4.4.2.2.9 1000-acre lake

This alternative consists of a 1000-acre once-through cooling lake on Steel Creek (Figure 4-25). The normal water surface elevation would be 58 meters above mean sea level. The embankment for this cooling lake would be at the same location as that for the 500-acre lake described in Section 4.4.2.2.6. This alternative would require the relocation of two 115-kilovolt electric transmission lines and buried supervisor control and relay cable lines that cross Steel Creek near Road A-14. Roads A-14, A-14.1, and B-5 would have to be abandoned.

The lake would have a length of about 7000 meters including about 1500 meters of tailwater upstream of the outfall canal. The embankment would be about 750 meters long, 28 meters high, and 210 meters wide at its base. The water would be discharged several meters below the top of the embankment. Several small earthen berms would be required to prevent high water from overflowing natural saddles into adjacent watersheds. One of these points could be controlled for use as an emergency spillway to prevent unusually large storm flows from overtopping the embankment.

The construction of the 1000-acre lake would begin after permits had been obtained from the appropriate State and Federal agencies. The estimated time for the design and construction of this alternative would be about 36 months without an expedited schedule. This schedule assumes there would be no major permitting delays. With an expedited schedule, this alternative could be completed in 6 months, as discussed in Section 4.5 and Appendix L.

The construction of the earthen embankment, baffle structures, and water diversion system for the lake would cause some temporary increases in suspended solids in the creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the impoundment, and (2) during emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas. About 1.2 million cubic meters of fill material would be required for the embankment.

Borrow pits of suitable materials and similar quantities have been identified in the past for similar construction at the Savannah River Plant, and have been controlled in an environmentally acceptable manner. For this alternative, the most economically suitable pit would be identified and similarly controlled.

Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met necessary environmental control requirements. In one case, special precautions were taken to protect a Thermal Effects Laboratory operated for environmental purposes on Upper Three Runs Creek. These measures were completely successful. Spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive species; contaminated spoil would be disposed of in a suitable manner. During construction, the location and number of access roads would be minimized to reduce environmental impacts. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the 1000-acre lake would be approximately $25 million. Operating and maintenance costs would be about $3.4 million. The present worth of this alternative would be $56 million and the annualized cost would be $6.6 million (Du Pont, 1983d). An estimated 550 workers would be required for the construction of the lake.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-39 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without reduction in power (Du Pont, 1983d). These temperatures could be lowered by a reduction in reactor power, as discussed in Section 4.5 and Appendix L. The 1000-acre lake without power reductions would probably be uninhabitable to aquatic and semiaquatic biota. A depauperate biological community could exist in the lower reaches of the impoundment near the embankment. Projected water temperatures in the summer (5-day worst-case) at the Steel Creek delta, the mid-swamp, and the mouth of Steel Creek would be within 2°C of ambient. In the spring, water temperatures at Steel Creek delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions do not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7° to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek, and also cause the phenomenon of cold shock. This alternative would not adversely impact access and spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta.

Table 4-39. Temperatures (°C) downstream in Steel Creek with a 1000-acre lake

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	34	32	26	17
Road A	34	32	26	17
Swamp at delta	34	31	25	15
Mid-swamp	31	29	22	13
Month of creek at river	31	28	22	13

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor.

[c]Temperature of water leaving lake.

The habitat impacted by the 1000-acre lake alternative would include between 520 and 680 acres of wetlands in the Steel Creek corridor. The lake would also inundate 775 acres of uplands. An additional 100 acres of uplands would be impacted due to the relocation of electric and cable rights-of-way. The flow rate would adversely impact between 215 and 335 acres of wetlands in the Steel Creek delta and swamp that provide foraging habitat for the endangered wood stork and the endangered American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. It could also prevent access by riverine and anadromous fish in summer to about 2280 acres of wetlands along Steel Creek above L-Reactor and along Meyers Branch. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

Because this alternative would require approximately 11 cubic meters per second of Savannah River water, the impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek from this alternative would be no more than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system have been determined to be eligible for inclusion in the National Register of Historic Places. No direct impacts are expected to the prehistoric site or to three of the historic sites because they would be below the embankment and outside the area affected by high-water flow conditions. One historic site area would be inundated when the lake was filled. In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register. Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). The study results, determination eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth of about 1 to 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the lake, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The ground-water level would be altered in the vicinity of the lake.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, (6) the preparation of a biological assessment for endangered species, and (7) consultation with the SHPO for archeological resources.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 1000-acre-lake alternative would not begin until the end of the construction period.

4.4.2.2.10 Penstock diversion to Pen Branch/lake-canal diversion to Pen Branch

Heated secondary coolant leaving L-Reactor could be diverted to Pen Branch, which presently carries heated effluent from K-Reactor back to the Savannah River. Because of physical location, the input to Pen Branch from L-Reactor would occur a few kilometers upstream of the point at which Indian Grave Branch, which receives K-Reactor discharges, joins Pen Branch.

Two possible methods of water diversion to Pen Branch have been evaluated. They are (1) by penstock and canal (Figure 4-26) and (2) by lake and canal (Figure 4-27).

Under the first option, cooling effluent from L-Reactor would be diverted through an underground pipe that would begin at the 904-L sump, which is where secondary cooling water from L-Reactor accumulates after passing through the reactor heat exchangers. The pipe would convey the flow to the northwest, about 1200 meters to the north side of SRP Road 7, where it would discharge into an open canal. The water would flow through the canal about 1000 meters to Pen Branch. No pumping would be required in either the pipe or the canal. Structural improvements to bridges crossing Pen Branch might be required because of increased flows.

The estimated minimum time required to design and construct this alternative is 38 months (Du Pont, 1983d). All construction would take place away from Steel Creek. Therefore, L-Reactor shutdown would be required for approximately 1 to 2 months for the installation of a pipe connection and valves.

For the penstock-and-canal diversion to Pen Branch, the estimated capital cost would be $7 million. The annual operating cost would be $3.4 million and the present worth would be $36 million. The annualized cost would be $4.2 million. An estimated 120 construction personnel would be required.

