concentration from MEPAS modeling.
d. Source: DOE (1995c); DWPF emissions are included in waste management.
e. Source: SCDHEC (1976).
f. NA = Not available. No ambient air monitoring is performed for toxics. Concentrations assumed to be zero.
g. Source: Stewart (1996).

Table 4-73. Estimated maximum annual cumulative radiological doses and resulting health effects to offsite population and facility workers.

Activity	Offsite maximally exposed individual (rem)			Annual Fatal cancer risk[b]	Total collective[a] (to 80-kilometer population)			Annual Latent cancers fatalities[c]	All workers	
	Dose from airborne releases	Dose from aqueous releases	Total dose		Dose from airborne releases	Dose from aqueous releases	Total dose		Dose (person-rem)	Latent cancer fatalities[c]
Shut Down and Deactivate	6.9×10^{-6}	1.4×10^{-8}	6.9×10^{-6}	3.5×10^{-9}	2.7×10^{-3}	3.5×10^{-5}	2.7×10^{-3}	1.4×10^{-6}	2.9×10^{-2}	1.2×10^{-5}
Waste Management	3.2×10^{-5}	6.9×10^{-7}	3.3×10^{-5}	1.7×10^{-8}	1.5	6.8×10^{-3}	1.5	7.5×10^{-4}	81	0.032
Current SRS practices	6.0×10^{-5}	1.4×10^{-4}	2.0×10^{-4}	1.0×10^{-7}	3.5	1.6	5.1	2.6×10^{-3}	251	0.10
Interim management of nuclear materials[d]	9.7×10^{-4}	2.4×10^{-5}	9.9×10^{-4}	5.0×10^{-7}	40	0.09	40	0.02	127	0.051
Stabilization of plutonium solutions[e]	8.61×10^{-6}	2.9×10^{-7}	8.9×10^{-6}	4.5×10^{-9}	0.38	3.7×10^{-4}	0.38	1.9×10^{-4}	131	0.052
Defense Waste Processing Facility[f]	1.0×10^{-6}	NA[g]	1.0×10^{-6}	5.0×10^{-10}	0.07	NA	0.07	3.5×10^{-5}	118	0.047
TC Plant Vogtle[h]	3.7×10^{-7}	1.7×10^{-4}	1.7×10^{-4}	8.5×10^{-8}	0.047	9.7×10^{-3}	0.057	2.9×10^{-5}	NA	NA
SRS spent nuclear fuel[i]	4.0×10^{-4}	1.0×10^{-4}	5.0×10^{-4}	2.5×10^{-7}	16.0	2.4	18.4	9.2×10^{-3}	79	0.032
Total	1.5×10^{-3}	4.3×10^{-4}	1.9×10^{-3}	9.6×10^{-7}	61	4.1	66	0.033	787	0.31

a. Collective dose (person-rem): for the 80-kilometer (50-mile) population from atmospheric releases; for downstream users of Savannah River water from liquid releases.
b. Probability of an excess fatal cancer.
c. Incidence of excess latent fatal cancers.
d. Source: DOE (1995d).
e. Source: DOE (1995e).
f. Source: DOE (1995f).
g. NA = not applicable. There are no direct radioactive releases to surface water from the Defense Waste Processing Facility operations.
h. NRC (1994).
i. Highest values from Appendix C of DOE (1995g).

fall well below applicable State and Federal standards.

DOE expects only minor unavoidable adverse impacts on public or worker health as a result of the shutdown alternatives. The amount of radioactivity that exposed lakebed sediments would release would be a small fraction of releases at the SRS and would be well below applicable regulatory standards. The hypothetical maximally exposed individual would receive an annual effective dose equivalent of 6.9×10^{-9} millirem, compared to about 300 millirem from natural radiation sources.

Exposure to contaminated lakebed sediments for the onsite worker would be well below established DOE limits.

Implementing either shutdown alternative would result in the recession of L-Lake; eventually L-Lake would reach equilibrium or recede to stream conditions. The recession of the lake would be unavoidable and would result in the loss of up to 1,000 acres (4 square kilometers) of lacustrine habitat. The loss of habitat would displace aquatic species, some of which could be lost depending on the rate of recession. Federally listed threatened or endangered species, such as the bald eagle, wood stork, and American alligator would be affected directly or by disruptions and loss to benthic and foraging habitat. These species would be able to disperse to more suitable habitats in the area. These impacts would not affect regional populations.

The shutdown of the River Water System would result in minor to nonexistent impacts to soils, groundwater, land use, and aesthetics. A minor impact to groundwater resources would result to support small equipment cooling loads in K- and L-Areas that the River Water System supplies. Groundwater resources in the area would accommodate the withdrawal needed to support these systems.

For the most part, impacts would be similar under both shutdown alternatives. However, under the Preferred Alternative, DOE would preserve the capability to pump water to reservoirs if unforeseen and unacceptable impacts occurred.

4.7 Short-Term Uses and Long-Term Productivity

This section considers the short-term uses of the environment and the maintenance of its long-term productivity. The implementation of the Proposed Action would stop river water flow to L-Lake, but would not involve construction, emissions, decommissioning, or waste generation associated with actions that typically place short-term demands on resources. However, the Proposed Action would affect resources of the L-Lake/Steel Creek ecosystem. The primary and secondary productivity of the lake would decrease from the reduction in nutrient loading that river water inputs had supplied. The standing crop of fish, in particular, would be reduced over time, and ultimately would be reduced to small populations of stream fish. Although the productivity of the lake would shift with recession, the decline in productivity would be temporary. An increase in terrestrial productivity would accompany the decline in aquatic productivity; as grasses, forbs, shrubs, and trees recolonized the former lakebed over time, a variety of terrestrial and semiaquatic animal species would inhabit the former lakebed. The regrowth of forested wetlands and uplands would enhance the long-term productivity and diversity of the area.

4.8 Irreversible or Irretrievable Commitment of Resources

The commitment of a resource is irreversible when the primary and secondary impacts of an alternative would limit future options for that resource. An irretrievable commitment is the use or consumption of recourses neither renewable nor recoverable for use by future generations. The National Environmental Policy Act TE requires the identification of irreversible and irretrievable commitments of resources.

The DOE Proposed Action and Preferred Alternative does not involve the construction of new facilities, operational processes, or waste generation that typically would require a commitment of resources. The implementation of either shutdown alternative would result in the loss of L-Lake, exposure of contaminated sediments, and remobilization of these sediments. Although the loss of L-Lake is technically reversible under the Proposed Action to Shut Down and Maintain the River Water System, the commitment of the natural resources associated with L-Lake would be unavoidable. TE Table 4-74 details these commitments of various resources.

DOE anticipates no long-term resource commitments (electricity consumption, materials, etc.). However, the No-Action Alternative would consume small amounts of energy. Operating the River Water System with a 5,000-gallon-per-minute (0.32-cubic-meter-per-second) pump requires approximately 3,600 megawatt hours of electricity annually. The shutdown alternatives would consume a TE small amount of energy to perform the layup activities. The Preferred Alternative would consume a fraction of the amount required under No Action to perform the surveillance and maintenance activities necessary to ensure restart capability. For the range of layup and restart options, the annual energy consumption would range from 680 to 2,500 megawatt hours.

Table 4-74. Irreversibly or irretrievably committed resources.

Resource	Alternatives: No Action	Alternatives: Shutdown/Maintain[a]
Groundwater	Increased groundwater demand of approximately 190 and 210 gallons per minute (0.012 and 0.014 cubic meter per second) from Crouch Branch and McQueen Branch aquifers to provide auxiliary equipment cooling water in L- and K-Area respectively.	Additional demand at K- and L-Areas of up to 200 gallons per minute (0.013 cubic meter per second) to support fire protection at each reactor.
Terrestrial Ecology		As L-Lake recedes there will be a loss of shoreline habitat for semiaquatic and terrestrial animals using the reservoir for drinking water and food, a loss of eagle foraging habitat and a loss of alligator habitat.
	Loss of waterfowl habitat in Par Pond as the water level is allowed to fluctuate.	The same resources committed in the No Action Alternative for Par Pond would apply.
Aquatic Ecology	Continued loss of primary and secondary productivity in L-Lake due to the elimination of Savannah River water inputs.	As L-Lake recedes, there will be a loss of up to a 1000 acres of laucustrine habitat. L10-15 L12-03 L15-06
	Aquatic communities in Par Pond and Lower Three Runs will be reduced in number, diversity, and productivity.	Aquatic communities in L-Lake, Steel Creek, Lower Three Runs, and Par Pond will be reduced in number, diversity, and productivity.
	Entrainment losses of an estimated 234,000 larval fish and 117,000 fish eggs each spawning season with the continued Savannah River water withdrawals for L-Lake.	
Wetlands Ecology	Loss of open water and marsh habitat in the Steel Creek corridor and delta, and continued loss of riparian habitat in Lower Three Runs due to the prior reduction of flows to 10 cubic feet (0.28 meter) per second.	The same resources committed in the No Action Alternative would apply.
	Reduction of littoral zone wetlands around Par Pond of up to 200 acres.	The same resources committed in the No Action Alternative would apply.

a. The same resources committed in the Shutdown and Maintain Alternative would apply to the Shutdown and Deactivate Alternative.

CHAPTER 5. ENVIRONMENTAL PERMITS AND REGULATIONS

This chapter summarizes major regulatory requirements applicable to this environmental impact statement (EIS) and the actions the U.S. Department of Energy (DOE) is considering. The requirements come from Federal and State of South Carolina statutes, regulations, Executive Orders, and compliance agreements. This chapter also summarizes the status of compliance with these requirements, emphasizing issues of greatest potential concern to the decisionmaker.

5.1 National Environmental Policy Act

5.1.1 REQUIREMENTS

The National Environmental Policy Act (NEPA) of 1969 (42 USC 4321 *et seq.*) requires Federal agencies to evaluate the effect their proposed actions would have on the quality of the human environment and to document that effect in a detailed statement. Further, NEPA requires agencies to consider the environmental impacts of an alternative during the planning and decisionmaking stages.

The Council on Environmental Quality (CEQ) has issued regulations that Federal agencies must follow (40 CFR 1500-1508). CEQ also directed the agencies to develop their own regulations to ensure compliance with NEPA requirements (see the DOE regulations at 10 CFR 1021). An agency must prepare an EIS if it proposes a major action that could significantly affect the environment.

5.1.2 STATUS

The analyses in this EIS that address the environmental impacts of alternative actions comply with applicable NEPA requirements.

In March 1991 a routine inspection noted a depression on the slope of Par Pond Dam. Based on the inspection report, DOE initiated a precautionary drawdown of Par Pond. After consulting with CEQ, DOE prepared a Special Environmental Analysis (SEA; DOE 1992) that covered this emergency action in accordance with the CEQ regulations for implementing NEPA (40 CFR 1506.11). The special analysis assessed environmental impacts on the aquatic and terrestrial ecosystem during drawdown, dam repair, and refill to full pool [200 feet (61 meters) above sea level, plus or minus 1 foot (0.3 meter)].

DOE then prepared an environmental assessment (EA; DOE 1995a) that evaluated the consequences of the proposal to allow the water level in Par Pond to fluctuate naturally. Section 5.5.2.3 discusses the actions in detail.

As a cost-saving initiative, DOE replaced the last operating 28,000-gallon-per-minute River Water System pump with a 5,000-gallon-per-minute pump. This project was categorically excluded under NEPA and forms the basis for the No-Action Alternative.

5.2 Atomic Energy Act

5.2.1 REQUIREMENTS

The Atomic Energy Act of 1954 (42 USC 201 *et seq.*) makes the Federal government responsible for regulatory control of the production, possession, and use of three types of radioactive material: source material, special nuclear material, and by-product material. This Act requires DOE to establish standards that protect human health and the environment to minimize dangers from activities under DOE jurisdiction. DOE established an extensive system of standards and requirements, called DOE Orders, to ensure compliance with the Atomic Energy Act. In addition to the DOE requirements, this Act, Reorganization Plan No. 3 of 1970 [5 USC (app. at 1343)], and other statutes give the U.S. Environmental Protection Agency (EPA) responsibility and authority for developing generally applicable standards for the protection of the environment from releases of radioactive materials. EPA has promulgated several regulations under this authority.

5.2.2 STATUS

Actions proposed in this EIS that involve the management of radioactive materials would comply with Atomic Energy Act requirements set forth in DOE Orders and other applicable regulations.

5.3 Resource Conservation and Recovery Act

5.3.1 REQUIREMENTS

The Resource Conservation and Recovery Act (RCRA) regulates the treatment, storage, and disposal of hazardous and solid waste. RCRA and Executive Order 12088, "Federal Compliance with Pollution Control Standards," require Federal facilities to comply with RCRA requirements. A state that wants to administer and enforce a hazardous waste program under RCRA can apply to EPA for authorization. The South Carolina Department of Health and Environmental Control (SCDHEC) has received authorization to implement a hazardous waste program in the State of South Carolina. The EPA and SCDHEC regulations implementing RCRA (40 CFR 260-280; R.61-79.260-280) define hazardous wastes and establish requirements for the transportation, treatment, storage, and disposal of such wastes.

SCDHEC and EPA Region IV issued the original Savannah River Site (SRS) RCRA Part B permit in 1987 and renewed it in 1995. The permit includes requirements for the remediation of releases from solid waste management units. The SRS Federal Facility Agreement (FFA; EPA 1993a) establishes an integrated approach to address both Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedial action requirements and corrective action for releases from solid waste management units under RCRA. Section 5.5 discusses remedial activities under the FFA.

5.3.2 STATUS

The actions considered in this EIS would comply with the hazardous waste management requirements imposed by RCRA. Section 5.5 discusses compliance with RCRA corrective action requirements.

5.4 Comprehensive Environmental Response, Compensation, and Liability Act

5.4.1 REQUIREMENTS

EPA administers CERCLA (42 USC 9601 *et seq.*), also called Superfund, which provides a statutory framework for responding to releases or threats of releases of hazardous substances and for cleaning up waste sites that contain hazardous substances (i.e., remedial response). CERCLA and Executive Order 12580, "Superfund Implementation," require Federal facilities to comply with the Act. DOE is the CERCLA lead response agency for releases or threats of releases at the SRS.

Section 107(f) of CERCLA and Executive Order 12580 require Federal officials to act on behalf of the public as trustees for natural resources. Because DOE is the SRS land manager, it is also the primary Federal trustee. Natural Resource Trustees are responsible for evaluating natural resource injuries and for assessing damages related to such an injury. If there is a release or threat of a release from the SRS, DOE must notify and coordinate its trustee activities with other state and Federal "co-trustees." As a CERCLA lead response agency, DOE must conduct a natural resource damage assessment to determine the ecological threat posed by an actual or possible release of a hazardous substance (43 CFR 11). TC

In accordance with Section 120 of CERCLA, DOE has entered into an interagency agreement with EPA and SCDHEC (EPA 1993a). The *Federal Facility Agreement for the Savannah River Site* directs the comprehensive remediation of the SRS in accordance with CERCLA and RCRA, and thus integrates the CERCLA response action process and the corrective measures provisions of RCRA Sections 3004(u) and 3004(v). The FFA also provides specific direction for the implementation of the CERCLA natural resource damage assessment provisions at the SRS (see Section 5.5).

5.4.2 STATUS

Section 5.5 discusses SRS compliance with remedial response and natural resource damage assessment requirements.

5.5 Federal Facility Agreement

5.5.1 REQUIREMENTS

The FFA, which became effective on August 16, 1993, directs the comprehensive remediation of the SRS. It contains requirements for site investigation and remediation of releases and potential releases of hazardous substances under CERCLA, and for corrective action for releases of hazardous wastes or hazardous constituents under RCRA (EPA 1993a). As such, it integrates the CERCLA response action process with the corrective measures provisions of RCRA Sections 3004(u) and 3004(v). The following paragraphs describe the overall response action process in the FFA.

The first step in the response action process is the evaluation of newly discovered releases and potential releases of hazardous substances to determine if they should be included in Appendix G.1 of the FFA, the Site Evaluation List. Site evaluations, which are described in Section X of the FFA, are preliminary analyses of potential and known releases to determine the need for further investigation under the provisions for a RCRA Facility Investigation/Remedial Investigation (RFI/RI), removal action, or no further action. Removal actions consist of near-term actions to abate, minimize, stabilize, mitigate, or eliminate a release or the threat of release. These actions, which are conducted in accordance with Section XIV of the FFA, can result in the listing of areas in Appendix G.2 (No Further Action) or they can be a preliminary step in the remedial action process.

The remedial action process is conducted for units listed in Appendix C, RCRA/CERCLA Units, of the FFA. DOE has designated some of these as Operable Units, which generally include contaminated surface water, soils, or groundwater in designated geographical portions of the Site (i.e., an Operable Unit is a geographical location or area). The topography and hydrology of the Site enable its division into six larger units, which represent the watersheds of the primary stream systems. This process designates the stream systems as Integrator Operable Units (IOUs). SRS streams and tributaries defined as IOUs were moved from Appendix G of the FFA to Appendix C, making them subject to the development of an RFI/RI work plan rather than the site evaluation process.

The remedial action process for the units listed in Appendix C includes the development of an RFI/RI Work Plan that describes the investigation strategy for the collection of data to assess the nature and extent of the release based on the Conceptual Site Release Model. RFI/RI studies are conducted in accordance with the work plan to determine the nature and extent of contamination. A Baseline Risk Assessment addresses the current or potential future impact to human health and the environment. Next, an evaluation of various remedial alternatives is performed using the nine CERCLA criteria contained in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP; 40 CFR Part 300). The corrective measures study/feasibility study (CMS/FS) report presents the results of this analysis. Next, a Statement of Basis/Proposed Plan is prepared and made available for public review of the preferred alternative. The RCRA permit modification and Record of Decision (ROD) provide the final documentation of the selection of the remedial alternative and the response to public input.

An interim remedial action can be taken to address a threat in the short term while a permanent remedial solution is being developed. The implementation of interim remedial actions often achieves a quick reduction of risk or the stabilization of an ongoing migration of releases of hazardous substances. In general, the interim nature of these actions makes it appropriate to proceed with the remedy selection process.

Appendixes C and G.1 of the FFA identify components of the River Water System as RCRA/CERCLA units or Site Evaluation areas, respectively. Table 5-1 lists these components.

Section XLV of the FFA affirms DOE responsibilities as Natural Resource Trustee at the SRS. As a trustee, DOE follows established procedures to assess damages to natural resources (43 CFR 11). Further, in accordance with CERCLA, DOE must devise and implement a plan to restore, replace, or acquire the equivalent of such resources.

5.5.2 STATUS

The following paragraphs provide information on the compliance of the alternatives presented in this EIS to the FFA, in relation to the units described above.

5.5.2.1 L-Lake

Under the No-Action Alternative, the River Water System would continue to supply water to the K- and L-Reactor areas and L-Lake would remain at full pool; under the other two alternatives, DOE would shut down the system and would pump no water to L-Lake, resulting in the gradual lowering of the water level to the historic stream channel exposing contaminated sediments. Section 4.1 discusses the affected environment and impacts to L-Lake.

Table 5-1. River Water System components subject to remedial action under the Federal Facility Agreement.

Unit	Status
Par Pond (including the precooler ponds and canals)	RCRA/CERCLA unit[a]
L-Lake	Site Evaluation area[b]
Fourmile Branch IOU[c] (including unnamed tributary south of C-Area)	RCRA/CERCLA unit
Lower Three Runs IOU	RCRA/CERCLA unit
Pen Branch IOU (including Indian Grave Branch)	RCRA/CERCLA unit
Steel Creek IOU	RCRA/CERCLA unit

a. RCRA/CERCLA units are listed in Appendix C of the Federal Facility Agreement.
b. Site Evaluation areas are listed in Appendix G of the Federal Facility Agreement.
c. IOU = Integrator Operable Unit.

DOE is conducting the site evaluation for the L-Lake unit under the requirements set forth in Section X of the FFA, and has prepared an internal draft site evaluation report. Appendix A discusses the preliminary characterization and other remedial activities under the FFA for L-Lake. TC

5.5.2.2 SRS Streams

DOE would conduct the remedial action process for the SRS streams listed as IOUs in Appendix C of the FFA. Ongoing monitoring and characterization (summarized in the SRS Annual Environmental Report) would continue for each area. DOE will evaluate each IOU as part of the ongoing FFA-driven environmental restoration process. Impacts at SRS streams would not vary significantly among the alternatives. TE

5.5.2.3 Par Pond

In March 1991 a routine inspection of the Par Pond Dam noted a small surface depression on the downstream face. Based on the inspection report, DOE conducted a detailed structural investigation and initiated a simultaneous precautionary drawdown of the Par Pond reservoir. On July 17, 1991 DOE notified EPA Region IV that possible dam failure at Par Pond could be an imminent and substantial endangerment to public health, safety, and the environment under CERCLA, Section 104. DOE and EPA viewed the drawdown of Par Pond as a removal action under Section 300.415(d)(3) of the National Contingency Plan. From June through September 1991 DOE lowered the level from 200 feet (61.0 meters) to 181 feet (55.2 meters) to reduce risk and consequences of potential flooding in downstream communities in the event of a catastrophic dam failure. The dam repair was approved under a CERCLA 106 Abatement Action Letter (WSRC 1995e). By July 1, 1994 the repairs were complete and the Par Pond Dam was structurally sound to restore the reservoir to predrawdown water levels.

Lowering the elevation of the surface water level at Par Pond resulted in the exposure of approximately 1,340 acres (5.4 square kilometers) of sediments contaminated with cesium and mercury. DOE conducted a limited, qualitative human health risk assessment on the exposed sediments. The assessment identified a potential for additional exposure and the need to evaluate alternatives for reducing that exposure (WSRC 1992). In addition, DOE performed an assessment of environmental risks based on existing information (DOE 1993c). Remedial alternatives were developed for the Par Pond operable unit to reduce the human health and environment risk from cesium-137 contamination in the exposed sediments. The selected interim remedy consisted of restoring and maintaining the water level in Par Pond to the 200-foot (61.0-meter) level after the repair of the dam (WSRC 1995e).

Based on public comments on the interim action proposed plan, DOE conducted an environmental assessment (EA; DOE 1995a) to evaluate potential environmental impacts of allowing the water level in Par Pond to fluctuate naturally. The model indicated that the water level would not be likely to fall below 196.2 feet (59.8 meters); therefore, 195 feet (59.4 meters) became the lower limit for bounding the assessment of the potential environmental impacts of the natural fluctuation of the water level. The final EA process ended with a Finding of No Significant Impact (DOE 1995b). Beyond what the EA addressed, likely impacts at Par Pond would not vary among the alternatives considered in this EIS. A review of Par Pond and the interim action continue through the implementation of the Remedial Investigation/Feasibility Study process, which is required in accordance with the terms of the FFA, with field activities scheduled to begin during the first quarter of Fiscal Year 2004 (FFA, Appendix E). Section 4.3 describes the affected environment and impacts to Par Pond. TE

5.5.2.4 Natural Resource Damages

NEPA requires Federal agencies to consider the environmental impacts of an action during the planning and decisionmaking stages of a project. The RCRA/CERCLA process that DOE has implemented at the SRS specifically requires an ecological assessment during the baseline and alternatives risk assessment phase. This assessment can be a constructive link to the natural resource trustee process because the data generated for the RCRA/CERCLA study is also useful for determining injury and quantifying resource service reductions.

In addition to the NEPA requirement to identify any irreversible and irretrievable commitment of resources, DOE intends to identify such resources within the meaning of CERCLA [Section 107(f)(1)]. Timely considerations of Natural Resource Damage Assessment issues during the NEPA process can be important because Section 107 of CERCLA excludes liability for damages that result from a discharge or release "when the damages are specifically identified as an irreversible and irretrievable commitment of a natural resource in an environmental impact statement or other comparable environmental analysis."

The analyses in this EIS address the environmental impacts of alternative actions in accordance with CERCLA and NEPA. Section 4.8 identifies the irreversible and irretrievable commitments of resources that would occur under implementation of the Proposed Action.

5.6 Emergency Planning and Community Right-to-Know Act

5.6.1 REQUIREMENTS

The Emergency Planning and Community Right-to-Know Act of 1986 (42 USC 11001 *et seq.*) requires emergency planning including notification to communities and government agencies of the presence and release of specific chemicals. EPA implements the Act (40 CFR 355, 370, and 372). Under Subtitle A, Federal facilities, including those that DOE owns, must provide a variety of information (such as inventories of specific chemicals used or stored and releases that occur from these facilities) to state emergency response commissions and local emergency planning committees to ensure that emergency plans are ready to respond to accidental releases of hazardous substances.

Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," requires Federal facilities to comply with the Act.

5.6.2 STATUS

Each year, DOE submits hazardous chemical inventory and toxic release inventory reports to SCDHEC and to local emergency planning committees in Aiken, Allendale, and Barnwell Counties. The alternatives in this EIS would not result in changes to chemical inventories or the use of toxic chemicals; therefore, DOE anticipates no changes in the hazardous chemical inventory and toxic release inventory reports.

5.7 Clean Water Act

5.7.1 REQUIREMENTS

The objectives of the Clean Water Act are to restore and maintain the chemical, physical, and biological integrity of the nation's waterways. This Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 requires the branches of the Federal government to comply with Federal, state, interstate, and local requirements. In addition to setting water quality standards for the nation's waterways, the Act establishes guidelines and limitations for discharges from point sources, and a permitting program for these sources known as the

National Pollutant Discharge Elimination System (NPDES; 40 CFR 122 *et seq*.).

EPA has overall responsibility for enforcing the Clean Water Act but has delegated to SCDHEC primary enforcement authority for waters in South Carolina. Under the South Carolina Pollution Control Act, SCDHEC operates a permitting program (R.61-9, "The National Pollutant Discharge Elimination System"). The Clean Water Act and implementing regulations apply to naturally occurring and accelerator-produced radioisotopes. However, they do not apply to source, by-product, or special nuclear material as defined by the Atomic Energy Act. DOE discharges containing radioactive materials that are not source, by-product, or special nuclear material would be regulated by Clean Water Act programs.

South Carolina classifies all SRS waters as "freshwaters" (R.61-68). Water quality standards for this classification [R.61-68.G(3)] indicate that these waters are "suitable for fishing and the survival and propagation of a balanced indigenous aquatic community." In addition, SCDHEC antidegradation rules (R.61-68.D) state that "the stream flows necessary to protect classified and existing uses and water quality supporting these uses shall be maintained consistent with riparian rights to reasonable use of water."

Lower Three Runs Creek is a State-designated navigable water below Par Pond Dam. The U.S. Army Corps of Engineers (USACE) and SCDHEC administer permits for construction in such waters. USACE also issues permits under Section 404 of the Clean Water Act for the discharge of dredged or fill material into navigable waters. Under Section 401 of the Clean Water Act, applicants for a permit for an activity that may result in a discharge to navigable waters must receive certification from SCDHEC that applicable State water quality standards will not be violated. | TE

DOE has sought the assistance of the Federal Energy Regulatory Commission (FERC) in the implementation of the Federal Guidelines for Dam Safety. FERC performs inspections on dam structures at DOE facilities, including the Par Pond and L-Lake Dams, to fulfill the Department's responsibility for dam safety.

In 1996 SCDHEC issued NPDES permit Number SC0000175 (SCDHEC 1996c), which addresses the outfalls associated with the River Water System (Table 5-2).

Table 5-2. National Pollutant Discharge Elimination System Permit Number SC0000175 outfalls.

Reactor	Outfall	Receiving water body
C-Reactor	C-4	Fourmile Branch
K-Reactor	K-18	Indian Grave Branch of Pen Branch
L-Reactor	L-07	L-Lake
P-Reactor	P-19	Par Pond

These outfalls accept discharges, if any, from the River Water System. The K- and L-Area outfalls also receive sanitary wastewater effluents from the reactor areas. DOE can divert the flow from outfall P-19 to outfall P-13, which also receives the sanitary wastewater effluent from P-Area, and discharge to the headwaters of Steel Creek above L-Lake. The SRS is in compliance with NPDES permit requirements for these outfalls.

5.7.2 STATUS

The following sections present pertinent information on the compliance status of the alternatives considered in this EIS.

5.7.2.1 <u>No Action</u>

Small sanitary wastewater treatment plants in K- and P-Areas discharge through NPDES outfalls to the headwaters of Indian Grave Branch and Steel Creek, respectively. DOE has evaluated alternatives to resolve the compliance issues, if any, that would occur at these NPDES-permitted outfalls if DOE selected the No-Action Alternative (the small pump would continue to supply river water to L-Area, but the pumping of river water to K- and P-Areas would stop).

5.7.2.2 Shut Down and Deactivate

Navigable Waters Requirements

DOE has consulted with the USACE on the proposed shutdown of the River Water System and potential impacts from the drawdown of L-Lake. USACE solicited comments on the DOE proposal from relevant State and Federal permitting and natural resource agencies, and received none. Therefore, USACE concluded that no restoration or other remedial action in relation to L-Lake would be necessary (Veal 1996).

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DOE also consulted with the FERC on requirements related to the L-Lake Dam as a result of the proposed shutdown of the River Water System. FERC indicated that DOE must continue to maintain the dam after the drawdown in the same manner as if the lake was still in place; therefore, this alternative includes these activities. Ongoing maintenance activities would include ensuring that the dam gates do not become obstructed with debris in a way that could cause refill of the reservoir (Jones 1996b).

NPDES Permit Requirements

A small sanitary wastewater treatment plant in L-Area discharges through an NPDES outfall to L-Lake. Preliminary calculations indicate that the effluent from the L-Area sanitary wastewater treatment plant would not be able to meet the SCDHEC standards for water quality without blending from other area effluents such as river water flows. DOE has prepared a study that presents three options (using septic tanks and tile fields, using spray fields, and tying into the existing central system) and an approximate cost for treating the L-Area sanitary wastewater (Huffines 1996b). If DOE selected a shutdown alternative, it would evaluate in detail the cost impacts of alternative methods to address compliance for the L-Area sanitary wastewater treatment effluent (see Section 4.1.2.2.2).

DOE would obtain any required permits (e.g., for septic tank installation) to implement the selected method for treating the L-Area sanitary wastewater.

5.7.2.3 Shut Down and Maintain

Compliance status and issues under this alternative would be the same as those described in Section 5.7.2.2, assuming the layup scheme selected does not include continued operation of the small pump.

5.8 Safe Drinking Water Act

5.8.1 REQUIREMENTS

The Safe Drinking Water Act protects the quality of public water supplies and other sources of drinking water. It establishes drinking water quality standards that must be met. The Act and Executive Order 12088 direct Federal facilities to comply with the Safe Drinking Water Act. EPA has promulgated regulations implementing the Safe Drinking Water Act (40 CFR 100-149), and has delegated primary enforcement authority to SCDHEC for public water systems in South Carolina. Under the authority of the South Carolina Safe Drinking Water Act, SCDHEC has established a drinking water regulatory program.

The regulations specify that the average annual concentration of manmade radionuclides in drinking water delivered to the user shall not produce a dose equivalent greater than 4 millirem per year of beta-gamma radioactivity.

5.8.2 STATUS

DOE does not expect impacts from radiological releases to downstream water users or SRS drinking water systems under the alternatives it considers in this EIS. These water supplies would continue to conform to Federal drinking water standards.

5.9 Clean Air Act

5.9.1 REQUIREMENTS

The Clean Air Act establishes a national program to protect air quality and regulates sources of air pollution. Requirements include permits, emissions and operating standards, and monitoring. The Act is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Act and Executive Order 12088 require each Federal agency with jurisdiction over property or facility that might result in the discharge of air pollutants to comply with "all federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires EPA to:

- Establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated effect of a regulated pollutant
- Establish national standards of performance for new or modified stationary sources or air pollutants (42 USC 7411)
- Evaluate specific emissions increases to prevent significant deterioration in air quality

The Government regulates hazardous air pollutants, including radionuclides, separately. Air emissions are regulated in 40 CFR 50-99, and radionuclide emissions are regulated under the National Emission Standards for Hazardous Air Pollutants program (40 CFR 61).

EPA has overall authority for the Clean Air Act, but it can delegate primary authority to the states. In South Carolina, EPA has retained authority over DOE radionuclide emissions (40 CFR 61) and has delegated to SCDHEC the responsibility for the rest of the regulated pollutants and other requirements. Under the authority of the South Carolina Pollution Control Act, SCDHEC established the State's air pollution control program.

5.9.2 STATUS

The SCDHEC Bureau of Air Quality Control issues operating permits and performs Prevention of Significant Deterioration reviews. None of the alternatives in this EIS would require new SCDHEC operating permits or modifications to existing permits for facilities associated with the River Water System. No EPA approvals for radionuclide emissions would be required.

The Clean Air Act, as amended in 1990, requires Federal actions to conform to any State implementation plan approved or promulgated under Section 110 of the Act. The Final Rule (40 CFR 51 Subpart W) provides regulatory guidelines and *de minimis* levels. The guidelines specify requirements for conformity analyses. However, Federal actions that do not contribute pollutants above the specified *de minimis* levels are exempt from conformity analysis requirements. Emissions resulting from the alternatives considered in this EIS would be less than the *de minimis* levels. Therefore, these actions would be exempt from conformity analysis.

Toxic air pollutant emissions resulting from the alternatives in this EIS would remain in compliance with the South Carolina Standard 8 regulations (R.61-62).

The SRS operates within the EPA limits for the regulation of airborne radionuclides (40 CFR 61). Airborne releases from contaminated sediments exposed as a result of the alternatives in this EIS would remain in compliance with these limits.

5.10 Endangered Species Act and Related Statutes

5.10.1 REQUIREMENTS

The Endangered Species Act is intended to prevent the further decline of endangered and threatened species and to restore such species and their habitats. This Act also promotes biodiversity of genes, communities, and ecosystems. The U.S. Department of Commerce (National Marine Fisheries Service) and U.S. Department of the Interior (Fish and Wildlife Service) administer the Act jointly. Section 7 of the Act requires Federal agencies to consult with the National Marine Fisheries Service or the Fish and Wildlife Service, as appropriate, to ensure that any action they authorize, fund, or perform is not likely to jeopardize the continued existence of an endangered species or to result in the destruction or adverse modification of critical habitat of such species unless the agency receives an exemption in accordance with Section 7(h).

The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying things such as the mode of harvest, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill...any migratory bird." Although no permit for this project is required under the Act, DOE is required to consult with the Fish and Wildlife Service regarding impacts to migratory birds to evaluate ways to avoid or minimize these effects in accordance with the Fish and Wildlife Service Mitigation Policy (DOI 1981).

Several other statutes (Fish and Wildlife Coordination Act, Anadromous Fish Conservation Act, Bald Eagle Protection Act, and South Carolina Nongame and Endangered Species Conservation Act) require Federal and state agencies to consider the impacts of their actions on biological resources.

5.10.2 STATUS

DOE directed the preparation of a biological assessment (LeMaster 1996) to evaluate the effects of the proposed actions related to the River Water System on several Federally protected species (bald eagle, wood stork, American alligator, and the shortnose sturgeon). DOE has initiated formal consultation with the Fish and Wildlife Service and National Marine Fisheries Service concerning the impacts of the Proposed Action.

5.11 Executive Orders 11990 and 11988

5.11.1 REQUIREMENTS

Executive Order 11990, "Protection of Wetlands," requires Federal agencies to avoid short- and long-term adverse impacts to wetlands if a practicable alternative exists. Executive Order 11988, "Floodplain Management," directs Federal agencies to establish procedures to ensure that they consider potential effects of flood hazards and floodplain management for any action undertaken. Agencies are to avoid impacts to floodplains to the extent practicable. DOE regulations (10 CFR 1022) establish procedures for compliance with these Executive Orders.

5.11.2 STATUS

Sections 4.1.5, 4.2.5, and 4.3.5 contain the floodplain/wetland assessment required by DOE regulations (10 CFR 1022.12). In addition, these regulations require DOE to design or modify its actions to minimize potential harm to wetlands or in floodplains (10 CFR 1022.15). DOE policy is to preserve and protect SRS wetland resources in accordance with the national goal of "no net loss" of wetlands. DOE would implement the necessary mitigation measures to achieve this goal under the alternatives considered in this EIS.

5.12 Executive Order 12898

5.12.1 REQUIREMENTS

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority and Low-Income Populations," requires each Federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental effects of its programs, policies, or activities on minority populations and low-income populations."

5.12.2 STATUS

This EIS incorporates environmental justice in its analyses of the alternatives.

5.13 Cultural Resource Statutes

5.13.1 REQUIREMENTS

Cultural resources on the SRS are subject to the American Indian Religious Freedom Act (AIRFA) of 1978 (42 USC 1996), the Native American Graves Protection and Repatriation Act (25 USC 3001), and the National Historic Preservation Act (16 USC 470 *et seq.*). AIRFA reaffirms Native American religious freedom under the First Amendment and protects and preserves the right of American Indians to believe, express, and exercise their traditional religions. The Act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of those religions. The Native American Graves Protection and Repatriation Act of 1990 directs the Secretary of the Interior to promote repatriation of Federal archaeological collections that are culturally affiliated with Native American tribes and such collections held by museums that receive Federal funds. These Acts require DOE to notify affected tribes of the discovery of sites or items of religious importance or human remains and other objects belonging to Native Americans. DOE has committed to provide copies of environmental impact documents related to its activities in the Central Savannah River Valley to the Yuchi Tribal Organization, Inc., the National Council of the Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy.

The National Historic Preservation Act, as amended, enables the placement of sites with significant historic value on the National Register of Historic Places. The Act requires no permits or certifications. However, if a Federal activity could impact a historic property, consultation with the Advisory Council on Historic Preservation must take place and will usually lead to a Memorandum of Agreement with stipulations that the agency must follow to minimize adverse impacts. Coordination with the State Historic Preservation Officer ensures the proper identification of potentially significant resources and the implementation of appropriate mitigation actions.

5.13.2 STATUS

A February 1981 archeological and historic survey of the Steel Creek terrace and floodplain system revealed five sites that were nominated to the National Register of Historic Places (i.e., important and worthy of preservation from adverse effects). DOE submitted the survey report to the South Carolina State Historic Preservation Officer, which conducted a site visit in March 1982 and subsequently concurred with DOE that the proposed L-Reactor restart would not affect the sites. DOE developed and implemented a monitoring plan to protect the sites, and initiated reconsultation with the State Historic Preservation Officer on the mitigation of new sites of historic significance that L-Lake might inundate or that additional surveys of the lake might discover (DOE 1984).

DOE does not expect activities performed under the alternatives in this EIS to cause impacts to cultural resources because initial construction in the affected areas would have destroyed important resources. DOE would mitigate impacts to cultural resources that might be discovered through avoidance or data recovery.

CHAPTER 6. REFERENCES

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APPENDIX A. INVESTIGATION AND POTENTIAL REMEDIAL ACTIONS FOR L-LAKE

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APPENDIX A. INVESTIGATION AND POTENTIAL REMEDIAL ACTIONS FOR L-LAKE

As discussed in Section 1.1, the U.S. Department of Energy (DOE) views potential future remedial actions regarding L-Lake and actions it might take in the near term regarding operation of the River Water System to be connected actions. The purpose of this environmental impact statement (EIS) is to assist DOE in making a decision in 1997 on the operation of the River Water System that could change the current status of L-Lake with respect to such parameters as water levels and associated potential risks from exposure to contaminated lakebed sediments.

DOE has initiated discussions with EPA and SCDHEC to ensure appropriate consistency and coordination is maintained between this operation decision and remedial decisions for L-Lake. L10-04 Remedial decisions for the lake will be in accordance with the process set forth in the Federal Facility Agreement (FFA; EPA 1993), which provides the appropriate framework for planning site remediations. L10-04

The DOE Office of National Environmental Policy Act (NEPA) Policy and Assistance has provided recommendations regarding the appropriate way to address such connected actions in its NEPA documents (DOE 1993). In accordance with these recommendations, DOE describes in this EIS (Section 4.5) the cumulative impacts of the Proposed Action and potential remedial actions regarding L-Lake that could result from the FFA process, but is deferring any analysis of remedial action alternatives until they are ready for consideration.

This appendix supports the cumulative impacts discussion in Section 4.5 by describing potential future remedial actions that DOE could take under the FFA with respect to L-Lake.

A.1 Current and Potential Future Status of L-Lake Under the Federal Facility Agreement

As discussed in Section 5.5, DOE has entered into an FFA with the U.S. Environmental Protection Agency (EPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) in accordance with Section 120 of the Comprehensive Environmental Response, TE Compensation, and Liability Act (CERCLA). This agreement establishes the process DOE uses to evaluate actually or potentially contaminated sites at the Savannah River Site (SRS) and, if necessary, to remediate contaminated sites with appropriate consideration of the potential risks they pose to human health and the environment.

In general, newly discovered sites and other sites that merit preliminary evaluation are designated as Site Evaluation units and are listed in Appendix G.1 of the FFA. These sites receive formal site evaluations that rely primarily on existing and available information; field investigations conducted during this phase are normally limited in scope. Results of a site evaluation can provide the basis for no further action, near-term actions to reduce or eliminate an actual or potential threat (i.e., a removal action), or a decision to list the unit in Appendix C of the FFA for further evaluation. L-Lake is currently listed as a Site Evaluation unit in Appendix G.1 of the FFA.

Sites listed in Appendix C, called Resource Conservation and Recovery Act (RCRA)/CERCLA units, are subject to the remedial action process established in the FFA. This process generally includes detailed RCRA Facility Investigation/Remedial Investigation (RFI/RI) studies to determine the nature and extent of contamination, a baseline risk assessment to determine the risk posed by the contamination and, if necessary, remedial actions selected on the basis of a formal Corrective Measures Study/Feasibility Study (CMS/FS), which includes a rigorous alternatives analysis. Public comments on the proposed remedial alternative will be facilitated with a Statement of Basis/Proposed Plan. The RCRA permit modification and Record of Decision provide the final documentation of the selection of remedial alternative and response to public comment.

The RCRA/CERCLA units listed in Appendix C of the FFA include contaminated stream systems on the SRS. These systems are termed Integrator Operable Units (IOUs) in recognition of the need to consider multiple sources of contamination in their watersheds as part of the remedial action process for these streams. In view of this peculiarity, the scope of the remedial action strategy for an IOU is more similar in scope to a long-term site evaluation than the traditional remedial action process applied to individual RCRA/CERCLA units, as described above. The Steel Creek stream channel and floodplain above, below, and beneath the L-Lake impoundment are among the IOUs listed in Appendix C. Investigations to determine the nature and extent of contamination and studies to determine appropriate remedial actions for the Steel Creek watershed will be conducted in accordance with the FFA.

DOE had originally planned to complete a Site Evaluation Report for L-Lake by December 1996. This report was being prepared in accordance with the FFA to determine the need for additional future investigations and identify any removal actions that may be appropriate for this unit and to help determine the appropriate relationship of this unit to the Steel Creek IOU. However, in response to EPA's comments on the Draft EIS, DOE believes that sufficient information is presented in this Appendix to accomplish these objectives without completing the final Site Evaluation Report.

Existing information indicates that the stream channel and floodplain of Steel Creek upstream, downstream, and within L-Lake are contaminated by radionuclides, primarily cesium-137 but also cobalt-60, as a result of discharges from reactor operations before the construction of the impoundment. In some locations, low level of this contamination extends to lakebed sediments beyond the original stream channel and floodplain. If DOE implements the Proposed Action considered in this EIS, L-Lake would be dewatered, ultimately restoring Steel Creek and its floodplain to conditions similar to those existing before its impoundment and exposing these contaminated sediments.

As noted above, DOE believes that sufficient information to make ultimate remedial decisions for L-Lake will not be available until required studies under the FFA are complete. Therefore, DOE undertook a specific study (PRC 1996, 1997a, 1997b, 1997c) to identify and evaluate the likely range of remedial action alternatives that it might ultimately consider under the FFA. A particular objective of the study is to make a preliminary estimate of potential remediation costs for various alternatives to control risks from exposure to contaminated sediments within the lake exclusive of the Steel Creek stream channel and floodplain. (DOE would evaluate and, if appropriate, propose remediation of the stream channel and floodplain as part of the Steel Creek IOU.) The remedial alternatives study, which was conducted to help guide DOE economic decisions associated with the River Water System in the near term, is summarized in Section A.2, based on the initial study report (PRC 1996) and subsequent analysis revisions (PRC 1997a, 1997b, 1997c).

A.2 Range of Remedial Options for L-Lake

The DOE study of potential remedial options and associated costs for L-Lake (PRC 1996, 1997a, 1997b, 1997c) uses historic process knowledge about contaminant release mechanisms and L-Lake development, and results of past and ongoing sampling activities to estimate the nature and extent of contamination in lake sediments. Remedial goal options (RGOs), expressed as sediment contaminant concentrations corresponding to target risk levels, were established using hypothetical exposure scenarios. Based on this information, spatial distribution of contamination in lake bottom sediments above RGOs was delineated. Finally, remedial action options likely to be able to meet preliminary remedial action goals were identified and evaluated with respect to cost and other relevant factors, as described in Section A.2.4. The following subsections summarize these elements of the study. TE

A.2.1 GENERAL NATURE AND EXTENT OF L-LAKE SEDIMENT CONTAMINATION

Detailed information on the nature and extent of contamination to support final remedial decisions will be developed in the context of the FFA. However, sufficient information is available from historic process knowledge and from past and ongoing sampling activities to examine a range of potential remedial options for L-Lake. This information indicates that the contaminants of most concern in the lake sediments are radionuclides, particularly cesium-137 and to a lesser extent cobalt-60, which are the focus of the potential remedial options study (PRC 1996, 1997a, 1997b). TE

Radionuclide contamination of Steel Creek is primarily from purge water discharges from disassembly basins containing fuel elements at P-Reactor and L-Reactor before this practice was discontinued in the early 1970s (DOE 1984). TE The large flow of the cooling water discharge containing the purge water raised the stream level consistent with the floodplain, so contaminants from the purge water tended to be deposited in both the stream channel and the floodplain. Radioactivity release reports suggest that most of these contaminant releases occurred before 1971; only minimal releases have occurred since the formation of L-Lake in 1985. TE Cesium-137 has a strong affinity for sediments, so the majority of this contaminant was adsorbed or deposited in the sediments of the 11.2-mile (18.0-kilometer) Steel Creek system before reaching the Savannah River. Based on DOE sponsored studies cited by PRC (1996), the estimated cesium-137 inventory in the entire creek system from upstream of L-Reactor to the Savannah River, including L-Lake, is 58 curies (decay corrected to 1996).

DOE has conducted extensive investigations of the L-Lake vicinity using a variety of sampling and analysis techniques. Data from a preimpoundment aerial radiological survey of the L-Lake vicinity conducted in 1985 indicated that the contamination zone for cesium-137 and cobalt-60 corresponded to the historic stream channel and floodplain. Another aerial radiological survey conducted in 1986 after the impoundment of L-Lake indicated only minor changes from the previous year in the spatial distribution of these contaminants upstream and downstream from L-Lake. This technique could not obtain data for submerged areas of L-Lake.

DOE conducted underwater gamma surveys in 1995 and 1996 to identify any post-impoundment changes in the distribution of manmade radiation levels in L-Lake. The 1995 study included *in situ* measurements from 96 locations on the lake bottom and laboratory analysis results from sediment samples from 20 locations. The 1996 study involved the use of approximately 195 *in situ* measurement locations and 76 sediment sample locations. The results from these surveys indicted no major change in manmade radionuclide distributions since radiological mapping of the lake basin in 1985, though minor differences are apparent.

Additional samples of lake bottom sediments were obtained and analyzed in 1995 and 1996. Analytical results for samples obtained in 1995, consisting of sediment samples from eight locations including the submerged stream channel and floodplain, indicate that organic contaminants are well below EPA Region IV risk-based concentrations used as screening levels at the SRS.

L9-16 In the summer of 1996 surface sediment samples (0 to 1 foot) (0 to 0.3 meter) were collected from approximately 45 locations in the lake (including the stream channel and floodplain) and 13 background locations for analysis of toxic metals, gross alpha, nonvolatile beta, gamma pulse height analysis, plutonium-alpha series, and uranium-alpha series (Phase 1 sampling). Analysis of validated data from this sampling effort indicates that low concentrations of radionuclide contamination are present in the lakebed outside of the original stream channel and floodplain (PRC 1996, 1997b). Analysis of these data also indicates that some toxic metals are present at low concentrations in the lake. Later in 1996, DOE collected lake sediment core samples from additional 22 selected locations in L-Lake (Phase 2 sampling).

TC DOE used analytical results from the summer of 1996 sampling to identify areas of the lake bottom that could present a risk above target levels under assumed exposure scenarios. The results were used in combination with the 1996 underwater gamma survey data as the basis for the potential remedial options study (PRC 1996). L9-19 Subsequent analyses reported by PRC (1997a, 1997b, 1997c) also used validated radionuclide analysis results from the 0 to 1 foot (0 to 0.3 meter) level in cores obtained during the Phase 2 sampling. The updated options analysis based on these analyses is summarized in this appendix. The location of data points in L-Lake upon which the study is based are shown in Figure A-1.

A.2.2 PRELIMINARY REMEDIAL GOAL OPTIONS AND SCREENING VALUES

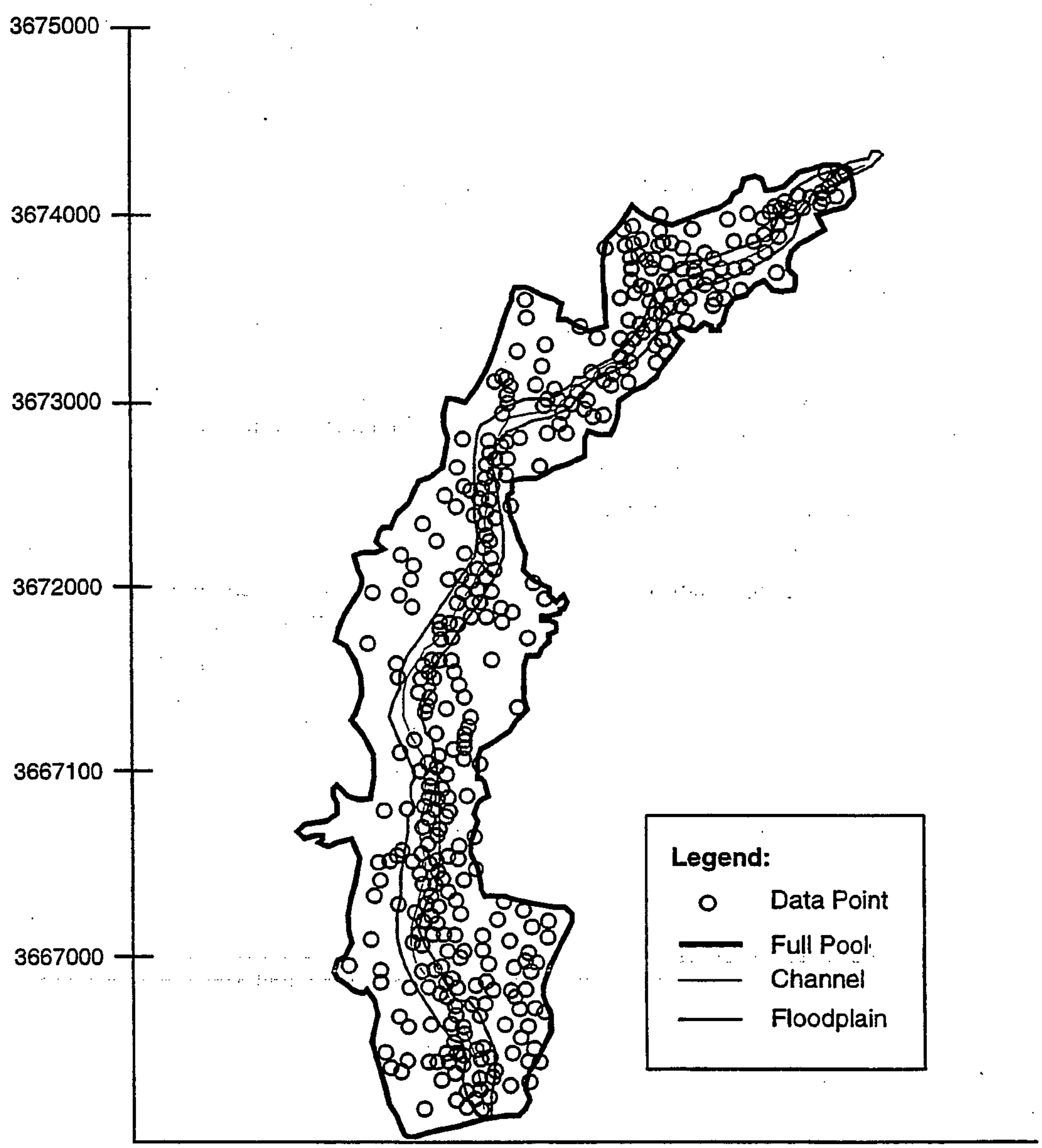
For comparison purposes, the potential remedial options study considered two exposure scenarios, current/future onsite worker and hypothetical future resident. Screening values for sediment contaminant concentrations were derived for each scenario.

TE For the Draft EIS, DOE developed the onsite worker exposure scenario and associated exposure parameter values using the information from EPA's Hazardous Waste Remedial Action Program (HAZWRAP 1996) with input from the Savannah River Technology Center (SRTC) at the SRS. DOE used best professional judgment, knowledge of the types of activities that occur at the SRS, and the likely parameters these activities would generate in place of standard EPA default values (i.e., EPA 1991).

TC This onsite worker exposure scenario was revised for the Final EIS to reflect a more realistic exposure assessment for an environmental researcher or sampler than that reflected in HAZWRAP (1996). The current scenario assumes that an environmental researcher or sampler is present in the L-Lake vicinity for 5 years, 15 weeks per year, and 6 hours per week. This scenario is consistent with that used in Section 4.1.8.2 of this EIS.

Exposure routes considered for the onsite worker scenario were inhalation of resuspended particulates from dried lake basin sediments and ingestion, dermal exposure, and external exposure attributable to direct contact with soil and sediment in the lake basin.

The screening values for the hypothetical onsite resident exposure scenario were determined using risk-based assessment methods developed by the EPA. The scenario assumes a human population living and working in the contaminated area for as long as 30 years. Exposure assumptions include incidental soil ingestion, direct radiation, and inhalation of contaminated particulates.



Source: PRC (1997b)

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Figure A-1. Data points used for L-Lake remedial options analysis.

Screening values for both cesium-137 and cobalt-60 were derived from these risk analyses for each scenario at two risk levels: 10^{-4} (i.e., one additional estimated cancer per 10,000 exposed persons) and 10^{-6} (i.e., one additional estimated cancer per 1 million exposed persons). These screening values, listed in Table A-1, do not take credit for radioactive decay or a period of institutional control (i.e., uncontrolled exposure is assumed to begin immediately). These are conservative assumptions considering DOE's anticipated nonresidential use of the site and the half-life of these radionuclides (30 years for cesium-137 and 5.24 years for cobalt-60).

Overall, these screening values are conservative (i.e., low). This conservatism is particularly indicated by the screening concentration for cesium-137 corresponding to the 10^{-6} risk level for the residential scenario (0.02 picocurie per gram), which is well below the average concentration of 0.09 picocurie per gram observed in the 13 background soil samples obtained in the summer of 1996.

Assuming a 30-year period of institutional control and accounting for radioactive decay would increase the screening values in Table A-1 by a factor of 2.7 for cesium-137 and a factor of 200 for cobalt-60. However, DOE used the lower values for this remedial options analysis because EPA Region IV and SCDHEC have not endorsed the use of radiological decay and institutional control in risk analyses performed under the FFA. For similar reasons, DOE did not establish screening values for this remedial options analysis based on its current SRS worker limits (700 millirem per year) and limits to the general public (100 millirem per year), or a 15-millirem-per-year cleanup standard for unrestricted (i.e., residential) use being considered by DOE and EPA, all of which would result in higher screening values and less stringent cleanup goals.

Only those screening values listed in bold type in Table A-1 were selected as preliminary RGOs for the options analysis (PRC 1996). DOE dropped cobalt-60 values because sampling data indicate that cobalt-60, where it exceeds screening values, is colocated with cesium-137 in excess of screening values, and cesium-137 has a longer half-life than cobalt-60 (30 years versus 5.24 years). Similarly, the use of cesium-137 screening values was assumed to adequately accommodate the low levels of toxic metals that exist in lake sediments based on analysis of validated data observed in the lake; no organic contaminants have been noted above screening levels (Section A.2.1). Cesium-137 was thus considered to be the primary "risk driver" for the analysis.

Table A-1. Risk-based screening values for cesium-137 and cobalt-60 in L-Lake sediments.

	Sediment concentration (picocuries per gram)[a]			
	Onsite worker scenario		Future onsite resident scenario	
Contaminant	Risk = 10^{-4}	Risk = 10^{-6}	Risk = 10^{-4}	Risk = 10^{-6}
Cesium-137	**930**	**9.3**	**2.1**	**0.021**
Cobalt-60	100	2.7	0.48	0.0048

a. Values in bold denote remedial goal options.

A.2.3 DELINEATION OF CONTAMINATION ZONES CORRESPONDING TO REMEDIAL GOAL OPTIONS

Assuming that some form of action or remediation would be required if a cesium-137 RGO was exceeded, areas of lake-bottom sediment contamination corresponding to the four selected RGO values (i.e., bold values in Table A-1) were delineated on the basis of sampling and survey data as described in Section A.2.1. Figure A-2 shows the results. As shown, no cesium-137 sediment concentrations exceeded 930 picocuries per gram, indicating that no remedial action would be necessary under an onsite worker scenario at the 10^{-4} risk level. Similarly, the analysis indicates that only a very small area (perhaps 1 acre) outside of the Steel Creek channel and floodplain may require remediation, assuming the onsite worker scenario at the 10^{-6} risk level. TC

At the other extreme, approximately 750 acres (3.0 square kilometers) comprised of virtually all the lake bottom except the area occupied by the inundated Steel Creek channel and floodplain would require remediation to protect onsite residents at the 10^{-6} risk level. This would not be a realistic option, since background concentrations are above the 10^{-6} risk level as well. TC

For the intermediate scenario, which assumes protection of future residents at the 10^{-4} risk level, an estimated 170 acres (0.69 square kilometer) of the lake bottom, except the currently inundated stream channel and floodplain, would require remediation (Figure A-2). TC

The inundated stream channel and floodplain, which occupies about 170 acres (0.69 square kilometer) of the lake bottom, is not part of the area considered for the remedial options analysis (PRC 1996) because corresponding areas above, below, and beneath L-Lake exhibit radiological contamination above risk-based screening levels and are part of the Steel Creek watershed IOU. In addition, any remedial actions determined under the FFA for the Steel Creek IOU would necessarily include that portion of the creek and floodplain currently occupied by L-Lake.

A.2.4 DESCRIPTION OF REMEDIAL OPTIONS

DOE evaluated four remedial options for areas of the former lake bottom considered to be contaminated under the risk scenarios considered in the analysis, as follows:

- Option 1 - No Action
- Option 2 - Institutional Control
- Option 3 - Soil Cover
- Option 4 - Excavation and Disposal of Contaminated Soil TE

These options were the most reasonable within the range of possible alternatives based on professional judgment, knowledge of SRS activities, and prior experience obtained as a result of detailed feasibility studies completed for two SRS waste sites where similar remedial alternatives were considered.

No-Action Option TE

Under the no-action remedial option, DOE would take no action to address contamination of exposed L-Lake sediments; to monitor, remove, treat, or otherwise mitigate this contamination under any of the identified risk scenarios; or to minimize the threat or potential threat to human health and the environment.

Institutional Control Option TE

The institutional controls determined to be most applicable to areas of contaminated sediments exposed in L-Lake and thus assumed for the alternatives analysis consist of existing SRS access controls to maintain the SRS industrial use; deed notifications and, if appropriate, deed restrictions in the event the property is transferred to non-Federal ownership; and posting of warning signs. It was assumed that during the

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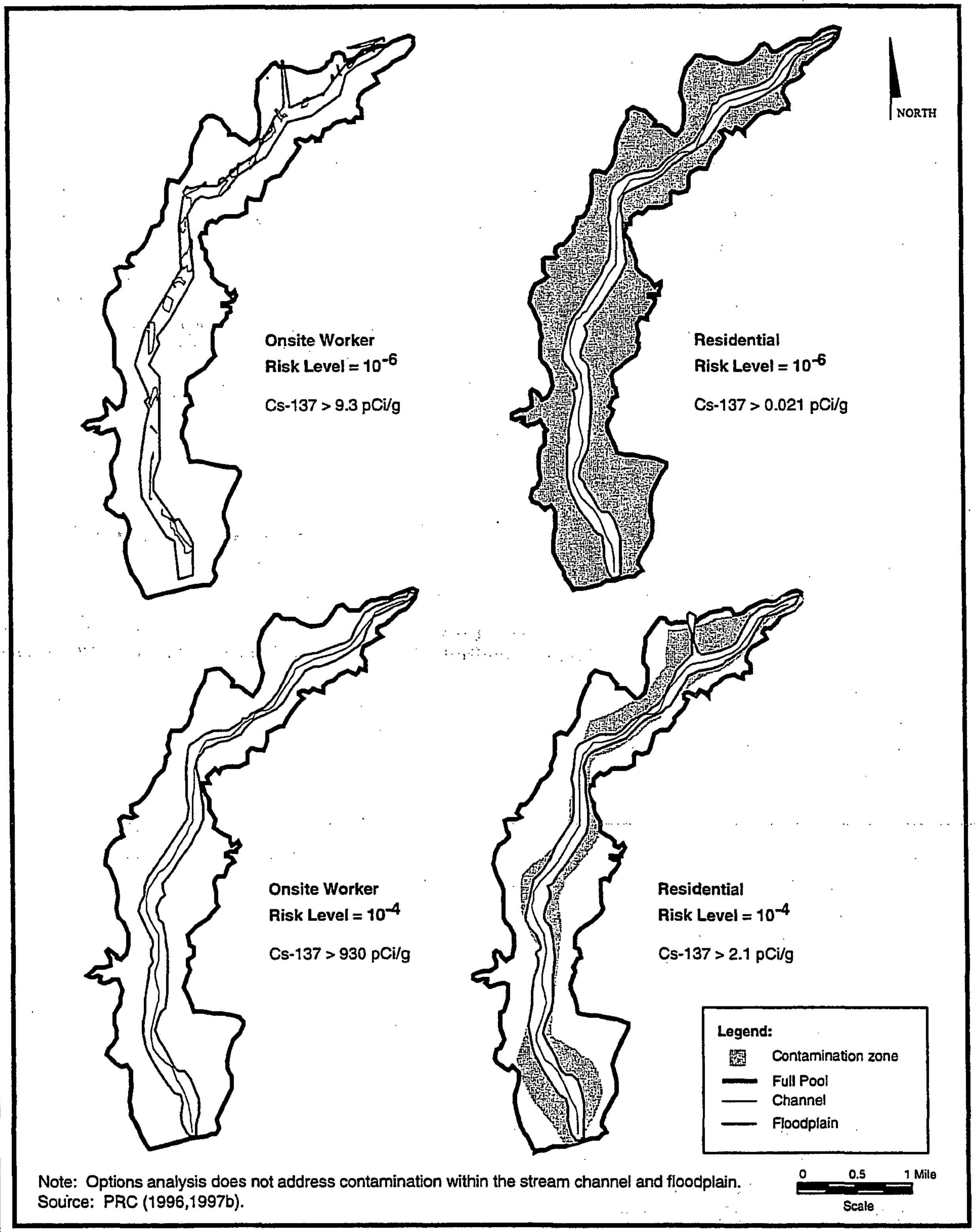

Figure A-2. Assumed contamination zones for L-Lake remedial options analysis.

period of DOE control, such existing access controls as barriers, fences, and controlled areas would be used to maintain the SRS for industrial use. If the property is transferred to non-Federal ownership, the U.S. Government would, in accordance with CERCLA Section 120(h), create a deed that includes notification in perpetuity of the contamination. It was also assumed that a survey plat of L-Lake prepared by a professional land surveyor would be placed in the county records. In addition to the notification, a deed restriction to preclude residential use of the property may also be utilized when and if the area was to be transferred to private ownership. Warning signs would be posted at all roads intersecting the contaminated zone.

Soil Cover Option | TE

The soil cover option considered most appropriate for this site consists of a native soil cover; vegetative cover for erosion control; short-term institutional controls to limit worker exposure during drawdown and in the long term to ensure designated land use, prevent excavation and shallow wells, etc.; 30 years of inspection and maintenance; and reviews of the remedy with regulators at 5-year intervals for 30 years. The primary purpose of the barrier would be to limit exposure to gamma radiation associated with the radionuclide contaminants present. The extent and thickness of needed soil cover would depend on the scenario considered. None would be required for the onsite worker (10^{-4} risk) scenario. A 1-foot (0.3-meter) thick cover over approximately 1 acre (4,000 square meters) would be used for the worker (10^{-6} risk) scenario and a 4-foot (1.2-meter) thick cover over 750 acres (3.0 square kilometers) or 170 acres (0.69 square kilometers) would be used for the resident (10^{-6} risk) and resident (10^{-4} risk) scenarios, respectively. Deed notifications may be effected to restrict a small area to industrial use under the worker (10^{-6} risk) scenario and would be effected to prevent deep excavation and installation of shallow wells under both resident scenarios. | TC

Soil Excavation and Disposal Option | TC

The option of excavation and disposal of contaminated soil would involve the removal of contaminated soil with conventional earthmoving equipment to a depth of 2 feet (0.6 meter) over approximately 1 acre (4,000 square meters) for the onsite worker scenario at the 10^{-6} risk level, or 3 feet (0.9 meter) over 750 acres (3.0 square kilometers) or 170 acres (0.69 square kilometers) depending on the resident scenario analyzed (10^{-6} risk and 10^{-4} risk, respectively). | TC The assumptions for excavation depth are based on information collected during construction of the L-Lake Dam, which indicate that the approximate depth of the 1.1 picocuries per gram contour is 24 inches (61 centimeters) (PRC 1996). | TC Existing SRS disposal facilities are not designed to manage large quantities of contaminated soil; therefore, the analysis assumes that the contaminated soil would be disposed of at a licensed offsite facility (e.g., the Chemical Waste Management Facility, Emile, Alabama; the Envirocare Facility, Clive, Utah). Excavated areas would be filled with clean soil and revegetated.

A.2.5 EVALUATION OF REMEDIAL OPTIONS

DOE used methods similar to those that would be conducted in a CERCLA feasibility study under the FFA (see Section 5.5) to evaluate remedial options. DOE used the following six (of the nine) CERCLA criteria normally used for such evaluations:

- Overall protection of human health and the environment
- Cost
- Implementability
- Short-term effectiveness
- Long-term effectiveness
- Reduction of contaminant toxicity, mobility, and volume

Compliance with state and Federal regulations, one of the three criteria that was not used, was assumed to be achieved, or appropriate waivers obtained, regardless of the remedial action selected. The two remaining criteria, state agency acceptance and community acceptance, are modifying criteria in the development of a preferred alternative under the CERCLA process and were not considered appropriate to the NEPA remedial options analysis.

Results of the evaluation with respect to the six selected criteria are described below.

- No Action (Table A-2) – The no-action option is clearly the remedial option of choice

TC

with respect to the onsite worker (10^{-4} risk) scenario because none of the L-Lake sediment contamination exceeds the remedial goal option of 930 picocuries per gram. However, this option would not protect onsite workers at the 10^{-6} risk level, at least within a small area, or future residents at either the 10^{-4} or 10^{-6} risk levels because DOE would take no action to reduce risk posed by contaminated sediments. Existing radiological contamination is at levels that would result in doses significantly below the 1-rad-per-day threshold commonly cited for ecological receptors. As with all remedial options considered, no reduction of

Table A-2. L-Lake remedial options analysis evaluation criteria ratings for the no-action option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	Good – No contamination above 930 picocuries -per-gram RGO.[a]	Moderate – Not protective at 9.3-picocuries-per-gram RGO but in only a small area [approximately 1 acre (4,000 square meters)].	Poor – Not protective at 2.1-picocuries-per-gram RGO.	Poor - Not protective at 0.021-picocurie-per-gram RGO.
Cost	Good - No cost.	Good - No cost.	Good - No cost.	Good - No cost.
Implementability	Good - No active remediation needed.	Good - No active remediation.	Good - No active remediation.	Good - No active remediation.
TC Short-term effectiveness	Good - No risk above RGO.	Moderate - No short-term protection of workers at 9.3-picocuries-per-gram RGO, but in only a small area, and no construction activities and associated impacts.	Moderate - Existing land use controls limit access. No construction activities and associated impacts.	Moderate - Existing land use controls limit access. No construction activities and associated impacts.
Long-term effectiveness	Good - No risk above RGO.	Moderate - No effort to mitigate exposure to contaminated sediments, but they are confined to a small area, and natural decay would reduce radiological risk.	Poor - No effort to mitigate exposure to contaminated sediments, but natural decay would reduce radiological risk.	Poor - No effort to mitigate exposure to contaminated sediments, but natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA[b]	Poor - No active remediation.	Poor - No active remediation.	Poor - No active remediation.

a. RGO = Remedial goal option.
b. NA = Not applicable.

contaminant toxicity, mobility, or volume would be effected, but overall risk would be reduced by radioactive decay of the cesium-137 (half-life = 30 years), which would reach background levels in approximately 100 years.

Institutional Control (Table A-3) – Institutional control, consisting primarily of SRS security measures, sign postings, deed notifications and, if appropriate, restrictions, would be inexpensive and readily implemented under all scenarios. This remedial option is rated as having good effectiveness in the short term and as moderate with respect to long-term effectiveness and overall protection of human health under the onsite worker (10^{-6} risk) and both future resident scenarios. TC

Table A-3. L-Lake remedial options analysis evaluation criteria ratings for the institutional control option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	NA[a]	Moderate - If controls were not observed, risk to worker would exceed 10^{-6} for approximately 1 acre along the floodplain. Natural decay would reduce radiological risk.	Moderate - Land would be restricted to industrial use. Effective as long as warning signs and security measures are maintained and deed restrictions are enforced. If controls are not observed, risk to residents would exceed 10^{-4}. Natural decay would reduce radiological risk.	Moderate - Land would be restricted to industrial use. Effective as long as warning signs and security measures are maintained and deed restrictions are enforced. If controls are not observed, risk to residents would exceed 10^{-6}. Natural decay would reduce radiological risk. TC
Cost	NA	Good - $10,000 for sign placement and deed notification costs.	Good - $15,000 for sign placement and deed notification costs.	Good - $15,000 for sign placement and deed notification costs.
Implementability	NA	Good - No active remediation.	Good - No active remediation.	Good - No active remediation.
Short-term effectiveness	NA	Good - Worker exposure would be limited. No construction activities necessary for implementation.	Good - Land use controls would limit access. No construction activities necessary for implementation.	Good - Land use controls would limit access. No construction activities necessary for implementation. TC
Long-term effectiveness	NA	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.	Moderate - Effective as long as warning signs and security measures are maintained and land use controls are observed. Natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - No active remediation.	Poor - No active remediation.	Poor - No active remediation.

a. NA = Not applicable.

- Soil Cover (Table A-4) – This option is rated good in terms of overall protection of human health for both onsite workers (10^{-6} risk level) and future residents (10^{-4} and 10^{-6} risk levels) assuming cover is maintained and land use controls are observed. It would not be as readily implementable or as effective in the short-term under the 10^{-6} risk future resident scenario because of the additional soil cover required [1 foot versus 4 feet (0.3 meter versus 1.2 meters)] compared to the 10^{-6} risk worker scenario and the additional time required to install the cover [e.g., 1 year versus 5 years after the 10-year lake drawdown period (Jones and Lamarre 1994)]. This option would be expensive to implement for the future resident scenario (estimated costs of approximately $30 to $131 million, depending on risk level).

- Soil Excavation and Offsite Disposal (Table A-5) – This option is rated good in terms of overall protection of human health and the environment and long-term effectiveness for onsite worker (10^{-6} risk level) and future resident scenarios because all contaminated soils above the respective RGOs would be removed. However, short-term effectiveness is rated poor for both future resident scenarios because of the long construction periods required [13 years and 55 years based on the capability to move 180 cubic yards (138 cubic meters) per day (PRC 1996)], increased probability of worker injuries or fatalities, and adverse effects from the transportation of large amounts of contaminated soils to an offsite disposal facility.

  Implementability is rated good for the onsite worker (10^{-6} risk) but poor for the future resident scenarios, because of the large amount of soil excavation and disposal required. Cost for this alternative would be very high for either of the future resident scenarios ($380 million or $1.7 billion, depending on risk level).

A.2.6 CONCLUSIONS

The preliminary analysis summarized in Section A.2 indicates that remedial options to reduce risk posed by contaminated lakebed sediments above the Steel Creek stream channel and floodplain may range from no action to very intensive remediation involving removal and offsite disposal of contaminated soils.

Based on the evaluations presented in this analysis, DOE believes that institutional controls to prevent residential use of this area for a period that allows for natural radiological decay to safe levels may be the most reasonable option. No action may be necessary to protect workers at the 10^{-4} risk level. In addition, this preliminary analysis indicates that onsite worker exposure levels would be well below the current SRS occupational standard for radiation protection of 700 millirem per year, which corresponds to a cesium-137 concentration of approximately 1,962 picocuries per gram (compared to 9.3 picocuries per gram of cesium-137 for the onsite worker scenario at 10^{-6} risk). If the cleanup standard for unrestricted use (residential scenario) of 15 millirem per year proposed by EPA and DOE was promulgated, no remedial action for this area may be necessary. An annual effective dose equivalent of 15 millirem corresponds to approximately 9 picocuries per gram for cesium-137 and an average excess lifetime carcinogenic risk of approximately 3×10^{-4}. Moreover, natural decay would reduce cesium-137 to near background levels in 100 years.

Table A-4. L-Lake remedial options analysis evaluation criteria ratings for the soil cover option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health	NA[a]	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.	Good - Cover and observance of land use controls would prevent direct exposure. Natural decay would reduce radiological risk.
Cost	NA	Moderate - $100,000 cost of filling plus inspection and maintenance costs.	Poor - $29.7 million (29.6 million cubic feet at $1 per cubic foot plus inspection and maintenance costs).	Poor - $131 million (130.7 million cubic feet at $1 per cubic foot plus inspection and maintenance costs).
Implementability	NA	Good - Equipment and materials could be readily obtained. Cover could be installed in 1 year.	Moderate - Equipment and materials could be readily obtained but quantity of soil required would be very large and would require 1 year or more to install.	Moderate - Equipment and materials could be obtained readily, but quantity of soil required would be very large and would require as long as 5 years to install.
Short-term effectiveness	NA	Moderate - Reliance on institutional controls during drawdown period but contamination is limited to approximately 1 acre near floodplain. Protective equipment and other controls would be required to protect workers during construction period (less than 1 year).	Moderate - Reliance on institutional controls during drawdown period. Protective equipment and other controls would be required to protect workers during 1-year construction period.	Poor - Reliance on institutional controls during drawdown period. Protective equipment and other controls would be required to protect workers during 5-year construction period. TC
Long-term effectiveness	NA	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.	Moderate - Effective as long as land use controls are observed and cover is maintained. Natural decay would reduce radiological risk.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.	Poor - Airborne dust would be reduced, but no other reductions would be effected. However, natural decay would reduce cesium-137 concentrations to background in approximately 100 years.

a. NA = Not applicable.

Table A-5. L-Lake remedial options analysis evaluation criteria ratings for the soil excavation and off-site disposal option.

Evaluation criteria	Onsite worker (Risk = 10^{-4})	Onsite worker (Risk = 10^{-6})	Future resident (Risk = 10^{-4})	Future resident (Risk = 10^{-6})
Overall protection of human health and environment	NA[a]	Good - Complete protection of onsite worker after soils contaminated above 9.3 picocuries per gram of cesium-137 are removed and backfilling and regrading with clean soil was complete.	Good - Complete protection of onsite worker after soils contaminated above 2.1 picocuries per gram of cesium-137 are removed and backfilling and regrading with clean soil was complete.	Good - Complete protection of human health and environment after soils contaminated above approximate background concentrations of cesium-137 were removed and backfilling and regrading with clean soil was complete.
Cost	NA	Moderate - Approximately $1.4 million exclusive of transportation costs.	Poor - Approximately $380 million exclusive of transportation costs (22.2 million cubic feet at $0.80 per cubic foot for excavation, regrading, plus $16.30 per cubic foot for disposal; 7.4 million square feet at $0.20 per square foot for revegetation).	Poor - Approximately $1.7 billion exclusive of transportation costs (98 million cubic feet at $0.80 per cubic foot for excavation, regrading plus $16.30 per cubic foot for disposal; 32.7 million square foot at $0.20 per square foot for revegetation).
Implementability	NA	Good - Equipment and materials could be obtained but would take approximately 1 year to implement.	Moderate - Equipment and materials could be obtained but would take up to 13 years to implement.	Poor - Equipment and materials could be obtained readily, but quantity of soil required would be large and would require as long as 55 years to implement.
TC Short-term effectiveness	NA	Moderate - Requires institutional controls during drawdown period but contamination is limited to approximately 1 acre near floodplain. Protective equipment and other controls would be required to protect workers during 1-year construction period. Some risk to public and environment during transportation.	Poor - Requires institutional controls during drawdown period. Protective equipment and other controls would protect workers but likelihood of injury or fatality during 13-year construction period would be high. Some risk to public and environment during transportation.	Poor - Requires institutional controls during drawdown period. Protective equipment and other controls would protect workers but likelihood of injury or fatality during 55-year construction period would be high. Some risk to public and environment during transportation.
Long-term effectiveness	NA	Good - Contaminated materials above 9.3 picocuries per gram of cesium-137 would be removed and replaced by clean fill.	Good - Contaminated materials above 2.1 picocuries per gram of cesium-137 would be removed and replaced by clean fill.	Good - Contaminated materials above approximate background concentrations of cesium-137 would be removed and replaced by clean fill.
Reduction of contaminant toxicity, mobility, and volume	NA	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.	Poor - No treatment to reduce toxicity, mobility, or volume, although natural decay of cesium-137 would reduce concentrations to background in approximately 100 years.

a. NA = Not applicable.

A.3 Conclusions Regarding Potential Remedial Actions for L-Lake

Based on the preliminary options analysis summarized in Section A.2, institutional control or L10-04 possibly no action may be the most appropriate remedial option for areas of contaminated lake-bottom sediments above the stream channel and floodplain areas that would be eventually exposed if the lake was drained. Remediation options for the contaminated stream channel and floodplain currently submerged in the lake were not examined in the preliminary remedial options analysis, but would be considered as part of the Steel Creek IOU, which is similarly contaminated.

DOE recognizes that draining L-Lake under the alternatives it is considering in this EIS would change the nature but not the range of remedial options available for exposed contamination in TC the stream channel, floodplain, and other lake bottom areas from those currently available (i.e., with the lake intact). For example, the risk posed by exposed contaminated sediments would have to be considered under any option in which the lake was drained, and such parameters as control of woody vegetation on exposed areas and the feasibility and cost of refilling the lake (e.g., to reduce risk to acceptable levels by natural decay of radionuclides) are likely to be important parameters that would be of little or no concern if L-Lake remained intact.

However, DOE is coordinating with EPA and SCDHEC as necessary to ensure that decisions it makes with respect to the River Water System in this EIS are compatible with potential remedial decisions to be made for L-Lake under the FFA. As appropriate, DOE will document in a mitigation action plan actions it would have to take to ensure this compatibility in the interim between issuance of a Record of Decision for this EIS and issuance of remedial decisions under the FFA.

