United States General Accounting Office

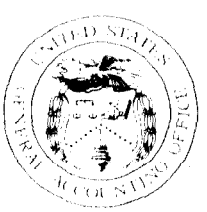
GAO

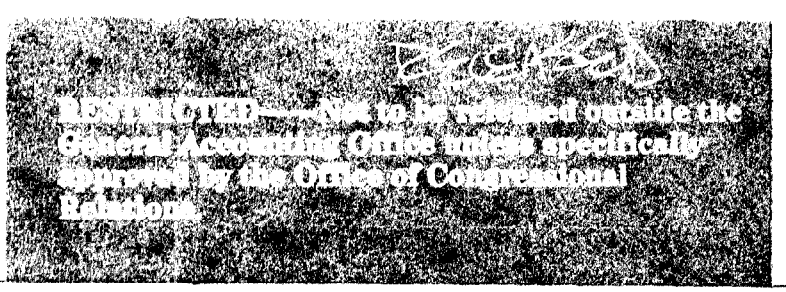
Report to Congressional Requesters

March 1991

NUCLEAR SAFETY

Status of Reactor Restart Efforts and Safety Culture Changes





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GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-236604

March 13, 1991

The Honorable John Glenn
Chairman, Committee on
Governmental Affairs
United States Senate

The Honorable Mike Synar
Chairman, Environment,
Energy and Natural
Resources Subcommittee
Committee on Government Operations
House of Representatives

In a June 1990 letter, you cited continuing concerns about the Department of Energy's (DOE) activities to restart three nuclear reactors—known as the K, L, and P reactors—at its Savannah River Site (SRS) in South Carolina. Your letter also referred to the reactor safety culture[1] concerns we reported on in April 1990[2] and asked us to monitor the restart activities of DOE and the Westinghouse Savannah River Company, the contractor who manages and operates SRS. We briefed your staff in November 1990 on the results of our monitoring efforts and agreed to provide you with a status report. This report describes (1) slippages in the restart schedule, (2) factors causing the latest delays, and (3) safety oversight changes and safety culture concerns.

The three SRS reactors have been shut down since 1988 to make hardware improvements, upgrade operator qualifications, expand staffing and training, increase management involvement, and improve oversight. DOE restart schedules have been changed several times to reflect revised startup dates. The most recent schedule was announced in February 1991.

The Secretary of Energy has stated that restarting the SRS reactors is a high priority because they are the nation's only production source of tritium, a radioactive gas used in nuclear weapons. The Secretary has also stated that there are important milestones to be reached before the

[1]Within the nuclear industry, safety culture is defined as an underlying philosophy whereby personnel believe that they are accountable for the safe operation of a facility, take personal interest in constantly striving to improve safety, communicate effectively, follow procedures, and are well-trained. DOE has basically adopted this philosophy for its facilities.

[2]Nuclear Safety: Concerns About Reactor Restart and Implications for DOE's Safety Culture (GAO/RCED-90-104, Apr. 12, 1990).

K reactor[3] is ready for operation and that K reactor operations will not be authorized until he is personally assured that applicable environmental, safety, and health considerations have been satisfied.

As discussed in a report we issued in early February 1991,[4] U.S. defense tritium requirements have decreased dramatically from 1988 through 1990 and may decrease further in future years. DOE's analyses of tritium requirements indicate that, without starting any reactors, sufficient tritium supplies will exist to meet the anticipated needs of the nuclear weapons stockpile for the next several years.

Results in Brief

As of February 1991, the three SRS reactors remained shut down. DOE's latest schedule—announced on February 4, 1991—projects a K reactor restart in the summer of 1991, with the L reactor's operation projected for early 1992. However, under the newly announced plan, the P reactor will not be restarted but will be terminated as an operational reactor and maintained in a cold standby status. Prior to the February 1991 announcement, the K reactor was scheduled for a December 1990 restart.

A wide variety of factors caused the delays in meeting the K reactor's December 1990 restart date and thus resulted in DOE's revising the schedule to the summer of 1991. These factors included (1) the late development of a reactor startup test program, (2) delays in completing originally scheduled work, (3) the large volume of new maintenance requirements discovered during testing, (4) new requirements added to the scope of required restart work, and (5) environmental issues. Even under the new restart schedule for the summer of 1991, DOE faces some issues, such as fire protection, that could result in added restart work and thus have the potential to affect the new schedule.

DOE and others have taken actions focusing increased attention on safety. These actions have included DOE reorganizations to address safety management and oversight issues and the Defense Nuclear Facilities Safety Board's extensive involvement in providing independent external oversight of DOE's nuclear safety activities. Although DOE has

[3]Because the K reactor is the first reactor scheduled for restart, this report focuses primarily on K reactor activities and DOE's December 1990 restart schedule for the K reactor.

[4]Nuclear Materials: Decreasing Tritium Requirements and Their Effect on DOE Programs (GAO/RCED-91-100, Feb. 8, 1991).

made positive safety oversight changes, both DOE and Westinghouse officials have recognized that the process of improving the underlying safety attitude—or safety culture—is a long-term effort that may not be fully completed before restart. Examples still persist that reemphasize the continuing need to focus on safety culture issues.

Background

A series of evaluations and an operating event led to shutting down the three SRS nuclear reactors to make a variety of improvements. The decision to make these improvements was precipitated by an August 1988 incident that occurred during an attempted startup of the P reactor. This incident occurred because reactor operators continued startup even though they were faced with unexplained abnormalities in reactor operations. This incident, and how the contractor[5] and DOE subsequently addressed it, raised a number of concerns about the complacent attitude of DOE and contractor employees toward safety, inadequate operator procedures and training, poor communication, and ineffective DOE management and oversight. Because of this incident, the P reactor was shut down on August 17, 1988. The K and L reactors were already in an outage status as part of normal operations. We testified about this incident in September 1988.[6]

Restart Schedules Continue to Slip

Since the 1988 shutdown of the reactors, SRS' restart schedules have slipped. In June 1989, Westinghouse originally proposed to restart the K reactor in September 1990, with the L and P reactors to resume operation in December 1990 and March 1991, respectively. In May 1990, however, DOE announced that the K reactor would restart in December 1990, with the P and L reactors to resume operation in March 1991 and September 1991, respectively. The K reactor did not restart in December 1990. In February 1991, DOE announced a revised schedule, which now projects that the K reactor can be safely restarted in the summer of 1991. (See app. I for more details on the restart schedules.)

[5]E.I. du Pont de Nemours (DuPont) managed and operated the SRS reactors for DOE from the 1950s until April 1, 1989, when the Westinghouse Savannah River Company became the new SRS operating contractor.

[6]Ineffective Management and Oversight of DOE's P-reactor at Savannah River, S.C., Raises Safety Concern (GAO/T-RCED-88-68, Sept. 30, 1988).

Factors Affecting Restart

The delays in meeting the December 1990 restart schedule for the K reactor are attributable to many factors, ranging from the late development of a reactor startup test program to the large volume of new corrective maintenance requirements to additional requirements for restart work. In addition, even if the work had remained on schedule, the K reactor could not have been restarted in December 1990 because of unresolved environmental issues. These factors and issues are highlighted in the following sections and are discussed in more detail in appendix II.

Late Development of the Startup Test Program

Development of the startup test program[7] experienced many problems that contributed to schedule delays. For example, even though the program's scope was to be completed in December 1989, the program was still under initial development in April 1990 when Westinghouse issued the revised schedule showing a December 1990 K reactor restart date.

Although the scope of the test program had been defined by the end of May 1990, DOE found in June 1990 that Westinghouse's plan for implementing the test program was not fully developed, the program's organization was weak, the procedure development effort was not properly defined, and fundamental tools such as an adequate test index and sequence—a compilation of all startup test program procedures—was not available. Westinghouse provided DOE with the startup test sequence and index in late September 1990 and with the overall startup test program schedule in early October 1990. The Savannah River Special Projects Office[8] told us that Westinghouse and DOE had originally thought that many of DuPont's old startup test procedures could be used with little or no modification, but that assumption proved to be incorrect in many cases. It is still possible that the startup test program could uncover unanticipated problems that may have the potential to affect the new schedule.

Delays in Completing Originally Scheduled Work

Another reason that the December 1990 restart date slipped was that some work set forth in the April 1990 Reactor Operations Management Plan—the detailed management plan and integrated work schedule for

[7]The purpose of the startup test program is to demonstrate the adequacy of physical structures, systems, and components used during normal operation and to demonstrate the performance of accident prevention and mitigation systems. The program includes preoperational testing activities performed prior to restart and startup testing activities.

[8]Since mid-1989, two DOE units—the Savannah River Special Projects Office and the Savannah River Restart Office—have had primary responsibility for ensuring that the reactors are restarted safely.

restarting the reactors—simply fell behind schedule owing to a variety of problems, some of which may have been controllable. For example, DOE's assessment of Westinghouse's performance during April-September 1990 stated that scheduled work tasks had been subject to excessive rework. DOE said that although there was no quantitative measurement of rework, the progress of startup testing had been consistently delayed by the need to perform the same task several times. DOE's assessment also stated that work performance was adversely affected by shortcomings in planning, work supervision, and the quality of performance.

Corrective Maintenance Requirements Discovered During Testing

The large volume of new corrective maintenance requirements discovered during testing was a further factor affecting the restart schedule. According to the Director, Savannah River Special Projects Office, this larger-than-anticipated volume of work occurred primarily because of the extensive past deferral of preventive maintenance work. For example, as of September 1990, about 84 percent of the preventive maintenance for the K reactor was overdue.