Water requirements for the penstock-and-canal diversion to Pen Branch would be 11 cubic meters per second. Production efficiencies would be 100 percent. During summer periods of high river temperatures, reactor operating power would be reduced, though the same flow rate would be maintained.

Although Steel Creek temperatures would not be increased above ambient, Pen Branch would receive about 11 cubic meters per second of water at 73°C, which exceeds the State limit of 32.2°C. The reported temperature (73°C) is for extreme summer meteorological conditions and reflects reduced reactor operating power due to elevated Savannah River temperatures. A previously unaffected 5-kilometer portion of Pen Branch would experience increased temperatures well above ambient.

The second diversion option would require an earthen embankment in Steel Creek about 1500 meters downstream from the L-Reactor effluent canal discharge. The embankment would require 17,000 cubic meters of material. Truck access roads for embankment construction would be routed to minimize environmental impacts. The embankment would form a small (60-acre) lake (Figure 4-27) to provide additional cooling. A canal and a pipe with a combined length of about 1400 meters would divert the flow from the lake to Pen Branch. Just north of Road A, the diversion from Steel Creek would join Pen Branch, which carries the effluent stream discharged from K-Reactor. No pumping would be required.

A diversion of L-Reactor effluent would cause extensive additional impacts to the Pen Branch system. The penstock-and-canal alternative would impact approximately 5 kilometers of the stream, or 55 acres of wetland that have not been impacted by earlier reactor operations. In addition, about 210 acres of the Pen Branch delta and 960 acres of the Savannah River swamp would be affected. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). Construction of the canal would affect 10 acres of upland habitat. No wetlands (i.e., Steel Creek above L-Reactor, Meyers Branch, or Boggy Gut Creek) would be isolated by this alternative.

With a lake and canal, a discharge structure could be constructed away from the existing stream to carry reactor effluent. The diversion pipe, canal, and drop structure could be constructed and most clearing completed during this time. The estimated time required to design and construct this alternative would be 33 months.

For the lake-and-canal diversion to Pen Branch, the estimated capital cost would be $4 million. The annual operating cost would be $3.4 million, and the present worth would be $33 million. Annualized costs would be $3.9 million. An estimated 315 construction personnel would be required.

Water use from the Savannah River for the lake-and-canal diversion would be 11 cubic meters per second. The production efficiency would be 100 percent.

Thermal impacts are not expected in Steel Creek below the 60-acre lake and embankment. The lake-and-canal alternative would cause approximately 4 kilometers of unimpacted stream and floodplain along Pen Branch to receive heated effluent at about 73°C during extreme summer meteorological conditions. A total of about 1280 acres of wetlands would be impacted by the lake-and-canal alternative, including (1) Pen Branch (50 acres), (2) Steel Creek (60 acres), (3) Pen Branch delta (210 acres), and (4) the Savannah River swamp (960 acres). These wetlands are also classified as Resource Category 2 by the FWS (USDOI, 1981).

About 10 acres of uplands would be affected by the construction of the canal. This alternative would isolate about 100 acres of wetlands above the embankment. The temperature at the Pen Branch entry to the swamp would be about 58°C and the temperature at the mouth of Steel Creek would be 30°C in summer. The lake-and-canal diversion to Pen Branch would result in discharge water temperatures well above the 32.2°C State discharge limit.

A reactor shutdown of about 1 month would allow the diversion of stream flows through the discharge structure and the clearing of land adjacent to the stream. The dam would be constructed and the discharge stopped to fill the lake and divert flows to Pen Branch.

Any alternative involving a diversion to Pen Branch would result in average water temperatures at the mouth of Steel Creek of 29°C in summer, 23°C in spring, and 18°C in winter without power reduction. This would be about 2°C above ambient in summer, and spring, and 6°C above ambient in winter.

The penstock-and-canal alternative would not have a direct impact on aquatic habitat in Steel Creek upstream from the swamp. However, the lake-and-canal alternative, in addition to diverting L-Reactor effluent to Pen Branch, would convert the upper reach of Steel Creek into a tributary of Pen Branch, which is much less productive biologically due to long-term thermal impacts from the operation of K-Reactor. The thermal effluent discharging into this modified stream would eliminate any access to the upper reach of Steel Creek during the operation of either K- or L-Reactor. Aquatic organisms in the upper reach that survive these modified conditions would become isolated unless neither reactor were operational.

Either alternative would result in a loss of habitat in the lower reaches of Pen Branch due to increased flows of heated water. This would occur primarily in backwater areas that have not been impacted directly by the main thermal stream.

The occurrence of resident alligators above the Pen Branch delta is unlikely (Murphy, 1981), although the 7800-acre swamp bordering the Savannah River might support a small population. The impact of this option on endangered and threatened species is considered to be insignificant.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Radiocesium transport would consist of about 0.25 curie per year from Steel Creek plus a component from Pen Branch. About 0.15 curie would be remobilized and transported in Pen Branch to Steel Creek during the first year of resumed L-Reactor operation. The total transport from Steel Creek is estimated to be 0.4 curie per year. Liquid releases of tritium from L-Reactor would be about 9600 curies per year.

An estimated seven or eight archeological sites are assumed to be impacted by this alternative as the result of the construction of the diversion canal and the increased flow down Pen Branch. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Additional impacts to existing aquatic habitat in Pen Branch would result from erosion and sedimentation effects. The stream flow would increase to about ten times normal in the upper reach between the points of entry into the stream of the L-Reactor and K-Reactor discharges. The increased erosion, downcutting, widening, and straightening of the stream would result in the loss of existing aquatic habitat. In addition, erosion would be expected in the lower reach where, with either option, the stream flow would be twice the present flow. Changes in sedimentation due to either alternative would result in the Pen Branch delta growth rate reaching about 18 acres per year.

The chemical characteristics of the L-Reactor liquid effluent are estimated to be similar to those of Steel Creek and the Savannah River, and not unlike those presently being discharged by K-Reactor to Pen Branch. No appreciable change is expected in the characteristics of the effluent as it flows through the lake-and-canal system, except about 4 percent of the suspended sediment load would be lost. About 100 metric tons of silt and clay would be deposited in the lake each year.