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APPENDIX B. ECOLOGICAL RISK ASSESSMENT

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B.1 ECOLOGICAL RISK ASSESSMENT APPROACH[1]

Ecological receptors on and near Par Pond, L-Lake, Lower Three Runs, and Steel Creek might be at risk from contaminants present in their surface water, sediment, and biota as a result of the Proposed Action. Increased concentrations of tritium in other onsite streams also pose a potential ecological risk. Accordingly, an ecological risk assessment (ERA) that focused on the Proposed Action was performed to characterize the potential risks from site-related contaminants to ecological receptors that inhabit the waterbody areas. This section provides an outline of the general approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment generally followed a two-step process, as follows:

Step 1: Preliminary Problem Formulation and Ecological Effects Characterization (Section B.1.1)

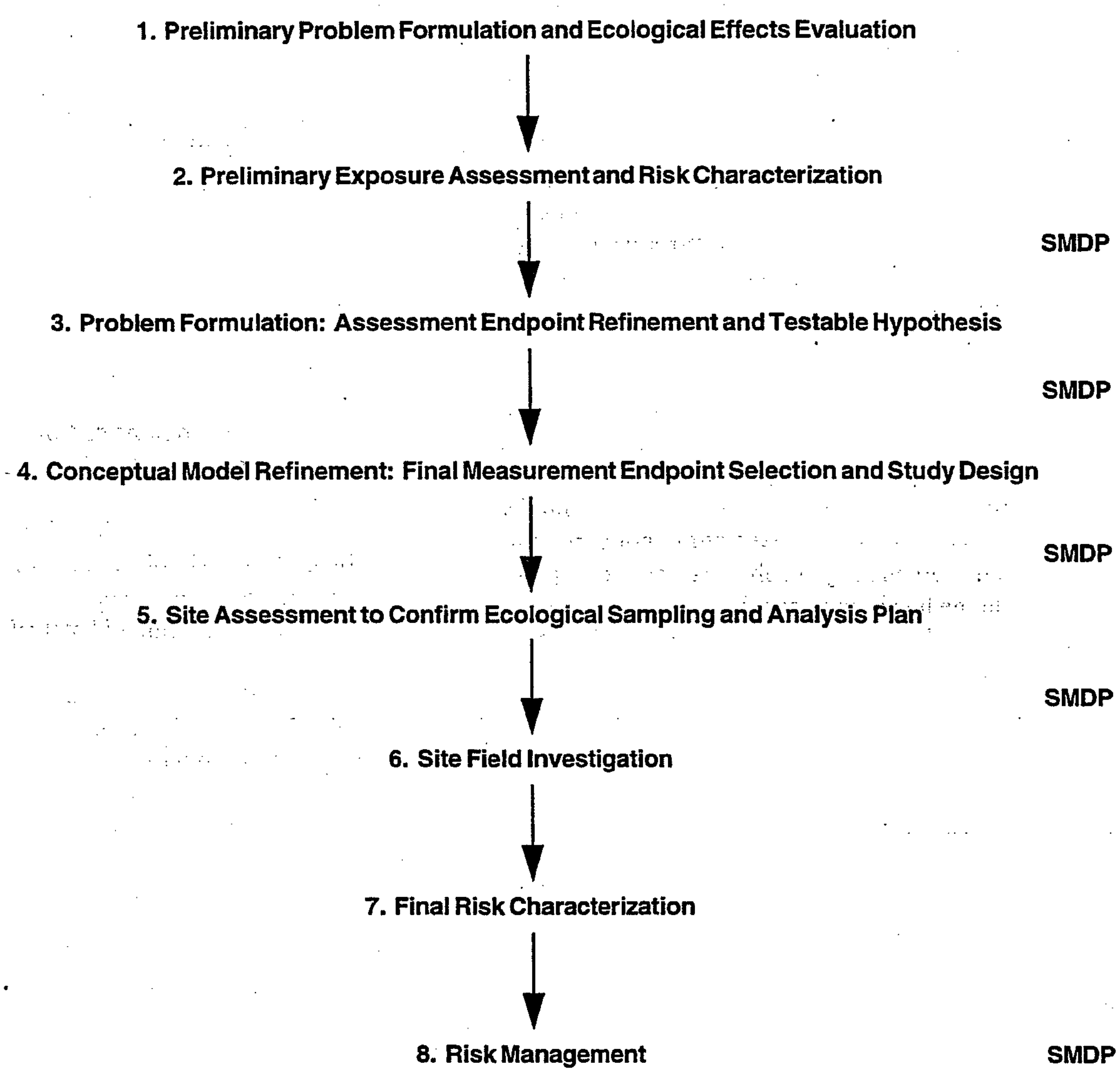
- Preliminary Problem Formulation - This is the first phase of an ERA, which discusses the goals, breadth, and focus of the assessment. It includes general descriptions of the waterbodies to be investigated with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of ecological contaminants of potential concern (COPCs). Assessment and measurement endpoints that will be evaluated are also selected in this phase. Finally, a conceptual model is developed that describes how contaminants associated with the waterbodies may come into contact with ecological receptors.
- Ecological Effects Characterization - In this phase, medium-specific ecological screening values for each COPC (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. Receptor-specific toxicity reference values (TRVs) are also derived during this step. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Characterization (Section B.1.2)

- Preliminary Exposure Assessment - This portion of the ERA includes the identification of the data used to represent concentrations of contaminants to which ecological receptors may be exposed in various media and the actual selection of exposure point contaminant concentrations from those data. Calculation of receptor-specific contaminant doses is also performed.
- Risk Characterization - In this step, exposure point concentrations are compared to screening values in order to characterize potential risk to ecological receptors of concern from contaminant exposure. TRVs are also compared to contaminant doses. COPCs found to pose potential risk after these comparisons are placed on a list of ecological contaminants of concern (COCs).

When these two steps are completed, the results can be interpreted and the uncertainties associated with the ERA can be addressed. The above process, described in further detail below, represents the general ERA approach recommended in U.S. Environmental Protection Agency (EPA) guidance for Superfund (EPA 1996a), and is a summation of EPA Region 4 recommended ERA guidelines (EPA 1995a), which served as the basis for the ERA methodology (Figure B.1). Furthermore, the ERA was conducted in accordance with other available ERA guidance documents (EPA 1996b; Wentsel et al. 1996), and recent publications (Suter 1993; Calabrese and Baldwin 1993).

1 Appendix B was substantially expanded in response to a comment in the letter from EPA (L10-02); no change bars appear.



Source: Adapted from EPA (1996a).
SMDP: Scientific/Management Decision Points.

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Figure B-1. Steps in the Ecological Risk Assessment process.

Due to the potential complexity of ERAs, they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs; Figure B-1), which are meetings involving the risk assessors, risk managers, and clients to control costs, prevent unnecessary analyses, and ensure that the ERA is proceeding in an efficient, timely manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met and then may be used to identify the data required for the next tier, if necessary. This Tier 1 ERA can be considered a "screening-level" assessment, or "preliminary risk evaluation" (EPA 1995a), since it is based on only a conservative initial screening of contaminant concentrations against contaminant-specific screening values (EPA 1995a).

Tier 2 and Tier 3 assessments, referred to as "semi-quantitative" and "quantitative" assessments, respectively, are more focused studies that incorporate the initial screening but also encompass detailed laboratory and field studies or extensive modeling (EPA 1996a). This ERA, designed to focus mainly on the potential risks to ecological receptors from contaminant exposure that could result from the Proposed Action, may be useful for Tier 2 or Tier 3 assessments that may be conducted as part of the remedial investigation/feasibility study process. The same process summarized above was used to assess potential ecological risks at each waterbody investigated in this ERA.

B.1.1 Preliminary Problem Formulation and Ecological Effects Characterization

Section B.1.1.1 discusses the components of preliminary problem formulation and Section B.1.1.2 discusses the components of ecological effects characterization.

B.1.1.1 PRELIMINARY PROBLEM FORMULATION

Site Backgrounds and Ecological Settings

The preliminary problem formulation of an ERA contains a description of the background of each study site as well as a description of the ecological setting. However, as detailed descriptions of these items have been presented elsewhere in this EIS, they will not be presented here.

Habitat Types and Ecological Receptors

The preliminary problem formulation of an ERA also contains a description of the specific habitat types and ecological receptors that are found on each study area. However, detailed descriptions of these items are presented elsewhere in this EIS.

Major Contaminant Sources, Migration Pathways, and Exposure Routes

The major contaminant sources for all waterbodies are sediments. As such, contaminants are largely bound to sediments and are not expected to significantly migrate to other areas or other media. It is likely that receding or fluctuating water levels would lead to the exposure of sediments to the elements, creating new surface soils. This would also preclude significant contaminant migration via surface water as water levels decrease. However, a potential migration pathway is resuspension of contaminants into surface water via fluctuating water levels. Constituents in the exposed sediments (soils) may also volatilize from surficial material or become airborne via resuspension. Contaminated fugitive dust may also be generated during ground-disturbing activities, such as recontouring of the L-Lake basin that may be necessary. Yet, volatilization and fugitive dust generally represent a negligible release pathway and exposure route for wildlife except in certain situations, such as following a large spill of a volatile compound. Since the water bodies of concern in this assessment were already considered to be contaminated and do not potentially receive groundwater contaminated with non-radiological contaminants, the groundwater-to-surface water pathway was not applicable.

Aquatic and semi-aquatic organisms inhabiting the waterbodies of interest in this ERA may be exposed to contaminants via direct contact with surface water, submerged sediments, and exposed sediments, via incidental ingestion of surface water, submerged sediments, and exposed sediments, and via consumption of contaminated food items. Again, since water levels are assumed to recede in the reservoirs, exposure to contaminants in surface water was considered only in certain instances in this assessment, such as at Par Pond, where water levels will be maintained and will fluctuate.

Selection of Ecological Contaminants of Potential Concern

COPCs were all contaminants, both radiological and non-radiological, detected in the studies that are discussed in detail in Section B.1.2.1. However, for the non-radiological contaminants, calcium, iron, magnesium, potassium, and sodium were excluded as COPCs since they are essential nutrients that are toxic only in extremely high concentrations. For radiological contaminants, potassium-40 was excluded since it is a naturally occurring radionuclide. Also, radiological and non-radiological contaminants that were detected in 5 percent or less of the samples collected in any medium for any study at each area were initially excluded as COPCs.

Assessment and Measurement Endpoints

As discussed in EPA (1995a) and Wentsel et al. (1996), one of the major tasks in problem formulation is the selection of assessment and measurement endpoints. An assessment endpoint is defined as "an explicit expression of actual environmental values that are to be protected" (EPA 1996b). Measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (EPA 1996b). For this ERA, the most appropriate assessment endpoint was the maintenance of aquatic and terrestrial receptor populations. Note that the maintenance of receptor populations applies only to exposure to contaminants. That is, it is not intended to relate to declines in certain receptor populations from physical changes as a result of the Proposed Action. Therefore, the specific objectives of this assessment were to determine if exposure to contaminants in the surface water, sediments, and exposed sediments (surface soils) on and near Par Pond, L-Lake, Lower Three Runs, and Steel Creek are likely to result in declines in ecological receptor populations, primarily as a result of the Proposed Action. Declines in populations as a result of contaminant exposure could result in a shift in community structure and possible elimination of resident species from aquatic environments.

It should be noted that for this screening-level ERA, broad assessment endpoints were conservatively selected to apply to all possible species. More focused assessment endpoints will be selected if additional, more focused ecological investigations are warranted. These more focused endpoints would likely be contaminant-specific or applicable to only species that are shown to potentially be at risk in the screening-level ERA.

As indicated above, measurement endpoints are related to assessment endpoints, but these endpoints are more easily quantified or observed. In essence, measurement endpoints serve as surrogates for assessment endpoints. While declines in populations and shifts in community structure can be quantified, studies of this nature are generally time-consuming and difficult to interpret. However, measurement endpoints indicative of observed adverse effects on individuals are relatively easy to measure in toxicity studies and can be related to the assessment endpoint. For example, contaminant concentrations that lead to decreased reproductive success or increased mortality of individuals in toxicity tests could, if found in the environment, result in shifts in population structure, potentially altering the community composition of the waterbodies investigated in this ERA.

For surface water, the measurement endpoints were contaminant concentrations in surface water associated with adverse effects on growth, survival, and reproduction of aquatic organisms (surface water screening levels). Again, exposure to contaminated surface water was considered only in certain situations since surface water levels are generally assumed to fluctuate or recede, such as at L-Lake. For sediments, the measurement endpoints were contaminant concentrations in sediment associated with adverse effects on growth, survival, and reproduction of benthic organisms (sediment screening levels). For surface soils (exposed sediments), the measurement endpoints were contaminant concentrations in surface soil associated with adverse effects on growth, survival, and reproduction of terrestrial invertebrates (surface soil screening levels). For terrestrial plants, the measurement endpoints were contaminant concentrations in surface soil associated with adverse effects on growth, survival, and reproduction of vegetation (terrestrial plant screening levels). For terrestrial wildlife, the measurement endpoints were doses of contaminants associated with adverse effects on growth, survival, and reproduction (TRVs).

Conceptual Site Model

The conceptual model is designed as a diagram to identify potentially exposed receptor populations and applicable exposure routes, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the waterbodies assessed in this ERA were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment; a route of contaminant transport through an environmental medium; and an exposure or contact point for an ecological receptor. A comprehensive conceptual model for this ERA is presented in Figure B.2.

B.1.1.2 ECOLOGICAL EFFECTS ASSESSMENT

B.1.1.2.1 <u>Non-radiological</u>

For this ERA, ecologically-based screening values, concentrations of contaminants in various media protective of ecological receptors, were selected to screen exposure point concentrations of COPCs in surface water, sediment, and surface soil (exposed sediments) to determine if they should be retained as COCs. The focus of this assessment is primarily potential risks from submerged and exposed sediments, and therefore, surface water screening levels were obtained only for Par Pond. It is assumed that at L-Lake the water level will eventually recede to a small stream, rendering current assessment of potential risks from surface water contaminants irrelevant. Methods used for the selection of media-specific screening levels used in this ERA are provided below.

Selection of Surface Water Screening Levels

Surface water screening levels used for this ERA were primarily EPA Region 4 ecological screening levels for freshwater systems (EPA 1995a). When these values were not available for certain contaminants, suitable screening levels were obtained from EPA (1996c). Surface water screening levels used in this assessment are presented in Table B-1.

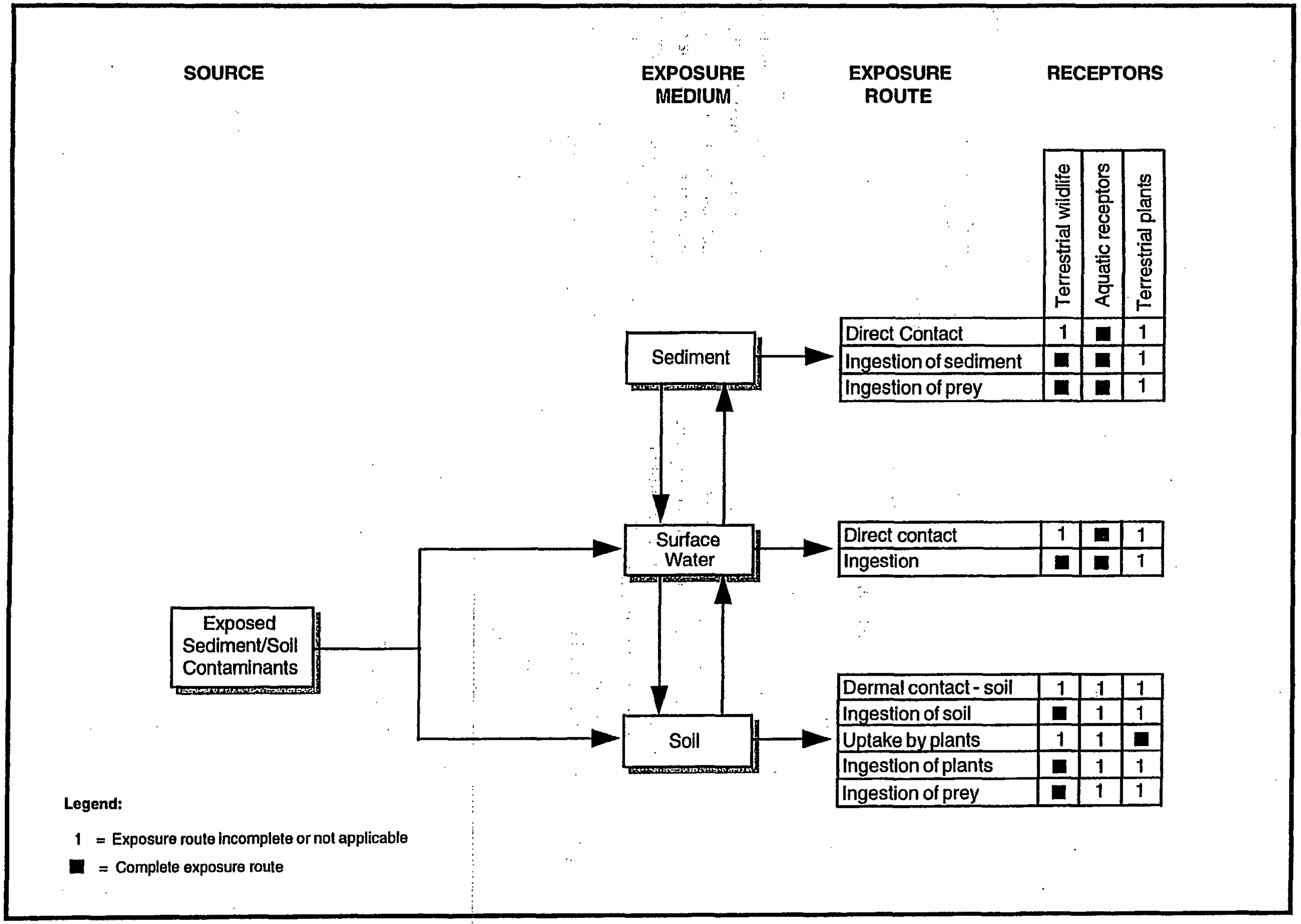

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Figure B-2. Conceptual site model for Par Pond, L-Lake, Lower Three Runs, and Steel Creek.

Table B-1. Ecological screening levels for Par Pond surface water.

Contaminant of Potential Concern	Ecological Screening Level (µg/L)	Source
Aluminum	87	EPA Region 4 surface water screening level (EPA 1995a)
Antimony	160	EPA Region 4 surface water screening level (EPA 1995a)
Arsenic	190	EPA Region 4 surface water screening level (EPA 1995a)
Barium	3.9	EPA Tier II value (EPA 1996c)
Beryllium	0.53	EPA Region 4 surface water screening level (EPA 1995a)
Cadmium	0.66	EPA Region 4 surface water screening level (EPA 1995a)
Cobalt	3	EPA Tier II value (EPA 1996c)
Iron	1,000	EPA Region 4 surface water screening level (EPA 1995a)
Manganese	80	EPA Tier II value (EPA 1996c)
Nickel	87.7	EPA Region 4 surface water screening level (EPA 1995a)
Selenium	5	EPA Region 4 surface water screening level (EPA 1995a)
Thallium	4	EPA Region 4 surface water screening level (EPA 1995a)
Zinc	58.9	EPA Region 4 surface water screening level (EPA 1995a)

Selection of Sediment Screening Levels

Although the primary focus of the non-radiological assessment is the new surface soils created by receding water levels and potentially affected terrestrial receptors, fluctuating water levels may cause newly created surface soils to be frequently inundated. Thus, potential risks to benthic receptors were also investigated.

Screening levels for sediment-dwelling organisms were obtained from the most widely accepted guidance. EPA Region 4 ecological screening levels were preferentially used, which are primarily Effects Range-Low values from National Oceanic and Atmospheric Administration (Long et al. 1995; Long and Morgan 1991). When values were not available from these sources, screening levels were obtained from most recent EPA guidance (EPA 1996c), which includes EPA sediment quality criteria and EPA sediment quality benchmarks calculated using equilibrium partitioning methods. Ontario Ministry of the Environment sediment screening levels (OME 1992) were also used when values were not available from the sources listed above. Sediment screening levels used in this assessment are presented in Table B-2.

Selection of Surface Soil Screening Levels

Surface soil screening levels were obtained from the Oak Ridge National Laboratory On-line Ecological Database (ORNL 1996). These values are based on potential toxicity to earthworms and soil microbes. These receptors could presumably inhabit exposed sediments as water levels recede and exposed sediments become surface soils. EPA Region III ecological soil screening levels were also used (EPA 1995b). Surface soil screening levels used in this assessment are presented in Table B-3.

Table B-2. Ecological screening levels for Par Pond and L-Lake sediment.

Contaminant of Potential Concern	Ecological Screening Level	Source
Inorganics (mg/kg)		
Aluminum	NA	
Antimony	12	EPA Region 4 sediment screening level (EPA 1995a)
Arsenic	7.24	EPA Region 4 sediment screening level (EPA 1995a)
Barium	NA	
Beryllium	NA	
Chromium	52.3	EPA Region 4 sediment screening level (EPA 1995a)
Cobalt	NA	
Copper	18.7	EPA Region 4 sediment screening level (EPA 1995a)
Lead	30.2	EPA Region 4 sediment screening level (EPA 1995a)
Manganese	460	Ontario Lowest Effects Level (OME 1992)
Mercury	0.13	EPA Region 4 sediment screening level (EPA 1995a)
Nickel	15.9	EPA Region 4 sediment screening level (EPA 1995a)
Selenium	NA	
Thallium	NA	
Vanadium	NA	
Zinc	124	EPA Region 4 sediment screening level (EPA 1995a)
Organics (ug/kg)		
Acetone	NA	
Xylene	25	EPA sediment screening level using Equilibrium Partitioning (EPA 1996c)

NA = Not available.

Selection of Terrestrial Plant Screening Levels

Screening levels for assessing risk to terrestrial plants were also gathered from the ORNL database. These screening levels are concentrations of contaminants in soils associated with toxicity to plants. Terrestrial plants would most likely invade newly exposed sediments as water levels recede. Terrestrial plant screening levels used in this ERA are presented in Table B-4.

Derivation of Toxicity Reference Values

In addition to contaminant concentration screening against ecological screening levels, modeling of potential risks to terrestrial receptors from mercury in Par Pond and L-Lake sediments was also performed. Mercury was chosen for modeling since it has been of concern on Savannah River Site (SRS) waterbodies, at least in part, as a result of mercury inputs from Savannah River water. Unlike most metals, mercury is known to biomagnify in the foodchain, potentially resulting in elevated body burdens for species in higher trophic levels. Other metals were not included in the modeling since they did not generally exceed screening levels used in this ERA (i.e., were not elevated), and are generally not known to biomagnify.

For modeling potential risks of mercury to terrestrial receptors, toxic doses (TRVs) for individual terrestrial receptors were derived for comparison to doses that the receptors may receive in the environment. TRVs were determined for the representative terrestrial receptors chosen for this ERA, which are described below. TRVs were identified that

Table B-3. Ecological screening levels for Par Pond and L-Lake surface soil.

Contaminant of Potential Concern	Ecological Screening Level	Source
Inorganics (mg/kg)		
Aluminum	600	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Antimony	NA[a]	
Arsenic	60	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Barium	3,000	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Beryllium	NA	
Chromium	0.4	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Cobalt	1,000	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Copper	50	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Lead	500	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Manganese	100	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Mercury	0.1	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Nickel	200	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Selenium	70	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Thallium	NA	
Vanadium	20	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Zinc	200	ORNL soil screening level for earthworms or soil microbes (ORNL 1996)
Organics (μg/kg)		
Acetone	NA	
Xylene	100	EPA Region III surface soil screening level (EPA 1995b)

a. NA = Not available.

represent a threshold for sublethal effects. Sublethal effects are defined as those based on the measurement endpoint, impairment of reproduction, growth, or survival. TRVs were derived separately for avian and mammalian species, as discussed below. Since toxicity data for the specific representative receptors chosen were not available, toxicity data from laboratory species were extrapolated to be representative of receptor species. In these instances, a metabolic scaling factor was employed to extrapolate from laboratory species to receptor species, which is also discussed below.

Representative species were chosen to represent the species most likely to be exposed to the highest contaminant concentrations because of its position in the food web, diet (ingestion rate and food type), home range (contained within the area of contamination), and body size. The species selected were assumed to be representative of other species within the same trophic level or guild. Also, the socio-cultural nature of the receptor species (e.g. threatened or endangered species) was also considered. For each of the representative species, information on life history was collected, including diet, average body weight, food ingestion rates, water ingestion rates, home range, and exposure durations (percent of total time that a receptor may reside at the site), when applicable.

For the non-radiological terrestrial modeling in this ERA, the representative species chosen include the bald eagle (*Halieeatus leucocephalus)*, eastern cottontail (*Sylvilagus floridanus*), and wood stork (*Mycteria americana*). The bald eagle was chosen primarily since it is a federally threatened species protected by the Endangered Species Act, and is of special concern on SRS. This species is of special social, political, aesthetic, and cultural concern as well, and is widely regarded as a symbol of ecological health. It is

Table B-4. Ecological screening levels for Par Pond and L-Lake terrestrial plants.

Contaminant of Potential Concern	Ecological Screening Level	Source
Inorganics (mg/kg)		
Aluminum	50	ORNL screening level for terrestrial plants (ORNL 1996)
Antimony	5	ORNL screening level for terrestrial plants (ORNL 1996)
Arsenic	10	ORNL screening level for terrestrial plants (ORNL 1996)
Barium	500	ORNL screening level for terrestrial plants (ORNL 1996)
Beryllium	10	ORNL screening level for terrestrial plants (ORNL 1996)
Chromium	1	ORNL screening level for terrestrial plants (ORNL 1996)
Cobalt	20	ORNL screening level for terrestrial plants (ORNL 1996)
Copper	100	ORNL screening level for terrestrial plants (ORNL 1996)
Lead	50	ORNL screening level for terrestrial plants (ORNL 1996)
Manganese	500	ORNL screening level for terrestrial plants (ORNL 1996)
Mercury	0.3	ORNL screening level for terrestrial plants (ORNL 1996)
Nickel	30	ORNL screening level for terrestrial plants (ORNL 1996)
Selenium	1	ORNL screening level for terrestrial plants (ORNL 1996)
Thallium	1	ORNL screening level for terrestrial plants (ORNL 1996)
Vanadium	2	ORNL screening level for terrestrial plants (ORNL 1996)
Zinc	50	ORNL screening level for terrestrial plants (ORNL 1996)
Organics (µg/kg)		
Acetone	NA	
Xylene	100,000	ORNL screening level for terrestrial plants (ORNL 1996)

NA = Not available.

also representative of other fish-eating raptors found on SRS (e.g., osprey). For conservatism, the bald eagle was assumed to forage on largemouth bass from either Par Pond or L-Lake exclusively. The diet of bald eagles in South Carolina consists almost exclusively of fish, and eagles on SRS have been observed feeding on largemouth bass (Hart et al. 1996). Since they are generally a larger, piscivorous fish, bass contain higher body burdens of mercury than smaller fish, adding additional conservatism to the model. Also, recent studies have detected mercury in Par Pond and L-lake bass, as described below.

Although bald eagles are known to drink water, no mercury was detected in recent surface water samples in L-Lake (Paller 1996) and Par Pond (Paller and Wike 1996a). Hence, exposure to mercury via drinking surface water was not included in the model. Also, most raptors such as eagles generally prey on fish while near aquatic environments and, as a result, would not be expected to come into contact with, and ingest, contaminated sediment. Although an eagle may incidentally ingest sediment while consuming dead fish or carrion on exposed sediments, this exposure route was assumed to be minimal and inconsequential compared to exposure from contaminated fish flesh. Thus, it was not included in the model. The exposure parameters used in this ERA for the bald eagle are presented on Table B-5.

Table B-5. Summary of receptor parameter information for Par Pond and L-Lake modeling of potential risks from exposure to mercury.

Receptor	Parameter	Value	Reference
Bald Eagle	Body Weight	4,500 g	EPA (1993)
	Food Ingestion Rate	0.540 kg/day	Calculated from EPA (1993)
	Soil/Sediment Ingestion Rate	NA[a]	NA
	Diet Composition	100% largemouth bass	NA
	Home Range (% time on Par Pond or L-Lake)	Assumed to be 100%	NA
	Laboratory Toxicity Value	0.064 mg/kg/day	ORNL (1996)
	Body/Metabolic Scaling Factor	0.61	NA
	Final Toxicity Reference Value	0.04 mg/kg/day	NA
Cottontail Rabbit	Body Weight	1,134 g	EPA (1993)
	Food Ingestion Rate	0.096 kg/day	Estimated from EPA (1993)
	Soil/Sediment Ingestion Rate	6.3% of diet	Based on jackrabbit, from EPA (1993)
	Diet Composition	93.7% vegetation	NA
	Home Range (% time on Par Pond or L-Lake)	Assumed to be 100%	NA
	Laboratory Toxicity Value	0.16 mg/kg/day	ORNL (1996)
	Body/Metabolic Scaling Factor	0.67	NA
	Final Toxicity Reference Value	0.11 mg/kg/day	NA
Wood Stork	Body Weight	2,268 g	Estimated from EPA (1993)
	Food Ingestion Rate	0.40 kg/day	Estimated from EPA (1993)
	Soil/Sediment Ingestion Rate	7.3% of diet	Based on sandpiper, from EPA (1993)
	Diet Composition	92.7% small fish	NA
	Home Range (% time on Par Pond or L-Lake)	Assumed to be 100%	NA
	Laboratory Toxicity Value	0.064 mg/kg/day	ORNL (1996)
	Body/Metabolic Scaling Factor	0.76	NA
	Final Toxicity Reference Value	0.05 mg/kg/day	NA

a. NA = Not applicable.

Since no data were available from toxicity studies on the bald eagle, toxicity information was gathered from the Oak Ridge National Laboratory for a study on mercury exposure for the mallard (ORNL 1996). The study investigated reproductive impairment of this avian species from exposure to methyl mercury diacyandiamide in the laboratory. The study calculated a Lowest-Observed-Adverse-Effects-Level (LOAEL) of 0.064 mg/kg/day[2]. The LOAEL was used instead of the No-Observed-Adverse-Effects-Level (NOAEL) since it is based on actual effects. That is, the NOAEL is derived from the lowest concentration at which no effects were observed in the test, whereas the LOAEL is based on the lowest concentration in the laboratory at which adverse effects were

[2] mg/kg/day = milligram of contaminant per kilogram of tissue per day.

observed. To extrapolate between the mallard and the bald eagle, a body size (metabolic) scaling factor was employed. The scaling factor is based on the relative sizes of the laboratory test species and the receptor species; therefore, it adjusts the toxicity data, in this case the LOAEL, based on size-related differences in metabolism. That is, smaller species generally have a higher metabolism and are expected to metabolize and excrete contaminants at a faster rate (ORNL 1996). The metabolic (body size) scaling factor is calculated as follows (derived from ORNL 1996):

$$(BM_L/BM_I)^{1/3}$$

where: BM_L = body mass of the laboratory test species

BM_I = body mass of the receptor species

This value was multiplied by the test species LOAEL to calculate the bald eagle LOAEL of 0.04 mg/kg/day. The eagle LOAEL for mercury was then used in the model and compared to the modeled mercury dose for Par Pond and L-Lake.

The eastern cottontail was chosen as a representative species because it is a common small, herbivorous mammal found on SRS (Cothran et al. 1991). It would be expected to forage on newly created surface soils (exposed sediments) as the water levels fluctuate in Par Pond and L-Lake and eventually recede in L-Lake over several years. It would be in constant contact with the surface soil, increasing the chances of contaminant exposure. It was also chosen since it is relatively representative of other small mammals found on SRS. The cottontail was conservatively assumed to forage exclusively on exposed Par Pond or L-Lake sediments. Given the size of the rabbit's home range [as small as 0.8 hectare (2 acres); EPA 1993], this may be a realistic (i.e., not overly conservative) assumption. The primary exposure route for this herbivore was assumed to be exposure from consuming contaminated vegetation. Uptake of mercury by plants was modeled using the maximum and average concentrations in soil, which were multiplied by a mercury-specific plant biotransfer factor presented by Baes et al. (1984). Since the cottontail also spends most of its time in contact with the soil, exposure to contaminated surface soils via incidental ingestion was also considered in the model. Again, since no mercury was detected in surface water of either Par Pond or L-Lake, exposure to contaminated drinking water was not considered. The exposure parameters used in this ERA for the cottontail rabbit are presented on Table B-5.

Since no data were available from mercury toxicity studies on the cottontail rabbit, toxicity information was obtained from the Oak Ridge National Laboratory for a study on the rat (ORNL 1996). The rat is known to be especially sensitive to contaminants; therefore, its use as the laboratory species adds conservatism to the assessment. The endpoint for that study was impairment of reproduction from exposure to methyl mercuric chloride. A LOAEL of 0.16 mg/kg/day was calculated for that study. The body scaling factor was also employed to derive the final LOAEL for the rabbit of 0.11 mg/kg/day.

The wood stork was chosen primarily since it is a federally threatened species protected by the Endangered Species Act, and is of special concern on SRS. Like the bald eagle, this species is of special social, political, aesthetic, and cultural concern as well. The wood stork was assumed to forage on small fish from either Par Pond or L-Lake exclusively, since it is known to feed primarily on small fish (Stokes and Stokes 1996). Although wood storks have not been observed foraging on Par Pond or L-Lake in several years (LeMaster 1996), they have been observed on other sites on SRS, and Par Pond and L-Lake may provide foraging areas for this species. Therefore, they were conservatively assumed to forage in these areas. They are also representative of other piscivorous wading birds that occur on Par Pond and L-Lake, such as the great blue heron.

Although wood storks are expected to ingest water, no mercury was detected in recent surface water samples in L-Lake (Paller 1996) and Par Pond (Paller and Wike 1996a). Hence, exposure to mercury via drinking surface water was not included in the model. The wood stork may incidentally ingest sediment while feeding. Thus, incidental ingestion of sediment was included as an exposure parameter. The exposure parameters used in this ERA for the wood stork are presented on Table B-5.

Since no data were available from toxicity studies on the wood stork, toxicity information was gathered from the Oak Ridge National Laboratory for a study of mercury exposure for the mallard, as discussed above for the bald eagle (ORNL 1996). The study calculated an LOAEL of 0.064 mg/kg/day. The body scaling factor was employed to derive the final LOAEL of 0.05 mg/kg/day for the wood stork.

B.1.1.2.2. Radiological

Screening values for radiological constituents were established as two times the average concentration in the reference sediment samples (i.e., background). Only radiological constituents that exceeded two times the average background concentration were incorporated into radiological modeling of potential risks to several ecological receptors. A concentration less than two times the background concentration is not indicative of a contaminant release (EPA 1996c) and can be considered statistically insignificant considering the applicable dose limits. It should be noted that, unlike non-radiological contaminants, simple radiological screening levels akin to ambient water quality criteria or Region 4 sediment screening levels do not exist. Hence, only modeling, and not simple screening of concentrations against screening levels, was performed.

The U.S. Department of Energy (DOE) radiation dose limit to aquatic organisms is 1.0 rad per day (DOE Order 5400.5). For terrestrial organisms, this ERA uses a radiation dose limit of 0.1 rad per day. The International Atomic Energy Agency has concluded that "there is no convincing evidence from the scientific literature that chronic radiation dose rates below 1 milligray per day (36.5 rad per year) will harm animal or plant populations" (IAEA 1992).

The radiological portion of this ERA analyzed two of the same receptor species selected for the non-radiological portion of the study (i.e., bald eagle and wood stork) for the reasons described earlier in the non-radiological discussion. Also, potential risks from radiological contaminants were modeled for a generalized minnow-sized fish, largemouth bass, osprey, and the great blue heron. Potential risk to fish from non-radiological contaminants was not modeled since sufficient contaminant data for these receptors were available from several other studies. The conservative dietary assumptions for the species used in the non-radiological portion of this ERA (as described earlier), and the others, were also used in the radiological portion of the analysis.

B.1.2 Preliminary Exposure Assessment and Risk Characterization

Section B.1.2.1 describes the components of preliminary exposure assessment and Section B.1.2.2 describes the components of risk characterization.

B.1.2.1 PRELIMINARY EXPOSURE ASSESSMENT

Non-radiological and Radiological: Exposure Point Concentrations and Contaminant Doses

Data used to obtain exposure point contaminant concentrations for the waterbodies assessed in this ERA were gathered from several sources. A discussion of the data and studies used to obtain exposure point contaminant concentrations for this ERA is provided below.

Non-radiological and radiological sediment contaminant concentration data for Par Pond were obtained from Paller and Wike (1996a). For that study, fifteen surface soil samples spread among each major region of Par Pond (North Arm, Intake Arm, Hot Arm, and Main Body) were collected from exposed sediments during the drawdown in 1995, and each were analyzed for radionuclides and mercury. Also, several sediment samples were collected in each major region of Par Pond and composited for each region, resulting in a total of four samples. Ten samples were also collected from two reference locations, one near Lost Lake and one near Road D. The composite and reference samples were analyzed for radionuclides and mercury, as well as total chlorinated hydrocarbon (TCL) organics, target analyte list (TAL) metals, and polychlorinated biphenyls. The maximum and average concentrations of all non-radiological and radiological contaminants detected in all samples described above were used to represent exposure point contaminant concentrations in sediments/exposed soils. The maximum and average concentrations of mercury from that study were also used to represent the soil concentrations of that constituent in the modeling of exposure for the cottontail rabbit at Par Pond.

For L-Lake, sediment data from recent sampling as part of a Site Evaluation were used to obtain representative exposure point contaminant concentrations (Dunn, Gladden, and Martin. 1996). Selected data from that study germane to this assessment were re-evaluated and analyzed for this ERA (Dunn and Martin 1997). Forty-four surface sediment samples (0 to 6 inches) collected throughout the lake as part of the site evaluation, in both the floodplain and stream channel, were used for this ERA (Appendix F). Samples were also collected from reference areas, including drainages of Steel Creek and Meyers Branch, its main tributary. The L-Lake and reference location samples were analyzed for radionuclides and metals. Organics were not analyzed for and were not evaluated for L-Lake in this ERA since they were not detected in L-Lake sediments in a previous study (Koch et al. 1996). Also, no known major releases or sources of organic contaminants to L-Lake have existed or are known to exist. Maximum and average concentrations of metals and radionuclides in the 44 samples were used to represent exposure point contaminant concentrations in sediments/exposed soils. The maximum and average concentrations of mercury from that study were also used to represent the soil concentrations of that constituent in the modeling of exposure for the cottontail rabbit at L-Lake. Since fluctuating water levels in Par Pond and L-Lake may result in re-inundation of exposed sediments, the sediment contaminant concentrations were considered to be characteristic of both surface soil and sediment. Surface sediment samples were used since they are the horizon of sediments that terrestrial receptors may be exposed to when water levels recede or fluctuate.

Recently collected non-radiological sediment contaminant data for Steel Creek and Lower Three Runs are not abundant. Sufficient data were not available to conduct a thorough sediment contaminant screening for these areas. However, one sediment sample in Steel Creek and Lower Three Runs is collected each year as part of SRS-wide environmental monitoring and analyzed for inorganics, pesticides, and herbicides (WSRC 1996). Data from environmental monitoring of sediments in 1994 and 1995 were used to obtain exposure point contaminant concentrations for each stream.

However, the most recent inorganic data for Lower Three Runs and Steel Creek are from 1994. The samples were collected at a location approximately 4 miles and 1 mile downstream of Par Pond and L-Lake, respectively. Two samples also collected from the same sampling location in each stream, one in 1994 and one in 1995, were used to obtain exposure point contaminant concentrations for pesticides and herbicides. The highest of the two values was used as the exposure point concentration.

Recently collected radiological sediment contaminant data for Steel Creek and Lower Three Runs are not sufficient to conduct a thorough sediment contaminant screening for these areas. Results from seven surface water samples from Steel Creek were reported in the SRS Environmental Data supplement to the 1995 SRS Environmental Report (WSRC 1996). However, only one sample was reported from Lower Three Runs, and this sample was taken at the mouth of the stream.

Due to the nature of the data described above, averages could not be calculated for each class of contaminants at each stream. Organics other than pesticides and herbicides were not analyzed for, presumably since no upstream sources of these contaminants are known to exist or have existed. Also, the absence of extensive sediment data for inorganics, pesticides, and herbicides is somewhat mitigated by several factors. First of all, it is assumed that the contaminated portions of the streams (i.e., the channels) would remain wet or generally inundated under the Proposed Action due to groundwater inputs, flooding, and the maintenance of 10 cubic-foot (0.28-cubic-meter) per second (minimum) stream flow in Lower Three Runs and Steel Creek. This would minimize exposure for many types of terrestrial receptors, such as small mammals, to exposed contaminated sediments, as well as exposure for terrestrial plants that would invade permanently exposed soils. Further, avian predators such as the eagle, and osprey are expected to feed much more often on the open water of the lakes rather than on the smaller streams.

Surface water exposure point contaminant concentrations for Par Pond were obtained from Paller and Wike (1996b). For that study, a surface water sample was collected in each arm of Par Pond (north, middle, west, and near the dam). Samples were collected from near the surface and near the bottom, resulting in a total of eight samples. Each sample was analyzed for TAL metals and radionuclides. Organics were not analyzed for, presumably due to the absence of organic contaminant sources along Par Pond and upstream in Upper Three Runs. No suitable, recently collected background or reference data were available for surface water. Also, since L-Lake water levels are expected to recede to the original stream bed, current surface water data for that waterbody were not assessed since the results would be of limited value.

In addition to the studies listed above, numerous other investigations have been performed on the waterbodies evaluated in this ERA and their ecological receptors. These include, but are not limited to, studies involving surface water chemistry, terrestrial receptors and terrestrial ecology, and aquatic receptors and aquatic ecology. Applicable studies, both non-radiological and radiological, were qualitatively assessed in the ERA and used in the weight of evidence approach to assessing potential ecological risks in the risk characterization step for each site described in Section B.1.2.2.

Non-radiological: Contaminant Doses for Representative Receptors

The actual dose of a COPC (in this case, mercury) a receptor species receives as the result of indirect or direct exposure is dependent upon the habits of the species and other factors. As mentioned earlier, a simple model was used to predict dietary exposures for representative receptor species to be compared to TRVs discussed previously. Both the maximum and average detected concentrations of contaminants were used in the model. Model runs were performed for the bald eagle using the maximum and average concentrations of mercury detected in largemouth bass in Par Pond (Paller and Wike 1996b) and L-Lake (Paller 1996). For the cottontail, both the maximum and average detected concentrations in sediments (exposed soils) from the studies discussed above were used to determine contaminant concentrations in terrestrial vegetation and were also used to calculate incidental ingestion of mercury from contaminated soil. For the wood stork, contaminant concentrations in small fish that this receptor was assumed to forage on were obtained from preliminary data generated by the Savannah River Ecology Laboratory as part of on-going wood stork ecology studies (Bryan, Brisbin, and Jagoe 1997). Several species of fish in Par Pond and L-Lake were collected and analyzed for mercury by SREL, including largemouth bass, bluegill, brook silversides, warmouth, sunfish (several types), and lake chubsucker. For each of these species, only fish of a size that the wood stork would be expected to forage on (approximately 120 millimeters or smaller) were collected.

The equations used to calculate the dose of mercury ingested for each exposure route for the bald eagle, wood stork, and cottontail rabbit are presented below.

Incidental Ingestion of Soil/Sediment

Intestinal absorption of mercury in soil/sediment was conservatively assumed to equal 100 percent. Daily intake of mercury as a result of ingestion of soil/sediment was determined using the following equation:

PD ingestion of soil =

$$\frac{(C_{soil} \times FI \times SA \times AF \times F)}{(WR \times CF)}$$

where: PD = predicted dose from ingestion of soil (mg/kg/day)

C_{soil} = concentration in soil (mg/kg)

FI = fractional intake (percent of home range that overlaps impacted area; assumed to be 100%)

SA = percent of diet that equals soil

AF = absorption fraction (unitless; assumed to = 100%)

F = food consumed (mg/day)

WR = body weight (kg)

CF = conversion factor (kg to mg)

Ingestion of Food items

Intestinal absorption of mercury was conservatively assumed to equal 100 percent. The following equation was used to estimate mercury intake from ingestion of contaminated food items:

PD ingestion of food =

$$\frac{(C_{food} \times F \times FA \times FI \times AF)}{(WR \times CF)}$$

where: PD = predicted dose from ingestion of food items (mg/kg/day)

C_{food} = contaminant concentration (vegetation or prey; mg/kg)

F = food consumed (mg/day)

FA = animals/vegetation as a percentage of diet

FI = fractional intake (percent of home range that overlaps affected area; assumed to be 100%)

AF = absorption fraction (unitless; assumed to = 100%)

WR = weight of receptor (kg)

CF = conversion factor (kg to mg)

Radiological: Contaminant Doses for Representative Receptors

Radiation dose to receptor species from radiological COCs is dependent on species-specific habits and other species-specific parameters, such as bioaccumulation factors. A simple but conservative model was used to estimate radiation doses to receptor species based on exposure to contaminants in ambient water, uptake of contaminants in water, exposure to contaminants in sediments (for fish), and exposure to contaminants through the ingestion of fish (for avian species).

Radiation dose to fish from exposure to contaminants in ambient water was calculated by multiplying the concentration of each radiological COC in the ambient water by a submersion dose conversion factor. Radiation dose to fish from uptake of contaminants in water was calculated by multiplying the concentration of each radiological COC in the ambient water by a species-specific bioaccumulation factor for the given COC, and by a species-specific internal dose conversion factor. Likewise, the radiation dose to fish from exposure to contaminants in sediments was calculated by multiplying the concentration of each radiological COC in the sediment by an external dose conversion factor. Radiation doses from these three pathways were added together for a total radiation dose. Total radiation dose was calculated for both the maximum and average COC concentrations in applicable media.

Radiation doses to avian species were calculated for the consumption of contaminated food items. It is conservatively assumed that each avian species subsists entirely on a diet of contaminated minnows or largemouth bass, as appropriate for the given avian species. The radiation dose for the avian species was calculated by multiplying the concentration of the COC in the food source by the food consumption rate, and by a species-specific dose conversion factor.

The calculation of dose conversion factors for ingestion for all avian species is similar. For purposes of these calculations, the animals are assumed to possess similar metabolic processes as humans with regard to retention and excretion of radioisotopes; the chemistry of radioisotopes in the animals' bodies is assumed to be the same as that of humans. Equations from the International Commission on Radiological Protection were used to predict the uptake rate and body burden of radioactive material over the lifespan of the animals, which is assumed to be one year. All isotopes were assumed to be uniformly distributed throughout the body of the animal. For purposes of this calculation, the entirety of the alpha and beta particle energies was assumed to be absorbed within the body of the animals. Although only a small fraction of the energy emitted by the isotopes of concern is due to gamma rays, their contribution to the absorbed dose is taken into account by assuming that the animals have the following effective radii: osprey - 1.2 inches (3 centimeters), heron - 2 inches (5 centimeters), bald eagle - 4 inches (10 centimeters), and wood stork - 4 inches (10 centimeters). Tabulated values (Baker and Soldat 1992) of absorbed energy per disintegration were utilized.

Internal dose conversion factors for minnows and largemouth bass were calculated by assuming a steady-state concentration of radioactive material within the tissues of the animal. The absorbed dose due to particulate radiation is calculated as described above for avian species. For photon radiation, the absorbed fractions are assumed to be equal to that for a sphere of water with an effective radius of 0.6 inches (1.4 centimeters) (minnow) and 2.8 inches (7 centimeters) (bass) (Baker and Soldat 1992). The external dose to minnows and largemouth bass in streams is assumed to result from two sources: the water surrounding the fish and the sediment beneath the fish. For purposes of the submersion dose calculation, the minnows and largemouth bass are assumed to be surrounded at all times in their lifespan by an infinite body of water with a uniform distribution of radioactive material. The external dose is assumed to arise entirely from photon radiation. Tabulated values (Baker and Soldat 1992) of immersion dose conversion factors were utilized. External dose conversion factors from exposure of minnows and largemouth bass to sediment on the bottom of the streams were calculated using the MicroShield computer code.

B.1.2.2 RISK CHARACTERIZATION

B.1.2.2.1 Non-Radiological

As identified by EPA (1995a), the preliminary risk characterization step in the ecological risk assessment process compares exposure point contaminant concentrations with screening levels protective of ecological receptors, or contaminant doses to TRVs. Once this step was completed for this study, the results were reviewed to determine whether little or no ecological risk is associated with the Proposed Action at the sites or if additional information must be generated to verify that ecological receptors are at risk. Prior to the comparisons described above, the maximum and average concentrations of inorganic contaminants at each site were compared to two times the average concentrations in background samples. Inorganic COPCs that did not have maximum or average concentrations in excess of two times the background concentration were excluded from further consideration. This step is performed since concentrations of inorganics can be naturally high and not indicative of contaminant releases (EPA 1996c).

The ratio of the exposure point contaminant concentration to the screening level is called the Hazard Quotient (HQ), and is defined as follows:

$$HQ_i = EPC_i/ESL_i$$

where: HQ_i = Hazard Quotient for COPC "i" (unitless)

EPC_i = Exposure Point Concentration for COPC "i" (ug/kg or mg/kg)

ESL_i = Ecological Screening Level for COPC "i" (ug/kg or mg/kg)

When the ratio of the exposure point concentration to its respective screening level exceeded 1.0, adverse impacts were considered possible, and the COPC was retained as COC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a screening level. When HQ values exceed 1.0, they are an indication that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most screening levels are conservatively derived. Furthermore, other factors, such as low frequency of detection, may mitigate potential risks for a COC with an elevated HQ value. Because of the conservatism inherent in most screening level derivation, EPA Region III (EPA 1994) has suggested that HQs greater than one are indicative of low to moderate potential risk; HQs greater than 10 are indicative of moderate potential risk; and HQs greater than 100 are indicative of high potential risk. However, these classifications were used only as a general guide, and individual exceedances of screening levels and HQ values were each scrutinized.

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.

- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. Also, it uses single values for exposure concentrations and screening levels and does not account for the variability in both these parameters nor for incremental or cumulative toxicity. To address cumulative toxicity, HQs were summed for all contaminants with similar modes of action in a given medium to obtain a Hazard Index (HI). Although similar to an HQ in that an HI value of one or greater indicates potential risk, the HI should be interpreted with caution. The HI value may exacerbate the preceding uncertainties in the assessment. For example, most of an HI value may be due to a single contaminant that has a high HQ but a low frequency of detection. Also, ecological toxicity is not necessarily additive even if modes of action are similar. As mentioned above, multiple contaminants may have synergistic, and even ameliorating, effects.

The comparisons described above are presented in site-specific screening tables to select COCs for each individual waterbody assessment section. Screening tables include the frequency of detection for each COPC, as well as the exposure point concentration, and as mentioned earlier, contaminant-specific screening levels. Note that due to the absence of extensive non-radiological data for Lower Three Runs and Steel Creek, the data and results were not tabled. Some contaminants were present in some media for which no suitable screening values were available. In these instances, these contaminants were conservatively retained as COCs and qualitatively assessed. For comparison of doses to TRVs, the HQ method was also used. HQ values for each exposure route were summed to obtain a HI based on all exposure routes.

B.1.2.2.2 <u>Radiological</u>

For radiological contaminants, the preliminary risk characterization step in the ecological risk assessment process compares exposure point contaminant concentrations with screening levels (background), and, for the remaining radionuclides, radiation doses to the guideline doses described earlier. For this study, the results of the preliminary risk characterization were reviewed to determine if ecological risk is associated with the Proposed Action at the waterbodies or if additional information must be generated to verify that ecological receptors are at risk.

Again, as a screening value, the maximum and average concentrations of radiological contaminants at each site were compared to two times the average concentrations in background samples. Radiological COPCs that did not have maximum or average concentrations in excess of two times the background concentration were excluded from further consideration. Any inorganic concentration less than two times the background concentration may not be indicative of a contaminant release (EPA 1996c) and can be considered statistically insignificant considering the applicable dose limits. Radiological doses were compared to DOE radiation dose limit for aquatic organisms of 1.0 rad per day (DOE Order 5400.5). For terrestrial organisms, this ERA used a radiation dose limit of 0.1 rad per day. The International Atomic Energy Agency has concluded that there is "no convincing evidence from the scientific literature that chronic radiation dose rates below 1 milligray per day (36.5 rad per year) will harm animal or plant populations" (IAEA 1992).

B.1.3 Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. This section provides a summary of the general uncertainties involved in this ERA, with a discussion of how they may affect the final risk values and conclusions. Some additional discussion of site-specific uncertainties are also contained in site-specific assessment sections below.

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ERA process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward overpredicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. The risk assessment reflects the accumulated variances of the individual values used for several different parameters. Informational uncertainty stems from the limited availability of necessary information. Often the gap between what is needed and what is available is significant; information regarding the effects of some contaminants on wildlife receptors, the biological mechanism of a contaminant, the impact of physiological differences on exposure pathways, or the behavior of a contaminant in various environmental media is often absent.

Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in preliminary problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.
- Uncertainty in the ecological effects characterization arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.
- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations or calculate contaminant doses.
- Uncertainty in risk characterization includes that associated with combining conservative assumptions made in earlier activities.

B.1.3.1 UNCERTAINTY IN THE PRELIMINARY PROBLEM FORMULATION

For the most part, ecological risk assessments are performed to assess the potential for current or future risks given a constant environmental scenario. Although ERAs are occasionally conducted that are based on modeled data for changing environmental conditions in the future, uncertainties are introduced into the process when assessing potential risks for a future scenario that is not fully understood. In particular, fluctuating water levels in the future under the Proposed Action introduce variables that are difficult to fully account for in the assessment. This includes uncertainty involved in determining contaminant migration and exposure routes. For example, mercury may be resuspended in the water column from fluctuating water levels, but it is difficult to predict the magnitude of such contaminant migration and the extent to which receptors may be adversely affected.

B.1.3.2 UNCERTAINTY IN THE ECOLOGICAL EFFECTS CHARACTERIZATION

A great deal of uncertainty in this risk assessment arises from the nature and quality of the available toxicity data used to derive screening levels. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when postulated mechanisms of toxicity are similar for laboratory and wildlife species. Most screening levels are based on the most conservative assumptions possible. Although an inherent level of conservatism is needed in a screening-level ecological risk assessment to ensure that the most sensitive receptors are protected, conservative screening levels may heavily overestimate potential risks and the resulting HQ values may be misleading. Both ambient water quality criteria (as used in Region 4 screening levels) and many sediment screening values used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. Therefore, uncertainty is introduced into the assessment, and the results tend to overestimate potential risks.

In addition, ERAs, unlike human health risk assessments, must consider risks to many different species. Calculation of risk values for every potential receptor species is not possible. For this ERA, conservative screening levels protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these screening levels is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, some contaminants were present in some media for which no suitable screening levels were available, and as a result, they could not be quantitatively assessed. For these reasons, the use of screening levels, while necessary, will introduce error into the results of an assessment.

Individual receptor species were chosen for modeling of potential risks from exposure to mercury. As discussed earlier, toxicity reference values were obtained for each species. Since no toxicity tests have been conducted for the receptors chosen, laboratory toxicity data from similar species were obtained and extrapolated. Toxicity data for the mallard were used to extrapolate for the bald eagle and wood stork, and rat toxicity data were used for the cottontail rabbit. Both the mallard and rat are generally considered to be sensitive to contaminants. Therefore, the use of data for these organisms may increase the chances that potential risks are being over-predicted. Nonetheless, the use of toxicity data for species other than those investigated in the modeling introduces uncertainty.

B.1.3.3 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

Uncertainty in the exposure assessment arises mainly in the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were generally used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant concentrations associated with the sites, then this approach is conservative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination, and may be much higher than the remaining values in the data set. Again, although use of maximum values is appropriate for screening in an ERA, they may grossly overpredict potential risks. To somewhat mitigate these uncertainties, average concentrations were also used, but they do not fully account for the uncertainties involved in selecting exposure point contaminant concentrations.

Also, several input parameters were used in the modeling calculations for each receptor. To maintain a relatively high level of conservatism in this screening-level assessment, worst-case values were used to calculate risk values for each receptor (e.g., exposure to maximum concentration of mercury in fish for the wood stork and eagle). However, it is highly unlikely that the very conservative values used for each exposure parameter will hold true in the environment. The use of several of these assumptions in the calculations increases the chances that the risks are over-predicted, introducing uncertainty into the results.

Furthermore, data used to obtain exposure point contaminant concentrations and contaminant concentrations in fish for the mercury modeling were obtained from several different sources. Although each of these studies was scrutinized to determine if it was adequate for its use in this assessment, the use of data from different sources contributes to uncertainties. For example, laboratory analyses were performed by different laboratories which may have different detection limits in their methods, slightly different analytical protocols, and so forth.

B.1.3.4 UNCERTAINTY IN THE RISK CHARACTERIZATION

Uncertainty in the risk characterization is affected by all aspects of the ERA process described in the above sections. Uncertainty in risk characterization also stems, in part, from the fact that different components of the ERA are combined and compared in this step. Each of those components already contains different types of uncertainty, as discussed above. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight of evidence approach is used to make risk decisions. This approach takes the results of all aspects of the assessment into account, including the uncertainties, to make determinations of potential risk/no risk.

B.2 PAR POND

The major elements of preliminary problem formulation, ecological effects assessment, and exposure assessment for the Par Pond ERA are discussed in Section B.1. Hence, only the risk characterization results and discussion are presented in this section.

B.2.1 NON-RADIOLOGICAL CONTAMINANTS

Risk Characterization - Results

The results of the risk characterization step for each aspect of the Par Pond assessment are presented below.

Surface Water

In Par Pond surface water, barium (HQ = 4.62), beryllium (HQ = 2.83), and cadmium (HQ = 1.52) had HQ values in excess of one (Table B-6). These three metals also had average concentrations with HQs greater than 1 (Table B-7). Since no suitable site-specific background data were available, concentrations were not compared to two times the average background concentration.

Sediments

Only the maximum concentration of mercury exceeded its sediment screening level, with a HQ value of 3.72 (Table B-8). Most contaminants' maximum concentrations did not exceed two times the average background concentration. Thallium was conservatively retained as a sediment COC since the maximum detected concentration exceeded two times the average background concentration and no suitable sediment screening level was available. Acetone was conservatively retained as a sediment COC since no suitable screening level was available. No inorganic contaminants had average concentrations in excess of two times their background concentrations (Table B-9). Acetone was also conservatively retained as a COC under the average scenario since no suitable screening level was available.

Surface Soil

Manganese (HQ = 3.96) and mercury (HQ = 4.8) were present in maximum concentrations in excess of screening levels (Table B-10). Thallium was conservatively retained as a COC

Table B-6. Selection of surface water contaminants of concern for Par Pond maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[b]	Surface Water Screening Level[c]	Hazard Quotient[d]	Retained as a COC?
Inorganics (μg/L)						
Aluminum	8/8	NA[e]	79	87	0.91	No - does not exceed screening level
Antimony	3/8	NA	3	160	0.02	No - does not exceed screening level
Arsenic	5/8	NA	4	190	0.02	No - does not exceed screening level
Barium	8/8	NA	18	3.9	4.62	Yes - exceeds screening level
Beryllium	1/8	NA	1.5	0.53	2.83	Yes - exceeds screening level
Cadmium	1/8	NA	1.0	0.66	1.52	Yes - exceeds screening level
Cobalt	2/8	NA	2	3	0.67	No - does not exceed screening level
Iron	8/8	NA	318	1,000	0.32	No - does not exceed screening level
Manganese	8/8	NA	73	80	0.91	No - does not exceed screening level
Nickel	2/8	NA	5	87.7	0.06	No - does not exceed screening level
Selenium	3/8	NA	3	5	0.6	No - does not exceed screening level
Thallium	2/8	NA	2.7	4	0.68	No - does not exceed screening level
Zinc	3/8	NA	4	58.9	0.07	No - does not exceed screening level

a. No suitable data was available.
b. Source: Paller and Wike (1996b).
c. See Table B-1.
d. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
e. NA = Not available.

Table B-7. Selection of surface water contaminants of concern for Par Pond average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[b]	Surface Water Screening Level[c]	Hazard Quotient[d]	Retained as a COC?
Inorganics (μg/L)						
Aluminum	8/8	NA[e]	47	87	0.54	No - does not exceed screening level
Antimony	3/8	NA	2	160	0.01	No - does not exceed screening level
Arsenic	5/8	NA	2.5	190	0.01	No - does not exceed screening level
Barium	8/8	NA	10.5	3.9	2.69	Yes - exceeds screening level
Beryllium	1/8	NA	1.4	0.53	2.64	Yes - exceeds screening level
Cadmium	1/8	NA	1	0.66	1.52	Yes - exceeds screening level
Cobalt	2/8	NA	2	3	0.67	No - does not exceed screening level
Iron	8/8	NA	272.5	1,000	0.27	No - does not exceed screening level
Manganese	8/8	NA	40	80	0.5	No - does not exceed screening level
Nickel	2/8	NA	3.5	87.7	0.04	No - does not exceed screening level
Selenium	3/8	NA	2.5	5	0.5	No - does not exceed screening level
Thallium	2/8	NA	2.5	4	0.63	No - does not exceed screening level
Zinc	3/8	NA	3	58.9	0.05	No - does not exceed screening level

a. No suitable data was available.
b. Source: Paller and Wike (1996b).
c. See Table B-1.
d. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
e. NA = Not available.

Table B-8. Selection of sediment contaminants of concern for Par Pond maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Sediment Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	2,100	NA[d]	---	No - does not exceed two times the average background
Antimony	1/4	2.7	4	12	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	4	7.24	---	No - does not exceed two times the average background
Barium	4/4	43.4	24.7	NA	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	NA	---	No - does not exceed two times the average background
Chromium	4/4	6.6	3.2	52.3	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.7	NA	---	No - does not exceed two times the average background
Copper	4/4	3.3	2.4	18.7	---	No - does not exceed two times the average background
Lead	4/4	5.7	6.1	30.2	---	No - does not exceed two times the average background
Manganese	4/4	137.4	396.2	460	0.86	No - does not exceed screening level
Mercury	127/149	0.067	0.484	0.13	3.72	Yes - exceeds two times the background and screening level
Nickel	4/4	2.5	1.3	15.9	---	No - does not exceed two times the average background
Selenium	1/4	2.8	4	NA	---	No - does not exceed two times the average background
Thallium	2/4	3.0	6.4	NA	---	Yes - exceeds two times the average background and no suitable screening level available
Vanadium	4/4	9.9	5.5	NA	---	No - does not exceed two times the average background
Zinc	4/4	6.6	5.2	124	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	20.6	NA	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.46	25	0.02	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

Table B-9. Selection of sediment contaminants of concern for Par Pond average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[a]	Sediment Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	1,619	NA[d]	---	No - does not exceed two times the average background
Antimony	1/4	2.7	3.4	12	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	3.4	7.24	---	No - does not exceed two times the average background
Barium	4/4	43.4	17.2	NA	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	NA	---	No - does not exceed two times the average background
Chromium	4/4	6.6	2.4	52.3	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.5	NA	---	No - does not exceed two times the average background
Copper	4/4	3.3	1.8	18.7	---	No - does not exceed two times the average background
Lead	4/4	5.7	4.1	30.2	---	No - does not exceed two times the average background
Manganese	4/4	137.4	169.1	460	---	No - does not exceed two times the average background
Mercury	127/149	0.067	0.077	0.13	---	No - does not exceed two times the average background
Nickel	4/4	2.5	1	15.9	---	No - does not exceed two times the average background
Selenium	1/4	2.8	3.1	NA	---	No - does not exceed two times the average background
Thallium	2/4	3.0	4.1	NA	---	No - does not exceed two times the average background
Vanadium	4/4	9.9	3.6	NA	---	No - does not exceed two times the average background
Zinc	4/4	6.6	3.3	124	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	16.2	NA	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.28	25	0.01	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

Table B-10. Selection of surface soil contaminants of concern for Par Pond maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Surface Soil Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	2,100	600	---	No - does not exceed two times the average background
Antimony	1/4	2.7	4	NA[d]	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	4	60	---	No - does not exceed two times the average background
Barium	4/4	43.4	24.7	3,000	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	NA	---	No - does not exceed two times the average background
Chromium	4/4	6.6	3.2	0.4	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.7	1,000	---	No - does not exceed two times the average background
Copper	4/4	3.3	2.4	50	---	No - does not exceed two times the average background
Lead	4/4	5.7	6.1	500	---	No - does not exceed two times the average background
Manganese	4/4	137.4	396.2	100	3.96	Yes - exceeds two times the background and screening level
Mercury	127/149	0.067	0.484	0.1	4.84	Yes - exceeds two times the background and screening level
Nickel	4/4	2.5	1.3	200	---	No - does not exceed two times the average background
Selenium	1/4	2.8	4	70	---	No - does not exceed two times the average background
Thallium	2/4	3.0	6.4	NA	---	Yes - exceeds two times the average background and no suitable screening level available
Vanadium	4/4	9.9	5.5	20	---	No - does not exceed two times the average background
Zinc	4/4	6.6	5.2	200	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	20.6	NA	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.46	100	0.00	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-3.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

since the maximum detected concentration exceeded two times the average background concentration and no suitable soil screening level was available. All other inorganics had maximum concentrations that did not exceed two times the average background concentrations. Acetone was conservatively retained as a sediment COC since no suitable screening level was available. No inorganic contaminants had average concentrations in excess of two times their background concentrations (Table B-11). Acetone was also conservatively retained as a COC under the average scenario since no suitable soil screening level was available.

Terrestrial Plants

Mercury (HQ = 1.61) and thallium (HQ = 6.4) were the only inorganic contaminants whose maximum concentration exceeded its terrestrial plant screening level (Table B-12). All other inorganics except manganese had maximum concentrations less than two times the average background concentrations. Acetone was conservatively retained as a terrestrial plant COC under the maximum scenario since no suitable screening level was available. No inorganics had average concentrations that exceeded two times the average background concentrations (Table B-13). Acetone was conservatively retained as a sediment COC under the average scenario since no suitable screening level was available.

Mercury Modeling in the Foodchain

Using the maximum concentration of mercury in fish, the HI for the bald eagle at Par Pond was 9.54 (Table B-14). Using the average concentrations, a HI value of 2.02 was calculated. For the cottontail rabbit, a HI of 0.34 was calculated using the maximum concentrations of mercury in plants and surface soils (Table B-14). A HI value of 0.05 was calculated for the cottontail rabbit using the average concentrations of mercury in those media. For the wood stork, an HI of 1.50 was calculated using the maximum fish and sediment concentrations (Table B-14). Using the average concentrations, a HI of 0.58 was generated.

Risk Characterization - Discussion

To begin with, due to the general absence of COCs with similar modes of action, the calculation of HI values for sediments, surface soils, or terrestrial plants was not applicable.

Surface Water

In Par Pond surface water barium, beryllium, and cadmium exceeded screening levels. However, the HQ values were relatively low. Beryllium and cadmium were detected only in one sample, suggesting that the presence of these inorganics in surface waters is not widespread. Barium was detected in all surface water samples, but the HQ values may be due to the conservatism inherent in the screening level. For example, background barium concentrations in river waters in the U.S. range up to 150 micrograms per liter (Jorgensen, Nielsen, and Jorgensen 1991), two orders of magnitude higher than the screening level. Appreciable levels of barium sulfate occur in surface waters because natural waters often contain high sulfate concentrations (ATSDR 1992). Background levels of barium at many Department of Defense sites frequently exceed the screening level. Also, barium was not a COC in sediments, as discussed below. Fluctuating water levels in Par Pond under the Proposed Action could potentially result in resuspension of contaminants into the water column. However, Paller and Wike (1996b) did not observe increased inorganic contaminant concentrations in Par Pond surface water during the recent drawdown and refill of the impoundment. For these reasons, it is unlikely that barium, beryllium, or cadmium pose significant potential risks to aquatic receptors.

Table B-11. Selection of surface soil contaminants of concern for Par Pond average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[a]	Surface Soil Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	1,619	600	---	No - does not exceed two times the average background
Antimony	1/4	2.7	3.4	NA[d]	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	3.4	60	---	No - does not exceed two times the average background
Barium	4/4	43.4	17.2	3,000	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	NA	---	No - does not exceed two times the average background
Chromium	4/4	6.6	2.4	0.4	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.5	1,000	---	No - does not exceed two times the average background
Copper	4/4	3.3	1.8	50	---	No - does not exceed two times the average background
Lead	4/4	5.7	4.1	500	---	No - does not exceed two times the average background
Manganese	4/4	137.4	169.1	100	---	No - does not exceed two times the average background
Mercury	127/149	0.067	0.077	0.1	---	No - does not exceed two times the average background
Nickel	4/4	2.5	1	200	---	No - does not exceed two times the average background
Selenium	1/4	2.8	3.1	70	---	No - does not exceed two times the average background
Thallium	2/4	3.0	4.1	NA	---	No - does not exceed two times the average background
Vanadium	4/4	9.9	3.6	20	---	No - does not exceed two times the average background
Zinc	4/4	6.6	3.3	200	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	16.2	NA	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.28	100	0.00	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-3.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

Table B-12. Selection of terrestrial plant contaminants of concern for Par Pond maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Terrestrial Plant Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	2,100	50	---	No - does not exceed two times the average background
Antimony	1/4	2.7	4	5	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	4	10	---	No - does not exceed two times the average background
Barium	4/4	43.4	24.7	500	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	10	---	No - does not exceed two times the average background
Chromium	4/4	3.3	3.2	1	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.7	20	---	No - does not exceed two times the average background
Copper	4/4	6.6	2.4	100	---	No - does not exceed two times the average background
Lead	4/4	5.7	6.1	50	---	No - does not exceed two times the average background
Manganese	4/4	137.4	396.2	500	0.79	No - does not exceed screening level
Mercury	127/149	0.067	0.484	0.3	1.61	Yes - exceeds two times the background and screening level
Nickel	4/4	2.5	1.3	30	---	No - does not exceed two times the average background
Selenium	1/4	2.8	4	1	---	No - does not exceed two times the average background
Thallium	2/4	3.0	6.4	1	6.4	Yes - exceeds two times the background and screening level
Vanadium	4/4	9.9	5.5	2	---	No - does not exceed two times the average background
Zinc	4/4	6.6	5.2	50	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	20.6	NA[d]	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.46	100,000	0.00	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-4.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

Table B-13. Selection of terrestrial plant contaminants of concern for Par Pond average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[a]	Terrestrial Plant Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	4/4	6,456	1,619	50	---	No - does not exceed two times the average background
Antimony	1/4	2.7	3.4	5	---	No - does not exceed two times the average background
Arsenic	1/4	2.5	3.4	10	---	No - does not exceed two times the average background
Barium	4/4	43.4	17.2	500	---	No - does not exceed two times the average background
Beryllium	4/4	0.2	0.1	10	---	No - does not exceed two times the average background
Chromium	4/4	6.6	2.4	1	---	No - does not exceed two times the average background
Cobalt	4/4	0.6	0.5	20	---	No - does not exceed two times the average background
Copper	4/4	3.3	1.8	100	---	No - does not exceed two times the average background
Lead	4/4	5.7	4.1	50	---	No - does not exceed two times the average background
Manganese	4/4	137.4	169	500	---	No - does not exceed two times the average background
Mercury	127/149	0.067	0.077	0.3	---	No - does not exceed two times the average background
Nickel	4/4	2.5	1	30	---	No - does not exceed two times the average background
Selenium	1/4	2.8	3.1	1	---	No - does not exceed two times the average background
Thallium	2/4	3.0	4.1	1	---	No - does not exceed two times the average background
Vanadium	4/4	9.9	3.6	2	---	No - does not exceed two times the average background
Zinc	4/4	6.6	3.3	50	---	No - does not exceed two times the average background
Organics (ug/kg)						
Acetone	4/4	18.7	16.2	NA[d]	---	Yes - no suitable screening level available
Xylene	2/4	0.18	0.28	100,000	0.00	No - does not exceed screening level

a. Source: Paller and Wike (1996a).
b. See Table B-4.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not available.

Table B-14. Results of mercury modeling in the foodchain for bald eagle, cottontail rabbit, and wood stork in Par Pond and L-Lake.

Receptor	Waterbody	Hazard Index: Maximum Concentration	Hazard Index: Average Concentration
Bald eagle	Par Pond	9.54	2.02
	L-Lake	3.21	1.28
Eastern cottontail	Par Pond	0.34	0.05
	L-Lake	0.26	0.05
Wood stork	Par Pond	1.5	0.58
	L-Lake	0.81	0.29

Sediments

Of all of the contaminants detected in Par Pond sediments, only mercury had a maximum concentration in excess of two times the average background concentration and the screening level, and its HQ value (3.7) was not significantly elevated. Moreover, it is unlikely that benthic invertebrates would be exposed to the maximum concentration of mercury in sediments. The average concentration of mercury was less than two times the average background concentration and the sediment screening level. The relatively large number of samples analyzed for mercury in Par Pond sediments (n = 149) increases the confidence in use of the average concentration. Acetone was conservatively retained as a COC since no suitable screening level was available. Although this organic does not naturally occur in sediments, the maximum detected concentration only slightly exceeded the average concentration in background samples, and the average concentration in Par Pond was less than the average concentration in background. Also, acetone is a common laboratory contaminant. Thus, it is unlikely that adverse effects to benthic organisms are occurring or would occur as a result of exposure to mercury or acetone in sediments.

Surface Soils

In soils, mercury was also a COC (HQ = 4.8) using the maximum concentration, as was manganese (HQ = 4). Yet both HQ values were not significantly elevated. It is unlikely that soil invertebrates would be exposed to the maximum concentration of these inorganics in surface soils. The average concentration of mercury was less than two times the average background concentration and the soil screening level. Again, the relatively large number of samples analyzed for mercury in Par Pond sediments (soils) increases the statistical validity of the average concentration. The average concentration of manganese did not exceed two times the average background concentration. Acetone was conservatively retained as a COC since no suitable screening level was available. Although this organic is not naturally occurring in soils, the maximum detected concentration only slightly exceeded the average concentration in background samples, and the average concentration in Par Pond was less than the average concentration in background. Also, acetone is a common laboratory contaminant. Thallium was conservatively retained as a COC since its maximum concentration exceeded two times the average background and no screening level was available. Yet thallium was only detected in two of four samples and the average detected concentration did not exceed two times the average background concentration. As a result, it is unlikely that adverse effects to earthworms or soil microbes would occur as a result of exposure to mercury, manganese, acetone, or thallium in exposed sediments that become surface soils.

Terrestrial Plants

Of all of the contaminants detected in Par Pond sediments that could eventually become surface soils, mercury had a maximum concentration in excess of two times the average background concentration and the plant screening level, but its HQ value (1.6) was rather low. The maximum concentration of thallium exceeded the screening level. Yet this appears to be due in large part to the conservatism inherent in the screening level. Specifically, the average background concentration of thallium was three times the screening level. Similar to benthos and soil invertebrates, it is unlikely that terrestrial plants would be exposed to the maximum concentration of mercury or thallium in sediments. The average concentrations of mercury and thallium were less than two times the average background concentrations and the terrestrial plant screening levels. Again, the relatively large number of samples analyzed for mercury in Par Pond sediments (n = 149) increases the confidence in use of the average concentration.

Acetone was conservatively retained as a terrestrial plant COC since no suitable screening level was available. Although this organic is not naturally occurring in sediments, the maximum detected concentration only slightly exceeded the average concentration in background samples, and the average concentration in Par Pond was less than the average concentration in background. Organics are also not transferred from soil to plant tissue to the degree that inorganics are. Also, wetland and semi-aquatic plants aggressively invaded newly created wetland soils during the recent drawdown, suggesting that conditions conducive to growth and propagation of plants exist regardless of the presence of contaminants (Wike et al. 1994). Therefore, it is unlikely that terrestrial plants would experience adverse effects as a result of exposure to mercury or acetone in surface soils (exposed sediments).

Modeling of Mercury in the Foodchain

For the modeling of mercury in the foodchain, HI values for the cottontail indicated that risks were insignificant. This was the case for both the maximum and average mercury concentrations in plants and soil. Paller and Wike (1996a) collected cotton rats along the shore of Par Pond during drawdown in 1995 and analyzed them for selected radiological and non-radiological contaminants. Mercury was detected in 37 percent of the cotton rat samples (n = 29) and the maximum whole body concentration was 0.03 mg/kg. Based on a review of the literature on the effects of mercury on wildlife, Thompson (1996) suggested a mercury concentration of approximately 30 mg/kg wet weight in the liver or kidney as lethal or at least harmful to wild mammals. Note that the mercury concentrations in cotton rats were generally below soil levels, indicating little or no bioconcentration of this metal.

Cadmium and lead were also detected in cotton rat samples at maximum whole body concentrations of 0.765 and 2.5 mg/kg, respectively, and average concentrations of 0.19 and 2.19 for cadmium and lead, respectively. In a systematic study of background lead levels in soft tissues of small mammals Ma (1996) concluded that on sandy soils average kidney concentrations of lead are 0.11 to 0.44 mg/kg in mice and voles and 3.8 to 5.5 mg/kg for shrews. Whole-body background levels would undoubtedly be much higher, especially since most lead is sequestered in the bones; certainly higher than the maximum and average detected concentrations in Par Pond cotton rats.

Cooke and Johnson (1996) suggest a 100 mg/kg kidney cadmium concentration as a critical concentration in wild mammals. The maximum detected whole body concentrations of cadmium in Par Pond cotton rats was much lower than this critical concentration. For these reasons, it is likely that arsenic, cadmium, and mercury would most likely pose little or no potential risk to small mammals who may inhabit the shores of Par Pond as the lake level fluctuates or decreases.

As mentioned earlier, modeling of mercury in the foodchain was undertaken in this ERA for several reasons. Most importantly, the modeling was performed due to the presence of detectable levels of mercury in Par Pond and L-Lake fish that are prey for piscivorous receptors. In particular, they are prey for birds such as the bald eagle and wood stork. Mercury concentrations in fish in several Par Pond studies exceeded the mercury value in fish that has been proposed as protective of piscivorous birds of 0.1 mg/kg (Eisler 1987). However, this value is a generalized concentration that is not species-specific for toxicity. It also does not take into account species-specific differences in behavior and physiology that influence the amount of contaminated fish a species may consume and amount of mercury they absorb. As such, the value of 0.1 mg/kg should be viewed only as an initial screening concentration. Therefore, again, due to exceedances of this value in Par Pond (and L-Lake) fish, modeling was performed which incorporated site-specific parameters and species-specific toxicity data.

For the modeling of potential risks to the bald eagle, the HI value for the average and maximum mercury concentration in Par Pond fish indicated potential risks. However, this value was calculated using several conservative assumptions, including the following:

- 100 percent absorption of mercury in the gut
- 100 percent of food as Par Pond fish
- home range = Par Pond
- exposure to the maximum concentration detected in fish
- 100 percent of fish contain the maximum detected concentration of mercury

It is highly unlikely that these assumptions are indicative of actual field conditions. Par Pond was assumed to equal the home range of the eagle. Par Pond is approximately 1,012 hectare in size. Although the home range of the bald eagle can vary greatly and is dependent on a number of factors, EPA (1993) has presented a typical home range for the eagle of 1,830 hectares (18.3 square kilometers). Using the alternative home range and the other conservative assumptions, HI values of 5.3 and 1.1 are generated for the maximum and average exposure scenarios, respectively.

The fact that individual bald eagles are present on SRS for only a portion of the year, generally late fall/early winter to late spring (Sprunt and Chamberlain 1970), also reduces the potential risks associated with exposure to mercury from Par Pond. If the bald eagle's time on SRS is taken into account (an average of nine months of the year, or 75 percent of the year; Wike et al. 1994), the HI values decrease to 3.9 and 0.8 for the maximum and average scenarios, respectively.

Also, 100 percent absorption in the gut is highly unlikely. As little as 24 percent of ingested metals may be absorbed into the gut (Freeman et al. 1993). Absorption of mercury in the gut is dependent on the amount of methyl mercury ingested, which is more toxic and is absorbed more readily than elemental mercury (Klaassen, Amdur, and Doull 1986). Methyl mercury generally comprises up to 95 percent of total mercury found in fish (Wiener and Spry 1996), but the actual amount of ingested mercury absorbed is likely to be less than 95 percent of total mercury. It was also assumed that the bald eagle fed exclusively on Par Pond fish. Bald eagles are opportunistic feeders known to eat a variety of foods, including birds, small mammals, and road kills (Stalmaster 1987), and birds on SRS have been observed foraging not only on fish but on coots (Hart et al. 1986) and on road kills (Mayer, Hoppe, and Kennamer

1986). As a result, it is unlikely that bald eagles would feed exclusively on Par Pond fish or exclusively on any forage from Par Pond.

Also, it is unlikely that the eagle would be exposed to the maximum detected concentrations of mercury in fish. Statistically it is more likely that they would be exposed to the average concentration which again yielded a HI less than 1. Since the average concentration scenario HI value was less than 1.0 when using only a few of the more realistic parameters, it is unlikely that mercury in Par Pond fish pose a significant potential risk to the bald eagle.

It should also be noted that for this ERA, the most conservative TRV available from all avian laboratory toxicity studies for mercury was used. Other studies in the literature present less conservative toxicity data for avian species exposure to mercury. To illustrate, ORNL (1996) presented an LOAEL of 0.9 mg/kg/day for the Japanese quail. Using the metabolic scaling factor for the eagle, a final TRV of 0.29 mg/kg/day is calculated. If this TRV is used in the model, HI values of 1.32 and 0.28 are generated for the maximum and average concentration exposure scenarios, respectively. Taking the realistic home range described above into account for the maximum concentration scenario, an HI value of 0.73 is obtained, indicating insignificant potential risks. It should be noted that for the inclusion of the more realistic home range, it was assumed that concentrations of mercury in forage from other areas on SRS were lower than at Par Pond.

In addition to the modeling discussed above, a study on the potential effects of mercury and cesium-137 on bald eagles on Par Pond and L-Lake was recently conducted (Hart et al. 1996). The study compared the levels of mercury in largemouth bass with doses of mercury known to cause toxic effects in laboratory studies. The study concluded that the consumption of mercury-contaminated fish would not result in toxic effects on bald eagles, although it conceded that sublethal effects may be possible. Yet the foodchain modeling study discussed above, which was based on sublethal effects, indicated that adverse, chronic effects are unlikely. Most importantly, bald eagles occupying the nest near Par Pond have successfully reproduced in recent years (Hart et al. 1996). Hart et al. (1996) suggested that the successful reproduction of eagles on SRS indicates that if sublethal effects on eagles are occurring, they are not substantially affecting reproduction.

HI values for the wood stork were 1.5 for the maximum concentration scenario and 0.58 for the average exposure scenario. For the average concentration, this indicates that if this species forages on Par Pond fish, potential risks from exposure to mercury would be insignificant. The HI value for the maximum scenario indicates potential risks. However, calculations were also performed with several conservative assumptions. If more realistic values had been used for these parameters, the HI values would have been much lower. For example, as mentioned earlier, the wood stork is found on SRS for an average of eight months of the year (66 percent of the year; LeMaster 1996). If this value is used in the equations to calculate potential risks for the maximum concentration scenario, the HI value drops to 0.99. Also, it is much more likely that the wood stork would be exposed to the average concentration of mercury in small fish; the average concentration HI is approximately 39 percent of the maximum concentration HI. Taking this into account, the maximum HI value of 0.99 decreases to 0.39. Wood storks have not been observed feeding on Par Pond in many years (LeMaster 1996), but if they were to forage on the impoundment, it appears that potential risks from exposure to mercury would be low.