New Work Requirements

Subsequent to DOE's May 1, 1990, announcement that the K reactor would be restarted in December 1990, a number of new requirements were added to the scope of required restart work. As of mid-October 1990, Westinghouse had adjusted the schedule to incorporate 32 schedule change documents—some of which contained multiple new work items. Many of these new work requirements appeared in DOE's draft August 1990 Safety Evaluation Report[9] as "open" items that must be closed before restart.

According to an October 1990 Westinghouse memorandum, about 100 "open" items were added and required a significant effort: generating reports and procedures, conducting training, and justifying current positions. However, when incorporating the new work requirements into the schedule, none of the additions was shown to extend the time required to restart the reactors. Examples of new restart requirements included new work on the Supplementary Safety System and on the seismic capabilities of reactor structures and equipment.

[9]The Safety Evaluation Report provides the technical basis and documentation needed to justify a decision to restart. The report is patterned after the process used by the Nuclear Regulatory Commission to assess the safety condition of troubled nuclear plants.

In September 1990, the Westinghouse Reactor Safety Advisory Committee[10] said it was concerned that significant scope additions were being made that had a high potential for adversely affecting the schedule and creating excessive stress on the organization.

Under the new summer of 1991 restart schedule, DOE faces some issues that could uncover new restart work. For example, under the power limits program, additional modifications may be required to achieve a 50-percent operating power level at restart, and questions raised about fire protection could require more extensive analysis. These issues are under review by the Defense Nuclear Facilities Safety Board and/or DOE's Office of Nuclear Safety. Because the outcome of such reviews could result in new work, it is still possible that the new schedule could be affected.

Environmental Issues

Even if the work contained in the K reactor restart schedule had been completed on time, the K reactor could not have been restarted in December 1990 because of issues related to (1) completing the Environmental Impact Statement (EIS) required for the SRS reactors and (2) complying with the Environmental Protection Agency's (EPA) air pollution control requirements.

In addition, K reactor cooling tower litigation has created further uncertainty over any planned restart date. As we reported in April 1990, the state of South Carolina, under the Clean Water Act, issues the National Pollutant Discharge Elimination System permit for SRS.[11] Because of restrictions on discharges of hot water into streams and wetlands, DOE and the state entered into a consent order in 1984 requiring that DOE build a cooling tower for the K reactor by December 1992. The consent order allows DOE to operate the K reactor until the end of 1992 without a cooling tower but not thereafter. DOE expects the cooling tower to be completed by June 1992. However, in June 1990, the Natural Resources Defense Council and the Energy Research Foundation filed a suit in federal court to prevent DOE from operating the K reactor before the cooling tower is completed. These groups maintain that the K reactor should not be operated without a cooling tower unless the President exempts the K

[10]The Reactor Safety Advisory Committee is a group of external nuclear experts appointed by Westinghouse to advise Westinghouse of reactor operations safety. The Committee reports to Westinghouse management.

[11]We previously reported on this issue in Nuclear Health and Safety: Policy Implications of Funding DOE's K Reactor Cooling Tower Project (GAO/RCED-89-212, Sept. 27, 1989). Our April 1990 report (GAO/RCED-90-104) provides further information on the issue.

reactor from Clean Water Act requirements on the basis of national security needs. The litigation's outcome was still undecided as of mid-February 1991.

Safety Oversight Changes and Safety Culture Concerns

The oversight of SRS reactor operations has received increased attention since 1988 when the attempted startup of the P reactor had to be aborted. Safety oversight changes have included DOE reorganizations to address safety management and oversight concerns and the extensive involvement of the Defense Nuclear Facilities Safety Board in examining safety issues. These changes, when combined with DOE's expanding efforts to develop ways to assess the adequacy of the safety culture, reflect an ever increasing awareness of the importance of safety culture at SRS. Safety culture concerns continue to exist at SRS, however.

Changes in Safety Oversight

DOE and others, such as the Defense Nuclear Facilities Safety Board, have taken many steps to begin the process of addressing technical vigilance and safety oversight concerns in the operation of the SRS reactors. Much of DOE's oversight effort is directed toward monitoring, assessing, and improving the reactor operations' safety culture, which was recognized as a root cause of the problems that led to shutting down the SRS reactors in 1988.

In September 1988, we testified that three critical elements are required for an effective DOE safety management and oversight program: (1) strong line management responsibility and accountability for safety, (2) an effective internal oversight organization to oversee how line management is carrying out its role, and (3) an independent organization outside the control of DOE that oversees the agency's internal safety program.

In 1989, the Secretary of Energy took actions to address the first two critical elements. In mid-1989, he reorganized the reactor restart program management to provide greater line management accountability. In late September 1989, DOE also announced the establishment of the Office of Nuclear Safety, which reports to the Office of the Secretary, to advise the Secretary of whether line management and DOE's self-assessment functions are adequately ensuring nuclear safety. In late 1989, the third critical element began functioning in the form of the Defense Nuclear Facilities Safety Board, an oversight body mandated by the Congress. The Board has been heavily involved in providing independent external oversight not only of SRS reactor restart issues, but of public health and

safety issues at other DOE facilities. In February 1991, we issued a report on the Safety Board's first year of operations.[12] (See app. III for more details on safety oversight issues.)

Safety Culture Concerns

In our April 1990 report, we discussed safety culture problems at SRS and the recognition by both DOE and Westinghouse that the safety culture at SRS needs improvement and that such improvement will be a slow process. We also recognized the difficulty in measuring changes in employees' attitudes toward safety. We recommended that a comprehensive plan be prepared with specific tasks, milestones, and measurement indicators to achieve the desired safety culture changes. In carrying out work for this status report, we continued to note safety culture concerns at SRS.

In its October 1990 response to our April 1990 recommendation, DOE disagreed with the need for such a plan, but did indicate that both Westinghouse and DOE have initiated actions to strengthen the attitude toward reactor safety. DOE stated that the Reactor Operations Management Plan contains a discussion of the culture change program and that Westinghouse "recognized that many fundamental issues . . . require changes in the culture at SRS." DOE also stated that its Safety Evaluation Report will include discussions of the safety culture change at both Westinghouse and DOE, and, as part of this effort, DOE has established adequate acceptance criteria for restart. In addition, DOE plans to perform an Operational Readiness Review, which is a critical part of DOE's effort to assess safety culture before restart. These criteria, according to DOE, represent the measure against which the improvement of the safety culture will be judged. We did not assess the adequacy of the criteria for purposes of this report.

We believe that these are positive steps, even though DOE and Westinghouse officials recognize that the process of improving safety culture is a long-term effort that may not be completed before restart. For example, during the Defense Nuclear Facilities Safety Board's first year of operation, it found that training for reactor operators and supervisors was not adequate. The Board recommended that DOE review the qualifications it requires for operators and supervisors and modify the training procedures to ensure that personnel are qualified. The following K

[12]Nuclear Safety: The Defense Nuclear Facilities Safety Board's First Year of Operations (GAO/RCED-91-54, Feb. 5, 1991).

reactor example also illustrates the type of problem DOE and Westinghouse must address in dealing with safety culture weaknesses at SRS.

In August 1990, DOE representatives observed central control room operators while the primary coolant was drained from the K reactor tank and piping. Because the primary coolant contains radioactive tritium, the operators are supposed to monitor tritium-sensing equipment that can alert operators to primary coolant leakage during the draining operation. The DOE representatives reported, among other things, the following observations: (1) although a DOE representative noted irregular sensor equipment activity during preparations for tank drainage, the operators declared the tritium sensor to be functional (the sensor was subsequently found to be nonfunctional); (2) no operating personnel observed the tritium sensor during the operation until prompted by a DOE representative; (3) no operating personnel were aggressive in resolving the problem, and a supervisor said the sensor problem was not important; (4) the shift manager did not actively participate in resolving the problem; and (5) the Operations Manager, who was present as management oversight, took control of the operation and appeared to want the draining to continue despite the apparent equipment problem. The DOE representatives also stated that operating personnel at all levels demonstrated a lack of sensitivity to equipment status that was disturbing, especially at the late date in the restart effort. The DOE representatives were particularly concerned that they had to repeatedly bring attention to the problem to convince the operating personnel to take prudent actions. (See app. III for additional safety culture examples.)

Estimated Cost of Pre- and Post-Reactor Restart Activities

Several billion dollars will be spent on pre- and post-reactor restart activities over the next few years. According to DOE, between fiscal years 1989 and 1993, an estimated $3.2 billion will be spent on reactor restart and operations. For safety improvement activities not required for restart, according to DOE, the estimated costs for projects started during the fiscal year 1991-93 period are $1.05 billion. (See app. IV for more details on the cost estimates.)

Observations

DOE and Westinghouse officials are dealing with issues and problems affecting the restart of the K reactor as such issues and problems are identified. Although DOE and Westinghouse have a new detailed plan to restart the K reactor in the summer of 1991, past schedule experience has demonstrated the problems encountered in completing work to meet

restart dates. It is also difficult at this time to predict whether new or unanticipated problems may be uncovered while work is progressing toward the summer of 1991 restart date. As we stated in early February 1991, the decrease in tritium requirements and the prospect of further decreases provide additional time to evaluate outstanding safety and environmental issues before restarting the SRS reactors.