Additional impacts would be caused by changes in existing stream flow patterns. The diversion of flows from upper Steel Creek would reduce flows in the lower reaches of this stream, thereby modifying or eliminating some existing aquatic habitat, particularly in backwater areas.

These alternatives would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If either of the Pen Branch diversion alternatives is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge begins, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from the penstock/canal diversion alternative would include no impacts to wetlands of the Steel Creek corridor (i.e., 420 to 580 acres); the lake/canal alternative would cause no impacts to wetlands below the dam. Between 1225 and 1280 acres of wetlands associated with Pen Branch and the Savannah River swamp, however, would be impacted. Mitigative effects would not begin until the end of the 18-month construction period.

4.4.2.3 Cooling towers

The following sections describe three types of cooling towers--once-through, recirculation, and partial-recirculation. Figure 4-28 shows the estimated discharge-water temperatures for cooling towers with 2.8°C, 5.6°C, and 8.4°C approach temperature designs, which are based on recorded average wet-bulb temperatures at the SRP. The approach temperature is the number of degrees over the ambient wet-bulb temperature to which the reactor secondary cooling water can be reduced by the cooling tower. The curves on Figure 4-28 show the resultant cooled/cooling-water temperatures for the three approach temperatures. If the 1-percent worst-case meteorological condition (the 1-percent design wet-bulb temperature is 26.7°C) had been used to develop the curves, the resulting cooling-tower discharge-water temperatures would have been higher by about 3.5°C than those shown. With the 1-percent design wet-bulb temperature, both the 5.6°C and the 8.4°C approach temperature towers would exceed the State of South Carolina water-discharge temperature limit of 32.2°C part of the time.

For commercial power plants, recirculating cooling towers have been constructed as fast as 18 months from award of contract. The temperature of the L-Reactor cooling water would be higher than that of commercial power plants, which would require special consideration in the engineering design of the cooling towers and pumps. Although the time period required for the design, procurement, construction, and testing of recirculating cooling towers and pumps for L-Reactor could be expedited, DOE does not believe that the 27-month schedule could be greatly shortened without sacrificing proper consideration of the operability and reliability of the recirculating cooling tower system.

4.4.2.3.1 Cooling towers--once through

4.4.2.3.1.1 Once-through--discharge to Steel Creek

Cooling towers could be added to L-Area that treat the heated effluent and discharge it directly to Steel Creek. Such towers could be constructed adjacent to the existing reactor discharge canal, as shown in Figure 4-29. A diversion valve box would be built onto the 904-L sump to route the reactor discharge water through 750 meters of new 2.5-meter diameter pipe to the new cooling towers. The tower location would be a relatively flat area just north of Steel Creek along the west side of the discharge canal. This location is about 21 meters lower than the L-Reactor area and 12 meters lower than the outlet of the 904-L sump. The discharge from the cooling towers would run through short pipes to the existing discharge canal and then into Steel Creek at the original discharge point.

The differences in elevation between the diversion valve box and the cooling-tower sprays would be sufficient to eliminate the need for pumps. This would result in a capital cost and time savings, an energy savings, and less dependence on the operation of mechanical equipment.

This alternative could meet the 32.2°C temperature criterion for water discharged to State waters. River water would be passed through the reactor heat exchangers and cooling towers and diverted to the outfall. Water withdrawal from the river would be about 11 cubic meters per second, the same quantity as that for the direct discharge case.

About 27 months would be required to design and construct this alternative. On an expedited schedule this alternative could be constructed in a little more than 1 year. If L-Reactor operation starts before the alternative is implemented, a shutdown of about 1 month would be required while the new cooling system is connected into existing facilities.

The capital cost for the 2.8°C approach tower would be approximately $55 million; the cost of the 5.6°C approach tower would be $50 million. Annual operating costs for the 2.8°C and 5.6°C approach tower designs would be $5.5 million and $5.4 million, respectively. The present worth of this alternative would be $102 million for the 2.8°C approach tower and $96 million for the 5.6°C approach tower. The annualized costs would be $12 million and $11.3 million, respectively. An estimated 135 construction personnel would be required for either tower.

The production efficiency would be the same as that for the direct discharge alternative, 100 percent. The reactor would have a volume flow rate of about 11 cubic meters per second from the Savannah River. This alternative would discharge cooling effluent into Steel Creek at a flow of about 10.2 cubic meters per second.

The temperature of the effluent would be lower than that from the direct discharge alternative due to the cooling by the towers, and would vary according to the cooling tower approach temperature (i.e., 2.8° or 5.6°C).

With a 2.8°C approach temperature tower, the average effluent temperature entering Steel Creek would range from about 18°C in January to 28°C in July (Du Pont, 1983d). A preliminary analysis of SRP wet bulb data (Du Pont, 1983f) indicates the 32.2°C temperature maximum at the outfall would be exceeded once every 4.5 years. If the 5.6°C approach tower were used in this once-through system, the 32.2°C maximum at the outfall would be exceeded about five times a year. Downstream temperatures are listed in Tables 4-40 and 4-41, and shown (for the 2.8°C approach) in Figure 4-30. These temperatures assume no power reduction. Average ambient Steel Creek temperatures measured over a 30-year period at Road A are about 29°C in summer, 22°C in spring, and 8°C in winter.

Table 4-40. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (2.8°C approach)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	28	27	23	18
Road A	29	28	23	17
Swamp at delta	30	28	23	15
Mid-swamp	29	27	21	13
Mouth of creek at river	29	27	21	13

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering Steel Creek.

Once-through cooling towers (either the 2.8°C or the 5.6°C approach temperature) with a discharge to Steel Creek would provide normal compliance with the 32.2°C maximum discharge temperature during average meteorological conditions.

