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Licensee: Duke Power Company
422 South Church Street
Charlotte, NC 28242

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Facility Name: Oconee 1, 2 and 3

Inspection Conducted: November 1 through December 14, 1993

Inspector: [signature] 2/10/94
for Walter G. Rogers, Team Leader — Date Signed

Accompanying Personnel: L. Mellen
C. Rapp
L. King
K. Kavanaugh (Intern)
D. Tamai (Intern)
P. Holmes-Ray

Approved by: [signature] 2/10/94
for Thomas A. Peebles, Chief — Date Signed
Operational Programs Section
Operations Branch
Division of Reactor Safety

SUMMARY

This routine, announced inspection was conducted in the areas of Service Water System Operational Performance Inspection (SWSOPI) on November 1 through December 14, 1993, in accordance with NRC Temporary Instruction 2515/118.

RESULTS

General Weaknesses:

The NRC Temporary Instruction for Service Water Inspections, SIMS item 2515/118, was not closed due to licensee inadequacies in response to GL 89-13. Design control measures contained numerous weaknesses. Unvalidated and nonconservative assumptions were used in various calculations. Calculations or analyses did not exist for some SWS operating modes. Engineering analyses of some conditions were inadequate. Vague criteria had been established for updating calculations. The testing program had but omitted critical functions of some systems and equipment. The procedural guidance for some abnormal situations was weak. The safety classification system had numerous omissions. Resolution to self-assessment findings were sometimes untimely and occasionally inadequate.

General Strengths:

The SWSs were in good material condition. The design review portion of the licensee's self assessment was thorough and comprehensive for the system reviewed. Instrument calibration procedures contained detailed and complete descriptions of the instrument's function. The corrosion monitoring program, though of limited scope, was excellent. The DBD concept and the associated testing acceptance criteria were good initiatives.

Findings

LPSW System - For some low probability situations required by the facility's license, the system would be incapable of performing its safety function. For example, RBCU cooling coil leak repair material had not been qualified for accident conditions; failure of the material would affect containment integrity. A fairly complete hydraulic computer model had been developed, but inadequate controls existed for maintaining the hydraulic model valid. Significant material condition improvements had been accomplished (replacement of the unreliable radiation monitoring system) and others were planned (replacement of all RBCUs). Extensive analysis/calculations existed on which the system design was based. However, analyses dealing with LPSW NPSH and RBCU waterhammer were inadequate. Also, the RBCU performance evaluation process contained two questionable inputs.

CCW System - Corrective actions to SITA findings associated with the ECCW subsystem had been untimely. Portions of the CCW system necessary to provide flow to the LPSW system were not properly classified as safety-related. The situation had been recognized by the licensee, and adequate corrective actions were being implemented. No analyses existed to support Oconee's capability to withstand failure of the Keowee Dam/loss of inventory of the Lake Keowee. Also, the procedures for this scenario contained weaknesses. The test procedure and heat transfer calculations for the ECCW subsystem were inadequate. Fortunately, a large safety margin existed in the actual system's performance.

HPSW System - The system was not classified, constructed, tested, or maintained commensurate with its importance to safety. The licensee's engineering organization recognized this deficiency. However, communication to the rest of the organization had been untimely. Also, some of the corrective actions taken by the licensee in response to this deficiency were weak.

SSF - The SSF would not remain operational following a failure of the Jocassee Dam. Therefore, no system was available to provide decay heat removal of the three units in this situation. Also, the decay heat removal function of the SSF had not been adequately confirmed. The minimum flow requirements to the steam generators were nonconservative. Numerous calculations had not been updated following facility modifications affecting the calculations. The periodic testing program elements did not add up to an integrated test of the SWS systems. Air entrapment affecting ASW pump performance could not be identified during periodic pump testing due to a procedure deficiency. Finally, certain aspects of the licensee's GL actions had not been performed.

ASW System - The system was marginal in its capabilities and did not contain flow instrumentation or provide the operators the ability to control plant conditions from the control room. Testing of the system failed to provide full assurance that the personnel could perform necessary tasks within the requisite time constraints. The testing of specific components in the system was inadequate, but the licensee had recognized the deficiencies and was taking timely corrective actions. Calculations for NPSH and pump minimum flow protection lacked rigor.