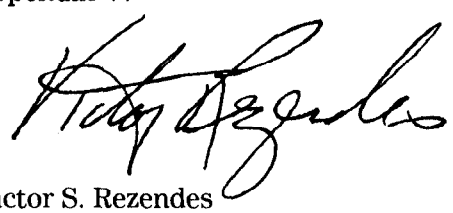
In your June 19, 1990, letter to us expressing concerns about various reactor restart activities, you asked us to monitor DOE's and Westinghouse's restart activities and to obtain information on how DOE planned to determine if improvements in the safety culture have sufficiently progressed to allow safe restart. We briefed your staff in November 1990 on the results of our work to date, and, at that time, agreed to provide you with an overview report on restart activities.

To develop the information for this report, we reviewed Westinghouse's restart plans, DOE's organization and oversight plans, reports on technical restart issues prepared by Westinghouse and DOE, reports on restart progress and problems prepared by DOE and Westinghouse, reports prepared by DOE consultants and contractors providing support services to DOE personnel at the Savannah River Site, and other files and documents related to reactor restart.

We interviewed DOE and Westinghouse officials responsible for reactor restart in Washington, D.C., and at the Savannah River Site. We also interviewed officials from DOE's Office of Nuclear Safety and members of the Defense Nuclear Facilities Safety Board. In addition, we reviewed reports and other correspondence of the Defense Nuclear Facilities Safety Board. We performed our work between July 1990 and February 1991 in accordance with generally accepted government auditing standards.

We discussed the facts in this report with DOE staff, who generally agreed with the material, and we incorporated their views where appropriate. As requested, however, we did not obtain official agency comments on a draft of this report. As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies of this report to the appropriate congressional committees; the Secretary of Energy; and the Director, Office of Management and Budget. Copies will also be made available to other interested parties who request them.

Should you have questions or need additional information, please contact me on (202) 275-1441. Major contributors to this report are listed in appendix V.



Victor S. Rezendes
Director, Energy Issues

Contents

Abbreviations

DOE	Department of Energy
EIS	environmental impact statement
EPA	Environmental Protection Agency
GAO	General Accounting Office
NRC	Nuclear Regulatory Commission
SRS	Savannah River Site

Reactor Restart Schedule Delays

In April 1990, we issued a report on reactor restart activities at the Savannah River Site (SRS).[1] In June 1989, Westinghouse's schedule proposed to restart the K reactor in September 1990, with the L and P reactors to resume operation in December 1990 and March 1991, respectively.[2] In May 1990, DOE announced that the K reactor would restart in December 1990, with the P and L reactors to resume operation in March 1991 and September 1991, respectively. K reactor did not restart in December. DOE announced a new restart schedule in early February 1991 that continued the trend in extending out the restart dates.

Restart Date Slippages

Since DOE's first announcement of restart dates in late 1988, each date has slipped. On February 4, 1991, DOE announced its latest revision to the restart dates. Under the current plan, DOE projects that the K reactor could be ready to be safely restarted during the summer of 1991. The L reactor is expected to be ready to resume production early in 1992. However, under the newly announced plan, P reactor will not be restarted but will be terminated as an operational reactor and maintained in a cold standby status.

During the period that the reactors have been shut down, various attempts were taken by DOE and the SRS contractors[3] to schedule and understand the complexity of restart activities.

For example, the K reactor restart strategy report[4] required that DuPont establish a controlled, formal, deliberate restart program for K reactor. In late December 1988, DuPont submitted a draft restart plan to DOE. In late March 1989, Westinghouse—which was due to take over officially

[1]Nuclear Safety: Concerns About Reactor Restart and Implications for DOE's Safety Culture (GAO/RCED-90-104, Apr. 12, 1990). Because the K reactor is the first reactor scheduled for restart, this report focuses primarily on K reactor activities.

[2]Depending on DOE's operational plans, the shortest time after restarting a reactor that tritium would be available to put in weapons would be about 12 months.

[3]In the 1950s, E.I. du Pont de Nemours (DuPont) built five SRS reactors known as the C, K, L, P, and R reactors. Only the K, L, and P reactors remain operable. The R reactor—shut down in 1964 owing to a lack of production requirements—has been cannibalized for parts, and the C reactor was shut down indefinitely in 1985 because of cracks in the reactor vessel. DuPont managed and operated the reactors for DOE until April 1, 1989, when the Westinghouse Savannah River Company became the new SRS operating contractor.

[4]In November 1988, DOE, DuPont, and Westinghouse officials met to identify specific actions required to restart the SRS K reactor. The meeting resulted in a November 25, 1988, report entitled Savannah River Plant K-Reactor Restart Strategy. They derived the basic restart safety needs from an analysis of the August 1988 P reactor event and from specific safety concerns raised in earlier reviews by such groups as the National Academy of Sciences and DOE's Office of Environment, Safety, and Health.

as the SRS operating contractor on April 1, 1989—submitted a projected schedule for the restart of K reactor. Westinghouse projected that a startup test program for K reactor could begin in February 1990. However, in mid-April 1989, the DOE Savannah River Operations Office Manager told Westinghouse that the restart plan had to be supported by an integrated schedule incorporating (1) restart criteria, (2) required maintenance and in-service inspections, (3) periodic equipment tests, (4) the resolution of outstanding technical questions on fuel quality and cooling water system recertification, (5) the documentation of technical positions and readiness assessments, and (6) the provision for oversight/peer review.

In late June 1989, Westinghouse provided DOE with the first detailed management plan and integrated work schedule for restarting the reactors. The detailed plan and schedule are referred to as the Reactor Operations Management Plan. In this Management Plan, Westinghouse proposed restarting K reactor in September 1990. After reviewing the plan, DOE said that an official restart schedule would not be announced until the spring of 1990. From June 1989 to early 1990, Westinghouse reported that the restart work contained in the June 1989 Reactor Operations Management Plan was essentially on schedule. However, according to Westinghouse's January 1990 monthly report, a reevaluation of the restart schedule was initiated to incorporate major work items not included in the June 1989 Reactor Operations Management Plan.

In mid-April 1990, Westinghouse published a revised version of the Reactor Operations Management Plan previously submitted to DOE in June 1989. On the basis of this revised schedule, DOE announced in early May 1990 that Westinghouse would restart K reactor in December 1990. K reactor did not restart in December 1990, and in February 1991, DOE announced that the summer of 1991 is the new restart time frame for this reactor.

Factors Affecting the K Reactor Restart Schedule

It has been about 2-1/2 years since the August 1988 reactor incident at SRS which precipitated the decision to make operational, management, and safety improvements to the SRS reactors. During this period, DOE and the contractors have been addressing a multitude of problems and issues that have resulted in changes and slippages in all restart schedules. A wide variety of factors can be cited for the delays in meeting the December 1990 restart date. These factors are

- the late development of a reactor startup test program,
- delays in completing originally scheduled work,
- the large volume of new maintenance requirements discovered during testing,
- new requirements added to the scope of required restart work, and
- environmental issues.

Even under the new summer of 1991 restart schedule, DOE faces some issues, such as the power limits program and fire protection, that could uncover new restart work that may have the potential to affect the new schedule.

Startup Test Program Delays

The Westinghouse June 1989 Reactor Operations Management Plan recognized the need for a startup test program; however, the late development of the Startup Test Program was a primary factor contributing to the December 1990 schedule delay. It is still possible that the program could uncover unanticipated problems that may have the potential to affect the new summer of 1991 restart schedule.

The purpose of the program—derived from test programs for troubled commercial reactors—is to demonstrate the adequacy of physical structures, systems, and components used during normal operation and to demonstrate the performance of accident prevention and mitigation systems. The program includes preoperational testing activities performed prior to restart and startup testing activities that occur during the initiation of criticality and power ascension.

According to an August 1989 version of the Reactor Operations Management Plan, the startup test program's scope was to be completed in mid-December 1989, and preoperational and power ascension testing for K reactor would be completed in September 1990. However, according to

DOE's Savannah River Restart Special Projects Office,[1] the program was still under initial development in April 1990 when Westinghouse issued the revised schedule on which the December 1990 K reactor restart date was predicated.

In early May 1990, according to Special Projects Office weekly reports, Westinghouse submitted Restart Test Identification Reports for the 34 systems/components selected for testing.[2] However, according to the DOE Special Projects Office, Westinghouse briefed DOE on the startup test program in June 1990, and DOE concluded that the plan for implementing the test program was not fully developed, the program's organization was weak, the procedure development effort was not properly defined, and fundamental tools such as an adequate test index and sequence—a compilation of all startup test program procedures—was not available. According to the Special Projects Office, because of problems in identifying safety related systems and systems important to safety, Westinghouse did not finalize the process for implementing the test program until September 1990.

Westinghouse provided DOE with the startup test sequence and index in late September 1990 and with the overall startup test program schedule in early October 1990. According to a Special Projects Office weekly report, by late October 1990, 108 of 187 required test procedures had been approved by the Joint Test Group[3] and DOE. The Special Projects Office told us that Westinghouse and DOE had originally thought that many of DuPont's old startup test procedures could be used with little or no modification, but that assumption proved to be incorrect in many cases.

[1]Since mid-1989, two DOE units—the Savannah River Special Projects Office and the Savannah River Restart Office—have had primary responsibility for ensuring that the reactors are restarted safely. These offices are discussed in more detail in appendix III.

[2]A Restart Test Identification Report identifies all tests required to demonstrate compliance with system functional requirements and identifies the test procedures required to complete each test. Westinghouse began preparing these reports in late 1989.

[3]The Joint Test Group provides independent review and approval of test-related activities, a practice consistent with established commercial industry test programs. Membership of the Joint Test Group includes experienced personnel from Westinghouse Reactor Operations, Reactor Engineering, Reactor Startup Testing Restart Quality Engineering, and Reactor Safety Evaluation Section, plus involvement of DOE representatives. The membership includes personnel with commercial nuclear industry experience.