The towers would substantially mitigate the thermal effects associated with direct discharge; the environmental impacts of this alternative would be

Table 4-41. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	31	30	28	24
Road A	32	30	26	21
Swamp at delta	32	30	26	19
Mid-swamp	30	28	23	15
Mouth of creek at river	30	28	22	14

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering Steel Creek.

somewhat less than those for direct discharge because of flow rate; they are summarized as follows:

- The high flow rate would eliminate between 420 and 580 acres of wetlands in the Steel Creek corridor. In addition, about 30 acres of uplands would be impacted by the construction of the cooling towers. Because the effluent would not have markedly elevated temperatures, the high flow rate would impact between 70 and 80 percent of the area predicted for direct discharge. Thus, between 215 and 335 acres of wetlands would be eliminated in the delta and swamp. The total amount of wetlands that would be impacted by this alternative is between 635 and 915 acres. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

- The spring water temperatures in mid-swamp would be within 4°C of ambient for the 5.6°C approach, and within 2°C of ambient for the 2.8°C approach. Thus, approximately 2500 acres of wetlands and aquatic habitat would be available to spawning riverine and anadromous fishes and other aquatic and semiaquatic biota.

- The impingement of 16 fish per day (5840 fish per year), and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

- The remobilization and transport of 3.2 curies (2.8°C approach) or 3.3 curies (5.6°C approach) of radiocesium (first year). Liquid releases of tritium to the Savannah River would be about 8850 curies per year. These values would be about the same for both the 2.8°C and 5.6°C approach.

- Fogging conditions (i.e., visibility is reduced to less than 1000 meters) would occur about 5 hours per year within 1.0 kilometer of the towers. Icing to an average thickness of 1.0 millimeter on horizontal surfaces within 0.5 kilometer of the towers would occur 55 hours per year. Salt drift deposition within 1 kilometer is estimated to be 0.37 kilogram per acre per month.

- Potential impacts to five archeological sites eligible for the National Register. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

- No impacts to substrate, water quality, or water levels due to dredging and filling.

This alternative would require the following permits or processes: (1) an NPDES permit, (2) a 316(a) demonstration, (3) consultations with the FWS, and (4) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, environmental impacts would be as described above (i.e., loss of about 635 to 915 acres of wetlands due to flow effects). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.2 Once through--canal to swamp

Under this alternative, 2.8°C, 5.6°C, or 8.4°C approach cooling towers would be constructed on the south side of Road B, approximately 1000 meters southwest of L-Reactor, as shown in Figure 4-29. The cooling-water effluent would be pumped to the towers through a buried pipeline from a new sump constructed over the existing cooling-water discharge pipe. The sump, approximately 9 meters square and 11 meters deep with pumps, would be built over the existing outfall pipe.

As shown in Figure 4-31, the discharge from the cooling tower would flow into a new excavated and lined canal, which would be constructed along or near the top of the west bank of Steel Creek. The canal would be routed adjacent to Steel Creek above the floodplain and extend for approximately 10.4 kilometers before discharging at the delta. This canal, which would be similar to those constructed with Par Pond, would cross under two railroad tracks, roads A-14, A, A-17.1, and A-17.2, and several 115-kilovolt and super control and relay cable lines. The canal would have to feed into a pile-supported aerial pipeline or viaduct where it crosses a low area about 1200 meters below Road A. This pipe or viaduct would discharge back into a canal and continue to the edge of the swamp. A discharge structure would be constructed in the Savannah River swamp west of the Steel Creek delta with diffusers to control erosion and to mix the cooling-water discharge.

About 27 months would be required to design, construct, and permit this alternative. If L-Reactor is started operating before this alternative is constructed, a shutdown of about 1 month would be required while all new facilities are completed to cut the existing pipe and install a valve to retain water in the sump.

Dredge material from the canal and the area in the swamp around the diffuser will be handled and monitored to meet applicable regulatory requirements. Thus, no significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or Savannah River due to dredge and fill activities. Access roads to construction areas would be selected to minimize impacts.

Capital costs for the pumping station, cooling towers, canal/pipeline, and other related items would be an estimated $68 million to $89 million, depending on cooling-tower efficiency. Annual operating costs would be an estimated $5.2 million to $5.6 million. The present worth of this alternative would be from about $112 million to $136 million, and the annualized cost would be $13.2 million to $16 million. An estimated 300 construction personnel would be required.

Production efficiency is estimated to be 100 percent of that for the direct discharge case. About 11 cubic meters per second of water would be required from the Savannah River. This alternative would discharge cooling-water effluent directly at the Steel Creek delta at a rate of flow of about 10.1 cubic meters per second.

These towers could be 2.8°C, 5.6°C, or 8.4°C approach temperature towers designed for about a 27°C wet bulb; however, only the cooling-water temperature from the 2.8°C tower would be near ambient when the water is discharged to the delta. Tables 4-42, 4-43, and 4-44 list seasonal temperatures for these three approach temperatures. Ambient temperatures (30-year average) in Steel Creek measured at Road A are 29°C in summer, 22°C in spring, and 8°C in winter.

Table 4-42. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (2.8°C approach)--canal-to-swamp

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	28	27	23	18
Swamp at delta	28	27	23	18
Mid-swamp	29	27	21	13
Mouth of creek at river	29	27	21	13

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering swamp.

Table 4-43. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach)--canal to swamp

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	31	30	28	24
Swamp at delta	31	30	28	24
Mid-swamp	30	26	23	15
Mouth of creek at river	30	25	22	14

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering swamp.

Table 4-44. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (8.4°C approach)--canal to swamp

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	34	34	31	28
Swamp at delta	34	32	28	21
Mid-swamp	31	29	24	17
Mouth of creek at river	31	29	23	16

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering swamp.

The discharge at the swamp from the 2.8°C approach cooling tower would exceed State discharge temperature limits only infrequently. The 5.6°C and 8.4°C towers would be in compliance under average summer conditions. Under some conditions, power reduction would be necessary.

This alternative (all approach temperatures) would avoid Steel Creek to its delta, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. About 30 acres of uplands would be impacted by construction of the towers. The effluent would reach the swamp via the canal parallel to Steel Creek and would enter the swamp through a diffuser at temperatures between 28° and 31°C during the summer; this would allow riverine and anadromous fish and other aquatic biota to have access to the swamp during the spawning season and partial access during the summer for the 2.8°C and 5.6°C approaches. However, the impacts on the swamp (i.e., loss of 215 to 335 acres of wetlands) from the 10.1-cubic-meter-per-second flow would be almost the same as those described for direct discharge. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). The canal would impact about 120 acres of upland pine forest and open fields, and require the disposal of approximately 850,000 cubic meters of spoil. Dredged material would be monitored and handled to meet applicable regulatory requirements.