Also, if the less conservative toxicity study data mentioned in the bald eagle discussion is considered, a final TRV for the wood stork of 0.40 mg/kg/day is obtained. When this value is used in the model calculations, HI values of 0.19 and 0.07 are generated for the maximum and average concentration exposure scenarios, respectively. These would also indicate insignificant potential risks to the wood stork.

Par Pond Fish Community

Several studies have been conducted to evaluate the concentration of mercury in Par Pond fish with respect to adverse effects on the fish community. Paller and Wike (1996b) reported maximum concentrations of 3.18 mg/kg of mercury in Par Pond bass, 0.216 mg/kg in lake chubsucker, and 0.203 mg/kg in bluegill. Newman and Messier (1994) investigated mercury bioaccumulation in mosquitofish on SRS. The maximum detected concentration in Par Pond mosquitofish was 0.02 mg/kg. As part of the Savannah River Ecology Laboratory Wood Stork Program mentioned earlier, several species of fish were collected and analyzed for mercury. A maximum concentration among all fish of 0.42 was detected in a warmouth (Bryan, Brisbin, and Jagoe 1997). In mercury-sensitive species such as walleye, brain tissue concentrations of 3 mg/kg or greater probably indicate toxic effects (Wiener and Spry 1996). For muscle tissue, field studies indicated that residues of 6 to 20 mg/kg are associated with toxicity, and in the laboratory ranges are similar, with muscle residues of 5 to 8 mg/kg in walleyes and 10 to 20 mg/kg in salmonids causing sublethal effects or death (Wiener and Spry 1996).

All of these toxic concentrations are higher than the concentrations observed in Par Pond fish, with the exception of the maximum value detected in bass in Par Pond. However, it should be noted that the Par Pond values are whole body concentrations, whereas the toxic concentrations mentioned above are organ-specific. Wiener and Spry (1996) indicate that whole body concentrations associated with sublethal or lethal toxic effects are about 5 mg/kg for brook trout and 10 mg/kg for rainbow trout. These same authors suggest a NOAEL of 3 mg/kg whole body for brook trout. EPA (1985) suggested a criterion of 5.0 mg/kg whole body as protective of brook trout. Eisler (1987) has suggested that individual tissue concentrations (liver, kidney, blood, brain) in excess of 1.1 mg/kg can be considered to be presumptive evidence of an environmental mercury problem. Also, the value of 1.1 mg/kg presented by Eisler (although tissue specific) is approximately twice the average whole body concentration of mercury detected in Par Pond bass (0.673 mg/kg; Paller and Wike 1996b). The maximum concentrations in chubsucker, bluegill, and mosquitofish are much lower than Eisler's value. From these values, it is evident that little overlap exists between the concentrations of mercury detected in Par Pond fish and the concentrations of mercury known to cause toxic effects in fish. Hence, it is unlikely that mercury poses potential risks to fishes that inhabit Par Pond.

It should be noted that the average concentration of mercury detected in Par Pond bass (and L-Lake bass) is comparable to or lower than the average concentration detected in bass from many streams, reservoirs, and rivers in South Carolina (Younginer 1997). Table B-15 presents the average concentration of mercury in largemouth bass in a number of South Carolina waterbodies where concentrations are comparable to or higher than those in Par Pond bass.

These data suggest that bald eagles that forage on Par Pond or L-Lake largemouth bass are generally exposed to lower levels of mercury than eagles that forage on other rivers and reservoirs in the Coastal Plain of South Carolina. As such, potential risks from mercury exposure appear to be lower for this species if they forage on SRS reservoirs than if they forage on other Coastal Plain Waterbodies.

Moreover, Scheuhammer, and Blancher (1994) observed reproductive effects on loons (*Gavia immer*) when mercury concentrations in prey, generally small fish, averaged less than 0.3 mg/kg. Concentrations of mercury in small fish in Par Pond and L-Lake of the size preferred by the wood stork averaged greater than 0.3 mg/kg (Bryan, Brisbin, and Jagoe 1997). Also, Scheuhammer and Blancher (1994) determined

Table B-15. Average concentrations of mercury in largemouth bass in selected South Carolina lakes and rivers.

Waterbody	Concentration (mg/kg)
Par Pond[a]	0.673
L-Lake[b]	0.425
Black River	2.01
Combahee River	1.61
Edisto River	1.84
Flat Rock Pond	0.72
Great Pee Dee River	1.28
Intracoastal Waterway	1.34
Lake Marion	0.37
Langley Pond	1.65
Little Pee Dee River	2.33
Lyches River	1.52
North Fork Edisto River	1.41
Pocotaligo River	1.63
Savannah River (Beech Island area)	0.75
South Fork Edisto River	2.18
Webb Wildlife Center	1.24
Vaucluse Pond	0.92
Waccamaw River	1.63
Windsor Lake	0.47

a. As reported by Paller and Wike (1996b).
b. As reported by Paller (1996).

that up to 30 percent of the lakes in Ontario with fish small enough for loons to forage on had mercury concentrations in fish greater than 0.3 mg/kg, although mercury concentrations were pH dependent.

The EPA National Study of Chemical Residues in Fish (EPA 1992) presents data on mercury concentrations in several fish species collected from 1986-1989 at 374 locations (a mix of sites known to be contaminated and background sites). More than 60 percent of the waterbodies contained fish tissue with concentrations greater than 0.1 mg/kg (Eisler's value for protection of avian piscivores).

It should be noted that all of the mercury concentrations in fish discussed in the text and tables above pertain to total mercury. It is widely known that methyl mercury is the more toxic form of this metal. Also, toxic effects of methyl mercury on more critical life stages, such as eggs and embryos, are the most likely manifestations of mercury in the aquatic environment. In fact, Wiener and Spry (1996) concluded that the primary effect of elevated methyl mercury on fish populations is reduced reproductive success resulting from toxicity of maternally derived mercury to embryonic and larval stages. However, if it is assumed that the ratios of methyl mercury in the laboratory study fish are comparable to the levels of methyl mercury in Par Pond fish, there is still little overlap in toxic and observed concentrations. Also, the species most sensitive to mercury, such as walleye and trout, were used in the toxicity studies cited above. Most importantly, despite the presence of contaminants, Par Pond supports a diverse, self-sustaining, and relatively stable fish community that is similar to those found in other southeastern reservoirs (Paller and Wike 1996b).

B.2.2 RADIOLOGICAL CONTAMINANTS

Risk Characterization - Results and Discussion

In Par Pond, only cesium-137 and cobalt-60 exceeded the initial screening level of two times the reference background concentration. Radiation doses for each pathway and each receptor species for these COCs for fish are presented in Table B-16. Radiation doses for avian species are presented in Table B-17.

These radiation dose values (a maximum of 360 millirad per year for fish and 2,517 millirad a year for avian species) are well below the 365,000 millirad per year (1.0 rad per day) DOE limit for aquatic organisms or the 36,500 mrad/yr (0.1 rad per day) limit for terrestrial organisms. Therefore, the potential ecological risks from radiological contaminants in Par Pond media can be considered to be very small.

Table B-16. Radiation dose to fish in Par Pond (in millirad per year).

Receptor	Dose from Submersion Cs-137	Dose from Submersion Co-60	Dose from Ingestion Cs-137	Dose from Ingestion Co-60	Dose from Sediment Cs-137	Dose from Sediment Co-60	Total dose (mrad/yr)
Maximum Concentrations							
Minnow	0.05	0.0	10.4	0.0	204.7	5.6	221
Largemouth Bass	0.05	0.0	149	0.0	204.7	5.6	360
Average Concentrations							
Minnow	0.03	0.0	7.1	0.0	39.3	0.7	47.2
Largemouth Bass	0.03	0.0	101	0.0	39.3	0.7	141

Table B-17. Radiation dose to avian species from consumption of fish from Par Pond.

Receptor	Food consumption Rate (kg/yr)	Dose from food source (millirad per year) Cs-137	Dose from food source (millirad per year) Co-60	Total dose (millirad per year)
Maximum Concentrations				
Osprey	122	2,517	0.0	2,517
Great blue heron	146	221	0.0	221
Bald Eagle	197	1,962	0.0	1,962
Wood Stork	146	205	0.0	205
Average Concentrations				
Osprey	122	1,708	0.0	1,708
Great blue heron	146	150	0.0	150
Bald Eagle	197	1,331	0.0	1,331
Wood Stork	146	139	0.0	139

In addition, another study of contaminants in Par Pond sediments, Paller and Wike (1996a), examined the potential ecological effects to small mammals (using the cotton rat as a representative receptor). This study concluded that the principal radiological contaminant in Par Pond, cesium-137, is not present in concentrations likely to produce deleterious effects on terrestrial organisms that may utilize the sediments when they are exposed by lower water levels.

B.3 L-LAKE

The major elements of preliminary problem formulation, ecological effects assessment, and exposure assessment for the L-Lake ERA are discussed in Section B.1. Hence, only the risk characterization results and discussion and the site-specific uncertainties are presented in this section.

B.3.1 Non-radiological Contaminants

Risk Characterization - Results

The results of the risk characterization step for each aspect of the L-Lake assessment are presented below.

Sediments

Several of the inorganics detected in L-Lake sediments were present in maximum concentrations that exceeded two times the average background concentration and their sediment screening level (Table B-18). These include arsenic, chromium, copper, lead, manganese, mercury, nickel, and zinc. In addition, aluminum, beryllium, barium, cobalt, thallium, and vanadium were conservatively retained as COCs since their maximum concentrations exceeded background and no suitable sediment screening levels were available. Using the average detected concentrations, no inorganics exceeded two times the average background concentration and the screening level (Table B-19). Beryllium, cobalt, thallium, and vanadium were conservatively retained as COCs since their average concentrations exceeded two times the average background concentration and no suitable screening levels were available.

Surface Soil

Using the maximum detected concentrations, aluminum, arsenic, chromium, manganese, mercury, and vanadium exceeded two times the average background concentration and their soil screening levels (Table B-20). Beryllium and thallium were conservatively retained as COCs since they exceeded two times average background and no suitable screening level was available. The average concentrations of chromium and vanadium exceeded two times the average background concentrations and their screening levels (Table B-21). Beryllium and thallium were conservatively retained as COCs since their average concentrations exceeded two times average background and no suitable screening level was available.

Terrestrial Plants

The maximum concentrations of several inorganics exceeded two times the average background concentrations and screening levels (Table B-22). These include aluminum, arsenic, chromium, lead, manganese, mercury, selenium, thallium, vanadium, and zinc. Using average concentrations, chromium, thallium, and vanadium exceeded two times background and screening levels (Table B-23).

Mercury Modeling in the Foodchain

For the bald eagle, HI values of 3.21 and 1.28 were calculated for the maximum and average exposure scenarios, respectively (Table B-14). The cottontail rabbit had HI values of 0.26 for the maximum scenario and 0.05 for the average scenario (Table B-14). For the wood stork, a HI of 0.81 was calculated for the maximum exposure scenario and a value of 0.29 was generated for the average scenario (Table B-14).

Risk Characterization - Discussion

To begin with, due to the general absence of COCs with similar modes of action, the calculation of HI values for sediments, surface soils, or terrestrial plants was not applicable.

Sediments

The maximum detected concentrations of several metals exceeded sediment screening levels. However, most of these exceedances were low. The HQ value for arsenic (8.49) was slightly elevated, but arsenic was detected in only about one-fourth of the samples. It is unlikely that benthic invertebrates will be exposed to the maximum detected concentrations of all contaminants, including arsenic. Statistically they are likely to be exposed to the average concentrations. Yet, no

Table B-18. *Selection of sediment contaminants of concern for L-Lake maximum contaminant concentrations.*

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Sediment Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6,855	35,000	NA[d]	---	Yes - Exceeds two times the average background and no suitable screening level available
Arsenic	12/44	10.2	61.5	7.24	8.49	Yes - exceeds two times the background and screening level
Barium	44/44	45.7	239	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Beryllium	44/44	0.23	2.29	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Chromium	41/44	6.63	56.1	52.3	1.07	Yes - exceeds two times the background and screening level
Cobalt	42/44	1.33	15.5	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Copper	42/44	2.59	39.2	18.7	2.1	Yes - exceeds two times the background and screening level
Lead	39/44	6.14	56.4	30.2	1.87	Yes - exceeds two times the background and screening level
Manganese	44/44	255	2160	460	4.7	Yes - exceeds two times the background and screening level
Mercury	37/44	0.021	0.365	0.13	2.81	Yes - exceeds two times the background and screening level
Nickel	42/44	2.47	18.2	15.9	1.14	Yes - exceeds two times the background and screening level
Selenium	3/44	12.9	67.5	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Thallium	5/44	9.94	67.5	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Vanadium	44/44	13.7	101	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Zinc	44/44	5.69	137	124	1.1	Yes - exceeds two times the background and screening level

a. Source: Dunn and Martin (1997).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not Available.

Table B-19. Selection of sediment contaminants of concern for L-Lake average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[a]	Sediment Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6,855	10,242	NA[d]	---	No - does not exceed two times the average background
Arsenic	12/44	10.2	17.6	7.24	---	No - does not exceed two times the average background
Barium	44/44	45.7	79.7	NA	---	No - does not exceed two times the average background
Beryllium	44/44	0.23	0.578	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Chromium	41/44	6.63	15.7	52.3	0.3	No - does not exceed screening level
Cobalt	41/44	1.33	3.25	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Copper	42/44	2.59	9.38	18.7	0.5	No - does not exceed screening level
Lead	39/44	6.14	14.9	30.2	0.49	No - does not exceed screening level
Manganese	44/44	255	400	460	---	No - does not exceed two times the average background
Mercury	37/44	0.021	0.064	0.13	0.49	No - does not exceed screening level
Nickel	42/44	2.47	5.07	15.9	0.32	No - does not exceed screening level
Selenium	3/44	12.9	21.7	NA	---	No - does not exceed two times the average background
Thallium	5/44	9.94	20.2	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Vanadium	44/44	13.7	29.0	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Zinc	44/44	5.69	29.6	124	0.24	No - does not exceed screening level

a. Source: Dunn and Martin (1997).
b. See Table B-2.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not Available.

Table B-20. Selection of surface soil contaminants of concern for L-Lake maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Surface Soil Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6,855	35,000	600	58.3	Yes - exceeds two times the background and screening level
Arsenic	12/44	10.2	61.5	60	1.03	Yes - exceeds two times the background and screening level
Barium	44/44	45.7	239	3,000	0.08	No - does not exceed screening level
Beryllium	44/44	0.23	2.29	NA[d]	---	Yes - Exceeds two times the average background and no suitable screening level available
Chromium	41/44	6.63	56.1	0.4	140.3	Yes - exceeds two times the background and screening level
Cobalt	42/44	1.33	15.5	1,000	0.02	No - does not exceed screening level
Copper	42/44	2.59	39.2	50	0.78	No - does not exceed screening level
Lead	39/44	6.14	56.4	500	0.11	No - does not exceed screening level
Manganese	44/44	255	2160	100	21.6	Yes - exceeds two times the background and screening level
Mercury	37/44	0.021	0.365	0.1	3.65	Yes - exceeds two times the background and screening level
Nickel	42/44	2.47	18.2	200	0.09	No - does not exceed screening level
Selenium	3/44	12.9	67.5	70	0.96	No - does not exceed screening level
Thallium	5/44	9.94	67.5	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Vanadium	44/44	13.7	101	20	5.05	Yes - exceeds two times the background and screening level
Zinc	44/44	5.69	137	200	0.69	No - does not exceed screening level

a. Source: Dunn and Martin (1997).
b. See Table B-3.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not Available.

Table B-21. Selection of surface soil contaminants of concern for L-Lake average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average concentration[a]	Surface Soil Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6,855	10,242	600	---	No - does not exceed two times the average background
Arsenic	12/44	10.2	17.6	60	---	No - does not exceed two times the average background
Barium	44/44	45.7	79.7	3,000	---	No - does not exceed two times the average background
Beryllium	44/44	0.23	0.578	NA[d]	---	Yes - Exceeds two times the average background and no suitable screening level available
Chromium	41/44	6.63	15.7	0.4	39.25	Yes - exceeds two times the background and screening level
Cobalt	42/44	1.33	3.25	1,000	0.00	No - does not exceed screening level
Copper	42/44	2.59	9.38	50	0.19	No - does not exceed screening level
Lead	39/44	6.14	14.9	500	0.03	No - does not exceed screening level
Manganese	44/44	255	400	100	---	No - does not exceed two times the average background
Mercury	37/44	0.021	0.064	0.1	0.64	No - does not exceed screening level
Nickel	42/44	2.47	5.07	200	0.03	No - does not exceed screening level
Selenium	3/44	12.9	21.7	70	---	No - does not exceed two times the average background
Thallium	5/44	9.94	20.2	NA	---	Yes - Exceeds two times the average background and no suitable screening level available
Vanadium	44/44	13.7	29.0	20	1.45	Yes - exceeds two times the background and screening level
Zinc	44/44	5.69	29.6	200	0.15	No - does not exceed screening level

a. Source: Dunn and Martin (1997).
b. See Table B-3.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.
d. NA = Not Available.

Table B-22. Selection of terrestrial plant contaminants of concern for L-Lake maximum contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Maximum Detected Concentration[a]	Terrestrial Plant Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6,855	35,000	50	700	Yes - exceeds two times the background and screening level
Arsenic	12/44	10.2	61.5	10	6.15	Yes - exceeds two times the background and screening level
Barium	44/44	45.7	239	500	0.48	No - does not exceed screening level
Beryllium	44/44	0.23	2.29	10	0.23	No - does not exceed screening level
Chromium	41/44	6.63	56.1	1	56.1	Yes - exceeds two times the background and screening level
Cobalt	42/44	1.33	15.5	20	0.78	No - does not exceed screening level
Copper	42/44	2.59	39.2	100	0.39	No - does not exceed screening level
Lead	39/44	6.14	56.4	50	1.13	Yes - exceeds two times the background and screening level
Manganese	44/44	255	2,160	500	4.32	Yes - exceeds two times the background and screening level
Mercury	37/44	0.021	0.365	0.3	1.22	Yes - exceeds two times the background and screening level
Nickel	42/44	2.47	18.2	30	0.61	No - does not exceed screening level
Selenium	3/44	12.9	67.5	1	67.5	Yes - exceeds two times the background and screening level
Thallium	5/44	9.94	67.5	1	67.5	Yes - exceeds two times the background and screening level
Vanadium	44/44	13.7	101	2	50.5	Yes - exceeds two times the background and screening level
Zinc	44/44	5.69	137	50	2.74	Yes - exceeds two times the background and screening level

a. Source: Dunn and Martin (1997).
b. See Table B-4.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.

Table B-23. Selection of terrestrial plant contaminants of concern for L-Lake average contaminant concentrations.

Contaminant of Potential Concern	Frequency of Detection	Average Background (Reference) Concentration[a]	Average Concentration[a]	Terrestrial Plant Screening Level[b]	Hazard Quotient[c]	Retained as a COC?
Inorganics (mg/kg)						
Aluminum	44/44	6855	10,242	50	---	No - does not exceed two times the average background
Arsenic	12/44	10.2	17.6	10	---	No - does not exceed two times the average background
Barium	44/44	45.7	79.7	500	---	No - does not exceed two times the average background
Beryllium	44/44	0.23	0.578	10	0.06	No - does not exceed screening level
Chromium	41/44	6.63	15.7	1	15.7	Yes - exceeds two times the background and screening level
Cobalt	42/44	1.33	3.25	20	0.16	No - does not exceed screening level
Copper	42/44	2.59	9.38	100	0.09	No - does not exceed screening level
Lead	39/44	6.14	14.9	50	0.3	No - does not exceed screening level
Manganese	44/44	255	400	500	---	No - does not exceed two times the average background
Mercury	37/44	0.021	0.064	0.3	0.21	No - does not exceed screening level
Nickel	42/44	2.47	5.07	30	0.17	No - does not exceed screening level
Selenium	3/44	12.9	21.7	1	---	No - does not exceed two times the average background
Thallium	5/44	9.94	20.2	1	20.2	Yes - exceeds two times the background and screening level
Vanadium	44/44	13.7	29.0	2	14.5	Yes - exceeds two times the background and screening level
Zinc	44/44	5.69	29.6	50	0.59	No - does not exceed screening level

a. Source: Dunn and Martin (1997).
b. See Table B-4.
c. No hazard quotient was calculated if the representative concentration did not exceed two times the average background or if no screening level was available.

sediment contaminants were present in average concentrations that exceeded screening levels.

Some metals (aluminum, barium, beryllium, selenium, and vanadium) had maximum concentrations that exceeded two times average background but could not be quantitatively assessed since no suitable sediment screening levels were available. Under the average concentration scenario, beryllium, cobalt, thallium and vanadium exceeded two times the average background but could not be quantitatively assessed due to the absence of screening levels. Of these inorganics, selenium and thallium were detected in only 3 and 5 of 44 samples, respectively. Also, the average concentrations of aluminum and cobalt either did not exceed two times the average background concentrations or were present in concentrations that did not greatly exceed background. The average concentration of vanadium, however, significantly exceeded the average background concentration. Nonetheless, vanadium is ubiquitous in the environment (Klaassen, Amdur, and Doull 1986), and is not believed to be highly toxic in the environment (Mailman 1980). Thus, it may be naturally elevated. For these reasons, although maximum concentrations of some inorganics exceed conservative screening levels, potential impacts to benthic receptors from inorganics in sediments appear to be unlikely.

Surface Soils

For potential risks to soil invertebrates from inorganics in L-Lake sediments that could become exposed, most HQ values were relatively low, with the exception of aluminum, chromium, and manganese, which were significantly elevated. Despite the high HQ values for these contaminants under the maximum scenario, the average concentrations of aluminum and manganese, which most likely represent realistic exposure concentrations, did not exceed two times the average background concentration. The HQ value for chromium is still in significant excess of its screening level. Yet the elevated HQ appears to be due in large part to the conservative nature of the screening level. The average concentration of chromium in background is more than 16 times the screening level 0.4 mg/kg. Also note that the average detected concentration of this inorganic in L-Lake is barely twice the average background concentration. Under the average scenario, beryllium and thallium were conservatively retained as COCs since they exceeded two times the average background concentration and no suitable soil screening levels were available. Thallium was only detected in 5 of 44 samples. Beryllium had a high frequency of detection, but its average detected concentration only slightly exceeded two times its average background concentration. Additionally, beryllium toxicosis is generally associated with human exposure to airborne forms (Klaassen, Amdur, and Doull 1986). Beryllium is known to decrease fidelity of DNA synthesis, but has not been shown to cause genetic effects to bacterial systems, which may be present in exposed sediments that become surface soils.

Terrestrial Plants

Several inorganics had maximum concentrations in excess of two times average background and terrestrial plant screening levels. Some HQ values were significantly elevated. Under the average scenario, only chromium, thallium and vanadium exceeded two times background and screening levels. Yet, thallium was only detected in 5 of 44 samples. The elevated HQ values for chromium and vanadium appear to be due in large part to the conservatism of the screening levels. The average background concentrations of chromium, thallium, and vanadium are over 6, 9, and 6 times the screening level for those inorganics, respectively. Thus, potential ecological effects to terrestrial plants if sediments are permanently exposed appear to be low.

In the late 1980s, over 40 species of wetland plants were transplanted from Par Pond to L-Lake (Kroeger 1990). The establishment of wetland vegetation exceeded expectations (Kroeger 1990). Almost all species planted in 1987 were present in 1989, and species diversity in planted areas was comparable to Par Pond. Also, the areal cover of macrophytes along L-Lake increased markedly, from 527.51 to 1,359.9 square meters per hectare (2,299.5 to 5,927.8 square feet per acre) from 1990 to 1991 (Wike et al. 1994). L-Lake currently supports a healthy, diverse macrophyte community, including both herbaceous and woody plants (Wike et al. 1994). As a result, it does not appear that adverse effects to L-Lake plants from contaminants are occurring or would occur under the Proposed Action.

Modeling of Mercury in the Foodchain

For modeling of potential risks from mercury uptake, HI values for the cottontail were less than 1.0 for both the maximum and average concentrations. HI values were also less than 1.0 for the wood stork for both the maximum and average mercury concentrations. These values indicated negligible potential risks to these receptors, and most likely indicate insignificant potential risks to other similar species. HI values for these two receptors were calculated using conservative, worst-case assumptions. Using more realistic values for the input parameters, the HI values would most likely have been minuscule.

For the bald eagle, the HI values using the average and maximum concentration scenarios indicated potential risk. Using more realistic values for the input parameters, however, the HI values decrease significantly. For example, using the more realistic home range for the eagle described in Par Pond discussion, the HI values of 3.21 and 1.28 for the maximum and average concentration scenarios, respectively, drop to 0.7 and 0.3 respectively. Using time spent on SRS during the year (75 percent), the values decrease to 0.5 and 0.2 for the maximum and average HI values, respectively. The eagles will also not ingest 100 percent of ingested mercury.

As described in the Par Pond bald eagle assessment, they will also not forage on L-Lake exclusively. They are also much more likely to be exposed to the average concentration of mercury in fish. Taking these mitigating factors into account, it is unlikely that eagles that forage on L-Lake fish would experience adverse effects. They may forage more extensively on the impoundment as water levels decrease and potentially trap fish in smaller areas, but over time, L-Lake would recede to the original stream bed, minimizing fish in the area and subsequent foraging by bald eagles.

As discussed in detail earlier, a study on the potential effects of mercury and cesium-137 on bald eagles on Par Pond and L-Lake was recently conducted (Hart et al. 1996). The study compared the levels of mercury in largemouth bass with doses of mercury known to cause toxic effects in laboratory studies. The study concluded that the consumption of mercury-contaminated fish would not result in toxic effects on bald eagles, although it conceded that sublethal effects may be possible. Yet, the modeling study discussed above, which was based on sublethal effects, indicated that adverse, chronic effects are unlikely. Most importantly, bald eagles on SRS have experienced a high level of breeding success in recent years (Hart et al. 1996).

L-Lake Fish Community

Several studies have been conducted to evaluate the concentration of mercury in L-Lake fish with respect to adverse effects on the fish community. Paller (1996) reported maximum concentrations of 1.07 mg/kg of mercury in L-Lake largemouth bass, 0.142 mg/kg in bluegill, and 0.107 mg/kg in redbreast sunfish. As part of the Savannah River Ecology Laboratory Wood Stork Program mentioned earlier, several species of fish were collected and analyzed for mercury. A maximum concentration among all fish of 0.22 was detected in a redbreast sunfish (Bryan, Brisbin, and Jagoe 1997). A detailed discussion of the effects of mercury on fish is presented in Par Pond fish discussion. In short, the maximum detected concentration in L-Lake bass, and all other fish analyzed, is below the lowest toxic effect levels and suggested criteria available. Hence, it is unlikely that mercury poses potential risks to fishes in L-Lake. Also, the average concentration of mercury in L-Lake largemouth bass (Paller 1996) were comparable or lower to the average concentrations in fish in many other South Carolina waterbodies (see Table B-15). Most importantly, Paller (1996) has observed that at least 19 species of fish are present in the L-Lake fish community which are all common to other southeastern reservoirs, and most or all of these species are successfully reproducing and maintaining self-sustaining populations in the impoundment.

B.3.2 Radiological Contaminants

Risk Characterization - Results

In L-Lake, like Par Pond, only cesium-137 and cobalt-60 exceeded the initial screening level of two times the reference background concentration. Radiation doses for each pathway and each receptor species for these COCs for fish are presented in Table B-24. Radiation doses for avian species are presented in Table B-25. Note that only radiation doses based on mean concentrations are reported for avian species because only mean concentrations were available for L-Lake surface water.

These radiation dose values (a maximum of 274 millirad per year for fish and 1,045 millirad per year for avian species) are well below the 365,000 millirad per year (1.0 rad per day) DOE limit for aquatic organisms or the 36,500 millirad per year (0.1 rad per day) limit for terrestrial organisms. Therefore, the ecological risk from radiological contaminants can be considered to be low.

Table B-24. Radiation dose to fish in L-Lake (millirad per year).

Receptor	Dose from Submersion Cs-137	Dose from Submersion Co-60	Dose from Ingestion Cs-137	Dose from Ingestion Co-60	Dose from Sediment Cs-137	Dose from Sediment Co-60	Total Dose
Maximum Concentrations							
Minnow	0.02	0.04	4.3	0.3	197	14	215
Largemouth Bass	0.02	0.04	62	0.8	197	14	274
Average Concentrations							
Minnow	0.02	0.04	4.3	0.3	13.4	1.1	18
Largemouth Bass	0.02	0.04	62	0.8	13.4	1.1	77

Table B-25. Radiation dose to avian species from consumption of fish from L-Lake (millirad per year).

Receptor	Food Consumption Rate (kg/yr)	Dose from Food Source Cs-137	Dose from Food Source Co-60	Total Dose
Maximum Concentrations				
Osprey	122	1045	0.4	1045
Great blue heron	146	91.8	0.5	92
Bald Eagle	197	815	0.5	815
Wood Stork	146	85.2	0.6	86
Average Concentrations				
Osprey	122	1045	0.4	1045
Great blue heron	146	91.8	0.5	92
Bald Eagle	197	815	0.5	815
Wood Stork	146	85.2	0.6	86

B.4 LOWER THREE RUNS

The major elements of preliminary problem formulation, ecological effects assessment, and exposure assessment for the Lower Three Runs ERA are discussed in Section B.1. Hence, only the risk characterization results and discussion are presented in this section.

B.4.1 NON-RADIOLOGICAL CONTAMINANTS

Risk Characterization - Results and Discussion

As mentioned in Section B.1, non-radiological data for Lower Three Runs sediment were gathered from several sources. In a sample collected in 1994 in Lower Three Runs, all pesticides and herbicides were below detection limits (WSRC 1995). In a 1995 sample, 4,4'-DDE and endrin aldehyde were detected at concentrations of 24 and 15 ug/kg, respectively (WSRC 1996). These detections were above the Region 4 screening value of 3.3 ug/kg. However, the concentration of 4,4'-DDE is less than the Effects Range-Median value from Long et al. (1995). The concentration above the effects range-low and below the effects range-medium is the concentration in which adverse effects may occasionally be observed. No effects range-medium is available for endrin aldehyde, but a Severe Effects Level (SEL) from the Ontario Ministry of the Environment (OME 1992) of 1.3E+05 ug/kg was obtained. The SEL is the concentration above which adverse effects to benthic organisms is highly likely. Since the values for these two compounds are below the effects range-medium and SEL, respectively, their presence does not appear to indicate significant potential risks to benthic organisms. Also, as mentioned above, they were not detected in the same location in 1994.

For inorganics, only aluminum, barium, and zinc were detected in the 1994 sample. Inorganics were not analyzed for in the 1995 sample. All three concentrations were lower than those detected in background samples used for the Par Pond assessment.

The absence of extensive non-radiological data for Lower Three Runs adds uncertainty to the results. However, as mentioned earlier, it is believed that the contaminated areas in the stream channel would remain wet under the Proposed Action due to several factors, decreasing the chances that lower water levels will expose terrestrial receptors to exposed sediments. More importantly, only the maximum concentration of mercury exceeded its sediment screening level in Par Pond; the average concentration did not exceed the screening level and only a few organics were detected at low concentrations. If concentrations of metals and organics are not elevated in Par Pond, it is unlikely that they are elevated downstream in Lower Three Runs.

Also, Newman and Messier (1994) sampled mosquitofish in Lower Three Runs at Patterson's Mill Bridge and analyzed them for mercury. The highest concentration of detected was 0.015 mg/kg. This value is well below all toxic effects levels and criteria for mercury in fish discussed in preceding sections.

B.4.2 RADIOLOGICAL

Risk Characterization - Results and Discussion

As mentioned in Section B.1, radiological data for Lower Three Runs sediments are not abundant. A 1970s study reported cesium-137 values at two sites, one 5 and one 16 miles (8 and 26 kilometers) downstream from the Par Pond dam (Hay and Ragsdale 1978). Cesium-137 values ranged from 2.3 to 215 picocuries per gram at the 5-mile site, and from 4.6 to 17 picocuries per gram at the 16-mile site. Another study characterized the suspended particle matter (5 to 80 micron size fraction) of Lower Three Runs as having 100 to 200 picocuries per gram of cesium-137 (Shure and Gottschalk 1976). These concentrations are comparable to, and somewhat lower than, the concentrations in Steel Creek, as discussed in Section B.5. Therefore, the potential ecological risks for Lower Three Runs, which were determined to be negligible, should be comparable to or lower than that for Steel Creek.

In addition, a series of aerial radiation surveys conducted over Par Pond during the drawdown (1991 through 1993) showed that radioactivity in Lower Three Runs varied slightly as the water level and flow rate changed during pumping, and little or no change occurred between surveys in the spatial distribution or the kinds of radionuclide sources detected (Feimster 1993). Cesium-137 was the only gamma emitter detected in these surveys and was not significantly elevated.

B.5 STEEL CREEK

The major elements of preliminary problem formulation, ecological effects assessment, and exposure assessment for the Steel Creek ERA are discussed in Section B.1. Hence, only the risk characterization results and discussion are presented in this section.

B.5.1 NON-RADIOLOGICAL CONTAMINANTS

Risk Characterization - Results and Discussion

All pesticides and herbicides analyzed for in the 1994 (WSRC 1995) and 1995 (WSRC 1996) samples were below detection limits. For inorganics, only aluminum, barium, and zinc were detected, but were all present in concentrations lower than the average background concentrations used for the L-Lake assessment.

The absence of extensive non-radiological data for Steel Creek adds uncertainty to the results. However, as mentioned earlier, it is believed that the contaminated areas in the stream channel will remain wet under the Proposed Action due to a number of factors, decreasing the chances that lower water levels will expose terrestrial receptors to exposed contaminated sediments. Also, although some metals concentrations in L-Lake sediments were slightly elevated, it did not appear likely that they posed significant potential risks. Since no or low potential risks were determined for L-Lake, it is unlikely that potential risks from inorganics are present downstream. Also, no known sources of organic contaminants are known to occur or have occurred in L-Lake. More importantly, organics were not detected in recent L-Lake sediment analysis (Koch et al. 1996). Therefore, it is unlikely that potential risks from organics are occurring or will occur downstream in Steel Creek.

Also, Newman and Messier (1994) sampled mosquitofish in Steel Creek at the Steel Creek Landing near the edge of SRS and analyzed them for mercury. The highest concentration of detected was 0.046 mg/kg. This value is well below all toxic effects levels and criteria for mercury in fish discussed in preceding sections.

B.5.2 RADIOLOGICAL CONTAMINANTS

Risk Characterization - Results and Discussion

Estimated radiation doses were calculated using the data reported in the SRS Environmental Data supplement to the 1995 SRS Environmental Report (WSRC 1996). However, given the limited amount of data available, the results should be interpreted as having a relatively high uncertainty. Radiation doses for each pathway for fish are presented in Table B-26. Radiation doses for avian species are presented in Table B-27. Only receptors

Table B-26. Radiation dose to fish in Steel Creek (millirad per year).

Receptor	Dose from Submersion		Dose from Uptake		Dose from Sediment		Total dose
	Cs-137	Co-60	Cs-137	Co-60	Cs-137	Co-60	
Minnow	0.06	0.0	13.4	0.0	1.3	2.5	17

Table B-27. Radiation dose to avian species from consumption of fish from Steel Creek (millirad per year).

Receptor	Food Consumption Rate (kg/yr)	Dose from Food		Total dose
		Cs-137	Co-60	
Great blue heron	146	284	0.0	284

historically found in or near Steel Creek were analyzed in this section.

After shutdown of the River Water System and associated drawdown of L-Lake, exposed contaminated sediments could become entrained in stormwater runoff to Steel Creek (as described in Section 4.1.8.2.2). In addition, after shutdown of the River Water System and associated drawdown of L-Lake, it is estimated that the concentration of elemental potassium in Steel Creek water would decrease from the current L-Lake value [approximately 1.4 mg/L (Kretchmer and Chimney 1993)] to a value of approximately 0.3 mg/L (Chimney et al. 1985; duPont 1987), a decrease of approximately 80 percent. In the absence of potassium, aquatic organisms more readily take up cesium, which is a potassium analog (cells "accept" it as potassium because of its chemical similarity). Therefore, as a result of decreased potassium levels in Steel Creek water after drawdown, the concentration of cesium-137 in fish would be expected to increase over the concentrations currently in L-Lake. For example, if cesium were conservatively assumed to increase by a factor of five, and taking into account runoff from exposed contaminated sediments, Tables B-28 and B-29 present the estimated incremental dose to fish and avian species, respectively, after shutdown of the River Water System and the associated drawdown of L-Lake.

The estimated radiation dose values after shutdown of the River Water System and the associated drawdown of L-Lake (a maximum of 71 millirad per year for fish and 1,425 millirad per year for the heron) are well below the 365,000 millirad per year (1.0 rad/day) DOE limit for aquatic organisms or the 36,500 millirad per year (0.1) rad per day) limit for terrestrial organisms. Therefore, the ecological risk from radiological contaminants may be considered insignificant.

Table B-28. Incremental radiation dose increase to fish in Steel Creek (in millirad per year) after shutdown.

Receptor	Dose increment from runoff		Dose increment from potassium decrease		Total dose increment
	Cs-137	Co-60	Cs-137	Co-60	
Minnow	5×10^{-2}	3×10^{-4}	54	Not available	54

Table B-29. Incremental radiation dose increase to avian species in Steel Creek (in millirad per year) after shutdown.

Receptor	Dose increment from runoff		Dose increment from potassium decrease		Total dose increment
	Cs-137	Co-60	Cs-137	Co-60	
Great blue heron	0.90	1.3×10^{-4}	1,141	NA	1,141

NA = Not avaliable.

B.6 TRITIUM IN SRS SURFACE WATERS

Potential ecological effects due to the presence of tritium in SRS waters warrants special attention since tritium is of particular concern to the public. Tritium levels are expected to increase from current levels under both the No-Action and Shutdown Alternatives (see Table 4-26). The highest current and projected concentrations occur in Fourmile Branch, which will increase from a concentration of approximately 227 picocuries per milliliter (September 1996) to approximately 234 picocuries per milliliter (under both the No Action and Shutdown alternatives). A concentration of 234 picocuries per milliliter would result in a radiation dose of approximately 25 millirad per year for minnows and largemouth bass; 92 millirad per year for osprey; 77 millirad per year for the great blue heron; 53 millirad per year for the bald eagle; and 59 millirad per year for the wood stork. All of these radiation dose values are well below the 365,000 millirad per yr (1.0 rad per day) DOE limit for aquatic organisms or the 36,500 millirad per year (0.1 rad per day) limit for these organisms. Therefore, since the radiation doses for the maximum projected tritium level are much lower than the applicable standards, the potential ecological risks from tritium can be considered to be negligible for all affected streams.

B.7 ERA SUMMARY AND CONCLUSIONS

B.7.1 NON-RADIOLOGICAL

A screening-level ERA was performed to assess potential ecological risks from contaminants in Par Pond, L-Lake, Lower Three Runs, and Steel Creek. For the most part, the ERA focused on contaminants in sediments in relation to potential effects of the Proposed Action. The results of contaminant screening against ecological screening levels indicated that only a few maximum concentrations, and fewer average concentrations had, HQ values greater than 1. However, these spotty exceedances were not shown to pose significant potential ecological risks to aquatic receptors, benthic receptors, terrestrial invertebrates, or terrestrial plants.

Modeling of potential ecological risks from exposure to mercury was also performed for two avian receptors, the bald eagle and wood stork, and one terrestrial species, the cottontail rabbit. Conservative exposure parameters were used in the model calculations for each receptor, and maximum and average mercury concentrations were used in applicable media considered in the model. All HI values for the cottontail rabbit were less than 1.0, indicating insignificant risks to this receptor. For the bald eagle and wood stork, HI values greater than 1.0 were calculated for some specific exposure scenarios at Par Pond and L-Lake. However, using more realistic exposure parameters in the model and taking several qualitative factors into consideration, it appears the potential risks from mercury to the bald eagle and wood stork are low. Also, the results of several other ecological studies were assessed qualitatively in the ERA. The results of these studies also supported the assessment of low to negligible risk for a variety of ecological receptors under the Proposed Action.

For these reasons, the assessment endpoints for the ERA, which were the maintenance of aquatic and terrestrial receptor populations, do not appear to be compromised. Therefore, it is unlikely that significant potential risks from non-radiological contaminants will occur in Par Pond, L-Lake, Lower Three Runs, or Steel Creek as a result of the Proposed Action.

B.7.2 RADIOLOGICAL

A screening-level ERA was performed to assess potential ecological risks from radiological contaminants in Par Pond, L-Lake, Lower Three Runs, and Steel Creek. Contaminant screening against ecological screening levels (background concentrations) and the comparison of estimated radiation dose rates to applicable standards indicate that for the two radionuclides that exceed two times the background level (cesium-137 and cobalt-60), the estimated radiation dose rates to selected receptor species are well below the applicable standards.

For this reason, the assessment endpoints for the ERA, which were the maintenance of aquatic and terrestrial receptor populations, do not appear to be compromised. Therefore, it is unlikely that significant potential risks from radiological contaminants will occur in Par Pond, L-Lake, Lower Three Runs, or Steel Creek as a result of the Proposed Action.

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APPENDIX C. OCCUPATIONAL AND PUBLIC HEALTH IMPACTS

LIST OF TABLES

Table C-1. L-Lake - Radiological doses associated with the No-Action Alternative and resulting health effects to the offsite maximally exposed individual (current use) and the general public.[a]

	Maximally exposed individual[b]				Offsite population[c]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[d]	Lifetime dose[e] (rem)	Probability of fatal cancer[d]	Annual dose (person-rem)	Number of fatal cancers[d]	Lifetime dose[e] (person-rem)	Number of fatal cancers[d]
Ingestion:								
Soil	5.7×10^{-11}	2.8×10^{-14}	9.9×10^{-10}	5.0×10^{-13}	5.2×10^{-7}	2.6×10^{-10}	9.0×10^{-6}	4.5×10^{-9}
Soil dermal	1.1×10^{-11}	5.6×10^{-15}	2.0×10^{-10}	9.8×10^{-14}	1.0×10^{-7}	5.1×10^{-11}	1.8×10^{-6}	8.9×10^{-10}
Leafy vegetables	9.8×10^{-9}	4.9×10^{-12}	1.7×10^{-7}	8.6×10^{-11}	8.9×10^{-5}	4.5×10^{-8}	1.6×10^{-3}	7.8×10^{-7}
Other vegetables	7.7×10^{-8}	3.8×10^{-11}	1.3×10^{-6}	6.7×10^{-10}	7.0×10^{-4}	3.5×10^{-7}	1.2×10^{-2}	6.1×10^{-6}
Meat	4.8×10^{-9}	2.4×10^{-12}	8.3×10^{-8}	4.2×10^{-11}	4.3×10^{-5}	2.2×10^{-8}	7.6×10^{-4}	3.8×10^{-7}
Milk	1.7×10^{-8}	8.7×10^{-12}	3.1×10^{-7}	1.5×10^{-10}	1.6×10^{-4}	8.0×10^{-8}	2.8×10^{-3}	1.4×10^{-6}
Subtotal	1.1×10^{-7}	5.5×10^{-11}	1.9×10^{-6}	9.5×10^{-10}	9.9×10^{-4}	5.0×10^{-7}	1.7×10^{-2}	8.7×10^{-6}
Inhalation:								
Air	4.0×10^{-8}	2.0×10^{-11}	7.0×10^{-7}	3.5×10^{-10}	3.6×10^{-4}	1.8×10^{-7}	6.3×10^{-3}	3.2×10^{-6}
Resuspension	2.7×10^{-11}	1.4×10^{-14}	4.8×10^{-10}	2.4×10^{-13}	2.5×10^{-7}	1.2×10^{-10}	4.3×10^{-6}	2.2×10^{-9}
Subtotal	4.0×10^{-8}	2.0×10^{-11}	7.0×10^{-7}	3.5×10^{-10}	3.6×10^{-4}	1.8×10^{-7}	6.3×10^{-3}	3.2×10^{-6}
Total	1.5×10^{-7}	7.5×10^{-11}	2.6×10^{-6}	1.3×10^{-9}	1.4×10^{-3}	6.8×10^{-7}	2.4×10^{-2}	1.2×10^{-5}

a. For the No-Action Alternative, general public doses result only from the volatilization of tritium from L-Lake.
b. The offsite maximally exposed individual is a member of the public residing at the SRS boundary.
c. Offsite population within 80 kilometers (50 miles) of SRS.
d. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
e. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-2. L-Lake - Radiological doses associated with the No-Action Alternative and resulting health effects to the maximally exposed individual (future use).[a]

Exposure Pathway	Annual dose (rem)[b]			Probability of fatal cancer[c]	Lifetime dose (rem)[d]			Probability of fatal cancer[c]
	Recreational	Offsite	Total		Recreational	Offsite	Total	
Ingestion:								
Finfish[e]	3.8×10^{-4}	NA[f]	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	NA	1.3×10^{-2}	6.5×10^{-6}
Leafy vegetables	NA	9.8×10^{-9}	9.8×10^{-9}	4.9×10^{-12}	NA	9.9×10^{-10}	9.9×10^{-10}	5.0×10^{-13}
Other vegetables	NA	7.7×10^{-8}	7.7×10^{-8}	3.8×10^{-11}	NA	1.3×10^{-6}	1.3×10^{-6}	6.7×10^{-10}
Meat	NA	4.8×10^{-9}	4.8×10^{-9}	2.4×10^{-12}	NA	8.3×10^{-8}	8.3×10^{-8}	4.2×10^{-11}
Milk	NA	1.7×10^{-8}	1.7×10^{-8}	8.7×10^{-12}	NA	3.1×10^{-7}	3.1×10^{-7}	1.5×10^{-10}
Soil	1.2×10^{-11}	5.7×10^{-11}	6.9×10^{-11}	3.4×10^{-14}	2.1×10^{-10}	9.9×10^{-10}	1.2×10^{-9}	6.0×10^{-13}
Soil dermal	1.7×10^{-9}	1.1×10^{-11}	1.7×10^{-9}	8.6×10^{-13}	3.0×10^{-8}	2.0×10^{-10}	3.0×10^{-7}	1.5×10^{-11}
Subtotal	3.8×10^{-4}	1.1×10^{-7}	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	1.7×10^{-6}	1.3×10^{-2}	6.5×10^{-6}
Inhalation:								
Air	2.9×10^{-9}	4.0×10^{-8}	4.3×10^{-8}	2.1×10^{-11}	5.1×10^{-8}	7.0×10^{-7}	7.5×10^{-7}	3.7×10^{-10}
Resuspension	3.9×10^{-12}	2.7×10^{-11}	3.1×10^{-11}	1.6×10^{-14}	6.8×10^{-11}	4.8×10^{-10}	5.4×10^{-10}	2.7×10^{-13}
Subtotal	2.9×10^{-9}	4.0×10^{-8}	4.3×10^{-8}	2.1×10^{-11}	5.1×10^{-8}	7.0×10^{-7}	7.5×10^{-7}	3.7×10^{-10}
Total	3.8×10^{-4}	1.5×10^{-7}	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	2.6×10^{-6}	1.3×10^{-2}	6.5×10^{-6}

a. The future land use scenario assumes recreational use of L-Lake. Doses to the maximally exposed individual result from exposure pathways related to tritium volatilization and contaminants existing in the surface water.
b. The dose received by the maximally exposed individual living at the site boundary (same as for current use).
c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.
e. The fish ingestion dose was calculated using the measured concentration of cesium-137 in L-Lake fish: 0.833 pCi/g of edible flesh (Arnett, Mamatey, and Spitzer 1996).
f. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-3. L-Lake - Nonradiological hazard indexes and cancer risks associated with the No-Action Alternative for the offsite maximally exposed individual (future use).[a]

Exposure pathway	Hazard quotient					Cancer risk		
	Barium	Magnesium	Manganese	Vanadium	Hazard index[b]	Beryllium	Total annual	Lifetime[c]
Ingestion:								
Finfish	1.1×10^{-2}	4.3×10^{-4}	5.0×10^{-2}	1.8×10^{-4}	6.2×10^{-2}	1.6×10^{-7}	1.6×10^{-7}	1.1×10^{-5}
Swimming	7.5×10^{-6}	1.1×10^{-6}	1.7×10^{-5}	2.4×10^{-6}	2.8×10^{-5}	1.1×10^{-9}	1.1×10^{-9}	7.7×10^{-8}
Swimming dermal	1.5×10^{-5}	4.4×10^{-7}	3.3×10^{-5}	4.7×10^{-5}	9.5×10^{-5}	4.4×10^{-8}	4.4×10^{-8}	3.1×10^{-6}
Shoreline dermal	3.5×10^{-5}	1.1×10^{-6}	7.8×10^{-5}	1.1×10^{-4}	2.2×10^{-4}	1.0×10^{-7}	1.0×10^{-7}	7.0×10^{-6}
Shoreline	4.1×10^{-6}	6.2×10^{-7}	9.2×10^{-6}	1.3×10^{-6}	1.5×10^{-5}	6.2×10^{-10}	6.2×10^{-10}	4.3×10^{-8}
Total	1.1×10^{-2}	4.3×10^{-4}	5.0×10^{-2}	3.4×10^{-4}	6.2×10^{-2}	3.1×10^{-7}	3.1×10^{-7}	2.1×10^{-5}

a. The future land use scenario assumes recreational use of L-Lake. Impacts to the maximally exposed individual result from exposure pathways associated with contaminants existing in the surface water. The maximally exposed individual (current use) is not exposed to any nonradiological contaminants.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 70-year exposure period.

Table C-4. L-Lake - Involved worker (current use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	1.4×10^{-10}	5.6×10^{-14}	6.1×10^{-10}	2.4×10^{-13}	9.8×10^{-9}	3.9×10^{-12}	4.3×10^{-8}	1.7×10^{-11}
Soil dermal	1.2×10^{-11}	4.6×10^{-15}	5.0×10^{-11}	2.0×10^{-14}	8.1×10^{-10}	3.2×10^{-13}	3.5×10^{-9}	1.4×10^{-12}
Subtotal	1.5×10^{-10}	6.1×10^{-14}	6.6×10^{-10}	2.6×10^{-13}	1.1×10^{-8}	4.2×10^{-12}	4.6×10^{-8}	1.8×10^{-11}
Inhalation:								
Air	5.0×10^{-8}	2.0×10^{-11}	2.2×10^{-7}	8.6×10^{-11}	3.5×10^{-6}	1.4×10^{-9}	1.5×10^{-5}	6.0×10^{-9}
Resuspension	6.8×10^{-11}	2.7×10^{-14}	2.9×10^{-10}	1.2×10^{-13}	4.7×10^{-9}	1.9×10^{-12}	2.1×10^{-8}	8.2×10^{-12}
Subtotal	5.0×10^{-8}	2.0×10^{-11}	2.2×10^{-7}	8.6×10^{-11}	3.5×10^{-6}	1.4×10^{-9}	1.5×10^{-5}	6.1×10^{-9}
Total	5.0×10^{-8}	2.0×10^{-11}	2.2×10^{-7}	8.7×10^{-11}	3.5×10^{-6}	1.4×10^{-9}	1.5×10^{-5}	6.1×10^{-9}

a. For the No-Action Alternative, workers are exposed to pathways associated with tritium volatilization and contaminants in the surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-5. L-Lake - Involved worker (future use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	3.1×10^{-9}	1.2×10^{-12}	4.2×10^{-8}	1.7×10^{-11}	2.2×10^{-7}	8.7×10^{-11}	2.9×10^{-6}	1.2×10^{-9}
Soil dermal	1.9×10^{-10}	7.7×10^{-14}	2.6×10^{-9}	1.0×10^{-12}	1.3×10^{-8}	5.4×10^{-12}	1.8×10^{-7}	7.2×10^{-11}
Subtotal	3.3×10^{-9}	1.3×10^{-12}	4.4×10^{-8}	1.8×10^{-11}	2.3×10^{-7}	9.2×10^{-11}	3.1×10^{-6}	1.2×10^{-9}
Inhalation:								
Air	1.1×10^{-6}	4.4×10^{-10}	1.5×10^{-5}	5.9×10^{-9}	7.7×10^{-5}	3.1×10^{-8}	1.0×10^{-3}	4.1×10^{-7}
Resuspension	1.5×10^{-9}	5.9×10^{-13}	2.0×10^{-8}	8.0×10^{-12}	1.0×10^{-7}	4.2×10^{-11}	1.4×10^{-6}	5.6×10^{-10}
Subtotal	1.1×10^{-6}	4.4×10^{-10}	1.5×10^{-5}	5.9×10^{-9}	7.7×10^{-5}	3.1×10^{-8}	1.0×10^{-3}	4.1×10^{-7}
Total	1.1×10^{-6}	4.4×10^{-10}	1.5×10^{-5}	5.9×10^{-9}	7.7×10^{-5}	3.1×10^{-8}	1.0×10^{-3}	4.1×10^{-7}

a. For the No-Action Alternative, workers are exposed to pathways associated with tritium volatilization and contaminants in the surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-6. L-Lake - Uninvolved worker radiological doses associated with the No-Action Alternative and resulting health effects.[a]

Exposure pathway	Individual worker[b] Annual dose (rem)	Probability of fatal cancer[d]	Lifetime dose (rem)[e]	Probability of fatal cancer[d]	Worker population[c] Annual dose (person-rem)	Number of fatal cancers[d]	Lifetime dose (person-rem)[e]	Number of fatal cancers[d]
Ingestion:								
Soil	5.5×10^{-11}	2.2×10^{-14}	7.4×10^{-10}	3.0×10^{-13}	1.4×10^{-8}	5.5×10^{-12}	1.9×10^{-7}	7.4×10^{-11}
Soil dermal	3.5×10^{-12}	1.4×10^{-15}	4.7×10^{-11}	1.9×10^{-14}	8.8×10^{-10}	3.5×10^{-13}	1.2×10^{-8}	4.7×10^{-12}
Subtotal	5.8×10^{-11}	2.3×10^{-14}	7.9×10^{-10}	3.1×10^{-13}	1.5×10^{-8}	5.9×10^{-12}	2.0×10^{-7}	7.9×10^{-11}
Inhalation:								
Air	2.0×10^{-8}	7.8×10^{-12}	2.6×10^{-7}	1.0×10^{-10}	4.9×10^{-6}	2.0×10^{-9}	6.6×10^{-5}	2.6×10^{-8}
Resuspension	2.7×10^{-11}	1.1×10^{-14}	3.6×10^{-10}	1.5×10^{-13}	6.8×10^{-9}	2.7×10^{-12}	9.1×10^{-8}	3.6×10^{-11}
Subtotal	2.0×10^{-8}	7.8×10^{-12}	2.6×10^{-7}	1.0×10^{-10}	4.9×10^{-6}	2.0×10^{-9}	6.6×10^{-5}	2.6×10^{-8}
Total	2.0×10^{-8}	7.8×10^{-12}	2.6×10^{-7}	1.1×10^{-10}	4.9×10^{-6}	2.0×10^{-9}	6.6×10^{-5}	2.6×10^{-8}

a. For the No-Action Alternative, the uninvolved worker is exposed only to pathways associated with the volatilization of tritium from L-Lake.
b. The maximally exposed uninvolved worker is located at L-Area.
c. L-Area. Total uninvolved workers estimated to be 251 (Simpkins 1996).
d. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
e. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-7. L-Lake - Involved worker (current use) nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Exposure pathway	Hazard quotient				Hazard index[b]	Cancer risk		
	Barium	Magnesium	Manganese	Vanadium		Beryllium	Total annual	Lifetime[c]
Ingestion:								
Shoreline dermal	2.3×10^{-7}	7.0×10^{-9}	5.3×10^{-7}	7.4×10^{-7}	1.5×10^{-6}	7.0×10^{-7}	7.0×10^{-10}	3.5×10^{-9}
Shoreline	5.6×10^{-5}	8.5×10^{-6}	1.3×10^{-4}	1.8×10^{-5}	2.1×10^{-4}	8.4×10^{-9}	8.4×10^{-9}	4.2×10^{-8}
Total	5.6×10^{-5}	8.5×10^{-6}	1.3×10^{-4}	1.9×10^{-5}	2.1×10^{-4}	9.1×10^{-9}	9.1×10^{-9}	4.5×10^{-8}

a. For the No-Action Alternative, workers are exposed to pathways associated with tritium volatilization and contaminants in the surface water.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 5-year exposure period.

Table C-8. L-Lake - Involved worker (future use) nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Exposure pathway	Hazard quotient				Hazard index[b]	Cancer risk		
	Barium	Magnesium	Manganese	Vanadium		Beryllium	Total annual	Lifetime[c]
Ingestion:								
Shoreline dermal	3.8×10^{-6}	1.2×10^{-7}	8.9×10^{-6}	1.2×10^{-5}	2.5×10^{-5}	1.2×10^{-8}	1.2×10^{-8}	2.9×10^{-7}
Shoreline	6.1×10^{-6}	9.3×10^{-7}	1.4×10^{-5}	2.0×10^{-6}	2.3×10^{-5}	9.2×10^{-10}	9.2×10^{-10}	2.3×10^{-8}
Total	9.9×10^{-6}	1.0×10^{-6}	2.3×10^{-5}	1.4×10^{-5}	4.8×10^{-5}	1.3×10^{-8}	1.3×10^{-8}	3.1×10^{-7}

a. For the No-Action Alternative, workers are exposed to pathways associated with tritium volatilization and contaminants in the surface water.
b Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.

Table C-9. L-Lake - Radiological doses from atmospheric releases associated with the Shut Down and Deactivate Alternative and resulting health effects to the offsite maximally exposed individual.[a]

Exposure Pathway	Annual dose (rem)[b] Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]
Ingestion:									
Soil	4.6×10^{-12}	9.2×10^{-15}	1.4×10^{-12}	5.4×10^{-17}	1.4×10^{-12}	7.5×10^{-12}	3.7×10^{-15}	3.6×10^{-10}	1.8×10^{-13}
Soil dermal	9.2×10^{-13}	4.9×10^{-15}	2.8×10^{-10}	1.8×10^{-15}	5.9×10^{-11}	3.4×10^{-10}	1.7×10^{-13}	2.4×10^{-8}	1.2×10^{-11}
Leafy green vegetables	2.8×10^{-8}	5.5×10^{-11}	8.3×10^{-9}	3.2×10^{-13}	8.7×10^{-9}	4.5×10^{-8}	2.2×10^{-11}	2.2×10^{-6}	1.1×10^{-9}
Other vegetables	2.6×10^{-8}	5.2×10^{-11}	7.4×10^{-9}	2.9×10^{-13}	7.9×10^{-9}	4.2×10^{-8}	2.1×10^{-11}	2.0×10^{-6}	1.0×10^{-9}
Meat	1.2×10^{-8}	2.3×10^{-11}	8.6×10^{-14}	3.3×10^{-14}	3.5×10^{-11}	1.2×10^{-8}	5.8×10^{-12}	4.1×10^{-7}	2.0×10^{-10}
Milk	1.3×10^{-7}	7.3×10^{-11}	5.6×10^{-13}	4.2×10^{-15}	3.3×10^{-9}	1.3×10^{-7}	6.7×10^{-11}	4.8×10^{-6}	2.4×10^{-9}
Subtotal	2.0×10^{-7}	2.0×10^{-10}	1.6×10^{-8}	3.3×10^{-13}	2.0×10^{-8}	2.3×10^{-7}	1.2×10^{-10}	9.4×10^{-6}	4.7×10^{-9}
Inhalation:									
Air	3.4×10^{-10}	8.4×10^{-12}	1.9×10^{-8}	2.4×10^{-13}	7.7×10^{-8}	9.7×10^{-8}	4.8×10^{-11}	6.7×10^{-6}	3.4×10^{-9}
Resuspension	2.9×10^{-12}	7.4×10^{-14}	1.7×10^{-10}	2.1×10^{-15}	6.7×10^{-10}	8.4×10^{-10}	4.2×10^{-13}	5.9×10^{-8}	2.9×10^{-11}
Subtotal	3.4×10^{-10}	8.4×10^{-12}	1.9×10^{-8}	2.4×10^{-13}	7.8×10^{-8}	9.7×10^{-8}	4.9×10^{-11}	6.8×10^{-6}	3.4×10^{-9}
External:									
Soil	7.4×10^{-8}	1.3×10^{-9}	2.3×10^{-13}	1.7×10^{-11}	8.5×10^{-12}	7.5×10^{-8}	3.8×10^{-11}	2.7×10^{-6}	1.3×10^{-9}
Air	4.2×10^{-12}	7.7×10^{-14}	2.9×10^{-18}	9.5×10^{-16}	3.0×10^{-16}	4.3×10^{-12}	2.2×10^{-15}	1.5×10^{-10}	7.6×10^{-13}
Subtotal	7.4×10^{-8}	1.3×10^{-9}	2.3×10^{-13}	1.7×10^{-11}	8.5×10^{-12}	7.5×10^{-8}	3.8×10^{-11}	2.7×10^{-6}	1.3×10^{-9}
Total	2.7×10^{-7}	1.5×10^{-9}	3.5×10^{-8}	1.8×10^{-11}	9.7×10^{-8}	4.0×10^{-7}	2.0×10^{-10}	1.9×10^{-5}	9.4×10^{-9}

a. For the Shut Down and Deactivate Alternative, the general public exposures result from the atmospheric and aqueous transport of exposed L-Lake sediments.
b. The offsite maximally exposed individual is a member of the public residing at the SRS boundary.
c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-10. L-Lake - Radiological doses from aqueous releases associated with the Shut Down and Deactivate Alternative and resulting health effects to the offsite maximally exposed individual.[a]

Exposure Pathway	Annual dose (rem)[b] Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]
Ingestion:									
Drinking Water	3.0×10^{-10}	2.5×10^{-12}	7.7×10^{-10}	4.1×10^{-12}	1.4×10^{-9}	2.5×10^{-9}	1.2×10^{-12}	1.6×10^{-7}	8.1×10^{-11}
Finfish	7.6×10^{-9}	1.0×10^{-11}	2.4×10^{-9}	1.3×10^{-12}	8.6×10^{-10}	1.1×10^{-8}	5.4×10^{-12}	4.9×10^{-7}	2.5×10^{-10}
Swimming	5.0×10^{-13}	4.2×10^{-15}	1.3×10^{-12}	6.8×10^{-15}	2.3×10^{-12}	4.1×10^{-12}	2.1×10^{-15}	2.7×10^{-10}	1.3×10^{-13}
Swimming Dermal	1.0×10^{-13}	9.1×10^{-16}	2.6×10^{-10}	2.3×10^{-13}	9.7×10^{-12}	2.7×10^{-10}	1.4×10^{-13}	1.9×10^{-8}	9.4×10^{-12}
Shoreline Dermal	6.6×10^{-16}	1.5×10^{-17}	1.7×10^{-12}	1.5×10^{-15}	6.9×10^{-14}	1.8×10^{-12}	8.9×10^{-16}	1.2×10^{-10}	6.2×10^{-14}
Shoreline	1.3×10^{-14}	1.1×10^{-16}	3.4×10^{-14}	1.7×10^{-16}	6.0×10^{-14}	1.1×10^{-13}	5.4×10^{-17}	7.0×10^{-12}	3.5×10^{-15}
Subtotal	7.9×10^{-9}	1.3×10^{-11}	3.4×10^{-9}	5.7×10^{-12}	2.3×10^{-9}	1.4×10^{-8}	6.8×10^{-12}	6.7×10^{-7}	3.4×10^{-10}
External:									
Swimming	6.9×10^{-14}	5.6×10^{-15}	4.6×10^{-19}	1.9×10^{-14}	3.8×10^{-17}	9.4×10^{-14}	4.7×10^{-17}	2.6×10^{-12}	1.3×10^{-15}
Boating	3.5×10^{-14}	2.8×10^{-15}	2.3×10^{-19}	9.5×10^{-15}	1.9×10^{-17}	4.7×10^{-14}	2.4×10^{-17}	1.3×10^{-12}	6.6×10^{-16}
Shoreline	1.8×10^{-12}	1.2×10^{-13}	4.6×10^{-17}	4.4×10^{-13}	1.9×10^{-15}	2.4×10^{-12}	1.2×10^{-15}	6.7×10^{-11}	3.4×10^{-14}
Subtotal	1.9×10^{-12}	1.3×10^{-13}	4.6×10^{-17}	4.7×10^{-13}	2.0×10^{-15}	2.5×10^{-12}	1.3×10^{-15}	7.1×10^{-11}	3.5×10^{-14}
Total	7.9×10^{-9}	1.3×10^{-11}	3.4×10^{-9}	6.1×10^{-12}	2.3×10^{-9}	1.4×10^{-8}	6.8×10^{-12}	6.7×10^{-7}	3.4×10^{-10}

a. For the Shut Down and Deactivate Alternative, the general public exposures result from the atmospheric and aqueous transport of exposed L-Lake sediments.

b. For aqueous releases, the offsite maximally exposed individual is a member of the public residing along the Savannah River near the SRS boundary who uses the river as a drinking water source and for recreational activities and consumes fish caught in the river.

c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).

d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure.

Table C-11. L-Lake - Radiological doses from atmospheric releases associated with the Shut Down and Deactivate Alternative and resulting health effects to the offsite population.[a]

Exposure Pathway	Population annual dose (person-rem)[b]						Number of fatal cancers[c]	Lifetime population dose (person-rem)[d]	Number of fatal cancers[c]
	Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total			
Ingestion:									
Soil	5.2×10^{-9}	8.6×10^{-12}	1.2×10^{-9}	2.4×10^{-14}	1.2×10^{-9}	7.6×10^{-9}	3.8×10^{-12}	3.5×10^{-7}	1.8×10^{-10}
Soil dermal	1.0×10^{-9}	4.5×10^{-12}	2.4×10^{-7}	8.1×10^{-11}	5.1×10^{-8}	2.9×10^{-7}	1.4×10^{-10}	2.0×10^{-5}	1.0×10^{-8}
Leafy green vegetables	3.2×10^{-5}	5.2×10^{-8}	7.0×10^{-6}	1.4×10^{-10}	7.4×10^{-6}	4.6×10^{-5}	2.3×10^{-8}	2.1×10^{-3}	1.1×10^{-6}
Other vegetables	3.0×10^{-5}	4.9×10^{-8}	6.3×10^{-6}	1.3×10^{-10}	6.7×10^{-6}	4.3×10^{-5}	2.2×10^{-8}	2.0×10^{-3}	9.8×10^{-7}
Meat	1.3×10^{-5}	2.2×10^{-8}	7.3×10^{-11}	1.5×10^{-11}	2.9×10^{-8}	1.3×10^{-5}	6.6×10^{-9}	4.6×10^{-4}	2.3×10^{-7}
Milk	1.5×10^{-4}	6.8×10^{-8}	4.8×10^{-10}	1.9×10^{-12}	2.8×10^{-6}	1.5×10^{-4}	7.6×10^{-8}	5.3×10^{-3}	2.7×10^{-6}
Subtotal	2.2×10^{-4}	1.9×10^{-7}	1.4×10^{-5}	2.9×10^{-10}	1.7×10^{-5}	2.5×10^{-4}	1.3×10^{-7}	9.9×10^{-3}	4.9×10^{-6}
Inhalation:									
Air	3.8×10^{-7}	7.8×10^{-9}	1.6×10^{-5}	1.1×10^{-10}	6.5×10^{-5}	8.2×10^{-5}	4.1×10^{-8}	5.7×10^{-3}	2.9×10^{-6}
Resuspension	3.3×10^{-9}	6.9×10^{-11}	1.4×10^{-7}	9.5×10^{-13}	5.7×10^{-7}	7.1×10^{-7}	3.6×10^{-10}	5.0×10^{-5}	2.5×10^{-8}
Subtotal	3.8×10^{-7}	1.5×10^{-8}	1.6×10^{-5}	1.1×10^{-10}	6.5×10^{-5}	8.2×10^{-5}	4.1×10^{-8}	5.8×10^{-3}	2.9×10^{-6}
External:									
Soil	8.4×10^{-5}	1.2×10^{-6}	1.9×10^{-10}	7.5×10^{-9}	7.2×10^{-9}	8.5×10^{-5}	4.3×10^{-8}	3.0×10^{-3}	1.5×10^{-6}
Air	4.8×10^{-9}	7.2×10^{-11}	2.5×10^{-15}	4.2×10^{-13}	2.6×10^{-13}	4.9×10^{-9}	2.4×10^{-12}	1.7×10^{-7}	8.6×10^{-11}
Subtotal	8.4×10^{-5}	1.2×10^{-6}	1.9×10^{-10}	7.5×10^{-9}	7.2×10^{-9}	8.5×10^{-5}	4.3×10^{-8}	3.0×10^{-3}	1.5×10^{-6}
Total	3.0×10^{-4}	1.4×10^{-6}	3.0×10^{-5}	7.9×10^{-9}	8.2×10^{-5}	4.2×10^{-4}	2.1×10^{-7}	1.9×10^{-2}	9.3×10^{-6}

a. For the Shut Down and Deactivate Alternative, the general public exposures result from the atmospheric and aqueous transport of exposed L-Lake sediments.
b. Offsite population within 80 kilometers (50 miles) of SRS.
c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-12. L-Lake - Radiological doses from aqueous releases associated with the Shut Down and Deactivate Alternative and resulting health effects to the offsite population.[a]

Exposure pathway	Port Wentworth Annual dose (person-rem)	Port Wentworth Lifetime dose[b] (person-rem)	Beaufort/Jasper Annual dose (person-rem)	Beaufort/Jasper Lifetime dose[b] (person-rem)	Total population annual dose (person-rem)	Number of fatal cancers[c]	Total population lifetime dose[b] (person-rem)	Number of fatal cancers[c]
Drinking Water:								
Cs-137	1.5×10^{-6}	5.0×10^{-5}	4.0×10^{-6}	1.4×10^{-4}	5.5×10^{-6}	2.7×10^{-9}	1.9×10^{-4}	9.5×10^{-8}
Co-60	2.8×10^{-9}	2.1×10^{-8}	7.3×10^{-9}	5.6×10^{-8}	1.0×10^{-8}	5.0×10^{-12}	7.7×10^{-8}	3.8×10^{-11}
Pu-239/240	3.0×10^{-6}	2.1×10^{-4}	7.8×10^{-6}	5.5×10^{-4}	1.1×10^{-5}	5.4×10^{-9}	7.6×10^{-4}	3.8×10^{-7}
Pm-146	4.2×10^{-9}	3.4×10^{-8}	1.2×10^{-8}	9.5×10^{-8}	1.6×10^{-8}	8.1×10^{-12}	1.3×10^{-7}	6.4×10^{-11}
U-233/234	5.1×10^{-6}	3.6×10^{-4}	1.4×10^{-5}	9.8×10^{-4}	1.9×10^{-5}	9.5×10^{-9}	1.3×10^{-3}	6.7×10^{-7}
Total	9.5×10^{-6}	6.2×10^{-4}	2.6×10^{-5}	1.7×10^{-3}	3.5×10^{-5}	1.8×10^{-8}	2.3×10^{-3}	1.1×10^{-6}

a. For aqueous releases, doses are calculated for the 65,000 (Arnett, Mamatey, and Spitzer 1996) people using the Savannah River as a source of drinking water (Port Wentworth, Georgia and Beaufort and Jasper Counties, South Carolina).
b. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.
c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).

Table C-13. L-Lake - Offsite maximally exposed individual nonradiological hazard indexes and cancer risks from atmospheric releases associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Hazard quotient					Hazard index[b]	Annual cancer risk				Lifetime cancer risk[c]
	Manganese	Thallium	Antimony	Cadmium	Lead		Cadmium	Beryllium	Arsenic	Total	
Ingestion:											
Soil	3.3×10^{-12}	2.8×10^{-7}	2.0×10^{-8}	2.2×10^{-9}	1.2×10^{-8}	3.1×10^{-7}	NA[d]	1.6×10^{-13}	4.7×10^{-13}	6.3×10^{-13}	4.4×10^{-11}
Soil dermal	6.4×10^{-12}	5.4×10^{-8}	3.9×10^{-7}	8.6×10^{-8}	2.2×10^{-7}	7.5×10^{-7}	NA	6.2×10^{-12}	1.9×10^{-13}	6.4×10^{-12}	4.5×10^{-10}
Leafy green vegetables	2.0×10^{-8}	1.7×10^{-3}	1.2×10^{-4}	1.4×10^{-5}	6.7×10^{-5}	1.9×10^{-3}	NA	9.5×10^{-10}	2.8×10^{-9}	3.8×10^{-9}	2.6×10^{-7}
Other vegetables	2.1×10^{-8}	1.5×10^{-3}	1.0×10^{-4}	1.4×10^{-5}	5.9×10^{-5}	1.7×10^{-3}	NA	8.3×10^{-10}	2.5×10^{-9}	3.3×10^{-9}	2.3×10^{-7}
Meat	1.7×10^{-10}	1.4×10^{-3}	2.5×10^{-6}	1.6×10^{-7}	1.4×10^{-6}	1.4×10^{-3}	NA	1.6×10^{-11}	1.1×10^{-10}	1.3×10^{-10}	9.1×10^{-9}
Milk	4.7×10^{-9}	2.2×10^{-3}	7.8×10^{-6}	9.3×10^{-6}	4.5×10^{-6}	2.2×10^{-3}	NA	1.3×10^{-12}	1.1×10^{-10}	1.2×10^{-10}	8.1×10^{-9}
Subtotal	4.7×10^{-8}	6.5×10^{-3}	2.3×10^{-4}	3.7×10^{-5}	1.3×10^{-4}	6.9×10^{-3}	0.0×10^{0}	1.8×10^{-9}	5.6×10^{-9}	7.4×10^{-9}	5.2×10^{-7}
Inhalation:											
Air	1.8×10^{-8}	3.1×10^{-5}	2.2×10^{-6}	NA	1.3×10^{-6}	3.5×10^{-5}	7.3×10^{-12}	3.5×10^{-11}	4.6×10^{-10}	5.0×10^{-10}	3.5×10^{-8}
Resuspension	1.6×10^{-10}	2.7×10^{-7}	1.9×10^{-8}	NA	1.1×10^{-8}	3.0×10^{-7}	6.5×10^{-14}	3.1×10^{-13}	4.0×10^{-12}	4.3×10^{-12}	3.0×10^{-10}
Subtotal	1.8×10^{-8}	3.2×10^{-5}	2.3×10^{-6}	0.0×10^{0}	1.3×10^{-6}	3.5×10^{-5}	7.3×10^{-12}	3.5×10^{-11}	4.6×10^{-10}	5.0×10^{-10}	3.5×10^{-8}
Total	6.5×10^{-8}	6.5×10^{-3}	2.4×10^{-4}	3.7×10^{-5}	1.4×10^{-4}	6.9×10^{-3}	7.3×10^{-12}	1.8×10^{-9}	6.0×10^{-9}	7.9×10^{-9}	5.5×10^{-7}

a. Impacts to the maximally exposed individual result from exposure pathways associated with contaminants in the exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 70-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-14. L-Lake - Offsite maximally exposed individual nonradiological hazard indexes and cancer risks from aqueous releases associated with the Shut Down and Deactivate Alternative.[a]

	Hazard quotient					Hazard	Annual cancer risk				Lifetime
Exposure Pathway	Manganese	Thallium	Antimony	Cadmium	Lead	index[b]	Beryllium	Cadmium	Arsenic		cancer risk[c]
Ingestion:											
Drinking Water	1.9×10^{-9}	1.6×10^{-3}	4.2×10^{-6}	1.3×10^{-7}	1.5×10^{-6}	1.6×10^{-3}	6.7×10^{-12}	NA[d]	4.2×10^{-11}	4.9×10^{-11}	3.4×10^{-9}
Finfish	9.3×10^{-9}	2.1×10^{-1}	1.0×10^{-5}	3.3×10^{-7}	1.8×10^{-6}	2.1×10^{-1}	1.6×10^{-12}	NA	5.2×10^{-11}	5.4×10^{-11}	3.8×10^{-9}
Swimming	3.1×10^{-12}	2.7×10^{-6}	6.9×10^{-9}	2.2×10^{-10}	2.4×10^{-9}	2.7×10^{-6}	1.1×10^{-14}	NA	6.9×10^{-14}	8.0×10^{-14}	5.6×10^{-12}
Swimming Dermal	6.2×10^{-12}	5.4×10^{-7}	1.4×10^{-7}	8.7×10^{-10}	9.7×10^{-12}	6.8×10^{-7}	4.4×10^{-13}	NA	2.7×10^{-14}	4.7×10^{-13}	3.3×10^{-11}
Shoreline Dermal	4.1×10^{-14}	3.6×10^{-9}	9.2×10^{-10}	5.8×10^{-11}	1.6×10^{-11}	4.6×10^{-9}	3.0×10^{-15}	NA	1.8×10^{-16}	3.2×10^{-15}	2.2×10^{-13}
Shoreline	8.2×10^{-14}	7.3×10^{-8}	1.8×10^{-10}	5.8×10^{-12}	6.5×10^{-11}	7.3×10^{-8}	3.0×10^{-16}	NA	1.8×10^{-15}	2.1×10^{-15}	1.5×10^{-13}
Total	1.1×10^{-8}	2.1×10^{-1}	1.4×10^{-5}	4.6×10^{-7}	3.3×10^{-6}	2.1×10^{-1}	8.8×10^{-12}	0.0×10^{0}	9.4×10^{-11}	1.0×10^{-10}	7.2×10^{-9}

a. Impacts to the maximally exposed individual result from exposure pathways associated with contaminants in the exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 70-year exposure period.
d. NA = not applicable; cadmium is not an ingestion carcinogen.