Originally Scheduled Restart Work Delays

Another reason for restart delays was that some work set forth in the April 1990 revised Reactor Operations Management Plan simply fell behind schedule because of a variety of problems, some of which may have been controllable. For example, the DOE Award Fee Determination for Westinghouse's performance during April-September 1990 stated that scheduled work tasks had been subject to excessive rework.[4] DOE said that, although there was no quantitative measurement of rework, the progress of startup testing had been consistently affected by the need to perform the same task several times. DOE's assessment also stated that work performance was adversely affected by shortcomings in planning, work supervision, and the quality of performance.

One example of a significant project that fell behind schedule was the control rod drive system modification.

Control Rod Drive System Modification

On May 1, 1990, the day that DOE announced that the K reactor would restart in December 1990, Westinghouse reported that the restart critical-path had already fallen behind schedule because of delays in the control rod drive system modification project. This project involved replacing obsolete vacuum tube components (called T-amplifiers) with new solid-state components. The T-amplifiers electronically monitor control rods and prevent spurious rod movement. Westinghouse reported on May 1 that the project was behind schedule and that a task force had been formed to get it back on schedule.

On the basis of the schedule formulated in April 1990, startup testing of the of the new T-amplifiers was scheduled to be completed by the end of May 1990. However, owing to a succession of problems, startup testing was not completed until mid-January 1991. Some problems encountered were the following:

- In February 1990, some of the new solid state T-amplifiers failed bench testing.
- In March 1990, the Special Projects Office reported that quality assurance weaknesses at the vendor's plant had resulted in the shipment of faulty T-amplifiers, in that, 9 percent of the T-amplifiers tested failed

[4]Similar to contracts for the operation of other DOE facilities, the contract for operating SRS makes Westinghouse eligible for an award fee. DOE uses award fees to encourage contractors to work effectively and improve the quality of performance. DOE evaluates Westinghouse's performance over a 6 month period to determine whether the contractor should receive an award fee. Award fees are in addition to reimbursements of the contractor's costs and base fees. The most recently ended award fee evaluation period for Westinghouse covered April through September 1990.

functional testing, and 35 percent had defects such as bad wire crimping, missing fasteners or miscellaneous parts, and loose components.

- In April 1990, T-amplifier installation was completed, but testing was delayed because synchronizing units from which the T-amplifiers receive electronic signals had to be overhauled because of inadequate refurbishment done in late 1988.
- In May 1990, testing was delayed by problems such as blown fuses and the recurring inability to move control rods because of suspected binding.
- In June 1990, relay "chatter" in the T-amplifiers due to electronic "noise" emanating from the synchronizing units required the installation of heavier grade relays in the new T-amplifiers and replacement of faulty synchronizing units.
- In August 1990, testing was intermittent because support personnel had been diverted to Supplementary Safety System[5] testing.
- In August 1990, T-amplifier diode leakage that could cause spurious rod movements was determined to be due to damage during installation at the vendor's plant. This required 100-percent testing of diodes.
- In November 1990, diode tests resulted in 25 percent of the T-amplifiers having to be replaced or repaired.

New Corrective Maintenance Work Requirements

The large volume of new corrective maintenance requirements was another factor cited for restart delays. This new work resulted, according to DOE, because the material condition of the plant was worse than expected. For example, as of September 1990, about 84 percent of the preventive maintenance for K reactor was overdue.[6]

The Westinghouse June 1989 Reactor Operations Management Plan required either (1) the completion of all scheduled preventive maintenance and all identified corrective maintenance on process equipment or (2) an engineering justification for deferment. It also required the completion of preventive and corrective maintenance on nonprocess-related equipment so that the backlog would be no greater than 60 crew days. In addition, selected key valves had to be physically inspected to ensure the structural integrity of aging components.

[5]The Supplementary Safety System is defined later in this appendix.

[6]Periodically scheduled preventive maintenance is considered overdue when the prescribed interval for the maintenance is exceeded by more than 25 percent. For example, if the interval is every 2 years, the maintenance would be overdue if not completed within 6 months after the 2-year period elapsed.

In June 1989, about 63 percent of the corrective maintenance requirements were overdue, and by December 1989 it had declined to 46 percent overdue. However, the startup test program discovered more new corrective maintenance requirements than anticipated, and by June 1990, the level of overdue corrective maintenance had climbed to 81 percent and remained over 80 percent through July 1990. Even though overdue corrective maintenance had declined to 68 percent by September 1990, the percentage overdue was still slightly higher than the percentage existing in June 1989. Westinghouse's 1990 goal was to keep overdue corrective maintenance at not more than 50 percent.

According to the Director, Savannah River Special Projects Office, the larger-than-anticipated volume of new corrective maintenance work occurred primarily because the material condition of the plant was worse than expected. He cited the extensive past deferral of preventive maintenance work as a major factor causing this situation. For example, in June 1989 about 58 percent of scheduled preventive maintenance for K reactor was overdue. By December 1989, 81 percent of the preventive maintenance was overdue, and in September 1990, 84 percent was overdue. Westinghouse's 1990 goal was to keep overdue preventive maintenance at not more than 50 percent. According to Westinghouse, the high level of overdue preventive maintenance was due to a management decision to delay certain preventive maintenance orders to accommodate the restart schedule and to make other preventive maintenance ahead of schedule to accommodate equipment availability. Also, some equipment and systems were out of service, which precluded preventive maintenance actions. The following are examples of the poor material condition of the plant:

- Westinghouse had to delay tests of control-rod-drive-system modifications because synchronization motors in the system first required overhauling due to faulty refurbishing work done by SRS' Central Services Works Engineering Facility in late 1988.
- To prepare for tests of a modification of the Supplementary Safety System, Westinghouse examined the old part of the system and found problems such as reversed wiring, disagreements with vendor literature, and discrepancies between the hardware and system drawings.
- Testing of the process room spray pump revealed that a motor-operated valve would not open under full pressure because of undersized electrical wiring resulting in excessive voltage drop.

According to the Special Projects Office, another factor requiring much new corrective maintenance work was that Westinghouse's test standards required the reactors to meet design requirements, a practice not apparently followed in the past. Failure to meet the requirements resulted in a nonconformance report that could require additional work before restart. For example, the Cooling Water System pumping system showed 10-percent less pressure than the design requirement, and the Water Removal System sump pumps had a flow rate of only about 90 percent of the design requirement.

Because of such test findings, in November 1990, a Westinghouse Startup Test Program consultant stated in a report to the DOE Special Projects Office Director that:

"Results to date for the limited amount of system and equipment testing so far completed, often have shown that the historical understanding regarding the detailed functional capability is not fully accurate and continuing re-evaluation of the current assumptions and analyses for the design conditions is warranted."

New Restart Work Requirements

After DOE's May 1, 1990, announcement that K reactor would be restarted in December 1990, a number of new requirements were added to the scope of required restart work. These new requirements also affected the restart schedule. As of mid-October 1990, Westinghouse had adjusted the schedule to incorporate 32 schedule change documents—some of which contained multiple new deliverable work items. Many of these new work requirements appeared in DOE's August 1990 draft Safety Evaluation Report[7] as "open" items that must be closed before restart. According to an October 1990 Westinghouse memorandum, about 100 "open" items were added and required a significant effort: generating reports and procedures, conducting training, and justifying current positions. However, when incorporating the new work requirements into the schedule, none of the additions was shown to extend the time required to restart the reactors.

In September 1990, the Westinghouse Reactor Safety Advisory Committee[8] said it was concerned that significant scope additions were being

[7]The Safety Evaluation Report provides the technical basis and documentation needed to justify a decision to restart. The report is patterned after the process used by the Nuclear Regulatory Commission to assess the safety condition of troubled nuclear plants.

[8]The Reactor Safety Advisory Committee is a group of external nuclear experts appointed by Westinghouse to advise Westinghouse of reactor operations safety. The Committee reports to Westinghouse management.

made that had a high potential for adversely affecting the schedule and creating excessive stress on the organization.

Two examples of requirements added to the scope of required restart work for the December 1990 restart date were the Supplementary Safety System and the seismic capabilities of reactor structures and equipment. Furthermore, DOE faces some issues, such as the power limits program and fire protection safe shutdown analysis, that could uncover new restart work that may affect the new summer of 1991 restart schedule. These issues are under review by the Defense Nuclear Facilities Safety Board and/or DOE's Office of Nuclear Safety.

Examples of New Required Restart Work Affecting the December 1990 Restart Schedule

Supplementary Safety System

In the event of a potentially damaging earthquake, the reactor must be shut down, that is, the nuclear reaction in the reactor core must be halted. The Supplementary Safety System[9] shuts down the reactor by injecting into the reactor tank a gadolinium nitrate solution called "ink" that absorbs neutrons, bringing the reactor to a subcritical state. The ink mixes with the primary coolant in the reactor vessel and poisons the nuclear reaction by absorbing the neutrons emitted by the fuel rod assemblies. The primary coolant is normally circulated through the reactor core by pumps powered by AC electrical power. But if the AC-powered pumps are lost owing to an earthquake, for example, the primary coolant is circulated by backup pumps operated with DC electrical power supplied by generators that are in continuous operation.