This alternative would have no impact on endangered and threatened species that inhabit Steel Creek above its delta because the creek corridor would not receive thermal effluent. The discharge of 10.3 cubic meters per second through a diffuser located at the Steel Creek delta could channelize portions of the existing wetlands. However, the discharge temperatures (28°C and 31°C for 2.8°C and 5.6°C approaches in summer, respectively) would not have adverse impacts on the American alligator. The greatest potential impact would result from elevated water levels, which could eliminate foraging habitat for the endangered wood stork, and foraging and roosting habitat for migratory waterfowl. The shortnose sturgeon would be unaffected by this alternative.

The impacts of impingement and entrainment would be the same as those for direct discharge--impingement of 16 fish per day (5840 fish per year) and annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Under this alternative, there would be no remobilization or transport of radionuclides from the substrate of the Steel Creek corridor. Approximately 1.4 curies of radiocesium from the delta and swamp would be remobilized and discharged to the Savannah River. Liquid releases of tritium to the Savannah River would be about 8900 curies per year.

Approximately 5 hours per year of fogging would occur within 1.0 kilometer of the towers. The estimated frequency of ice accumulation on horizontal surfaces will be 55 hours per year. Drift deposition of salts is predicted to be about 0.37 kilogram per acre per month.

Several archeological sites occur near or along the canal route and could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described under direct discharge.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit,

(4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetland in Steel Creek corridor and losses of 215 to 335 acres in the swamp). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.3 Once through--spray canal and canal to swamp

A variation on the previously described once-through, canal-to-swamp alternative using 2.8°C or 5.6°C approach cooling towers would be to add a spray system to the canal; this would reduce the cooling-tower discharge temperature of the water by about 3°C in the summer. The discharge would comply with State discharge criteria for the 2.8°C and 5.6°C towers. The spray canal location and configuration would be as shown in Figure 4-21.

About 27 months would be required to design and construct this alternative. A shutdown of about 1 month would be required while all new facilities are completed and connected to the cooling-water discharge of the reactor. Truck routes to construction areas would be selected to minimize environmental impacts. If a 5.6°C approach tower were used for this alternative, most of the discharge water temperature reduction that was caused by the spray canal would be lost due to the less efficient cooling tower.

Capital costs for the 2.8°C approach cooling towers, spray canal, and canal or pipeline to the Steel Creek delta would be about $98 million; annual maintenance and operating costs would be about $5.5 million. The present worth of this alternative would be $146 million, and the annualized cost would be $17.1 million (Du Pont, 1983d).

The capital cost for a 5.6°C approach cooling tower with a spray canal and canal to the swamp would be about $93 million. With annual maintenance and operating costs similar to those of the 2.8°C approach tower, the present worth would be $139 million and the annualized cost would be $16.4 million. An estimated 330 construction personnel would be required.

The production efficiency for this alternative would be the same as that for the direct discharge alternative, 100 percent. Production efficiency (reactor power) would be reduced in the summer when cooling-water temperatures from the Savannah River are elevated. This alternative would discharge cooling-water effluent into the swamp via a canal at a somewhat lower rate of flow (10.0 cubic meters per second) than direct discharge due to evaporation losses.

Downstream temperatures for this alternative are presented in Tables 4-45 and 4-46. Ambient temperatures in Steel Creek at the delta (30-year average) would be summer--33°C, spring--22°C, and winter--8°C.

Table 4-45. Temperatures (°C) downstream in Steel Creek with a once-through cooling tower (2.8°C approach)--spray canal and canal to swamp

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Swamp at delta	30	28	23	12
Mid-swamp	29	27	21	10
Mouth of creek at river	29	27	21	11

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

Table 4-46. Temperatures (°C) downstream in Steel Creek with once-through cooling towers (5.6°C approach) with a spray canal and canal to the swamp.

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Swamp at delta	32	30	24	15
Mid-swamp	30	28	22	13
Mouth of creek at river	30	28	22	13

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

This alternative would include complete avoidance of Steel Creek down to the swamp, allowing approximately 450 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via a canal near Steel Creek and enter the swamp through a diffuser at a temperature of 23°C in spring (2.8°C approach). This would allow access to the swamp and Steel Creek by spawning riverine and anadromous fish and other aquatic biota. However, the impacts on the swamp from the 10.0-cubic-meter-per-second flow would be somewhat less than those described for direct discharge.

Both the 2.8°C and the 5.6°C approach-temperature cooling towers would result in full-time compliance with the 32.2°C State discharge temperature limit as the cooling water enters the swamp.

The environmental impacts of this alternative would be similar to those for cooling towers with a once-through discharge via a canal to the swamp. These impacts are summarized as follows:

- About 55 acres of wetlands and 55 acres of uplands would be impacted by construction of the spray canal. No impacts to wetlands would occur within the Steel Creek corridor, but the increased flow rate would eliminate between 215 and 335 acres of wetlands in the swamp. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

- Approximately 120 acres of upland pine forest and open fields would be disturbed for construction of the canal; the towers would displace 30 acres of uplands. About 850,000 cubic meters of spoil would have to be removed and stored or utilized. Any dredged material would be monitored and handled to meet applicable regulatory standards.

- No impact to the American alligator and shortnose sturgeon would occur; foraging habitat of the endangered wood stork and roosting habitat for migratory waterfowl would receive adverse impacts from increased water levels.

- Approximately 16 fish per day (5480 fish per year) would be impinged, and 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would be entrained annually.

- No remobilization or transport of radionuclides from the Steel Creek corridor would occur. About 1.0 curie of radiocesium would be remobilized and transported to the Savannah River by either approach. Liquid releases of tritium to the river would be about 8640 curies per year.

- Approximately 5 hours of fogging and 55 hours of horizontal icing would occur, and 0.37 kilogram per acre per month of salt drift would be deposited.