Table C-15. L-Lake - Involved worker (current use) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Exposure Pathway	Annual dose (rem) Cs-137	Co-60	Pu-239/ 240	Pm-146	U-233/ 234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Soil	1.6×10^{-7}	1.4×10^{-9}	5.9×10^{-8}	1.3×10^{-11}	1.3×10^{-7}	3.5×10^{-7}	1.4×10^{-10}	1.7×10^{-6}	6.8×10^{-10}	2.5×10^{-5}	9.8×10^{-9}	1.2×10^{-4}	4.8×10^{-8}
Soil Dermal	1.4×10^{-8}	3.1×10^{-10}	4.9×10^{-6}	1.9×10^{-10}	2.5×10^{-7}	5.2×10^{-6}	2.1×10^{-9}	2.6×10^{-5}	1.0×10^{-8}	3.6×10^{-4}	1.5×10^{-7}	1.8×10^{-3}	7.3×10^{-7}
Subtotal	1.7×10^{-7}	1.7×10^{-9}	5.0×10^{-6}	2.0×10^{-10}	3.8×10^{-7}	5.6×10^{-6}	2.2×10^{-9}	2.8×10^{-5}	1.1×10^{-8}	3.9×10^{-4}	1.6×10^{-2}	1.9×10^{-3}	7.8×10^{-7}
Inhalation:													
Resuspension	2.1×10^{-9}	2.2×10^{-10}	1.4×10^{-7}	1.1×10^{-11}	1.2×10^{-6}	1.3×10^{-6}	5.4×10^{-10}	6.7×10^{-6}	2.7×10^{-9}	9.4×10^{-5}	3.8×10^{-8}	4.7×10^{-4}	1.9×10^{-7}
Subtotal	2.1×10^{-9}	2.2×10^{-10}	1.4×10^{-7}	1.1×10^{-11}	1.2×10^{-6}	1.3×10^{-6}	5.4×10^{-10}	6.7×10^{-6}	2.7×10^{-9}	9.4×10^{-5}	3.8×10^{-8}	4.7×10^{-4}	1.9×10^{-7}
External:													
Soil	2.2×10^{-4}	1.5×10^{-5}	7.9×10^{-10}	3.5×10^{-7}	4.1×10^{-8}	2.4×10^{-4}	9.4×10^{-8}	1.1×10^{-3}	4.4×10^{-7}	1.6×10^{-2}	6.6×10^{-6}	7.7×10^{-2}	3.1×10^{-5}
Subtotal	2.2×10^{-4}	1.5×10^{-5}	7.9×10^{-10}	3.5×10^{-7}	4.1×10^{-8}	2.4×10^{-4}	9.4×10^{-8}	1.1×10^{-3}	4.4×10^{-7}	1.6×10^{-2}	6.6×10^{-6}	7.7×10^{-2}	3.1×10^{-5}
Total	2.2×10^{-4}	1.5×10^{-5}	5.1×10^{-6}	3.5×10^{-7}	1.6×10^{-6}	2.4×10^{-4}	9.7×10^{-8}	1.1×10^{-3}	4.5×10^{-7}	1.7×10^{-2}	6.8×10^{-6}	7.9×10^{-2}	3.2×10^{-5}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed L-Lake sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-16. L-Lake - Involved worker (future use) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

	Annual dose (rem)												
Exposure Pathway	Cs-137	Co-60	Pu-239/ 240	Pm-146	U-233/ 234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Soil	3.6×10^{-6}	3.0×10^{-8}	1.3×10^{-6}	3.0×10^{-10}	2.8×10^{-6}	7.7×10^{-6}	3.1×10^{-9}	1.7×10^{-4}	6.8×10^{-8}	5.4×10^{-4}	2.2×10^{-7}	1.2×10^{-2}	4.8×10^{-6}
Soil Dermal	2.3×10^{-7}	5.1×10^{-9}	8.2×10^{-5}	3.2×10^{-9}	4.2×10^{-6}	8.7×10^{-5}	3.5×10^{-8}	2.2×10^{-3}	8.7×10^{-7}	6.1×10^{-3}	2.4×10^{-6}	1.5×10^{-1}	6.1×10^{-5}
Subtotal	3.8×10^{-6}	3.5×10^{-8}	8.3×10^{-5}	3.5×10^{-9}	7.0×10^{-6}	9.4×10^{-5}	3.8×10^{-8}	2.3×10^{-3}	9.3×10^{-7}	6.6×10^{-3}	2.6×10^{-6}	1.6×10^{-1}	6.5×10^{-5}
Inhalation:													
Resuspension	4.6×10^{-8}	4.9×10^{-9}	3.2×10^{-6}	2.3×10^{-10}	2.6×10^{-5}	2.9×10^{-5}	1.2×10^{-8}	7.3×10^{-4}	2.9×10^{-7}	2.0×10^{-3}	8.2×10^{-7}	5.1×10^{-2}	2.0×10^{-5}
Subtotal	4.6×10^{-8}	4.9×10^{-9}	3.2×10^{-6}	2.3×10^{-10}	2.6×10^{-5}	2.9×10^{-5}	1.2×10^{-8}	7.3×10^{-4}	2.9×10^{-7}	2.0×10^{-3}	8.2×10^{-7}	5.1×10^{-2}	2.0×10^{-5}
External:													
Soil	3.8×10^{-2}	2.8×10^{-3}	1.4×10^{-7}	6.2×10^{-5}	7.2×10^{-6}	4.1×10^{-2}	1.6×10^{-5}	7.4×10^{-1}	3.0×10^{-4}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{1}	2.1×10^{-2}
Subtotal	3.8×10^{-2}	2.8×10^{-3}	1.4×10^{-7}	6.2×10^{-5}	7.2×10^{-6}	4.1×10^{-2}	1.6×10^{-5}	7.4×10^{-1}	3.0×10^{-4}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{1}	2.1×10^{-2}
Total	3.8×10^{-2}	2.8×10^{-3}	8.7×10^{-5}	6.2×10^{-5}	4.0×10^{-5}	4.1×10^{-2}	1.6×10^{-5}	7.5×10^{-1}	3.0×10^{-4}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{1}	2.1×10^{-2}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed L-Lake sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-17. L-Lake - Uninvolved worker (L-Area) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Exposure Pathway	Annual dose (rem)[b] Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Population annual dose (person-rem)[e]	Number of fatal cancers[c]	Population lifetime dose (person-rem)[d,e]	Number of fatal cancers[c]
Ingestion:													
Soil	2.9×10^{-11}	2.4×10^{-13}	1.0×10^{-11}	2.3×10^{-15}	2.3×10^{-11}	6.3×10^{-11}	2.5×10^{-14}	1.4×10^{-9}	5.6×10^{-13}	1.6×10^{-8}	6.3×10^{-12}	3.5×10^{-7}	1.4×10^{-10}
Soil Dermal	1.8×10^{-12}	4.1×10^{-14}	6.6×10^{-10}	2.5×10^{-14}	4.2×10^{-10}	1.1×10^{-9}	4.3×10^{-13}	2.7×10^{-8}	1.1×10^{-11}	2.7×10^{-7}	1.1×10^{-10}	6.8×10^{-6}	2.7×10^{-9}
Subtotal	3.1×10^{-11}	2.8×10^{-13}	6.7×10^{-10}	2.7×10^{-14}	4.4×10^{-10}	1.1×10^{-9}	4.6×10^{-13}	2.8×10^{-8}	1.1×10^{-11}	2.9×10^{-7}	1.1×10^{-10}	7.1×10^{-6}	2.9×10^{-9}
Inhalation:													
Air	1.7×10^{-9}	1.8×10^{-10}	1.1×10^{-7}	8.5×10^{-12}	1.0×10^{-6}	1.1×10^{-6}	4.4×10^{-10}	2.8×10^{-5}	1.1×10^{-8}	2.8×10^{-4}	1.1×10^{-7}	7.0×10^{-3}	2.8×10^{-6}
Resuspension	1.8×10^{-11}	1.9×10^{-12}	1.2×10^{-9}	9.2×10^{-14}	1.1×10^{-8}	1.2×10^{-8}	4.8×10^{-12}	3.0×10^{-7}	1.2×10^{-10}	3.0×10^{-6}	1.2×10^{-9}	7.5×10^{-5}	3.0×10^{-8}
Subtotal	1.7×10^{-9}	1.8×10^{-10}	1.1×10^{-7}	8.6×10^{-12}	1.0×10^{-6}	1.1×10^{-6}	4.5×10^{-10}	2.8×10^{-5}	1.1×10^{-8}	2.8×10^{-4}	1.1×10^{-7}	7.0×10^{-3}	2.8×10^{-6}
External:													
Soil	3.1×10^{-7}	2.2×10^{-8}	1.1×10^{-12}	4.9×10^{-10}	9.9×10^{-11}	3.3×10^{-7}	1.3×10^{-10}	6.1×10^{-6}	2.4×10^{-9}	8.3×10^{-5}	3.3×10^{-8}	1.5×10^{-3}	6.1×10^{-7}
Air	1.4×10^{-11}	1.1×10^{-12}	1.2×10^{-17}	2.2×10^{-14}	2.5×10^{-15}	1.5×10^{-11}	6.0×10^{-15}	2.7×10^{-10}	1.1×10^{-13}	3.8×10^{-9}	1.5×10^{-12}	6.9×10^{-8}	2.8×10^{-11}
Subtotal	3.1×10^{-7}	2.2×10^{-8}	1.1×10^{-12}	4.9×10^{-10}	9.9×10^{-11}	3.3×10^{-7}	1.3×10^{-10}	6.1×10^{-6}	2.4×10^{-9}	8.3×10^{-5}	3.3×10^{-8}	1.5×10^{-3}	6.1×10^{-7}
Total	3.1×10^{-7}	2.2×10^{-8}	1.1×10^{-7}	5.0×10^{-10}	1.0×10^{-6}	1.5×10^{-6}	5.8×10^{-10}	3.4×10^{-5}	1.4×10^{-8}	3.7×10^{-4}	1.5×10^{-7}	8.6×10^{-3}	3.4×10^{-6}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. The maximally exposed uninvolved worker is located at L-Area.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
e. L-Area. Total uninvolved workers estimated to be 251 (Simpkins 1996).

Table C-18. L-Lake - Uninvolved worker (P-Area) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Exposure Pathway	Annual dose (rem) Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Soil	8.5×10^{-12}	7.1×10^{-14}	3.1×10^{-12}	7.0×10^{-16}	7.0×10^{-12}	1.9×10^{-11}	7.5×10^{-15}	4.1×10^{-10}	1.7×10^{-13}	2.0×10^{-9}	7.9×10^{-13}	4.4×10^{-8}	1.7×10^{-11}
Soil Dermal	5.3×10^{-13}	1.2×10^{-14}	2.0×10^{-10}	7.5×10^{-15}	1.3×10^{-10}	3.3×10^{-10}	1.3×10^{-13}	8.1×10^{-9}	3.3×10^{-12}	3.4×10^{-8}	1.4×10^{-11}	8.5×10^{-7}	3.4×10^{-10}
Subtotal	9.0×10^{-12}	8.3×10^{-14}	2.0×10^{-10}	8.2×10^{-15}	1.3×10^{-10}	3.4×10^{-10}	1.4×10^{-13}	8.5×10^{-9}	3.4×10^{-12}	3.6×10^{-8}	1.4×10^{-11}	9.0×10^{-7}	3.6×10^{-10}
Inhalation:													
Air	5.0×10^{-10}	5.3×10^{-11}	3.4×10^{-8}	2.5×10^{-12}	3.0×10^{-7}	3.4×10^{-7}	1.3×10^{-10}	8.4×10^{-6}	3.4×10^{-9}	3.5×10^{-5}	1.4×10^{-8}	8.8×10^{-4}	3.5×10^{-7}
Resuspension	5.4×10^{-12}	5.7×10^{-13}	3.7×10^{-10}	2.7×10^{-14}	3.2×10^{-9}	3.6×10^{-9}	1.4×10^{-12}	9.0×10^{-8}	3.6×10^{-11}	3.8×10^{-7}	1.5×10^{-10}	9.5×10^{-6}	3.8×10^{-9}
Subtotal	5.1×10^{-10}	5.4×10^{-11}	3.4×10^{-8}	2.5×10^{-12}	3.0×10^{-7}	3.4×10^{-7}	1.3×10^{-10}	8.5×10^{-6}	3.4×10^{-9}	3.6×10^{-5}	1.4×10^{-8}	8.9×10^{-4}	3.6×10^{-7}
External:													
Soil	9.1×10^{-8}	6.5×10^{-9}	3.4×10^{-13}	1.4×10^{-10}	2.9×10^{-11}	9.8×10^{-8}	3.9×10^{-11}	1.8×10^{-6}	7.1×10^{-10}	1.0×10^{-5}	4.1×10^{-9}	1.9×10^{-4}	7.5×10^{-8}
Air	4.3×10^{-12}	3.3×10^{-13}	3.6×10^{-18}	6.6×10^{-15}	7.6×10^{-16}	4.6×10^{-12}	1.9×10^{-15}	8.4×10^{-11}	3.4×10^{-14}	4.9×10^{-10}	1.9×10^{-13}	8.8×10^{-9}	3.5×10^{-12}
Subtotal	9.1×10^{-8}	6.5×10^{-9}	3.4×10^{-13}	1.4×10^{-10}	2.9×10^{-11}	9.8×10^{-8}	3.9×10^{-11}	1.8×10^{-6}	7.1×10^{-10}	1.0×10^{-5}	4.1×10^{-9}	1.9×10^{-4}	7.5×10^{-8}
Total	9.2×10^{-8}	6.6×10^{-9}	3.5×10^{-8}	1.5×10^{-10}	3.0×10^{-7}	4.4×10^{-7}	1.7×10^{-10}	1.0×10^{-5}	4.1×10^{-9}	4.6×10^{-5}	1.8×10^{-8}	1.1×10^{-3}	4.3×10^{-7}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. P-Area. Total uninvolved workers estimated to be105 (Simpkins 1996).

Table C-19. L-Lake - Uninvolved worker (R-Area) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Exposure Pathway	Annual dose (rem) Cs-137	Co-60	Pu-239/ 240	Pm-146	U-233/234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Soil	3.2×10^{-12}	2.7×10^{-14}	1.2×10^{-12}	1.2×10^{-12}	2.7×10^{-12}	7.1×10^{-12}	2.8×10^{-15}	1.6×10^{-10}	6.3×10^{-14}	3.5×10^{-11}	1.4×10^{-14}	7.9×10^{-10}	3.1×10^{-13}
Soil Dermal	2.0×10^{-13}	4.5×10^{-15}	7.5×10^{-11}	2.8×10^{-15}	4.6×10^{-11}	1.2×10^{-10}	4.9×10^{-14}	3.0×10^{-9}	1.2×10^{-12}	6.1×10^{-10}	2.4×10^{-13}	1.5×10^{-8}	6.1×10^{-12}
Subtotal	3.4×10^{-12}	3.2×10^{-14}	7.7×10^{-11}	3.1×10^{-15}	4.9×10^{-11}	1.3×10^{-10}	5.1×10^{-14}	3.2×10^{-9}	1.3×10^{-12}	6.4×10^{-10}	2.6×10^{-13}	1.6×10^{-8}	6.4×10^{-12}
Inhalation:													
Air	1.7×10^{-10}	1.8×10^{-11}	1.2×10^{-8}	8.9×10^{-13}	1.0×10^{-7}	1.2×10^{-7}	4.7×10^{-11}	2.9×10^{-6}	1.2×10^{-9}	5.8×10^{-7}	2.3×10^{-10}	1.5×10^{-5}	5.8×10^{-9}
Resuspension	2.0×10^{-12}	2.1×10^{-13}	1.4×10^{-10}	1.0×10^{-14}	1.2×10^{-9}	1.3×10^{-9}	5.3×10^{-13}	3.3×10^{-8}	1.3×10^{-11}	6.6×10^{-9}	2.7×10^{-12}	1.7×10^{-7}	6.6×10^{-11}
Subtotal	1.7×10^{-10}	1.9×10^{-11}	1.2×10^{-8}	9.0×10^{-13}	1.1×10^{-7}	1.2×10^{-7}	4.7×10^{-11}	2.9×10^{-6}	1.2×10^{-9}	5.9×10^{-7}	2.3×10^{-10}	1.5×10^{-5}	5.9×10^{-9}
External:													
Soil	3.4×10^{-8}	2.4×10^{-9}	1.3×10^{-13}	5.5×10^{-11}	1.1×10^{-11}	3.6×10^{-8}	1.5×10^{-11}	6.6×10^{-7}	2.7×10^{-10}	1.8×10^{-7}	7.3×10^{-11}	3.3×10^{-6}	1.3×10^{-9}
Air	1.5×10^{-12}	1.1×10^{-13}	1.2×10^{-18}	2.3×10^{-15}	2.6×10^{-16}	1.6×10^{-12}	6.5×10^{-16}	2.9×10^{-11}	1.2×10^{-14}	8.1×10^{-12}	3.2×10^{-15}	1.5×10^{-10}	5.9×10^{-14}
Subtotal	3.4×10^{-8}	2.4×10^{-9}	1.3×10^{-13}	5.5×10^{-11}	1.1×10^{-11}	3.6×10^{-8}	1.5×10^{-11}	6.6×10^{-7}	2.7×10^{-10}	1.8×10^{-7}	7.3×10^{-11}	3.3×10^{-6}	1.3×10^{-9}
Total	3.4×10^{-8}	2.4×10^{-9}	1.2×10^{-8}	5.6×10^{-11}	1.1×10^{-7}	1.5×10^{-7}	6.2×10^{-11}	3.6×10^{-6}	1.4×10^{-9}	7.7×10^{-7}	3.1×10^{-10}	1.8×10^{-5}	7.2×10^{-9}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. R-Area. Total uninvolved workers estimated to be five (Simpkins 1996).

Table C-20. L-Lake - Involved worker (current use) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

	Hazard quotient					Hazard	Cancer risk				Lifetime
Exposure Pathway	Manganese	Thallium	Antimony	Lead	Cadmium	Index[b]	Cadmium	Beryllium	Arsenic	Total annual	cancer risk[c]
Ingestion:											
Soil	9.5×10^{-8}	5.3×10^{-3}	3.8×10^{-4}	2.3×10^{-4}	4.5×10^{-5}	6.0×10^{-3}	NA[d]	3.1×10^{-9}	9.7×10^{-9}	1.3×10^{-8}	6.4×10^{-8}
Soil Dermal	7.8×10^{-8}	4.5×10^{-4}	3.2×10^{-3}	9.5×10^{-5}	7.4×10^{-4}	4.5×10^{-3}	NA	4.9×10^{-8}	1.6×10^{-9}	5.1×10^{-8}	2.5×10^{-7}
Subtotal	1.7×10^{-7}	5.8×10^{-3}	3.5×10^{-3}	3.2×10^{-4}	7.8×10^{-4}	1.0×10^{-2}	0.0×10^{0}	5.2×10^{-8}	1.1×10^{-8}	6.4×10^{-8}	3.2×10^{-7}
Inhalation:											
Resuspension	9.4×10^{-8}	1.1×10^{-4}	7.7×10^{-6}	1.5×10^{-5}	NA	1.3×10^{-4}	4.1×10^{-11}	1.2×10^{-10}	1.7×10^{-9}	1.9×10^{-9}	9.3×10^{-9}
Subtotal	9.4×10^{-8}	1.1×10^{-4}	7.7×10^{-6}	1.5×10^{-5}	0.0×10^{0}	1.3×10^{-4}	4.1×10^{-11}	1.2×10^{-10}	1.7×10^{-9}	1.9×10^{-9}	9.3×10^{-9}
Total	2.7×10^{-7}	5.9×10^{-3}	3.6×10^{-3}	3.4×10^{-4}	7.8×10^{-4}	1.1×10^{-2}	4.1×10^{-11}	5.3×10^{-8}	1.3×10^{-8}	6.6×10^{-8}	3.3×10^{-7}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 5-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-21. L-Lake - Involved worker (future use) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Hazard quotient: Manganese	Hazard quotient: Thallium	Hazard quotient: Antimony	Hazard quotient: Lead	Hazard quotient: Cadmium	Hazard Index[b]	Cancer risk: Cadmium	Cancer risk: Beryllium	Cancer risk: Arsenic	Cancer risk: Total annual	Lifetime cancer risk[c]
Ingestion:											
Soil	2.1×10^{-6}	1.2×10^{-1}	8.4×10^{-3}	5.0×10^{-3}	9.9×10^{-4}	1.3×10^{-1}	NA[d]	6.8×10^{-8}	2.2×10^{-7}	2.9×10^{-7}	7.2×10^{-6}
Soil Dermal	1.3×10^{-6}	7.5×10^{-3}	5.3×10^{-2}	1.6×10^{-3}	1.2×10^{-2}	7.4×10^{-2}	NA	8.2×10^{-7}	2.7×10^{-8}	8.5×10^{-7}	2.1×10^{-5}
Subtotal	3.4×10^{-6}	1.3×10^{-1}	6.1×10^{-2}	6.6×10^{-3}	1.3×10^{-2}	2.1×10^{-1}	0.0×10^{0}	8.9×10^{-7}	2.5×10^{-7}	1.1×10^{-6}	2.8×10^{-5}
Inhalation:											
Resuspension	2.1×10^{-6}	2.4×10^{-3}	1.7×10^{-4}	3.3×10^{-4}	NA	2.9×10^{-3}	9.0×10^{-10}	2.7×10^{-9}	3.7×10^{-8}	4.1×10^{-8}	1.0×10^{-6}
Subtotal	2.1×10^{-6}	2.4×10^{-3}	1.7×10^{-4}	3.3×10^{-4}	0.0×10^{0}	2.9×10^{-3}	9.0×10^{-10}	2.7×10^{-9}	3.7×10^{-8}	4.1×10^{-8}	1.0×10^{-6}
Total	5.5×10^{-6}	1.3×10^{-1}	6.1×10^{-2}	6.9×10^{-3}	1.3×10^{-2}	2.1×10^{-1}	9.0×10^{-10}	8.9×10^{-7}	2.8×10^{-7}	1.2×10^{-6}	2.9×10^{-5}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-22. L-Lake - Uninvolved worker (L-Area) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

	Hazard quotient					Hazard	Annual cancer risk				Lifetime
Exposure Pathway	Manganese	Thallium	Antimony	Cadmium	Lead	Index[b]	Cadmium	Beryllium	Arsenic	Total	cancer risk[c]
Ingestion:											
Soil	1.7×10^{-11}	9.4×10^{-7}	6.7×10^{-8}	7.9×10^{-9}	4.0×10^{-8}	1.1×10^{-6}	NA[d]	5.5×10^{-13}	1.7×10^{-12}	2.3×10^{-12}	5.6×10^{-11}
Soil Dermal	1.1×10^{-11}	6.0×10^{-8}	4.2×10^{-7}	1.0×10^{-7}	1.2×10^{-8}	6.0×10^{-7}	NA	6.8×10^{-12}	2.2×10^{-13}	7.1×10^{-12}	1.8×10^{-10}
Subtotal	2.8×10^{-11}	1.0×10^{-6}	4.9×10^{-7}	1.1×10^{-7}	5.2×10^{-8}	1.7×10^{-6}	0.0×10^{0}	7.4×10^{-12}	1.9×10^{-12}	9.3×10^{-12}	2.3×10^{-10}
Inhalation:											
Air	7.5×10^{-8}	8.5×10^{-5}	6.1×10^{-6}	NA	1.2×10^{-5}	1.0×10^{-4}	3.2×10^{-11}	9.6×10^{-11}	1.3×10^{-9}	1.4×10^{-9}	3.6×10^{-8}
Resuspension	8.1×10^{-10}	9.3×10^{-7}	6.6×10^{-8}	NA	1.3×10^{-7}	1.1×10^{-6}	3.5×10^{-13}	1.1×10^{-12}	1.5×10^{-11}	1.6×10^{-11}	4.1×10^{-10}
Subtotal	7.5×10^{-8}	8.6×10^{-5}	6.1×10^{-6}	0.0×10^{0}	1.2×10^{-5}	1.0×10^{-4}	3.2×10^{-11}	9.7×10^{-11}	1.3×10^{-9}	1.4×10^{-9}	3.6×10^{-8}
Total	7.5×10^{-8}	8.7×10^{-5}	6.6×10^{-6}	1.1×10^{-7}	1.2×10^{-5}	1.1×10^{-4}	3.2×10^{-11}	1.1×10^{-10}	1.3×10^{-9}	1.4×10^{-9}	3.6×10^{-8}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-23. L-Lake - Uninvolved worker (P-Area) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Hazard quotient					Hazard index[b]	Annual cancer risk				Lifetime cancer risk[c]
	Manganese	Thallium	Antimony	Cadmium	Lead		Cadmium	Beryllium	Arsenic	Total	
Ingestion:											
Soil	5.0×10^{-12}	2.8×10^{-7}	2.0×10^{-8}	2.3×10^{-9}	1.2×10^{-8}	3.1×10^{-7}	NA[d]	1.6×10^{-13}	5.1×10^{-13}	6.7×10^{-13}	1.7×10^{-11}
Soil Dermal	3.2×10^{-12}	1.8×10^{-8}	1.2×10^{-7}	2.9×10^{-8}	3.8×10^{-9}	1.7×10^{-7}	NA	2.1×10^{-12}	6.4×10^{-14}	2.1×10^{-12}	5.3×10^{-11}
Subtotal	8.2×10^{-12}	3.0×10^{-7}	1.4×10^{-7}	3.2×10^{-8}	1.6×10^{-8}	4.9×10^{-7}	0.0×10^{0}	2.2×10^{-12}	5.7×10^{-13}	2.8×10^{-12}	7.0×10^{-11}
Inhalation:											
Air	2.3×10^{-8}	2.6×10^{-5}	1.8×10^{-6}	NA	3.6×10^{-6}	3.1×10^{-5}	9.7×10^{-12}	2.9×10^{-11}	4.0×10^{-10}	4.4×10^{-10}	1.1×10^{-8}
Resuspension	2.4×10^{-10}	2.7×10^{-7}	2.0×10^{-8}	NA	3.8×10^{-8}	3.3×10^{-7}	1.0×10^{-13}	3.1×10^{-13}	4.3×10^{-12}	4.7×10^{-12}	1.2×10^{-10}
Subtotal	2.3×10^{-8}	2.6×10^{-5}	1.8×10^{-6}	0.0×10^{0}	3.6×10^{-6}	3.1×10^{-5}	9.8×10^{-12}	2.9×10^{-11}	4.0×10^{-10}	4.4×10^{-10}	1.1×10^{-8}
Total	2.3×10^{-8}	2.6×10^{-5}	1.9×10^{-6}	3.2×10^{-8}	3.6×10^{-6}	3.2×10^{-5}	9.8×10^{-12}	3.1×10^{-11}	4.0×10^{-10}	4.4×10^{-10}	1.1×10^{-8}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-24. L-Lake - Uninvolved worker (R-Area) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

	Hazard quotient					Hazard	Annual cancer risk				Lifetime
Exposure Pathway	Manganese	Thallium	Antimony	Cadmium	Lead	Index[b]	Cadmium	Beryllium	Arsenic	Total	cancer risk[c]
Ingestion:											
Soil	1.9×10^{-12}	1.0×10^{-7}	7.5×10^{-9}	8.8×10^{-10}	4.5×10^{-9}	1.1×10^{-7}	NA[d]	6.1×10^{-14}	1.9×10^{-13}	2.5×10^{-13}	6.3×10^{-12}
Soil Dermal	1.2×10^{-12}	6.6×10^{-9}	4.7×10^{-8}	1.1×10^{-8}	1.4×10^{-9}	6.6×10^{-8}	NA	7.5×10^{-13}	2.4×10^{-14}	7.8×10^{-13}	1.9×10^{-11}
Subtotal	3.1×10^{-12}	1.1×10^{-7}	5.5×10^{-8}	1.2×10^{-8}	5.9×10^{-9}	1.8×10^{-7}	0.0×10^{0}	8.1×10^{-13}	2.1×10^{-13}	1.0×10^{-12}	2.6×10^{-11}
Inhalation:											
Air	7.7×10^{-9}	8.8×10^{-6}	6.3×10^{-7}	NA	1.2×10^{-6}	1.1×10^{-5}	3.3×10^{-12}	1.0×10^{-11}	1.4×10^{-10}	1.5×10^{-10}	3.8×10^{-9}
Resuspension	9.0×10^{-11}	1.0×10^{-7}	7.4×10^{-9}	NA	1.4×10^{-8}	1.2×10^{-7}	3.9×10^{-14}	1.2×10^{-13}	1.6×10^{-12}	1.8×10^{-12}	4.4×10^{-11}
Subtotal	7.8×10^{-9}	8.9×10^{-6}	6.4×10^{-7}	0.0×10^{0}	1.2×10^{-6}	1.1×10^{-5}	3.4×10^{-12}	1.0×10^{-11}	1.4×10^{-10}	1.5×10^{-10}	3.8×10^{-9}
Total	7.8×10^{-9}	9.0×10^{-6}	6.9×10^{-7}	1.2×10^{-8}	1.2×10^{-6}	1.1×10^{-5}	3.4×10^{-12}	1.1×10^{-11}	1.4×10^{-10}	1.5×10^{-10}	3.9×10^{-9}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed L-Lake sediments.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-25. Pen Branch - Involved worker (current use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	4.4×10^{-10}	1.8×10^{-13}	5.9×10^{-9}	2.4×10^{-12}	3.1×10^{-8}	1.2×10^{-11}	4.1×10^{-7}	1.7×10^{-10}
Soil dermal	3.7×10^{-11}	1.5×10^{-14}	5.0×10^{-10}	2.0×10^{-13}	2.6×10^{-9}	1.0×10^{-12}	3.5×10^{-8}	1.4×10^{-11}
Subtotal	4.8×10^{-10}	1.9×10^{-13}	6.4×10^{-9}	2.6×10^{-12}	3.3×10^{-8}	1.3×10^{-11}	4.5×10^{-7}	1.8×10^{-10}
Inhalation:								
Resuspension	1.4×10^{-11}	5.4×10^{-15}	1.8×10^{-10}	7.3×10^{-14}	9.5×10^{-10}	3.8×10^{-13}	1.3×10^{-8}	5.1×10^{-12}
Subtotal	1.4×10^{-11}	5.4×10^{-15}	1.8×10^{-10}	7.3×10^{-14}	9.5×10^{-10}	3.8×10^{-13}	1.3×10^{-8}	5.1×10^{-12}
Total	4.9×10^{-10}	2.0×10^{-13}	6.6×10^{-9}	2.6×10^{-12}	3.4×10^{-8}	1.4×10^{-11}	4.6×10^{-7}	1.8×10^{-10}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-26. Pen Branch - Involved worker (future use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	9.9×10^{-9}	4.0×10^{-12}	1.3×10^{-7}	5.3×10^{-11}	6.9×10^{-7}	2.8×10^{-10}	9.3×10^{-6}	3.7×10^{-9}
Soil dermal	6.2×10^{-10}	2.5×10^{-13}	8.4×10^{-9}	3.4×10^{-12}	4.4×10^{-8}	1.7×10^{-11}	5.9×10^{-7}	2.3×10^{-10}
Subtotal	1.1×10^{-8}	4.2×10^{-12}	1.4×10^{-7}	5.7×10^{-11}	7.4×10^{-7}	2.9×10^{-10}	9.9×10^{-6}	4.0×10^{-9}
Inhalation:								
Resuspension	3.0×10^{-10}	1.2×10^{-13}	4.0×10^{-9}	1.6×10^{-12}	2.1×10^{-8}	8.4×10^{-12}	2.8×10^{-7}	1.1×10^{-10}
Subtotal	3.0×10^{-10}	1.2×10^{-13}	4.0×10^{-9}	1.6×10^{-12}	2.1×10^{-8}	8.4×10^{-12}	2.8×10^{-7}	1.1×10^{-10}
Total	1.1×10^{-8}	4.3×10^{-12}	1.5×10^{-7}	5.8×10^{-11}	7.6×10^{-7}	3.0×10^{-10}	1.0×10^{-5}	4.1×10^{-9}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-27. Fourmile Branch - Involved worker (current use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	5.8×10^{-11}	2.3×10^{-14}	7.8×10^{-10}	3.1×10^{-13}	4.1×10^{-9}	1.6×10^{-12}	5.5×10^{-8}	2.2×10^{-11}
Soil dermal	4.9×10^{-12}	2.0×10^{-15}	6.6×10^{-11}	2.7×10^{-14}	3.5×10^{-10}	1.4×10^{-13}	4.6×10^{-9}	1.9×10^{-12}
Subtotal	6.3×10^{-11}	2.5×10^{-14}	8.5×10^{-10}	3.4×10^{-13}	4.4×10^{-9}	1.8×10^{-12}	5.9×10^{-8}	2.4×10^{-11}
Inhalation:								
Resuspension	1.8×10^{-12}	7.2×10^{-16}	2.4×10^{-11}	9.7×10^{-15}	1.3×10^{-10}	5.0×10^{-14}	1.7×10^{-9}	6.8×10^{-13}
Subtotal	1.8×10^{-12}	7.2×10^{-16}	2.4×10^{-11}	9.7×10^{-15}	1.3×10^{-10}	5.0×10^{-14}	1.7×10^{-9}	6.8×10^{-13}
Total	6.5×10^{-11}	2.6×10^{-14}	8.7×10^{-10}	3.5×10^{-13}	4.5×10^{-9}	1.8×10^{-12}	6.1×10^{-8}	2.4×10^{-11}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-28. Fourmile Branch - Involved worker (future use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	1.3×10^{-9}	5.2×10^{-13}	1.7×10^{-8}	7.0×10^{-12}	9.1×10^{-8}	3.6×10^{-11}	1.2×10^{-6}	4.9×10^{-10}
Soil dermal	8.2×10^{-10}	3.3×10^{-14}	1.1×10^{-9}	4.4×10^{-13}	5.8×10^{-9}	2.3×10^{-12}	7.7×10^{-8}	3.1×10^{-11}
Subtotal	1.4×10^{-9}	5.5×10^{-13}	1.9×10^{-8}	7.4×10^{-12}	9.7×10^{-8}	3.9×10^{-11}	1.3×10^{-6}	5.2×10^{-10}
Inhalation:								
Resuspension	4.1×10^{-11}	1.6×10^{-14}	5.4×10^{-10}	2.2×10^{-13}	2.8×10^{-9}	1.1×10^{-12}	3.8×10^{-8}	1.5×10^{-11}
Subtotal	4.1×10^{-11}	1.6×10^{-14}	5.4×10^{-10}	2.2×10^{-13}	2.8×10^{-9}	1.1×10^{-12}	3.8×10^{-8}	1.5×10^{-11}
Total	1.4×10^{-9}	5.7×10^{-13}	1.9×10^{-8}	7.7×10^{-12}	1.0×10^{-7}	4.0×10^{-11}	1.3×10^{-6}	5.4×10^{-10}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-29. Steel Creek - Involved worker (current use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	3.1×10^{-10}	1.2×10^{-13}	4.2×10^{-9}	1.7×10^{-12}	2.2×10^{-8}	8.7×10^{-12}	2.9×10^{-7}	1.2×10^{-10}
Soil dermal	2.6×10^{-11}	1.1×10^{-14}	3.5×10^{-10}	1.4×10^{-13}	1.8×10^{-9}	7.4×10^{-13}	2.5×10^{-8}	9.9×10^{-12}
Subtotal	3.4×10^{-10}	1.3×10^{-13}	4.5×10^{-9}	1.8×10^{-12}	2.4×10^{-8}	9.4×10^{-12}	3.2×10^{-7}	1.3×10^{-10}
Inhalation:								
Resuspension	9.6×10^{-12}	3.8×10^{-15}	1.3×10^{-10}	5.2×10^{-14}	6.7×10^{-10}	2.7×10^{-13}	9.0×10^{-9}	3.6×10^{-12}
Subtotal	9.6×10^{-12}	3.8×10^{-15}	1.3×10^{-10}	5.2×10^{-14}	6.7×10^{-10}	2.7×10^{-13}	9.0×10^{-9}	3.6×10^{-12}
Total	3.5×10^{-10}	1.4×10^{-13}	4.7×10^{-9}	1.9×10^{-12}	2.4×10^{-8}	9.7×10^{-12}	3.3×10^{-7}	1.3×10^{-10}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-30. Steel Creek - Involved worker (future use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

	Individual worker				Worker population[b]			
Exposure pathway	Annual dose (rem)	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Annual dose (person-rem)	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:								
Soil	7.0×10^{-9}	2.8×10^{-12}	9.4×10^{-8}	3.8×10^{-11}	4.9×10^{-7}	2.0×10^{-10}	6.6×10^{-6}	2.6×10^{-9}
Soil dermal	4.4×10^{-10}	1.8×10^{-13}	5.9×10^{-9}	2.4×10^{-12}	3.1×10^{-8}	1.2×10^{-11}	4.1×10^{-7}	1.7×10^{-10}
Subtotal	7.4×10^{-9}	3.0×10^{-12}	1.0×10^{-7}	4.0×10^{-11}	5.2×10^{-7}	2.1×10^{-10}	7.0×10^{-6}	2.8×10^{-9}
Inhalation:								
Resuspension	2.1×10^{-10}	8.4×10^{-14}	2.8×10^{-9}	1.1×10^{-12}	1.5×10^{-8}	5.9×10^{-12}	2.0×10^{-7}	7.9×10^{-11}
Subtotal	2.1×10^{-10}	8.4×10^{-14}	2.8×10^{-9}	1.1×10^{-12}	1.5×10^{-8}	5.9×10^{-12}	2.0×10^{-7}	7.9×10^{-11}
Total	7.6×10^{-9}	3.1×10^{-12}	1.0×10^{-7}	4.1×10^{-11}	5.4×10^{-7}	2.1×10^{-10}	7.2×10^{-6}	2.9×10^{-9}

a. For the No-Action Alternative, the involved worker exposures result from increased concentrations of tritium in surface water.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-31. Steel Creek - Involved worker (current use) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

Exposure Pathway	Individual annual dose (rem) Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Shoreline Dermal	1.2×10^{-12}	2.7×10^{-14}	3.1×10^{-9}	2.8×10^{-12}	1.2×10^{-10}	3.3×10^{-9}	1.3×10^{-12}	1.6×10^{-8}	6.5×10^{-12}	2.3×10^{-7}	9.1×10^{-11}	1.1×10^{-6}	4.5×10^{-10}
Shoreline	1.4×10^{-11}	1.2×10^{-13}	3.6×10^{-11}	2.0×10^{-13}	6.4×10^{-11}	1.1×10^{-10}	4.6×10^{-14}	5.7×10^{-10}	2.3×10^{-13}	8.0×10^{-9}	3.2×10^{-12}	4.0×10^{-8}	1.6×10^{-11}
Subtotal	1.5×10^{-11}	1.5×10^{-13}	3.2×10^{-9}	3.0×10^{-12}	1.9×10^{-10}	3.4×10^{-9}	1.3×10^{-12}	1.7×10^{-8}	6.7×10^{-12}	2.4×10^{-7}	9.4×10^{-11}	1.2×10^{-6}	4.7×10^{-10}
External:													
Shoreline	3.1×10^{-8}	2.2×10^{-9}	8.1×10^{-13}	8.3×10^{-9}	3.4×10^{-11}	4.2×10^{-8}	1.7×10^{-11}	1.9×10^{-7}	7.4×10^{-11}	2.9×10^{-6}	1.2×10^{-9}	1.3×10^{-5}	5.2×10^{-9}
Subtotal	3.1×10^{-8}	2.2×10^{-9}	8.1×10^{-13}	8.3×10^{-9}	3.4×10^{-11}	4.2×10^{-8}	1.7×10^{-11}	1.9×10^{-7}	7.4×10^{-11}	2.9×10^{-6}	1.2×10^{-9}	1.3×10^{-5}	5.2×10^{-9}
Total	3.1×10^{-8}	2.2×10^{-9}	3.2×10^{-9}	8.3×10^{-9}	2.2×10^{-10}	4.5×10^{-8}	1.8×10^{-11}	2.0×10^{-7}	8.1×10^{-11}	3.1×10^{-6}	1.3×10^{-9}	1.4×10^{-5}	5.7×10^{-9}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from the aqueous transport of exposed L-Lake sediments in Steel Creek.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-32. Steel Creek - Involved worker (future use) radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects.[a]

	Individual annual dose (rem)												
Exposure Pathway	Cs-137	Co-60	Pu-239/240	Pm-146	U-233/234	Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:													
Shoreline Dermal	2.0×10^{-11}	4.5×10^{-13}	5.2×10^{-8}	4.7×10^{-11}	2.1×10^{-9}	5.4×10^{-8}	2.2×10^{-11}	1.4×10^{-6}	5.4×10^{-10}	3.8×10^{-6}	1.5×10^{-9}	9.5×10^{-5}	3.8×10^{-8}
Shoreline	3.2×10^{-10}	2.7×10^{-12}	8.1×10^{-10}	4.3×10^{-12}	1.5×10^{-9}	2.6×10^{-9}	1.1×10^{-12}	6.4×10^{-8}	2.6×10^{-11}	1.8×10^{-7}	7.4×10^{-11}	4.5×10^{-6}	1.8×10^{-9}
Subtotal	3.4×10^{-10}	3.2×10^{-12}	5.3×10^{-8}	5.1×10^{-11}	3.6×10^{-9}	5.7×10^{-8}	2.3×10^{-11}	1.4×10^{-6}	5.7×10^{-10}	4.0×10^{-6}	1.6×10^{-9}	9.9×10^{-5}	4.0×10^{-8}
External:													
Shoreline	6.8×10^{-7}	4.9×10^{-8}	1.8×10^{-11}	1.9×10^{-7}	7.5×10^{-10}	9.2×10^{-7}	3.7×10^{-10}	1.5×10^{-5}	6.4×10^{-9}	6.4×10^{-5}	2.6×10^{-8}	1.0×10^{-3}	4.1×10^{-7}
Subtotal	6.8×10^{-7}	4.9×10^{-8}	1.8×10^{-11}	1.9×10^{-7}	7.5×10^{-10}	9.2×10^{-7}	3.7×10^{-10}	1.5×10^{-5}	6.4×10^{-9}	6.4×10^{-5}	2.6×10^{-8}	1.0×10^{-3}	4.1×10^{-7}
Total	6.8×10^{-7}	4.9×10^{-8}	5.3×10^{-8}	1.9×10^{-7}	4.3×10^{-9}	9.7×10^{-7}	3.9×10^{-10}	1.6×10^{-5}	6.8×10^{-9}	6.8×10^{-5}	2.7×10^{-8}	1.1×10^{-3}	4.5×10^{-7}

a. For the Shut Down and Deactivate Alternative, the involved worker exposures result from the aqueous transport of exposed L-Lake sediments in Steel Creek.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are decay corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-33. Steel Creek - Involved worker (current use) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Hazard quotient: Manganese	Hazard quotient: Thallium	Hazard quotient: Antimony	Hazard quotient: Lead	Hazard quotient: Cadmium	Hazard Index	Annual cancer risk: Beryllium	Annual cancer risk: Arsenic	Annual cancer risk: Total	Lifetime cancer risk[c]
Ingestion:										
Shoreline Dermal	7.4×10^{-11}	6.6×10^{-6}	1.6×10^{-6}	2.9×10^{-8}	1.1×10^{-7}	8.4×10^{-6}	5.3×10^{-12}	3.3×10^{-13}	5.7×10^{-12}	2.8×10^{-11}
Shoreline	8.7×10^{-11}	7.7×10^{-5}	1.9×10^{-7}	6.9×10^{-8}	6.1×10^{-9}	7.7×10^{-5}	3.1×10^{-13}	1.9×10^{-12}	2.2×10^{-12}	1.1×10^{-11}
Total	1.6×10^{-10}	8.4×10^{-5}	1.8×10^{-6}	9.8×10^{-8}	1.1×10^{-7}	8.6×10^{-5}	5.7×10^{-12}	2.2×10^{-12}	7.9×10^{-12}	3.9×10^{-11}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the aqueous transport of exposed L-Lake sediments in Steel Creek.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 5-year exposure period.

Table C-34. Steel Creek - Involved worker (future use) nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative.[a]

	Hazard quotient					Hazard	Annual cancer risk			Lifetime
Exposure Pathway	Manganese	Thallium	Antimony	Lead	Cadmium	Index	Beryllium	Arsenic	Total	cancer risk[c]
Ingestion:										
Shoreline Dermal	1.2×10^{-9}	1.1×10^{-4}	2.7×10^{-5}	4.9×10^{-7}	1.8×10^{-6}	1.4×10^{-4}	8.9×10^{-11}	5.5×10^{-12}	9.5×10^{-10}	2.4×10^{-9}
Shoreline	2.0×10^{-9}	1.7×10^{-3}	4.4×10^{-6}	1.5×10^{-6}	1.4×10^{-7}	1.7×10^{-3}	7.1×10^{-12}	4.4×10^{-11}	5.1×10^{-11}	1.3×10^{-9}
Total	3.2×10^{-9}	1.8×10^{-3}	3.2×10^{-5}	2.0×10^{-6}	1.9×10^{-6}	1.8×10^{-3}	9.6×10^{-11}	4.9×10^{-11}	1.5×10^{-10}	3.6×10^{-9}

a. For the Shut Down and Deactivate Alternative, the uninvolved worker is exposed by the aqueous transport of exposed L-Lake sediments in Steel Creek.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.
c. Based on a 25-year exposure period.

Table C-35. Par Pond - Radiological doses associated with the No-Action Alternative and resulting health effects to the offsite maximally exposed individual.[a]

Exposure pathway	Individual annual dose (rem)[b] Cesium-137	Cobalt-60	Total	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]
Ingestion:						
Soil	1.2×10^{-9}	2.2×10^{-13}	1.2×10^{-9}	6.1×10^{-13}	4.2×10^{-8}	2.1×10^{-11}
Soil dermal	2.4×10^{-10}	1.1×10^{-13}	2.4×10^{-10}	1.2×10^{-13}	8.5×10^{-9}	4.2×10^{-12}
Leafy vegetables	2.0×10^{-8}	3.6×10^{-12}	2.0×10^{-8}	9.8×10^{-12}	6.8×10^{-7}	3.4×10^{-10}
Other vegetables	2.0×10^{-8}	3.4×10^{-12}	2.0×10^{-8}	9.8×10^{-12}	6.8×10^{-7}	3.4×10^{-10}
Meat	8.6×10^{-9}	1.5×10^{-12}	8.6×10^{-9}	4.3×10^{-12}	3.0×10^{-7}	1.5×10^{-10}
Milk	9.4×10^{-8}	4.8×10^{-12}	9.4×10^{-8}	4.7×10^{-11}	3.3×10^{-6}	1.6×10^{-9}
Subtotal	1.4×10^{-7}	1.4×10^{-11}	1.4×10^{-7}	7.2×10^{-11}	5.0×10^{-6}	2.5×10^{-9}
Inhalation:						
Air	2.4×10^{-8}	5.5×10^{-11}	2.4×10^{-8}	1.2×10^{-11}	8.5×10^{-7}	4.2×10^{-10}
Resuspension	2.4×10^{-10}	5.7×10^{-13}	2.4×10^{-10}	1.2×10^{-13}	8.5×10^{-9}	4.2×10^{-12}
Subtotal	2.4×10^{-8}	5.7×10^{-11}	2.4×10^{-8}	1.2×10^{-11}	8.5×10^{-7}	4.2×10^{-10}
External:						
Soil	6.3×10^{-6}	9.6×10^{-9}	6.4×10^{-6}	3.2×10^{-9}	2.2×10^{-4}	1.1×10^{-7}
Air	3.1×10^{-10}	5.1×10^{-13}	3.1×10^{-10}	1.5×10^{-13}	1.1×10^{-8}	5.4×10^{-12}
Subtotal	6.3×10^{-6}	9.6×10^{-9}	6.4×10^{-6}	3.2×10^{-9}	2.2×10^{-4}	1.1×10^{-7}
Total	6.5×10^{-6}	9.8×10^{-9}	6.5×10^{-6}	3.3×10^{-9}	2.3×10^{-4}	1.1×10^{-7}

a. For the No-Action Alternative, the general public exposures result from the atmospheric transport of exposed Par Pond sediments.
b. The offsite maximally exposed individual is a member of the public residing at the SRS boundary.
c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-36. Par Pond - Radiological doses associated with the No-Action Alternative and resulting health effects to the general public.[a]

Exposure pathway	Population annual dose (rem)[b] Cesium-137	Cobalt-60	Total	Number of fatal cancers[c]	Lifetime dose (person-rem)[d]	Number of fatal cancers[c]
Ingestion:						
Soil	4.2×10^{-7}	7.5×10^{-11}	4.2×10^{-7}	2.1×10^{-10}	1.5×10^{-5}	7.4×10^{-9}
Soil dermal	8.5×10^{-8}	3.9×10^{-11}	8.5×10^{-8}	4.2×10^{-11}	2.9×10^{-6}	1.5×10^{-9}
Leafy vegetables	6.8×10^{-6}	1.2×10^{-9}	6.8×10^{-6}	3.4×10^{-9}	2.4×10^{-4}	1.2×10^{-7}
Other vegetables	6.8×10^{-6}	1.1×10^{-9}	6.8×10^{-6}	3.4×10^{-9}	2.4×10^{-4}	1.2×10^{-7}
Meat	3.0×10^{-6}	5.0×10^{-10}	3.0×10^{-6}	1.5×10^{-9}	1.0×10^{-4}	5.2×10^{-8}
Milk	3.3×10^{-5}	1.6×10^{-9}	3.3×10^{-5}	1.6×10^{-8}	1.1×10^{-3}	5.7×10^{-7}
Subtotal	5.0×10^{-5}	4.6×10^{-9}	4.9×10^{-5}	2.5×10^{-8}	1.7×10^{-3}	8.7×10^{-7}
Inhalation:						
Air	8.5×10^{-6}	1.9×10^{-8}	8.5×10^{-6}	4.3×10^{-9}	2.9×10^{-4}	1.5×10^{-7}
Resuspension	8.5×10^{-8}	1.9×10^{-10}	8.5×10^{-8}	4.3×10^{-11}	2.9×10^{-6}	1.5×10^{-9}
Subtotal	8.5×10^{-6}	1.9×10^{-8}	8.5×10^{-6}	4.3×10^{-9}	2.9×10^{-4}	1.5×10^{-7}
External:						
Soil	2.2×10^{-3}	3.3×10^{-6}	2.2×10^{-3}	1.1×10^{-6}	7.7×10^{-2}	3.8×10^{-5}
Air	1.1×10^{-7}	1.7×10^{-10}	1.1×10^{-7}	5.4×10^{-11}	3.7×10^{-6}	1.9×10^{-9}
Subtotal	2.2×10^{-3}	3.3×10^{-6}	2.2×10^{-3}	1.1×10^{-6}	7.7×10^{-2}	3.8×10^{-5}
Total	2.3×10^{-3}	3.3×10^{-6}	2.3×10^{-3}	1.1×10^{-6}	7.6×10^{-2}	3.8×10^{-5}

a. For the No-Action Alternative, the general public exposures result from the atmospheric transport of exposed Par Pond sediments.

b. Offsite population within 80 kilometers (50 miles) of SRS.

c. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).

d. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-37. Par Pond - Nonradiological hazard index associated with the No-Action Alternative for the offsite maximally exposed individual (future use).[a]

Exposure pathway	Hazard quotient		
	Mercury	Thallium	Hazard index[b]
Ingestion:			
Soil	5.3×10^{-7}	1.4×10^{-7}	6.7×10^{-7}
Soil dermal	4.9×10^{-6}	2.6×10^{-8}	5.0×10^{-6}
Leafy vegetables	9.1×10^{-6}	2.2×10^{-6}	1.1×10^{-5}
Other vegetables	9.9×10^{-6}	2.0×10^{-6}	1.2×10^{-5}
Meat	4.9×10^{-5}	1.8×10^{-6}	5.1×10^{-5}
Milk	2.6×10^{-6}	2.9×10^{-6}	5.6×10^{-6}
Subtotal	7.8×10^{-5}	9.3×10^{-6}	8.7×10^{-5}
Inhalation:			
Air	5.7×10^{-5}	4.2×10^{-6}	6.1×10^{-5}
Resuspension	5.7×10^{-7}	4.3×10^{-8}	6.1×10^{-7}
Subtotal	5.7×10^{-5}	4.3×10^{-6}	6.1×10^{-5}
Total	1.4×10^{-4}	1.4×10^{-5}	1.5×10^{-4}

a. For the No-Action Alternative, the general public exposures result from the atmospheric transport of exposed Par Pond sediments. No carcinogenic constituents are released.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.

Table C-38. Par Pond - Involved worker (current use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

Exposure pathway	Annual dose (rem) Cesium-137	Annual dose (rem) Cobalt-60	Annual dose (rem) Total	Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
Ingestion:										
Soil	3.1×10^{-7}	6.1×10^{-10}	3.1×10^{-7}	1.2×10^{-10}	1.5×10^{-6}	5.9×10^{-10}	2.2×10^{-5}	8.7×10^{-9}	1.0×10^{-4}	4.1×10^{-8}
Soil dermal	2.5×10^{-8}	1.4×10^{-10}	2.6×10^{-8}	1.0×10^{-11}	1.2×10^{-7}	4.8×10^{-11}	1.8×10^{-6}	7.2×10^{-10}	8.5×10^{-6}	3.4×10^{-9}
Subtotal	3.4×10^{-7}	7.5×10^{-10}	3.4×10^{-7}	1.3×10^{-10}	1.6×10^{-6}	6.3×10^{-10}	2.4×10^{-5}	9.4×10^{-9}	1.1×10^{-4}	4.4×10^{-8}
Inhalation:										
Resuspension	3.9×10^{-9}	9.9×10^{-11}	4.0×10^{-9}	1.6×10^{-12}	1.9×10^{-8}	7.5×10^{-12}	2.8×10^{-7}	1.1×10^{-10}	1.3×10^{-6}	5.3×10^{-10}
Subtotal	3.9×10^{-9}	9.9×10^{-11}	4.0×10^{-9}	1.6×10^{-12}	1.9×10^{-8}	7.5×10^{-12}	2.8×10^{-7}	1.1×10^{-10}	1.3×10^{-6}	5.3×10^{-10}
External:										
Soil	4.1×10^{-4}	6.9×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	2.0×10^{-3}	7.8×10^{-7}	2.9×10^{-2}	1.2×10^{-5}	1.4×10^{-1}	5.5×10^{-5}
Subtotal	4.1×10^{-4}	6.9×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	2.0×10^{-3}	7.8×10^{-7}	2.9×10^{-2}	1.2×10^{-5}	1.4×10^{-1}	5.5×10^{-5}
Total	4.1×10^{-4}	6.9×10^{-6}	4.2×10^{-4}	1.7×10^{-7}	2.0×10^{-3}	7.9×10^{-7}	2.9×10^{-2}	1.2×10^{-5}	1.4×10^{-1}	5.5×10^{-5}

a. For the No-Action Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed Par Pond sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-39. Par Pond - Involved worker (future use) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

Exposure pathway	Individual annual dose (rem)			Probability of fatal cancer[b]	Lifetime dose (rem)[c]	Probability of fatal cancer[b]	Population annual dose (person-rem)[d]	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c,d]	Number of fatal cancers[b]
	Cesium-137	Cobalt-60	Total							
Ingestion:										
Soil	6.7×10^{-6}	1.3×10^{-8}	6.7×10^{-6}	2.7×10^{-9}	1.3×10^{-4}	5.1×10^{-8}	4.7×10^{-4}	1.9×10^{-7}	8.9×10^{-3}	3.6×10^{-6}
Soil dermal	4.2×10^{-7}	2.1×10^{-9}	4.2×10^{-7}	1.7×10^{-10}	8.0×10^{-6}	3.2×10^{-9}	2.9×10^{-5}	1.2×10^{-8}	5.6×10^{-4}	2.2×10^{-7}
Subtotal	7.1×10^{-6}	1.5×10^{-8}	7.1×10^{-6}	2.9×10^{-9}	1.4×10^{-4}	5.4×10^{-8}	5.0×10^{-4}	2.0×10^{-7}	9.5×10^{-3}	3.8×10^{-6}
Inhalation:										
Resuspension	8.6×10^{-8}	2.1×10^{-9}	8.8×10^{-8}	3.5×10^{-11}	1.6×10^{-6}	6.6×10^{-10}	6.2×10^{-6}	2.5×10^{-9}	1.2×10^{-4}	4.6×10^{-8}
Subtotal	8.6×10^{-8}	2.1×10^{-9}	8.8×10^{-8}	3.5×10^{-11}	1.6×10^{-6}	6.6×10^{-10}	6.2×10^{-6}	2.5×10^{-9}	1.2×10^{-4}	4.6×10^{-8}
External:										
Soil	2.3×10^{-2}	3.8×10^{-4}	2.3×10^{-2}	9.4×10^{-6}	4.4×10^{-1}	1.8×10^{-4}	1.6×10^{0}	6.5×10^{-4}	3.1×10^{1}	1.2×10^{-2}
Subtotal	2.3×10^{-2}	3.8×10^{-4}	2.3×10^{-2}	9.4×10^{-6}	4.4×10^{-1}	1.8×10^{-4}	1.6×10^{0}	6.5×10^{-4}	3.1×10^{1}	1.2×10^{-2}
Total	2.3×10^{-2}	3.8×10^{-4}	2.3×10^{-2}	9.4×10^{-6}	4.4×10^{-1}	1.8×10^{-4}	1.6×10^{0}	6.5×10^{-4}	3.1×10^{1}	1.2×10^{-2}

a. For the No-Action Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed Par Pond sediments.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. The number of involved workers is estimated to be 70.

Table C-40. Par Pond - Uninvolved worker (L-Area) radiological doses associated with the No-Action Alternative and resulting health effects.[a]

Exposure pathway	Individual annual dose (rem)[b] Cesium-137	Cobalt-60	Total	Probability of fatal cancer[c]	Lifetime dose (rem)[d]	Probability of fatal cancer[c]	Population annual dose (person-rem)[e]	Number of fatal cancers[c]	Population lifetime dose (person-rem)[d,e]	Number of fatal cancers[c]
Ingestion:										
Soil	2.1×10^{-11}	4.2×10^{-14}	2.1×10^{-11}	8.4×10^{-15}	4.0×10^{-10}	1.6×10^{-13}	2.2×10^{-9}	8.8×10^{-13}	4.2×10^{-8}	1.7×10^{-11}
Soil dermal	1.4×10^{-12}	7.5×10^{-15}	1.4×10^{-12}	5.5×10^{-16}	2.6×10^{-11}	1.0×10^{-14}	1.4×10^{-10}	5.8×10^{-14}	2.7×10^{-9}	1.1×10^{-12}
Subtotal	2.2×10^{-11}	5.0×10^{-14}	2.2×10^{-11}	9.0×10^{-15}	4.3×10^{-10}	1.7×10^{-13}	2.4×10^{-9}	9.4×10^{-13}	4.5×10^{-8}	1.8×10^{-11}
Inhalation:										
Air	4.4×10^{-10}	1.1×10^{-11}	4.5×10^{-10}	1.8×10^{-13}	8.4×10^{-9}	3.4×10^{-12}	4.7×10^{-8}	1.9×10^{-11}	8.9×10^{-7}	3.5×10^{-10}
Resuspension	4.4×10^{-12}	1.1×10^{-13}	4.5×10^{-12}	1.8×10^{-15}	8.4×10^{-11}	3.4×10^{-14}	4.7×10^{-10}	1.9×10^{-13}	8.9×10^{-9}	3.5×10^{-12}
Subtotal	4.4×10^{-10}	1.1×10^{-11}	4.5×10^{-10}	1.8×10^{-13}	8.4×10^{-9}	3.4×10^{-12}	4.7×10^{-8}	1.9×10^{-11}	8.9×10^{-7}	3.5×10^{-10}
External:										
Soil	7.5×10^{-8}	1.3×10^{-9}	7.6×10^{-8}	3.1×10^{-11}	1.4×10^{-6}	5.7×10^{-10}	8.0×10^{-6}	3.2×10^{-9}	1.5×10^{-4}	6.0×10^{-8}
Air	3.7×10^{-12}	6.7×10^{-14}	3.8×10^{-12}	1.5×10^{-15}	7.1×10^{-11}	2.8×10^{-14}	4.0×10^{-10}	1.6×10^{-13}	7.4×10^{-9}	3.0×10^{-12}
Subtotal	7.5×10^{-8}	1.3×10^{-9}	7.6×10^{-8}	3.1×10^{-11}	1.4×10^{-6}	5.7×10^{-10}	8.0×10^{-6}	3.2×10^{-9}	1.5×10^{-4}	6.0×10^{-8}
Total	7.5×10^{-8}	1.3×10^{-9}	7.7×10^{-8}	3.1×10^{-11}	1.4×10^{-6}	5.8×10^{-10}	8.1×10^{-6}	3.2×10^{-9}	1.5×10^{-4}	6.1×10^{-8}

a. For the No-Action Alternative, the uninvolved worker is exposed by the atmospheric transport of exposed Par Pond sediments.
b. The maximally exposed uninvolved worker is located at L-Area.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
e. L-Area. Total uninvolved workers estimated to be 251 (Simpkins 1996).

Table C-41. Par Pond - Involved worker (current use) nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Exposure pathway	Hazard quotient: Mercury	Manganese	Thallium	Hazard index[b]
Ingestion:				
Soil	5.6×10^{-6}	5.3×10^{-8}	1.1×10^{-6}	6.8×10^{-6}
Soil dermal	2.3×10^{-5}	4.5×10^{-8}	9.5×10^{-8}	2.4×10^{-5}
Subtotal	2.9×10^{-5}	9.8×10^{-8}	1.2×10^{-6}	3.0×10^{-5}
Inhalation:				
Resuspension	4.0×10^{-7}	5.2×10^{-8}	2.3×10^{-8}	4.8×10^{-7}
Subtotal	4.0×10^{-7}	5.2×10^{-8}	2.3×10^{-8}	4.8×10^{-7}
Total	2.9×10^{-5}	1.5×10^{-7}	1.2×10^{-6}	3.1×10^{-5}

a. For the No-Action Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed Par Pond sediments. The worker is not exposed to any carcinogenic contaminants.

b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.

Table C-42. Par Pond - Involved worker (future use) nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Exposure pathway	Hazard quotient			Hazard index[b]
	Mercury	Manganese	Thallium	
Ingestion:				
Soil	1.3×10^{-4}	1.2×10^{-6}	2.5×10^{-5}	1.6×10^{-4}
Soil dermal	3.9×10^{-4}	7.5×10^{-7}	1.6×10^{-6}	3.9×10^{-4}
Subtotal	5.2×10^{-4}	2.0×10^{-6}	2.7×10^{-5}	5.5×10^{-4}
Inhalation:				
Resuspension	8.8×10^{-6}	1.2×10^{-6}	5.0×10^{-7}	1.1×10^{-5}
Subtotal	8.8×10^{-6}	1.2×10^{-6}	5.0×10^{-7}	1.1×10^{-5}
Total	5.3×10^{-4}	3.2×10^{-6}	2.7×10^{-5}	5.6×10^{-4}

a. For the No-Action Alternative, the involved worker exposures result from direct contact with and atmospheric resuspension of the exposed Par Pond sediments. The worker is not exposed to any carcinogenic contaminants.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.

Table C-43. Par Pond – Uninvolved worker (L-Area) nonradiological hazard indexes and cancer risks associated with the No-Action Alternative.[a]

Exposure pathway	Hazard quotient: Mercury	Hazard quotient: Manganese	Hazard quotient: Thallium	Hazard index[b]
Ingestion:				
Soil	1.1×10^{-10}	1.0×10^{-12}	2.1×10^{-11}	1.3×10^{-10}
Soil dermal	3.4×10^{-10}	6.3×10^{-13}	1.4×10^{-12}	3.4×10^{-10}
Subtotal	4.5×10^{-10}	1.6×10^{-12}	2.2×10^{-11}	4.7×10^{-10}
Inhalation:				
Air	1.2×10^{-8}	1.5×10^{-9}	6.6×10^{-10}	1.4×10^{-8}
Resuspension	1.2×10^{-10}	1.6×10^{-11}	6.9×10^{-12}	1.4×10^{-10}
Subtotal	1.2×10^{-8}	1.5×10^{-9}	6.6×10^{-10}	1.4×10^{-8}
Total	1.2×10^{-8}	1.5×10^{-9}	6.8×10^{-10}	1.5×10^{-8}

a. For the No-Action Alternative, the involved worker exposures result from the atmospheric transport of exposed Par Pond sediments. The worker is not exposed to any carcinogenic contaminants.
b. Hazard index is the sum of hazard quotients added across exposure pathways or pollutants.

Table C-44. Combined radiological doses associated with the No-Action Alternative and resulting health effects to the offsite maximally exposed individual (current use).[a]

Exposure Pathway	Individual annual dose (rem) L-Lake	Individual annual dose (rem) Par Pond	Individual annual dose (rem) Combined	Probability of fatal cancer[b]	Individual lifetime dose (rem)[c] L-Lake	Individual lifetime dose (rem)[c] Par Pond	Individual lifetime dose (rem)[c] Combined	Probability of fatal cancer[b]
Ingestion:								
Soil	5.7×10^{-11}	1.2×10^{-9}	1.3×10^{-9}	6.4×10^{-13}	9.9×10^{-10}	4.2×10^{-8}	4.3×10^{-8}	2.2×10^{-11}
Soil Dermal	1.1×10^{-11}	2.4×10^{-10}	2.6×10^{-10}	1.3×10^{-13}	2.0×10^{-10}	8.5×10^{-9}	8.7×10^{-9}	4.3×10^{-12}
Leafy Vegetables	9.8×10^{-9}	2.0×10^{-8}	2.9×10^{-8}	1.5×10^{-11}	1.7×10^{-7}	6.8×10^{-7}	8.5×10^{-7}	4.2×10^{-10}
Other Vegetables	7.7×10^{-8}	2.0×10^{-8}	9.7×10^{-8}	4.8×10^{-11}	1.3×10^{-6}	6.8×10^{-7}	2.0×10^{-6}	1.0×10^{-9}
Meat	4.8×10^{-9}	8.6×10^{-9}	1.3×10^{-8}	6.7×10^{-12}	8.3×10^{-8}	3.0×10^{-7}	3.8×10^{-7}	1.9×10^{-10}
Milk	1.7×10^{-8}	9.4×10^{-8}	1.1×10^{-7}	5.6×10^{-11}	3.1×10^{-7}	3.3×10^{-6}	3.6×10^{-6}	1.8×10^{-9}
Subtotal	1.1×10^{-7}	1.4×10^{-7}	2.5×10^{-7}	1.3×10^{-10}	1.9×10^{-6}	5.0×10^{-6}	6.9×10^{-6}	3.5×10^{-9}
Inhalation:								
Air	4.0×10^{-8}	2.4×10^{-8}	6.4×10^{-8}	3.2×10^{-11}	7.0×10^{-7}	8.5×10^{-7}	1.5×10^{-6}	7.7×10^{-10}
Resuspension	2.7×10^{-11}	2.4×10^{-10}	2.7×10^{-10}	1.4×10^{-13}	4.8×10^{-10}	8.5×10^{-9}	9.0×10^{-9}	4.5×10^{-12}
Subtotal	4.0×10^{-8}	2.4×10^{-8}	6.4×10^{-8}	3.2×10^{-11}	7.0×10^{-7}	8.5×10^{-7}	1.5×10^{-6}	7.7×10^{-10}
External:								
Soil	0.0×10^{0}	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	0.0×10^{0}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Air	0.0×10^{0}	3.1×10^{-10}	3.1×10^{-10}	1.5×10^{-13}	0.0×10^{0}	1.1×10^{-8}	1.1×10^{-8}	5.4×10^{-12}
Subtotal	0.0×10^{0}	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	0.0×10^{0}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Total	1.5×10^{-7}	6.5×10^{-6}	6.6×10^{-6}	3.3×10^{-9}	2.6×10^{-6}	2.3×10^{-4}	2.3×10^{-4}	1.1×10^{-7}

a. For the current land use scenario, the offsite maximally exposed individual is a member of the public residing at the SRS boundary.
b. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-45. Combined radiological doses associated with the No-Action Alternative and resulting health effects to the offsite maximally exposed individual (future use).[a]

Exposure Pathway	Individual annual dose (rem)			Probability of fatal cancer[b]	Individual lifetime dose (rem)[c]			Probability of fatal cancer[b]
	L-Lake	Par Pond	Combined		L-Lake	Par Pond	Combined	
Ingestion:								
Finfish	3.8×10^{-4}	NA[d]	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	NA	1.3×10^{-2}	6.5×10^{-6}
Leafy Vegetables	9.8×10^{-9}	2.0×10^{-8}	2.9×10^{-8}	1.5×10^{-11}	9.9×10^{-10}	6.8×10^{-7}	6.8×10^{-7}	3.4×10^{-10}
Other Vegetables	7.7×10^{-8}	2.0×10^{-8}	9.7×10^{-8}	4.8×10^{-11}	1.3×10^{-6}	6.8×10^{-7}	2.0×10^{-6}	1.0×10^{-9}
Meat	4.8×10^{-9}	8.6×10^{-9}	1.3×10^{-8}	6.7×10^{-12}	8.3×10^{-8}	3.0×10^{-7}	3.8×10^{-7}	1.9×10^{-10}
Milk	1.7×10^{-8}	9.4×10^{-8}	1.1×10^{-7}	5.6×10^{-11}	3.1×10^{-7}	3.3×10^{-6}	3.6×10^{-6}	1.8×10^{-9}
Soil	6.9×10^{-11}	1.2×10^{-9}	1.3×10^{-9}	6.4×10^{-13}	1.2×10^{-9}	4.2×10^{-8}	4.4×10^{-8}	2.2×10^{-11}
Soil Dermal	1.7×10^{-9}	2.4×10^{-10}	2.0×10^{-9}	9.8×10^{-13}	3.0×10^{-8}	8.5×10^{-9}	3.8×10^{-8}	1.9×10^{-11}
Subtotal	3.8×10^{-4}	1.4×10^{-7}	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	5.0×10^{-6}	1.3×10^{-2}	6.5×10^{-6}
Inhalation:								
Air	4.3×10^{-8}	2.4×10^{-8}	6.7×10^{-8}	3.4×10^{-11}	7.5×10^{-7}	8.5×10^{-7}	1.6×10^{-6}	8.0×10^{-10}
Resuspension	3.1×10^{-11}	2.4×10^{-10}	2.8×10^{-10}	1.4×10^{-13}	5.4×10^{-10}	8.5×10^{-9}	9.0×10^{-9}	4.5×10^{-12}
Subtotal	4.3×10^{-8}	2.5×10^{-8}	6.8×10^{-8}	3.4×10^{-11}	7.5×10^{-7}	8.6×10^{-7}	1.6×10^{-6}	8.0×10^{-10}
External:								
Soil	NA	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	NA	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Air	NA	3.1×10^{-10}	3.1×10^{-10}	1.5×10^{-13}	NA	1.1×10^{-8}	1.1×10^{-8}	5.4×10^{-12}
Subtotal	0.0×10^{0}	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	0.0×10^{0}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Total	3.8×10^{-4}	6.5×10^{-6}	3.8×10^{-4}	1.9×10^{-7}	1.3×10^{-2}	2.3×10^{-4}	1.3×10^{-2}	6.6×10^{-6}

a. Since there is no recreational use of Par Pond for the future land use scenario, the combined impacts are the same as those reported in Table C-2 for L-Lake.
b. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-46. Combined radiological doses associated with the No-Action Alternative and resulting health effects to the general public.[a]

Exposure Pathway	Population annual dose (person-rem) L-Lake	Par Pond	Combined	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c] L-Lake	Par Pond	Combined	Number of fatal cancers[b]
Ingestion:								
Soil	5.2×10^{-7}	4.2×10^{-7}	9.4×10^{-7}	4.7×10^{-10}	9.0×10^{-6}	1.5×10^{-5}	2.4×10^{-5}	1.2×10^{-8}
Soil Dermal	1.0×10^{-7}	8.5×10^{-8}	1.9×10^{-7}	9.3×10^{-11}	1.8×10^{-6}	2.9×10^{-6}	4.7×10^{-6}	2.4×10^{-9}
Leafy Vegetables	8.9×10^{-5}	6.8×10^{-6}	9.6×10^{-5}	4.8×10^{-8}	1.6×10^{-3}	2.4×10^{-4}	1.8×10^{-3}	9.0×10^{-7}
Other Vegetables	7.0×10^{-4}	6.8×10^{-6}	7.1×10^{-4}	3.5×10^{-7}	1.2×10^{-2}	2.4×10^{-4}	1.2×10^{-2}	6.2×10^{-6}
Meat	4.3×10^{-5}	3.0×10^{-6}	4.6×10^{-5}	2.3×10^{-8}	7.6×10^{-4}	1.0×10^{-4}	8.6×10^{-4}	4.3×10^{-7}
Milk	1.6×10^{-4}	3.3×10^{-5}	1.9×10^{-4}	9.6×10^{-8}	2.8×10^{-3}	1.1×10^{-3}	3.9×10^{-3}	2.0×10^{-6}
Subtotal	9.9×10^{-4}	5.0×10^{-5}	1.0×10^{-3}	5.2×10^{-7}	1.7×10^{-2}	1.7×10^{-3}	1.9×10^{-2}	9.6×10^{-6}
Inhalation:								
Air	3.6×10^{-4}	8.5×10^{-6}	3.7×10^{-4}	1.9×10^{-7}	6.3×10^{-3}	2.9×10^{-4}	6.6×10^{-3}	3.3×10^{-6}
Resuspension	2.5×10^{-7}	8.5×10^{-8}	3.3×10^{-7}	1.7×10^{-10}	4.3×10^{-6}	2.9×10^{-6}	7.3×10^{-6}	3.6×10^{-9}
Subtotal	3.6×10^{-4}	8.5×10^{-6}	3.7×10^{-4}	1.9×10^{-7}	6.3×10^{-3}	2.9×10^{-4}	6.6×10^{-3}	3.3×10^{-6}
External:								
Soil	0.0×10^{0}	2.2×10^{-3}	2.2×10^{-3}	1.1×10^{-6}	0.0×10^{0}	7.7×10^{-2}	7.7×10^{-2}	3.8×10^{-5}
Air	0.0×10^{0}	1.1×10^{-7}	1.1×10^{-7}	5.4×10^{-11}	0.0×10^{0}	3.7×10^{-6}	3.7×10^{-6}	1.9×10^{-9}
Subtotal	0.0×10^{0}	2.2×10^{-3}	2.2×10^{-3}	1.1×10^{-6}	0.0×10^{0}	7.7×10^{-2}	7.7×10^{-2}	3.8×10^{-5}
Total	1.4×10^{-3}	2.2×10^{-3}	3.6×10^{-3}	1.8×10^{-6}	2.4×10^{-2}	7.6×10^{-2}	1.0×10^{-1}	5.0×10^{-5}

a. Offsite population within 80 kilometers (50 miles) of SRS.
b. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-47. Combined nonradiological hazard indexes associated with the No-Action Alternative for members of the public (current use).[a]

Exposure pathway	Hazard index L-Lake[b]	Par Pond	Combined
Ingestion:			
Soil	NA[c]	6.7×10^{-7}	6.7×10^{-7}
Soil dermal	NA	5.0×10^{-6}	5.0×10^{-6}
Leafy vegetables	NA	1.1×10^{-5}	1.1×10^{-5}
Other vegetables	NA	1.2×10^{-5}	1.2×10^{-5}
Meat	NA	5.1×10^{-5}	5.1×10^{-5}
Milk	NA	5.6×10^{-6}	5.6×10^{-6}
Subtotal	0.0×10^{0}	8.7×10^{-5}	8.7×10^{-5}
Inhalation:			
Air	NA	6.1×10^{-5}	6.1×10^{-5}
Resuspension	NA	6.1×10^{-7}	6.1×10^{-7}
Subtotal	0.0×10^{0}	6.1×10^{-5}	6.1×10^{-5}
Total	0.0×10^{0}	1.5×10^{-4}	1.5×10^{-4}

a. No carcinogenic constituents are released from either L-Lake or Par Pond for current land use under the No-Action Alternative.
b. Nonradiological constituents not released from L-Lake.
c. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-48. Combined nonradiological hazard indexes and cancer risks associated with the No-Action Alternative for members of the public (future use).[a]

Exposure pathway	Hazard index			Annual cancer risk			Lifetime
	L-Lake	Par Pond	Combined	L-Lake	Par Pond[b]	Combined	cancer risk[c]
Ingestion:							
Finfish	6.2×10^{-2}	NA[d]	6.2×10^{-2}	1.6×10^{-7}	NA	1.6×10^{-7}	1.1×10^{-5}
Swimming	2.8×10^{-5}	NA	2.8×10^{-5}	1.1×10^{-9}	NA	1.1×10^{-9}	7.7×10^{-8}
Swimming dermal	9.5×10^{-5}	NA	9.5×10^{-5}	4.4×10^{-8}	NA	4.4×10^{-8}	3.1×10^{-6}
Shoreline dermal	2.2×10^{-4}	NA	2.2×10^{-4}	1.0×10^{-7}	NA	1.0×10^{-7}	7.0×10^{-6}
Shoreline	1.5×10^{-5}	NA	1.5×10^{-5}	6.2×10^{-10}	NA	6.2×10^{-10}	4.3×10^{-8}
Soil	NA	6.7×10^{-7}	6.7×10^{-7}	NA	NA	NA	NA
Soil dermal	NA	5.0×10^{-6}	5.0×10^{-6}	NA	NA	NA	NA
Leafy vegetables	NA	1.1×10^{-5}	1.1×10^{-5}	NA	NA	NA	NA
Other vegetables	NA	1.2×10^{-5}	1.2×10^{-5}	NA	NA	NA	NA
Meat	NA	5.1×10^{-5}	5.1×10^{-5}	NA	NA	NA	NA
Milk	NA	5.6×10^{-6}	5.6×10^{-6}	NA	NA	NA	NA
Subtotal	6.2×10^{-2}	8.7×10^{-5}	6.2×10^{-2}	3.1×10^{-7}	0.0×10^{0}	3.1×10^{-7}	2.1×10^{-5}
Inhalation:							
Air	NA	6.1×10^{-5}	6.1×10^{-5}	NA	NA	NA	NA
Resuspension	NA	6.1×10^{-7}	6.1×10^{-7}	NA	NA	NA	NA
Subtotal	0.0×10^{0}	6.1×10^{-5}	6.1×10^{-5}	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Total	6.2×10^{-2}	1.5×10^{-4}	6.2×10^{-2}	3.1×10^{-7}	0.0×10^{0}	3.1×10^{-7}	2.1×10^{-5}

a. Assumes future recreational use of L-Lake.
b. No carcinogenic constituents are released from Par Pond for future land use under the No-Action Alternative.
c. Based on a 70-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-49. Combined involved worker (current use) radiological doses and resulting impacts associated with the No-Action Alternative.

	Individual annual dose (rem)			Probability of	Individual lifetime dose (rem)[c]			Probability of
Exposure pathway	L-Lake	Par Pond	Combined[a]	fatal cancers[b]	L-Lake	Par Pond	Combined[a]	fatal cancers[b]
Ingestion:								
Soil	1.4×10^{-10}	3.1×10^{-7}	3.1×10^{-7}	1.2×10^{-10}	6.1×10^{-10}	1.5×10^{-6}	1.5×10^{-6}	5.9×10^{-10}
Soil dermal	1.2×10^{-11}	2.6×10^{-8}	2.6×10^{-8}	1.0×10^{-11}	5.0×10^{-11}	1.2×10^{-7}	1.2×10^{-7}	4.8×10^{-11}
Subtotal	1.5×10^{-10}	3.4×10^{-7}	3.4×10^{-7}	1.3×10^{-10}	6.6×10^{-10}	1.6×10^{-6}	1.6×10^{-6}	6.3×10^{-10}
Inhalation:								
Air	5.0×10^{-8}	NA[e]	5.0×10^{-8}	2.0×10^{-11}	2.2×10^{-7}	NA	2.2×10^{-7}	8.6×10^{-11}
Resuspension	6.8×10^{-11}	4.0×10^{-9}	4.0×10^{-9}	1.6×10^{-12}	2.9×10^{-10}	1.9×10^{-8}	1.9×10^{-8}	7.5×10^{-12}
Subtotal	5.0×10^{-8}	4.0×10^{-9}	5.0×10^{-8}	2.0×10^{-11}	2.2×10^{-7}	1.9×10^{-8}	2.2×10^{-7}	8.6×10^{-11}
External:								
Soil	NA	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	NA	2.0×10^{-3}	2.0×10^{-3}	7.8×10^{-7}
Subtotal	0.0×10^{0}	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	0.0×10^{0}	2.0×10^{-3}	2.0×10^{-3}	7.8×10^{-7}
Total	5.0×10^{-8}	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	2.2×10^{-7}	2.0×10^{-3}	2.0×10^{-3}	7.9×10^{-7}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-50. Combined involved worker population (current use) radiological doses associated with the No-Action Alternative.

Exposure pathway	Population annual dose (person-rem)[b] L-Lake	Par Pond	Combined[a]	Number of fatal cancers[c]	Population lifetime dose (person-rem)[b,d] L-Lake	Par Pond	Combined[a]	Number of fatal cancers[c]
Ingestion:								
Soil	9.8×10^{-9}	2.2×10^{-5}	2.2×10^{-5}	8.7×10^{-9}	4.3×10^{-8}	1.0×10^{-4}	1.0×10^{-4}	4.1×10^{-8}
Soil dermal	8.1×10^{-10}	1.8×10^{-6}	1.8×10^{-6}	7.2×10^{-10}	3.5×10^{-9}	8.5×10^{-6}	8.5×10^{-6}	3.4×10^{-9}
Subtotal	1.1×10^{-8}	2.4×10^{-5}	2.4×10^{-5}	9.4×10^{-9}	4.6×10^{-8}	1.1×10^{-4}	1.1×10^{-4}	4.4×10^{-8}
Inhalation:								
Air	3.5×10^{-6}	NA[c]	3.5×10^{-6}	1.4×10^{-9}	1.5×10^{-5}	NA	1.5×10^{-5}	6.0×10^{-9}
Resuspension	4.7×10^{-9}	2.8×10^{-7}	2.8×10^{-7}	1.1×10^{-10}	2.1×10^{-8}	1.3×10^{-6}	1.3×10^{-6}	5.3×10^{-10}
Subtotal	3.5×10^{-6}	2.8×10^{-7}	3.5×10^{-6}	1.4×10^{-9}	1.5×10^{-5}	1.3×10^{-6}	1.5×10^{-5}	6.1×10^{-9}
External:								
Soil	NA	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	NA	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}
Subtotal	0.0×10^{0}	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	0.0×10^{0}	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}
Total	3.5×10^{-6}	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	1.5×10^{-5}	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.
e. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-51. Combined involved worker (future use) radiological doses associated with the No-Action Alternative.

Exposure Pathway	Individual annual dose (rem)			Probability of fatal cancer[b]	Individual lifetime dose (rem)[c]			Probability of fatal cancer[b]
	L-Lake	Par Pond	Combined[a]		L-Lake	Par Pond	Combined[a]	
Ingestion:								
Soil	3.1×10^{-9}	6.7×10^{-6}	6.7×10^{-6}	2.7×10^{-9}	4.2×10^{-8}	1.3×10^{-4}	1.3×10^{-4}	5.1×10^{-8}
Soil Dermal	1.9×10^{-10}	4.2×10^{-7}	4.2×10^{-7}	1.7×10^{-10}	2.6×10^{-9}	8.0×10^{-6}	8.0×10^{-6}	3.2×10^{-9}
Subtotal	3.3×10^{-9}	7.1×10^{-6}	7.1×10^{-6}	2.9×10^{-9}	4.4×10^{-8}	1.4×10^{-4}	1.4×10^{-4}	5.4×10^{-8}
Inhalation:								
Air	1.1×10^{-6}	NA[d]	1.1×10^{-6}	4.4×10^{-10}	1.5×10^{-5}	NA	1.5×10^{-5}	5.9×10^{-9}
Resuspension	1.5×10^{-9}	8.8×10^{-8}	8.8×10^{-8}	3.5×10^{-11}	2.0×10^{-8}	1.6×10^{-6}	1.6×10^{-6}	6.6×10^{-10}
Subtotal	1.1×10^{-6}	8.8×10^{-8}	1.1×10^{-6}	4.4×10^{-10}	1.5×10^{-5}	1.6×10^{-6}	1.5×10^{-5}	5.9×10^{-9}
External:								
Shoreline	0.0×10^{0}	NA	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	NA	0.0×10^{0}	0.0×10^{0}
Soil	NA	2.3×10^{-2}	2.3×10^{-2}	9.4×10^{-6}	NA	4.4×10^{-1}	4.4×10^{-1}	1.8×10^{-4}
Subtotal	0.0×10^{0}	2.3×10^{-2}	2.3×10^{-2}	9.4×10^{-6}	0.0×10^{0}	4.4×10^{-1}	4.4×10^{-1}	1.8×10^{-4}
Total	1.1×10^{-6}	2.3×10^{-2}	2.3×10^{-2}	9.4×10^{-6}	1.5×10^{-5}	4.4×10^{-1}	4.4×10^{-1}	1.8×10^{-4}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-52. Combined involved worker population (future use) radiological doses associated with the No-Action Alternative.