In April 1990, Westinghouse became concerned about whether the flow pattern of the primary coolant under DC power would provide the concentration of poison ink in the reactor vessel needed to keep the reactor shut down. Consequently, DOE directed Westinghouse in May 1990 to modify the Supplementary Safety System to provide additional injection

[9]At restart, the Supplementary Safety System will be the only shutdown system that is seismically qualified. A seismically qualified system is one that is designed and built to function effectively after a design basis earthquake. An earthquake of 0.2g ground acceleration—the equivalent of about 6.0 on the Richter scale—is the maximum earthquake force that the SRS reactors are to be designed to successfully withstand. See Nuclear Health and Safety: Better Earthquake Protection Needed at DOE's Savannah River Site (GAO/RCED-90-24, Dec. 26, 1989) for a detailed discussion of SRS seismic issues.

sources for the poison ink to ensure safe shutdown. According to the Special Projects Office, testing of the modifications will be performed during the power ascension stage of restart. However, scale model tests of the system's performance will not be made until after restart. In January 1991, the Defense Nuclear Facilities Safety Board raised the question of why such important tests will not be done until after restart.

In addition to the question about testing, an issue has been raised about the ability of the Supplementary Safety System to shut down the reactor in certain earthquake scenarios. According to a Defense Nuclear Facilities Safety Board member, the system has a seismically qualified "trigger" that will automatically take steps to shut down the reactor in the event of an earthquake greater than 0.05g ground acceleration. For a smaller earthquake, the reactor-stopping process would have to be activated by the safety computer. However, the safety computer is not seismically qualified and therefore cannot be relied upon to automatically activate the stopping process. As a result, successful shutdown would depend on the ability of a reactor operator to pull a ring in the control room that manually activates the process. In early February 1991, the Special Projects Office told us that DOE and Westinghouse consider an earthquake of 0.05g or less to be nondamaging, thus not requiring shutdown. However, at that time, the issue was still under review by the Defense Nuclear Facilities Safety Board.

Seismic Capabilities of Reactor Facilities

Westinghouse and DOE plan to seismically qualify some reactor safety systems before restart and some after restart; some will never be seismically qualified. Since the issuance of the revised Reactor Operations Management Plan on April 10, 1990, DOE has added several seismic work requirements to the scope of required restart work owing to inquiries by the Defense Nuclear Facilities Safety Board and consultants' recommendations. These new restart requirements will not result in any additional systems' being seismically qualified before restart. However, the seismic adequacy of grouted pipe support plates in reactor buildings was still undergoing analysis as of early February 1991.

From the beginning of its oversight of reactor restart, the Defense Nuclear Facilities Safety Board has exhibited keen interest in the seismic capabilities of the reactors. According to a Special Projects Office report, in late January 1990 Board members expressed general concern that not enough justification had been developed to support the adequacy of the seismic upgrades planned for restart, and the Board members requested extensive information on the seismic issue. In mid-April 1990, DOE made a commitment to the Safety Board to increase the

scope of seismic improvements before restart, and in June 1990 the Special Projects Office instructed Westinghouse to accomplish additional seismic work before restart, such as the following:

- Shifting the implementation of certain planned Airborne Activity Confinement System[10] seismic modifications from post-restart to prerestart.
- Conducting additional structural analyses of the seismic capability of cooling water basin walls.
- Conducting quantitative stress analyses of the entire safety-related cooling water and process water piping systems.
- Conducting a soils characterization program to demonstrate the adequacy of seismic analyses of the soils structure underlying safety-related structures/buildings and around buried cooling water piping.
- Documenting fully the basis for the conclusion that the appropriate SRS design basis earthquake is a seismic event of 0.2g ground acceleration.

Ongoing work examining the seismic adequacy of grouted pipe support plates in the reactor buildings provides an illustration of an uncertainty that could still affect the summer of 1991 restart schedule. In the early 1960s, DuPont installed larger cooling water and primary coolant pipes so that the operating power level of the reactors could be increased, according to the Special Projects Office. To accommodate the larger pipes, stronger pipe supports had to be installed on the concrete ceilings and walls in the reactor buildings. At each location where a new pipe support had to be installed, concrete in the ceiling or wall had to be excavated down to the steel rebar so that a pipe support plate could be anchored to the rebar. After installing the anchors on the rebar, the excavated areas were backfilled with concrete grout. In February 1990, a seismic consultant raised the issue of whether the pipe support plates and their anchors are seismically adequate.

In early February 1991, the DOE Special Projects Office told us that destructive testing had been performed in R reactor[11] that indicated that

[10]Commercial nuclear reactors have containment domes to prevent the release of nuclear fission products to the atmosphere in the event of a loss-of-coolant accident that could lead to reactor core damage. The SRS reactors, however, do not have containment domes. Instead, they have a ventilation and filtration system (Airborne Activity Confinement System) designed to keep radioactive releases to the atmosphere at an acceptable level. The design basis accident that the system is designed to mitigate is a 3-percent core melt that is assumed to occur during fuel loading. However, a DOE study has concluded that the system is capable of successfully mitigating a core melt accident up to 10 times greater than the design basis accident.

[11]As mentioned in appendix I, the R reactor was shut down in 1964 because of a lack of production requirements and has been cannibalized for parts.

the pipe support plates are seismically adequate. However, Westinghouse is analyzing whether the test results from R reactor can be extrapolated to K reactor. As of early February 1991, nondestructive ultrasonic inspections of K reactor pipe support plates were in progress.

Examples of Potential New Work That May Affect the 1991 Restart Schedule

Power Limits Program

One basic purpose of the Power Limits Program is to determine the highest power level at which the SRS reactors can be safely operated. According to the June 1989 Power Limits Program plan, Westinghouse believed the reactors would probably be able to operate at about 50 percent of full normal power at restart. After extensive analysis of the reactors' ability to respond to a severe loss-of-coolant accident, the 50-percent restart power level seemed achievable.[12] However, other issues have arisen that could further limit the power level or could require new plant hardware modifications to achieve the 50-percent power level at restart. This program is under review by the Defense Nuclear Facilities Safety Board, DOE's Office of Nuclear Safety,[13] and a peer review committee comprising external experts selected by the DOE Special Projects Office.

During the 1970s and early 1980s, the reactors operated at full normal power levels ranging from 2,000 to 2,700 megawatts. Designed to prevent reactor damage, the permitted power levels were based on computational analyses and experimental results. However, by 1987, because of concerns raised by DuPont engineers and the National Academy of Sciences about the Emergency Cooling System's ability to prevent significant core damage after a severe loss-of-coolant accident, the operating power level was limited to 50 percent of full normal power. Their concerns called into question the reliability of the existing analyses that supported the permitted power levels.

As late as mid-August 1990, DOE reported that the Power Limits Program would likely support a 50-percent restart power level on the basis

[12]The severe loss-of-coolant accident is defined as a double-ended guillotine break in the largest pipe in the Process Water System (the system that circulates the primary coolant from the reactor vessel through heat exchangers and back into the reactor vessel).

[13]The Office of Nuclear Safety is discussed in greater detail in appendix III.

of analyses of the severe loss-of-coolant accident. However, in early September 1990, DOE reported that analysis of another postulated accident—the loss-of-pumping accident—had raised uncertainties that could reduce the power level to 35 percent. The loss-of-pumping accident is defined as a double-ended guillotine break in a cooling water pipe that floods the reactor building and eventually shuts off all pumps that circulate primary coolant through the reactor vessel.

To avert a fuel-melting accident in a loss-of-pumping accident, the Emergency Cooling System must be actuated before all primary coolant pumping is lost. In mid-November 1990, Westinghouse informed DOE of several modification options for achieving timely actuation of the Emergency Cooling System. The estimated impact on the schedule would range from no impact to a 3-year delay. Westinghouse recommended the no-impact option. In early February 1991, the Special Projects Office told us that DOE had approved Westinghouse's no-impact recommendation and that the loss-of-pumping accident was no longer a threat to the 50-percent power level for restart.

However, in early October 1990, DOE reported another threat to the power level—the possibility that control rod and safety rod hardware could overheat and melt owing to irradiation after a loss-of-coolant accident. This problem could result in a restart power level of less than 21 percent of normal power. In late November 1990, Westinghouse proposed a hardware modification solution to the problem that would not affect the restart schedule, but the Special Projects Office staff raised a concern that the proposed modification could adversely affect other aspects of reactor operation. According to the Director, DOE Savannah River Special Projects Office, the projected date for a final decision on how to deal with these problems is April 1991. However, according to the Director, the restart power level in the summer of 1991 may be less than 21 percent and then be increased later after modifications are completed.

Fire Protection Safe Shutdown Analysis

In early December 1990, the DOE Office of Nuclear Safety reviewed reactor restart issues, including fire protection, at SRS. According to the DOE Special Projects Office, the fire protection concerns raised by the Office of Nuclear Safety were that:

- The DOE Safety Evaluation Report criteria do not clearly state that Westinghouse must demonstrate that issues raised by the safe shutdown analysis will not prevent reaching and maintaining safe shutdown in the event of fire. The Special Projects Office told us in early February 1991

that its draft Safety Evaluation Report did in fact contain this requirement.

- The validity of the safe shutdown analysis conclusion regarding fire protection was questioned because it is not supported by a fire hazards analysis.[14] In early February 1991, the Special Projects Office told us that a limited fire hazards analysis had been performed but that a more rigorous, comprehensive analysis, which was scheduled to begin soon, is not a restart requirement.
- Fire suppression capability has not been clearly demonstrated. The Special Projects Office told us it expected this issue would be addressed through a combination of compensatory measures, training, and drills prior to restart.
- Questions about the adequacy of configuration management raised concerns about the validity of the drawings used in the safe shutdown analysis of fire protection. The Special Projects Office expects this issue to be resolved through verification walk downs performed in the reactors during the safe shutdown analysis and any supplemental walk downs deemed necessary.
- The program for controlling movement of combustible materials did not appear to restrict transient combustibles in areas of the reactor building. According to the Special Projects Office, a transient combustible control program has now been instituted at the K reactor, including the reactor building.
- Questions were raised about the ability of the Fire Department and reactor operators to respond to and combat fires and implement operating procedures.