- Several archeological sites near or along the canal route could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

- The bottom contour of the swamp near the diffuser would be modified.

- No impacts to water quality or increased suspended particulates and turbidity would result from the dredging of the canal. Short-term impacts could be associated with the installation of the diffuser.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.1.4 Once through--canal to swamp; pipe to river

Another variation of the once-through cooling-tower alternative would use the same canal to the swamp as that described previously, except it would not discharge near the Steel Creek delta. Instead, it would discharge into a pile-supported pipeline extending approximately 2500 meters across the swamp to a new discharge structure with diffusers to be constructed in the Savannah River below the mouth of Steel Creek. This alternative is shown in Figure 4-32. The effluent completely bypasses the Steel Creek corridor and swamp.

For this design, K-Reactor would still discharge through the mouth of Steel Creek, but L-Reactor would discharge downstream into the K-Reactor plume.

The canal would be parallel to the Steel Creek floodplain. It would be constructed by using material from cuts as fill material where needed. The pipeline across the swamp would be supported on pilings to prevent the pipe from acting as a water barrier when the swamp is flooded. Because a pile-driver would be used, no material would have to be dredged for the pilings. Barges would be floated in during periods of high water and tied together to form a working platform or temporary causeway. Equipment for building the pipeline would work from the barges. Vegetation adjacent to the pipeline would be removed to provide room for the barges. Some dredging and fill at the river would be needed to place the diffuser. The dredged material would be monitored and handled to meet applicable regulatory standards.

About 27 months would be required to design, construct, and permit this alternative. All construction would take place away from Steel Creek. A shutdown of about 1 month would be required while the new facilities are completed and connected to the cooling-water discharge if L-Reactor operation starts before this alternative is implemented.

Temporary, limited impact to wetlands from this alternative would result from the construction of the pipeline. This raised structure would extend from a point near the Steel Creek delta to the Savannah River, a distance of 2500 meters. Pipeline construction could have adverse impacts on the Savannah River swamp because of: (1) piles driven into the substrate to support the pipeline, (2) the use of heavy equipment affecting wetlands by compacting the substrate, and (3) increased erosion and sedimentation due to disturbances of the substrate.

Capital costs for the cooling towers, the canal to the swamp, and the pipeline over the swamp to the river would be about \$103 million for the 8.4°C approach tower or \$112 million for the system with the 5.6°C approach tower. Yearly maintenance and operating costs would be \$5.2 million to \$5.4 million and the present worth would be \$140 million to \$158 million. Annualized cost would be \$16.5 million to \$18.6 million (Du Pont, 1983d). An estimated 375 construction personnel would be required.

The production efficiency for this alternative would be 100 percent, the same as that for the direct discharge alternative. Water withdrawal from the river would be the same as for direct discharge. The only environmental impact to the swamp would be due to the pipeline construction.

The water discharge flow rate to the Savannah River would be about 10.1 cubic meters per second for this alternative. No discharges would be released to Steel Creek.

Because this alternative would completely avoid Steel Creek and the swamp, approximately 730 to 1000 acres of wetland would continue to undergo successional recovery; fish would have full access to Steel Creek and the swamp. However, the access of fish to Boggy Gut Creek would be limited, especially during the spring and summer.

In summer, considering extreme meteorological conditions, this alternative would discharge effluent into the Savannah River at temperatures of 5°C and 7°C above ambient for the 5.6°C and 8.4°C approaches, respectively. In the spring, temperatures at the mouth of Steel Creek would be 5° to 7°C above ambient. Effluent temperatures in winter at this discharge point would be 19° to 21°C. These temperatures would be 7° to 9°C above ambient temperature. The 5.6°C approach alternative would comply with maximum discharge temperature criteria; the 8.4°C approach alternative would not comply.

The diffuser would be constructed to mix the effluent rapidly with the river. Based on seasonal outfall temperatures, a zone of passage would be maintained to allow movement of anadromous fish past SRP; the mouth of Steel Creek would not be blocked by temperatures high enough to exclude riverine and anadromous fish from entering and spawning in the Steel Creek swamp system (for both 5.6°C and 8.4°C approach temperatures). Discharge temperatures could attract some fish species into the thermal plume during the winter; however, insignificant impacts are expected on riverine species due to overwintering stress.

The pipeline would be constructed above the high-flood mark (about 7 to 9 meters), so it could not act as a dam and impede water flow during flooding.

Proper buffers would be installed during construction to prevent movement of suspended particulates, which could cause turbidity impacts. Discharge water quality would be the same as that described for direct discharge. No significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or the Savannah River.

Other environmental consequences of this alternative would be as follows:

- Construction of the canal would impact about 120 acres of upland pine forest and open fields, and would require the disposal of approximately 850,000 cubic meters of spoil material. The construction of the towers would impact 30 acres of upland pine forest.

- Construction of the pipeline would impact foraging habitat of the endangered wood stork.

- The impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would occur.

- No remobilization and transport of radionuclides in sediments of Steel Creek and the swamp would occur. About 0.25 curie of radiocesium would be released annually from Steel Creek as the result of P-Area discharges and natural flow. Liquid releases of tritium to the Savannah River would be about 8900 curies per year.

- Atmospheric discharges from the canal and cooling towers would result in approximately 5 hours of increased fogging, 55 hours of icing on horizontal surfaces, and salt drift deposition of 0.37 kilogram per acre per month.

- Several archeological sites occur near or along the canal route and could receive adverse impacts from construction activities. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.2 Cooling towers--recirculation

4.4.2.3.2.1 Total recirculation--blowdown to Steel Creek

Cooling towers that completely recirculate the cooling water could be added to the L-Reactor site. The towers would be designed for a 2.8°C or 8.4°C approach temperature at a 27°C wet bulb. The secondary cooling water would be discharged from the reactor heat exchanger, cooled by the cooling towers, and returned to the 186-L reservoir for recirculation. Makeup water would be required to replace evaporative and blowdown losses.