Exposure pathway	Population annual dose (person-rem)[b] L-Lake	Par Pond	Combined[a]	Number of fatal cancers[c]	Population lifetime dose (person-rem)[b,d] L-Lake	Par Pond	Combined[a]	Number of fatal cancers[c]
Ingestion:								
Soil	2.2×10^{-7}	4.7×10^{-4}	4.7×10^{-4}	1.9×10^{-7}	2.9×10^{-6}	8.9×10^{-3}	8.9×10^{-3}	3.6×10^{-6}
Soil dermal	1.3×10^{-8}	2.9×10^{-5}	2.9×10^{-5}	1.2×10^{-8}	1.8×10^{-7}	5.6×10^{-4}	5.6×10^{-4}	2.2×10^{-7}
Subtotal	2.3×10^{-7}	5.0×10^{-4}	5.0×10^{-4}	2.0×10^{-7}	3.1×10^{-6}	9.5×10^{-3}	9.5×10^{-3}	3.9×10^{-6}
Inhalation:								
Air	7.7×10^{-5}	NA[e]	7.7×10^{-5}	3.1×10^{-8}	1.0×10^{-3}	NA	1.0×10^{-3}	4.1×10^{-7}
Resuspension	1.0×10^{-7}	6.2×10^{-6}	6.2×10^{-6}	2.5×10^{-9}	1.4×10^{-6}	1.2×10^{-4}	1.2×10^{-4}	4.6×10^{-8}
Subtotal	7.7×10^{-5}	6.2×10^{-6}	7.7×10^{-5}	3.1×10^{-8}	1.0×10^{-4}	1.2×10^{-4}	1.0×10^{-3}	4.1×10^{-7}
External:								
Soil	NA	1.6×10^{0}	1.6×10^{0}	6.5×10^{-4}	NA	3.1×10^{1}	3.1×10^{1}	1.2×10^{-2}
Subtotal	0.0×10^{0}	1.6×10^{0}	1.6×10^{0}	6.5×10^{-4}	0.0×10^{0}	3.1×10^{1}	3.1×10^{1}	1.2×10^{-2}
Total	7.7×10^{-5}	1.6×10^{0}	1.6×10^{0}	6.5×10^{-4}	1.0×10^{-3}	3.1×10^{1}	3.1×10^{1}	1.2×10^{-2}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
e. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-53. Combined uninvolved worker radiological doses and resulting impacts associated with the No-Action Alternative.[a]

Exposure pathway	Individual annual dose (rem) L-Lake	Individual annual dose (rem) Par Pond	Individual annual dose (rem) Combined	Probability of fatal cancer[b]	Individual lifetime dose (rem)[c] L-Lake	Individual lifetime dose (rem)[c] Par Pond	Individual lifetime dose (rem)[c] Combined	Probability of fatal cancer[b]
Ingestion:								
Soil	5.5×10^{-11}	5.8×10^{-12}	6.1×10^{-11}	2.4×10^{-14}	7.4×10^{-10}	1.1×10^{-10}	8.5×10^{-10}	3.4×10^{-13}
Soil dermal	3.5×10^{-12}	3.6×10^{-13}	3.9×10^{-12}	1.5×10^{-15}	4.7×10^{-11}	6.9×10^{-12}	5.4×10^{-11}	2.2×10^{-14}
Subtotal	5.8×10^{-11}	6.2×10^{-12}	6.5×10^{-11}	2.6×10^{-14}	7.9×10^{-10}	1.2×10^{-10}	9.0×10^{-10}	3.6×10^{-13}
Inhalation:								
Air	2.0×10^{-8}	1.1×10^{-10}	2.0×10^{-8}	7.8×10^{-12}	2.6×10^{-7}	2.1×10^{-9}	2.6×10^{-7}	1.1×10^{-10}
Resuspension	2.7×10^{-11}	1.2×10^{-12}	2.8×10^{-11}	1.1×10^{-14}	3.6×10^{-10}	2.3×10^{-11}	3.9×10^{-10}	1.5×10^{-13}
Subtotal	2.0×10^{-8}	1.2×10^{-10}	2.0×10^{-8}	7.9×10^{-12}	2.6×10^{-7}	2.3×10^{-9}	2.6×10^{-7}	1.1×10^{-10}
External:								
Soil	NA[d]	2.0×10^{-8}	2.0×10^{-8}	8.1×10^{-12}	NA	3.8×10^{-7}	3.8×10^{-7}	1.5×10^{-10}
Air	NA	9.9×10^{-13}	9.9×10^{-13}	4.0×10^{-16}	NA	1.9×10^{-11}	1.9×10^{-11}	7.4×10^{-15}
Subtotal	0.0×10^{0}	2.0×10^{-8}	2.0×10^{-8}	8.1×10^{-12}	0.0×10^{0}	3.8×10^{-7}	3.8×10^{-7}	1.5×10^{-10}
Total	2.0×10^{-8}	2.0×10^{-8}	4.0×10^{-8}	1.6×10^{-11}	2.6×10^{-7}	3.8×10^{-7}	6.5×10^{-7}	2.6×10^{-10}

a. The maximally exposed uninvolved worker is located in L-Area.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-54. Combined uninvolved worker population radiological doses and resulting impacts associated with the No-Action Alternative.[a]

Exposure pathway	Population annual dose (person-rem) L-Lake	Population annual dose (person-rem) Par Pond	Population annual dose (person-rem) Combined	Number of fatal cancers[b]	Population lifetime dose (person-rem)[c] L-Lake	Population lifetime dose (person-rem)[c] Par Pond	Population lifetime dose (person-rem)[c] Combined	Number of fatal cancers[b]
Ingestion:								
Soil	1.4×10^{-8}	1.5×10^{-9}	1.5×10^{-8}	6.1×10^{-12}	1.9×10^{-7}	2.8×10^{-8}	2.1×10^{-7}	8.5×10^{-11}
Soil dermal	8.8×10^{-10}	9.2×10^{-11}	9.7×10^{-10}	3.9×10^{-13}	1.2×10^{-8}	1.7×10^{-9}	1.4×10^{-8}	5.4×10^{-12}
Subtotal	1.5×10^{-8}	1.6×10^{-9}	1.6×10^{-8}	6.5×10^{-12}	2.0×10^{-7}	2.9×10^{-8}	2.3×10^{-7}	9.1×10^{-11}
Inhalation:								
Air	4.9×10^{-6}	2.8×10^{-8}	4.9×10^{-6}	2.0×10^{-9}	6.6×10^{-5}	5.3×10^{-7}	6.6×10^{-5}	2.7×10^{-8}
Resuspension	6.8×10^{-9}	3.1×10^{-10}	7.1×10^{-9}	2.8×10^{-12}	9.1×10^{-8}	5.8×10^{-9}	9.7×10^{-8}	3.9×10^{-11}
Subtotal	4.9×10^{-6}	3.1×10^{-8}	4.9×10^{-6}	2.0×10^{-9}	6.6×10^{-5}	5.8×10^{-7}	6.6×10^{-5}	2.7×10^{-8}
External:								
Soil	NA[d]	5.1×10^{-6}	5.1×10^{-6}	2.0×10^{-9}	NA	9.6×10^{-5}	9.6×10^{-5}	3.8×10^{-8}
Air	NA	2.5×10^{-10}	2.5×10^{-10}	9.9×10^{-14}	NA	4.7×10^{-9}	4.7×10^{-9}	1.9×10^{-12}
Subtotal	0.0×10^{0}	5.1×10^{-6}	5.1×10^{-6}	2.0×10^{-9}	0.0×10^{0}	9.6×10^{-5}	9.6×10^{-5}	3.8×10^{-8}
Total	4.9×10^{-6}	5.1×10^{-6}	1.0×10^{-5}	4.0×10^{-9}	6.6×10^{-5}	9.7×10^{-5}	1.6×10^{-4}	6.5×10^{-8}

a. L-Area; total uninvolved workers is estimated to be 251 (Simpkins 1996).
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-55. Combined nonradiological hazard indexes and cancer risks associated with the No-Action Alternative for the involved worker (current use).

Exposure pathway	Hazard index: L-Lake	Hazard index: Par Pond	Hazard index: Combined[a]	Annual cancer risk: L-Lake	Annual cancer risk: Par Pond[b]	Annual cancer risk: Combined[a]	Lifetime cancer risk[c]
Ingestion:							
Shoreline dermal	1.5×10^{-6}	NA[d]	1.5×10^{-6}	7.0×10^{-10}	NA	7.0×10^{-10}	3.5×10^{-9}
Shoreline	2.1×10^{-4}	NA	2.1×10^{-4}	8.4×10^{-9}	NA	8.4×10^{-9}	4.2×10^{-8}
Soil	NA	6.8×10^{-6}	6.8×10^{-6}	NA	NA	0.0×10^{0}	0.0×10^{0}
Soil dermal	NA	2.4×10^{-5}	2.4×10^{-5}	NA	NA	0.0×10^{0}	0.0×10^{0}
Subtotal	2.1×10^{-4}	3.0×10^{-5}	2.1×10^{-4}	9.1×10^{-9}	0.0×10^{0}	9.1×10^{-9}	4.5×10^{-8}
Inhalation:							
Resuspension	NA	4.8×10^{-7}	4.8×10^{-7}	NA	NA	0.0×10^{0}	0.0×10^{0}
Subtotal	0.0×10^{0}	4.8×10^{-7}	4.8×10^{-7}	NA	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Total	2.1×10^{-4}	3.1×10^{-5}	2.1×10^{-4}	9.1×10^{-9}	0.0×10^{0}	9.1×10^{-9}	4.5×10^{-8}

a. Hazard indexes and cancer risks from the two release sites are not additive; the combined result is the maximum of either site.
b. No carcinogenic constituents are released from Par Pond for current land use under the No-Action Alternative.
c. Based on a 5-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-56. Combined nonradiological hazard indexes and cancer risks associated with the No-Action Alternative for the involved worker (future use).

	Hazard index			Annual cancer risk			Lifetime
Exposure pathway	L-Lake	Par Pond	Combined[a]	L-Lake	Par Pond[b]	Combined[a]	cancer risk[c]
Ingestion:							
Shoreline dermal	2.5×10^{-5}	NA[d]	2.5×10^{-5}	1.2×10^{-8}	NA	1.2×10^{-8}	2.9×10^{-7}
Shoreline	2.3×10^{-5}	NA	2.3×10^{-5}	9.2×10^{-10}	NA	9.2×10^{-10}	2.3×10^{-8}
Soil	NA	1.6×10^{-4}	1.6×10^{-4}	NA	NA	0.0×10^{0}	0.0×10^{0}
Soil dermal	NA	3.9×10^{-4}	3.9×10^{-4}	NA	NA	0.0×10^{0}	0.0×10^{0}
Subtotal	4.8×10^{-5}	5.5×10^{-4}	5.5×10^{-4}	1.3×10^{-8}	0.0×10^{0}	1.3×10^{-8}	3.1×10^{-7}
Inhalation:							
Resuspension	NA	1.1×10^{-5}	1.1×10^{-5}	NA	NA	0.0×10^{0}	0.0×10^{0}
Subtotal	0.0×10^{0}	1.1×10^{-5}	1.1×10^{-5}	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}	0.0×10^{0}
Total	4.8×10^{-5}	5.6×10^{-4}	5.6×10^{-4}	1.3×10^{-8}	0.0×10^{0}	1.3×10^{-8}	3.1×10^{-7}

a. Hazard indexes and cancer risks from the two release sites are not additive; the combined result is the maximum of either site.
b. No carcinogenic constituents are released from Par Pond for current land use under the No-Action Alternative.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-57. Combined nonradiological hazard indexes associated with the No-Action Alternative for uninvolved workers.[a]

	Hazard index		
Exposure pathway	L-Lake[b]	Par Pond	Combined
Ingestion:			
Soil	NA[c]	1.3×10^{-10}	1.3×10^{-10}
Soil Dermal	NA	3.4×10^{-10}	3.4×10^{-10}
Subtotal	0.0×10^{0}	4.7×10^{-10}	4.7×10^{-10}
Inhalation:			
Air	NA	1.4×10^{-8}	1.4×10^{-8}
Resuspension	NA	1.4×10^{-10}	1.4×10^{-10}
Subtotal	0.0×10^{0}	1.4×10^{-8}	1.4×10^{-8}
Total	0.0×10^{0}	1.5×10^{-8}	1.5×10^{-8}

a. No carcinogenic constituents are released from either L-Lake or Par Pond for current land use under the No-Action Alternative. The uninvolved worker is located in L-Area.
b. Nonradiological constituents not released from L-Lake.
c. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-58. Combined radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects to the offsite maximally exposed individual.

	Individual annual dose (rem)			Probability	Individual lifetime dose (rem)[b]			Probability
Exposure Pathway	L-Lake	Par Pond	Combined	of fatal cancer[a]	L-Lake	Par Pond	Combined	of fatal cancer[a]
Ingestion:								
Drinking Water	2.5×10^{-9}	NA[c]	2.5×10^{-9}	1.2×10^{-12}	1.6×10^{-7}	NA	1.6×10^{-7}	8.1×10^{-11}
Finfish	1.1×10^{-8}	NA	1.1×10^{-8}	5.4×10^{-12}	4.9×10^{-7}	NA	4.9×10^{-7}	2.5×10^{-10}
Swimming	4.1×10^{-12}	NA	4.1×10^{-12}	2.1×10^{-15}	2.7×10^{-10}	NA	2.7×10^{-10}	1.3×10^{-13}
Swimming Dermal	2.7×10^{-10}	NA	2.7×10^{-10}	1.4×10^{-13}	1.9×10^{-8}	NA	1.9×10^{-8}	9.4×10^{-12}
Shoreline Dermal	1.8×10^{-12}	NA	1.8×10^{-12}	8.9×10^{-16}	1.2×10^{-10}	NA	1.2×10^{-10}	6.2×10^{-14}
Shoreline	1.1×10^{-13}	NA	1.1×10^{-13}	5.4×10^{-17}	7.0×10^{-12}	NA	7.0×10^{-12}	3.5×10^{-15}
Soil	7.5×10^{-12}	1.2×10^{-9}	1.2×10^{-9}	6.1×10^{-13}	3.6×10^{-10}	4.2×10^{-8}	4.3×10^{-8}	2.1×10^{-11}
Soil Dermal	3.4×10^{-10}	2.4×10^{-10}	5.8×10^{-10}	2.9×10^{-13}	2.4×10^{-8}	8.5×10^{-9}	3.2×10^{-8}	1.6×10^{-11}
Leafy Vegetables	4.5×10^{-8}	2.0×10^{-8}	6.4×10^{-8}	3.2×10^{-11}	2.2×10^{-6}	6.8×10^{-7}	2.8×10^{-6}	1.4×10^{-9}
Other Vegetables	4.2×10^{-8}	2.0×10^{-8}	6.1×10^{-8}	3.1×10^{-11}	2.0×10^{-6}	6.8×10^{-7}	2.7×10^{-6}	1.3×10^{-9}
Meat	1.2×10^{-8}	8.6×10^{-9}	2.0×10^{-8}	1.0×10^{-11}	4.1×10^{-7}	3.0×10^{-7}	7.1×10^{-7}	3.5×10^{-10}
Milk	1.3×10^{-7}	9.4×10^{-8}	2.3×10^{-7}	1.1×10^{-10}	4.8×10^{-6}	3.3×10^{-6}	8.0×10^{-6}	4.0×10^{-9}
Subtotal	2.5×10^{-7}	1.4×10^{-7}	3.9×10^{-7}	2.8×10^{-10}	1.0×10^{-5}	5.0×10^{-6}	1.5×10^{-5}	7.5×10^{-9}
Inhalation:								
Air	9.7×10^{-8}	2.4×10^{-8}	1.2×10^{-7}	6.1×10^{-11}	6.7×10^{-6}	8.5×10^{-7}	7.6×10^{-6}	3.8×10^{-9}
Resuspension	8.4×10^{-10}	2.4×10^{-10}	1.1×10^{-9}	5.4×10^{-13}	5.9×10^{-8}	8.5×10^{-9}	6.7×10^{-8}	3.4×10^{-11}
Subtotal	9.7×10^{-8}	2.4×10^{-8}	1.2×10^{-7}	6.1×10^{-11}	6.8×10^{-6}	8.5×10^{-7}	7.7×10^{-6}	3.8×10^{-9}
External:								
Swimming	9.4×10^{-14}	NA	9.4×10^{-14}	4.7×10^{-17}	2.6×10^{-12}	NA	2.6×10^{-12}	1.3×10^{-15}
Boating	4.7×10^{-14}	NA	4.7×10^{-14}	2.4×10^{-17}	1.3×10^{-12}	NA	1.3×10^{-12}	6.6×10^{-16}
Shoreline	2.4×10^{-12}	NA	2.4×10^{-12}	1.2×10^{-15}	6.7×10^{-11}	NA	6.7×10^{-11}	3.4×10^{-14}
Soil	7.5×10^{-8}	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	2.7×10^{-6}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Air	4.3×10^{-12}	3.1×10^{-10}	3.1×10^{-10}	1.6×10^{-13}	1.5×10^{-10}	1.1×10^{-8}	1.1×10^{-8}	5.4×10^{-12}
Subtotal	7.5×10^{-8}	6.4×10^{-6}	6.4×10^{-6}	3.2×10^{-9}	2.7×10^{-6}	2.2×10^{-4}	2.2×10^{-4}	1.1×10^{-7}
Total	4.2×10^{-7}	6.5×10^{-6}	6.9×10^{-6}	3.5×10^{-9}	1.9×10^{-5}	2.3×10^{-4}	2.4×10^{-4}	1.2×10^{-7}

a. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
b. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.
c. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-59. Combined radiological doses associated with the Shut Down and Deactivate Alternative and resulting health effects to the general public.[a]

Exposure Pathway	Population annual dose (person-rem) L-Lake	Population annual dose (person-rem) Par Pond	Population annual dose (person-rem) Combined	Number of fatal cancer[b]	Population lifetime dose (person-rem)[c] L-Lake	Population lifetime dose (person-rem)[c] Par Pond	Population lifetime dose (person-rem)[c] Combined	Number of fatal cancer[b]
Ingestion:								
Drinking Water	3.5×10^{-5}	NA[d]	3.5×10^{-5}	1.8×10^{-8}	2.3×10^{-3}	NA	2.3×10^{-3}	1.1×10^{-6}
Soil	7.6×10^{-9}	4.2×10^{-7}	4.3×10^{-7}	2.2×10^{-10}	3.5×10^{-7}	1.5×10^{-5}	1.5×10^{-5}	7.5×10^{-9}
Soil Dermal	2.9×10^{-7}	8.5×10^{-8}	3.7×10^{-7}	1.9×10^{-10}	2.0×10^{-5}	2.9×10^{-6}	2.3×10^{-5}	1.1×10^{-8}
Leafy Vegetables	4.6×10^{-5}	6.8×10^{-6}	5.3×10^{-5}	2.6×10^{-8}	2.1×10^{-3}	2.4×10^{-4}	2.3×10^{-3}	1.2×10^{-6}
Other Vegetables	4.3×10^{-5}	6.8×10^{-6}	5.0×10^{-5}	2.5×10^{-8}	2.0×10^{-3}	2.4×10^{-4}	2.2×10^{-3}	1.1×10^{-6}
Meat	1.3×10^{-5}	3.0×10^{-6}	1.6×10^{-5}	8.1×10^{-9}	4.6×10^{-4}	1.0×10^{-4}	5.6×10^{-4}	2.8×10^{-7}
Milk	1.5×10^{-4}	3.3×10^{-5}	1.8×10^{-4}	9.2×10^{-8}	5.3×10^{-3}	1.1×10^{-3}	6.5×10^{-3}	3.2×10^{-6}
Subtotal	2.9×10^{-4}	5.0×10^{-5}	3.4×10^{-4}	1.7×10^{-7}	1.2×10^{-2}	1.7×10^{-3}	1.4×10^{-2}	7.0×10^{-6}
Inhalation:								
Air	8.2×10^{-5}	8.5×10^{-6}	9.1×10^{-5}	4.5×10^{-8}	5.7×10^{-3}	2.9×10^{-4}	6.0×10^{-3}	3.0×10^{-6}
Resuspension	7.1×10^{-7}	8.5×10^{-8}	8.0×10^{-7}	4.0×10^{-10}	5.0×10^{-5}	2.9×10^{-6}	5.3×10^{-5}	2.6×10^{-8}
Subtotal	8.3×10^{-5}	8.5×10^{-6}	9.1×10^{-5}	4.6×10^{-8}	5.8×10^{-3}	2.9×10^{-4}	6.1×10^{-3}	3.0×10^{-6}
External:								
Soil	8.5×10^{-5}	2.2×10^{-3}	2.3×10^{-3}	1.1×10^{-6}	3.0×10^{-3}	7.7×10^{-2}	8.0×10^{-2}	4.0×10^{-5}
Air	4.9×10^{-9}	1.1×10^{-7}	1.1×10^{-7}	5.6×10^{-11}	1.7×10^{-7}	3.7×10^{-6}	3.9×10^{-6}	1.9×10^{-9}
Subtotal	8.5×10^{-5}	2.2×10^{-3}	2.3×10^{-3}	1.1×10^{-6}	3.0×10^{-3}	7.7×10^{-2}	8.0×10^{-2}	4.0×10^{-5}
Total	4.6×10^{-4}	2.3×10^{-3}	2.7×10^{-3}	1.4×10^{-6}	2.1×10^{-2}	7.6×10^{-2}	9.7×10^{-2}	4.9×10^{-5}

a. For atmospheric pathways, offsite population within 80 kilometers (50 miles) of SRS; for aqueous pathway, downstream population using Savannah River as a drinking water source.
b. Based on a risk of 0.0005 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 70-year exposure period. Doses are corrected for radioactive decay over the exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-60. Combined nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative for members of the public.

Exposure Pathway	Hazard Index			Annual cancer risk			Lifetime cancer risk[a]
	L-Lake	Par Pond	Combined	L-Lake	Par Pond	Combined	
Ingestion:							
Drinking Water	1.6×10^{-3}	NA[b]	1.6×10^{-3}	4.9×10^{-11}	NA	4.9×10^{-11}	3.4×10^{-9}
Finfish	2.1×10^{-1}	NA	2.1×10^{-1}	5.4×10^{-11}	NA	5.4×10^{-11}	3.8×10^{-9}
Swimming	2.7×10^{-6}	NA	2.7×10^{-6}	8.0×10^{-14}	NA	8.0×10^{-14}	5.6×10^{-12}
Swimming Dermal	6.8×10^{-7}	NA	6.8×10^{-7}	4.7×10^{-13}	NA	4.7×10^{-13}	3.3×10^{-11}
Shoreline Dermal	4.6×10^{-9}	NA	4.6×10^{-9}	3.2×10^{-15}	NA	3.2×10^{-15}	2.2×10^{-13}
Shoreline	7.3×10^{-8}	NA	7.3×10^{-8}	2.1×10^{-15}	NA	2.1×10^{-15}	1.5×10^{-13}
Soil	3.1×10^{-7}	6.7×10^{-7}	9.8×10^{-7}	6.3×10^{-13}	NA	6.3×10^{-13}	4.4×10^{-11}
Soil Dermal	7.5×10^{-7}	5.0×10^{-6}	5.7×10^{-6}	6.4×10^{-12}	NA	6.4×10^{-12}	4.5×10^{-10}
Leafy Vegetables	1.9×10^{-3}	1.1×10^{-5}	1.9×10^{-3}	3.8×10^{-9}	NA	3.8×10^{-9}	2.6×10^{-7}
Other Vegetables	1.7×10^{-3}	1.2×10^{-5}	1.7×10^{-3}	3.3×10^{-9}	NA	3.3×10^{-9}	2.3×10^{-7}
Meat	1.4×10^{-3}	5.1×10^{-5}	1.4×10^{-3}	1.3×10^{-10}	NA	1.3×10^{-10}	9.1×10^{-9}
Milk	2.2×10^{-3}	5.6×10^{-6}	2.2×10^{-3}	1.2×10^{-10}	NA	1.2×10^{-10}	8.1×10^{-9}
Subtotal	2.2×10^{-1}	8.5×10^{-5}	2.2×10^{-1}	7.5×10^{-9}	0.0×10^{0}	7.5×10^{-9}	5.2×10^{-7}
Inhalation:							
Air	3.5×10^{-5}	6.1×10^{-5}	9.6×10^{-5}	5.0×10^{-10}	NA	5.0×10^{-10}	3.5×10^{-8}
Resuspension	3.0×10^{-7}	6.1×10^{-7}	9.1×10^{-7}	4.3×10^{-12}	NA	4.3×10^{-12}	3.0×10^{-10}
Subtotal	3.5×10^{-5}	6.1×10^{-5}	9.6×10^{-5}	5.0×10^{-10}	0.0×10^{0}	5.0×10^{-10}	3.5×10^{-8}
Total	2.2×10^{-1}	1.5×10^{-4}	2.2×10^{-1}	8.0×10^{-9}	0.0×10^{0}	8.0×10^{-9}	5.6×10^{-7}

a. Based on a 70-year exposure period.
b. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-61. Combined involved worker (current use) radiological doses associated with the Shut Down and Deactivate Alternative.

Exposure Pathway	Individual annual dose (rem) L-Lake	Par Pond	Combined[a]	Probability of fatal cancer[b]	Individual lifetime dose (rem)[c] L-Lake	Par Pond	Combined[a]	Probability of fatal cancer[b]
Ingestion:								
Soil	3.5×10^{-7}	3.1×10^{-7}	3.5×10^{-7}	1.4×10^{-10}	1.7×10^{-6}	1.5×10^{-6}	1.7×10^{-6}	6.8×10^{-10}
Soil Dermal	5.2×10^{-6}	2.6×10^{-8}	5.2×10^{-6}	2.1×10^{-9}	2.6×10^{-5}	1.2×10^{-7}	2.6×10^{-5}	1.0×10^{-8}
Subtotal	5.6×10^{-6}	3.4×10^{-7}	5.6×10^{-6}	2.2×10^{-9}	2.8×10^{-5}	1.6×10^{-6}	2.8×10^{-5}	1.1×10^{-8}
Inhalation:								
Resuspension	1.3×10^{-6}	4.0×10^{-9}	1.3×10^{-6}	5.4×10^{-10}	6.7×10^{-6}	1.9×10^{-8}	6.7×10^{-6}	2.7×10^{-9}
Subtotal	1.3×10^{-6}	4.0×10^{-9}	1.3×10^{-6}	5.4×10^{-10}	6.7×10^{-6}	1.9×10^{-8}	6.7×10^{-6}	2.7×10^{-9}
External:								
Soil	2.4×10^{-4}	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	1.1×10^{-3}	2.0×10^{-3}	2.0×10^{-3}	7.8×10^{-7}
Subtotal	2.4×10^{-4}	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	1.1×10^{-3}	2.0×10^{-3}	2.0×10^{-3}	7.8×10^{-7}
Total	2.4×10^{-4}	4.2×10^{-4}	4.2×10^{-4}	1.7×10^{-7}	1.1×10^{-3}	2.0×10^{-3}	2.0×10^{-3}	7.9×10^{-7}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-62. Combined involved worker population (current use) radiological doses associated with the Shut Down and Deactivate Alternative.

Exposure Pathway	Population annual dose (person-rem)[a] L-Lake	Par Pond	Combined[b]	Number of fatal cancers[c]	Population lifetime dose (person-rem)[a,d] L-Lake	Par Pond	Combined[b]	Number of fatal cancers[c]
Ingestion:								
Soil	2.5×10^{-5}	2.2×10^{-5}	2.5×10^{-5}	9.8×10^{-9}	1.2×10^{-4}	1.0×10^{-4}	1.2×10^{-4}	4.8×10^{-8}
Soil Dermal	3.6×10^{-4}	1.8×10^{-6}	3.6×10^{-4}	1.5×10^{-7}	1.8×10^{-3}	8.5×10^{-6}	1.8×10^{-3}	7.3×10^{-7}
Subtotal	3.9×10^{-4}	2.4×10^{-5}	3.9×10^{-4}	1.6×10^{-7}	1.9×10^{-3}	1.1×10^{-4}	1.9×10^{-3}	7.8×10^{-7}
Inhalation:								
Resuspension	9.4×10^{-5}	2.8×10^{-7}	9.4×10^{-5}	3.8×10^{-8}	4.7×10^{-4}	1.3×10^{-6}	4.7×10^{-4}	1.9×10^{-7}
Subtotal	9.4×10^{-5}	2.8×10^{-7}	9.4×10^{-5}	3.8×10^{-8}	4.7×10^{-4}	1.3×10^{-6}	4.7×10^{-4}	1.9×10^{-7}
External:								
Soil	1.7×10^{-2}	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	7.7×10^{-2}	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}
Subtotal	1.7×10^{-2}	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	7.7×10^{-2}	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}
Total	1.7×10^{-2}	2.9×10^{-2}	2.9×10^{-2}	1.2×10^{-5}	7.9×10^{-2}	1.4×10^{-1}	1.4×10^{-1}	5.5×10^{-5}

a. The number of involved workers is estimated to be 70.
b. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 5-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-63. Combined involved worker (future use) radiological doses associated with the Shut Down and Deactivate Alternative.

Exposure Pathway	Individual annual dose (rem) L-Lake	Par Pond	Combined[a]	Probability of fatal cancer[b]	Individual lifetime dose (rem)[c] L-Lake	Par Pond	Combined[a]	Probability of fatal cancer[b]
Ingestion:								
Soil	7.7×10^{-6}	6.7×10^{-6}	7.7×10^{-6}	3.1×10^{-9}	1.7×10^{-4}	1.3×10^{-4}	1.7×10^{-4}	6.8×10^{-8}
Soil Dermal	8.7×10^{-5}	4.2×10^{-7}	8.7×10^{-5}	3.5×10^{-8}	2.2×10^{-3}	8.0×10^{-6}	2.2×10^{-3}	8.7×10^{-7}
Subtotal	9.4×10^{-5}	7.1×10^{-6}	9.4×10^{-5}	3.8×10^{-8}	2.3×10^{-3}	1.4×10^{-4}	2.3×10^{-3}	9.3×10^{-7}
Inhalation:								
Resuspension	2.9×10^{-5}	8.8×10^{-8}	2.9×10^{-5}	1.2×10^{-8}	7.3×10^{-4}	1.6×10^{-6}	7.3×10^{-4}	2.9×10^{-7}
Subtotal	2.9×10^{-5}	8.8×10^{-8}	2.9×10^{-5}	1.2×10^{-8}	7.3×10^{-4}	1.6×10^{-6}	7.3×10^{-4}	2.9×10^{-7}
External:								
Soil	4.1×10^{-2}	2.3×10^{-2}	4.1×10^{-2}	1.6×10^{-5}	7.4×10^{-1}	4.4×10^{-1}	7.4×10^{-1}	3.0×10^{-4}
Subtotal	4.1×10^{-2}	2.3×10^{-2}	4.1×10^{-2}	1.6×10^{-5}	7.4×10^{-1}	4.4×10^{-1}	7.4×10^{-1}	3.0×10^{-4}
Total	4.1×10^{-2}	2.3×10^{-2}	4.1×10^{-2}	1.6×10^{-5}	7.5×10^{-1}	4.4×10^{-1}	7.5×10^{-1}	3.0×10^{-4}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-64. Combined involved worker population (future use) radiological doses associated with the Shut Down and Deactivate Alternative.

Exposure Pathway	Population annual dose (person-rem)[a]			Number of	Population lifetime dose (person-rem)[a,d]			Number of
	L-Lake	Par Pond	Combined[b]	fatal cancers[c]	L-Lake	Par Pond	Combined[b]	fatal cancers[c]
Ingestion:								
Soil	5.4×10^{-4}	4.7×10^{-4}	5.4×10^{-4}	2.2×10^{-7}	1.2×10^{-2}	8.9×10^{-3}	1.2×10^{-2}	4.8×10^{-6}
Soil Dermal	6.1×10^{-3}	2.9×10^{-5}	6.1×10^{-3}	2.4×10^{-6}	1.5×10^{-1}	5.6×10^{-4}	1.5×10^{-1}	6.1×10^{-5}
Subtotal	6.6×10^{-3}	5.0×10^{-4}	6.6×10^{-3}	2.6×10^{-6}	1.6×10^{-1}	9.5×10^{-3}	1.6×10^{-1}	6.5×10^{-5}
Inhalation:								
Resuspension	2.0×10^{-3}	6.2×10^{-6}	2.0×10^{-3}	8.2×10^{-7}	5.1×10^{-2}	1.2×10^{-4}	5.1×10^{-2}	2.0×10^{-5}
Subtotal	2.0×10^{-3}	6.2×10^{-6}	2.0×10^{-3}	8.2×10^{-7}	5.1×10^{-2}	1.2×10^{-4}	5.1×10^{-2}	2.0×10^{-5}
External:								
Soil	2.9×10^{0}	1.6×10^{0}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{-1}	3.1×10^{1}	5.2×10^{1}	2.1×10^{-2}
Subtotal	2.9×10^{0}	1.6×10^{0}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{-1}	3.1×10^{1}	5.2×10^{1}	2.1×10^{-2}
Total	2.9×10^{0}	1.6×10^{0}	2.9×10^{0}	1.1×10^{-3}	5.2×10^{-1}	3.1×10^{1}	5.2×10^{1}	2.1×10^{-2}

a. Doses from the two release sites are not additive; the combined dose is the maximum dose of either site.
b. The number of involved workers is estimated to be 70.
c. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
d. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-65. Combined uninvolved worker radiological doses and resulting impacts associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Individual annual dose (rem) L-Lake	Individual annual dose (rem) Par Pond	Individual annual dose (rem) Combined	Probability of fatal cancer[b]	Individual lifetime dose (rem)[c] L-Lake	Individual lifetime dose (rem)[c] Par Pond	Individual lifetime dose (rem)[c] Combined	Probability of fatal cancer[b]
Ingestion:								
Soil	6.3×10^{-11}	5.8×10^{-12}	6.8×10^{-11}	2.7×10^{-14}	1.4×10^{-9}	1.1×10^{-10}	1.5×10^{-9}	6.0×10^{-13}
Soil Dermal	1.1×10^{-9}	3.6×10^{-13}	1.1×10^{-9}	4.3×10^{-13}	2.7×10^{-8}	6.9×10^{-12}	2.7×10^{-8}	1.1×10^{-11}
Subtotal	1.1×10^{-9}	6.2×10^{-12}	1.2×10^{-9}	4.6×10^{-13}	2.8×10^{-8}	1.2×10^{-10}	2.9×10^{-8}	1.1×10^{-11}
Inhalation:								
Air	1.1×10^{-6}	1.1×10^{-10}	1.1×10^{-6}	4.4×10^{-10}	2.8×10^{-5}	2.1×10^{-9}	2.8×10^{-5}	1.1×10^{-8}
Resuspension	1.2×10^{-8}	1.2×10^{-12}	1.2×10^{-8}	4.8×10^{-12}	3.0×10^{-7}	2.3×10^{-11}	3.0×10^{-7}	1.2×10^{-10}
Subtotal	1.1×10^{-6}	1.2×10^{-10}	1.1×10^{-6}	4.5×10^{-10}	2.8×10^{-5}	2.3×10^{-9}	2.8×10^{-5}	1.1×10^{-8}
External:								
Soil	3.3×10^{-7}	2.0×10^{-8}	3.5×10^{-7}	1.4×10^{-10}	6.1×10^{-6}	3.8×10^{-7}	6.4×10^{-6}	2.6×10^{-9}
Air	1.5×10^{-11}	9.9×10^{-13}	1.6×10^{-11}	6.4×10^{-15}	2.7×10^{-10}	1.9×10^{-11}	2.9×10^{-10}	1.2×10^{-13}
Subtotal	3.3×10^{-7}	2.0×10^{-8}	3.5×10^{-7}	1.4×10^{-10}	6.1×10^{-6}	3.8×10^{-7}	6.4×10^{-6}	2.6×10^{-9}
Total	1.5×10^{-6}	2.0×10^{-8}	1.5×10^{-6}	5.9×10^{-10}	3.4×10^{-5}	3.8×10^{-7}	3.5×10^{-5}	1.4×10^{-8}

a. The maximally exposed uninvolved worker is located in L-Area.
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-66. Combined uninvolved worker population doses and resulting impacts associated with the Shut Down and Deactivate Alternative.[a]

Exposure Pathway	Population annual dose (person-rem)			Number of fatal cancers[b]	Population liftime dose (person-rem)[c]			Number of fatal cancers[b]
	L-Lake	Par Pond	Combined		L-Lake	Par Pond	Combined	
Ingestion:								
Soil	1.6×10^{-8}	1.5×10^{-9}	1.7×10^{-8}	6.9×10^{-12}	3.5×10^{-7}	2.8×10^{-8}	3.8×10^{-7}	1.5×10^{-10}
Soil Dermal	2.7×10^{-7}	9.2×10^{-11}	2.7×10^{-7}	1.1×10^{-10}	6.8×10^{-6}	1.7×10^{-9}	6.8×10^{-6}	2.7×10^{-9}
Subtotal	2.9×10^{-7}	1.6×10^{-9}	2.9×10^{-7}	1.2×10^{-10}	7.1×10^{-6}	2.9×10^{-8}	7.2×10^{-6}	2.9×10^{-9}
Inhalation:								
Air	2.8×10^{-4}	2.8×10^{-8}	2.8×10^{-4}	1.1×10^{-7}	7.0×10^{-3}	5.3×10^{-7}	7.0×10^{-3}	2.8×10^{-6}
Resuspension	3.0×10^{-6}	3.1×10^{-10}	3.0×10^{-6}	1.2×10^{-9}	7.5×10^{-5}	5.8×10^{-9}	7.5×10^{-5}	3.0×10^{-8}
Subtotal	2.8×10^{-4}	3.1×10^{-8}	2.8×10^{-4}	1.1×10^{-7}	7.0×10^{-3}	5.8×10^{-7}	7.0×10^{-3}	2.8×10^{-6}
External:								
Soil	8.3×10^{-5}	5.1×10^{-6}	8.9×10^{-5}	3.5×10^{-8}	1.5×10^{-3}	9.6×10^{-5}	1.6×10^{-3}	6.5×10^{-7}
Air	3.8×10^{-9}	2.5×10^{-10}	4.0×10^{-9}	1.6×10^{-12}	6.9×10^{-8}	4.7×10^{-9}	7.3×10^{-8}	2.9×10^{-11}
Subtotal	8.3×10^{-5}	5.1×10^{-6}	8.9×10^{-5}	3.5×10^{-8}	1.5×10^{-3}	9.6×10^{-5}	1.6×10^{-3}	6.5×10^{-7}
Total	3.7×10^{-4}	5.1×10^{-6}	3.7×10^{-4}	1.5×10^{-7}	8.6×10^{-3}	9.7×10^{-5}	8.7×10^{-3}	3.5×10^{-6}

a. L-Area. Total uninvolved workers is estimated to be 251 (Simpkins 1996).
b. Based on a risk of 0.0004 latent fatal cancers per person-rem of radiation exposure (NCRP 1993).
c. Based on a 25-year exposure period. Doses are corrected for radioactive decay over the exposure period.

Table C-67. Combined nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative for the involved worker (current use).

Exposure Pathway	Hazard index			Annual cancer risk			Lifetime
	L-Lake	Par Pond	Combined[a]	L-Lake	Par Pond[b]	Combined[a]	cancer risk[c]
Ingestion:							
Soil	6.0×10^{-3}	6.8×10^{-6}	6.0×10^{-3}	1.3×10^{-8}	NA[d]	1.3×10^{-8}	6.4×10^{-8}
Soil Dermal	4.5×10^{-3}	2.4×10^{-5}	4.5×10^{-3}	5.1×10^{-8}	NA	5.1×10^{-8}	2.5×10^{-7}
Subtotal	1.0×10^{-2}	3.0×10^{-5}	1.0×10^{-2}	6.4×10^{-8}	0.0×10^{0}	6.4×10^{-8}	3.2×10^{-7}
Inhalation:							
Resuspension	1.3×10^{-4}	4.8×10^{-7}	1.3×10^{-4}	1.9×10^{-9}	NA	1.9×10^{-9}	9.3×10^{-9}
Subtotal	1.3×10^{-4}	4.8×10^{-7}	1.3×10^{-4}	1.9×10^{-9}	0.0×10^{0}	1.9×10^{-9}	9.3×10^{-9}
Total	1.1×10^{-2}	3.1×10^{-5}	1.1×10^{-2}	6.6×10^{-8}	0.0×10^{0}	6.6×10^{-8}	3.3×10^{-7}

a. Hazard indexes and cancer risks from the two release sites are not additive; the combined result is the maximum of either site.
b. No carcinogenic constituents are released from Par Pond for current land use under the No-Action Alternative.
c. Based on a 5-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-68. Combined nonradiological hazard indexes and cancer risks associated with the Shut Down and Deactivate Alternative for the involved worker (future use).

Exposure Pathway	Hazard index			Annual cancer risk			Lifetime
	L-Lake	Par Pond	Combined[a]	L-Lake	Par Pond[b]	Combined[a]	cancer risk[c]
Ingestion:							
Soil	1.3×10^{-1}	1.6×10^{-4}	1.3×10^{-1}	2.9×10^{-7}	NA[d]	2.9×10^{-7}	7.2×10^{-6}
Soil Dermal	7.4×10^{-2}	3.9×10^{-4}	7.4×10^{-2}	8.5×10^{-7}	NA	8.5×10^{-7}	2.1×10^{-5}
Subtotal	2.1×10^{-1}	5.5×10^{-4}	2.1×10^{-1}	1.1×10^{-6}	0.0×10^{0}	1.1×10^{-6}	2.8×10^{-5}
Inhalation:							
Resuspension	2.9×10^{-3}	1.1×10^{-5}	2.9×10^{-3}	4.1×10^{-8}	NA	4.1×10^{-8}	1.0×10^{-6}
Subtotal	2.9×10^{-3}	1.1×10^{-5}	2.9×10^{-3}	4.1×10^{-8}	NA	4.1×10^{-8}	1.0×10^{-6}
Total	2.1×10^{-1}	5.6×10^{-4}	2.1×10^{-1}	1.2×10^{-6}	0.0×10^{0}	1.2×10^{-6}	2.9×10^{-5}

a. Hazard indexes and cancer risks from the two release sites are not additive; the combined result is the maximum of either site.
b. No carcinogenic constituents are released from Par Pond for current land use under the No-Action Alternative.
c. Based on a 25-year exposure period.
d. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-69. Combined nonradiological hazard indexes and cancer risk associated with the Shut Down and Deactivate Alternative for uninvolved workers.

Exposure Pathway	Total Hazard index			Annual cancer risk			Lifetime
	L-Lake	Par Pond	Combined	L-Lake	Par Pond[a]	Combined	cancer risk[b]
Ingestion:							
Soil	1.1×10^{-6}	1.3×10^{-10}	1.1×10^{-6}	2.3×10^{-12}	NA[c]	2.3×10^{-12}	5.6×10^{-11}
Soil Dermal	6.0×10^{-7}	3.4×10^{-10}	6.0×10^{-7}	7.1×10^{-12}	NA	7.1×10^{-12}	1.8×10^{-10}
Subtotal	1.7×10^{-6}	4.7×10^{-10}	1.7×10^{-6}	9.3×10^{-12}	0.0×10^{0}	9.3×10^{-12}	2.3×10^{-10}
Inhalation:							
Air	1.0×10^{-4}	1.4×10^{-8}	1.0×10^{-4}	1.4×10^{-9}	NA	1.4×10^{-9}	3.6×10^{-8}
Resuspension	1.1×10^{-6}	1.4×10^{-10}	1.1×10^{-6}	1.6×10^{-11}	NA	1.6×10^{-11}	4.1×10^{-10}
Subtotal	1.0×10^{-4}	1.4×10^{-8}	1.0×10^{-4}	1.4×10^{-9}	0.0×10^{0}	1.4×10^{-9}	3.6×10^{-8}
Total	1.1×10^{-4}	1.5×10^{-8}	1.1×10^{-4}	1.4×10^{-9}	0.0×10^{0}	1.4×10^{-9}	3.6×10^{-8}

a. No carcinogenic constituents are released from Par Pond for current land use under the No-Action Alternative.
b. Based on a 25-year exposure period.
c. NA = not applicable; the contaminant is not transferred through the listed exposure pathway.

Table C-70. Assumed human health exposure parameters.

Receptor	Parameter	Value	Comments	Source
Offsite maximally exposed individual (current use) and general (offsite) population	Exposure time	24 hr/d	Hours per day used for resident receptor in Par Pond Baseline Risk Assessment and MEPAS default.	WSRC 1992; Strenge and Chamberlain 1995
	Exposure frequency	365 d/yr	Days per year - MEPAS default.	Strenge and Chamberlain 1995
	Exposure duration	70 yr	Typical full lifetime expose based on DOE NEPA guidance and MEPAS default.	DOE 1993; Strenge and Chamberlain 1995
	Outdoor/Indoor time fraction	0.75/0.25	Offsite resident/maximally exposed individual spend 75 percent of time indoors and 25 percent of time outdoors.	Hamby 1993 (outdoor time fraction); best estimate (indoor time fraction)
	Body weight	70 kg	EPA standard default weight of an average adult.	EPA 1991
	Inhalation rate	20 m^3/d	EPA standard default adult breathing rate.	EPA 1991
	Soil ingestion rate	100 mg/d	EPA standard default soil and dust ingestion rate for adult residents.	EPA 1991
	Leafy vegetable intake rate	21 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Other vegetable intake rate	163 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Meat intake rate	43 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Milk intake rate	120 L/yr	Site-specific data for SRS area.	Hamby 1993
	Skin area available for contact	19,400 cm^2	Offsite resident's whole body exposed. Based on EPA body part-specific areas for male adult.	EPA 1989
	For aqueous release pathways under Shut Down and Deactivate Alternative only:			
	Drinking water intake rate	2 L/d	EPA standard default for adult resident intake of drinking water.	EPA 1991
	Time spent boating	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977
	Time spent swimming	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977
	Shoreline exposure time	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977
	Skin area exposed during swimming	19,400 cm^2	Offsite resident's whole body exposed to water while swimming. Based on EPA body part-specific areas for male adult.	EPA 1989

Table C-70. (continued).

Receptor	Parameter	Value	Comments	Source
Offsite maximally exposed individual (current use) and general	Water ingestion during swimming	100 mL/hr	MEPAS default.	Strenge and Chamberlain 1995
(offsite) population (continued)	Ingestion of shoreline sediments	100 mg/hr	MEPAS default.	Strenge and Chamberlain 1995
	Fish ingestion rate	9 kg/yr	Site-specific data for SRS area.	Hamby 1993
Offsite maximally exposed individual (future use)	Exposure time	24 hr/d	Hours per day used for resident receptor in Par Pond Baseline Risk Assessment and MEPAS default.	WSRC 1992; Strenge and Chamberlain 1995
	Exposure frequency	365 d/yr	Days per year - MEPAS default.	Strenge and Chamberlain 1995
	Exposure duration	70 yr	Typical full lifetime expose based on DOE NEPA guidance and MEPAS default.	DOE 1993; Strenge and Chamberlain 1995
	Outdoor/Indoor time fraction	0.75/0.25	Offsite resident/maximally exposed individual spend 75 percent of time indoors and 25 percent of time outdoors.	Hamby 1993 (outdoor time fraction); best estimate (indoor time fraction)
	Body weight	70 kg	EPA standard default weight of an average adult.	EPA 1991
	Inhalation rate	20 m^3/d	EPA standard default adult breathing rate.	EPA 1991
	Soil ingestion rate	100 mg/d	EPA standard default soil and dust ingestion rate for adult residents.	EPA 1991
	Leafy vegetable intake rate	21 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Other vegetable intake rate	163 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Meat intake rate	43 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Milk intake rate	120 L/yr	Site-specific data for SRS area.	Hamby 1993
	Skin area available for contact	19,400 cm^2	Offsite resident's whole body exposed. Based on EPA body part-specific areas for male adult.	EPA 1989
	For recreational pathways on L-Lake under No-Action Alternative only:			
	Time spent boating	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977
	Time spent swimming	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977

Table C-70. (continued).

Receptor	Parameter	Value	Comments	Source
Offsite maximally exposed individual (future use) (continued)	Shoreline exposure time	12 hr/yr	MEPAS and NRC Regulatory Guide 1.109 default.	Strenge and Chamberlain 1995; NRC 1977
	Fish ingestion rate	9 kg/yr	Site-specific data for SRS area.	Hamby 1993
	Skin area exposed during swimming	19,400 cm^2	Offsite resident's whole body exposed to water while swimming. Based on EPA body part-specific areas for male adult.	EPA 1989
	Water ingestion during swimming	100 mL/hr	MEPAS default.	Strenge and Chamberlain 1995
	Ingestion of shoreline sediments	100 mg/hr	MEPAS default.	Strenge and Chamberlain 1995
Involved worker (current use)	Exposure time	6 hr/wk	Value specified in inter-office memorandum from Hamm to Sidey. Based on discussions with field groups.	Hamm 1996
	Exposure frequency	15 wk/yr	Value specified in inter-office memorandum from Hamm to Sidey. Based on discussions with field groups.	Hamm 1996
	Exposure duration	5 yr	Value specified in inter-office memorandum from Hamm to Sidey. Based on discussions with field groups.	Hamm 1996
	Outdoor/Indoor time fraction	1.00/0.00	Worker spends100 percent of exposure time outdoors.	Most conservative estimate.
	Body weight	70 kg	EPA standard default weight of an average adult.	EPA 1991
	Inhalation rate	1.5 m^3/d	Based on daily inhalation rate of 30 m3/d for a worker performing moderate activity (24-hour exposure time) used in Par Pond Baseline Risk Assessment. Volume is scaled to reflect amount inhaled during a 6 hour work week (1.2 hr/d for 75 days per year).	WSRC 1992
	Soil ingestion rate	7.5 mg/d	Based on EPA standard default soil ingestion rate of 50 mg/d for commercial/industrial land use (8-hour exposure time). Volume is scaled to reflect amount ingested during a 6-hour work week (1.2 hr/d for 75 days per year).	EPA 1991

Table C-70. (continued).

Receptor	Parameter	Value	Comments	Source
Involved worker (current use) (continued)	Ingestion of potable water	NA	Worker does not ingest any contaminated drinking water.	NA
	Skin area available for contact	3,120 cm^2/day	Worker's hands and arms are exposed. Based on EPA body part-specific areas for male adult.	EPA 1989
Involved worker (future use)	Exposure time	8 hr/d	EPA standard default exposure duration for commercial/industrial land use. Also used in Par Pond Baseline Risk Assessment for future condition on-Par Pond Unit worker.	EPA 1991; WSRC 1992
	Exposure frequency	250 d/yr	EPA standard default exposure duration for commercial/industrial land use.	EPA 1991
	Exposure duration	25 yr	EPA standard default exposure duration for commercial/industrial land use.	EPA 1991
	Outdoor/Indoor time fraction	1.00/0.00	Worker spends100 percent of exposure time outdoors.	Most conservative estimate.
	Body weight	70 kg	EPA standard default weight of an average adult.	EPA 1991
	Inhalation rate	10 m^3/d	Based on daily inhalation rate of 30 m3/d for a worker performing moderate activity (24-hour exposure time) used in Par Pond Baseline Risk Assessment. Rate is scaled to reflect amount inhaled during an 8-hour work day.	WSRC 1992; EPA 1991
	Soil ingestion rate	50 mg/d	Based on EPA standard default soil ingestion rate of 50 mg/d for commercial/industrial land use (8-hour exposure time).	EPA 1991
	Ingestion of potable water	NA	Worker does not ingest any contaminated drinking water.	NA
	Skin area available for contact	3,120 cm^2	Worker's hands and arms are exposed. Based on EPA body part-specific areas for male adult.	EPA 1989
Uninvolved worker	Exposure time	8 hr/d	EPA standard default exposure duration for commercial/industrial land use.	EPA 1991
	Exposure frequency	250 d/yr	EPA standard default exposure duration for commercial/industrial land use.	EPA 1991
	Exposure duration	25 yr	EPA standard default exposure duration for commercial/industrial land use.	EPA 1991

Table C-70. (continued).

Receptor	Parameter	Value	Comments	Source
Uninvolved worker (continued)	Outdoor/Indoor time fraction	0.75/0.25	Uninvolved worker spends 75 percent of time indoors and 25 percent of time outdoors.	Best estimate.
	Body weight	70	EPA standard default weight of an average adult.	EPA 1991; NRC 1977
	Inhalation rate	10 m^3/d	Based on EPA standard default for average adult breathing rate. Rate is scaled to reflect amount inhaled during an 8-hour work day.	EPA 1991; NRC 1977
	Soil ingestion rate	50 mg/d	Based on EPA standard default soil ingestion rate of 50 mg/d for commercial/industrial land use (8-hour exposure time).	EPA 1991
	Ingestion of potable water	NA	Worker does not ingest any contaminated drinking water.	NA
	Skin area available for contact	3,120 cm^2	Worker's hands and arms are exposed. Based on EPA body part-specific areas for male adult.	EPA 1989

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APPENDIX D. ECOLOGICAL RESOURCES, FLORA, AND FAUNA

TABLE OF CONTENTS

Table D-1. Reptiles and amphibians of Savannah River Site aquatic habitats.[a]

Group	Common name	Species
Salamanders	spotted salamander	*Ambystoma maculatum*
	marbled salamander	*Ambystoma opacum*
	mole salamander	*Ambystoma talpoideum*
	tiger salamander	*Ambystoma tigrinum*
	two-toed amphiuma	*Amphiuma means*
	southern dusky salamander	*Desmognathus auriculatus*
	two-lined salamander	*Eurycea cirrigera*
	long-tailed salamander	*Eurycea longicauda*
	dwarf salamander	*Eurycea quadridigitata*
	dwarf waterdog	*Necturus punctatus*
	eastern newt	*Notophthalmus viridescens*
	mud salamander	*Pseudotriton montanus*
	lesser siren	*Siren intermedia*
	greater siren	*Siren lacertina*
Frogs and toads	northern cricket frog	*Acris crepitans*
	southern cricket frog	*Acris gryllus*
	oak toad	*Bufo quercicus*
	bird-voiced treefrog	*Hyla avivoca*
	Cope's gray treefrog	*Hyla chrysoscelis*
	green treefrog	*Hyla cinerea*
	pine woods treefrog	*Hyla femoralis*
	barking treefrog	*Hyla gratiosa*
	southern chorus frog	*Pseudacris nigrita*
	little grass frog	*Pseudacris ocularis*
	ornate chorus frog	*Pseudacris ornata*
	crawfish frog	*Rana areolata*
	bullfrog	*Rana catesbeiana*
	bronze frog	*Rana clamitans*
	pig frog	*Rana grylio*
	pickerel frog	*Rana palustris*
	southern leopard frog	*Rana sphenocephala*
	carpenter frog	*Rana virgatipes*
	eastern spadefoot toad	*Scaphiopus holbrooki*
Alligators	American alligator	*Alligator mississippiensis*
Turtles	snapping turtle	*Chelydra serpentina*
	chicken turtle	*Deirochelys reticularia*
	striped mud turtle	*Kinosternon bauri*
	eastern mud turtle	*Kinosternon subrubrum*
	river cooter	*Pseudemys concinna*
	Florida cooter	*Pseudemys floridana*
	stinkpot	*Sternotherus odoratus*
	slider turtle	*Trachemys scripta*
	spiny softshell turtle	*Trionyx spiniferus*
Snakes	rat snake	*Elaphe obsoleta*
	mud snake	*Farancia abacura*
	rainbow snake	*Farancia erytrogramma*
	common kingsnake	*Lampropeltis getulus*
	green water snake	*Nerodia cyclopion*

Table D-1. (continued).

Group	Common name	Species
Snakes (continued)	red-bellied water snake	*Nerodia erythrogaster*
	banded water snake	*Nerodia fasciata*
	brown water snake	*Nerodia taxispilota*
	glossy crayfish snake	*Regina rigida*
	queen snake	*Regina septemvittata*
	black swamp snake	*Seminatrix pygaea*
	brown snake	*Storeria dekayi*
	eastern ribbon snake	*Thamnophis sauritus*
	garter snake	*Thamnophis sirtalis*
	cottonmouth	*Agkistodon piscivorous*

a. Sources: Scott, Patterson, and Giffin (1990); Gibbons and Semlitsch (1991).

Table D-2. Birds of Savannah River Site streams, reservoirs, wetlands, and adjacent forests.[a]

Group	Common name	Species
Ducks and duck-like birds	Canada goose	*Branta canadensis*
	mallard	*Anas platyrhynchos*
	black duck	*Anas rubripes*
	gadwall	*Anas strepera*
	green-winged teal	*Anas crecca*
	blue-winged teal	*Anas discors*
	American widgeon	*Anas americana*
	northern shoveler	*Anas clypeata*
	common merganser	*Mergus merganser*
	ring-necked duck	*Aythya collaris*
	lesser scaup	*Aythya affinis*
	bufflehead	*Bucephala albeola*
	ruddy duck	*Oxyura jamaicensis*
	hooded merganser	*Lophodytes cucullatus*
	pied-billed grebe	*Podilymbus podiceps*
	wood duck	*Aix sponsa*
	purple gallinule	*Porphyrula martinica*
	common gallinule	*Gallinula chloropus*
	sora	*Porzana carolina*
	American coot	*Fulica americana*
Seabirds/gulls	black tern	*Chlidonias niger*
Wading birds	black-crowned night heron	*Nycticorax nycticorax*
	great blue heron	*Ardea herodias*
	little blue heron	*Egretta caerulea*
	tricolored heron	*Egretta tricolor*
	green heron	*Butorides striatus*
	white ibis	*Eudocimus albus*
	great egret	*Casmerodius albus*
	snowy egret	*Egretta thula*
	killdeer	*Charadrius vociferus*
	long-billed dowitcher	*Limnodromus scalopaceus*
	northern phalarope	*Lobipes lobatus*
	American anhinga	*Anhinga anhinga*
	least bittern	*Ixobrychus exilis*
	American bittern	*Botaurus lentiginosus*
	wood stork	*Mycteria americana*
Fowl-like birds	wild turkey	*Meleagris gallopavo*
	bobwhite quail	*Colinus virginianus*
	American woodcock	*Philohela minor*
Pigeons and doves	mourning dove	*Zenaida macroura*
	rock dove	*Columba livia*
Birds of prey	black vulture	*Coragyps atratus*
	turkey vulture	*Cathartes aura*
	great horned owl	*Bubo virginianus*
	common nighthawk	*Chordeiles minor*
	red-tailed hawk	*Buteo jamaicensis*
	red-shouldered hawk	*Buteo lineatus*
	bald eagle	*Haliaeetus leucocephalus*

Table D-2. (continued).

Group	Common name	Species
Birds of prey (continued)	osprey	*Pandion haliaetus*
	sharp-shinned hawk	*Accipiter striatus*
	broad-winged hawk	*Buteo platypterus*
	Cooper's hawk	*Accipiter cooperii*
	marsh hawk	*Circus cyaneus*
	American kestrel	*Falco sparverius*
	barred owl	*Strix varia*
	screech owl	*Otus asio*
Non-passerine land birds	Chuck-will's widow	*Caprimulgus carolinensis*
	ruby-throated hummingbird	*Archilochus colubris*
	belted kingfisher	*Megaceryle alcyon*
	red-bellied woodpecker	*Melanerpes carolinus*
	hairy woodpecker	*Picoides villosus*
	red-headed woodpecker	*Melanerpes erythrocephalus*
	downy woodpecker	*Picoides pubescens*
	pileated woodpecker	*Dryocopus pileatus*
	red-cockaded woodpecker	*Picoides borealis*
	yellow-shafted flicker	*Colaptes auratus*
	yellow-bellied sapsucker	*Sphyrapicus varius*
	yellow-billed cuckoo	*Coccyzus americanus*
Passerines (perching birds)	eastern kingbird	*Tyrannus tyrannus*
	great crested flycatcher	*Myiarchus critinus*
	Acadian flycatcher	*Empidonax virescens*
	eastern phoebe	*Sayornis phoebe*
	eastern peewee	*Contopus virens*
	water pipit	*Anthus spinoletta*
	house wren	*Troglodyte aedon*
	Carolina wren	*Thryothorus ludovicianus*
	long-billed marsh wren	*Cistothorus palustris*
	winter wren	*Troglodytes troglodytes*
	golden-crowned kinglet	*Regulus satrapa*
	ruby-crowned kinglet	*Regulus calendula*
	blue-gray gnatcatcher	*Polioptila caerulea*
	chimney swift	*Chaetura pelagica*
	bank swallow	*Riparia riparia*
	barn swallow	*Hirundo rustica*
	fish crow	*Corvus ossifragus*
	American crow	*Corvus brachyrhynchos*
	blue jay	*Cyanocitta cristata*
	Carolina chickadee	*Parus carolensis*
	tufted titmouse	*Parus bicolor*
	white-breasted nuthatch	*Sitta carolinensis*
	brown-headed nuthatch	*Sitta pusilla*
	mockingbird	*Mimus polyglottos*
	gray catbird	*Dumetella carolinensis*
	brown thrasher	*Toxostoma rufum*
	American robin	*Turdus migratorius*
	wood thrush	*Hylocichla mustelina*
	hermit thrush	*Catharus guttatus*

Table D-2. (continued).

Group	Common name	Species
Passerines (perching birds) (continued)	eastern bluebird	Sialia sialis
	orchard oriole	Icterus spurius
	summer tanager	*Piranga rubra*
	solitary vireo	*Vireo solitarius*
	white-eyed vireo	*Vireo griseus*
	red-eyed vireo	*Vireo olivaceus*
	yellow-throated vireo	*Vireo flavifrons*
	prothonotary warbler	*Protonotaria citrea*
	yellow-throated warbler	*Dendroica dominica*
	northern parula warbler	*Parula americana*
	pine warbler	*Dendroica pinus*
	black-and-white warbler	*Mniotilta varia*
	yellow-rumped warbler	*Dendroica coronata*
	prairie warbler	*Dendroica discolor*
	Kentucky warbler	*Oporornis formosus*
	hooded warbler	*Wilsonia citrina*
	orange-crowned warbler	*Vermivora celata*
	northern waterthrush	*Seiurus novaboracensis*
	common yellowthroat	*Geothlypis trichas*
	yellow-breasted chat	*Icteria virens*
	eastern meadowlark	*Sturnella magna*
	common grackle	*Quiscalus quiscula*
	American redstart	*Setophaga ruticilla*
	ovenbird	*Seiurus aurocapillus*
	cardinal	*Cardinalis cardinalis*
	blue grosbeak	*Guiraca caerulea*
	indigo bunting	*Passerina cyanea*
	painted bunting	*Passerina ciris*
	rufous-sided towhee	*Pipilo erythrophthalmus*
	starling	*Sturnus vulgaris*
	red-winged blackbird	*Agelaius phoeniceus*
	brown-headed cowbird	*Molothrus ater*
	rusty blackbird	*Euphagus carolinus*
	LeConte's sparrow	*Ammospiza leconteii*
	field sparrow	*Spizella pusilla*
	chipping sparrow	*Spizella passerina*
	Savannah sparrow	*Passerculus sandwichensis*
Tropical introductions	yellowthroat	*Geothlypis rostrata*

a. Sources: Smith, Sharitz, and Gladden (1981); Bildstein et al. (1994); Scott, Patterson, and Giffin (1990).

Table D-3. Mammals of Savannah River Site stream corridors and wetlands.[a]

Family	Group	Species	Common name
Didelphidae	New World Opossums	*Didelphis virginiana*	opossum
Soricidae	Shrews	*Blarina carolinensis*	short-tailed shrew
		Cryptotis parva	least shrew
		Sorex longirostris	southeastern shrew
Talpidae	Moles	*Condylura cristata*	star-nosed mole
		Scalopus aquaticus	eastern mole
Cricetidae	New World Rats and Mice	*Oryzomys palustris*	marsh rice rat
		Microtus pinetorum	pine vole
		Ochrotomys nuttalli	golden mouse
		Peromyscus spp.[b]	white-footed deer mouse
		Neotoma floridana	eastern wood rat
		Sigmodon hispidus	hispid cotton rat
		Ondatra zibethicus	muskrat
Sciuridae	Tree Squirrels	*Sciurus carolinensis*	gray squirrel
		Sciurus niger	fox squirrel
		Glaucomys volans	flying squirrel
Cervidae	Deer	*Odocoileus virginianus*	white-tailed deer
Suidae	Old World Swine	*Sus scrofa*	feral swine
Ursidae	Bears	*Ursus americana*	black bear
Procyonidae	Raccoons	*Procyon lotor*	raccoon
Canidae	Coyotes and Foxes	*Urocyon cinereoargenteus*	gray fox
Castoridae	Beaver	*Castor canadensis*	beaver
Mustelidae	Weasels and Skunks	*Lutra canadensis*	otter
		Mustela frenata	long-tailed weasel
		Spilogale putorius	spotted skunk
		Mustela vison	mink
		Mephitis mephitis	striped skunk
Leporidae	Rabbits	*Sylvilagus floridanus*	eastern cottontail
		Sylvilagus palustris	marsh rabbit
Felidae	Bobcat	*Felix rufus*	bobcat
Vespertilionidae	Bats	*Lasiosycteris noctivagans*	silver-haired bat
		Pipistrellus subflavus	eastern pipistrelle
		Lasiurus borealis	red bat
		L. intermedius	northern yellow bat
		L. seminolus	Seminole bat
		Plocotus rafinesquii	Rafinesque's big-eared bat

a. Sources: Smith, Sharitz, and Gladden (1982); Wike et al. (1994).
b. spp. = species (plural).

Table D-4. Wetland types of the Steel Creek Corridor.[a]

Wetland types	Description	
Aquatic bed - open water	The outfall canal of L-Reactor contains open water bordered by persistent herbaceous species and occasional shrubs.	
Emergent - persistent	Although the dominant herbaceous species vary with water depth and location on the deltaic fan, scattered shrubs [buttonbush (*Cephalanthus occidentalis*) and black willow (*Salix nigra*)] are usually present. Cut grass (*Leersia* spp.[b]) is dominant with abundant redtop panicgrass (*Panicum agrostoides*) as ground cover except under dense woody vegetation and in the deeper stream channels. These grasses are usually overtopped by knot grass (*Scirpus cyperinus*, approximately 2.5 meters tall) which is the aspect dominant on aerial photos as well as on the ground. There are also several, nearly monotypic, stands of cattail (*Typha latifolia*).	TE
Emergent - nonpersistent	This mapping unit is dominated by *Polygonum lapathifolium* with a border of persistent herbs including cattail, burreed (*Sparganium americanum*), Canada rush (*Juncus canadensis*), and sugarcane beard grass (*Erianthus giganteus*).	
Scrub-shrub wetlands - broad-leaved deciduous (*Alnus serrulata*)	Alder (*Alnus serrulata*) is the dominant species in the corridor on Steel Creek C orridor with locally abundant wax myrtle (*Myrica Cerifera*) and willow (*Salix* sp.[c]). Beneath these shrubs, blackberry (*Rubus* spp.) is abundant over a diverse herbaceous flora of *Hypericum* spp., false nettle (*Boehmeria cylindrica*), goldenrod (*Solidago canadensis*), wapato (*Sagittaria latifolia*), jewelweed (*Impatiens capensis*), *Polygonum* spp., *Aneilema keisak*, cut grass, knot grass, and *Ludwigia virgata*. These herbs also covered open areas along stream channels within this vegetation type and are the dominant ground covers in some of the other woody mapping units. This mapping unit generally borders the stream channels and, throughout most of the length of Steel Creek, extends nearly across the width of the floodplain. Narrow strips of young hardwood trees bordering the upland are included in the boundary of this unit. The height of the shrubs decreases upstream from approximately 5 meters near the mouth of Steel Creek to 3 meters near the L-Reactor outfall. Density is also variable with nearly impenetrable thickets between transects 60 and 70 and between transects 20 and 40 but lower density between 40 and 60.	TE
Scrub-shrub wetlands - broad-leaved deciduous (*Cephalanthus occidentalis - Salix nigra*)	A dense shrub canopy composed of buttonbush and black willow dominates this mapping unit near the mouth of Steel Creek.	
Forested wetlands - broad-leaved deciduous (*Salix* sp.)	Willows exceeding 5 meters in height are dominant near the mouth of Steel Creek and in a few locations near bridges and power lines further upstream. Occasionally hardwood species [e.g., sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*)] join the willow in the canopy. Beneath the willow is a shrub layer of alder, wax myrtle, and blackberry with sparse herb cover which includes some of the plants listed in the alder-dominated scrub-shrub wetlands.	TE TE

Table D-4. (continued).

Wetland types	Description
Forested wetlands - broad-leaved deciduous (*Alnus serrulata-Myrica cerifera*)	Wax myrtle and alder (up to 7 meters tall) are codominant, growing in dense stands on most of the floodplain between transects 70 and 100. Willow is also abundant. This shrub canopy is broken by occasional hardwood trees [sycamore (*Platanus occidentalis*), sweetgum, red maple] on some of the more stable sandbars. Beneath the alder-wax myrtle canopy is dense blackberry and a sparse covering of the herbs listed in the alder-dominated scrub-shrub wetland description. These herbs are also dominant in old stream beds which lack abundant woody vegetation.
Forested wetlands - broad-leaved deciduous (*Liquidamber styraciflua-Acer rubrum-Salix* sp.)	Tree species common on the upland adjacent to Steel Creek have become established on some of the more stable sandbars, at stream obstructions such as bridges and dikes, and along the Steel Creek upland border, especially upstream from L-Reactor. The most frequent canopy species include tulip tree (*Liriodendron tulipifera*), sycamore, red maple and sweetgum. Saplings of these trees, wax myrtle, alder, blackberry, and groundsel-tree (*Baccharis halimifolia*) are abundant in the understory. Although nearly half of the substrate surface is covered by leaf-litter, numerous herb and vine species grow beneath the trees. Chief among the herbs are: sensitive fern (*Onoclea sensibilis*), false nettle, *Hypericum* spp., sericea (*Lespedeza cuneata*), and goldenrod. The most frequent vines include pepper vine (*Ampelopsis arborea*), and honeysuckle (*Lonicera japonica*).
Forested wetlands - mixed deciduous (*Taxodium distichum - Nyssa sylvatica* var. *biflora*)	This vegetation type is dominated by cypress (*Taxodium distichum*) on some portions of Steel Creek corridor with some water gum (*Nyssa sylvatica* var. *biflora*). In the Savannah River swamp system, cypress and water typelo (*N. aquatica*) dominate this mapping unit.

a. Source: Smith, Sharitz, and Gladden (1981).
b. spp. = species (plural).
c. sp. = species (singular).

Table D-5. Species and quantities planted at L-Lake by Southern Tier Consulting between January and August 1987.[a]

Scientific name	Common name	Quantity planted
Submersed/floating-leaved zone		
Brasenia schreberi	Water shield	<1,000
Eleocharis acicularis	Spike rush	<2,000
Najas gracillima	Bushy pondweed	<100
Nelumbo lutea	American lotus	<1,000
Nymphaea odorata	White waterlily	>2,000
Nymphoides aquatica	Floating heart	<100
Potamogeton pulcher	Pondweed	<1,000
Potamogeton vaseyi	Pondweed	<100
Vallisneria americana	Water celery	>2,000
Emergent zone		
Axonopus sp.[b]	Carpet grass	10 lbs[c]
Bacopa caroliniana	Bacopa	>2,000
Carex comosa	Sedge	<2,000
Carex glaucescens	Sedge	<100
Dulichium arundinaceum	Three-way sedge	<100
Echinochloa crusgalli	Wild millet	25 lbs[c]
Echinodorus cordifolius	Burhead	<100
Eleocharis equisetoides	Spike rush	<2,000
Eleocharis quadrangulata	Spike rush	<2,000
Erianthus giganteus	Beard grass	<100
Glyceria striata	Manna grass	<100
Hydrochloa caroliniensis	Grass	<1,000
Hydrocotyle umbellata	Water pennywort	<100
Juncus acuminatus	Rush	<100
Juncus brachycarpus	Rush	<100
Juncus effusus	Soft rush	>2,000
Juncus diffusisimus	Rush	<100
Leersia oryzoides	Rice cutgrass	>2,000
Lycopus rubellus	Water horehound	<1,000
Panicum hemitomon	Panic grass	>2000
Panicum virgatum	Switchgrass	10 lbs[c]

Table D-5. (continued).

Scientific name	Common name	Quantity planted
Emergent zone (continued)		
Paspalum distichum	Knot grass	<1,000
Polygonum sp.	Smartweed	<2,000
Pontederia cordata	Pickerelweed	<1,000
Sagittaria latifolia	Arrowhead	2,000
Scirpus cyperinus	Bulrush	<2,000
Sparganium americanum	Bur reed	<100
Typha domingensis	Cattail	<1,000
Typha latifolia	Cattail	>2,000
Upper emergent/shrub zone		
Acer rubrum	Red maple	>2,000
Cephalanthus occidentalis	Buttonbush	>2,000
Mikania scandens	Climbing hempweed	<100
Nyssa sylvatica	Blackgum	>2,000
Salix nigra	Black willow	>2,000
Taxodium distichum	Cypress	>2,000

a. Source: Kroeger (1990).
b. sp. = species (singular).
c. Planted as a seed.

Table D-6. Annual mean whole lake species specific areal cover (square meters per hectare) and frequency, January-December 1992.[a]

Taxon	Mean cover (m^2/ha)[b]	Frequency
Vallisneria americana	926.09	12
Potamogeton diversifolius	610.05	11
Typha latifolia	221.65	10
Hydrocotyle umbellata	76.75	16
Panicum hemitomon	70.95	15
Myrica cerifera	70.50	8
Leersia oryzoides	29.17	8
Alternanthera philoxeroides	28.09	14
Nelumbo lutea	25.21	2
Paspalum distichum	23.87	9
Baccharis halimifolia	20.66	8
Eleocharis quadrangulata	20.35	5
Juncus effusus	20.31	16
Paspalum notatum	17.83	4
Salix spp.[c]	12.60	16
Scirpus cyperinus	9.86	15
Sacciolepis striata	7.31	8
Alnus serrulata	6.74	4
Boehmeria cylindrica	6.07	10
Juncus dichotomus	5.36	11
Andropogon virginicus	4.72	9
Rubus spp.	3.58	9
Acer rubrum	3.30	12
Panicum scoparium	2.64	1
Lycopus spp.	2.55	8
Mikania scandens	2.38	8
Erechtites hieracifolia	2.36	6
Triaddnum walteri	2.31	9
Chara sp.[d]	1.99	1
Sagittaria latifolia	1.60	3
Cephalanthus occidentalis	1.36	8
Habenaria repens	1.25	4
Juncus validus	1.22	7
Cyperus spp.	1.20	5
Eupatorium spp.	1.05	8
Paspalum spp.	1.03	1
Aster spp.	0.86	9
Pontederia cordata	0.75	4
Galium spp.	0.70	7
Paspalum urvillei	0.63	1
Panicum sp.	0.39	4
Ludwigia leptocarpa	0.37	5
Ludwigia alternifolia	0.36	4
Geranium carolinianum	0.36	4
Rubus trivialis	0.35	2
Myriophyllum aquaticum	0.33	3

Table D-6. (continued).

Taxon	Mean cover (m²/ha)	Frequency
Polygonum densiflorum	0.31	4
Lonicera japonica	0.28	3
Platanus occidentalis	0.26	4
Polygonum sp.	0.26	5
Solidago sp.	0.26	9
Lemna spp.	0.24	1
Micranthemum umbrosum	0.22	1
Bidens sp.	0.21	3
Murdannia keisak	0.20	4
Juncus sp.	0.19	1
Lespedeza sp.	0.18	1
Hypericum hypericoides	0.17	1
Lactuca sp.	0.15	1
Polygonum punctatum	0.13	3
Cyperaceae	0.12	6
Populus deltoides	0.12	1
Chenopodium sp.	0.10	1
Erianthus giganteus	0.10	1
Carex spp.	0.08	2
Toxicodendron radicans	0.08	1
Hypericum sp.	0.07	4
Polygonum sagittatum	0.07	2
Digitaria sp.	0.07	1
Juncus marginatus	0.07	1
Campsis radicans	0.06	3
Ludwigia decurrens	0.04	2
Hibiscus sp.	0.04	2
Furiena sp.	0.03	1
Pyrrhopappus carolinianus	0.03	2
Gelsemium sempervirens	0.03	1
Ptilimnium sp.	0.02	3
Rumex hasatatulus	0.02	2
Gnaphalium purpureum	0.02	1
Ampelopsis arborea	0.02	1
Ceratophyllum demersum	0.02	1
Rubus argutus	0.01	1
Ludwigia palustris	0.01	3
Pluchea sp.	0.01	1
Taraxacum officinale	0.01	1
Acalypha gracilens	0.01	1
Desmodium sp.	0.01	1

a. Source: Westbury (1993).
b. To convert square meters per hectare to square feet per acre, multiply by 4.355.
c. spp. = species (plural).
d. sp. = species (singular).

Table D-7. Taxa present (greater than 2 percent abundance) in the vegetation and seed bank.

Species	Depths
Acer rubrum L.	A, W
Acer negundo L.	A
Alternantha philoxeroides Grisebach	A, W, 33
	(A, W, 33, 66, 1)
Ambrosia artemisiifolia L.	(W)
Ammannia coccinea Rottboell	(W)
Andropogon spp.	A, W
	(A, W)
Aneilema keisak Hasskarl.	A, W
	(A, W, 33, 66, 1)
Aster pilosus Willd	(W)
Azolla spp.	W
	(W)
Baccharis halimifolia L.	A
	(A, W, 33, 1)
Bacopa caroliniana Robinson[a]	A, W
Bidens spp.	A
Boehmeria cylindrica Swartz	A, W
	(A, W, 33, 66)
Cephalanthus occidentalis L.	A
Carex spp.[b]	A, W
	(A)
Carex albolutescens Schweinitz	(A, W, 33, 66, 1)
Cenchrus longispinus Fernald	A
Cyperus spp.	(A, W, 33, 66, 1)
Cyperus ovularis Torrey	(A, W, 33, 66, 1)
Cyperus strigosus L.	(A, W, 33, 66, 1)
Digitaria spp.	(A, W, 33, 1)
Digitaria ischaemum Schreber	(A, 66)
Echinochloa crusgalli Beauvois[a]	A
	(A, W, 33, 66)
Eclipta alba Hasskarl	(A, W, 33, 1)
Eleocharis accicularis Roemer, Schultes	W
Eleocharis quadrangulata Schultes[a]	A, W, 33
	(A, W, 33)
Erechtites hieracifolia Raf.	A, W
	(A, W, 66, 1)

Table D-7. (continued)

Species	Depths
Erigeron spp.	A
	(A, W, 33, 66, 1)
Eupatorium capillifolium Small	A
	(A, W, 33, 66, 1)
Fuirena squarrosa Michaux	(A, W, 1)
Galium spp.	A
	(A)
Gelsemium sempervirens W. T. Aiton	W
Gnaphalium spp.	(A, W, 33, 1)
Gratiola virginiana L.	(A)
Habenaria repens Nuttall	A
	(A)
Hydrocotyle umbellata L.[a]	A, W, 33, 66, 1
	(A, W, 33, 66, 1)
Hypericum spp.	A
	(A, 1)
Juncus spp.	A
	(A, W, 33,66, 1)
Juncus debilis Gray	(A, W, 33, 66)
Juncus dichotomus Ell.	(A, W, 33, 66)
Juncus diffusissimus Buckley[a]	A
	(A, W, 33, 66, 1)
Juncus effusus L.[a]	A, W
	(A, W, 1)
Juncus tenuous Willd.	A
Leersia spp.	A, W
Leersia hexandra Swartz[a]	A, W
	(A, W)
Lemna spp.	W
Lespedeza cuneata G. Don	(A)
Linaria canadensis Dumont	(A, W, 33, 66, 1)
Ludwigia spp.	A, W
Ludwigia alternifolia L.	(A, W, 33)
Ludwigia decurrens Walter	(A, W, 33, 1)
Ludwigia leptocarpa Hara	A
	(A, W, 33, 66, 1)
Ludwigia palustris Ell.	(A, W, 33, 1)
Lycopus spp.	(W)

Table D-7. (continued)

Species	Depths
Lycopus americanus Muhl.	A
	(A)
Lycopus rubellus Moench[a]	(A)
Mikania scandens Willd.[a]	A, W
	(A, W)
Mollugo verticillata L.	(A, 1)
Myrica cerifera L.	A, W
	(A)
Myriophyllum spp.	W
	(A)
Nelumbo lutea Persoon[a]	33, 66, 1
Panicum spp.	(A, W, 33, 66, 1)
Panicum anceps Michaux	(A, W, 66, 1)
Panicum hemitomon Schultes[a]	A, W
	(A, W, 33, 66)
Parthenocissus quinquefolia Planchon	W
Paspalum spp.	(1)
Paspalum notatum Parodi	A, W
	(W)
Paspalum urvillei Steudel	A
	(A)
Phytolacca americana L.	W
	(W)
Pluchea foetida de Candolle	(W, 1)
Polygonum spp.	W
	(W, 33, 1)
Polygonum densiflorum Meissner[b]	(A, W)
Polygonum hydropipereoides Michaux[b]	A, W, 1
	(A, W, 33, 66)
Polygonum sagittatum L.[b]	A
	(A, W, 1)
Polypremum procumbens L.	(A, W, 33, 66, 1)
Pontederia cordata L.	A
Potomogeton diversifolius Raf.	A, W, 33, 66, 1
Ptilimnium capillaceum Raf.	A, W
	(A, W)
Raphanus raphanistrum L.	A
	(A)

Table D-7. (continued)

Species	Depths
Rorippa islandica Borbas	(1)
Rubus spp.	A, W
	(A, W, 66, 1)
Rumex acetosella L.	A
Sacciolepis striata Nash[a]	A, W
	(A, W, 33, 66, 1)
Sagittaria latifolia L.[a]	A, W
	(A, W)
Salix nigra Marshall	A, W
Scirpus cyperinus Kunth	A, W
	(A, W, 33, 66, 1)
Setaria geniculata Beauvois	(W)
Solidago spp.	(A, W, 33, 66)
Solidago rugosa Miller	A
	(A, W)
Specularia perfoliata de Candolle	(A, W)
Sphenopholis obtusata Scribner	(A, W, 33)
Typha latifolia L.[a]	A, W, 33, 66
	(A, W, 33, 66, 1)
Ulmus spp.	W
Vallisneria americana Michaux[a]	A, W, 33, 66, 1

a. Planted species.
b. Multiple or mixed species planted.
Note: Seed bank taxa in parentheses; at each depth 1 above waterline A; at the waterline W; and at 33 cm, 66 cm, and 1 m below waterline.