As of early February 1991, the Special Projects Office did not anticipate any significant new work that could delay the new restart date because of Office of Nuclear Safety concerns. However, on February 14, 1991, the Office of Nuclear Safety Director told us that his office was still reviewing fire protection issues, in particular, the question of whether a more comprehensive fire hazards analysis should be completed before restart.

[14]As defined by 10 C.F.R. 50, Appendix R, a fire hazards analysis is performed by qualified fire protection and reactor systems engineers to (1) consider potential in-position and transient fire hazards; (2) determine the consequences of fire in any location in the plant on the ability to safely shut down the reactor or on the ability to minimize and control the release of radioactivity to the environment; and (3) specify measures for fire prevention, detection, suppression, and containment and alternative shutdown capability as required for each fire area containing structures, systems, and components important to safety.

Impact of Environmental Issues on Delaying Restart

Even if the work contained in the Westinghouse April 1990 K reactor restart schedule had been completed on time, the K reactor could not have been restarted in December 1990 because of issues related to completing the Environmental Impact Statement (EIS) required for the SRS reactors and complying with the Environmental Protection Agency's (EPA) National Emission Standard for Hazardous Air Pollutant (NESHAP) requirements. In addition, K reactor cooling tower litigation creates additional uncertainty over any planned restart date.

Environmental Impact Statement

Because of issues involving the EIS, delays in portions of a key startup test required to restart K reactor would have prevented a December 1990 restart of K reactor even if all other work had been completed on time. As we reported in April 1990, public interest groups filed a lawsuit in 1988 contending that the National Environmental Policy Act required DOE to prepare a new EIS before restarting the reactors. In December 1989, DOE made a commitment to prepare an EIS before restart, and in July 1990 DOE reached an agreement with the public interest groups to not restart any reactor until 30 days after notice of availability of the final EIS is published in the Federal Register and to issue a Record of Decision before restarting any reactor. The notice of availability was published on December 21, 1990, and the Record of Decision, detailing DOE's decisions on reactor restart at SRS, was published in the Federal Register on February 11, 1991.

In August 1990, Westinghouse informed DOE that the Cooling Water System pumps needed to be tested before restarting K reactor. Some of the testing for these pumps requires full-flow pumping that can result in adverse environmental impacts.[15] According to the Special Projects Office, DOE's commitment to prepare an EIS led to a decision that it would be inappropriate to perform a test having adverse environmental impacts before issuing the final EIS. According to the Special Projects Office, at the time the decision was made, the EIS was scheduled to be issued in late October 1990, which would have provided enough time to do the full-flow testing before restarting the K reactor in December 1990. However, as noted above, the notice of availability of the final EIS was not published until December 21, 1990.

[15]The increased water velocity and higher water levels in the streams into which water would be discharged would displace fish and insects, cause stream erosion, transport sediments to the delta, resuspend solids, and flood vegetation.

National Emission Standard for Hazardous Air Pollutant Requirements

In July 1990, EPA adopted a position on the application of NESHAP rules to SRS that became a threat to the December 1990 restart date. Under the NESHAP rules that took effect in December 1989, the annual maximum allowable radioactive dosage for a person at the SRS plant boundary is 10 millirems. Also, all radioactive release sources must be sampled and must be monitored continuously with approved monitoring equipment and procedures. In March 1990, Westinghouse informed EPA that SRS complied with the dosage requirement but not with the monitoring requirements.

In early July 1990, EPA commented on DOE's draft reactor EIS and told DOE that it should verify that all applicable release points associated with the reactors would be monitored in accordance with NESHAP requirements before restart. DOE and Westinghouse proceeded with restart activities believing that K reactor could be restarted in December 1990 and that compliance with NESHAP requirements would have to be achieved by June 30, 1991. However, in mid-November 1990, when the restart schedule was already being reevaluated, EPA told DOE during a meeting that restart was dependent on demonstrating compliance with NESHAP monitoring requirements. DOE expects that K reactor compliance can be demonstrated by the end of June 1991 because all that remains to demonstrate compliance is the provision of acceptable documentation that monitoring equipment currently in place is properly calibrated and operated.

Uncertain Impact of K Reactor Cooling Tower Litigation

As we reported in April 1990, the state of South Carolina, under the Clean Water Act, issues the National Pollutant Discharge Elimination System permit for SRS.[16] Because of restrictions on discharges of hot water into streams and wetlands, DOE and the state entered into a consent order in 1984 requiring that DOE build a cooling tower for the K reactor by December 1992. The consent order allows DOE to operate K reactor until the end of 1992 without a cooling tower but not thereafter. DOE expects the cooling tower to be completed by June 1992.

However, in June 1990, the Natural Resources Defense Council and the Energy Research Foundation filed a suit in federal court to prevent DOE from operating K reactor before the cooling tower is completed. These groups maintain that K reactor should not be operated without a cooling

[16]We previously reported on this issue in Nuclear Health and Safety: Policy Implications of Funding DOE's K Reactor Cooling Tower Project (GAO/RCED-89-212, Sept. 27, 1989). Our April 1990 report (GAO/RCED-90-104) provides further information on the issue.

tower unless the President exempts the K reactor from Clean Water Act requirements on the basis of national security needs. The potential outcome of this litigation creates additional uncertainty over any planned restart date. In early December 1990, the Savannah River Operations Office's Chief Counsel told us that DOE had petitioned the court to dismiss the suit filed by the public interest groups. As of mid-February 1991, the court had not ruled on the petition, according to the Special Projects Office.

Safety Oversight Changes and Safety Culture Concerns

The oversight of SRS reactor operations has received increased attention since 1988 when the attempted startup of P reactor had to be aborted. Safety oversight changes have included DOE reorganizations to address safety management and oversight concerns and the extensive involvement of first the Secretary of Energy's Advisory Committee on Nuclear Facility Safety and later the Defense Nuclear Facilities Safety Board in examining safety issues. DOE has increased its technical oversight at SRS and has expanded its efforts to develop measures to assess the adequacy of the nuclear safety culture.[1] Both DOE and Westinghouse have recognized that the process of improving the safety culture is a long-term effort that may not be completed before restart. Problems in dealing with safety culture changes still remain at SRS.

As we reported in April 1990, ensuring the safe restart of the SRS reactors required not only the upgrading of plant and equipment to improve technical reactor performance, but also upgrading of the safety culture to improve human performance. Although DOE is the owner of the SRS reactors, DOE also is the regulator. To ensure safe operation, DOE must oversee both the technical and the human performance aspects of reactor operations.

However, as we reported in September 1988 testimony,[2] a DOE task force concluded in 1981 that DOE relied too heavily on contractors to provide adequate safety assurance, and the National Academy of Sciences reached a similar conclusion in 1987. The Academy questioned DOE's technical vigilance and noted DOE's tendency to defer almost exclusively to contractors that operate production reactors and to place undue reliance on them to ensure safe operations. In our testimony, we stated that three critical elements are required for an effective DOE safety management and oversight program:

- Strong line management responsibility and accountability for safety.
- An effective internal oversight organization to oversee how line management is carrying out its role.
- An independent organization outside the control of DOE that oversees the agency's internal safety program.

[1]Within the nuclear industry, safety culture is defined as an underlying philosophy whereby personnel believe that they are accountable for the safe operation of a facility, take personal interest in constantly striving to improve safety, communicate effectively, follow procedures, and are well-trained. DOE has basically adopted this philosophy for its facilities.

[2]See Ineffective Management and Oversight of DOE's P-reactor at Savannah River, S.C., Raises Safety Concern (GAO/T-RCED-88-68, Sept. 30, 1988) for our detailed statement.

Changes in DOE's Line Management Accountability for Reactor Safety

Since mid-1989, two DOE units—the Savannah River Special Projects Office and the Savannah River Restart Office—have had primary responsibility for ensuring that the reactors are restarted safely. When restart efforts began in late 1988, DOE's Savannah River Operations Office Manager was responsible for restart efforts, along with all other SRS operations. To provide a single management focus on the restart effort, the Secretary of Energy created the Special Projects Office and the Restart Office to manage the restart effort. According to the Special Projects Office's management plan, the justification for recommending reactor restart will require a joint consensus of the Special Projects Office and the Restart Office. The Special Projects Office, with concurrence of the Restart Office and the Deputy Assistant Secretary for Nuclear Materials Production, would recommend to the Assistant Secretary for Defense Programs that restart authorization be requested from the Secretary.

Located at SRS, the Special Projects Office is DOE's on-site unit for managing and overseeing the safe and timely restart of the reactors. The Director of the Special Projects Office reports directly to the Office of the Assistant Secretary for Defense Programs, who is responsible and accountable for all operational programs and activities at SRS. The Restart Office, which is located at DOE headquarters, also reports to the Assistant Secretary, but the Restart Office's mission is to provide coordination, independent technical review, and staff support to the Assistant Secretary in directing the safe and timely restart of the SRS reactors.