This option would require the construction of cooling towers adjacent to the reactor (Figure 4-33). A reinforced concrete sump, approximately 9 meters square and 11 meters deep with pumps, would be built over the existing outfall pipe. The sump pit could be constructed around the existing outfall pipe while reactor flows continue. Discharge pipes from the pumps would run above ground to connections with an underground pipe that would convey the heated water to the top of the cooling towers. The flow would proceed by gravity to reinforced concrete basins beneath the towers and then to the 186-L reservoir. About 27 months would be required to design and construct this option (Du Pont, 1983f).

All construction would take place away from Steel Creek. If L-Reactor is restarted before this alternative is implemented, a shutdown of about 1 month would be required to cut the existing pipe and install a valve to retain water in the sump.

Approximately 300 meters of the north perimeter fence and road would have to be relocated around the north side of the new cooling towers to provide space for the structures and the connecting pipes to the reservoir. A control building (approximately 8 by 15 meters) for miscellaneous electrical and mechanical items would also be required. Power could be run from existing sources in the L-Reactor complex to both new areas. Construction roads would be located to minimize environmental impacts.

Capital costs for the 2.8°C approach towers are estimated to be $60 million. Annual operating and maintenance costs for the cooling towers would be $2.5 million. The present worth would be $142 million, and the annualized cost would be $16.7 million. Towers designed for a 8.4°C approach temperature at a 27°C wet bulb would have a capital cost of about $39 million, which is somewhat less than that for the 2.8°C approach temperature towers. Operating and maintenance costs would be $2.2 million; the present worth would be $198 million; and the annualized cost would be $23.3 million (Du Pont, 1983d). An estimated 150 construction personnel would be required. The overall configuration of the cooling-tower water recirculation system would be similar to that shown for the more efficient towers in Figure 4-33.

Production efficiency for the 2.8°C approach towers is estimated to be 94 percent (derived from Du Pont, 1983d) of that for the direct discharge case. Production efficiency for the 8.4°C approach towers is estimated to be 85 percent (derived from Du Pont, 1983d). The makeup-water requirement for a 2.8°C or 8.4°C approach cooling tower is estimated to be approximately 1.4 cubic meters per second, of which about 0.6 cubic meter per second would be due to blowdown and about 0.8 cubic meter per second would be due to evaporation.

Under extreme meteorological conditions, the cooling-tower blowdown (0.6 cubic meter per second) to Steel Creek would have summer exit temperatures of 28°C (2.8°C approach) and 34°C (8.4°C approach).

The blowdown water discharge temperature from the cooling towers would vary depending on existing meteorological conditions and reactor operating power. Downstream temperatures are listed in Tables 4-47 and 4-48 and shown in Figures 4-34 and 4-35. The 30-year-average ambient Steel Creek temperatures measured at Road A are 29°C in summer, 22°C in spring, and 8°C in winter.

Under extreme summer meteorological conditions, the cooling-tower blowdown to Steel Creek would have an exit temperature of about 34°C (8.4°C approach). Near-ambient temperatures would be reached at the Steel Creek delta in the summer and spring for the 2.8°C approach. Temperatures at the delta in winter would be about ambient with the 2.8°C and 8.4°C approaches. Winter temperatures at the mouth of Steel Creek would be at ambient for both designs.

The 2.8°C approach tower would comply with the 32°C maximum discharge temperature except under extreme summer meteorological conditions. The 8.4°C approach system could be expected to regularly exceed the 32°C maximum temperature in summer.

Table 4-47. Temperatures (°C) downstream in Steel Creek with total recirculation cooling towers (2.8°C approach)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	28	27	23	18
Road A	32	29	23	10
Swamp at delta	33	29	22	9
Mid-swamp	29	26	19	7
Mouth of creek at river[d]	30	27	21	12

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering Steel Creek.

[d]Temperature increase due to mixing with K-Reactor effluent.

Table 4-48. Temperatures (°C) downstream in Steel Creek with total recirculation cooling towers (8.4°C approach)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	34	34	31	28
Road A	33	30	24	12
Swamp at delta	33	29	23	10
Mid-swamp	29	26	19	7
Mouth of creek at river[d]	30	27	21	12

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering Steel Creek.

[d]Temperature increase due to mixing with K-Reactor effluent.

The 2.8°C and 8.4°C approach recirculation alternatives would substantially reduce thermal discharge to Steel Creek, and would result in minimal impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge. This alternative would have low discharge rates, and impacts due to flow would be minimal.

The construction of the towers would affect approximately 30 acres of upland pine forest. This area is contiguous with the L-Reactor facility and does not provide habitat for endangered or threatened species or other important wildlife.

Based on an estimated requirement of 7 percent makeup or 1.4 cubic meters per second of Savannah River water usage for the cooling towers, there would be approximately 743 fish impinged per year, and 9.8×10^5 fish eggs and 1.5×10^6 fish larvae entrained per year as the result of L-Reactor operation with cooling towers.

Radiocesium transport down Steel Creek would be about 0.8 curie per year by either approach. Liquid releases of tritium from L-Reactor to the Savannah River would be about 8900 curies per year.

Nonradioactive atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., the visibility reduced to less than 1000 meters) within about 1 kilometer, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be deposited from tower drift within about 1 kilometer of the tower.

No archeological sites are expected to be impacted by this alternative.

The ion-concentration ratio in the blowdown to Steel Creek is expected to be about 3. Thus, the chemical constituents in the creek water near the L-Reactor outfall would be about 1.7 times their normal concentration without the blowdown. At Road A, the increases in concentration would be only about 1.4 times normal. The blowdown is not expected to have an appreciable impact on the water quality of Steel Creek, the swamp, or the Savannah River.

This alternative would require consultation with the FWS. No other consultations or permits are required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the construction period.

4.4.2.3.2.2 Total recirculation--blowdown treatment

As indicated in Table 4-47 in Section 4.4.2.3.2.1, the resultant temperature rise in Steel Creek could exceed the State discharge criteria of 2.8°C above ambient due to reactor secondary cooling-water discharge temperatures during certain months of the year. Winter compliance would be the most difficult. Measures could be taken to ensure that the State requirements would always be met by additional blowdown treatment. Such measures could include one of the following: (1) refrigerating the blowdown before discharge to Steel Creek, (2) piping all the blowdown to Par Pond or K-Reactor and thereby eliminating the blowdown discharge to Steel Creek, (3) using a small cooling tower to further reduce the blowdown temperature before discharge, or (4) using a holding pond for the blowdown with or without a spray system.