Table D-8. Species present in Steel Creek area 1956-1957.[a]

Species surviving in Steel Creek		Summer 1956 stations			Summer 1957 stations		
Scientific name	Common name	3	4	5	3	4	5
Cephalanthus occidentalis	Common buttonbush	X	X	X	-	X	X
Bigonia radicans	Cow itch	X	X	X	-	X	-
Rhus radicans	Poison ivy	-	X	X	X	X	-
Taxodium distichum	Baldcypress	-	X	X	-	X	X
Ampelopsis arborea	Pepper vine	-	X	X	-	X	X
Fraxinus caroliniana	Water ash	-	X	X	-	X	X
Acer rubrum	Red maple	-	X	X	-	X	X
Nyssa sylvatica	Black gum	-	X	X	-	X	X
Boehmeria cylindrica	False nettle	-	X	X	-	X	X
Quercus nigra	Water oak	-	X	X	-	X	X
Smilax rotundifolia	Greenbrier	-	X	X	-	X	-
Triadenum walteri	St. John's-wort	-	X	X	-	-	X
Ulmus americana	American elm	-	X	X	-	-	X
Carpinus caroliniana	Bluebeech	-	-	X	-	X	X
Salix nigra	Black willow	-	-	X	-	X	X
Nyssa aquatica	Water tupelo	-	-	X	-	X	X
Liquidambar styraciflua	Sweetgum	-	X	X	-	X	-
Mikania scandens	Climbing hempvine	-	X	X	-	-	-
Itea virginica	Virginia willow	-	X	X	-	-	-
Ludwigia palustris	Water purslane	-	X	X	-	-	-
Smilax laurifolia	Laurelleaf smilax	-	-	X	-	X	-
Smilax smallii	Greenbrier	-	-	X	-	X	-
Osmunda regalis	Royal fern	-	-	X	-	X	-
Polygonum hydropiperoides	Water pepper	-	-	-	-	X	X
Robinia	Locust	-	-	X	-	-	X
Platanus occidentalis	Sycamore	-	-	X	-	-	X
Decumaria barbara	Wood vamp	X	-	X	-	-	-
Sambucus canadensis	Common elder	-	X	-	-	-	X
Quercus phellos	Willow oak	X	X	-	-	-	-
Vitis rotundifolia	Muscadine grape	-	X	-	-	X	-
Tilia heterophylla	Basswood	-	-	X	-	-	X
Berchemia scandens	Supple jack	-	X	-	-	-	-
Lonicera japonica	Japanese honeysuckle	X	-	-	-	-	-
Alnus serrulata	Smooth alder	-	-	X	-	-	-
Liriodendron tulipifera	Tulip tree	-	-	X	-	-	-
Gelsemium sempervirens	Yellow jessamine	-	-	X	-	-	-
Rhus toxicodendron	Poison oak	-	-	X	-	-	-
Sabal minor	Dwarf palmetto	-	X	-	-	-	-
Lobelia cardinalis	Cardinal flower	-	X	-	-	-	-

Table D-8. (continued).

Species surviving in Steel Creek		Summer 1956 stations			Summer 1957 stations		
Scientific name	Common name	3	4	5	3	4	5
Wisteria frutescens	Wisteria	-	X	-	-	-	-
Quercus lyrata	Overcup oak	-	X	-	-	-	-
Smilax bona-nox	Greenbrier	-	-	X	-	-	-
Quercus laurifolia	Laurel oak	-	-	X	-	-	-
Carya aquatica	Water hickory	-	-	-	-	-	X
Arundinaria tecta	Switch cane	-	-	-	X	-	-
Saururus cernuus	Lizard's tail	-	-	-	-	-	X

a. Source: Welbourne (1958).

Table D-9. Species typically growing along Steel Creek which have not been able to survive flooding.[a]

Scientific name	Common name
Pinus taeda	Loblolly pine
Cornus florida	Flowering dogwood
Ilex glabra	Inkberry
Ilex opaca	American holly
Lyonia lucida	Fetterbush
Magnolia virginiana	Sweetbay
Myrica cerifera	Southern waxmyrtle
Osmunda cinnamomea	Cinnamon fern
Persea palustris	Swampbay
Quercus falcata	Southern red oak
Quercus michauxii	Swamp chestnut oak

a. Source: Welbourne (1958).

Table D-10. Plant species in the Steel Creek Corridor, Summer 1981.[a]

Scientific name	Common name
Aspidiaceae	
Athyrium asplenioides	Southern lady fern
Onoclea sensibilis	Sensitive fern
Blechnaceae	
Woodwardia areolata	Netted chain-fern
Pinaceae	
Pinus taeda	Loblolly pine
Taxodiaceae	
Taxodium distichum	Bald cypress
Typhaceae	
Typha latifolia	Common cattail
Sparganiaceae	
Sparganium americanum	Bur reed
Alismataceae	
Sagittaria latifolia	Wapato, duck-potato
Poaceae	
Uniola latifolia	River oats
Elymus virginicus	Wild rye grass
Leersia	Cut grass
Panicum agrostoides	Redtop panicgrass
Panicum dichotomum	Spreading witchgrass
Erianthus giganteus	Sugarcane beard grass
Cyperaceae	
Scirpus cyperinus	Knot grass
Rhynchospora corniculata	
Carex glaucescens	
Araceae	
Peltandra virginica	Arrow arum
Commelinaceae	
Commelina virginica	Dayflower
Aneileme keisak	

Table D-10. (continued).

Scientific name	Common name
Juncaceae	
Juncus effusus	Common rush
Juncus canadensis	Canada rush
Liliaceae	
Smilax rotundifolia	Greenbrier
Smilax glauca	Sawbrier
Saururaceae	
Saururus cernuus	Lizard's tail
Salicaceae	
Salix	Willow
Myricaceae	
Myrica cerifera	Wax myrtle
Betulaceae	
Alnus serrulata	Tag alder
Fagaceae	
Quercus laurifolia	Laurel oak
Ulmaceae	
Celtis laevigata	Sugarberry
Urticaceae	
Boehmeria cylindrica	False nettle
Polygonaceae	
Polygonum pensylvanicum	Pinkweed
Polygonum hirsutum	Hairy knotweed
Polygonum persicaria	
Polygonum hydropiperoides	Waterpepper
Polygonum sagittatum	Arrow-leaved tearthumb
Polygonum lapathifolium	
Magnoliaceae	
Liriodendron tulipifera	Tulip tree
Magnolia virginiana	Sweet bay
Saxifragaceae	
Itea virginica	Virginia willow

Table D-10. (continued).

Scientific name	Common name
Hamamelidaceae	
Liquidambar styraciflua	Sweetgum
Platanaceae	
Platanus occidentalis	Sycamore
Rosaceae	
Rubus	Blackberry
Prunus serotina	Black cherry
Amelanchier	Serviceberry
Fabaceae (Leguminosae)	
Lespedeza cuneata	Sericea
Apios americana	Groundnut
Anacardiaceae	
Rhus copallina	Winged sumac
Aquifoliaceae	
Ilex opaca	Holly
Aceraceae	
Acer rubrum	Red maple
Balsaminaceae	
Impatiens capensis	Jewelweed
Rhamnaceae	
Berchemia scandens	Supple jack
Vitaceae	
Parthenocissus quinquefolia	Virginia creeper
Vitis rotundifolia	Muscadine
Ampelopsis arborea	Pepper vine
Hypericaceae	
Hypericum hypericoides	St. Andrew's cross
Hypericum mutilum	Dwarf St. John's-wort
Hypericum walteri	Marsh St. John's-wort
Onagraceae	
Ludwigia decurrens	Primrose willow
Ludwigia leptocarpa	
Ludwigia virgata	

Table D-10. (continued).

Scientific name	Common name
Apiaceae (Umbelliferae)	
Cicuta maculata	Water hemlock
Nyssaceae	
Nyssa sylvatica var. biflora	Water gum
Cornaceae	
Cornus florida	Flowering dogwood
Ebenaceae	
Diospyros virginiana	Persimmon
Oleaceae	
Ligustrum	Privet
Loganiaceae	
Gelsemium sempervirens	Yellow jessamine
Polypremum procumbens	
Convolvulaceae	
Cuscuta compacta	Compact dodder
Cuscuta gronovii	Dodder
Hydrophyllaccae	
Hydrolea quadrivalvis	
Verbenaceae	
Callicarpa americana	French mulberry
Lamiaceae (Labiatae)	
Scutellaria lateriflora	Skullcap
Lycopus americanus	Bugleweed
Lycopus rebellus	Water horehound
Scrophulariaceae	
Mimulus alatus	Monkey flower
Bignoniaceae	
Campsis radicans	Trumpet vine, cow-itch vine
Rubiaceae	
Cephalanthus occidentalis	Button bush
Galium tinctorium	

Table D-10. (continued).

Scientific name	Common name
Caprifoliaceae	
Lonicera japonica	Japanese honeysuckle
Sambucus canadensis	Elderberry
Asteraceae (compositae)	
Eupatorium capillifolium	Dog-fennel
Mikania scandens	Climbing hempweed
Baccharis halimifolia	Groundsel-tree
Aster	Aster
Solidago canadensis	Goldenrod
Solidago gigantea	Goldenrod
Solidago rugosa	Goldenrod

a. Source: Smith, Sharitz, and Gladden (1981).

Table D-11. Plant species found in Steel Creek Delta, Summer 1981.[a]

Scientific name	Common name
Ophioglossaceae	
Botrychium	Grapefern
Osmundaceae	
Osmunda regalis spectabilis	Royal fern
Aspidiaceae	
Onoclea sensibilis	Sensitive fern
Aspleniaceae	
Asplenium platyneuron	Ebony spleenwort
Azollaceae	
Azolla caroliniana	Mosquito fern
Taxodiaceae	
Taxodium distichum	Bald cypress
Typhaceae	
Typha latifolia	Common cattail
Sparganiaceae	
Sparganium americanum	Bur reed
Potamogetonaceae	
Potamogeton berchtoldii	Pondweed
Alismataceae	
Echinodorus cordifolius	Burhead
Sagittaria graminea	
Sagittaria latifolia	Wapato, duck-potato
Poaceae	
Arundinaria gigantea	Giant cane
Leersia	Cut grass
Paspalum urvillei	Vasey grass
Paspalum fluitans	
Panicum agrostoides	
Panicum gymnocarpon	Redtop panicgrass
Panicum	

Table D-11. (continued).

Scientific name	Common name
Cyperaceae	
Cyperus haspan	Sheathed cyperus
Cyperus	
Eleocharis	
Eleocharis quadrangulata	
Scirpus cyperinus	Knot grass
Rhynchospora corniculata	
Carex joorii	
Carex	
Aracaceae	
Sabal minor	Palmetto
Lemnaceae	
Spirodela oligorrhiza	
Lemna perpusilla	Duckweed
Wolffia papulifera	Water-meal
Bromeliaceae	
Tillandsia usneoides	Spanish moss
Commelinaceae	
Commelina virginica	Dayflower
Aneilema keisak	
Juncaceae	
Juncus effusus	Common rush
Liliaceae	
Smilax rotundifolia	Greenbrier
Smilax bona-nox	Catbrier
Smilax walteri	Coral greenbrier
Smilax tamnoides	Bristly greenbrier
Medeola virginiana	Indian cucumber-root
Orchidaceae	
Spiranthes	Ladies' tresses
Saururaceae	
Saururus cernuus	Lizard's tail

Table D-11. (continued).

Scientific name	Common name
Salicaceae	
Salix nigra	Black willow
Populus deltoides	Cottonwood
Populus heterophylla	Swamp cottonwood
Myricaceae	
Myrica cerifera	Wax myrtle
Juglandaceae	
Carya aquatica	Water hickory
Betulaceae	
Carpinus caroliniana	Ironwood
Fagaceae	
Quercus lyrata	Overcup oak
Quercus michauxii	Swamp chestnut oak
Quercus laurifolia	Laurel oak
Quercus nigra	Water oak
Ulmaceae	
Ulmus americana	American elm
Ulmus alata	Winged elm
Planera aquatica	Water elm
Celtis laevigata	Sugarberry
Urticaceae	
Boehmeria cylindrica	False nettle
Polygonaceae	
Polygonum hydropiperoides	Waterpepper
Polygonum lapathifolium	
Polygonum sagittatum	Arrow-leaved tearthumb
Phytolaccaceae	
Phytolacca americana	Poke
Ceratophyllaceae	
Ceratophyllum demersum	Hornwort

Table D-11. (continued).

Scientific name	Common name
Nymphaeaceae	
Nuphar luteum	Cow-lily
Saxifragaceae	
Itea virginica	Virginia willow
Decumaria barbara	Climbing hydrangea
Hamamelidaceae	
Liquidambar styraciflua	Sweetgum
Platanceae	
Platanus occidentalis	Sycamore
Rosaceae	
Rubus	Blackberry
Crataegus	Hawthorn
Fabaceae	
Gleditsia aquatica	Water locust
Wisteria frutescens	Wisteria
Apios americana	Groundnut
Meliaceae	
Melia azedarach	China-berry
Callitrichaceae	
Callitriche heterophylla	Water starwort
Anacardiaceae	
Rhus radicans	Poison ivy
Aquifoliaceae	
Ilex opaca	Holly
Ilex decidua	Possum haw
Acaraceae	
Acer rubrum	Red maple
Hippocastanaceae	
Aesculus pavia	Red buckeye
Aesculus sylvatica	Buckeye

Table D-11. (continued).

Scientific name	Common name
Balsaminaceae	
Impatiens capensis	Jewel-weed
Rhamnaceae	
Berchemia scandens	Rattan vine
Vitaceae	
Vitis rotundifolia	Muscadine
Vitis aestivalis	Summer grape
Ampelopsis arborea	Pepper vine
Malvaceae	
Hibiscus militaris	Halbard-leaved marsh mallow
Hypericaceae	
Hypericum walteri	Marsh St. John's-wort
Hypericum mutilum	Dwarf St. John's-wort
Violaceae	
Viola	Violet
Onagraceae	
Ludwigia decurrens	Primrose willow
Ludwigia leptocarpa	
Ludwigia palustris	Water purslane
Haloragaceae	
Myriophyllum brasiliense	Parrot-feather
Apiaceae (Umbelliferae)	
Hydrocotyle ranunculoides	Marsh pennywort
Hydrocotyle	Marsh pennywort
Cicuta maculata	Water hemlock
Nyssaceae	
Nyssa aquatica	Tupelo gum, water tupelo
Oleaceae	
Fraxinus caroliniana	Water ash
Fraxinus americana	White ash
Forestiera acuminata	Swamp privet

Table D-11. (continued).

Scientific name	Common name
Asclepiadaceae	
Asclepias	Milkweed
Convolvulaceae	
Cuscuta	Dodder
Hydrophyllaceae	
Hydrolea quadrivalvis	Hydrolea
Lamiaceae (Labiatae)	
Scutellaria lateriflora	Skullcap
Lycopus virginicus	Bugleweed
Lycopus rubellus	Water horehound
Scrophulariaceae	
Mimulus alatus	Monkey flower
Mimulus ringens	Monkey flower
Bignoniaceae	
Campsis radicans	Trumpet vine, cow-itch vine
Lentibulariaceae	
Utricularia subulata	Bladderwort
Acanthaceae	
Justicia ovata	Water-willow
Rubiaceae	
Cephalanthus occidentalis	Button bush
Diodia virginiana	Larger buttonweed
Galium obtusum	Bedstraw
Galium tinctorium	
Caprifoliaceae	
Lonicera japonica	Japanese honeysuckle
Campanulaceae	
Sphenoclea zeylandica	
Lobelia cardinalis	Cardinal flower

Table D-11. (continued).

Scientific name	Common name
Loganiaceae	
Gelsimium sempervirens	Yellow jessamine
Asteraceae (*Compositae*)	
Mikania scandens	Climbing hempweed
Pluchea rosea	Marsh-fleabane
Aster	Aster
Solidago gigantea	Goldenrod
Bidens frondosa	Beggar ticks

a. Source: Smith, Sharitz, and Gladden (1981).

Table D-12. Wetland types of the Steel Creek Delta.[a]

Wetland types	Description
Aquatic bed - rooted vascular (*Myriophyllum brasiliense*)	In the canopy-reduced-deepwater zone, where the main flow of Steel Creek courses northeasterly, the ground aspect is one of open water, approximately 2 meters deep beneath scattered live bald cypress (*Taxodium distichum*) trees which are remnants from the pre-Savannah River Site swamp. Scattered stumps of dead trees occur bearing shrubs [e.g., buttonbush (*Cephalanthus occidentalis*), Virginia willow (*Itea virginica*)], young trees [e.g., water ash (*Fraxinus caroliniana*), water elm (*Planera aquatica*)], and herbs [e.g., false nettle (*Boehmeria cylindrica*), marsh St. John's-wort (*Hypericum walteri*)]. Patches of duckweed (*Lemna perpusilla*) collect on mats of submerged vascular plants such as hornwort (*Ceratophyllum demersum*) and parrot-feather (*Myriophyllum brasiliense*) which root on subsurface logs, tree and stump bases. Where the water flow is slow, *Polygonum lapathifolium* forms dense colonies.
Emergent wetland - persistent (*Leersia* spp.)	Persistent emergent monocots dominate a large area (17.7 percent of the delta) of the deltaic fan. Except during extreme drought periods, the water level during the growing season is 10 to 50 centimeters deep, excluding old stream channels which are as much as 1 meter deep. Although the dominant herbaceous species vary with water depth and location on the deltaic fan, scattered shrubs [buttonbush and black willow (*Salix nigra*)] are usually present. Cut grass (*Leersia* spp.) is dominant with abundant redtop panicgrass (*Panicum agrostoides*) as ground cover except under dense woody vegetation and in the deeper stream channels. These grasses are usually overtopped by knot grass (*Scirpus cyperinus*, approximately 2.5 meters tall) which is the aspect dominant on aerial photos as well as on the ground. There are also several, nearly monotypic, stands of cattail (*Typha latifolia*). The numerous old stream channels which cross the deltaic fan are dominated by the herbaceous species characteristic of the Nonpersistent emergent wetland (see below).
Emergent - nonpersistent (*Hydrolea quadrivalvis*)	This mapping unit is characterized by emergent vascular plants that die back to the ground during the winter. Relatively monospecific, as well as mixed, colonies of hydrolea (*Hydrolea quadrivalvis*), *Aneilema keisak*, waterpepper (*Polygonum hydropiperoides*), water purslane (*Ludwigia palustris*), and wapato (*Sagittaria latifolia*) dominate. These characteristic, nonpersistent species are also common in old stream beds throughout the deltaic fan in the Persistent emergent and Scrub-shrub wetland types. Standing dead trees and stumps are numerous and bear characteristic stump community vegetation including buttonbush, water ash, water elm, false nettle, and marsh St. John's-wort.
Scrub-shrub wetland - broad-leaved deciduous (*Cephalanthus occidentalis - Salix nigra*)	On the deltaic fan, where the water is less than 50 centimeters deep (deeper in stream channels), buttonbush or black willow dominate the uppermost layer. Buttonbush dominates the canopy in some areas and composes the understory of sites dominated by willow (*Salix* sp.). Knot grass joins the woody species in the upper stratum while cut grass covers most of the ground. Redtop panicgrass, beggar ticks (*Bidens frondosa*), false nettle, and marsh St. John's-wort are common in many places. Climbing hemp (*Mikania scandens*) and pepper vine (*Ampelopsis arborea*) are vines which are frequently found in the shrubland. Within the Scrub-shrub wetland there are also open areas of Persistent emergent wetland and old stream channels dominated by herbs.

Table D-12. (continued).

Wetland types	Description
Mixed scrub-shrub/nonpersistent emergent wetland (*Cephalanthus occidentalis/Polygonum lapathifolium*)	In the delta, shrubs and young trees (buttonbush, Virginia willow, water elm, water ash) are restricted to the many stumps remaining from the original forest. Numerous live bald cypress (20 meters tall) are scattered about. The stump bases have the characteristic stump-community herbs (false nettle and marsh St. John's-wort) as well as several vines including poison ivy (*Rhus radicans*), pepper vine, and wisteria (*Wisteria frutescens*).
Forested wetlands - broad-leaved deciduous (*Salix nigra*)	Black willow trees over 5 meters tall dominate the more elevated portions of the deltaic fan with buttonbush as an understory. The ground is dry or flooded by less than 15 centimeters of water. The herbaceous vegetation under the willow is relatively sparse due to the density of canopy closure. Small patches of herbs include: redtop panicgrass, waterpepper, false nettle, marsh St. John's-wort, and sensitive fern (*Onoclea sensibilis*).
Forested wetlands - broad-leaved deciduous (*Quercus lyrata - Carya aquatica - Nyssa aquatica*)	Adjacent to, and slightly higher in substance elevation than the cypress-tupelo (*Nyssa aquatica*) swamp, is an area of broad-leaved deciduous trees. Although dry during most of the growing season, this area is subject to seasonal flooding of longer duration than areas on the deltaic fan. Several of the more common species in this vegetation type leaf-out late in the season and can withstand flooding that lasts even as late as July.
Forested wetlands - broad-leaved deciduous (*Quercus laurifolia*)	This mapping unit is found only on islands in the swamp which are slightly higher in elevation than the surrounding swamp and therefore inundated for shorter periods. The canopy (over 20 meters tall) contains laurel oak (*Quercus laurifolia*), overcup oak (*Quercus lyrata*), swamp chestnut oak (*Queras michauxii*), red maple (*Acer rubrum*), and water hickory (*Carya aquatica*).
Forested wetlands - mixed deciduous (*Taxodium distichum - Nyssa aquatica*)	The natural cypress-typelo swamp typifying the pre-Savannah River Plant swamp composition extends beyond the delta to the Savannah River. Water to 2 meters deep flows slowly over a shallow substrate (less than 0.5 meter deep) of organic and fine particulate material. Flooding is maintained during the growing season by regulation of reservoir levels upstream on the Savannah River and by flow from Fourmile Creek and Pen Branch.
Forested wetland - mixed forested/scrub-shrub wetland (*Taxodium distichum/ Cephalanthus occidentalis*)	This mapping unit occupies a portion of the delta to the west of the deltaic fan. A patchy canopy of bald cypress (greater than 20 meters tall) covers about 50 percent of the zone. The understory is a mixture of buttonbush, water ash, and water elm. Cut grass dominates the ground cover with abundant marsh St. John's-wort and beggar ticks. Open areas where the cypress canopy is very sparse are dominated by species of the Nonpersistent emergent wetland intermixed with many stumps bearing woody growth. The water varies from 50 to 80 centimeters deep (except in channels) over a deep (more than 50 centimeters) substrate of organic and fine inorganic sediment.

a. Source: Smith, Sharitz, and Gladden (1981).

b. spp. = species (plural).

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APPENDIX E. PUBLIC COMMENTS AND DOE RESPONSES DRAFT ENVIRONMENTAL IMPACT STATEMENT SHUTDOWN OF THE RIVER WATER SYSTEM AT THE SAVANNAH RIVER SITE

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APPENDIX E

PUBLIC COMMENTS AND DOE RESPONSES

DRAFT ENVIRONMENTAL IMPACT STATEMENT

SHUTDOWN OF THE RIVER WATER SYSTEM AT THE SAVANNAH RIVER SITE

E.1 Introduction

The U.S. Department of Energy (DOE) published the Draft Environmental Impact Statement (EIS) on the Shutdown of the River Water System in November 1996. DOE announced the availability of the document in the *Federal Register* on November 15, 1996. On December 4, 1996, DOE held public meetings to receive oral and written comments on the Draft EIS in North Augusta, South Carolina. The public comment period ended on December 30, 1996. The Final EIS (FEIS) is available for review in DOE reading rooms in Washington, D.C. and Aiken, South Carolina, and DOE has distributed it to individuals, public agencies, Federal and state officials who requested a copy, and to persons and agencies who commented on the Draft EIS.

Court reporters documented comments from 29 people in official transcripts. DOE also received 16 letters on the Draft EIS through regular mail, facsimile transmission (fax), and electronic mail (E-mail). Five of the letters were from Federal agencies and three were from agencies and offices of the State of South Carolina.

This appendix presents the comments received and the DOE responses to those comments. It includes comments made at the public meetings and the letters submitted to DOE. If a statement or comment prompted a revision to the EIS, DOE identified the revision by a vertical line (change bar) in the margin of the document along with a letter-code.

- Hearings H1
- Letters L1 though L16

DOE numbered the specific comments in each letter or oral presentation sequentially (01, 02, etc.) to provide unique identifiers. Table E-1 lists the individuals, government agencies, and other organizations that submitted comments and their unique identifiers. The hearing comments are organized in categories, which are discussed below.

The comments and statements reflected a number of issues about the EIS. The following sections describe those issues and provide responses to the comments. The U.S. Environmental Agency (EPA) gave the Draft EIS a rating of EC-2, which means that EPA had environmental concerns about the project and that it wanted more information to assess the impacts fully. In particular, the issue of ecological risks warranted further discussion in the Final EIS. EPA stated that "overall the draft EIS is well written and illustrated. We agree that the format used enhances the clarity of the presentation of analyses."

Table E-1. Public Comments on the Draft River Water Environmental Impact Statement.

Comment Received at the December 4, 1996 Public Meeting

Comment Source Number	Commentor	Page No.
H1	Karen Patterson	E-9

Correspondence Received from Government Agencies and the Public

Comment Source Number	Commentor	Page No.
L1	Todd V. Crawford	E-12
L2	Todd V. Crawford	E-14
L3	K. G. Craigo	E-16
L4	Andreas Mager, Jr. National Marine Fisheries Service	E-18
L5	John G. Irwin Savannah River Forest Station	E-21
L6	Robert E. Duncan South Carolina Department of Natural Resources	E-24
L7	I. Lehr Brisbin, Jr. Savannah River Ecology Laboratory	E-26
L8	F. Ward Whicker Colorado State University	E-34
L9	Tim Connor Energy Research Foundation	E-39
L10	Heinz J. Mueller U.S. Environmental Protection Agency	E-52
L11	Gary Wein Savannah River Ecology Laboratory	E-64
L12	W. Lee Poe, Jr.	E-71
L13	Sally C. Knowles South Carolina Department of Health and Environmental Control	E-75
L14	Rodney P. Grizzle Office of the Governor	E-80
L15	Citizen Advisory Board	E-91
L16	Willie R. Taylor U.S. Department of the Interior	E-95

E.2 Synopsis of Comment Categories

Future Missions/Costs

DOE wrote this EIS to determine if, in a period of decreasing funding, it should continue to operate the River Water System at the Savannah River Site; the system has no current mission and will become more expensive to operate. The proposed action of the EIS is to shut down the River Water System and to place all or part of the system in a standby condition that would enable restart if conditions or mission changes required its operation. Commentors expressed concerns about the true cost savings that shutdown would bring or how future unknown missions could require the use of the system. One organization expressed concern that shutdown might be "penny wise and dollar foolish" (Energy Research Foundation letter L9 of December 30, 1996) because the recession of L-Lake could undermine the DOE environmental remediation program. Six commentors made 15 comments on future mission and cost issues.

Loss of Terrestrial, Aquatic, or Wetlands Habitat/Effects on Endangered Species

The implementation of the shutdown alternatives would cause a reduction in habitat for fish, amphibians, reptiles, semiaquatic mammals, wading birds, and waterfowl; replace the reservoir ecosystem with a small stream ecosystem; potentially expose animals foraging in the lakebed after drawdown to contaminated sediments, cause a loss of submerged and floating-leaved aquatic plants; cause a loss of foraging habitat for bald eagles; potentially expose wood storks to increased levels of contaminants; and over time displace L-Lake alligators. Commentors in 12 letters and in both sessions of the public hearing expressed concern about these impacts.

Land Use/Privatization

DOE discussed land use in the 1996 *SRS Future Use Project Report*, which summarized stakeholder- preferred future use recommendations that DOE uses to consider ongoing and future land use needs. The report recommended unchanged SRS boundaries and maintenance of the land under Federal ownership; prohibition of residential uses of SRS land; multiple land uses (e.g., recreation, natural resource management) and consideration of privatization; and pursuit of natural resource management where possible. Three letters and one meeting comment discussed future land use/privatization issues.

Human (Occupational and Public) Health/Ecological Risk

Analysis of the proposed action indicates that the level of L-Lake would recede to the original Steel Creek stream channel, thereby exposing contaminated sediment, and that the surface-water level of Par Pond would continue to fluctuate naturally near full pool of about 200 feet. The changes in the lakebed would expose sediments (e.g., a lake level of 196 feet would expose about 340 acres of sediment). The exposed sediment would dry and could become suspended in the atmosphere, available for inhalation by onsite workers and the offsite population within 50 miles. DOE would also stop pumping water to the reactor areas and stream flows would revert to original levels, which would not expose additional sediments. Minimal impacts would occur from increased concentrations of contaminants in the affected streams. The effects of increased concentrations are addressed in Sections 4.2.8.2 and B.6. Four comment letters and several meeting participants expressed concerns about human health risks from radiological exposure; several letters were concerned about ecological risk.

Potential Remediation and NEPA/CERCLA Integration

DOE has established the process for environmental restoration activities at the SRS in accordance with the Federal Facility Agreement (FFA). In evaluating the shutdown of the River Water System, the EIS considers a number of actions that DOE would have to implement before shutting the system down or continuing operation with a small pump. DOE also considers potential future actions that could affect decisions on appropriate actions for the River Water System. Commentors in three letters and at the meetings expressed concerns about coordinating the EIS and FFA processes, expediting the FFA process to facilitate the implementation of cleanup and operational shutdown activities; and the possibility of an expensive cleanup action.

E.3 Summary Analysis of Hearing Comments and Issues

The public meetings consisted primarily of informal discussions on the draft EIS. The transcripts yielded a number of public comments and concerns, but because of the informal nature of the hearing, these comments were not sequential or easy to assign identifying numbers. Therefore, this section contains a synopsis of the hearing comments. The comments are grouped in the categories listed in Table E-2. Table E-2 also lists the number of comments received in each category. The sections following the table discuss the comments by category, the DOE responses, and any resulting changes to the Final EIS. DOE did not identify comments from the meetings that dealt with Potential Remediation.

Transcripts of the public meetings are available for review at the DOE Public Reading Room at the University of South Carolina, Aiken Campus, Gregg-Graniteville Library, 2nd floor, University Parkway, Aiken, South Carolina, 803-648-6851.

Future Missions/Cost

A number of commentors identified concerns about future missions at the SRS and potential interactions with the River Water System. In addition, commentors were concerned about whether shutting down the River Water System would actually save money. These concerns included the following:

- The potential future need for L-Lake
- Keeping the River Water System available for the accelerator project
- The future of the River Water System

Table E-2. Summary of informal public hearing comments applicable to the River Water Environmental Impact Statement.[a]

Comment category	Number of comments
Future missions/cost	15
Loss of habitat/endangered species	3
Land use/privatization	1
Human health	3
Potential remediation	0
No specific category	5

a. DOE held two sessions of the public hearings on December 4. Three commentors contributed 13 comments at the afternoon session; 6 commentors contributed 14 comments at the evening session.

- Maintaining the level of Par Pond
- Impacts on SRS if the system is shut down
- The amount of money a shutdown would save
- The amount of water in the watershed to generate enough flow
- The lack of cohesive and unified plans for new missions at the SRS
- The need for water emergency purposes
- Consistency with the SRS 10-year plan

The hearing attendees asked several questions about the future of the River Water System, including its use for potential new missions, potential future needs for L-Lake, and maintaining the level of Par Pond.

DOE proposes to shut down the River Water System but maintain it for potential future uses. The Proposed Action (and Preferred Alternative) offers flexibility in the portions of the system that would be maintained, the time it would take to restart the system, and the methods employed during layup to enable restart. The Proposed Action represents a middle ground between two other alternatives evaluated in the EIS. Under the No-Action Alternative, DOE would operate the system with a small pump that is sufficient to maintain L-Lake at its normal water level and provide water for other minor uses. Under the other bounding alternative, Shut Down and Deactivate, DOE would shut down the system with no measures to permit restart of the system.

DOE presented three examples for restarting the system. DOE does not wish to imply that it expects to need to restart the system for the situations presented but selected them to cover a range of actions that maintenance in standby would support (i.e., pump to L-Lake, Par Pond, or a new facility).

Under either shutdown alternative, L-Lake is expected to drain and expose very low levels of contamination in the lake exclusive of the stream channel and floodplain. Because the stream channel and floodplain that are beneath L-Lake have similar contamination levels as the upstream and downstream reaches of exposed channel and floodplain, DOE believes the example possibility of refilling the system as a mediation measure is very remote. DOE has not identified future missions that would require L-Lake.

Similarly, DOE presented an example of restarting the system to pump to Par Pond. Maintenance in standby would enable DOE to honor its commitment to remedy the unlikely drawdown of Par Pond in the near term until final CERCLA remedial actions are implemented. DOE believes that Par Pond would not fall below the 195 foot level unless there was a catastrophic drought that would also affect water quality in other regional lakes and streams. In calendar year 1996, a dryer-than-average year, the lowest daily lake level was 199.21 feet. Nevertheless, DOE prefers to maintain the River Water System after shutdown and, if necessary, would restart the system, pump to Par Pond, and bring the water level to an appropriate level above 195 feet. See Section 3.3.1.1.

One commentor asked how much money a shutdown would save. DOE describes costs of shutdown versus operation (no action) in Sections 3.1, 3.2, and 3.3. Maximum savings would occur in the Shutdown and Deactivate Alternative. This alternative would save about $1.5 million per year. Annual savings under the Shutdown and Maintain Alternative would vary from about $175,000 and $1.4 million depending on the time required to restart the system, whether the system piping is pressurized by a jockey pump or drained, and whether the line that Accelerator Production of Tritium (APT) would use is maintained or deactivated.

There are other known or potential costs associated with the shutdown alternatives (e.g., a septic tank and tile field to replace blending water for the L-Area sanitary wastewater discharge). DOE has revised Section 3.3 to include these costs.

The impacts on SRS if DOE selects a shutdown alternative are documented in Chapter 4. As presented in Section 4.1.5, the most dramatic effects would be on the ecology of L-Lake. DOE believes there are also beneficial impacts associated with a shutdown action. In addition to cost savings, DOE has considered indirect beneficial impacts such as reduced energy consumption, reduced entrainment of fish larvae and fish eggs and impingement of fish in the Savannah River, and restoration of the pre-SRS ecosystem, including 225 acres floodplain forest.

Although planning for new missions is not within the scope of this EIS, DOE identified its Preferred Alternative in response to potential new missions. The example that was presented for a new mission was APT. Other potential missions that might require enough cooling water to make the use of the River Water System a viable option include the Tritium Extraction Facility, International Thermonuclear Experimental Reactor and Mixed Oxide Fuel Manufacturing Plant. Under the Proposed Action, the River Water System could be restarted in time to provide cooling water for these potential missions.

The average annual natural flow to L-Lake dam is estimated to be 10 cubic feet (0.28 cubic meters) per second. This rate is based on watershed size, adjacent gaged sites of similar size that are upstream of river water discharges, and the characteristics of Steel Creek when it was not receiving the large cooling water flows from P- or L-Reactor. DOE performed an in-stream flow study and found that this discharge would support an aquatic community similar to that which existed prior to the restart of L-Reactor. This natural flow would not be sufficient to sustain L-Lake, but it would allow regrowth and restoration of diverse ecosystem as the lake recedes.

DOE has carefully evaluated the shutdown alternatives and has not identified a need for continued or new uses of the River Water System. The system has not been used for emergency purposes, and DOE is well equipped to respond to emergencies without the River Water System (e.g., to provide firewater).

DOE has determined that current river water flows to C- and P-Reactors are not needed. For example, although the 10-Year Plan identifies P-Area transition to long-term monitoring in 2002, the P-Area sanitary wastewater plant was disconnected in November 1996. Because it is a package unit, it is being maintained for potential use at another location.

Loss of Terrestrial, Aquatic, or Wetlands Habitat/Effects on Endangered Species

A number of commentors identified concerns about sensitive habitats and threatened and endangered species in the area of L-Lake and Par Pond, including the following:

- Use of L-Lake by wood storks
- Proximity of bald eagle nests to L-Lake
- Coordination with other SRS environmental organizations such as the Savannah River Ecology Laboratory on the restoration of natural habitat to Steel Creek

Tables S-2 and 3-4 list expected impacts to wood storks and bald eagles from the alternatives; Section 4.1.5 discusses potential impacts to ecological resources. DOE coordinates with many Federal and state agencies; it has received comments from Savannah River Ecology Laboratory (Letters 7 and 11). DOE appreciates the comments from Savannah River Ecology Laboratory and has attempted to take these comments into consideration in writing the FEIS.

Land Use/Privatization

One commentor was concerned about the condition of Steel Creek below the dam. This person asked if the stream had returned to a normal vegetative system as it was in 1951.

No studies characterizing the wetland vegetation of the Steel Creek corridor before the establishment of the SRS are available, but Upper Three Runs, a relatively undisturbed blackwater stream on the SRS, can illustrate the likely wetland vegetation of the Steel Creek corridor before the development of the SRS. Trees adjacent to the stream include tulip poplar, beech, sweetgum, willow oak, swamp chestnut oak, water oak, sycamore, and loblolly pine. Dogwood, red buckeye, and American holly are also abundant. Tag alder is common along sandy stream margins. Macrophytes in wet sites with open canopies include eelgrass (*V. americana*), pondweed (*Potamogeton epihydrous*), and bulrush (*Scirpus* subterminalis). Golden club (*Orontium aquaticum*), wapato (*S. latifolia*), water primrose (*Ludwigia* spp.), and knotweed (*Polygonum* spp.) occur on small floodplains.

Although the Steel Creek corridor has not fully re-established its historic vegetative system, signs of recovery are evident.

A recent mapping effort by the Savannah River Ecology Laboratory mapped aerial coverage of the Steel Creek corridor and delta in 1996. Three vegetation classes were identified: marsh, scrub-shrub, and hardwood. The hardwood class covered the largest acreage, 1,185.1, and was predominated by a young developing stand of bald cypress, tupelo, and ash. The marsh class covered 48.3 acres and was dominated by cutgrass (*Leersia* spp.) and wapato. The scrub-shrub class covered 20.7 acres and was predominated by willow and buttonbush.

Human (Occupational and Public) Health/Ecological Risk

A number of commentors identified the following concerns about increased radioactivity levels that could result from a shutdown of the River Water System and the subsequent exposure of the bed of L-Lake:

- The effect of wind blowing the radioactive contamination from the lakebed
- The amount of low-level and other radioactive contaminants in the area
- The types of instruments used to determine radioactivity levels and the readings they showed

As discussed in Section 4.1.8.2 in the EIS and Figures 4-23 and 4-24, the Multimedia Environmental Pollutant Assessment System (MEPAS) code (Droppo et al. 1995) evaluated several contaminant pathways to human receptors including those arising from suspension and resuspension of sediment particles from the dry lakebed. Factors considered in the impact evaluation included contaminant concentrations in the soil, area of exposed dry sediment, average wind speed, maximum wind speed, number of disturbances in the sediment by humans, number of thunderstorms per year, annual average rainfall, local mass-loading factors, resuspension factors, atmospheric dispersion, and plum depletion. All of these factors were used to estimate impacts to onsite workers and offsite populations through the inhalation and ingestion pathways. These impacts resulting from the drawdown of L-lake estimated as latent cancer fatalities are presented in Section 4.1.8.2.2.

Section 4.1.8.1 of the EIS discusses the methods used to obtain a contaminant concentration in the L-Lake sediments. These validated data are presented in Table 4-14 and in Appendix C. To obtain these data, samples obtained from the L-Lake sediment were analyzed in the laboratory using appropriate instrumentation (e.g., hyper-pure germanium solid state detectors were used to detect and identify radionuclides). All laboratory analyses were performed by trained laboratory technicians using state-of-the-art equipment traceable to the National Institute of Standards and Technology.

Appendix C presents the results of DOE's measurements of radioactivity and radioactive contamination. The ecological and human health analyses presented in this EIS utilize this comprehensive data to determine the potential risks associated with those contaminants found in the lakebed sediments and contaminants that could be released as a result of human or natural actions (wind). Any necessary remedial actions for the two locations will be assessed in accordance with the process set forth in the Federal Facility Agreement.

<u>No Specific Category</u>

A number of commentors expressed concerns that did not belong in a specific category. The following sections address these concerns.

- Amount of Water Pumped

  Although the current River Water System demand is 5,000 gallons per minute, DOE is operating one of the 10 pumps in Pumphouse 3G, which supplies approximately 28,000 gallons of river water per minute to C-, K-, L-, and P-Areas. DOE has purchased and will soon operate a small 5,000-gallon-per-minute pump and save about 23,000 gallons per minute of excess withdrawal. Because the small pump will operate before DOE decides which alternative to select, it is used as the baseline condition for assessing the No-Action Alternative.

- Pump and Treat

  Pump and treat is a groundwater cleanup method that pumps contaminated groundwater to treatment systems to reduce contaminant concentrations. After treatment, the water is either injected back to the groundwater aquifer or discharged to a surface-water stream. In relation to this EIS, DOE has not identified relevant applications of this method.

- Water Reduction Impacts

  A reduction in water flow would cause areas currently beneath L-Lake to become exposed and dry out. DOE analyzed the impacts of such a drying process, which could result in increased levels of airborne contaminants and erosion. DOE expects these increased levels to occur over a short period (less than a year after complete equilibrium) and to be far below levels of Federal and state regulatory concern.

- References cited in text and qualifications of EIS authors

  Each referenced document cited in the EIS appears in a reference list (Chapter 6); the documents referenced in the EIS and its appendixes are available in public reading rooms at the University of South Carolina, Aiken Campus, Gregg-Graniteville Library, 2nd floor, University Parkway, Aiken, South Carolina, 803-648-6851.

The EIS contains a List of Preparers, which includes each person who contributed to the EIS and that person's qualifications, education, and skills.

COMMENT FORM

PUBLIC MEETING ON THE
DRAFT ENVIRONMENTAL IMPACT STATEMENT
SHUTDOWN OF THE RIVER WATER SYSTEM
AT THE SAVANNAH RIVER SITE
DECEMBER 4, 1996

Please provide the following information:

Karen Patterson
Full name (please print)

The organization you represent (if any)

Street address
1103 Conger Dr.

Aiken SC 29803
City, state, zip code

COMMENT – Please use back of form for continuation.

The EIS use a CDC (1993) number of 23.5/100 deaths ~~cancer~~ from cancer per year. Last week the journal Cancer published a number of 130-135/100,000 cancer deaths per year. Since this is a huge difference, I would appreciate knowing the reason for the big difference and why DOE has selected the CDC number. H1-01

PK64-32PC

Comment H1. Page 1 of 2.

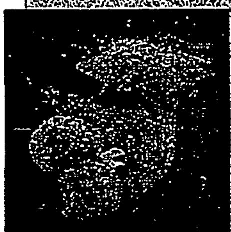
CANCER: THE GOOD NEWS

IN THE RUSH OF SCIENTIFIC OPTIMISM THAT FOLLOWED the polio vaccine and the first moon walk, Richard Nixon declared war on America's second-biggest killer: cancer. Twenty-five years and $30 billion later, the news from the cancer front is good and bad.

The good news is that for the first time since 1900 the overall cancer death rates in the U.S. are coming down. According to a report published last week in the journal *Cancer*, the number of cancer deaths fell from a peak of

C.135 135 per 100,000 in 1990 to 130 last year—a 3.1% drop. Even more encouraging, that trend seems to be accelerating. Experts predict that within 20 years, deaths from cancer could easily be cut an additional 25%, and with luck they could be cut in half. As Health Secretary Donna Shalala proudly declared last week, "We are starting to win the war on cancer."

The bad news is that all those billions spent on research into basic science may have had little to do with it. Doctors have still not found a magic bullet against cancer, and it is becoming increasingly clear that they probably never will. Instead, most of the gains reported last week stemmed from such factors as changes in life-style, reduced exposure to chemicals in the workplace and better detection of malignant growths.

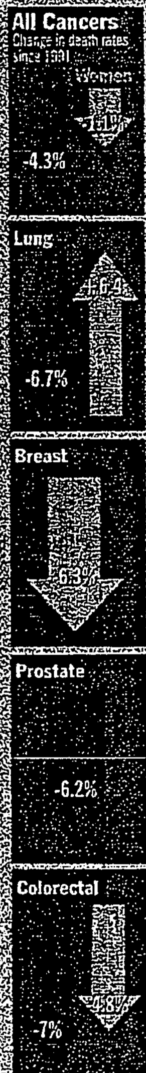


[illegible]: Rapidly dividing malignant cells

The single most important factor in the new cancer statistics—both good and bad—was smoking. Cigarette consumption has dropped sharply in the past 30 years—from 4,194 per capita annually in 1964 to 2,515 today—and the effects of that drop are finally starting to show up. Lung cancers still account for 30% of all cancer deaths, but in those demographic groups that cut back sharply—male Caucasians, for example—lung-cancer death rates have dropped impressively (6.7%). Conversely, a lot of women took up smoking over the same period, which may account for the rise in lung-cancer rates among older women over the past five years (6.4%).

Cancer awareness has paid off as well. Patients are much more conscious today of cancer's early warning signs—and more likely to go in for regular Pap smears and prostate exams. Those tests, meanwhile, have become exquisitely sensitive. Breast cancers, for example, can now be spotted when they are only 2 cm in size, compared with 3 cm a few years ago. "The smaller the cancer," says Harmon Eyre, chief medical officer of the American Cancer Society, "the better the chances of survival."

The good news may be short-lived, however. American teens are taking up tobacco in alarming numbers. Today, 19% of all eighth-graders use tobacco regularly, up from 14% in 1991. By tenth grade, about 28% are smoking. If they keep it up, they can forget about living longer—or healthier—lives. —*By Dick Thompson/Washington*



gineering all 7,000 would be impossible.

For the time being, therefore, many researchers are shifting their focus to goals that are more achievable. If the genes responsible for regulating senescence can't yet be manipulated, they wonder, is it possible to directly treat parts of the body they affect? Jerry Shay, a biologist specializing in cancer research at the University of Texas Southwestern Medical Center in Dallas, does not rule it out. Instead of engineering genes, he says, "we might be able to squirt some chemical to trigger telomerase at a particular site. The enzyme would turn on for a few weeks, change the expression of cells and revert them to a younger profile. We wouldn't have to treat the whole body."

Still other researchers are using what they've learned about telomeres and the other cellular mechanisms to attack the diseases that keep the very old from becoming still older. Researchers at Geron Pharmaceuticals recently published a study in which telomerase RNA was used to block the enzyme in a cancer culture, leading to withering of telomeres and the death of the no-longer-so-prolific cells. Elsewhere, investigators are looking into using the anticaramelization drug pimagedine to help clear arteries and improve cardiac health. Remove heart disease from the constellation of late-life illnesses, and you add three years to the national life expectancy. The detection of a gene that seems to confer protection against Alzheimer's disease may help treat yet another scourge of the aged, currently afflicting 4 million Americans.

While none of these therapies would take human beings anywhere near the tripled and quadrupled life-spans achieved in fruit flies and nematodes, they could at least improve our life *expectancies*—the number of years even our shortened telomeres and caramel-gummed cells would allow us to achieve if illness didn't claim us first. For much of the time our species has been on the planet, that figure is thought to have been a mere 20 years—barely long enough for contemporary people living contemporary lives to move out of their parents' home. The fact that those lives now routinely exceed 80 years is a monumental achievement. A little more progress in studying telomerase, glycosylation and other aspects of senescence science, and researchers like Butler believe there's no reason today's adults could not realistically hope to see 120.

For people dreaming of immortality, that prospect may fall a little short. But for those of us who are contemplating a life that ends around age 80, four or five additional decades sounds like a splendid first step. —*With reporting by Elaine Lafferty/Los Angeles, Alice Park/New York and Dick Thompson/Washington*

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Comment H1. Page 2 of 2.

E.4 Responses to Comments on Draft RWEIS: Hearings

<u>**Response to Comment H1**</u>

The percentage of cancer deaths reported in the EIS, 23.5 percent, represents the number of deaths due to cancer (505,322) as compared to the total number of deaths from all causes (2,148,463) occurring in the United States during 1990. These mortality statistics were published by the Center for Disease Control, National Center for Health Statistics report *Advance Report of Final Mortality Statistics, 1990.* The 1990 rate of 135 cancer deaths per 100,000 standard population reported in the journal *Cancer* is the age-adjusted cancer death rate as published in the same CDC document. These statistics use two different representative populations, the total number of deceased individuals and the entire U.S. population, and, thus, are not directly comparable.

The age-adjusted rate is computed by applying age-specific death rates for a given cause of death (in this instance, cancer) to a standard population distributed by age. The standard population used by CDC for determining age-adjusted rates is the total population as enumerated in 1940. The age-adjusted death rates show what the level of mortality would be if no changes occurred in the age composition of the population from year to year and thus better show the changes in the risk of death over a duration than when the age distribution is changing. Therefore, the age-adjusted rate is not comparable with and appears to be lower than the unadjusted or crude death rates specified for the population enumerated by 1990 census data.

NEPA at Savannah River

From: Todd v. Crawford
To: Andrew R. Grainger
Subject: EIS's APT and River Water Shut Down
Date: Friday, October 25, 1996 9:58AM

I would like to encourage you to keep the above two EIS's consistent.

I was pleased to see that the preferred alternative for a source of cooling water for the APT is the river. Earlier rumors had it being the groundwater which concerned me from the standpoint of groundwater resources and weakening the "head reversal" over much of the 200-area. I do not know what is now the preferred action with respect to the Shut Down of the SRS River Water System EIS but I do know that the push behind this EIS was the desire to shut down the river water system. L1-01

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Comment L1. Page 1 of 1.

E.5 Responses to Comments on Draft RWEIS: Letters

Response to Comment L1-01

As indicated throughout this EIS, the DOE Preferred Alternative is to shut down the River Water System but to maintain all or portions in a standby condition. This condition would enable potential restart to support a new mission. Section 3.3.2 has been revised to include the additional cost of maintaining the section of existing pipe that would be used to supply make-up water to recirculating cooling towers located at the Accelerator Production of Tritium (APT) site (the preferred APT cooling water alternative) as well as the cost to maintain sufficient pumping capacity to supply full flow, on a once through basis, to heat exchangers located at the APT site.

NEPA at Savannah River

From: Todd v. Crawford
To: Andrew R. Grainger
Subject: Draft EIS Shutdown SRS River Water System
Date: Monday, December 02, 1996 10:32AM

I have another committment on December 4, 1996 which will prevent me from attending the public hearing so wanted to send you this comment.

I support putting the system in a standby situation. I support the condition indicated in Table 3.1 as 30 months, Jockey pump. I do not believe any significant new mission could come into place before 30 months. HOWEVER, I believe that enough of the R-Area piping system should be maintained to provide cooling water for the APT. L2

I also believe that the regulatory situation with EPA and SCDHEC needs to be carefully negioated so that L-Lake does not have to be cleaned up as a CERCLA site upon exposing some of the Cs-137 contaminated sediments. L2

Page 1

PK64-11PC

Comment L2. Page 1 of 1.

Response to Comment L2-01

Section 3.3.1.3 confirms that 30 months is sufficient time to make the required upgrades and replacements to the River Water System without affecting the schedule for a new mission such as Accelerator Production of Tritium (APT). Section 3.3.2 has been revised to indicate the additional cost of maintaining the R-Area piping system.

Response to Comment L2-02

DOE is committed to coordinating NEPA actions being considered in this EIS with SRS remediation activities planned and conducted in accordance with CERCLA under the FFA, and proposes to initiate discussions with EPA and SCDHEC to determine reasonable means of expediting the FFA process to achieve appropriate coordination.

Neither DOE or its regulators would agree not to require cleanup of the exposed sediments until characterization and evaluations under CERCLA are complete. Because there has been little, if any, additional contamination since DOE built L-Lake, the concentration of contaminants in L-Lake exclusive of the Steel Creek channel and floodplain is relatively low and based on preliminary evaluations summarized in Appendix A. However, DOE believes that institutional controls for a period that allows sufficient natural radioactive decay are consistent with current land use plans and is probably the most reasonable and cost efficient option. This option will have to be considered among other alternatives consistent with CERCLA requirements.

Contamination in the portion of the Steel Creek channel and floodplain that is beneath L-Lake is approximately equal to that which exists above and below the lake and the portion which is beneath L-Lake would probably receive the same remediation, if any.

Dec. 13, 1996

Andrew R. Grainger
SR NEPA Compliance Officer
Savannah River Operations Office
P.O. Box 5031
Aiken, South Carolina 29804-5031

Dear Mr. Grainger:

I would like to see this site closed permanently. I would recommend that this land be made a part of Sumter National Forest for multi use management. However, timber harvest should be restricted, especially along rivers, streams, roadways, and other areas of high visibility. Thank you for the opportunity to comment. L3-

Sincerely,

K. G. Craigo

107 Locksley Drive
Greenwood, S.C. 29649

PK64-12PC

Comment L3. Page 1 of 1.

Response to Comment L3-01

At this time, the Forest Service of the U.S. Department of Agriculture performs many of the functions at the SRS that it performs in the National Forest System by managing more than 90 percent of the Site area through an Interagency Agreement. Although there is limited public access to these SRS areas, Forest Service management includes activities normally performed in national forests – timber and wildlife management programs, including limited timber sales and care of threatened or endangered species.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

December 18, 1996

Mr. Andrew R. Grainger
SR NEPA Compliance Officer
U.S. Department of Energy
Savannah River Operations Office
P.O. Box 5031
Aiken, South Carolina 29804-5031

Dear Mr. Grainger:

The National Marine Fisheries Service (NMFS) has reviewed the Draft Environmental Impact Statement (DEIS) for Shutdown of the River Water System at the Savannah River Site (DOE/EIS-0268D). We find that the document is well written and adequately addresses matters pertaining to aquatic resources under our purview. We concur with your determination that the Proposed Action will not significantly harm aquatic resources of the Savannah River.

The Proposed Action, which involves shutdown of the River Water System and placing it in standby status, would substantially eliminate withdrawals from the Savannah River. This would benefit both resident and migratory fishes of the Savannah River since entrainment and impingement of fish eggs, larvae, juveniles, and adults would be eliminated except in situations requiring restart. This mode of operation represents a significant improvement over conditions that existed when withdrawal levels approximated 380,000 gallons per minute (24 cubic meters per second) and estimated average losses of about 17,600,000 fish larvae and 9,300,000 fish eggs were experienced during the February-July spawning period. It is also an improvement over conditions that would exist under the No Action Alternative (existing condition) which accounts for fish losses of about 234,000 larval fish and 117,000 eggs during the February-July spawning period.

Since any restart of the system could have a significant adverse effect of aquatic resources of the Savannah River, such plans should be thoroughly coordinated with the NMFS and other Federal and state agencies having stewardship responsibilities for fish and wildlife. L4-1

Finally, in accordance with Section 5.10.2 of the DEIS we note that the Department of Energy plans to initiate formal consultation with the NMFS concerning possible effects on the shortnose sturgeon. The appropriate NMFS contact person for such consultation is Mr. Charles Oravetz who is Chief of the NMFS Southeast Region's Protected Species Branch. Mr. Oravetz may be reached at the letterhead address, or at (813) 570-5312. L4-2

PK64-13PC

Comment L4. Page 1 of 2.

We appreciate the opportunity to review the DEIS. Related questions or comments should be directed to the attention of David Rackley who is Chief of the NMFS Habitat Conservation Division Charleston Branch Office. He may be reached at 219 Fort Johnson Road, Charleston, South Carolina 29412-9110, or at (803) 762-8574.

Sincerely,

Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

PK64-13PC

Comment L4. Page 2 of 2.

Response to Comment L4-01

Should it be necessary to restart the River Water System, DOE would discuss and coordinate any restart plans with Federal and state regulatory agencies (including National Marine Fisheries Service, United States Fish and Wildlife Service, South Carolina Department of Health and Environmental Control, and South Carolina Department of Natural Resources) to ensure that possible impacts to fish and wildlife resources are adequately addressed and mitigated if unavoidable.

Response to Comment L4-02

DOE submitted a copy of the DEIS and a biological assessment to the National Marine Fisheries Service's Southeast Regional Office (Protected Species Branch) on December 31, 1996, in accordance with the requirements of the Endangered Species Act and its implementing regulations. DOE subsequently received a letter from Mr. Andrew Kemmerer, Regional Administrator of the NOAA-National Marine Fisheries Service, that states:

> We have reviewed the information provided and concur that the proposed project is not likely to adversely impact threatened or endangered species under our jurisdiction....This concludes consultation responsibilities under Section 7 of the ESA.

United States Department of Agriculture | Forest Service | Savannah River Forest Station | P. O. Box 710 New Ellenton, SC 29809

File Code: 1900 | Date: December 19, 1996
Route To:

Subject: Draft EIS For River Water Shut Down
SRFS Response

To: Andrew Grainger, DOE
703-47A, Rm 236

After review of the draft by the Forest Service at Savannah River, we believe there are a number of opportunities that need to be incorporated in the final EIS. If the elected alternative is to shut down the system and maintain the distribution network, there are a number of cost-effective options to stabilize exposed sediments in L-Lake.

If natural re-vegetation is slow, a mixture of grass species can be established through seeding and fertilization comparable to what the SRS already uses to stabilize bare soil areas and prevent erosion. This can be implemented on an as needed basis as the basin sediments dewater. Another option is to establish tree species. Most of these soils originally supported an upland pine type prior to L-Lake. With the low level of contamination in the upper portion, these areas could be returned to productive forests. Following the draw down of Par Pond, pine began to naturally invade the open areas. This is likely to occur again. However, more uniform and assured regeneration could be obtained through hand planting. Mixed species of hardwoods can also be planted to enhance wildlife. These can be implemented in conjunction with the normal SRS reforestation efforts. L5-01

The Forest Service, in developing the mitigation plan for Pen Branch, designated check strips that could be left alone to follow natural vegetation succession. This enhanced the value of the project for researchers, maintained some open habitat for certain species, and reduced reforestation costs. In areas of the old L-Lake basin that contain higher radioactive contaminants, the DOE can plant dense canopies of hardwoods or pines to discourage ground vegetation that deer and hogs forage upon that might increase contaminant uptake, distribution, and exposure to hunters.

As the water level drops and the old Steel Creek channel is gradually exposed, we would expect that some minimal effort to create debris dams and pools to stabilize the most contaminated sediments will be possible. The increase velocity and re-initiation of a stream channel has the potential of moving contaminants in the old flood plain sediments downstream. Small dams to create pools to trap sediment could be installed.

Phyto remediation opportunities also exist in the flood plain areas that are more heavily contaminated. Cesium is readily accumulated by vegetation. The materials can be harvested and composted or incinerated to concentrate the

Caring for the Land and Serving People

FS-6200-28b(3/92)

PK64-14PC

Comment L5. Page 1 of 2.

contaminants. The DOE and USDA are collaborating on the development of this technology. While it may not be cost-effective at this point in time in terms of the risks to human health, the flood plain does offer opportunities for research activities to develop this technology using R&D funding sources such as the recent NABIR initiative through the Office of Science, Technology, and Business Development.

It is not apparent from reading DEIS what the plans are for managing vegetation on the pipeline corridors. If there is a need to keep water lines functional, treatments will be required to prevent them from being overgrown with woody stem vegetation. L5 (cc

The Forest Service is available to provide additional information on these options or assist with implementation

JOHN G. IRWIN
Forest Manager

CC: K. Sidey, DOE

PK64-14PC

Comment L5. Page 2 of 2.

Response to Comment L5-01

DOE is committed to restoring the Steel Creek stream ecosystem and associated floodplain forest that existed prior to the creation of L-Lake. If DOE selects the Proposed Action, the Record of Decision for the EIS will contain a commitment to prepare a Mitigation Action Plan as well as a more detailed implementation plan that provides a practical, step-by-step guide to restoring the plant communities of the riparian corridor and floodplain that were lost when L-Lake was created. As noted in Section 3.2.1 of this EIS, DOE would apply appropriate measures to stabilize the lakebed. These could include fertilizing and seeding bare areas to prevent erosion and could include a variety of other soil conservation measures. DOE fully intends to seek the assistance of the soil scientists, ecologists, and foresters of the Savannah River Forest Station in the development and implementation of a soil conservation and reforestation plan that involves stabilizing exposed L-Lake sediments and ensuring that trees and shrubs propagate in the Steel Creek floodplain.

South Carolina Department of

Natural Resources

James A. Timmerman, Jr., Ph.D.
Director

December 20, 1996

Andrew R. Grainger
SR NEPA Compliance Officer
U.S. Department of Energy
P.O. Box 5031
Aiken, SC 29804-5031

REF: Shutdown of the River Water System

Dear Mr. Grainger:

The South Carolina Department of Natural Resources has evaluated potential impacts of the proposed shutdown on wildlife and fisheries habitat, water quality, recreation and other factors relating to the conservation of natural resources.

We believe that the proposed activity has potential to impact the fisheries and wildlife habitat of L-Lake and Parr Pond. L-Lake and Parr Pond to some extent, contain excellent habitat for a number of wildlife species such as the bald eagle, American alligator, white-tailed deer and various fur bearers. They also support well balanced fish communities and a number of wading birds, water fowl and osprey. L6-(

The concern is that due to the small size of the watershed for L-Lake and Parr Pond, water quality problems could occur if the reservoirs are allowed to drop significantly below full pool. In addition, fluctuating water levels could have negative effects on fish recruitment and other wildlife usage. L6-(

L-Lake was intended to be a naturalized wildlife and fisheries habitat and should be managed to optimize it's natural resource value. To allow water levels to lower would not be compatible with that initiative. However, if the Department of Energy would remove the dam and restore the wetland forest and stream channel of Steel Creek, we believe that an equitable exchange of natural resources may occur. It is our position that no lowering and/or dewatering of L-Lake should occur without an approved plan for Steel Creek restoration. The restoration plan should be submitted to and approved by appropriate resource agencies. Elements of the plan should include tree plantings, stream bank stabilization, monitoring and contingency plans. Restoration should address upstream and downstream impacts with consideration given to reduce flows. L6-(

It should be noted that a possibility exists that some level of contamination may be present in the aquasols that comprise the lake bottoms of both reservoirs. Before any plan is initiated to lower water levels, the bottom sediments should be tested for contamination. If hazardous materials are found in the sediments, then a plan for removal of those contaminants should be submitted prior to any shutdown of the SRS River Water System. L6-(

Sincerely,

Danny Johnson for

Robert E. Duncan
Environmental Programs Director

Rembert C. Dennis Building • 1000 Assembly St • P.O. Box 167 • Columbia, S.C. 29202 • Telephone: 803/734-4007

EQUAL OPPORTUNITY AGENCY PRINTED ON RECYCLED PAPER

PK64-12PC

Comment L6. Page 1 of 1.

Response to Comment L6-01

The EIS discusses potential impacts of the proposed action to fish and wildlife habitat of L-Lake in considerable detail in Section 4.1.5.2. These impacts include, but are not limited to: (1) the elimination of most fish habitat in L-Lake, (2) the loss of most wading bird foraging habitat in L-Lake, (3) the loss of most waterfowl wintering habitat in L-Lake, and (4) the loss of bald eagle foraging habitat in L-Lake. More subtle impacts that may result from the proposed action are also discussed in Section 4.1.5.2. These include increased predation on amphibians, reptiles, and small mammals that would be forced to venture farther from shoreline cover to drink and forage around reservoir edges. Potential impacts to fish and wildlife habitat of Par Pond are considered in Section 4.3.5.2.

Response to Comment L6-02

The EIS discusses effects of fluctuating water levels on fish recruitment and other wildlife usage in Section 4.1.5.2 (L-Lake), Section 4.3.5.2 (Par Pond) and Section 4.3.5.3 (threatened and endangered species using both reservoirs).

Response to Comment L6-03

L-Lake was designed and built by DOE to be a cooling reservoir. DOE was required to monitor L-Lake's fish and wildlife as a condition of an amended NPDES permit (#SC0000175) issued by SCDHEC in 1984. Further, as a condition of this NPDES permit, DOE was required to conduct studies to demonstrate that a "balanced biological community (BBC)" existed in the lower half of the reservoir only; the upper half was designated as a mixing zone and was never intended to support a BBC.

DOE is committed to restoring the stream ecosystem and associated floodplain forest that existed prior to the creation of L-Lake. Although a final restoration plan has not been prepared, DOE is currently drafting a plan for restoration of the upper portion of Steel Creek and its floodplain forest in consultation with ecologists and foresters at the Savannah River Forest Station and WSRC-Savannah River Technology Center. If DOE selects the proposed action, the Record of Decision for the EIS will contain a commitment to prepare a Mitigation Action Plan as well as a more detailed implementation plan that provides a practical, step-by-step guide to restoring the plant communities of the riparian corridor and floodplain that were lost when L-Lake was created. DOE will make copies of the Mitigation Action Plan available to all interested parties. As noted in Section 3.2.1 of this EIS, DOE would apply appropriate measures to stabilize the lakebed and minimize erosion. DOE would also, in consultation with the ecologists and foresters, develop a reforestation plan that involves planting and/or transplanting trees and shrubs that are likely to survive and propagate in the Steel Creek floodplain. The Mitigation Action Plan would also contain monitoring requirements to ensure successful restoration.

Response to Comment L6-04

DOE has performed extensive sampling of both Par Pond and L-Lake to determine the types and levels of contaminants existing in the bottom sediments. The ecological and human health analyses presented in this EIS utilize this comprehensive data to determine the potential risks associated with those contaminants found in the lakebed sediments. Any necessary remedial actions for the two locations will be assessed in accordance with the process set forth in the Federal Facility Agreement.

The University of Georgia

Savannah River Ecology Laboratory

(803) 725-2472
FTS 239-2472
FAX 803-725-3309

Drawer E
Aiken, SC 29802

December 23, 1996

Mr. Andrew R. Grainger
Engineering and Analysis Division
SR NEPA Compliance Officer
U.S. Department of Energy
Savannah River Operations Office
P.O. Box 5031, Code DRW
Aiken, SC 29804-5031

Dear Mr. Grainger:

I am submitting herewith for your consideration comments on the "Shutdown of the River Water System at the Savannah River Site - Draft Environmental Impact Statement". These comments are based largely on information gathered here in my research program sponsored by the DOE at the Savannah River Ecology Laboratory. Much of this information has been obtained only recently and some newly-published references from my program apparently were not available to the authors of the Draft EIS when it was written.

I have kept my comments brief and they outline only the general findings in each of the areas of concern which are addressed. For further details concerning our findings about these matters I would refer you to the indicated publication(s) and/or I would be glad to provide you or anyone else in your office with any additional information I can.

At the very least, I hope that these comments will convey my concern that if actions such as the draining of L-Lake are undertaken, follow-up studies should be supported to evaluate environmental issues such as these.

Thank you for your consideration of these comments.

Yours very truly,

I. Lehr Brisbin, Jr.

I. Lehr Brisbin, Jr.
Senior Ecologist
Savannah River Ecology Laboratory

enclosure

PK64-15PC

Comment L7. Page 1 of 6.

Comments on the "Shutdown of the River Water System at the Savannah River Site - Draft Environmental Impact Statement"

Submitted by:

I. Lehr Brisbin, Jr.
Senior Ecologist
Savannah River Ecology Laboratory, P. O. Drawer E
Aiken, SC 29802; 803-725-2472; fax: 803-725-3309

December 20, 1996

There is a considerable amount of new information available in the form of research data that has not yet been formally published in the peer-reviewed scientific literature or which in some cases, appears in recently-published manuscripts which were apparently not available to the writers of this Draft EIS. This information has resulted from DOE-funded research programs here at the Savannah River Ecology Laboratory. I will attempt to summarize below the general areas and findings of this new work and its implications for the River Water Shutdown environmental impact concerns. Further information can be obtained by contacting me directly at the above address.

The new information provided here can be grouped into three general areas: (1) potential environmental impacts upon American alligators (Alligator mississippiensis) resident on the SRS, (2) potential for contaminant uptake by upland game birds, particularly mourning doves (Zenaidura macroura) utilizing exposed former lakebed sediments which may be contaminated with radionuclides and/or heavy metals, and (3) radionuclide uptake and transport by migratory waterfowl and general displacement of the waterfowl themselves through habitat loss. Each of these areas of concern will be discussed separately below.

Potential for Environmental Impacts on Alligators

The findings concerning potential environmental impacts upon alligators, which are predicted for the "Shut Down and Deactivate" alternative (page 4-152), lack recent information which appears in a newly-published research paper from the Savannah River Ecology Laboratory's alligator research program (Brisbin et al., 1996). This paper was apparently not available to the writers of this EIS when it was drafted. New data in the above-cited paper now suggest that the drawdown of Par Pond apparently also had a negative affect on alligator reproduction in addition to the previously reported probable decrease in the survivorship of young alligators due to a lack of emergent shoreline macrophyte cover. This newly reported effect was indicated by a lower quality of young (as judged by reduced weight-length relationships) hatching from eggs in nests which were constructed during the drawdown. Moreover, as also shown in this same paper, most of the resident breeding female alligators in Par Pond did not leave the reservoir during the drawdown but rather remained in their degraded breeding locations and experienced what was almost certainly negative impacts upon their L7-01

PK64-15PC

reproductive output. These findings would suggest that the prediction in the EIS that breeding alligators resident in L-Lake would simply leave the drained reservoir and set-up breeding territories elsewhere may not be correct, and without further research and documentation, this prediction may significantly underestimate the potential impact of this action on the resident alligators. Although no formal census of alligator nesting activity has yet been undertaken for L-Lake, that reservoir now has a sizeable resident population of breeding-sized adults and if reproduction is currently not taking place there it almost certainly will in the near future. The draining of L-Lake thus has the potential to significantly reduce the overall reproductive output of the site's alligator population as a whole. I feel that further research should be undertaken during the coming year to clearly document the extent to which breeding activity is taking place at L-Lake and in the associated wetlands surrounding that reservoir and particularly downstream from the dam.

Because of their long life spans and high trophic levels, alligators also tend to accumulate certain contaminants such as mercury. As indicated in the Draft EIS, the drawdown and/or periodic fluctuation of SRS reservoir water levels could significantly affect the bioavailability of mercury in the sediments of some of these lakebeds. As also documented in your Draft EIS, the drawdown and refill of Par Pond affected mercury levels in Par Pond fish. Mercury concentrations in the muscle of Par Pond alligators, which may be legally harvested as nuisance animals and be marketed for human consumption if they should leave the site, averaged about 4 mg/kg dry mass, a concentration above that considered suitable for human consumption (Yanochko et al., in press). After the refill, one of the largest alligators ever recorded in South Carolina was found dead of as yet unknown causes in Par Pond and,as will be detailed later in another letter under separate cover to your office, analyses revealed an extremely high mercury concentration in the liver of this individual. These observations suggest that mercury may be a serious problem in Par Pond alligators, and that mercury dynamics may be altered by drawdown and refill. Little is known of contaminant levels in L-Lake alligators, or the potential consequences of major habitat alterations on contaminant dynamics. Further work is clearly needed to clarify these issues, and to predict the effects on those animals that may remain in the area of the Steel Creek corridor and watershed if L-Lake is drained. L7-02

Because the SRS alligator population has a long history of documented study, and because this population is uniquely situated at the northern limit of the species' range in the inland southeastern United States, these animals represent an important natural resource whose response to the river water shutdown process should be carefully monitored and evaluated during the course of any activity which may impact their population numbers, reproductive success and/or spatial distribution. L7-03

Uptake and Distribution of Radionuclide Contaminants by Upland Game Birds

Analyses have now been completed and a manuscript written for submission to The Journal of Wildlife Management, describing the uptake and concentration of radiocesium (cesium-137) by doves which were attracted to old-field food resources which developed on the exposed lakebed sediments produced by the drawdown of the Par Pond reservoir. A companion paper has also been submitted to a toxicology journal, describing the uptake and concentration of

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PK64-16PC

Comment L7. Page 3 of 6.

heavy metals in these same birds. The information contained in these manuscripts should be considered in any assessment of potential environmental impacts associated with the proposed river water shutdown. Potential effects should be related to the issue of impacts upon the well-being of the birds themselves and, even more importantly, with regard to the issue of the transport of contaminants from the exposed lakebed sediments to the hunting public who might consume such birds as food (mourning doves are legal game birds in South Carolina, and they are commonly harvested and eaten by the public in lands bordering the SRS). L7-04

Preliminary risk assessment analyses undertaken by Drs. Joanna Burger and Michael Gochfield of the Rutgers University Consortium for Risk Evaluation with Stakeholder Participation (CRESP), suggest that the risk of exceeding a 10^{-6} risk of excess lifetime cancer could be exceeded by hunters consuming birds for every day of the legal 70-day hunting season if those birds were to contain the average level of radiocesium we found in dove meat during our Par Pond dove study. Other details concerning the assumptions and consequences of this risk assessment can be obtained by contacting our laboratory. Of particular importance to the present EIS is the potential for newly-exposed L-Lake bottom sediments to similarly attract doves which might forage in areas showing possibly even higher concentrations of radiocesium than were found in the case of the drawndown Par Pond reservoir. L7-05

Radiocesium Uptake by Migratory Waterfowl

Studies which have not yet been published, from the waterfowl research program at the Savannah River Ecology Laboratory, have shown that an unexpected sudden increase in radiocesium body burdens occurred in American coots (Fulica americana) following the refill of the Par Pond reservoir. As discussed in a presentation made to the Par Pond CERCLA Natural Resource Trustees, coots were found to average as high as 2,774 bequerels of radiocesium/kg of live weight in January-February of 1995. Possible mechanisms of this body burden increase and its relevance to future reservoir drawdowns and associated management activities at the SRS were discussed in a published abstract and a poster presentation which was made at a national scientific meeting. The unexpectedly high increase in radiocesium body burdens of these waterfowl suggests the importance of continuing to monitor both contaminant levels and the spatial/temporal movement patterns of waterfowl using SRS reservoirs. During the present winter (1996-97) for example, large concentrations of wintering waterfowl have moved away from Par Pond to L-Lake which on one of our most recent aerial census counts, was being used by more that 2000 waterfowl! The draining of L-Lake would certainly displace these birds, many of which would undoubtedly leave the site and thus be vulnerable to hunter harvest and other sources of disturbance which they would not normally face in the "sanctuary" of the SRS wetlands. The potential for the proposed river water shutdown to impact regional populations of wintering waterfowl in this part of the Central Savannah River area (CSRA) thus also needs to be considered, I feel, in any evaluation of proposed alternatives for reservoir and wetland management on the SRS. The extraordinary importance of the SRS reactor cooling reservoirs as a wintering site and sanctuary of regional importance for wintering waterfowl, particularly diving ducks, and the potential for these birds to accumulate and transport radionuclide contaminants offsite to the hunting public, have all been well-documented in a number of publications from our laboratory's research program (e.g., Brisbin et al., 1973; Mayer et al., 1986; Brisbin, 1991; L7-06

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Stephens et al., in press). I feel that publications such as these describing original detailed research findings should be cited by the Draft EIS, in addition to the more general review articles which are currently referenced.

Appendix B of the Draft EIS uses fish-eating species for calculating radiocesium dose to birds. However, our data (Brisbin et al., 1973) showed that herbivorous avian species (e.g., coots) were the proper worse-case indicator species for radiocesium uptake, not the fish-eating carnivorous avian species. The fish-eater model should rather be considered as a worse case indicator species for other cotaminants such as mercury impacts. Moreover, this section did not refer to our published studies of radionuclide contaminant levels and doses to wood duck (Aix sponsa) eggs/embryos from the SRS including sites such as Steel Creek, Par Pond and Pond B (Kennamer et al., 1993; Colwell et al., 1996). L7-07

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Response to Comment L7-01

The FEIS includes a discussion of the recently-published study of the effect of the Par Pond drawdown on alligator reproduction and the implications of this study with respect to the Proposed Action.

Response to Comment L7-02

The FEIS discusses elevated levels of mercury in muscle tissue of Par Pond alligators. This issue was not addressed in the 1995 *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995) or the DEIS because this information was not available to the preparers. DOE will also relay this information to the South Carolina Department of Natural Resources, the agency that issues permits for the destruction of nuisance alligators, to ensure that permittees are apprised of the potential risk.

Response to Comment L7-03

DOE agrees that the SRS alligator population is a unique and important resource and worthy of study. However, in an era of reduced funding and intense scrutiny of all Federal expenditures, DOE is not certain of its ability to provide financial support for many worthwhile research projects that have been proposed by cooperating scientists.

Response to Comment L7-04

The FEIS includes a discussion of the recently-completed Par Pond mourning dove studies, the results of which were not available when the *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995) and the DEIS were prepared.

The FEIS presents a discussion of uptake and concentration of radiocesium and mercury by doves feeding on vegetation in the Par Pond lakebed during the drawdown. Although levels of both contaminants are lower in L-Lake than Par Pond, these studies are clearly relevant to the L-Lake drawdown and merit discussion.

Response to Comment L7-05

As noted in the response to the previous comment, the FEIS includes a discussion of uptake and concentration of radiocesium and mercury by doves feeding on vegetation in the Par Pond lakebed during the drawdown. Although levels of both contaminants are lower in L-Lake than Par Pond, these studies are clearly relevant to the L-Lake drawdown and merit discussion.

In a recently-completed study of mourning doves that fed on vegetation in Par Pond during the 1992-1994 drawdown Kennamer et al. (1997) found that only one of 102 doves collected from Par Pond exceeded the European Economic Community limit for radioactivity in "fresh meat" (human food). Based on the maximum observed concentration of cesium-137 in 102 doves collected during this study (22 picocuries per gram), no more than 41 Par Pond doves could be consumed by an individual before the EPA accepted cancer risk of 1×10^6 is exceeded (one "excess" cancer per million people). Based on the average concentration of cesium-137 in these doves (5.95 picocuries per gram), no more than 152 Par Pond doves could be consumed by an individual before the EPA accepted cancer risk of 1×10^6 is exceeded.

However, the authors of this study point out that (1) no dove hunting is allowed on the SRS, (2) doves collected from nearby control sites contained only background levels of cesium-137, and (3) radiocesium in edible tissues of doves is quickly eliminated when the birds leave contaminated areas. The authors suggest that a dove's entire body burden of radiocesium would be eliminated in 12 to 15 days once it left the SRS, due to the species' small size and high basal metabolic rate. When all of these factors are considered, the risk to hunters from eating doves that are killed offsite after feeding in L-Lake during a drawdown would be small to insignificant.

Response to Comment L7-06

The FEIS contains more background information on a more detailed discussion of waterfowl usage of Par Pond and L-Lake than the DEIS and presents a more detailed discussion of possible impacts of the Proposed Action to wintering waterfowl.

Response to Comment L7-07

The DEIS and associated "Ecological Effects of Alternative" (Appendix B) Assessment focused on fish-eating birds either because these species were known to be sensitive to contaminants (e.g., the osprey) or because they were species protected by the Endangered Species Act (e.g., the wood stork and the bald eagle). The known tendency of carnivorous species to accumulate higher levels of (most) contaminants than herbivorous species was also factored into the selection of receptor species. Based on this comment, however, a discussion of radiocesium uptake and body burdens in birds has been added to the FEIS.