According to the Special Projects Office's management plan, the office has taken a number of actions to provide on-site technical vigilance and oversight of Westinghouse's restart efforts. The Office has developed and implemented a DOE technical training program; stationed DOE staff at each of the reactors to oversee operations; formed an engineering group to provide oversight of Westinghouse's design, testing, and analytical efforts; and formed a group of engineers to provide independent safety oversight. The Special Projects Office's technical staff has experience from the nuclear industry, the nuclear Navy, and/or the Nuclear Regulatory Commission (NRC).

The Special Projects Office has relied extensively on DOE national laboratories, contractors, or consultants to study technical restart issues. In addition, because DOE judged three technical issues critical to safety, the Special Projects Office established panels of external technical experts

to peer review the Power Limits Program,[3] the Probabilisitic Risk Assessment,[4] and the Vessel Integrity Program.[5] DOE originally intended to establish a peer review panel for seismic issues; however, it did not do this because of the level of seismic expertise available within DOE and from DOE consultants and because of the detailed review of seismic issues conducted by the Defense Nuclear Facilities Safety Board, according to the Special Projects Office.

Firsthand observation of reactor operations is important in the oversight of both technical issues and human performance. The Special Projects Office has located four DOE on-site representatives in the K reactor area. These on-site representatives are supported by two technical personnel from support contractors. According to DOE's draft Safety Evaluation Report, the Special Projects Office has developed formal guidance for the on-site inspectors to use for inspection and surveillance of the SRS reactors. These guidelines were modeled after NRC inspection plans for commercial nuclear facilities. The on-site inspectors have been hired from the nuclear Navy, NRC, and the commercial nuclear industry, and they must attend additional training before restart.

To reinforce accountability, the Special Projects Office assigned management and technical oversight of specific restart topics to specific technical staff members. These staff members—with assistance from technical support contractors—are responsible for monitoring quality and schedule commitments. According to the Office Director, the technical staff responsible for specific restart topics spend an estimated 50

[3]See appendix II for a description of the Power Limits Program.

[4]A Probabilistic Risk Assessment (PRA) is usually done on three levels, each level building on the other. The levels are the (1) analysis of plant design and operation, (2) examination of the physical processes of an accident and their effect on the reactor systems, and (3) analysis of the movement of radiation after an accident and its effect on public health. At restart, only level 1 of the PRA will be completed. Levels 2 and 3 are expected to be completed in draft form by late February 1991, according to the Special Projects Office. The PRA is undergoing a review by both an external peer review panel, DOE's Advisory Committee on Nuclear Facility Safety, and the Defense Nuclear Facilities Safety Board.

[5]As we reported in April 1990, ultrasonic inspection is a state-of-the-art method for detecting cracks in nuclear reactor vessels. Westinghouse originally did not plan to inspect the K reactor vessel before restart, but in September 1989 DOE decided to require the inspection. Westinghouse inspected 60 percent of accessible welds in K reactor and 40 percent in P reactor and found no cracks. In November 1990, DOE informally instructed Westinghouse to inspect 100 percent of the accessible welds in the L reactor vessel because it was dropped during fabrication and required special repair welds, according to the DOE Special Projects Office. Westinghouse is also inspecting the Process Water System piping. This program is also being reviewed by the Defense Nuclear Facilities Safety Board, which has asked for a justification for limiting the inspection to 60 percent of the accessible welds in the K reactor vessel before restart.

percent of their time either on-site in the reactor areas or dealing directly with Westinghouse personnel.

The Special Projects Office also has a Safety Oversight Division which reports directly to the Office Director. According to the Safety Oversight Division Director, the Safety Oversight staff spend an estimated 50 percent of their time in the reactor areas performing on-site inspections, and they receive technical support from 10 support contractor personnel.

Changes in DOE's Internal Nuclear Safety Oversight

In late 1987, DOE established an Advisory Committee on Nuclear Facility Safety to conduct independent safety oversight of DOE's nuclear facilities. However, as we noted in 1988, the Advisory Committee is not a pure form of independent oversight because it is not structured distinctively and separately from DOE and does not have the authority to require DOE to address its findings and recommendations.[6]

Between late 1988 and early 1990, the Secretary asked the Advisory Committee to provide oversight of a wide range of SRS reactor restart issues. However, on the basis of instructions given by the Secretary, the Advisory Committee had withdrawn from reactor restart oversight by March 1990 because the Defense Nuclear Facilities Safety Board, which is discussed later in this appendix, had started providing external oversight.

Under a DOE restructuring plan issued in May 1989, the Secretary announced that the DOE Office of Environment, Safety, and Health would no longer have responsibility for nuclear safety oversight. In late September 1989, DOE announced the establishment of the Office of Nuclear Safety, which reports to the Office of the Secretary. The purpose of the new Office is to advise the Secretary of whether line management and its self-assessement functions are adequately ensuring nuclear safety. In early December 1990, the Office of Nuclear Safety sent a team of representatives to SRS to evaluate restart issues included in the DOE Safety Evaluation Report Assessment Program, which is discussed later in this appendix. Fire protection systems, as discussed in appendix II, was one area the office examined.

[6]Nuclear Health and Safety: Oversight at DOE's Nuclear Facilities Can Be Strengthened (GAO/RCED-88-137, July 8, 1988).

Changes in the External Oversight of Reactor Restart

As discussed earlier in this appendix, between late 1988 and early 1990, the Advisory Committee on Nuclear Facility Safety—although not a pure form of external oversight—advised the Secretary of reactor restart issues. By early 1990, however, the Advisory Committee had withdrawn from reactor restart oversight because the newly established Defense Nuclear Facilities Safety Board was ready to provide independent, external oversight.[7]

The Safety Board—comprising five members—was established by Public Law 100-456 in 1988 and began operations in October 1989. The legislation authorized up to 100 staff and required that the Board investigate situations at DOE defense nuclear facilities that could adversely affect public health and safety. The Board was also required to make recommendations to the Secretary of Energy on operations, standards, and research necessary to ensure protection of public health and safety. The recommendations and the Secretary's responses must, in most circumstances, be available to the public.

In February 1991, we issued a report on the Safety Board's first year of operations.[8] During its first year, the Board issued seven sets of recommendations to improve the safety of DOE defense nuclear facilities. These recommendations involved four major facilities—including SRS—and addressed topics such as operator training, safety standards, radioactive waste storage, restarting plutonium operations, and the need for systematic evaluations of safety issues.

As previously discussed, the Board has been extremely active in examining SRS reactor restart safety issues. For example, when it found that training for SRS reactor operators and supervisors was not adequate, the Board recommended that DOE review the qualifications it requires for operators and supervisors and modify the training procedures to ensure that personnel are qualified. Our February 1991 report also describes how the Board found at four DOE facilities that some design, construction, operating, and decommissioning standards had not been established, were not uniform, or were less specific than corresponding NRC standards. The Board recommended that DOE clarify applicable standards and study the adequacy and implementation of the standards.

[7]The Advisory Committee is still reviewing the SRS reactor PRA because the development of the PRA at SRS has wider application to the development of PRAs at other DOE facilities.

[8]Nuclear Safety: The Defense Nuclear Facilities Safety Board's First Year of Operation (GAO/RCED-91-54, Feb. 5, 1991).

SRS Nuclear Safety Culture: A Continuing Concern

In our April 1990 report, we discussed safety culture problems at SRS and the recognition by both DOE and Westinghouse that the safety culture at SRS needs improvement and that such improvement will be a slow process. We also recognized the difficulty in measuring changes in employees' attitudes toward safety. We recommended that a comprehensive plan be prepared with specific tasks, milestones, and measurement indicators to achieve the desired safety culture changes. In carrying out work for this report, we continued to note safety culture concerns at SRS.

In its October 1990 response to our April 1990 recommendation, DOE disagreed with the need for such a plan, but did indicate that both Westinghouse and DOE have initiated actions to strengthen the attitude toward reactor safety. DOE stated that the Reactor Operations Management Plan contains a discussion of the culture change program and that Westinghouse "recognized that many fundamental issues . . . require changes in the culture at SRS." DOE also stated that its Safety Evaluation Report will include discussions of the safety culture change at both Westinghouse and DOE, and, as part of this effort, DOE has established adequate acceptance criteria for restart. In addition to DOE's Safety Evaluation Report Assessment Program, DOE plans to perform an Operational Readiness Review, which is a critical part of DOE's effort to assess safety culture before restart, according to the Special Projects Office Director. These criteria, according to the Director, are critical measures for judging the adequacy of the safety culture for restarting the reactors. We did not assess the adequacy of the criteria for purposes of this report.

The Safety Evaluation Report Assessment Program is patterned after the process used by the NRC to assess the safety condition of troubled nuclear plants. The program is designed to provide the technical basis and documentation needed to justify a decision to restart. The program is to be executed jointly by the Special Projects Office and the Restart Office staff. The Safety Evaluation Report will be provided to the Defense Nuclear Facilities Safety Board for its review before restart. The Special Projects Office and Restart Office will use acceptance criteria established by DOE to assess the acceptability of actions taken by Westinghouse and DOE in 15 major areas: management issues, quality assurance, design control and verification, radiation protection, operating limits, design issues, fire protection, testing and startup, safety reviews, operations, emergency preparedness, maintenance, inspection and testing, engineering and technical support, and operational readiness reviews. The Office of Nuclear Safety Director told us in mid-February 1991 that his office was evaluating DOE's acceptance criteria for these major areas.