The application of a large refrigeration system (estimated 10,000 tons refrigeration capacity--see Figure 4-36) to cool the blowdown flow would guarantee full-time compliance with State discharge requirements, because the blowdown would always be discharged at near-ambient stream temperature. This alternative represents the "Best Technology Available" for minimizing thermal discharge impacts. Piping the blowdown to Par Pond or K-Reactor is being considered at this time with regard to its practical application. The small cooling tower or holding ponds could significantly reduce the discharge temperature, but possibly not enough to meet the 2.8°C criterion in the winter. Cost estimates are available at this time only for the refrigeration blowdown treatment.

Construction time and reactor downtime for this alternative have been estimated to be about the same as those for the total recirculation system without blowdown treatment (Section 4.4.2.3.2.1).

The capital cost of the total-recirculation 2.8°C approach cooling-tower system with blowdown refrigeration is estimated to be $75 million. Yearly operating and maintenance costs for this alternative would be $3.2 million. Present worth would be $163 million and annualized cost would be $19.1 million. An estimated 170 construction personnel would be required.

Although the refrigeration system would ensure compliance with State requirements, it would represent a significantly increased capital cost and annual operating cost over a cooling-tower system without blowdown treatment. Production efficiency would be 93.5 percent for this alternative with refrigeration.

This cooling-system alternative would discharge 0.6 cubic meter per second of blowdown effluent at the same temperatures in summer and spring as those achieved by cooling towers having total recirculation (2.8°C approach). In summer, winter, and spring, near-ambient temperatures (calculated) would be achieved from the outfall to the Savannah River. Winter temperatures at the mouth of Steel Creek would be 11°C. This slightly over-ambient-temperature water could attract and concentrate fish near the mouth of Steel Creek.

Table 4-49 lists Steel Creek temperatures for various seasons with this alternative. Ambient temperatures in Steel Creek at Road A are 29°C in the summer, 22°C in the spring, and 8°C in the winter.

The total-recirculation cooling towers with blowdown refrigeration would be in continuous compliance with the maximum 32°C discharge temperature except during extreme summer meteorological conditions. If less efficient cooling towers were used, additional refrigeration could be used to meet State requirements; cost, however, would increase accordingly. The refrigeration unit would be operated for a longer time period over the year if less efficient towers were used.

This alternative would have essentially the same environmental impacts as those resulting from the implementation of cooling towers having total recirculation (2.8°C approach) without blowdown cooling during the spring and summer

Table 4-49. Temperatures (°C) downstream in Steel Creek with a total-recirculation cooling tower (2.8°C approach) with blowdown treatment (refrigeration)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	28	27	23	11
Road A	32	29	23	9
Swamp at delta	33	29	22	9
Mid-swamp	29	26	19	7
Mouth of creek at river[d]	30	27	21	11

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water entering Steel Creek.

[d]Temperature increase due to mixing with K-Reactor effluent.

because the blowdown would meet criteria without treatment. During the winter the impacts would be less with treatment because the blowdown would be treated to meet criteria. These impacts are summarized as follows:

- Construction of the towers would affect approximately 30 acres of upland pine forest. There would be no impact to wetlands or the biota that inhabit the Steel Creek ecosystem and swamp.

- There would be no impact to endangered and threatened species.

- The makeup requirement would be about 1.4 cubic meters per second. Approximately 743 fish would be impinged annually; annual entrainment of fish eggs and larvae would be 9.8×10^5 and 1.5×10^6, respectively.

- Transport of radiocesium would be maintained at its normal level, about 0.8 curie per year. Tritium discharges in liquid effluents would be about 8900 curies per year.

- Atmospheric releases would result in (1) a maximum of 5 hours per year of fogging (i.e., visibility reduced to less than 1000 meters) within 1.0 kilometer of the towers, and (2) a maximum of 55 hours per year of ice accumulation on horizontal surfaces. An estimated 0.37 kilogram per acre per month of salts would be emitted.

- No archeological sites would be impacted.

Because of the low discharge rate, little or no change in present erosion or sedimentation patterns is expected. There would be no impacts to aquatic substrate or water quality from dredging and filling activities, because they are not required.

This alternative would require consultation with the FWS. No other consultations or permits are required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

4.4.2.3.3 Cooling towers--partial recirculation

4.4.2.3.3.1 Partial recirculation--discharge to Steel Creek

Cooling towers (2.8°C or 8.4°C approach temperature) that only recirculate a portion of the cooling water could be added to the L-Reactor site. From April through October the towers would cool water on a once-through basis and discharge all the effluent directly to Steel Creek. Based on equilibrium temperature calculations for these months, the discharge to Steel Creek under normal weather conditions would continuously meet the 32.2°C/+2.8°C temperature criteria if a 2.8°C approach cooling tower is used. Equilibrium temperature calculations indicate that, from November through March (Du Pont, 1983d,e), a portion of the cooling water must be recirculated to the 186-Basin. Table 4-50 lists the percent of the cooling-water flow exiting the cooling tower that would be allowed to discharge into Steel Creek. The percent of direct river water flow indicated in Table 4-50 is the blending water that would be mixed with the cooling-tower discharge to meet the State +2.8°C temperature criteria.

Table 4-50. Cooling-water usage for cooling-tower system with partial recirculation (2.8°C approach temperature tower)

Month	Percent of cooling tower flow into creek (tower discharge)	Percent of river water diverted directly to Steel Creek (blending water)
November	34	66
December	12	88
January	22	78
February	46	54
March	74	26

This alternative would require the construction of cooling towers adjacent to the reactor (Figure 4-33) as described for the complete recirculation tower alternative. In addition, a diversion box and piping would be required to direct the cooling water to either Steel Creek or the 186-L reservoir. About 27 months would be required to design and construct this alternative. Construction would take place away from Steel Creek. A shutdown of about 1 month would be