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December 23, 1996

Andrew R. Grainger
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Savannah River Operations Office
P.O. Box 5031
Aiken, SC 29804-5031

Dear Mr. Grainger:

I wish to offer a few comments on the Draft Environmental Impact Statement - "Shutdown of the River Water System at the Savannah River Site." DOE/EIS-0268D (November 1996). I am very interested in this because of my research over the past 15 years on Pond B, Par Pond, L-Lake, and other reservoirs on the SRS (see attached references). My beliefs concerning the proposed action (shutting down the river water distribution system) are that:

1. The environmental impacts to L-Lake would be dramatic, and highly undesirable. These include: Loss of fisheries, wildlife, and wetland habitat; Increased erosion and sedimentation throughout the Steel Creek corridor; Increased contaminant movement downstream (mainly ^{137}Cs in floodplain sediments from high water flows); Increased contaminant accumulation in L-Lake fish and wildlife due to a decreased water volume/floodplain sediment ratio and reduced potassium inputs from the river water (potassium reduces ^{137}Cs uptake). L8-0

2. The environmental impacts to Par Pond would be more subtle, but they can be expected to include reduced biodiversity and increased ^{137}Cs uptake by fish and wildlife due to the cessation of biotic and nutrient inputs from the river; and fluctuation and possible loss of littoral zone and wetland habitat, and exposure of contaminated sediments, under drought conditions. L8-0

3. The expected cost savings as stated in the Draft EIS are likely to be heavily overshadowed in the future by costs associated with the effects of the water shutdown. These include sediment control, stabilization or removal of the Steel Creek Dam, and the likely need under CERCLA for remediation (removal) of contaminated sediments in the Steel Creek floodplain. L8-0

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Andrew R. Grainger
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Before a final decision is made concerning termination of the river water distribution system at the SRS, it is respectfully requested that more thorough and careful consideration be given to: L8-04

1. Privatizing the pumping and maintenance operation of the system in an effort to reduce costs.

2. The inevitable environmental impacts of allowing L-Lake to dry up, such as loss of aquatic and wetland habitat, sedimentation of the corridor, and exposure of the contaminated Steel Creek floodplain. Key scientific references on such impacts were developed on Par Pond when it was drawn down. These and others are conspicuously missing in the Draft EIS, and apparently were not considered. L8-05

3. The true, total cleanup costs, environmental and aesthetic damage, and worker risks involved, should the L-Lake drawdown expose sediments with sufficient levels of Cs-137 to warrant remedial action. L8-06

Sincerely,

F. Ward Whicker

F. Ward Whicker, Ph.D.
Professor

FWW:jb

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Response to Comment L8-01

DOE acknowledges that implementing the Proposed Action would profoundly affect L-Lake and its plant and animal communities, as the reservoir ecosystem that currently exists would be replaced by a stream ecosystem. The EIS discusses these impacts in Section 4.1.5.2. These impacts include, but are not limited to: (1) the elimination of most fish habitat in L-Lake, (2) the loss of most wading bird foraging habitat in L-Lake, (3) the loss of most waterfowl wintering habitat in L-Lake, and (4) the loss of bald eagle foraging habitat in L-Lake. More subtle impacts that may result from the Proposed Action are also discussed in Section 4.1.5.2. These include increased predation on amphibians, reptiles, and small mammals that would be forced to venture farther from shoreline cover to drink and forage around reservoir edges.

As discussed in Section 4.1.5.1.3 of the EIS, approximately 225 acres of floodplain wetlands were inundated when the headwaters of Steel Creek were impounded to form L-Lake. Approximately 122 acres of wetland vegetation have become established along the shore of L-Lake as a result of secondary succession and an aggressive planting program funded by DOE and carried out by the Savannah River Ecology Laboratory. Under the Proposed Action, L-Lake would gradually recede and could empty in as few as 10 years. As the reservoir recedes, littoral (shoreline) wetland vegetation would be lost, would become re-established during periods (high rainfall) when reservoir levels stabilize, and would be lost again during drought periods when the reservoir level drops precipitously, until the reservoir reaches an equilibrium. These anticipated cycles of dessication-revegetation-dessication are described in Section 4.1.5.2.2 of the EIS. The analysis in the EIS assumes that the old Steel Creek channel would ultimately become re-established in the L-Lake basin, with some pooling of water just upstream of the dam as described in Section 4.1.2.2 of the EIS. The wetland acreage that ultimately develops would be approximately the same as that which existed circa 1983, before Steel Creek was impounded. Thus, although there would be short- and intermediate-term losses of wetland habitat as the reservoir recedes, there would be no appreciable loss of wetlands over the long term.

There are no plans to increase flows in Steel Creek downstream of the L-Lake dam. The EIS is based on a minimum flow in Steel Creek below the L-Lake dam and in Lower Three Runs below the Par Pond dam (during drawdown) of 10 cubic feet (0.28 cubic meters) per second under any of the alternatives (see Chapter 3.0 of the EIS). Therefore DOE does not believe that there would be an increase in erosion and sedimentation or in contaminant movement downstream. On the contrary, the EIS asserts that stream flows below the two dams would show less seasonal fluctuation and less flooding, which could slow the movement of contaminants downstream. Similarly, because DOE has committed to maintaining flows of 10 cfs in Steel Creek downstream of the L-Lake dam, there is no reason to believe that low stream levels caused by droughts would expose contaminated sediments.

DOE is committed to restoring the stream ecosystem and associated floodplain forest that existed prior to the creation of L-Lake. Although a final restoration plan has not been prepared, DOE is currently drafting a plan for restoration of the upper portion of Steel Creek and its floodplain forest in consultation with ecologists and foresters at the Savannah River Forest Station and WSRC-SRTC. If DOE selects the Proposed Action, the Record of Decision for the EIS will contain a commitment to prepare a Mitigation Action Plan as well as a more detailed implementation plan that provides a practical, step-by-step guide to restoring the plant communities of the riparian corridor and floodplain that were lost when L-Lake was created. As noted in Section 3.2.1 of this EIS, DOE would apply appropriate measures to stabilize the lakebed and minimize erosion. DOE would also, in consultation with the ecologists and foresters of the Savannah River

Forest Station and WSRC-SRTC, develop a reforestation plan that involves planting and/or transplanting trees and shrubs that are likely to survive and propagate in the Steel Creek floodplain.

Response to Comment L8-02

The 1995 *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site* (DOE 1995) assessed the expected impacts of allowing Par Pond to fluctuate from a full pool of approximately 200 feet (61 meters) to 195-feet (59.4 meters). The alternatives considered in the *Shutdown of the River Water System at the Savannah River Site EIS* would also allow Par Pond to fluctuate between 200 feet (61 meters) and 195 feet (59.4 meters). The alternatives differ only to the extent that DOE would maintain the operability of the River Water System. The actions considered in this EIS, at least in relation to Par Pond, have therefore already undergone a thorough NEPA review. Sections 4.3.5.1 and 4.3.5.2 review the findings of the 1995 EA and supplement them with the results of a number of recently-completed monitoring studies.

Response to Comment L8-03

The FEIS discusses a number of mitigative actions (Section 4.1.5.22) that would, in addition to restoration, help control sediment. These include: (1) lowering reservoir levels slowly to minimize erosion and encourage the establishment of plants around lake margins, (2) planting grasses on exposed slopes to stabilize bare areas and prevent erosion, (3) planting pine trees in upland areas once they have stabilized, and (4) planting hardwoods in areas where survival is likely.

The comment also addressed the cost of removing the L-Lake Dam. If DOE decides to deactivate the River Water System immediately or after a period of standby, DOE would leave most, if not all of the dam in place after L-Lake drains. See the response to Comment L10-14 for the regulatory basis for this plan.

The DOE response regarding the cost of cleanup is fully covered in its responses to Comments L9-03, -11, and -18. Basically, DOE believes that the draining of L-Lake would not increase the cost of a complete cleanup of contaminated areas in the Steel Creek Watershed, including cleanup of that portion of the watershed that is beneath L-Lake.

Response to Comment L8-04

DOE has not ruled out privatizing operations that would result in cost savings. Currently, the River Water System maintenance and operations requires eight staff representing about one-third of the annual costs. DOE believes that the system could not be operated with fewer staff by another organization. Due to the size of the system (pumphouse with 10 operable pumps, each with traveling screens measuring 60 feet tall by 6 feet wide, discharging to lines that feed a 1 and 1/2 mile stretch of very large pipe from which distribution piping to the reactor areas originates), it is likely that only an organization such as a power generating utility company would have the experienced staff to operate and maintain the pumping system and associated lakes (L-Lake and Par Pond). Another large component of the operating costs is energy usage, in fact, approximately one-fourth of the costs. There is no apparent savings in energy costs with privatization either. There are other factors to consider, such as, required dredging of the intake canals from the Savannah River every ten years, and degradation of the 40-year old piping system.

Response to Comment L8-05

As noted in the response to Comment 08-01, DOE acknowledges that implementing the Proposed Action would dramatically alter L-Lake, as the reservoir ecosystem that currently exists would be replaced by a stream ecosystem. The EIS discusses these impacts in Section 4.1.5.2.

As noted previously in the response to Comment 08-01, DOE does not believe that implementation of the Proposed Action would result in higher stream flows in the Steel Creek corridor or in increased erosion and sedimentation. There may be some losses of soil as the waters of L-Lake recede and bare lakebed is exposed to weathering. As noted in Section 3.2.1 of the EIS, DOE would apply appropriate measures to stabilize the lakebed and minimize erosion.

The EIS (Section 4.1.2.2.2) suggests that there could be increased sediment loading to Steel Creek if the ponded area just upstream of the L-Lake dam fills with silt and unusually-heavy rainfall forces some of this accumulated silt downstream. DOE believes that this is unlikely, however, given the plans to stabilize the exposed lakebed and the amount of silt that this basin would be able to accommodate.

The EIS discusses the impacts of allowing L-Lake to drain in considerable detail in Section 4.1. DOE believes this constitutes an adequate impact analysis, and one that satisfies the requirements of NEPA. The NEPA regulations (at 40 CFR 1502) make clear that NEPA documents are intended to "...provide full and fair discussion of significant environmental effects..." and be "...analytical rather than encyclopedic."

Response to Comment L8-06

As indicated in the FEIS, Section 4.1.8 and Appendix A, the L-Lake drawdown is unlikely to expose L-Lake sediments with sufficient levels of Cs-137 to warrant active remediation (e.g., soil cover, excavation). However, DOE does anticipate the need for appropriate land use and administrative controls, erosion control measures, monitoring, and similar activities, which can be accomplished at moderate cost relative to cost savings realized from DOE's proposed action. Potential cleanup costs, environmental and aesthetic damage, and worker risk in the event remediation of contaminated lakebed sediments is required are addressed in Chapter 3 of this FEIS.

ENERGY
RESEARCH
FOUNDATION

Frances Close
Board Chairwoman

Theodore K. Harris, Esq.
President

December 30, 1996

Andrew R. Grainger
Engineering and Analysis Division
SR NEPA Compliance Officer
U.S. Department of Energy
Savannah River Operations Office
P.O. Box 5031, Code DRW
Aiken, South Carolina 29804-5031

Attention: RWEIS

Dear Mr. Grainger:

The attached five pages contain the Energy Research Foundation's comments on the Draft Environmental Impact Statement, Shutdown of the River Water System at the Savannah River Site, (DOE/EIS-0268D).

Beyond the specific concerns we've enumerated, we strongly urge decision-makers at SRS to carefully reconsider the proposed action forming the basis for this DEIS and to look diligently and creatively for alternatives that would preserve L Lake and its extraordinary and valuable ecosystem. We believe enactment of the proposed action could result in the loss to the nation and the region of a rare and valuable ecological resource. We also believe the proposed action, as presented, poses an unacceptable risk to federal taxpayers in that the action may require a costly and prolonged environmental remediation effort which would be unnecessary without the proposed action. L9-01

We encourage SRS decision-makers to find ways to lower the projected maintenance and energy costs associated with providing a steady flow of river water upstream of the L Lake dam. We think this can be done in ways that substantially reduce long-term costs while preserving the valuable ecological resource. L9-02

We also encourage SRS decision-makers to consider that the proposed action runs the considerable risk of developing into a debacle that would further undermine the credibility of the national DOE environmental remediation program and the environmental remediation program at SRS in particular. To be blunt, allowing L Lake to recede appears, almost by design, to be penny wise and dollar foolish. Aren't there enough contaminated areas at SRS that require active remediation (not to mention costly sampling and analysis) without purposely creating another? L9-03

We trust our comments on this matter will receive careful attention and that whatever decisions ensue about the fate of the River Water System, L Lake, and other aspects of this proposal will be made thoughtfully and without haste.

Sincerely,

Brian Costner, Director. 537 Harden Street, Columbia, SC 29205. 803/256-7298, fax 803/256-9116
Tim Connor, Associate Director, S. 1016 Buena Vista Drive, Spokane, WA 99204. 509/838-4580, fax 509/624-9188

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Dec. 27, 1996

Energy Research Foundation

Comments on DOE/EIS-0268D, Shutdown of the River Water System at the Savannah River Site

Summary Comments: The Draft EIS attempts to frame considerations for a decision on whether to shutdown the system for pumping river water from the Savannah River to reactor areas at SRS. The sole stated purpose for the proposed shutdown is the potential savings in annual operational costs associated with the river water system. The DEIS estimates that maintaining the equivalent capacity of the existing system would cost just over $2 million annually, and that shutting down the system would result in costs of between $.5 million and $1.3 million annually, depending on whether the system is completely deactivated or maintained with capacity for restart. The evidence presented suggests that a decision to completely deactivate the system would be irresponsible, so the annual cost savings projected under the proposed alternative is approximately $1 million.

The principle negative effect of the proposed action is the gradual disappearance of a 1,000 acre lake (L Lake), the loss of valuable wetlands associated with the permanent drawdown, and the resulting destruction of the abundant fish and wildlife community that has developed since the lake was created in 1984. The gradual disappearance of the lake under the proposed action would also expose sediments known to be contaminated with cesium-137, a radionuclide with a half-life of approximately 30 years. By exposing these sediments, the proposed action clearly invites the possibility that state and federal environmental regulators may require an expensive cleanup action. If so, it is conceivable--perhaps probable---that the objective of the proposed action (cost savings) could backfire. What is more certain is that in order for the projected cost savings to be realized, regulators will have to agree, in advance, not to require active remediation of the exposed soils. L9-0

L Lake was created on Steel Creek which is the most heavily contaminated of all site surface streams at SRS because of large releases of cesium-137 in the early years of plant operation. Out of the estimated total inventory of 560 curies of cesium-137 released to SRS surface streams, a little more than half (an estimated 284 Ci) were released into Steel Creek. Due to radioactive decay, the remaining inventory in Steel Creek should now be substantially less than 200 Ci (the DEIS provides an estimate of 58 Ci) but this is still a substantial inventory and one that warrants concern. Not only would the loss of pumped river water result in the gradual loss of the water "cover" over the contaminated sediments, it would also result in an unfavorable change in water chemistry with the likely consequence of enhanced uptake of cesium-137 by largemouth bass and other aquatic organisms. L9-0

Further, the loss of L Lake would require a decision about the fate of the L Lake dam: either removing the large dam or maintaining it. Annual maintenance of the dam is estimated at $500,000 but there is no cost provided in the EIS for removing the dam. L9-(Loss of the dam would, of course, result in the loss of an important flood control mechanism for Steel Creek, a capacity that could be important to avoiding episodes where flood waters suddenly move large amounts of contaminated sediments downstream toward the Savannah River and the site boundary.

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Another negative factor is that deactivating the river water pumping system would result in a loss of capacity to provide makeup water to Par Pond. Without capacity to pump water to Par Pond there is the clear risk that, in the event of a regional drought, the pond water level would drop below 195 feet and result in contaminated soils becoming exposed. L9-07

Under Section X of the SRS Federal Facility Agreement, DOE is required to prepare a Site Evaluation (SE) report of L Lake and other sites listed in Appendix G of the FFA. The SE report is to be submitted to EPA and SCDHEC for their approval. Considering the effect the proposed action would have on the condition of L Lake, it is clear that taking the proposed action without submission and approval of a site evaluation report would violate the spirit, and perhaps the letter, of the FFA. L9-08

Finally, the proposed action appears to be in clear conflict with Executive Order 11990 for the protection of wetlands and DOE's own policy of preserving and protecting SRS wetland resources in accordance with the national "no net loss" of wetlands goal. Indeed, the DEIS concedes that there would be major losses of prime habitat for wading birds under the proposed action. The EO requires steps to mitigate loss of wetlands but there are no substantive plans to offset these losses included in the DEIS. L9-09

SPECIFIC COMMENTS

Cost and Alternatives: Given that the sole basis for the proposed action in this Draft EIS is the potential for cost savings, the final EIS should provide a better organized, more thorough, and better documented discussion of the factors that will ultimately effect direct and indirect costs. L9-10

Direct Costs: The only purported benefits projected to accrue from the proposed action is the savings in direct costs by the shutdown of the river water pumping system. The final EIS should include further analysis of possible approaches for reducing the direct costs associated with maintaining at least that part of the River Water System that will effectively avoid the greatest potential for ecological and human health impacts--the loss of L Lake. These approaches should include, but not be limited to, such options as the installation of higher efficiency pumps, potential for reducing energy costs associated with pump operation, and the potential for working with independent contractors, independent conservation and/or wildlife foundations, and other state and federal agencies whose mission involves the protection of natural wetland resources. It is at least conceivable, for example, that the personnel costs associated with maintaining the supply of river water to L Lake and the maintenance of the L Lake dam could be donated by a private or public foundation with an interest in preserving the valuable L Lake ecosystem. If so, this by itself would reduce the projected cost of the No Action alternative from roughly $2 million annually to $.5 million annually. And still there should be a way to substantially lower these costs to benefit the taxpayer. L9-11

Even without these potential direct cost savings, it should be noted that the benefits of the No Action alternative as presented in the EIS would appear, on their face, to be well worth the projected costs. Not only would the L Lake habitat be preserved but the No Action alternative would avoid the unavoidable and substantial costs to both the Department of Energy and the U.S. Environmental Protection Agency for the additional sampling, analysis, etc., that would be required in order to determine

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what, if any, remedial actions are necessary to satisfy CERCLA requirements as L Pond recedes.

Indirect Costs: Whatever the projected savings in direct costs under the proposed action, this potential savings must be evaluated against the prospect that the proposed action will necessitate a costly cleanup effort as the declining level of L Lake exposes soils contaminated with radioactive cesium-137. In our view, the National Environmental Policy Act (NEPA) requires a thorough evaluation of the potential remediation costs that are likely to result from the proposed action. The final EIS should include this evaluation. L9-12

In addition to the legal issues of NEPA compliance, it would be plainly irresponsible for the Department of Energy to proceed with this action without having obtained a substantive answer from the U.S. Environmental Protection Agency that the action:

a) is unlikely to subject SRS to immediate enforcement actions for violations of the Comprehensive Environmental Response, Compensaton and Liability Act (CERCLA) and other federal and/or state laws, and, L9-13

b) is unlikely to result in subsequent determinations by EPA that the consequences of the proposed action will necessitate significant cleanup actions involving substantial costs to ensure protection of public health and the environment.

The prospective environmental remediation costs associated with the proposed action could actually result in a substantial net loss to the taxpayer. In addition to fully analyzing the potential environmental remediation costs, the final environmental impact statement should thoroughly consider other potential indirects costs that may be associated with the proposed action and alternatives. For example, under the Shut Down and Deactivate option the substantial cost of removing the current L Lake dam is not factored into the cost equation and should be. L9-14

Finally, the EIS should factor in the contingency costs of maintaining surface water outfalls which receive water from the River Water System. Loss of water in these canals would inevitably lead to their becoming clogged with new vegetation which would either have to be removed on a regular basis or at a future time when circumstances may require reactivation of the system--either to support future site missions or to mitigate unforeseen environmental effects. The final EIS should include the maintenance costs of keeping the canals clear and the one-time costs for future canal clearing operations should use of the outfalls again become necessary. L9-15

Human Health Risks: The analysis and discussion of human health risks associated with the proposed action are inadequate in several respects.

1) The Draft EIS contains only a few scattered clues as to what the extensive sediment analysis at L Lake, as referenced on page A-3, revealed. This data (reportedly involving in-situ measurements at over 90 locations) and its implications, should be at the center of the discussion of the worker and public health consequences of the proposed action. Yet, the results of this sampling aren't provided--apparently because the data is reported to be unvalidated. It is ERF's view that SRS should not have distributed for comment a draft EIS without having taken the time to validate such important data. It is puzzling and somewhat disturbing that SRS would L9-16

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publish a draft EIS without having validated this data for use in assessing the affected environment. It is clear that Figure A-1 on page A-6 was composed using this unvalidated data. This was improper because it allows authors of the DEIS to present a synthesis of data without producing the underlying data that supports the presentation. Furthermore, it was improper not to publish a disclaimer on Figure A-1, noting the fact that it was composed using unvalidated data.

2) On page B-2 there is a discussion of a much more limited core sampling effort involving 8 sediment cores. Here it is reported that Cs-137 concentrations from these core samples ranged as high as 103 picocuries per gram, with a mean concentration of 8.7 picocuries. This, alone, should give SRS decision-makers pause because one must, for the time being, make the conservative assumption that the draw down of L Lake that will occur as a result of the proposed action will expose sediments at or near this level of contamination. If so, there is a good likelihood that a major environmental remediation effort will be required by EPA to deal with this contamination. The cost of such a remediation could easily negate--even exceed--whatever cost savings are projected by shutdown of the River Water System. L9-17 L9-18

3) Figure A-1 on page A-6 should be recomposed using validated data from sediment samples. The figure should, to the extent practicable, provide the locations of specific sampling locations so readers can get a clearer sense of how the designated isopleths are composed. It should also include a depiction of the areas greater than 2 picocuries per gram of sediment Cs-137 because it is this level of contamination that would (assuming the formula being used in the DEIS for these conversions is accurate) reach the 10^{-4} risk level for the residential scenario, a more likely threshhold for remediation than the 10^{-6} risk level for the residential scenario that is presented (along with two worker scenario risk projections) in Figure A-1.

Moreover, it is important that the Department's decision-makers have a clearer understanding of the potential hazard that would be created if the Department pursues the proposed action. At this point it would be prudent for DOE to assume that EPA will require remedial actions for those areas where risk levels are at or exceed the 10^{-4} lifetime risks calculated at the 2 pCi/gram level for Cs-137. L9-19

4) With the shutdown of the river water system it is inevitable that the water chemistry in L Lake and Steel Creek will change. Among other changes, there will be lower nutrient loading and a decline in specific conductance. As was observed during a recent drawdown at Par Pond, the decline in potassium (attributable to lower levels of potassium in groundwater and other natural inflows relative to Savannah River water) results in increased biologic mobility of cesium-137. This change is likely to increase the cesium-137 concentrations in largemouth bass and other aquatic organisms not only in what remains of L Lake but in the entire Steel Creek system down to the Savannah River. This is significant because the State of South Carolina (with support from the Environmental Protection Agency's Region IV office) has already issued a fish consumption advisory for the Savannah River near and downstream of SRS because of the relatively high concentrations of Cs-137 in fish. While this increase in health risk may only be marginal, it does provide another reason to carefully consider the environmental and human health consequences of the proposed action. L9-20

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Ecological Impacts, Risks and Potential Opportunities: Overall, the Draft EIS does a thorough job of detailing and explaining the real and potential ecological effects of the proposed action and alternatives. The discussion of the ecological effects of the proposed action should include an independent assessment of the value of the L Lake ecosystem, such as estimates of the value of the lake's fishery, the value of the extraordinary wading bird habitat, and the value of the lake in terms of maintaining the site's bald eagle population. The value of the L Lake ecosystem should be assessed within a regional context. For example, it would be useful to know the extent to which ecosystems similar in abundance and variety are found elsewhere in the Central Savannah River Area and the southeast United States. L9-:

This discussion could also benefit by assessing the value of L Lake as a potential ecological research area within the mission associated with SRS's designation as a National Environmental Research Park.

Coordination with EPA and other Federal and State Agencies

Given the potential for increasing human health risks and the threatened loss of a substantial natural resource like L Lake, the Department of Energy must ensure that its decision making is coordinated with the Environmental Protection Agency, the South Carolina Department of Health and Environmental Control, and other federal and state agencies who may have a legitimate role to play in deciding the fate of L Lake.

Specifically with regard to EPA, L Lake, Steel Creek, and other contaminated areas potentially affected by the proposed action, are listed in Appendix G of the SRS Federal Facility Agreement (FFA) as sites requiring evaluation under terms of the FFA. DOE is obliged to conduct actions at sites listed in Appendix G in accordance with specified requirements of the National Oil and Hazardous Substances Pollution Contengency Plan (NCP). These obligations include the submission to EPA and SCDHEC of Removal Site Evaluation Reports (SEs) so these agencies can make determinations as to what, if any, remedial actions are required at the listed site(s). Under Section X of the FFA, if DOE should disagree with the response actions recommended by EPA and SCDHEC, it can then submit the matter for dispute resolution. L9-:

In our view, any decision to move ahead with the shutdown of the water system at SRS without approval by EPA and SCDHEC of the SE for L Lake is a violation of the intent of Section X of the FFA. We therefore recommend that concurrent with this NEPA process, the SE for L Lake should be prepared and reviewed by the agencies under terms set forth in the FFA. A determination on the required SE for L Lake should be used to inform the options set forth in this DEIS.

Executive Order 11990

The proposed action in this Draft Environmental Impact Statement appears to violate Executive Order 11990, "Protection of Wetlands," which requires federal agencies to avoid impacts to wetlands if a practicable alternative exists. In addition, federal policy is to achieve the goal of "no net loss" of wetlands. In this case, DOE has not proposed a mitigation measure to accompany the proposed action; the net loss would occur. More importantly, a practicable alternative to the proposed action does exist in the form of the "no action" alternative described in the DEIS. L9-:

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Response to Comment L9-01

DOE has carefully evaluated the beneficial and adverse effects of the action. Although DOE acknowledges loss of L-Lake and approximately 189 acres of littoral (shoreline fringe) wetlands, it is committed to restoring the valuable ecosystem that L-Lake inundated, including 225 acres of bottomland forest wetlands.

As indicated in this FEIS, Sections 4.1.8 and Appendix A, the L-Lake drawdown is unlikely to expose L-Lake sediments with sufficient levels of cesium-137 to warrant active remediation (e.g., soil cover, excavation). However, DOE acknowledges that the final decision on remediation would be made after completion of the FFA process. DOE does anticipate the need for appropriate land use and administrative controls, erosion control measures, monitoring, and similar activities, which can be accomplished at moderate cost relative to cost savings realized from DOE's proposed action. This EIS addresses potential cleanup costs (see Appendix A), environmental and aesthetic damage (see Sections 4.1.5 and 4.1.7), and worker risk (see Section 4.1.8) in the event remediation of contaminated lakebed sediments is required.

Response to Comment L9-02

The small pump layup scheme presented in Section 3.3.2 could preserve L-Lake and save up to $307,000 per year compared to savings of up to $797,000 per year for schemes that could not preserve L-Lake. This range of layup options for the proposed action is presented to enable the decisionmaker to evaluate the tradeoffs between three layup schemes. Section 3.3.2 has been revised to clarify that the small pump layup scheme could preserve L-Lake.

Response to Comment L9-03

DOE believes that the reversion of L-Lake to original Steel Creek levels would enhance the efficiency of rather than jeopardize final investigation and if necessary remediation of the Steel Creek channel and floodplain, which is an Integrator Operable Unit (IOU) under the FFA. Investigation would include the portions of Steel Creek upstream, downstream, and beneath L-Lake. Clearly the reach of the Steel Creek stream channel and floodplain that is currently beneath L-Lake would be more cost effectively investigated as the channel is exposed by the drawdown of L-Lake.

Contamination in L-Lake exclusive of the Steel Creek channel and floodplain is discussed in Appendix A. Because there is little, if any, additional contamination since DOE built L-Lake, the concentration of contaminants in this area is relatively low. Please see the DOE response to Comment L9-18 for details on this portion of the lake.

Response to Comment L9-04

Responses to Comments L9-03 and L9-18 are responsive to this comment as well. Also see the DOE responses to the EPA letter (L10).

If remediation is required in Steel Creek below L-Lake, failure to remediate the portion beneath L-Lake would cause continuing releases that negate the remediation. If remediation is not necessary above or below L-Lake it is doubtful that remediation would be required in the reach that is presently beneath L-Lake. Although there is considerable variability in contaminant concentrations from point to point in the streambed, the "hot spots" and average concentrations are essentially equal in the three reaches.

Neither DOE or its regulators would agree not to require active remediation of the exposed sediments until characterization and evaluations under the FFA are complete.

Response to Comment L9-05

Continued saturation of contaminated Steel Creek sediments is expected under the proposed action. As discussed in the EIS, aerial radiological surveys conducted since 1974 indicate that the radionuclides in the Steel Creek system have remained channeled in a zone that correlates with the historic stream channel and floodplain for the creek. Additionally, studies performed by DOE in support of the L-Reactor Operation EIS (DOE 1984) indicate that most contaminants deposited in Steel Creek stream bed are in the upper regions of the floodplains. Since the floodplains are likely to remain unchanged under all alternatives (i.e., these areas will remain saturated), incremental impacts are likely to be small.

Response to Comment L9-06

If DOE decides to implement a shutdown alternative, it would maintain both the Par Pond and L-Lake Dams at an annual cost of approximately $500,000 compared to approximately $2,250,000 per year to continue to operate the River Water System. After drawdown and a decision to deactivate the River Water System, DOE would not continue L-Lake Dam maintenance. It would either breach the L-Lake Dam or take the necessary actions to ensure continuous, unobstructed flow through the existing outflow structure.

It would be premature to make a decision on the dam deactivation option to pursue, which would not be implemented for approximately 10 years after a shutdown decision. DOE believes that this cost, in terms of present worth, is small relative to the immediate and cumulative savings that would occur under shutdown.

Response to Comment L9-07

DOE believes that Par Pond would not fall below the 195 foot level unless there was a catastrophic drought that would affect water quality in other regional lakes and streams. In calendar year 1996, a dryer-than-average year, the lowest daily lake level was 199.21 feet. Nevertheless, DOE prefers to maintain the River Water System after shutdown and, if necessary, it would restart the system, pump to Par Pond, and bring the water level to an appropriate level above 195 feet. See Section 3.3.1.1.

Response to Comment L9-08

Section X of the FFA requires that if EPA and SCDHEC determine further response action is necessary for an area, then DOE agrees to amend Appendix C of the FFA to include such areas and to conduct additional work at such areas under terms of the Agreement.

To expedite the FFA process, DOE will not submit a Site Evaluation Report for regulatory review but rather will propose for the assessment of L-Lake, with the performance of further evaluations such as the completion of appropriate studies under the terms of the FFA. This approach is consistent with the terms of the FFA and supports ongoing initiatives to expedite the FFA process (Johnston 1997).

Response to Comment L9-09

As discussed in Section 4.1.5.1.3 of the FEIS, approximately 225 acres of creek bottom wetlands were inundated when the headwaters of Steel Creek were impounded to form L-Lake. Savannah River Ecology Laboratory (SREL) scientists have estimated that there are approximately 190 acres of jurisdictional wetlands around the edges of L-Lake. These are areas with the requisite soils and hydrology to support wetland vegetation. Approximately 122 acres of wetland vegetation have actually become established along the shore of L-Lake as a result of secondary succession and an aggressive planting program funded by DOE and carried out by the SREL. Under the Proposed Action, L-Lake would gradually recede and could empty in as few as 10 years. As the reservoir recedes, littoral (shoreline) wetland vegetation would be lost, would become re-established during periods (high rainfall) when reservoir levels stabilize, and would be lost again during drought periods when the reservoir level drops precipitously, until the reservoir reaches an equilibrium. These anticipated cycles of dessication-revegetation-dessication are described in Section 4.1.5.2.2 of the FEIS. The analysis in the FEIS is based on the expectation that the old Steel Creek channel would ultimately become re-established in the L-Lake basin, with some pooling of water just upstream of the dam as described in Section 4.1.2.2.2 of the FEIS. The wetland acreage that ultimately develops would be approximately the same as that which existed circa 1983, before Steel Creek was impounded. Thus, although there would be short- and intermediate-term losses of wetlands as the reservoir recedes, there would be "no net loss" of wetlands over the long term.

The FEIS discusses a number of possible mitigative actions (Section 4.1.5.2.2) including: (1) lowering reservoir levels slowly to minimize erosion and encourage the establishment of wetland plants around lake margins, (2) planting grasses on exposed slopes to stabilize bare areas and prevent erosion, (3) planting loblolly and longleaf pine in upland areas once they have stabilized, and (4) planting hardwoods in areas where survival is likely. Although a final restoration plan has not been prepared, DOE is currently drafting a plan to implement these mitigative measures if DOE selects a shutdown alternative.

Response to Comment L9-10

In addition to cost savings, DOE has considered indirect beneficial impacts such as reduced energy consumption, reduced entrainment of fish larvae and fish eggs and impingement of fish in the Savannah River, and restoration of the pre-Lake ecosystem, including 225 acres of bottomland forest wetlands.

DOE acknowledges that cost savings is the predominant direct beneficial impact. DOE has followed Council on Environmental Quality regulations in its revision of Section 3.3 to include costs of shutdown that "can be supported by credible scientific evidence, are not based on pure conjecture, and are within the rule of reason."

Response to Comment L9-11

DOE responds to this comment by its components:

Avoid the loss of L-lake

Higher efficiency pumps/potential for reducing energy costs

DOE intends to operate a high efficiency pump (5,000 gallons per minute) that will reduce costs and save energy. Schedules indicate that operation of the River Water System with this pump and issuance of this Final EIS are nearly concurrent. Use of this pump would avoid loss of L-Lake under the No-Action Alternative or selection of the small pump layup scheme under the Proposed Action.

Working with independent contractors

DOE has not ruled out privatizing operations that would result in cost savings. It is doubtful that a private contractor could provide personnel with the required skills at less cost. Also, there is no apparent savings in energy costs by privatizing. DOE has an active vendor forum program in place and has received no proposals for privatizing the River Water System.

Working with independent conservation and/or wildlife foundations

DOE welcomes dialog with conservation and/or wildlife foundations but has received no proposals for involvement with the River Water System during the first 10 months of this NEPA process. DOE has revised the Foreword in this EIS to invite such dialog.

Working with other state and federal agencies

Other state and federal agencies have also been informed of the action that DOE is considering. It is unlikely that another government agency would seek to increase its mission in light of the reduction of budgets and downsizing that is underway.

Donation by private or public foundation to maintain river water supply and L-Lake dam

DOE welcomes such proposals and has revised the Foreword to indicate its willingness to consider donations for the preservation of L-Lake.

Benefits of No Action alternative appear to be well worth the projected costs

Preserve L-Lake habitat

DOE believes that there are both adverse and beneficial impacts in the loss of L-Lake. DOE attempts to evaluate both the positive and negative aspects of this issue in this EIS.

Avoid costs to satisfy CERCLA requirements as L Pond recedes

DOE is aware of the costs of investigation and potential remediation of the Steel Creek IOU including the stream channel and floodplain that is currently beneath L-Lake. It is not convinced that the drawdown of L-Lake and inclusion of the portion of L-Lake that is outside the stream channel and floodplain will increase these costs. Because the contamination of the channel and floodplain occurred prior to the impoundment of L-Lake, there is relatively little contamination in the lake exclusive of the channel and floodplain. The response to comment L9-18 provides additional discussion pertinent to cost for remediation.

Response to Comment L9-12

The DOE response regarding the cost of cleanup is fully covered in its responses to Comments L9-03, -11, and -18. Basically, DOE believes that the draining of L-Lake would not increase the cost of a complete cleanup of the Resource Conservation and Recovery Act (RCRA)/CERCLA units within the Steel Creek watershed, including cleanup of that portion of the watershed that is beneath L-Lake.

In accordance with NEPA, DOE has prepared this EIS at the earliest possible time to insure that planning and decisions on the operation of the River Water System reflect environmental values.

DOE has responded to the cleanup effort in the manner recommended by its Office of Policy and Assistance. Because the investigation and potential cleanup of the Steel Creek watershed is not ready for proposal, DOE treats it as a connected action, with indirect effects. DOE addresses this connected action in Appendix A and Section 4.5, Cumulative Impacts but defers alternatives for the connected action until feasibility studies under the FFA are initiated. If, at that time, the actions under the FFA call for the procedural and documentation requirements of NEPA, DOE would incorporate NEPA values in the FFA documents or, after consultation with stakeholders, could choose separate but integrated NEPA and FFA processes. This approach is described in *L-Lake Site Evaluation and Remedial Alternatives Study* in Section 1.4 and is fully compatible with the applicable order, recommendation, and policy statement of DOE.

Response to Comment L9-13

DOE will comply fully with applicable Federal and state laws in making its decisions on the operation of the River Water System. In addition, DOE will coordinate as necessary with EPA and SCDHEC to ensure that the decisions it makes on the system as a result of this EIS are compatible with potential remedial decisions it will make for L-Lake under the SRS FFA.

In response to historic releases of hazardous substances to the environment at the SRS, EPA included the Site on the National Priority List (NPL) under Section 105 of the CERCLA. This action became effective on December 21, 1989. A site on the NPL falls under the jurisdiction of CERCLA, which bases control on risk.

CERCLA requires decisions on site remediation to go through a formal process under the FFA. The proposed operational shutdown activities, while supporting possible future SRS operations, would also ensure the ability to refill L-Lake if an interim or final remedial action required the stabilization of exposed sediments. DOE would coordinate proposed operational shutdown activities with the activities and commitments in the FFA.

Response to Comment L9-14

The DOE position on potential remediation costs associated with the proposed action is fully covered in response to Comments L9-03, -11, and -18.

This comment also addressed the cost of removing the L-Lake Dam. If DOE decides to deactivate the River Water System immediately or after a period of standby, DOE plans to leave most, if not all of the dam in place after L-Lake drains.

DOE bases this plan on correspondence with the U.S. Army Corps of Engineers who, in turn, notified other relevant State and Federal permitting and resource agencies (i.e., U.S. Department of Interior, NOAA/National Marines Fisheries Service, EPA, SCDHEC, and the SC Department of Natural Resources). Based on the information provided by DOE and the fact that the agencies offered no comments or concerns, the Corps of Engineers concludes that DOE is not required to remove the embankment.

DOE would select an economical option that is protective of human health and the environment such as breaching or ensuring unobstructed flow through the existing conduit.

Response to Comment L9-15

DOE considers vegetation control in outfall canals to be within the uncertainty of the preliminary surveillance and maintenance cost ad one-time cost to restart presented in Section 3.3.2. Further, any attempt to estimate them would be based on conjecture because DOE doesn't know which outfall, if any, would be used in the event of an order to restart the River Water System.

Response to Comment L9-16

DOE believes that both the Draft and Final EIS clearly indicate what the sediment analysis of L-Lake revealed.

Validated data from 1996 sampling have been used in the Final EIS for the evaluations of human health and the environment, including Appendix A. The *in situ* gamma analyses represent scoping level analyses using special methods. The detailed results of these studies are available in the DOE Reading Room.

DOE believes that it was appropriate to use unvalidated data during preparation of the Draft EIS while the validation process was underway. Validation was completed just prior to issuance of the Draft EIS, and DOE determined that the validated data did not negate any of the evaluations in the Draft EIS. DOE has added a description of the sampling data sets used in the Final EIS (Appendix F) and has expanded and revised all affected sections based on validated 1996 data for L-Lake (see Sections 4.1.5 and 4.1.8 and Appendixes A, B, C, and F).

Response to Comment L9-17

As per guidance provided by the DOE Office of NEPA Oversight, EIS analyses are based on reasonable exposure conditions such as those represented by average concentrations. Using a maximum concentration to assess exposures would present the highest consequences but would not represent concentrations found throughout the dried lakebed. Both the human health and ecological impact analyses in the FEIS are based on validated data from extensive sampling of the entire lakebed.

Response to Comment L9-18

In support of the EIS, DOE has undertaken a study to identify and evaluate the likely range of remedial action alternatives that it might ultimately consider under the FFA with respect to the contaminated sediments within L-Lake exclusive of the Steel Creek stream channel and floodplain. A summary of the study results is presented in Appendix A. Based on these preliminary evaluations, DOE believes that institutional controls to prevent residential use of this area for a period that allows for natural radiological decay to safe levels may be the most reasonable remedial option. Natural decay would reduce cesium-137 (the primary contaminant of concern) to near background levels in 100 years. During that period, onsite worker exposure levels would be well below the current SRS occupational standards for radiation protection. This evaluation suggests that institutional control, and potentially no action, would be adequate to ensure protection of public health and the environment. Costs associated with those remedial options would not be great. For example, approximately $15,000 would be required for sign placement and deed notification under the institutional control option.

Response to Comment L9-19

DOE included Figure A-1 in the FEIS to show data points upon which the remedial options study is based. The revised remedial goal option for the onsite worker scenario at the 10^{-6} risk level presented in the FEIS is not representative of 10^{-4} risk level for the residential scenario as was the case for the DEIS. Therefore, the FEIS was revised to separately evaluate the onsite resident at the 10^{-4} risk level in the remedial options analyses presented in Appendix A.

Response to Comment L9-20

DOE found that calculated radiation doses to minnows in Par Pond, L-Lake, and Steel Creek were 1.3×10^{-5}, 4.9×10^{-5}, and 5.2×10^{-5} rad per day, respectively, well below the DOE aquatic organism limit of 1.0 rad per day. In addition to minnows, the Final EIS analyzed radiological impacts to largemouth bass. The calculated total radiation dose to largemouth bass in Par Pond was 3.9×10^{-4} rad per day, virtually all of which was due to exposure to one isotope, cesium-137. The calculated total radiation dose to largemouth bass in L-Lake was slightly lower, 2.1×10^{-4} rad per day, nearly all due to cesium-137.

Response to Comment L9-21

The FEIS presents a detailed description of the existing L-Lake ecosystem, with discussions of water quality, plankton, fish, wading birds, waterfowl, amphibians and reptiles, semi-aquatic mammals, and Federally-listed species, such as the bald eagle, that forage in and around the reservoir. The FEIS emphasizes L-Lake's ecological "value" as wading bird habitat, wintering waterfowl habitat, alligator habitat, and bald eagle foraging habitat. The importance of L-Lake as habitat for Federally-listed species is in a regional, as well as local, context in Section 4.3.5.3.

DOE has designated 30 areas on SRS totaling more than 14,000 acres as National Environmental Research Park (NERP) Set Aside Areas. These Set Aside Areas are undisturbed natural areas (e.g., Carolina bays and mature hardwood forests) that are protected to promote biological diversity locally and regionally and to provide baseline data to evaluate impacts of development on the SRS. They also serve as examples of how ecosystems should look and function after contaminated areas are remediated and restored. L-Lake, which is a man-made impoundment and has historically been influenced by SRS operations, would not be a good candidate for protection under the NERP Set-Aside program.

Response to Comment L9-22

DOE believes that submittal of a Site Evaluation Report for regulatory review under the terms of Section X of the FFA is unnecessary, and proposes further assessment of L-Lake under the FFA for consideration of early and final remedial actions. This approach is consistent with the terms of the FFA and supports ongoing initiatives to expedite the FFA process. (See the responses to Comments L10-01 and L9-09.)

Response to Comment L9-23

The response to Comment L9-09 addresses the "no net loss" of wetlands issue and mitigation measures. DOE agrees that continued operation of the River Water System is a reasonable and practicable alternative within the meaning of NEPA as it was evaluated in the EIS with the same scientific rigor and thoroughness as the other alternatives. However, the No-Action Alternative does not satisfy the purpose and need for agency action (see Section S.2 and Chapter 2 of the EIS), which is to identify surplus infrastructure such as the River Water System and develop an action plan for its disposition. This assumes that the River Water System has no mission and will become increasingly expensive to operate in the future.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
100 ALABAMA STREET, S.W.
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December 30, 1996

EAD/OEA-mh

Andrew R. Grainger
SR NEPA Compliance Officer
U.S. Department of Energy
P.O. Box 5031
Aiken, SC 29804-5031

SUBJECT: Draft Environmental Impact Statement (DOE/EIS-0268D) for the Shutdown of the River Water System at the Savannah River Site (SRS), Aiken, South Carolina

Dear Mr. Grainger:

We have reviewed the subject Environmental Impact Statement (EIS) in accordance with Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. The proposed action is to shut down the SRS River Water System and to place all or portions of the system in a standby condition. Overall, the Draft EIS is well written and illustrated. We agree that the format used enhances the clarity of the presentation of analyses (page 4-1). Our detailed comments are provided as an attachment.

This NEPA action should be coordinated to the fullest extent possible with Federal Facilities Agreement (FFA) activities. This coordination could be achieved in two ways: (1) a joint EIS/FFA Record of Decision (ROD); or, (2) expediting the FFA process so that implementation of the preferred alternative under the EIS ROD can be coordinated with the necessary FFA remedial action. It is EPA's opinion that coordinating the two decisions could best facilitate implementation of cleanup and operational shutdown activities. L10-01

Based on our review, we rate the Draft EIS "EC-2"; that is, we have environmental concerns about the project and more information is needed to fully assess the impacts. In particular, the issue of ecological risks warrants further discussion in the Final EIS. L10-02

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If you have questions about these comments, please contact Marion Hopkins of my staff at 404/562-9638. The EPA Remedial Project Manager for SRS is Jeff Crane. If you have questions specific to the FFA process, you may contact him at 404/562-8546.

Sincerely,

Heinz Mueller

Heinz J. Mueller, Chief
Office of Environmental Assessment

Attachment

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Comment L10. Page 2 of 7.

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Comments On
Draft Environmental Impact Statement
Shutdown of the River Water Distribution System at the
Savannah River Site
(DOE/EIS-0268D; November 1996)

General Comments

1. As summarized in Table S-2, the preferred alternative would result in the potential for increased exposure to contamination due to three primary changes in the physical state of the environment:

   Reduction of areal extent of impounded water would expose underlying contaminated sediments and thereby:

   1) Increase exposure to contamination by terrestrial fauna;
   2) Increase mobilization of contaminated sediments due to runoff erosion and wind dispersion; and,
   3) Decreased base flow of streams receiving both point source and non-point source discharges (e.g., contaminated ground water recharging streams) could effect an increase in contaminant concentrations within the stream.

   The resulting increases of contaminant exposure under the preferred alternative should be coordinated with a consideration of appropriate action under the terms of the FFA. The EIS provides a thorough documentation of the presence of L-Lake contamination. Therefore, in light of the thorough evaluation of L-Lake in the EIS, the L-Lake Site Evaluation under the terms of Section X of the FFA appears to be redundant documentation and unnecessary for the purposes of Section X of the FFA. The draft EIS provides sufficient information to add L-Lake to Appendix C of the FFA for consideration of early and final remedial actions. L10-0:

   Additionally, Appendix A to the EIS is an excellent resource for scoping the RI/FS for L-Lake. The thoroughness of the EIS documentation for L-Lake should support an expedited documentation process for a final remedy selection for L-Lake.

2. Section 1.4, pp. 1-6, and 7 The discussion of the FFA remedy selection process overstates the level of complexity and time necessary to yield cleanup decisions under the terms of the FFA. Terms such as "rigorous alternatives analysis", "long and involved" may be true for DOE internally; however, such terms are not implicit in the cleanup process under the FFA. L10-0

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The reference to a "near-term operational decision....in light of a long-term potential remedial action" is misleading. Whereas a remedial action for L-Lake may be a long-term solution, the evaluation and decision making process leading to a remedial action, as required under the FFA, may be expedited. DOE should be capable of accelerating a remedial action decision for L-Lake if DOE is interested in such an acceleration. In fact, as stated in General Comment 1 above, effort should be made to coordinate a cleanup decision and the preferred alternative. This coordination could be achieved in two ways:

1) a joint EIS/FFA ROD; or,
2) expediting the FFA process so that implementation of the preferred alternative under the EIS ROD can be coordinated with the necessary FFA remedial action.

It should be recognized under the two scenarios above that the end state objectives of the EIS ROD and the FFA ROD are similar (i.e., protect human health and the environment), although the cause for the RODs under the two programs differ considerably (i.e., EIS is operations driven, FFA is cleanup driven). Therefore, it is DOEs responsibility to pursue the approach which will best ensure protection of human health and the environment while effectively managing its resources to accomplish the objectives of both its operating program and cleanup program. It is EPA's opinion that coordinating the two decisions could best facilitate implementation of cleanup and operational shutdown activities which minimize funding needs for documentation and meet the common objectives of both programs. L10-04

3. Section 3.3.1.2, p. 3-6 Currently, L-Lake is a site included on Appendix G of the FFA. Appendix G includes sites which may require further investigation for consideration of remedial action. DOE's preferred alternative of standby is supported based on future site missions requiring water and the potential need to refill L-Lake as a CERCLA remedial action. Refilling Par Pond was chosen as an interim remedial action to stabilize the exposed sediments around the periphery of Par Pond. Final remedial action objectives have not been set for Par Pond. L10-05 Therefore, it appears inappropriately presumptive at this time to defend the preferred alternative of the EIS (i.e., standby) on the potential for establishing final remedial action objectives for L-Lake which require continued operation of the river water distribution system. Rather than base the EIS decision on a potential CERCLA ROD, the EIS and CERCLA programs should be combined to streamline documentation requirements and to select an alternative which is consistent with the objectives of the two programs. L10-06

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Specific Comments

1. Section S.3, p. S-2 Reference is made to "...apply other measures to minimize potential adverse effects of exposed sediments, which contains contaminants, in the lake bed." It is assumed that this is a reference to measures deemed necessary under the terms of the FFA. This reference should be clarified by expressing the expected approach, including scheduling, under the FFA. L10-07

2. Section 1.1, p. 1-4 A table illustrating the historic, current, and expected future flow rates to all waterways would help to convey the information presented in this section. L10-08

3. Section 1.1, p. 1-4 It appears that the reduction of flow through the river water distribution system from 23,000 gpm to 5,000 gpm could result in elevating concentrations of contaminants in portions of some streams due to a reduction of base flow rates with point source (e.g., NPDES discharges) and non-point source (e.g., ground water contaminant plume) discharges remaining constant. The appropriateness of the categorical exclusion, considering the reduced flow rates potential impact to stream contaminant levels, should be more thoroughly described. L10-09

4. Section 1.4, p. 1-7 The second to last paragraph of this section (L-Lake Site Evaluation...) states the basis for the EIS decision is various human health exposure scenarios. Exposure to ecological receptors is a primary decision factor for the actions under consideration and should be included in this discussion. L10-10

6. Section 1.4, p. 1-7 The last paragraph of this section (L-Lake Site Evaluation...) summarizes the approach to considering human health exposure and risk under the two decision making processes. Again, ecological risk is not mentioned. Additionally, as mentioned in General Comment 2 above, coordinating the decisions under the two programs could best facilitate effective use of DOEs resources. Such a coordinated decision must include the CERCLA risk evaluation methodology for remedy selection. L10-11

7. Section 1.4, p. 1-7 See Specific Comment 3 above. Irrespective of the appropriateness of the NEPA process for considering impacts to site streams for reducing base stream flow by a total of 18,000 gpm, implementation of the reduced pumping scenario (i.e., 5,000 gpm) should be evaluated under the terms of the FFA for consideration of remedial action to offset such an effect. Currently, the FFA mechanism for such consideration would be documented in the Remedial Investigation (RI) work plans for the Integrator Operable Units for the affected streams. However, timing of the development of these work plans and the startup of the reduced base flow may necessitate an earlier consideration of appropriate FFA action to offset reduced stream base flow. Alternatively, development and submission of the appropriate Integrator Operable Unit RI work plans to document the consideration of such early remedial actions could be expedited. L10-12

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Additionally, impact of reduced flow for non-point source discharges should be considered under the State's NPDES Program. It appears that the second to last subsection (Wastewater Discharges...) addresses this issue. A figure would be helpful to show the location of the permitted discharges. A table would be helpful which lists the streams, the reduced flow per stream and the discharge points per stream L10-13

9. Tables S-1 and 3-3 Present worth cost of the alternatives would more fairly portray the implications of life-cycle costs of the actions due to variations in long-term maintenance costs (e.g., Shutdown Deactivate may not require long-term maintenance of the L-Lake dam). L10-14

10. Section 4.1.1.2, p. 4-16 The fourth sentence begins "Elimination of river water from the geologic system could stimulate an earthquake..." Is this correct? If so, please elaborate. L10-15

11. Section 4.8, p. 4-186 This section refers the reader to Section 4.1 for details of commitments of natural resources associated with the loss of L-Lake. Given that Section 4.1 is eighty-five pages of material, it may be more appropriate to summarize the loss of natural resources in Section 4.8. L10-16

12. Section 5.4, pp. 5-2, and 3 This section states that "Natural Resource Trustees are responsible for evaluating natural resource injuries and for assessing damages related to such an injury." The EIS would benefit from a discussion of who the Trustees are and what their input in the proposed action has been to date. L10-17

13. Appendix A, p. A-1 The introduction states that "DOE anticipates that it will be several years before decisions for L-Lake can be made." DOE, as the Lead Agency under CERCLA, has the ability, and obligation under its new "10 Year Plan", to pursue acceleration of FFA activities. This section inappropriately describes the FFA schedules as being inflexible and apparently incapable of acceleration. See General Comment 2. L10-18

14. Appendix A, Section A.2 Although there are inadequacies in the evaluation (e.g., ecological risk based RGOs, preliminary RAOs which include 55 years of excavation at a cost of 1.7 billion), Appendix A and portions of the EIS are an excellent resource for scoping a streamlined RI/FS for L-Lake in a manner consistent with the "SAFER Methodology." L10-19

15. Appendix A, Section A.2.1 EPA agrees with the final two sentences of the opening paragraph to this section. Additionally, EPA believes that scoping the RI/FS for L-Lake, utilizing section A.2 as a starting point and following the "SAFER methodology" may support considerable streamlining of the RI/FS for this site. This streamlining may negate the need for developing significantly more detailed information beyond that which already exists, as expressed in the opening sentence to this paragraph. L10-20

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16. Appendix A, Section A.2.2 The lack of an ecological risk assessment is a fundamental gap in this analysis which would have to be addressed in scoping a final remedial action for L-Lake. L10-21

17. Appendix A, Section A.3 Accelerating the RI/FS for this site to be coordinated with the EIS action should negate the need for additional "Mitigation Plan" documentation identified in this section. L10-22

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Advance Delivery of Comments Included in Letter L10

DOE received a letter from EPA by facsimile transmission on December 13, 1996. DOE addresses the comments in that letter, which was from Jeffrey L. Crane to Brian Hennessy, in the responses to EPA's formal comment transmission in Letter L10.

Response to Comment L10-01

DOE is committed to coordinating NEPA actions being considered in this EIS with SRS remediation activities planned and conducted in accordance with CERCLA under the FFA, and has initiated discussions with EPA and SCDHEC to determine reasonable means of expediting the FFA process to achieve appropriate coordination.

As a first measure to expedite the FFA process, DOE has compared data on L-Lake contamination used to support the NEPA analyses presented in the EIS with criteria used under the FFA for Site Evaluations to decide if additional characterization and, if necessary, remediation, is needed (i.e., to determine if the site should be included on the RCRA/CERCLA Units List in Appendix C of the FFA). On the basis of this comparison and discussions with EPA and SCDHEC staff, DOE has proposed to assess L-Lake under the FFA and bypass preparation and review of a Site Evaluation Report. DOE agrees with EPA that available data are sufficient to expedite the FFA process for scoping additional studies to characterize and, if necessary, remediate L-Lake.

DOE also intends to coordinate this NEPA action with FFA activities by ensuring that data obtained in the context of NEPA evaluations are appropriately utilized in FFA activities. In addition, DOE will continue to ensure that its operational decisions regarding the River Water System made on the basis of this EIS are consistent with potential remedial decisions for L-Lake that may be made under the FFA, as demonstrated by the analysis presented in Appendix A of this EIS and by the fact that its preferred action in this EIS preserves the option of refilling the lake in the event that such action is determined to be necessary under the FFA. Further, if DOE selects a shutdown alternative, DOE would implement measures to limit potential risk from contaminated lake sediments that are exposed as lake drawdown occurs. These actions may include implementing institutional and/or administrative access controls, monitoring exposures to workers and visitors, implementing measures to control erosion of exposed lake sediments by wind and water, and surveying and monitoring of exposed sediment to further characterize the area and to ensure risk levels are at or below predicted levels.

DOE proposes that these and other potential measures to coordinate the NEPA and EIS processes be considered in the context of ongoing discussions being conducted under the FFA, which provides the appropriate framework for planning L-Lake remediation.

Response to Comment L10-02

In response to this comment, DOE has provided further evaluation of ecological risk in Appendix B.

Response to Comment L10-03

DOE will continue to consider appropriate remedial actions under the FFA in response to increases in contaminant exposure that could result if the DOE decision is implementation of its preferred alternative. DOE is encouraged that EPA feels that the documentation process for L-Lake remedy selection can be expedited due to the thorough analysis provided in the EIS. DOE agrees that a formal Site Evaluation prepared under the terms of Section X of the FFA is unnecessary, and be further assessed under the FFA. (See response to Comment L10-01.)

Response to Comment L10-04

In response to this comment, DOE revised Appendix A and the referenced statements in Section 1.4. DOE's experience indicates that the level of complexity and time necessary to yield cleanup decisions under the FFA can vary widely depending on the complexity of the site, availability of appropriate cleanup methods, and other factors. In the case of L-Lake, DOE believes that the decisionmaking process can be expedited considerably with respect to some actions. As noted in response to Comment L10-01, DOE believes that existing analyses are sufficient to allow for further assessment of L-Lake under the FFA (i. e., no Site Evaluation Report is needed) and to initiate the process for scoping additional studies that may be necessary under the FFA. Such actions would be relatively uncomplicated and expeditious.

However, DOE believes that a final cleanup decision for L-Lake under the FFA would be premature at this time. This belief was established in view of the possible need for additional characterization, risk determination and prioritization, and appropriate funding, and the fact that the impoundment is an important site to be considered in addressing remedial decisions for the Steel Creek IOU. There is a probable need for more detailed characterization of the lakebed sediments, which DOE could most cost-effectively conduct as sediments are exposed during drawdown (if DOE selects a shutdown alternative). In addition, final remedial decisions for the lake should be made in consideration of remediation options for the Steel Creek IOU, the determination of which will be based on comprehensive review of data available for component streams and contributing sources in the watershed (including submerged stream channel and floodplain areas within L-Lake) and appropriate risk evaluations. This process will take considerable time and resources.

Response to Comment L10-05

In response to this comment, DOE has revised Section 3.3.1.1 to confirm its commitment to remedy the unlikely drawdown of Par Pond in the near term until final CERCLA remedial actions are implemented. It has also revised Section 3.3.1 to clarify its intent in providing the three restart examples.

Response to Comment L10-06

As indicated in response to Comment L10-01, DOE believes that documentation requirements for L-Lake remediation can be streamlined by initiating the scoping process under the FFA without submittal of the Site Evaluation Report. This EIS demonstrates that a timely operational decision to implement its proposed action would be cost-effective, protective of human health and the environment, and provide for orderly consideration of relative risk and associated funding priorities under the FFA. The proposed action would also preserve the capability to supply cooling water in support of future site missions, refill Par Pond, or to refill L-Lake until final decisions are made with respect to these matters.

Response to Comment L10-07

As indicated in response to Comments L10-01, measures that DOE would apply to limit potential risk from contaminated lake sediments exposed as a result of lake drawdown may include institutional and/or administrative access controls, monitoring exposures to workers and visitors, erosion controls, and surveying and monitoring of exposed sediment to further characterize the area and to ensure risk levels are at or below predicted levels. In accordance with its NEPA implementing regulations at 10 CFR 1021.331, DOE would detail these commitments in its Record of Decision and, if necessary, would explain how these measures would be planned and implemented in a Mitigation Action Plan. DOE would coordinate with EPA and SCDHEC to ensure such measures are consistent with actions that may taken under the FFA regarding L-Lake and the extent to which such measures could be implemented under the FFA in consideration of such factors as scheduling. However, DOE would take appropriate measures to limit risk as part of NEPA actions considered in this EIS and the NEPA Record of Decision, irrespective of its obligations under CERCLA and the FFA.

Response to Comment L10-08

In response to this comment, DOE prepared the suggested table. See Table 1-1 in Section 1.1

Response to Comment L10-09

In response to this comment, DOE revised Section 1.1 to include a more thorough description of the process and the appropriateness of the categorical exclusion for operation of the 5,000 gallon per minute pump. DOE reviewed this categorical exclusion considering the reduced flow rates and increased concentrations in onset streams and determined that incremental adverse impacts would be very small (Section 4.2.2 compares September 1996 concentrations to those that will occur when operating the small pump and those that would occur under shutdown).

Although the streams are not used as a source of drinking, exposures to involved workers are assumed to occur due to incidental ingestion of sediments and through dermal absorption. It should be noted that the increase in contaminant concentrations in the streams would not result in incremental adverse impacts to uninvolved workers or offsite populations.

The first table in Section 4.2.8.2 has been revised to indicate the incremental risk for the involved worker resulting from small pump operation under the No-Action Alternative. Table 4-26 presents the tritium concentrations that relate to the stream (Pen Branch) with the largest increase in concentrations under this alternative. The values presented in this table represent very small increases in risk that would not result in measurable adverse impacts to the workers.

The hypothetical maximally exposed offsite individual and the drinking water population at Beaufort, Jasper, and Port Wentworth withdraw drinking water from the Savannah River. Because contaminant discharges would remain constant and the flow in the Savannah River downstream of the discharges of Fourmile Branch and Pen Branch would not change, concentrations in the Savannah River would not change and would remain well below drinking water limits. Further, Section B.6 demonstrates that ecological effects from contaminants are unlikely under each alternative, including the No-Action Alternative and its discharges of 5,000 gallons per minute to onsite streams.

Response to Comment L10-10

In response to this comment, DOE has revised the referenced paragraph to include the fact that exposures to ecological receptors, as well as human receptors, are evaluated for realistic exposure conditions. Appendix B has been revised to more thoroughly evaluate risk to ecological receptors.

Response to Comment L10-11

DOE acknowledges that ecological risk is an important component of decisionmaking on the River Water System and has provided detailed evaluations in Sections 4.1.5, 4.2.5, and 4.3.5. These evaluations are supported, in part, by the revised and expanded discussions in Appendix B.

As the responses to Comments L10-01 and L10-04 indicate, DOE will coordinate the decisionmaking processes of NEPA and CERCLA to the fullest extent practical.

Response to Comment L10-12

As indicated in the Response to Comment L10-09, DOE does not expect adverse impacts from this operational decision. It will rely on the prioritization and scheduling processes of the FFA to determine the need for expediting Integrator Operable Unit RI work plans. DOE believes that if it is necessary to reduce contaminant concentrations, the preferable method would be to reduce the discharge of contaminants by a customary method such as closing and capping the source rather than to augment the flow in the affected onsite streams.

Response to Comment L10-13

DOE agrees that the suggested figure and table permit a quicker understanding of the SRS wastewater discharge paths and will include them in the Final EIS. Non-point source (e.g., ground water contaminant plume seepline) discharges are not regulated under South Carolina's NPDES program. Nonetheless, the impact of reduced stream flow on such discharges is being evaluated by DOE and the results will be discussed in the Final EIS.

Response to Comment L10-14

DOE considered expressing the present worth of costs of the layup and restart expenditures in these tables. However, it decided that such presentation would be confusing due to the unknown need to restart and the period of layup. Further, in the absence of detailed project plans for layup and restart options, such "fine tuning" is not justified. If DOE decides to shut down and maintain the River Water System, it would prepare detailed project plans to further assist in identifying the preferred layup option.

Section 3.2 confirms that under the shutdown and deactivate alternative, maintenance of L-Lake dam would be discontinued after the lake is entirely drained.

Response to Comment L10-15

Elimination of river water from the geologic system could *not* stimulate an earthquake. This statement has been corrected in Section 4.1.1.2 of the document.

Response to Comment L10-16

Section 4.8 has been revised to include a table summarizing the irreversibly and irretrievably committed natural resources.

Response to Comment L10-17

A goal of NEPA is to provide the public, state, and Federal agencies and other interested parties an opportunity to present their views and comments on a proposed Federal action and its alternatives through the public scoping process and the document review process. DOE acknowledges the Natural Resources Trustees as one of many stakeholders with an interest in the Proposed Action and its impacts. In their role as primary Federal Trustee, DOE notified the SRS Natural Resource Trustees of the proposal concerning the shutdown of the River Water System in March 1996 and presented the Trustees with additional information at the June 11, 1996, meeting where comments were solicited. The roles and responsibilities of the Natural Resource Trustees in the evaluation of natural resource injuries and the assessment of damages related to such an injury are authorized in Section 107(f) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). DOE conducts these activities under the authority of and in compliance with the requirements of 43 CFR 11.

Because the role and responsibilities of the Natural Resource Trustees vested in CERCLA, DOE expanded the section of primary interest to the Natural Resource Trustees (Section 4.8, Irreversible or Irretrievable Commitment of

Resources). DOE believes that additional discussion within the text of the EIS is not warranted.

Response to Comment L10-18

DOE does not intend to imply that FFA schedules are inflexible and incapable of acceleration, and has revised the introduction to clarify its intent to explore reasonable means to streamline the remedial decision process with respect to L-Lake. DOE remains committed to pursue acceleration of FFA activities under its 10-Year Plan. (See response to Comments L10-01 and -04.)

Response to Comment L10-19

DOE agrees that information presented in the EIS will assist in streamlining the RI/FS process for L-Lake consistent with EPA's Streamlined Approach for Environmental Restoration (SAFER) methodology. (See responses to Comments L10-01 and -04.)

Response to Comment L10-20

DOE agrees that information presented in the EIS will assist in streamlining the RI/FS process for L-Lake consistent with SAFER methodology and that the SAFER methodology will be useful in determining additional data needs, if any. (See responses to Comments L10-01 and -04.)

Response to Comment L10-21

See response to comment L10-02.

Response to Comment L10-22

As noted in response to Comment L10-01, DOE would implement measures to limit potential risk from contaminated lake sediments that are exposed if its operational decision results in lake drawdown. These actions may include implementing institutional and/or administrative access controls, monitoring exposures to workers and visitors, implementing measures to control erosion of exposed lake sediments by wind and water, and surveying and monitoring of exposed sediment to further characterize the area and to ensure risk levels are at or below predicted levels. In accordance with its NEPA implementing regulations at 10 CFR 1021.331, DOE would detail these commitments in its Record of Decision and, if necessary, would explain how these measures would be planned and implemented in a Mitigation Action Plan.

01/02/97 THU 09:52 FAX 803 725 7888 ESHQ 001

12/31/96 TUE 15:59 FAX 803 725 3309 SREL 001

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FROM: Gary Wein

Number of pages (including cover sheet): 5

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Comment L11. Page 1 of 5.

01/02/97 THU 09:52 FAX 803 725 7888 ESHQ 002
12/31/96 TUE 15:59 FAX 803 725 3309 SREL 002

MEMO

TO:Drew Grainger

FROM: Gary R. Wein, Savannah River Ecology Laboratory December 31, 1996

Listed below are some general comments on the *Draft Environmental Impact Statement: Shutdown of the River Water System at the Savannah River Site.* Hopefully these comments and suggestions are helpful and self-explanatory. If not please do not hesitate to contact me for further information or detail (5-8228).

cc: Janecek

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01/02/97 THU 09:53 FAX 803 725 7688 ESHQ 005
12/31/96 TUE 15:59 FAX 803 725 3309 SREL 003

Page	Section	Paragraph	Comments	
S-3	S.5	3	The site description makes no note that upland pine communities are predominantly pine silviculture.	L11-01
3-4	3.2.1	bullet 2	Portions of L-Lake that are non-floodplain areas are not mentioned. How will these areas, that make up most of what would be the former lake bed be handled to avoid soil erosion or restored?	L11-02
4-2 Biological stocking, etc. discharge	4.1	2	While the construction of artificial reefs is mentioned, other activities that were conducted to promote a Balanced Community such as the planting of vegetation, fish are not mentioned. Nor is the latter addition of the canal.	L11-03
4-12	figure 4-6,7,8,9		There are GIS layers available that would make the production of these figures easier and also allow the construction of one or two figures rather than the 4.	L11-04
4-20	4.1.1.2		The section on Plant Nutrients is mistitled and should be changed to Nutrient Loading. There is no discussion of plant nutrients in this section but those based on sampling water chemistry. Also there is no discussion of impacts of heated effluent on water chemistry. One of the major impacts on nutrient availability in L-Lake was not the augmented flows with reactor operations but the heating of Savannah River water by the reactor releasing nutrients. This is the reason we cook food, to make nutrients more available to our digestive systems. This is an analogous situation.	L11-05
4-21	4.1.2.1		Chuck Jagoe of SREL may have mercury data in fish that contradict the findings of Paller (1996) and suggest that mercury levels in fish of L-Lake may be higher than those found in Par Pond.	L11-06
4-38	4.1.5.1		No mention is made of affected plant communities. The presence of animals is more determined by the structure provided by the plant communities then the mere presence of water.	L11-07
4-40	4.1.5.1.1	3	Birds have been censused by researchers associated with SREL since 1988 or 1989 on a quarterly basis. Contact Dr. I. Lehr Brisbin, Laura Janecek, or Bobby Kennamer for additional details.	L11-08
4-41	4.1.5.1.2		Plankton. The most definitive and complete survey of plankton in L-Lake is not mentioned or referenced in this section. See Taylor	L11-09

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Page	Section	Paragraph	Comments	
			et al.1993 as listed on page 4-199.	
4-48	4.1.5.1.3	2	See Collins and Wein. 1995. Wetlands 15:374-385 for a 1992 survey of extant and seedbank wetland vegetation from 43 sites in L-Lake.	L11-10
4-50	4.1.5.2.1	1	What is source of information that causes the authors to predict an expected reservoir decline in productivity?	L11-11
4-50	4.1.5.2.2	1	Many of the semiaquatic and terrestrial animals depend upon L-Lake for more than food and drink. This a bit simplistic and anthropomorphic. They do need L-Lake as a source of food resources, habitat for breeding, etc.	L11-12
4-50	4.1.5.2.2	2	Failure to maintain water levels in L-Lake is a major disturbance to the existing ecosystem, no matter how you cut it. What is the loss of habitat in acres per year if you follow the shut down and deactivate scenario.	L11-13
4-53	4.1.5.2.2		Wetlands Ecology. I find this section a bit confusing. There is an initial attempt to suggest that water loss in L-Lake will mimic natural yearly flucuations in bottomland hardwoods or Carolina bays. Neither of these systems are anything like a lake or reservoir. The loss of water is permanent and gradually decreasing not a yearly event. The rest of the section can best be summarized as "succession will occur." A discussion of succession should include potential plant propagule sources (seedbank, wind dispersed, surviving plants) and patterns of colonization expected as the water level drops. I would recommend that this section be rewritten and its objective be stated in an initial introductory paragraph.	L11-14
4-53	4.1.5.2.2	8	The list of 7 species listed as colonizer of Lost Lake only includes 3 wetland species and all but the buttonbush are indicative of highly disturbed undesirable habitats. I am not sure what the point of this paragraph is, but it does not assure me that a productive community will replace the current one.	L11-15
4-107	4.2.5.1.1	3	Steel Creek. Some recent work by Joel Snodgrass and Gary Meffe of SREL has recently summarized and evaluated long terms trends in Steel Creek fish using John Aho's data. This recent work may paint a different picture than the one that is presented.	L11-16

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01/02/97 THU 09:53 FAX 803 725 7688 ESHQ 004
12/31/96 TUE 16:00 FAX 803 725 3309 SREL 005

Page	Section	Paragraph	Comments	
4-113	4.2.5.2.1	2	Steel Creek. Please note that Steel Creek was highly disturbed before L-Lake was constructed and that a return to conditions before its construction does not mean a return to the aquatic community before L-Lake is desirable.	L11-17
4-115	4.2.5.2.1	3	*Quercus alba*, *Q. Velutina*, and *Carya tomentosa* are not the species I would have selected as future invaders of this area. More than likely it will be willow, loblolly pine, and sweetgum. If the site is at all wet you might expect cypress, willow, cottonwood, or tupelo. The noted species are much more commonly found on our bluff forests in thin strands along our stream drainages in locations that are almost never flooded. I would delete this sentence.	L11-18
4-139	4.3.5.1.3		Wetland Ecology. Par is not a palustrine swamp but a lacustrine emergent marsh with persistant and nonpersistant herbaceous vegetation. The reference that calls Par Pond a palustrine swamp should be checked for accuracy.	L11-19

General Comment
How does the losts of habitat at L-Lake affect the overall abundance of this habitat type in the southeastern US? Is this a rare habitat type or is it abundant and common? L11-20

PK64-28PC

Comment L11. Page 5 of 5.

Response to Comment L11-01

The description of SRS natural communities in the DEIS has been expanded in the FEIS to include a discussion of upland pine communities that are managed for timber production and the enhancement of wildlife habitat.

Response to Comment L11-02

The FEIS makes clear that portions of what is now L-Lake formerly supported mixed upland forests of loblolly pine, longleaf pine, and several hardwood species. As the lake level recedes, these native pine and hardwood species would be allowed to recolonize upland areas. It may also be necessary to hand-plant some of these species to accelerate the process of revegetation.

Response to Comment L11-03

The FEIS notes (in Section 4.1.5.1.2) that 40,000 bluegill and 4,000 largemouth bass were stocked in L-Lake in 1985 and 1986 to speed the development of a Balanced Biological Community. The FEIS also describes (in Section 4.1.5.1.3) the planting of wetland vegetation in L-Lake, also part of the effort to establish a Balanced Biological Community.

Response to Comment L11-04

The soil scientists who prepared these figures used readily-available aerial photographs and soils surveys, rather than relying on other SRS organizations for the production of GIS layers.

Response to Comment L11-05

The entire discussion in this section is on plant nutrients; the plant nutrients in question are the aquatic macrophytes and phytoplankton of the reservoir. This is implied by the discussions of primary productivity [which Odum defines as "energy stored by photosynthetic and chemosynthetic activity of producer organisms (chiefly green plants)"] and eutrophication (a trophic condition in which a body of water is rich in nutrients and high in plant productivity). This section of the FEIS has been renamed "Nutrient Loading" for the sake of clarity and to prevent any possible confusion.

Response to Comment L11-06

A number of studies have been conducted to determine mercury levels in the fish of Par Pond and L-Lake. Most of these studies, particularly in recent years, have determined that mercury levels are higher in Par Pond fish than L-Lake fish. A 1996 SREL study of potential wood stork prey (small sunfish and bass) also showed that levels of mercury were higher in Par Pond fish than L-Lake fish.

Response to Comment L11-07

The aquatic plant communities of L-Lake were described in considerable detail in the DEIS. A brief section describing the terrestrial plant communities surrounding L-Lake has been added to the FEIS.

Response to Comment L11-08

The FEIS contains an expanded and updated discussion of waterfowl usage of L-Lake and Par Pond.

Response to Comment L11-09

The Final EIS contains a thorough discussion of the development of the zooplankton community in L-Lake over the 1986-1992 period. The journal article mentioned by the comments (Taylor et al. 1993) focuses on the effects of heated reactor effluent over a short period (1986-1989).

Response to Comment L11-10

Collins and Wein (1995) is now the basis for some of the discussion in Section 4.1.5.2.2, as it suggests species that will recolonize the lakebed as the reservoir recedes.

Response to Comment L11-11

The FEIS presents sources for this assertion.

Response to Comment L11-12

This statement in the DEIS is simplistic and somewhat misleading. The FEIS is less simplistic, explaining that L-Lake provides many amphibians, reptiles, and semi-aquatic mammals with critical habitat needs (e.g., breeding and nesting habitat) as well as food and water.

Response to Comment L11-13

The FEIS discusses the two "end points" (reservoir ecosystem and stream ecosystem), but does not attempt to quantify the amount of fish and wildlife habitat that would be present in the interim stages. This is intentional, because it would be difficult to predict the rate of reservoir withdrawal with sufficient accuracy - the rate of change would be largely dependent on seasonal and annual cycles of rainfall. Clearly, these cycles would be impossible to predict.

Response to Comment L11-14

The "Wetlands Ecology" section of the DEIS has been reorganized and heavily revised, based on this and other comments. As noted previously, Collins and Wein (1995) is now the basis for some of the discussion in Section 4.1.5.2.2 of the FEIS, as it suggests plant species that would recolonize the lakebed as the reservoir recedes.

Response to Comment L11-15

See the response to Comment 11-14.

Response to Comment L11-16

The FEIS describes the results of a number of fish studies in the Steel Creek drainage conducted over a number of years. Subtle differences in interpretation of the same fish population studies would not affect in a meaningful way the predictions of impacts associated with the Proposed Action.

Response to Comment L11-17

The DEIS makes clear that Steel Creek is a highly disturbed system, noting that it began receiving thermal effluent from P- and R-Reactors in 1954. Clearly, a return to conditions that existed prior to the creation of the Savannah River Plant (or even prior to agricultural development in the watershed) would be preferable to some semi-disturbed or altered state. The FEIS is even more explicit, explaining that pre-1984 conditions are not the desired endpoint, but rather a condition in which historical stream flows are restored and the kinds of plant and animal communities that existed under historical (pre-SRS) stream flows and conditions (before cooling water and contaminants were introduced) are restored.

Response to Comment L11-18

The DEIS has been revised and the offending sentence removed. The FEIS makes clear that species such as alder, willow, and cottonwood will likely colonize wetter areas and species such as sweetgum, red maple, and loblolly pine will likely colonize drier areas.

Response to Comment L11-19

Section 4.3.5.1.3 of the FEIS has been revised accordingly.

Response to Comment L11-20

The FEIS attempts to place the reservoir and its plant and animal communities in more of a regional context, as the commentor recommends. For example, its regional importance as a wintering area for waterfowl (diving ducks in particular) is stressed.

January 3, 1997
807 E. Rollingwood Rd.
Aiken, SC 29801

Mr. Andrew R. Granger
Engineering & Analysis Division
SR NEPA Compliance Officer
U. S. Department of Energy
Savannah River Operations Office
P. O. Box 5031; Code DRW
Aiken, SC 29804-5031

FAX 725-7688

Attn.: RWEIS

Re: Comments on November 1996 DEIS, "Shutdown of the River Water System at the Savannah River Site."

Thank you for the opportunity to comment on the Draft EIS, "Shutdown of the River Water System at the Savannah River Site." My comments are later than the established comment period but I hope you will find them useful and be able to respond to them in your preparation of the final EIS.

I would like to provide four general comments and my recommendation on how I see the EIS decision. They are in the section on General Comments. In addition I am providing several specific comments.

General Comments:

- The proposed action described in the public meeting on December 4 and in the draft EIS seem to be inconsistent. In the public meeting, the proposed action was stated to be shutdown the water system and maintain it so it could be restarted in a relatively short time. In the draft EIS, the description of the proposed action is much less definitive. The EIS should be more specific on the consideration on the proposed action. As I understand the draft EIS, I support the shutdown portion but not the maintaining some part for the capability to pump to Par Pond, refill L-Lake, or to support some unspecified future mission. Based upon the information given in the DEIS, the risk of needing water for Par Pond or L-Lake is quite low and acceptable. Equipment replacement cost and time to restart the system is minimal and would be available from whatever new mission comes to SRS in the future and requires the water. The increased annual savings from shutdown justify this risk. L12-01
- The question of river water rights came up at the public meeting but no answers were available at the meeting. The EIS should include information on problems (political, permitting, etc.) that may be encountered in restarting river water withdrawal if it is stopped as part of this EIS's decision. Are there any water rights issues? L12-02
- Increased groundwater use should be more clearly defined in the EIS if it is required to replace river water. The EIS contains statements about increased ground water usage in various places in the EIS and draws the conclusion that the 200 gal/min L12-03

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Comment L12. Page 1 of 2.

groundwater in K and L-Areas will not result in the aquifer condition changing (p. 4-31). Dispersed throughout the report, comments are made about increased ground water usage. No where could I find this subject integrated so a reasonable conclusion could be reached on the impact of the increased ground water usage caused by decreased river water usage. Examples of some of these ground water usage are: compressor cooling water requirements (p. 1-8), fire protection requirements for L & K-Areas (p. 1-4), sanitary waste water treatment usage, etc.

- Some of the terms and schedules identified in the DEIS are inconsistent with similar actions in other DOE reports. For example on page 1-8 the statement is made that DOE intends to deactivate P-Area by early 1997. The DOE draft 10-Year Plan identifies R, P, and C-Areas transition to Long Term Monitoring in 2001, 2002, and 2003 respectively. The terms and schedules used are different. L12-04

Specific Comments:

- The lead-in statement on page S-4 calling out Table S-2 does not describe the intent of the table. L12-05
- Tables S-2 and 3-4 and other ecological sections use unfamiliar words such as "eqilimnion," "hypolimnion," etc. that are not included in the glossary. L12-06
- The paragraph on page 1-7 on CERCLA radiological analyses differences from those in the DEIS needs to be expanded to say why these two approaches are different and what is the relationship between them. Why is the issue raised? L12-07
- Tables S-2 and 3-4 entries should be reviewed to ensure wording provides an understanding of the relative consequences of the no action and the shutdown alternatives. L12-08
- I presume the "affect" referenced under esthetics on Tables S-2 and 3-4 is intended to say "viewed by". L12-09

Thanks again for the opportunity to review this draft EIS I hope these comments will help DOE make the appropriate decision.

Sincerely,

Lee Poe

W. Lee Poe, Jr.

2

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Comment L12. Page 2 of 2.

Response to Comment L12-01

DOE did not intend to convey a different understanding of the proposed action at the public meeting. The proposed action must provide flexibility in choosing layup options. Under the proposed action DOE presents in Section 3.3.2 a wide variety of layup options that vary in the time to restart (from 1 to 30 months), the layup scheme (e.g., maintain in a dry pipe condition), and cost.

DOE has revised Section 3.3.1.1 to confirm its commitment to remedy the unlikely drawdown of Par Pond in the near term until final CERCLA remedial actions are implemented.