Several sections of DOE's Safety Evaluation Report have acceptance criteria that incorporate safety culture concerns. However, one section of the report focuses on safety culture specifically. To satisfy the acceptance criteria in that specific section, Westinghouse management must before restart (1) develop a written, formally implemented safety-first policy in the form of administrative procedures; (2) develop administrative procedures that document a reactor operations organization with well-defined and clearly understood lines of authority; (3) create for each reactor a plant manager position responsible for all aspects of reactor operation; (4) foster professionalism through all organizational levels by promoting a professional working environment and developing and maintaining procedures that clearly define operating standards of conduct; (5) develop procedures for communicating goals, standards, and policies; and (6) take action demonstrating that management has primary responsibility for fostering the proper safety culture by developing formal and informal procedures for staying involved with day-to-day reactor operations and developing procedures to formally assess plant activities and track findings.

According to the Special Projects Office Director, before any reactor is restarted, it will undergo a DOE Operational Readiness Review. The review, according to a draft plan, will be conducted by a team of senior safety experts and technical experts. The review is conducted in three phases. In the first phase, the team will conduct a programmatic review about 12 weeks before restart. During the second phase, the team will assess procedure adequacy and reactor operator competency including oral examinations about 9 weeks before restart. Under the final phase, about 5 weeks before restart, the team will begin a 2-week performance-based assessment of operators, equipment, and programs. In mid-February 1991, the Office of Nuclear Safety Director told us that his office will assess the results of the Operational Readiness Review and the final Safety Evaluation Report to make its own judgment about the acceptability of the DOE and Westinghouse safety culture for reactor restart.

The Special Projects Office Director believes the safety culture is improving steadily; however, as recognized by DOE and Westinghouse, reaching the ultimately desired state of safety culture is a long-term effort that may not be completed before restart.

We recognize that making a judgment of the overall adequacy of safety culture is, of necessity, somewhat subjective. Because it involves human performance and attitudes, safety culture is not a condition that can be

precisely weighed and measured. As stated earlier, DOE has instituted or planned activities aimed at assessing the adequacy of safety culture, and we believe that the focus on safety culture must continue to be stressed because evidence of safety culture weaknesses continue to appear, as indicated in these examples.

- According to a Special Projects Office report, during the 5 months ending in April 1990, only 38 percent of scheduled management tours had been performed. Other weaknesses identified were the lack of back-shift coverage, short duration of tours, and quality of findings and their disposition. A Westinghouse independent review group had identified similar concerns, but proper corrective actions had not been implemented. In addition, the Special Projects Office found that managers in maintenance had made only 6 of 16 field visits scheduled for June 1990.
- Two reactor incidents involving the Supplementary Safety System, which was discussed in appendix II, gave indications of safety culture problems. On June 11, 1990, an L reactor shift adviser found that construction personnel had, in violation of procedures, installed a bolt in a manual back-up startup mechanism, thereby disabling the manual emergency mechanism for activating the Supplementary Safety System. Although installing the bolt ensured that the system could not be inadvertently started during maintenance, the ability to manually activate the system would have been unavailable during the filling of the reactor vessel if the bolt had not been detected and removed. A Westinghouse investigation report concluded that the disabled condition of the system potentially could have gone undetected when the system was returned to service. At the time the procedure violation occurred, the shift advisor was aware of the violation.

  Although this incident should have been reported promptly to K reactor personnel because of the potential for a similar incident, the K reactor Supplementary Safety System was disabled by maintenance personnel in exactly the same manner in late August 1990, over 2 months after the L reactor incident. After installing the bolt, the maintenance shift foreman informed the control room supervisor, who agreed that the bolt could remain installed until ongoing maintenance was completed. Neither of them recorded the installation of the bolt in his log. In an inspection report sent to Westinghouse, the DOE Special Projects Office stated that its assessment of the events indicated potentially significant weaknesses with maintenance personnel safety culture and their understanding of maintenance actions on equipment operability and design function.

- The previous restart schedule called for loading fuel into K reactor in August 1990. In July 1990, the Operational Readiness Review team reviewed readiness of personnel and the plant for fuel loading. The team reported a number of personnel concerns, including the following: (1) technical support organizations' attitude was that fuel loading is less important than the planned reactor restart and therefore should receive less attention; (2) operating personnel in the central control room were not always aware of existing equipment status or when changes to system and equipment configuration were made; (3) operators did not always demonstrate an inquisitive and responsive attitude in the performance of their duties, specifically relating to the health and safety of workers; and (4) component handling operators were not familiar with the possible accidents that had been evaluated for fuel loading. In August 1990, the DOE Special Projects Office Director told Westinghouse that the results of the review indicated that middle managers were not ensuring acceptable levels of technical, operational, managerial, or cultural performance.
- In July 1990, the Safety Oversight Division reviewed the Westinghouse self-assessment process for the reactor housekeeping performance indicator. The Safety Oversight Division found that the Westinghouse inspectors primarily had inspected the grounds outside the reactor building, giving little attention to conditions inside the building. Also, inspections were announced several days in advance, giving plant personnel time to prepare for the inspections.
- In August 1990, the Restart Subcommittee of the Westinghouse Reactor Safety Advisory Committee did a walkdown of K reactor to inspect the material condition and housekeeping of the reactor. The Subcommittee concluded that work practices, especially formality and discipline of operations, should be improved. The Subcommittee also concluded that lack of accountability for materials and the disorderly appearance in the reactor process room did not convey assurance that maintenance and outage activities were under control.
- In August 1990, DOE representatives observed central control room operators while the primary coolant was drained from the K reactor tank and piping. Because the primary coolant contains radioactive tritium, the operators are supposed to monitor tritium-sensing equipment that can alert operators to primary coolant leakage during the draining operation. The DOE representatives reported, among other things, the following observations: (1) although a DOE representative noted irregular sensor equipment activity during preparations for tank drainage, the operators declared the tritium sensor to be functional (the sensor was subsequently found to be nonfunctional); (2) no operating personnel observed the tritium sensor during the operation until prompted by a

DOE representative; (3) no operating personnel were aggressive in resolving the problem, and a supervisor said the sensor problem was not important; (4) the shift manager did not actively participate in resolving the problem; and (5) the Operations Manager, who was present as management oversight, took control of the operation and appeared to want the draining to continue despite the apparent equipment problem. The DOE report stated that operating personnel at all levels demonstrated a lack of sensitivity to equipment status that was disturbing, especially at the late date in the restart effort. The DOE representatives were particularly concerned that they had to repeatedly bring attention to the problem to convince the operating personnel to take prudent actions.

- In October 1990, members of the Defense Nuclear Facilities Safety Board, in commenting on the Unusual Occurrence Reporting System, said that Westinghouse reactor operations needed to make significant improvements in root cause analysis, the effectiveness of corrective actions to prevent recurring problems, and the use of lessons learned in problem solving.

Estimated Cost of Reactor Restart and Safety Improvement Programs

Before and after the 1988 shutdown of the SRS reactors, various special reviews had raised numerous issues about SRS reactor operations.[1] Many of the issues raised in these special reviews involved potential safety concerns which had not been addressed at the time of the shutdown.

Using a program called the Restart Issue Management Program, Westinghouse reviewed the issues raised in the special reviews to identify issues critical to a safe restart. The program established a process for identifying safety improvements and prioritizing them into those required for safe restart and those that could be deferred until after restart without compromising safety. Safety improvements not required for restart, according to DOE, are to be accomplished in the long-term Reactor Safety Improvement Program, which includes not only safety improvements but production-related improvements as well.

Table IV.1 shows, on the basis of information supplied by DOE's Special Projects Office, that the estimated expenditures through fiscal year 1993 for reactor restart and operations are $3.2 billion. Under the reactor safety improvement program, the estimated costs for projects started during the fiscal year 1991-93 period are estimated at $1.05 billion.

[1]One such review resulted in a 1987 report from the National Academy of Sciences and the National Academy of Engineering entitled Safety Issues at the Defense Production Reactors. This report, which was precipitated by the April 1986 nuclear accident at the Chernobyl Nuclear Power Station in the Soviet Union, provides an independent assessment of the accident's implications for the safe operation of four of DOE's reactors, including the K, L, and P reactors at SRS.

Table IV.1: Total Estimated Cost of Reactor Restart and Operations and Reactor Safety Improvement Program, Fiscal Years 1989-93

Dollars in millions

	Fiscal year				
Reactor restart	**1989-90[a]**	**1991[b]**	**1992[c]**	**1993[d]**	**Total**
Operating costs					
Reactor restart	$858.8	$641.0	$452.6	$452.6	**$2,405.0**
Reactor materials	131.8	77.9	74.6	74.6	**358.9**
DOE program direction	67.6	40.1	31.0	31.0	**169.7**
Total	**1,058.2**	**759.0**	**558.2**	**558.2**	**2,933.6**
Capital equipment	32.6	25.8	16.4	16.4	**91.2**
General plant projects	8.6	4.1	5.6	5.6	**23.9**
Construction line items	51.2	22.7	65.6	41.9	**181.4**
Total	**$1,150.6**	**$811.6**	**$645.8**	**$622.1**	**3,230.1**
Reactor safety improvement program					
Operating costs and capital funding for projects started during 1991-93					**1,050.0[e]**
Total					**$4,280.1**

[a]The amounts for reactor restart in fiscal years 1989-90 are actual costs. The Reactor Safety Improvement Program began in fiscal year 1991.

[b]The 1991 amounts include reprogramming.

[c]The 1992 amounts are from congressional budget data.

[d]The 1993 amounts are from draft congressional budget data.

[e]The estimated $1.05 billion will be spent during fiscal years 1991-96. Other projects will be scheduled to start after fiscal year 1993, but cost estimates were not available for these projects as of mid-February 1991.

Source: Information supplied by the DOE Savannah River Site's Special Projects Office in mid-February 1991.

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