DOE has also revised Section 3.3.1 to clarify its intent in providing the three restart examples. Basically, DOE does not wish to imply that it expects to actually need to restart the system for the situations presented but has selected them to cover a range of actions that maintenance in standby would support (i.e., pump to L-Lake, Par Pond, or a new facility).

The example that was presented for a new mission was Accelerator Production of Tritium (APT). Other potential missions that might require enough cooling water to make the use of the River Water System a viable option include Tritium Extraction Facility, International Thermonuclear Experimental Reactor, and Mixed Oxide Fuel Manufacturing Plant.

Response to Comment L12-02

There are no current river water rights issues (e.g., permitting) associated with restarting the River Water System which would likely cause a problem at restart. A permit is not required to withdraw water from the river. [See response to L15-2 for detail on regulatory issues which may need to be addressed, including a possible Section 316(b) study]. Likewise, there are no "water rights" regulations governing SRS's use of Savannah River water. It is not anticipated that downstream users of Savannah River water would be affected by the shutdown or potentially a restart of the River Water System. Any use of river water for other missions (e.g. APT) would be addressed in an EIS addressing that project.

Response to Comment L12-03

DOE revised Sections 1.4, 4.1.3.2 and 4.8 to clarify potential increased groundwater usage.

Response to Comment L12-04

The quoted dates for long-term monitoring from the DOE Draft 10-Year Plan are correct (DOE 1996). However, the P-Area sanitary wastewater plant was disconnected in November 1996. Because it is a package unit, it is being maintained for potential use at another location.

DOE has revised Section 1.4 to identify this shut down action in 1997 rather than deactivation of P-Area by early 1997.

Response to Comment L12-05

DOE has revised the lead-in statement to Tables S-2 and 3-6 to describe the intent of the table.

Response to Comment L12-06

DOE has expanded the glossary to include epilimnion and other unfamiliar words that had not been previously included.

Response to Comment L12-07

As stated in the EIS, CERCLA radiological analyses report impacts in terms of cancer morbidity (incidence) while impacts under NEPA are reported as latent cancer fatalities. Cancer morbidity is calculated by applying the EPA ingestion, inhalation, or external exposure slope factor to the lifetime committed effective dose equivalent. The fatal cancer risk is calculated by multiplying the lifetime committed effective dose equivalent by an ICRP fatal cancer lifetime risk, health-effects conversion factor. The two risks are not directly related; however, the fatal cancer risk can be approximated by multiplying the cancer morbidity risk by the ratio of the fatal cancer lifetime risk health-effects conversion factor to the total cancer lifetime risk health-effects conversion factor.

The differences between the two types of radiological analyses are discussed so that the reader understands that the risks reported in the Occupational and Public Health sections of this EIS are different than those risks reported in Appendix A or other documents related to on-going CERCLA activities for L-Lake.

Response to Comment L12-08

DOE reviewed Tables S-2 and 3-6 and determined that the wording, as supported by the introductory bullets, provides an understanding of the relative consequences of the no action and the shutdown alternatives.

Response to Comment L12-09

The aesthetics sections of Tables S-2 and 3-6 have been revised to state that the action "could be viewed by 1,800 SRS workers who pass by daily."

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201-1708

January 3, 1997

Department of Energy
Savannah River Operations Office
Attn: Mr. Andrew R. Grainger, SR NEPA Compliance Officer
P.O. Box A
Aiken, SC 29802

Shutdown of the River Water System at the Savannah River Site; Draft EIS Environmental Review

Dear Mr. Grainger:

We have reviewed the above referenced EIS received November 13, 1996. The South Carolina Department of Health and Environmental Control Bureau of Water Pollution Control administers applicable regulations pertaining to water quality standards and classifications, including wetland protection, in accordance with the South Carolina Pollution Control Act, the South Carolina Constitution, the Federal Clean Water Act, and associated regulations for these statutes. We are providing the following comments addressing impacts the proposed action will have to water quality, aquatic ecology and wetlands ecology in L-Lake, Par Pond, Steel Creek, Lower Three Runs Creek and other stream systems on the Savannah River Site.

Surface Water

Water quality in Par Pond would revert to that typically found in reservoirs due to reduction of nutrients from the Savannah River, however DOE could resume pumping to Par Pond if conditions warranted. The Department is of the opinion that existing water quality would be maintained or improved. L13-01

L-Lake would gradually recede and revert to stream conditions with potential for lake bed erosion and turbidity increases. The implementation of best management practices may be appropriate if natural vegetation is not quickly established and erosion becomes a problem. These practices may include use of mulches, hay bales, silt fences, or other devices capable of preventing erosion and migration of sediments. In addition, exposed lake bed subject to erosion should be stabilized with vegetative cover which may include sprigging, trees, shrubs, vines or ground cover. L13-02 During lake drawdown, a reduction in nutrients will reduce productivity, with the result that the reservoir may shift to a less eutrophic or even mesotrophic condition until drained. A reduction in dissolved oxygen, temperature and increased acidity in the epilimnion and hypolimnion of the lake is also anticipated, however these conditions will be temporary (lasting until the lake is drained) and should not contravene water quality standards nor change existing uses of L-Lake. L13-03

Existing NPDES permits for discharges into L and K areas must be reviewed by the Department and will be subject to NPDES regulations. The EIS reports that an alternate compliance method (septic tanks) will be L13-04

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Comment L13. Page 1 of 3.

Page 2
Mr. Andrew R. Grainger
January 3, 1997

required for the existing L-Area Sanitary Wastewater Treatment Plant. Septic tank installation must be permitted by the Department Lower Savannah Health District.

Steel Creek may be impacted by siltation below the L-Lake dam as potentially contaminated sediments are scoured from the lake bed and transported downstream after the lake is drained. It is anticipated that transported material will be detained in a small impounded area until filled with sediment, after which point the material could move downstream into Steel Creek during storm events. Although contaminants (e.g. cesium-137) are also present in Steel Creek sediments downstream of the L-Lake dam, the Department is concerned about the transport of additional contaminated sediments in the lake. Sediment material collected in the impounded area adjacent to the L-Lake dam should be periodically tested, removed and disposed of in accordance with the Department Bureau of Solid and Hazardous Waste requirements to avoid downstream migration. L13-(

Aquatic Ecology

The proposed draining of L-Lake would not require any State or Federal permits; however, SRS is responsible for insuring that water quality standards are not violated by this change. Certain precautions such as draining during cooler weather and releasing water from the surface of the lake will minimize adverse effects downstream. The proposed draining of L-Lake will replace a 1000-acre reservoir ecosystem with a small stream ecosystem. The SRS has put considerable effort into demonstrating a balanced biological community in the lake by constructing artificial fish habitats, planting littoral vegetation and implementing an intensive monitoring program. Thus, an aquatic life use of the lake has been established. Although this reservoir community habitat is significant, it does not represent the natural stream community and aquatic life uses of Steel Creek prior to construction of the Lake. Therefore, the Department supports stream restoration. L13-(

Wetlands

The draining of L-Lake will result in the eventual loss of approximately 122 acres of littoral community consisting of submerged, emergent, and floating-leaved aquatic plant species. However, the slow rate at which the lake is expected to recede should allow this community to migrate in shoreline areas and revert, through succession, to a stream wetland community. Re-establishment of the stream reach should result in the eventual regeneration of much of the approximately 225 acres of bottomland hardwood forested wetlands that were lost when L-Lake was constructed. The Department supports the reestablishment of the natural (pre-impoundment) wetland system associated with Steel Creek. Stream wetland restoration may require regrading to pre-impoundment contours and planting appropriate species in adequate densities to assure reestablishment of a stream associated wetland community. L13-(

The EIS reports that the proposed action should not result in other impacts to streams or lakes on the SRS. In addition, the Department is of the opinion that the proposed action will not change the existing

PK64-30PC

Comment L13. Page 2 of 3.

Page 3
Mr. Andrew R. Grainger
January 3, 1997

status of navigation in waters on the Site. We appreciate the opportunity to comment on this EIS. Please call Mark Giffin at (803) 734-5302 if you have any questions.

Sincerely,

Sally C. Knowles

Sally C. Knowles, Director
Division of Water Quality

SCK:MAG

PK64-31PC

Comment L13. Page 3 of 3.

Response to Comment L13-01

DOE agrees that changes in Par Pond water quality would be expected following a prolonged reduction of nutrient input, including that pumped from the Savannah River, and has documented this conclusion in the CERCLA Interim Action Proposed Plan and the environmental assessment that was prepared in response to public comments on the Interim Action Proposed Plan (DOE 1995).

If the No-Action Alternative or the Proposed Action is selected, DOE could resume pumping if conditions warranted. DOE could continue pumping if it selects the No-Action Alternative or resume pumping if it selects the Proposed Action. Your comment that SCDHEC is of the opinion that existing water quality would be maintained or improved is noted.

Response to Comment L13-02

DOE intends to implement best management practices. The FEIS discusses a number of possible mitigative actions (Section 4.1.5.2.2 including: (1) lowering reservoir levels slowly to minimize erosion and encourage the establishment of wetland plants around lake margins, (2) planting grasses on exposed slopes to stabilize bare areas and prevent erosion, (3) planting loblolly and longleaf pine in upland areas once they have stabilized, and (4) planting hardwood in areas where survival is likely.

Response to Comment L13-03

DOE agrees with the SCDHEC comment. To aid restoration, DOE would allow L-Lake to drain slowly and naturally over what is expected to be about a 10-year period.

Response to Comment L13-04

DOE agrees that existing National Pollutant Discharge Elimination System permits for discharges into L-Area must be reviewed by SCDHEC for compliance with National Pollutant Discharge Elimination System regulations.

DOE would obtain any permits required for implementation of the selected alternative (e.g., permit for septic tank installation) to treat the L-Area sanitary wastewater. Section 5.7.2.2 was modified to clarify this point.

Response to Comment L13-05

DOE will take appropriate measures to mitigate the passage of any impounded sediment downstream of the dam. Any sediment removed from the area will be managed in accordance with applicable regulations.

Response to Comment L13-06

Under CERCLA, DOE will investigate restoring the stream ecosystem and associated floodplain forest that existed prior to the creation of L-Lake. Although a final restoration plan has not been prepared, DOE is currently drafting a plan for restoration of the upper portion of Steel Creek and its floodplain forest in consultation with ecologists and foresters at the Savannah River Forest Station and WSRC-SRTC.

If DOE selects the Proposed Action, the Record of Decision for the EIS will contain a commitment to prepare a Mitigation Action Plan as well as a more detailed implementation plan that provides a practical, step-by-step guide to monitoring, mitigation, and restoration of plant communities of the riparian corridor and floodplain during the drawdown of L-Lake.

Response to Comment L13-07

See response to Comment L13-06. Additionally, it may be necessary to do some minor re-contouring of the basin (i.e., earthmoving) to ensure that stream flows are unimpeded by silt and sand that may have accumulated in certain areas and to encourage the stream to follow its historic, meandering channel (to the extent practicable). DOE will, in consultation with the ecologists and foresters of the Savannah River Forest Station and WSRC-SRTC, develop a reforestation plan that involves planting and/or transplanting trees and shrubs that are likely to survive and propagate in the Steel Creek floodplain.

State of South Carolina
Office of the Governor

DAVID M. BEASLEY
GOVERNOR

OFFICE OF EXECUTIVE
POLICY AND PROGRAMS

January 7, 1997

Mr. Andrew R. Grainger
SR NEPA Compliance Officer
Savannah River Operations Office
Post Office Box 5031
Aiken, South Carolina 29804-5031

Project Name: Draft Environmental Impact Statement Shutdown of the River Water System at the Savannah River Site DOE/EIS-0268D (Aiken, South Carolina)

Project Number: EIS-961120-020

Dear Mr. Grainger,

The Grant Services Unit, Office of the Governor, has conducted an intergovernmental review on the above referenced activity as provided by Presidential Executive Order 12372. All comments received as a result of the review are enclosed for your use.

The State Application Identifier number indicated above should be used in any future correspondence with this office. If you have any questions call me at (803) 734-0485.

Sincerely,

Rodney P. Grizzle
Grants Services Supervisor

Enclosures

PK64-33PC

Comment L14. Page 1 of 10.

Office of the Governor • Grant Services
South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

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DHEC-OCRM
CHARLESTON OFFICE

Jeannie R. Kelly
S.C. Coastal Council

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed and dated.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

- [ ] Project is consistent with our goals and objectives.
- [ ] Request a conference to discuss comments.
- [ ] Please discontinue sending projects with this CFDA# to our office for review.
- [ ] Comments on proposed Application is as follows:

Signature: Rob Mikell   Date: 12-5-96

Title: ______   Phone: ______

PK64-33PC

Comment L14. Page 2 of 10.

Office of the Governor • Grant Services

South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

Beth McClure
S.C. Department of Parks, Recreation and Tourism

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed and dated.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

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GRANT SERVICES

- [ ] Project is consistent with our goals and objectives.
- [ ] Request a conference to discuss comments.
- [ ] Please discontinue sending projects with this CFDA# to our office for review.
- [x] Comments on proposed Application is as follows:

No comments.

Signature: [signature] Date: 11/21/96

Title: Planner Phone: 803/734-0189

PK64-34PC

Comment L14. Page 3 of 10.

Office of the Governor • Grant Services
South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

42682

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

Bruce E. Rippeteau
South Carolina Archaeologist

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed and dated.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

- [ ] Project is consistent with our goals and objectives.
- [ ] Request a conference to discuss comments.
- [ ] Please discontinue sending projects with this CFDA# to our office for review.
- [ ] Comments on proposed Application is as follows: In case of avoidance or data recovery of cultural resources discovered during project, please notify our office or SHPO. L14-01

Signature: [illegible] for Dr. B. Rippeteau Date: 11/18/96

Title: U/W archaeologist Phone: 777-8170

PK64-34PC

Comment L14. Page 4 of 10.

Office of the Governor • Grant Services

South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

Hardee Clark Stith
~~State Development Board~~
South Carolina Department of Commerce

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed and dated.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

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GRANT SERVICES

- [x] Project is consistent with our goals and objectives.
- [ ] Request a conference to discuss comments.
- [ ] Please discontinue sending projects with this CFDA# to our office for review.
- [ ] Comments on proposed Application is as follows:

Signature: [signature] Date: 11/21/96

Title: Phone:

PK64-35PC

Comment L14. Page 5 of 10.

Office of the Governor • Grant Services

South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

Steve Davis
S.C. Department of Health and Enviromental Control

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed ~~and dated~~.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

GRANT SERVICES

- [ ] Project is consistent with our goals and objectives.
- [ ] Request a conference to discuss comments.
- [ ] Please discontinue sending projects with this CFDA# to our office for review.
- [x] Comments on proposed Application is as follows:

THIS DOCUMENT IS UNDER REVIEW BY THE DEPARTMENT

Signature: [signature] Date: 11/26/96

Title: Phone:

PK64-35PC

Comment L14. Page 6 of 10.

A95 AGENCY REFERRAL LIST
EIS-961120-020

Referrals Mailed: ____________

Project Number:
EIS-961120-020

Project Name:
Draft Environmental Impact Statement Shutdown of the River Water System at the Savannah River Site DOE/EIS-0268D (Aiken, South Carolina)

Contact Name:
Mr. Andrew R. Grainger

Project Address:
SR NEPA Compliance Officer
Savannah River Operations Office
Post Office Box 5031
Aiken, South Carolina 29804-5031

Project Phone:
1-800-242-8269

Coastal Council
SC Dept of Natural Resources
Wildlife & Marine Resources
Land Resources Commission
DHEC
SC Dept of Commerce
State Development Board
Parks, Recreation & Tourism
State Ports Authority
Adjutant General EPD
State Archaeologist
Human Affairs Commission
Lower Savannah COG (Dist. 5)
BCD COG (Dist. 9)

PK64-36PC

Comment L14. Page 7 of 10.

South Carolina Department of

Natural Resources

December 20, 1996

James A. Timmerman, Jr., Ph.D.
Director

Omeagia Burgess
Grant Services
Office of the Governor
Edgar Brown Building, Room 329
1205 Pendleton Street
Columbia, SC 29201

REF: EIS - 961120-020 - Shutdown of the River Water System

Dear Ms. Burgess:

The South Carolina Department of Natural Resources has evaluated potential impacts of the proposed shutdown on wildlife and fisheries habitat, water quality, recreation and other factors relating to the conservation of natural resources.

We believe that the proposed activity has potential to impact the fisheries and wildlife habitat of L-Lake and Parr Pond. L-Lake and Parr Pond to some extent, contain excellent habitat for a number of wildlife species such as the bald eagle, American alligator, white-tailed deer and various fur bearers. They also support well balanced fish communities and a number of wading birds, water fowl and osprey.

The concern is that due to the small size of the watershed for L-Lake and Parr Pond, water quality problems could occur if the reservoirs are allowed to drop significantly below full pool. In addition, fluctuating water levels could have negative effects on fish recruitment and other wildlife usage.

L-Lake was intended to be a naturalized wildlife and fisheries habitat and should be managed to optimize it's natural resource value. To allow water levels to lower would not be compatible with that initiative. However, if the Department of Energy would remove the dam and restore the wetland forest and stream channel of Steel Creek, we believe that an equitable exchange of natural resources may occur. It is our position that no lowering and/or dewatering of L-Lake should occur without an approved plan for Steel Creek restoration. The restoration plan should be submitted to and approved by appropriate resource agencies. Elements of the plan should include tree plantings, stream bank stabilization, monitoring and contingency plans. Restoration should address upstream and downstream impacts with consideration given to reduce flows.

It should be noted that a possibility exists that some level of contamination may be present in the aquasols that comprise the lake bottoms of both reservoirs. Before any plan is initiated to lower water levels, the bottom sediments should be tested for contamination. If hazardous materials are found in the sediments, then a plan for removal of those contaminants should be submitted prior to any shutdown of the SRS River Water System.

Sincerely,

Danny Johnson for

Robert E. Duncan
Environmental Programs Director

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Rembert C. Dennis Building • 1000 Assembly St • P.O. Box 167 • Columbia, S.C. 29202 • Telephone: 803/734-40''

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Comment L14. Page 8 of 10.

Office of the Governor • Grant Services

South Carolina Project Notification and Review

1205 Pendleton Street
Room 329
Columbia, SC 29201

State Application Identifier EIS-961120-020
Suspense Date 12/20/96

Dr. James A. Timmerman, Jr.
South Carolina Wildlife and Marine Resources Department

The Grant Services Unit, Office of the Governor is authorized to operate the South Carolina Project Notification and Review System (SCPNRS). Through the system the appropriate state and local officials are given the opportunity to review, comment, and be involved in efforts to obtain and use federal assistance, and to assess the relationship of proposals to their plans and programs.

Please review the attached information, mindful of the impact it may have on your agency's goals and objectives. Document the results of your review in the space provided. Return your response to us by the suspense date indicated above. Your comments will be reviewed and utilized in making the official state recommendation concerning the project. The recommendation will be forwarded to the cognizant federal agency.

Should you have no comment, please return the form signed and dated.

If you have any questions, call me at (803) 734-0495. Rodney Grizzle

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☐ Project is consistent with our goals and objectives.

☐ Request a conference to discuss comments.

☐ Please discontinue sending projects with this CFDA# to our office for review.

☑ Comments on proposed Application is as follows:
Comments attached

Signature: Robert E. Duncan (Danny Johnson for) Date: 12/20/96

Title: Env. Programs Director Phone: 737-0800

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Comment L14. Page 9 of 10.

South Carolina
DHEC
Department of Health and Environmental Control
1362 McMillan Avenue, Suite 400
Charleston, SC 29405
(803)744-5838 Fax (803)744-5847

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Bureau of Ocean and Coastal Resource Management
Christopher L. Brooks, Bureau Chief

December 5, 1996

Ms. Omegia Burgess
Office of the Governor, Grant Services
1205 Pendleton Street, Room 329
Columbia, SC 29201

Re: EIS961120-020
DEIS-Shutdown of the River Water at
The Savannah River Site
Various Counties
A-95

Dear Ms. Burgess:

The staff of the Bureau of Ocean and Coastal Resource Management (OCRM) certifies that the above referenced project is consistent with the Coastal Zone Management Program. This certification shall serve as the final approval by the OCRM.

Interested parties are provided ten days from receipt of this letter to appeal the action of the OCRM.

Sincerely,

Robert D. Mikell
Manager, Planning
and Federal Certification Section

JHA
JHA/25173/jk

cc: Mr. Christopher L. Brooks
Mr. H. Stephen Snyder

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Comment L14. Page 10 of 10.

Response to Comment L14-01

Because the alternatives, including the Proposed Action, would not require any construction, there would be little if any risk of damaging historic or archaeological resources or areas of cultural resources of areas of cultural importance to Native American tribes. Should the potential for impacts become apparent or if impacts, unexpected as they are, were to occur, DOE would notify the State of South Carolina Office of the Governor or the State Historic Preservation Office.

Savannah River Site

CITIZENS ADVISORY BOARD

Recommendation No. 31
January 28, 1997

Recommendation on the Shutdown of the River Water System at SRS

The SRS Citizens Advisory Board recognizes and commends DOE for wanting to shutdown the river water pumping system at SRS to save the costs of operating and maintaining this system which is no longer needed to provide cooling water for the SRS reactors. However, there are some additional factors related to this system which need to be considered. The SRS Citizens Advisory Board recommends that DOE:

1. Place the river water system in a minimum cost standby condition as soon as possible (see items 2, 3 and 6). Keep the system available to provide cooling water for the possible future missions that may require large amounts of cooling water with repairs and restart costs borne by the new missions. L15-01

2. Before making a decision to place the system on standby, investigate the legal requirements and the Savannah River water rights withdrawal restrictions that might be required prior to reactivating a river water pump house. L15-02

3. Consider as sufficient the National Environmental Policy Act (NEPA) data developed to evaluate the environmental impacts of different alternative actions on L-Lake for the Federal Facility Agreement (FFA) Remedial Investigation/Feasibility Study (RI/FS) process at L-Lake. Consider the potential Remedial Actions section of the Draft Environmental Impact Statement (DEIS) as the basis for those remedial actions in the FFA RI/FS process. Move the FFA RI/FS process forward on an expedited schedule to be completed before the Record of Decision (ROD) on the NEPA process. Should environmental remediation of L-Lake be required, consider the decision on it as part of the RI/FS process. Coordinate both decisions and move expeditiously to minimize unnecessary costs. L15-03

4. Include the ecological effects of possible remediation actions in the RI/FS process for L-Lake. L15-04

5. Consider only the onsite worker regarding human health risk scenarios in the decision process for L-Lake remedial actions under the FFA. It is not DOE-SR policy nor is it part of the SRS Future Use Plan to allow residents to live onsite SRS. This has been supported by the CAB and input from stakeholders. In addition, the DEIS evaluations indicate a greater risk to offsite residents from Cesium-137 fallout from prior atmospheric testing, than to hypothetical onsite residents who might have a risk from the Cesium-137 in L-Lake outside of the Steel Creek channel and its floodplain. L15-05

6. Complete consultations with the Natural Resource Trustees before issuing the Record of Decision on the Shutdown of the River Water System because endangered species (eagles and wood storks) reside in the L-Lake area. L15-06

SRS CAB Recommendation #31
Adopted January 28, 1997

PK64-38PC

Comment L15. Page 1 of 2.

Savannah River Site
CITIZENS ADVISORY BOARD
A U.S. Department of Energy Site-Specific Advisory Board

January 30, 1997

Dr. Mario Fiori, Manager
U.S. Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, S.C. 29808

Dear Dr. Fiori:

On behalf of the Savannah River Site Citizens Advisory Board, I am pleased to forward you two recommendations adopted at our January 28, 1997, meeting in Hilton Head Island, S.C.

The Board's Recommendation No. 31 regards the Shutdown of the River Water System at SRS and No. 32 addresses the Waste Isolation Pilot Plant (WIPP) Disposal Phase Draft SEIS-II. Comments on the WIPP document will be provided to the DOE-Carlsbad Office as well.

Both enclosures are also being forwarded to John Hankinson of the Environmental Protection Agency and Lewis Shaw of the South Carolina Department of Health and Environmental Control.

We would appreciate your written response prior to our next meeting on March 25 at the Savannah River Site. Where appropriate, we trust DOE, EPA and SCDHEC will carefully consider these recommendations and work together to develop a response for implementation.

Sincerely,

Bob Slay
Chairman

cc: Don Beck, EM22
Tom Heenan

PK64-38PC

Comment L15. Page 2 of 2.

Response to Comment L15-01

DOE agrees with the recommendation by the Citizens Advisory Board (CAB) to place the River Water System in standby; it is the DOE preferred alternative. In response to the recommendation by the CAB, DOE has expanded Section 3.3.2, *Layup Options,* to provide a standby condition that would be responsive to the potential future mission of an accelerator for the production of tritium (APT) at SRS. The wide variety of layup options presented for the decisionmaker depend on the time required to restart the River Water System (from 1 month to 30 months) and the layup scheme (keep portions of the piping system pressurized by operating the small pump or a still smaller jockey pump, or maintain those portions in a dry pipe condition). The minimum cost standby condition is the dry pipe scheme, which would require 30 months to restart the system. This option would cost about $650,000 per year of standby; the additional cost to include surveillance and maintenance of the portion of pipe that the APT would use is approximately $10,000 per year (dry pipe layup) or $35,000 per year (wet pipe layup). The decisionmaker will review the "minimum cost with system available for possible future missions" option in light of the recommendation by the CAB and the knowledge that repair and restart costs would be borne by the new mission.

Response to Comment L15-02

DOE has investigated the legal requirements and Savannah River water withdrawal restrictions that might be associated with reactivating the River Water System. In consultation with SCDHEC, DOE determined that these Savannah River water withdrawals are not subject to allocations or permit constraints. DOE will continue to report on a quarterly basis to SCDHEC the surface water usage, including any changes in Savannah River water withdrawals associated with the alternatives considered in this EIS. These reports, which are voluntary, were submitted to the South Carolina Water Resources Commission prior to consolidation of that agency with SCDHEC.

Possibility exists that further environmental review (e.g., a Section 316(b) entrainment and impingement study) may be required in conjunction with a future decision to restart the River Water System. Historically, the River Water System has withdrawn as much as 586,000 gallons per minute (37 cubic meters per second) from the Savannah River. As indicated in Section 3.3.2, the projected pumping rates associated with maintaining the system for potential restart of this system are significantly less; therefore, DOE believes that the cost and time of a Section 316(b) study, if any, would be minimal. DOE does not anticipate that such review, if necessary, would result in the imposition of constraints on SRS river water usage.

DOE acknowledges, however, that it would interact and negotiate with EPA and SCDHEC concerning the use of existing river water intakes. If new intakes or other mitigation requirements were needed, the cost would be substantial and proportional to the number of pumps to be restarted.

Response to Comment L15-03

DOE intends to coordinate NEPA and CERCLA activities regarding L-Lake as appropriate to minimize costs and ensure protection of human health and the environment. This coordination, including the extent to which remedial activities for L- Lake should be expedited, will be discussed with EPA and SCDHEC in the context of ongoing discussions being conducted under the FFA, which provides the agreed-upon framework for remediation planning, including consideration of such important factors as risk to human health and the environment, budgeting, and scheduling. (See responses to EPA comments, letter L10.)

Response to Comment L15-04

The remedial action process for L-Lake might be included within the Steel Creek Integrator Operable Unit. The FFA process includes detailed RCRA Facility Investigation/Remedial Investigation and a baseline risk assessment, which as a matter of procedure, considers potential risks to ecological receptors as well as human ones.

DOE prepared a revised and expanded ecological risk assessment in Appendix B. This analysis focuses on the proposed action in this EIS rather than remediation alternatives but might assist the preparation of the ecological effects portion of the baseline risk assessment in the FFA process.

Response to Comment L15-05

As stated in Section 1.4, this EIS analyzes realistic exposure conditions for the current facility worker, the collocated worker, the hypothetical maximally exposed offsite individual, the offsite population, and reasonably foreseeable future conditions, which are consistent with the *SRS Future Use Report* and include a future facility worker and public access for recreation, but do not include a future resident. Section 4.1.8 describes these risks for L-Lake.

Although the decision process for L-Lake remedial actions under the FFA is not in the scope of this EIS, DOE believes the future land use recommended by the Citizens Advisory Board and other stakeholders is a primary consideration in all cleanup decisions under the FFA. This is consistent with CERCLA, the FFA Implementation Plan, and DOE responses to earlier CAB recommendations on land use. Baseline Risk Assessment protocols include estimates of risk at a site, as is, to hypothetical receptors including a future resident, but risk management (cleanup) decisions must be consistent with the reasonably expected future use – in this case, the use recommended by the CAB and the *SRS Future Use Project Report*.

Response to Comment L15-06

The response to comment L16-05 provides details of the relationship of the Natural Resources Trustees and this EIS. Section 4.8 has been expanded to provide a more explicit comparison of irreversible or irretrievable commitments of resources under the alternatives in this EIS.

NEPA requires separate consultation with the U.S. Fish and Wildlife Service relative to threatened and endangered species under Section 7 of the Endangered Species Act. Formal consultation is in progress, and if DOE decides to shut down the River Water System, the Section 7 process would be accomplished prior to shutdown of the system. The Section 7 consultation process is described in greater detail in Section 5.10 and in responses to the Department of Interior comments (L-16).

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

In Reply Refer To:
ER 96/742

JAN 31 1997

Mr. Andrew R. Grainger
SR NEPA Compliance Officer
U. S. Department of Energy
Savannah River Operations Office
Post Office Box 5031
Aiken, South Carolina 29804-5031

Re: Draft Environmental Impact Statement, Shutdown of the River Water System at the Savannah River Site, Aiken, South Carolina (DOE/ETS-0268D)

Dear Mr Grainger:

The U. S. Department of the Interior (Department) has reviewed the above-referenced document and provides the following comments for your consideration. We are extremely concerned about the Proposed Action, its environmental consequences, and the inadequacy of the Draft Environmental Impact Statement (DEIS) as now written. The Proposed Action may have very significant effects on the Department's trust resources under the management jurisdiction of the Department's Fish and Wildlife Service (FWS), including endangered and threatened species. L16-01

Background The River Water System (RWS) at the Department of Energy's (DOE's) Savannah River Site (SRS) includes three pumphouses, two on the Savannah River and one on Par Pond. When the reactors were operating, the two pumps on the Savannah River delivered 179,000 gallons per minute (gpm) to each reactor area plus makeup water for a total of about 380,000 gpm (23.9 cubic meters per second). Water bodies receiving effluents from the reactors included L-Lake and Steel Creek, Par Pond and Lower Three Runs, Fourmile Branch, and Pen Branch. Due to shutdown of the reactors, DOE placed one of the Savannah River pumphouses in lay up in 1993 and deactivated and abandoned the Par Pond pumphouse in 1995. At that time, DOE decided to discharge a minimum flow of 10 cubic feet per second (cfs) to Lower Three Runs and to allow the water level in Par Pond to fluctuate naturally between its normal operating level of 200 feet above mean sea level (msl) and 195 feet above msl. In addition, DOE decided to reduce the flow to L-Lake as long as the lake was maintained at its normal operating level of 190 feet above msl and flow in Steel Creek below L-Lake did not fall below 10 cfs. These and other minor system requirements are currently satisfied by operating one of the 10 available pumps in the remaining Savannah River pumphouse which pumps approximately 28,000 gpm.

PK64-39PC

Comment L16. Page 1 of 4.

According to the DEIS, current operation of one pump provides approximately 23,000 gpm more water than is needed. DOE has thus decided to replace this pump with a 5,000 gpm pump which will keep L-Lake at it normal operating level and provide a minimum of 10 cfs to Steel Creek. Current discharges to Fourmile Branch via Castor Creek (approximately 0.5 cfs) and to the headwaters of Steel Creek (6.5 cfs) would be eliminated and flow to Pen Branch would be reduced from around 12.7 cfs to no more than 0.68 cfs. DOE has determined that the action of installing the small pump is categorically excluded from requiring either an Environmental Assessment or an EIS under the National Environmental Policy Act (NEPA). It is the operation of the small pump, to be operational by Spring 1997, and not the currently used pump, which DOE uses as the basis of its No Action alternative in this DEIS.

Environmental contamination at SRS and ongoing investigations and actions complicate DOE's proposed shutdown of the SRS RWS. L-Lake is currently undergoing a site evaluation in accordance with the Federal Facility Agreement (FFA) among DOE, the U. S. Environmental Protection Agency (EPA), and the South Carolina Department of Health and Environmental Control (SCDHEC). This agreement integrates DOE's responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, Superfund Act) and the Resource Conservation and Recovery Act (RCRA) for investigation of the nature and extent of contamination at SRS and for identification and implementation of necessary remedial, or cleanup, actions. If the L-Lake site evaluation recommends further investigation, L-Lake will be placed on the CERCLA/RCRA Units List and will be subject to the remedial action process defined by CERCLA/RCRA. As stated in this DEIS, that process would be "long and involved" under the current FFA.

Par Pond has already been placed on the Superfund list. While it has the fourth highest hazard score at SRS, the FFA calls for DOE to begin investigations in 2004 and to begin remedial actions, if required, in 2008. Fourmile Branch, Pen Branch, and Lower Three Runs are also on the CERCLA/RCRA list and are to receive future evaluation and potential remedial actions.

<u>Proposed Action</u> DOE's Proposed Action and Preferred Alternative is to shut down the RWS and to place all or portions of the system in standby. The cessation of river water input to L-Lake would result in the gradual disappearance of the 1000-acre lake, exposure of contaminated sediments, and potential downstream transport of contaminated sediments (Steel Creek and the Savannah River). DOE has apparently already ceased pumping river water to Par Pond and is allowing "natural fluctuation" of water levels over its contaminated sediments. Maintenance flows to Lower Three Runs below Par Pond would cease under the Proposed Action.

<u>Comments:</u>

1. Effects on Fish and Wildlife Resources: The DEIS adequately identifies the habitat losses that would occur under the Proposed Action and the positive environmental impacts associated with reduced entrainment and impingement of fish eggs, larvae, juveniles, and adult fishes of the Savannah River. Still, the DEIS fails to adequately evaluate the effects of the Proposed Action on fish and wildlife resources. The underlying basis of this failure is the conclusion contained in Appendix B: "Ecological effects from contaminants in Par L16-02

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Comment L16. Page 2 of 4.

Pond, L-Lake, Steel Creek, and Lower Three Runs are unlikely regardless of the status of the River Water System."

We strongly disagree with this statement. As noted in a June 2, 1992, letter to DOE from the FWS in which it did not concur with the DOE's assessment of no effect on the wood stork and the bald eagle relative to the 1991 emergency drawdown of Par Pond, the documented levels of mercury in fish in Par Pond far exceed levels known to cause adverse effects on sensitive avian species. Limited data presented at a wood stork meeting at SRS in 1996 indicate mercury levels in fishes in L-Lake are higher than those in Par Pond. Contrary to the conclusions presented in Appendix B, available data indicate sediments in L-Lake, Par Pond, Steel Creek, and Lower Three Runs likely present significant risk to exposed fish and wildlife populations, particularly avian species including the endangered wood stork and threatened bald eagle. Further investigations into the nature and extent of contamination associated with these water bodies and appropriate site specific ecological risk assessments are necessary to fully assess the ecological effects associated with contaminants in these water bodies. *These data are needed before the environmental impacts of the Proposed Action can be adequately evaluated and considered in the decisionmaking process.* L16-02 (cont.)

While not a part of this DEIS, the planned reduction in current pumping from 28,000 gpm to 5,000 gpm may also have a significant effect on trust resources associated with the receiving water bodies. Under the planned reduction which DOE has determined to be categorically excluded from requiring either an Environmental Assessment or an EIS under NEPA, current discharges to Fourmile Branch via Castor Creek (approximately 0.5 cfs) and to the headwaters of Steel Creek (6.5 cfs) would be eliminated and flow to Pen Branch would be reduced from around 12.7 cfs to no more than 0.68 cfs. Streamflow reductions result in stream and riparian habitat losses with potential adverse impacts on fish and wildlife populations. In addition, at SRS reductions in streamflow may also result in the exposure of contaminanted sediments and additional exposure pathways for avian and terrestrial wildlife. The DEIS should contain some discussion of the impacts of the planned streamflow reductions; at a minimum, there should be some explanation of DOE's determination that this action is categorically excluded from review under NEPA. L16-03

2. Endangered Species: While the DEIS states that DOE directed the preparation of a biological assessment to evaluate the effects of the proposed action on endangered and threatened species, the FWS has not been provided a copy of that assessment. The DEIS further states that DOE "plans to initiate formal consultation;" formal consultation under Section 7 of the Endangered Species Act is required if the biological assessment concludes the proposed action may affect endangered or threatened species. Under formal consultation, the FWS must prepare a Biological Opinion regarding the project and its impacts on endangered and threatened species. The evaluation of Proposed Action impacts cannot be completed until Section 7 consultation is completed; thus affecting the Final EIS completion. L16-04

3. Natural Resource Damages: The DEIS contains a discussion of natural resource damages L16-05

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Comment L16. Page 3 of 4.

(Section 5.5.2.4 and Section 4.8), and in particular the effect of a determination in an EIS that certain resources are irreversibly and irretrievably committed. The discussion in these sections is not clear; however, it implies that DOE's identification in the DEIS of any resource as irreversibly and irretrievably committed will preclude natural resource damages liability arising from the proposed action. Section 107(f) of CERCLA requires that damages to natural resources be specifically identified, that a permit or license be issued and the decision granting the permit or license authorize the commitment of resources, and that operations be conducted within the terms of the permit or license. It is not apparent from the DEIS that all of the conditions of the Section 107(f) exclusion would be met. Further, even if these conditions were met, it is not clear that the Section 107(f) exclusion would apply to a situation involving releases or contamination occurring prior to the preparation of the EIS. Accordingly, based on the information contained in the DEIS, it is our view that the Section 107(f) exclusion from liability would not apply. L16-05 (cont.)

The Department appreciates the opportunity to provide these comments. Any questions or comments should be directed to Ms. Diane Duncan, Environmental Contaminants Specialist, U. S. Fish and Wildlife Service, P. O. Box 69, Wadmalaw Island, South Carolina 29487, (803) 559-7909.

Sincerely,

Willie R. Taylor
Director
Office of Environmental Policy
and Compliance

PK64-40PC

Comment L16. Page 4 of 4.

Response to Comment L16-01

Section 4.3.5.3, as revised, presents a thorough evaluation of the affected environment and environmental consequence on threatened and endangered species due to implementation of the proposed action or an alternative. This evaluation is supported by a Biological Assessment and an Ecological Risk Assessment (Appendix B).

DOE appreciates the advice and cooperation of the Fish and Wildlife Service that is leading to the successful completion of the consultation process as required by Section 7 of the Endangered Species Act.

Response to Comment L16-02

DOE acknowledges that documented concentrations of mercury in fish in Par Pond and L-Lake in some cases have exceeded 0.1 mg/kg (ppm). However, it should be noted that the 0.1 mg/kg concentration of total mercury in prey items (fish) that is generally cited as protective of fish-eating birds (from Eisler's oft-cited 1987 monograph *Mercury Hazards to Fish, Wildlife, and Invertebrates)* is very conservative, and has been the subject of some debate in scientific circles. Moreover, this 0.1 mg/kg (ppm) standard is within the range of normal background mercury levels in fish in many streams, lakes, and reservoirs in the U.S.

For example, freshwater fish (bottom-dwelling species and predators) were sampled at more than 100 stations across the U.S. in the 1970s and 1980s as part of the National Contaminant Biomonitoring Program managed by the U.S. Fish and Wildlife Service. Mean concentrations of mercury in these fish samples were 0.11 ppm in both 1978-1979 and 1980-1981. The EPA *National Study of Chemical Residues in Fish* (EPA 823-R-92-008a) presents data on mercury concentrations in fish collected from 1986-1989 at 374 locations (a mix of contaminated and background sites). Generally speaking, concentrations were highest in the northeast and southeast and lowest in the midwest, southwest, and intermountain west. More than 60 percent of the water bodies contained fish with mercury concentrations greater than 0.1 mg/kg (ppm). The concentration of mercury in fish tissue from 21 background sites ranged from not detected to 1.77 mg/kg (ppm) with a mean of 0.34 mg/kg. This mean value is three times the Eisler standard of 0.1 ppm.

Mercury concentrations in fish in Par Pond have on occasion been higher than the 0.1 ppm concentration, but are not an imminent threat to fish and wildlife. Any effects would be subtle to imperceptible; there is no evidence to date of reduced survival or reproductive success in any of the sensitive species known to forage or nest in the area (such as the bald eagle and wood stork).

The "limited data presented at the 1996 wood stork meeting" do not indicate that mercury levels in fish in L-Lake are higher than those in Par Pond, nor are these data indicative of "significant risk to exposed fish and wildlife populations." These limited Savannah River Ecology Laboratory data show that mercury concentrations are roughly twice as high in Par Pond fish than L-Lake fish. Mercury concentrations appear to be slightly elevated in largemouth bass and four sunfish species in Par Pond. Mercury concentrations in L-Lake fish are indistinguishable from background levels, with the exception of one species, the redbreast, which appears to contain elevated concentrations of mercury. It should be noted that sunfish from isolated SRS wetlands unaffected by facility operations often contain mercury levels as high or higher than L-Lake and Par Pond, depending on the particular wetland's soils and water quality (pH, hardness/alkalinity, and total organic carbon).

The value presented in Eisler (1987) of 0.1 ppm should be viewed as an initial indicator of potential risk to sensitive bird species. This value is not species specific, and does not take into account site-specific physico-chemical parameters or the ecology of the avian receptors that use a given site (e.g., Par Pond and

L-Lake). The Eisler value, therefore, should be viewed as a starting point or screening level to investigate potential risks when fish have body burdens of greater than 0.1 ppm total mercury. The FEIS contains an expanded ecological risk assessment that evaluates potential risks to the wood stork and bald eagle (among other species) that is based on site-specific and species-specific parameters.

Response to Comment L16-03

The FEIS contains an expanded discussion of possible impacts to fish and wildlife from reductions in streamflow (Section 4.2.5), as well as an explanation for DOE's position that this action is categorically excluded from review under NEPA (Section 1.1).

Response to Comment L16-04

On December 23, 1996, the DOE NEPA Compliance Officer at the Savannah River Site, Mr. Drew Grainger, sent a copy of the Biological Assessment to Mr. Roger L. Banks of the Charleston, S.C., field office of the U.S. Fish and Wildlife Service. The cover letter that accompanied the Biological Assessment noted that:

> The biological assessment concludes that the proposed action may affect the bald eagle, which nests on the SRS, and the wood stork, which occasionally forages on the SRS. As a result,...DOE would like to begin the process of consultation pursuant to Section 7 of the Endangered Species Act...

DOE believes that it has fulfilled its obligations with respect to the consultation requirements of the Endangered Species Act.

Response to Comment L16-05

USFWS states that the discussion of the irreversible and irretrievably committed resources and the effect that such a determination in an EIS has on natural resources damage liability is not clear. USFWS further asserts that all the conditions of the CERCLA Section 107(f) exclusion would not be met by the DEIS as it is currently written. Under Section 107(f) of CERCLA there is exclusion of liability for an injury to, destruction of, or loss of natural resources if

> ...the damages to natural commitments of resources complained of were specifically identified as irreversible and irretrievable commitments of resources in an environmental impact statement, or other comparable environmental analysis, and the decision to grant a permit or license authorizes such commitment of natural resources, and the facility or project was otherwise operating within the terms of its permit or license, so long as, in the case of damages to an Indian tribe occurring pursuant to a Federal permit or license, the issuance of that permit or license was not inconsistent with the fiduciary duty of the United States with respect to such Indian tribe.

In Section 4.8 of RWEIS, the discussion of the resources that would be irreversibly and irretrievably committed has been clarified so as to satisfy the requirements of both NEPA and CERCLA. A discussion of the potential natural resource damages liability resulting from this action as addressed in Section 107(f) of CERCLA is not appropriate at this time and has been eliminated. It is premature to pursue a decision on a Section 107(f) exclusion on natural resource damages liability for the current action at this time.

In the USFWS comment, it is not clear, but seems to be implied that a permit or license must be issued in order to fulfill the requirements of Section 107(f) of CERCLA with regard to obtaining an exclusion for natural resource damage liability. In the case of the actions under consideration, a permit is not relevant to the activities involved and would not be necessary. Alternative remedial actions under CERCLA are not ready for decision at this time and are not included in this Final EIS.

Finally, USFWS raises the question of applicability of the Section 107(f) exclusion as it applies to releases and contamination occurring prior to the preparation of RWEIS. It cannot be implied that invocation of the Section 107(f) exclusion covers the prior releases and contamination. These prior releases are currently being addressed through the CERCLA remediation process with input from the Savannah River Site's Natural Resource Trustees.

E.6 References

Collins, B. and G. Wein, 1995, "Seed Bank and Vegetation of a Constructed Reservoir," *Wetlands*, 15, 4, December.

DOE (U.S. Department of Energy), 1995, *Environmental Assessment for the Natural Fluctuation of Water Level in Par Pond and Reduced Water Flow in Steel Creek Below L-Lake at the Savannah River Site,* DOE/EA-1070, Savannah River Operations Office, Aiken, South Carolina.

DOE (U.S. Department of Energy), 1996, *Savannah River Operations Office, U.S. Department of Energy Ten-Year Plan*, QC-96-0005, Aiken, South Carolina, July.

Eisler, R., 1987, *Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review,* Biological Report 85 (1.10), Fish and Wildlife Service.

Johnston, J. D., 1997, letter to T. F. Heenan, U.S. Department of Energy, Aiken, South Carolina, "Streamlining Opportunities L-Lake Site Evaluations Savannah River Site," U.S. Environmental Protection Agency, Atlanta, Georgia, January 2.

Kennamer, R. A., I. L. Brisbin, Jr., C. D. McCreedy, and J. Burger, 1997, *Radiocesium in Mourning Doves: Effects of a Contaminated Reservoir Drawdown and Risk to Human Consumers*, Manuscript, Savannah River Ecology Laboratory, Aiken, South Carolina.

APPENDIX F. DESCRIPTION OF L-LAKE SEDIMENT DATA AND DATA SOURCES

APPENDIX F. DESCRIPTION OF L-LAKE SEDIMENT DATA AND DATA SOURCES[1]

L-Lake sediment data used quantitatively in this Final Environmental Impact Statement (EIS) were obtained from initial sampling in 1995 and a four-phase series of studies which were conducted in 1996-1997 in support of this Final EIS and a Site Evaluation (SE) for L-Lake. The data were collected in accordance with CERCLA protocols to support the SE and subsequent investigations, if any, that may be conducted under the Federal Facility Agreement between EPA, SCDHEC, and DOE. Descriptions of the methods employed in the initial sampling and the first three phases are presented below. The fourth phase has not yet been conducted.

F.1 Initial Sediment Core Sampling

Prior to the initiation of Phases I-III, sediment core sampling was conducted in Par Pond, Pond C, and L-Lake in July 1995 (Koch, Martin, and Friday 1996). The study was conducted to develop a defensible characterization of contaminants in Par Pond, Pond C, and L-Lake sediments, and to serve as the basis for future studies to determine in detail the distribution and ecological effects of those contaminants. Since this section is limited to descriptions of L-Lake data, only data from L-Lake will be discussed.

Sediment cores in L-Lake were collected by vibracoring. In simple terms, the vibracore machine is a gasoline-powered engine with a vibrating head on a flexible steel wire. A 3-inch diameter (7.6-centimeter), thin-walled, aluminum pipe about 15-foot (4.6-meter) long is attached to the head. The pipe is raised to a vertical position and vibrated by the engine. Thus, the head vibrates the aluminum pipe into the sediment, capturing a core of sediment material. For deeper water samples, the apparatus is attached to a coring barge, and is slightly modified to advance the pipe under water.

In L-Lake, sampling locations were established by longitude and latitude coordinates using a digitized SRS map. Two cores were collected at each location to provide enough sample volume for analysis. Following retrieval, cores were transported to the sample processing facility where they were cut longitudinally using a circular saw. Each core was divided into five segments corresponding to depths of 0-1 foot, 1-2 feet, 2-4 feet, 4-6 feet, and 6-8 feet (0-0.3 meter, 0.3-0.6 meter, 0.6-1.2 meters, 1.2-1.8 meters, and 1.8-2.4 meters). Subsamples from approximately half the samples were immediately collected for volatile organic analyte analysis. Samples were also analyzed for a suite of other nonradiological contaminants and radiological contaminants. Non-radiological data from L-Lake samples were validated using standard data validation techniques.

[1] Appendix F is a new appendix that was not part of the DEIS.

F.2 Phase I

The Phase I study consisted of the collection of surface sediment samples in summer 1996 in L-Lake for radionuclide and trace metal analysis (Dunn, Gladden, and Martin 1996). Sampling locations were selected based on aerial photographs, the results of previous studies, and the SRS soil survey. Locations were selected to include dominant soil types and sites known or suspected to have been used as disposal sites for clean vegetation. These are sites where vegetation was piled up and burned during lake construction. Hence they are referred to as "ash pit" samples. Sites were also selected to include areas where radionuclide-contaminated soils were removed and buried during lake construction. A Global Position System was used to locate precise locations. A total of 45 sampling locations were identified. Thirteen reference sites were also selected from Steel Creek and Meyers Branch, its main tributary.

L-Lake samples were collected with an Ekman dredge, and reference samples were collected with an auger-type tool. L-Lake samples were collected from 0-0.5-foot (0-0.15-meter) depth, while reference samples were collected from 0-1-foot (0-0.3-meter) and 1-4-foot (0.3-1.2-meters) depth intervals. The sediment samples were analyzed for all EPA Target Analyte List metals (except cyanide), gross alpha activity, nonvolatile beta activity, gamma-pulse-height, plutonium alpha series isotopes, and uranium alpha series isotopes. All nonradiological and radiological data were validated using standard data validation techniques.

F.3 Phase II

The Phase II study of the four-phase investigation consisted of the collection of L-Lake sediment cores for radionuclide and trace metal analysis in August 1996 (Dunn, Koch, and Martin 1996). The vibracoring technique described above was used for sample collection. A GPS system was used to identify specific sampling locations. Each core was divided into sampling intervals. Four foot cores were sampled at 0-1-foot and 1-4-foot (0-0.3- and 0.3-1.2-meter) intervals, and 8-foot cores were sampled at 0-1, 1-4, and 4-8-feet (0-0.3-, 0.3-1.2-, and 1.2-2.4-meter) intervals. A maximum of 17 sample cores were collected, but this number of subsamples was not available for each depth. The same reference data described for the Phase I sampling were also used during the Phase II study (a total of 13 samples). All samples were analyzed for Target Analyte List metals (except cyanide), gross alpha, nonvolatile beta, Pu series, U series, and gamma spectroscopy. All nonradiological and radiological data were validated using standard data validation techniques.

F.4 Phase III

Phase III of the four-phase investigation consisted of *in situ* analysis for gamma-emitting radionuclides in L-Lake in summer 1996 (Dunn 1996). A GPS system was used to locate exact sampling locations, and 192 locations were sampled. At each location, an underwater gamma-detector, a High Purity Germanium detector (HPGe), was used to measure gamma-emitting radioisotopes, primarily cesium-137 and cobalt-60. The detector was lowered by a winch until its housing rested on the sediment surface. Two-minute counting intervals were made at each location. The goal of the HPGe sampling was to determine the edge of the gamma-emitting radionuclide contamination in the lakebed and compare it with the contour established in 1985.

In addition, grab samples of the bottom sediments were also collected. These samples were taken to determine the incidence of man-made radionuclides present in the sediments at levels below the detection limit of the underwater gamma detector. Grab samples were analyzed with low-level HPGe in the Underground Counting Facility.

F.5 L-Lake Sediment Data Reduction for the EIS

The full data sets from the studies described above were reduced and manipulated for use in the L-Lake human health evaluation (Appendix A and Section 4.1.8) and the L-Lake ecological risk assessment (Appendix B and Section 4.1.5) included in this Final EIS. The data used in these evaluations are described below.

F.5.1 L-LAKE SEDIMENT DATA USED IN THE HUMAN HEALTH EVALUATION

Validated analytical data from three of the data sets described above were combined for use in the Human Health Evaluation in this Final EIS (Dunn and Martin 1997a). The first data set included the 0-1-foot (0-0.3 meter) segments from 1995 sediment cores collected from shallow and deep-water locations in L-Lake (Koch, Martin, and Friday 1996). Secondly, 0-0.5-foot (0-0.15-meter) samples collected in submerged portions of the L-Lake basin as part of Phase I sampling were included in the data set (Dunn, Gladden, and Martin 1996). Third, 0-1-foot (0-0.3-meter) segments from 1996 Phase II sediment cores in submerged portions of L-Lake were included in the data set (Dunn 1996). Again, these data, both radiological and nonradiological, were combined into a single database prior to use in the evaluation. All constituents with 100 percent non-detects were then removed from the database. Additionally, if any constituent had an analytical result greater than the detection limit and with no data disqualifier, then the constituent was retained in the database. Also, reference soil data for the 0-1-foot (0-0.3-meter) segments collected during the 1996 Phase I study were used (Dunn, Gladden, and Martin 1996).

The remedial investigation reported in Appendix A used the three data sets described above and also used data from the Phase III underwater gamma study and data from an underwater gamma study conducted in 1995 (WSRC 1995). Due to the nature of the data described above, only cesium-137 data were used in Appendix A.

F.5.2 L-LAKE SEDIMENT DATA USED IN THE ECOLOGICAL RISK ASSESSMENT

For the ecological risk assessment, 0-0.5-foot (0-0.15-meter) Phase I sediment samples from both the floodplain and stream channel beneath L-Lake were used to obtain contaminant concentrations, both radiological and nonradiological (Dunn, Gladden, and Martin 1996). This is the horizon of sediments that terrestrial receptors may be exposed to when water levels recede or fluctuate. Only validated data were included in the data set (Dunn and Martin 1997b). All sample results were retained, and constituents with 100 percent non-detects were excluded from the data set. However, when a contaminant was present in one sample above the detection limit and did not possess a data disqualifier, one-half the detection limit was used for all non-detects of that constituent.

F.6 References

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CONTRACT NO. DE-AC09-92SR18220

Task 24, NEPA Documentation, Management, and Planning Support Subtask 08, Environmental Documentation/NEPA Requirements Support for River Water System Transition and Deactivation at SRS

I hereby certify (or as a representative of my organization, I hereby certify) that, to the best of my knowledge and belief, no facts exist relevant to any past, present, or currently planned interest or activity (financial, contractual, personal, organizational or otherwise) which relate to the proposed work and bear on whether I have (or the organization has) a possible conflict of interest with respect to (1) being able to render impartial, technically sound, and objective assistance or advice, or (2) being given an unfair */ competitive advantage.

Signature: Janet Mandel   Date: October 9, 1995

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*/ An unfair competitive advantage does not include the normal flow of benefits from the performance of this contract.

PK64-31PC

ACRONYMS, ABBREVIATIONS, AND USE OF SCIENTIFIC NOTATION

Acronyms

AEC	U.S. Atomic Energy Commission
AIFRA	American Indian Religious Freedom Act
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS/FS	Corrective Measures Study/Feasibility Study
COC	Contaminants of Concern
COPC	Contaminants of Potential Concern
CX	Categorical Exclusion
DOE	U.S. Department of Energy
EA	Environmental Assessment
EEC	Environmental Evaluation Checklist
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FERC	Federal Energy Regulatory Commission
FFA	Federal Facility Agreement
FR	Federal Register
HAZWRAP	Hazardous Waste Remedial Action Program
HI	Hazard Index
HPGe	High-purity germanium
HQ	Hazard Quotient
IOU	Integrator Operable Units
LOAEL	Lowest Observable Adverse Effects Level
MEPAS	Multimedia Environmental Pollutant Assessment System
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAEL	No Observable Adverse Effects Level
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometer turbidity units
O&M	Operation and Maintenance

PCB	Polychlorinated Biphenyls
PM_{10}	Particulate matter less than 10 microns in diameter
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RGO	Remedial Goal Options
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SE	Site Evaluation
SEA	Special Environmental Analysis
SEL	Severe Effects Level
SRS	Savannah River Site
SWTP	Sanitary Wastewater Treatment Plant
TAL	Target Analyte List
TCL	Total Chlorinated Hydrocarbon Organics
TRV	Toxicity Reference Value
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers

Abbreviations for Measurements

cfm	cubic feet per minute
cfs	cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second
cm	centimeter
g	acceleration of gravity = 32.17 feet per square second
gpm	gallons per minute
kg	kilogram
L	liter = 0.2642 gallon
lb	pound = 0.4536 kilogram
mg	milligram
μ	micron
μCi	microcurie
μg	microgram
pCi	picocurie
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation" rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., 10^n, or the number 10 multiplied by itself "n" times; 10^{-n}, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-2} = \frac{1}{10 \times 10} = 0.01$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$

0.049 is written 4.9×10^{-2}

1,490,000 or 1.49 million is written 1.49×10^6

A positive exponent indicates a number larger than or equal to one, a negative exponent indicates number less than one.

In some cases, a slightly different notation ("E-notation") is used, where "× 10" is replaced by "E" and the exponent is not superscripted. Using the above examples

$4{,}900 = 4.9 \times 10^3 = 4.9\text{E+03}$

$0.049 = 4.9 \times 10^{-2} = 4.9\text{E-02}$

$1{,}490{,}000 = 1.49 \times 10^6 = 1.49\text{E+06}$

GLOSSARY

accretion

The gradual addition of new land to old by deposition of sediment carried by the water of a stream.

activity

See *radioactivity*.

adsorption

The adhesion (attachment) of a substance to the surface of a solid or solid particles.

aggregate

Any of several hard, inert materials such as sand or gravel used for mixing with a cementing material to form concrete, mortar, or plaster.

air dispersion coefficients

Parameters that represent the dispersion of air pollutants with respect to distance from the source.

air quality

A measure of the levels of *constituents* in the air; they may or may not be pollutants.

air quality standards

The prescribed level of *constituents* in the outside air (*ambient air*) that should not be exceeded legally during a specified time in a specified area. (See *criteria pollutant*.)

air sampling

The collection and analysis of air samples for the purpose of measuring pollutants.

alluvial

Deposited by a stream or running water.

ambient air

The surrounding *atmosphere*, usually the outside air, as it exists around people, plants, and structures. It is not the air closest to emission sources.

anaerobic

Environments that are lacking molecular or dissolved oxygen.

annulus

The space between the two walls of a double-wall tank.

anoxia

Depletion of oxygen.

aqueous

Made from, with, or by water.

aquifer
A geologic formation that contains enough saturated, porous material to permit movement of groundwater and to yield groundwater to wells and springs.

atmosphere
The layer of air surrounding the Earth.

Atomic Energy Commission (AEC)
A five-member commission established after World War II to supervise the use of *nuclear energy*. The AEC was dissolved in 1975 and its functions transferred to the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), which later became the Department of Energy (DOE).

background exposure
See *exposure* to *radiation.*

background radiation
Normal radiation present in the lower *atmosphere* from cosmic rays and earth sources. Background radiation varies considerably with location depending on elevation above sea level and *natural radioactivity* present in the earth or building materials such as granite.

baseline
Assessment of existing conditions before the addition of pollutants.

benthic
Associated with the bottom of a body of water or living in the bottom sediments, as in "benthic organism."

benthic macroinvertebrate
An animal that lives in or on the bottom, that is visible to the naked eye, and has no vertebral column (backbone), such as the aquatic larvae of insects (mayflies and caddisflies) and adult mollusks (clams and mussels).

benthic region
The bottom of a body of water. This region supports the benthos, a type of life that not only lives on but contributes to the character of the bottom of the body of water.

biodiversity
The variety of organisms which inhabit a particular area.

biological dose
The radiation *dose*, measured in *rem*, absorbed in biological material.

biota
The plant and animal life of a region.

blackwater stream
A stream containing dark-colored water due to high levels of tannic and/or humic acid from leaf litter and detritus.

blending credit
The amount of dilution expected when wastewater is discharged into a water source such as a river or stream.

bottomland
Lowland formed by *alluvial* deposit along a stream or in a lake basin.

bottomland hardwood forest
Forested wetlands containing a predominance of hardwood species such as oak, hickory, sweetgum, tulip poplar, bald cypress, and blackgum found adjacent to streams and rivers in the southeastern United States.

°C
Degree *Celsius*. $°C = \frac{5}{9} \times (°F - 32)$.

cancer
A malignant tumor of potentially unlimited growth, capable of invading surrounding tissue or spreading to other parts of the body.

carcinogen
An agent capable of producing or inducing *cancer*.

carcinogenic
Capable of producing or inducing *cancer*.

Carolina Bay
Shallow depressional wetland area found on the southeastern Atlantic Coastal Plain.

catchment basin
A basin to catch drainage or *runoff*.

categorical exclusion
A *NEPA* term as defined by the Council on Environmental Quality as an action that does not individually or cumulatively have a significant effect on the human *environment*.

Category 2 species
Plant or animal species for which there is some evidence of vulnerability, but for which presently there is not enough data to support listing as threatened or endangered.

celsius
Of or relating to a temperature scale that registers the freezing point of water as 0°C and the boiling point as 100°C under normal atmospheric pressure.

Citizens Advisory Board
A formally chartered group of local private citizens who provide DOE with a consensus of public opinion on SRS issues.

collective dose
The sum of the individual *doses* to all members of a specific population.

collocated
To place together in proper order.

committed dose equivalent
The *dose equivalent* calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body.

committed effective dose equivalent
The sum of the *committed dose equivalents* to various tissues in the body.

concentration
The quantity of a substance contained in a unit quantity of a medium (e.g., micrograms of aluminum per liter of water).

condensate
Liquid water obtained by cooling the steam produced in an evaporator system.

confidence level
The certainty of a particular point (measurement, amount, value) being within a statistically determined range.

confining unit
A geologic *strata* which, because of its position and its impermeability or low *permeability* relative to the *aquifer*, gives the water in the *aquifer* artesian *head.*

confluence
The point where two streams meet.

constituents
Parts or components of a chemical system.

cooling water
Water which is pumped into a *nuclear reactor* to cool components and prevent damage from the intense heat generated when the reactor is operating.

corrective measures study
An evaluation of various remedial alternatives.

criteria pollutant
Air pollutants for which the U.S. Environmental Protection Agency has established *concentration* standards; *concentrations* below the standards do not pose a threat to public health and welfare.

cross section
A profile portraying an interpretation of a vertical section of the earth explored by geophysical or geologic methods.

cumulative effects
Additive environmental, health, or socioeconomic effects that result from a number of similar activities in an area.

curie (Ci)
A unit of measure of *radioactivity* equal to 37,000,000,000 decays per second. A curie is also a quantity of any nuclide or mixture of nuclides having one curie of *radioactivity*.

deactivation
To cease operation.

decay, radioactive
The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in the emission of *nuclear radiation* (alpha, beta, gamma, or neutron radiation).

decisionmaker
Group or individual whose responsibility is to make a decision concerning the future of the River Water System.

delta
A deposit of sediment, usually triangular in shape, at the mouth of a river, stream, or tidal inlet.

de minimus
Maximum plant-wide air emission of the toxic chemical that will not require further modeling review.

dose
The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the *rad*, equal to 0.01 joules per kilogram of irradiated material in any medium.

dose conversion factor
Factor used to calculate the *cancer* risk for a radiation *dose*.

dose equivalent
A term used to express the amount of effective radiation when modifying factors have been considered. It is the product of absorbed *dose* (*rads*) multiplied by a quality factor and other modifying factors. It is measured in *rem* (*Roentgen* equivalent man). (See *effective dose equivalent*.)

dose rate
The radiation *dose* delivered per unit time (e.g., *rem* per year).

drawdown (1)
The height difference between the water level in a formation and the water level in a well caused by the withdrawal of ground water.

drawdown (2)
To reduce the water level in a lake.

dry layup
Layup condition where the pipe distribution system is allowed to drain. No effort is made to pump low points dry, and inspections of distribution piping would continue.

ecology
The study of the relationships between living things and their *environments*.

ecosystem
The community of living things and the physical *environment* in which they live.

ecotone
TC The transitional area between two ecological communities (e.g., between a grassland and a forest).

effective dose equivalent
A quantity used to estimate the biological effect of ionizing radiation. It is the sum over all body tissues of the product of absorbed *dose*, the quality factor (to account for the different penetrating abilities of the various types of radiation), and the tissue weighting factor (to account for the different radiosensitivities of the various tissues of the body).

effluent
A liquid discharged into the *environment*, usually into surface streams. In this *EIS*, effluent refers to discharged wastes that are nonpolluting in their natural state or as a result of treatment.

effluent standards
Defined limits of waste discharge in terms of volume, content of contaminants, temperature, etc.

EIS
Environmental impact statement; a legal document required by the National Environmental Policy Act (NEPA) of 1969, for Federal actions involving significant or potentially significant environmental impacts.

embankment
A ridge of earth or stone to prevent water from passing beyond a desirable limit.

emission standards
Legally enforceable limits on the quantities and kinds of air contaminants that may be emitted to the *atmosphere*.

endangered species
Plant or animal species that are threatened with extinction.

environment
The sum of all external conditions and influences affecting the life, development, and ultimately, the survival of an organism.

environmental justice
The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of *pollution* or environmental hazards due to a lack of political or economic strength.

environmental restoration

To restore an area to the natural state which existed before it was degraded by human activity.

environmental transport

The movement through the *environment* of a substance, including the physical, chemical, and biological interactions undergone by the substance.

epilimnion

The upper, warmer layer of a stratified lake. TC L12-06

erosion

The process in which actions of wind or water carry away soil.

euphotic zone

The upper layer of a body of water that is penetrated by sunlight, this includes the *littoral* and *limnetic zones.*

eutrophic

A water body which has become enriched with excessive amounts of plant nutrients (such as nitrates and phosphates) and is characterized by excessive growth of aquatic plants.

exceedance

A value over a prescribed limit.

exposure to radiation

The incidence of radiation on living or inanimate material by accident or intent. *Background exposure* is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that occurs during a person's working hours. Population exposure is the exposure to a number of persons who inhabit an area.

external radiation

Being exposed to radiation from sources outside your body.

°F

Degree Fahrenheit. $°F = °C \times \frac{9}{5} + 32$.

facies

A group of rocks that differ from surrounding rocks.

facultative (wetland species)

Taking place under some conditions but not others.

fall line

An imaginary line drawn through the falls (or rapids) of successive rivers and roughly defining the area where streams pass from the harder rocks of the *Piedmont* to the softer rocks of the Coastal Plain.

fallout
: The descent to earth and deposition on the ground of particulate matter (which is usually radioactive) from the *atmosphere*.

fault
: A break in the Earth's crust along which movement has occurred.

fauna
: Animals.

feasibility study
: A detailed technical, economic, and legal review of a specific proposed project at a particular location. A feasibility study outlines all potential costs, benefits, and problems.

fiscal year
: Period of one year used to calculate financial data. As defined by the Federal government, this *EIS* uses a fiscal year which begins on October 1 and ends on September 30.

floodplain
: The relatively smooth valley floors adjacent to and formed by rivers subject to overflow.

flora
: Plants.

fluvial
: Relating to or living in, or near a river.

fold
: A bend in geologic *strata*.

full pool
: The highest water level reached in a lake without overflow of the *embankments*.

gamma rays
: High-energy, short-wavelength electromagnetic radiation accompanying fission, radioactive decay, or nuclear reactions. Gamma rays are very penetrating and require relatively thick *shields* to absorb the rays effectively.

genus/genera
: A group of structurally or phylogenetically related species.

geology
: The science that deals with the Earth: the materials, processes, *environments*, and history of the planet, especially the lithosphere, including the rocks and their formation and structure.

groundwater
: The supply of fresh water in an *aquifer* under the Earth's surface.

groundwater percolation
: The gravity flow of water through pores in underlying rock or soil into *groundwater*.

half-life (radiological)
: The time in which half the atoms of a radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

hazard index
: The sum of more than one *hazard quotient* for multiple substances and/or multiple exposure pathways. The hazard index is calculated separately for chronic, subchronic, and shorter-duration exposures.

hazard quotient
: The ratio of a single substance exposure level over a specified period of time (e.g., subchronic) to a reference *dose* for that substance derived from a similar exposure period.

head
: As related to water wells, the pressure of a fluid upon a unit area due to the height at which the surface of the fluid stands above the point at which the pressure is determined.

headwaters
: The source and upstream waters of a river or stream.

hydraulic conductivity
: The ability of water to move through an *aquifer*, also the ratio of the flow velocity to driving force for viscous flow under saturated conditions of *groundwater*.

hydraulic gradient
: As applied to an *aquifer* it is the rate of change of pressure *head* per unit of distance of flow at a given point and in a given direction.

hydrogeologic
: Pertaining to the rocks which bear water in the subsurface.

hydrostratigraphy
: Names used to identify the water-bearing properties of rocks.

hypolimnion
: The lower, cooler water layer found in stratified lakes.

impoundment
: An enclosed reservoir of water.

incision depth
: Depth that a river or creek has cut down into the earth's surface.

infrastructure
: Items that were once important parts of the processes with which SRS accomplished its missions.

inhibited water
: Water treated with chemicals to retard or halt corrosion, especially of metals.

in situ
In the original location.

institutional controls
Actions that limit human activities at or near facilities where hazardous and/or radioactive wastes exist. They may include land and resource use restrictions, well drilling prohibitions, building permit restrictions, and other types of restrictions.

Integrator Operable Units
Contaminated stream systems on the SRS that are also classed as RCRA/CERCLA units. IOUs have multiple contamination in their *watersheds*.

interim status
The period of operation for facilities that require RCRA permits until the permitting process is complete.

internal radiation
Being exposed to radioactive materials inside the body.

isotope
An atom of a chemical element with a specific atomic number and atomic mass. Isotopes of the same element have the same number of protons but different numbers of neutrons. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus. For example, plutonium-239 is a plutonium atom with 239 protons and neutrons.

jockey pump
A small, efficient pump used in place of larger pumps to maintain the River Water System.

lacustrine
Pertaining to, formed in or produced by a lake or lakes.

latent cancer fatalities
Deaths resulting from *cancer* that has become active following a period of inactivity.

layup
To maintain portions of the River Water System in a predetermined state of readiness, retaining the capability for restart in a timeframe that varies inversely with the state of readiness.

limnetic zone
The open-water zone of a lake or reservoir to the depth of light penetration.

littoral zone
The shallow-water zone of a pond, lake, or reservoir where light penetrates to the bottom. Typically occupied by rooted plants in natural (undisturbed) systems, but not as a rule in managed systems, such as flood-control *impoundments*.

lotic
Pertaining to flowing water.

low-income communities
A community in which 25 percent or more of the population is identified as living in poverty.

lower limit of detection
The smallest *concentration*/amount of the component being measured that can be reliably detected in a sample at a 95 percent *confidence level.*

macrophyte
An aquatic vascular plant.

maximally exposed individual
A hypothetical member of the public assumed to receive the highest calculated *dose*.

mesotrophic
Describes a body of water with a moderate nutrient content (compares to *eutrophic* and *oligotrophic*).

metalimnion
In a stratified lake, the transitional zone between the *hypolimnion* and the epilimnion where the change in temperature with depth is the most rapid. Also referred to as the "thermocline."

micron
A micrometer (10^{-6} meters).

migration
The natural travel of a material through the air, soil, or *groundwater.*

Miocene
Fourth of the five epochs of the Tertiary period (more recent than Eocene).

mobility
The ability of a chemical element or a pollutant to move into and through the *environment*.

morbidity risk
The frequency with which exposed individuals would contract both fatal and non-fatal *cancers.*

mortality risk
The frequency with which exposed individuals die from induced *cancer*.

mothball
To place and maintain facilities in a condition practical to restart, conducting only those activities necessary for routine maintenance or to protect human health and the *environment*.

natural radiation or natural radioactivity
Background radiation. Some elements are naturally radioactive, whereas others are induced to become radioactive by bombardment in a reactor or accelerator.

natural recharge
To fill and maintain a water body from the natural flow of sources such as streams, springs, or rivers; as opposed to pumping water from one of these sources.

NEPA

National Environmental Policy Act of 1969; it requires the preparation of an *EIS* for Federal projects that could present significant impacts to human health or the *environment*.

nonprocess water

At SRS, *potable* water.

NRC

Nuclear Regulatory Commission; the independent Federal commission that licenses and regulates commercial nuclear facilities.

nuclear energy

The energy liberated by a *nuclear reactor* (fission or fusion) or by radioactive decay.

nuclear power plant

A facility that converts *nuclear energy* into electrical power. Heat produced by a reactor is used to make steam to drive a turbine which drives an electric generator.

nuclear radiation

Radiation, usually alpha, beta, gamma, or neutron, which emanates from an unstable atomic nucleus.

nuclear reactor

A device in which a fission chain reaction is maintained and which is used for irradiation of materials or the generation of electricity.

nutrient loading

The amount of plant nutrients (such as nitrates or phosphates) released into a receiving stream, either from human or natural sources.

offsite population

In this *EIS*, all individuals located within an 80-kilometer (50-mile) radius of SRS.

oligotrophic

Describes a body of water with a low nutrient content (compares to *eutrophic* and *mesotrophic*).

operable units

CERCLA defined area being investigated for environmental remediation.

organic compounds

Chemical compounds containing carbon and usually hydrogen and/or oxygen.

outcrop

Place where *groundwater* is discharged to the surface. Springs, swamps, and beds of streams and rivers are outcrops of the water table.

outfall

Place where liquid *effluents* enter the *environment* and may be monitored.

Paleozoic
: First of two eras of geologic time, the other being the Mesozoic.

particulates
: Solid particles small enough to become airborne.

people of color communities
: A population that is classified by the U.S. Bureau of the Census as Black, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, or other nonwhite persons, the composition of which is at least equal to or greater than the state minority average of a defined area or jurisdiction.

percent attainment
: Percent of the time a facility is available for operations.

perched
: A water-bearing area of small lateral dimensions lying above a more extensive *aquifer*.

periphyton
: Organisms, such as attached algae, that live on rocks, submerged logs, stems and leaves of aquatic plants, and other substrates in aquatic habitats.

permeability
: Ability of rock, soil, or other substance to transmit a fluid.

person-rem
: The radiation *dose* to a given population; the sum of the individual *doses* received by a population segment.

pH
: A measure of the hydrogen ion *concentration* in *aqueous* solution. Pure water has a pH of 7, acidic solutions have a pH less than 7, and basic solutions have a pH greater than 7.

photosynthesis
: A process in green plants during which light energy is converted to chemical energy. During this process, oxygen is released.

physiographic
: Regions classified based on their physical geographic and geologic setting.

Piedmont
: Geographic region of the Appalachians that is characterized by plains formed by the coalescing of *alluvial* fans.

plankton
: Minute organisms in ponds, lakes, and reservoirs that float with the currents, and whose movements and distribution are largely determined by currents. Phytoplankton are floating plants (e.g., algae); zooplankton are floating animals (e.g., microscopic crustaceans).

plume

The elongated pattern of contaminated air or water originating at a point source, such as a smokestack or a hazardous waste disposal site.

pollution

The addition of any undesirable agent to an *ecosystem* in excess of the rate at which natural processes can degrade, assimilate, or disperse it.

porosity

The ratio of the total void space in rock or soil to its total volume.

postulated accident

An accident that is forwarded as having occurred to produce the described effects.

potable

Drinkable; for domestic use.

potentiometric map

A representation of the subsurface with contours, showing the elevations to which water would rise by hydrostatic pressure.

privatization

The transfer of government operations to the private sector. This is a long-term goal for many of the operations at SRS.

process well/water

At SRS, water used within a system or process and not used as *potable* water.

pro-deltaic

In reference to rocks or sediments deposited at sea in advance of the river *delta*.

production well/water

At SRS, water treated and used as *potable* water.

rad

Radiation absorbed *dose*; the basic unit of absorbed *dose* equal to the absorption of 0.01 joules per kilogram of absorbing material.

radiation shielding

Reduction of radiation by interposing a shield of absorbing material between a radioactive source and a person.

radioactivity

The spontaneous decay of unstable atomic nuclei, accompanied by the emission of radiation.

radioisotopes

Radioactive *isotopes*. Some radioisotopes are naturally occurring (e.g., potassium-40), while others are produced by nuclear reactions.

receiving waters

Rivers, lakes, oceans, or other bodies of water into which treated or untreated waste waters are discharged.

recharge

Process by which water is absorbed to or added to the subsurface water supply or to the streams of the area.

Record of Decision (ROD)

A document that provides a concise public record of DOE's decision on a proposed action for which as *EIS* was prepared. A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by DOE in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why the were not.

redox potential

An expression of the oxidizing or reducing potential of water from a particular source; this serves as an indicator of the state or form in which chemicals will occur. For example, reduced iron is soluble in water while oxidized iron precipitates as iron oxide (rust). Therefore, redox conditions can alter the environmental *mobility* and other properties of some chemicals.

rem (Roentgen equivalent man)

The unit of *dose* for biological absorption. It is equal to the product of the absorbed *dose* in *rads* and a quality factor and a distribution factor.

remedial investigation

A detailed technical study of the type and extent of contamination at a particular site, including alternatives for cleanup.

riparian

Pertaining to the banks of a body of water.

risk

In accident analysis, a measure of the impact of an accident considering the probability of the accident occurring and the consequences if it does occur (risk = probability ¥ consequences).

risk assessment

An analytical study of the probability and magnitude of harm associated with a physical or chemical agent, activity, or occurrence. A risk assessment defines the *risk* posed to human health and/or the *environment* by the presence of certain pollutants.

risk-based analysis

See *risk assessment*.

runoff

The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually is returned to water bodies. Runoff can carry pollutants or harmless chemical constituents into *receiving waters*.

scrub-shrub wetlands
Wetland areas dominated by woody vegetation less than 6 meters (20 feet) tall, including shrubs, young trees, and trees and shrubs that are small or stunted due to environmental conditions.

sedimentation
The settling of excess soil and mineral solids of small particle size (silt) contained in water.

seepage basin
An excavation that receives wastewater. Insoluble materials settle out on the floor of the basin and soluble materials seep with the water through the soil column where they are removed partially by *ion exchange* with the soil. Construction may include dikes to prevent overflow or surface *runoff*.

semivolatiles
Organic substances that partially evaporate at normal temperatures and pressures.

seston
TC The tiny plants and animals (i.e., plankton) and the nonliving particulate matter floating in a body of water.

shield
Material used to reduce the intensity of radiation that would irradiate personnel or equipment.

silt
Sediments with particle sizes between sand and clay.

siltation
The act of depositing sediment, as by a river.

slope factor
Radionuclide-specific lifetime average *cancer* incidence *risk* factors per unit intake or exposure usually expressed in picocuries for inhalation and ingestion pathways and picocuries per gram for direct exposure from contaminated soil.

solvent
A substance, usually liquid, that can dissolve other substances.

stakeholder
Any person or organization with an interest in or affected by DOE activities. Stakeholders may include representatives from Federal agencies, State agencies, Congress, Native American Tribes, unions, educational groups, industry, environmental groups, other groups, and members of the general public.

standby (cold standby)
Facility is maintained in a protected condition to prevent deterioration such that it can be brought back into operation.

strata
A series of individual sedimentary beds or layers.

stratigraphy
: Branch of geologic science concerned with the description, organization, and classification of layered rock units and associated non-layered rock units.

substratum
: In reference to the layer of soil directly below the top soil.

Superfund
: A trust fund established by the Comprehensive Environmental Response, Compensation, and Liability Act and amended by the Superfund Amendment and Reauthorization Act that finances long-term remedial action for hazardous waste sites.

surface water
: All the water on the Earth's surface (streams, ponds, etc.), as distinguished from *groundwater*, which is below the surface.

surficial deposit
: Most recent geological deposit lying on bedrock or on or near the earth's surface.

terrain
: Area of ground considered as to its extent and natural features in relation to its use in a particular operation.

thermal stratification
: Well-defined horizontal water temperature zones in a lake or pond.

topography
: The general configuration of a surface including its relief. This term may apply to a land or water-bottom surface.

toxicity
: The quality or degree of being poisonous or harmful to plant or animal life.

transmissivity
: The ability of *aquifer* to transmit water through the vertical plane of an *aquifer*.

Triassic
: The early (i.e., oldest) of three periods of geologic time within the Mesozoic Era.

turbidity
: The degree to which water is muddied or clouded by suspended sediments.

vadose zone
: The volume of rock and soil that is above the saturated zone.

volatile organic compounds
: An *organic compound* with a vapor pressure greater than 0.44 pounds per square inch at standard temperature and pressure.

volatilized
Caused to pass off as a vapor.

waste acceptance criteria
Criteria put forth by a waste management facility which defines the waste it will accept.

waste certification criteria
Criteria that must be met for transport, treatment, and disposal of waste.

waste minimization
Reduction of waste before treatment, storage, or disposal by source reduction or recycling activities.

water quality standard
Provisions of state or Federal law that consist of a designated use or uses for the waters of the United States and water quality standards for such waters based upon those uses. Water quality standards are used to protect the public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act.

watershed
The area drained by a given stream.

wind rose
A map showing the direction and magnitude of the wind.

DISTRIBUTION LIST

DOE is providing copies of the draft EIS to Federal, state, and local elected and appointed officials and agencies of government; Native American groups; Federal, state, and local environmental and public interest groups; and other organizations and individuals listed below. Copies will be provided to other interested parties upon request.

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Committee on National Security

The Honorable Bob Livingston
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