Keowee - The mechanical systems were very reliable. Keowee had been excluded from the licensee's GL response. Corrective actions to establish all aspects of the quality assurance program at Keowee had some minor weaknesses in quality of implementation and full integration. Also, some minor quality assurance program deficiencies were present. The calibration program contained some weaknesses including not verifying the annunciator panels alarm at the proper setpoint.

Four cited violations, two non-cited violations, two deviations, one unresolved item, and six inspector follow-up items were identified.

The following items are included as attachments to this inspection report:

APPENDIX A Persons Contacted
APPENDIX B Generic Letter 89-13 Action Items
APPENDIX C Acronyms and Abbreviations

REPORT DETAILS

1. Inspection Objectives

Numerous problems identified at various operating plants in the United States have called into question the ability of SWSs to perform their design function. These problems have included inadequate heat removal capability, biofouling, silting, single failure concerns, erosion, corrosion, insufficient original design margin, lapses in configuration control or improper 10 CFR 50.59 safety evaluations, and inadequate testing. NRC management concluded that an in-depth examination of SWSs was warranted based on these problems.

The team focused on the mechanical design, operational control, maintenance, and surveillance of the SWS and evaluated aspects of the quality assurance and corrective action programs related to the SWS. The inspection's primary objectives were to:

* Assess SWS performance through an in-depth review of the system's mechanical functional design and thermal-hydraulic performance including the content and implementation of SWS operating, maintenance, and surveillance procedures, and operator training on the SWS,

* Verify that SWS functional design and operational controls could meet the thermal and hydraulic performance requirements, and that SWS components were operated in a manner consistent with their design bases,

* Assess the licensee's planned and completed actions in response to Generic Letter 89-13, "Service Water System Problems Affecting Safety Related Equipment," July 1989, and

* Assess SWS unavailability resulting from planned maintenance, surveillance, and component failures.

The specific areas reviewed are described in paragraph 2 of this report. The observations and concerns identified are described in paragraphs 3 through 10 of this report. Personnel contacted and those who attended the exit on December 14, 1993, are identified in Appendix A.

2. Inspection Areas of the SWSs Associated with Oconee

The SWSs at Oconee encompassed numerous systems. These were the LPSW; HPSW; ASW; CCW (including the ECCW subsystem); the EDG cooling, HVAC cooling, steam generator cooling, and submersible pump subsystems of the SSF; and most of the mechanical systems of the Keowee hydroelectric station.

The team reviewed the mechanical design of each SWS, including the design bases, functional requirements, design assumptions, calculations, boundary conditions, analyses and models to determine if the design met licensing commitments and regulatory requirements. Each SWS's capability to meet the thermal and hydraulic performance specifications during accident and abnormal conditions was reviewed. The design features associated with the loss of the Jocassee and Keowee Dam were evaluated. Single and common mode failure vulnerabilities, selected modifications and proper reflection of SWS design in plant operations, testing, and maintenance procedures were reviewed. The team reviewed maintenance history on selected equipment, maintenance procedures, completed work packages, preventive maintenance schedules, preventive maintenance procedures, and associated LERs. The availability records of the LPSW system for the past two years was compared to the licensee's PRA submittal. Plant walkdowns were conducted on all SWSs to assess present operating configurations, conformance to design documents, housekeeping and material conditions. Normal, abnormal and emergency operating procedures were reviewed for adequacy. Simulator scenarios involving the LPSW system were evaluated. The team reviewed preoperational test procedures, surveillance procedures, and the IST program implementation to determine if sufficient testing had been conducted to confirm system design requirements and system operability. Also reviewed were the licensee's procedures, controls, and other activities associated with the calibration of instrumentation in the SWSs. The team reviewed the licensee's self-assessment of the LPSW system and select corrective action documents associated with the SWSs. The minutes of off-site committee meetings were reviewed for conformance to Technical Specification requirements. Also, the team evaluated the adequacy of the licensee's GL 89-13 actions associated with all the SWSs.

3. Generic Letter 89-13 Implementation

The NRC issued GL 89-13, "Service Water System Problems Affecting Safety Related Equipment," requesting licensees to take certain actions related to their SWS. These actions included establishing biofouling surveillance and control techniques, monitoring safety-related heat exchanger performance, establishing a routine inspection and maintenance program, reviewing the design to assure intended safety functions could be accomplished, and training personnel in the operation, maintenance, and testing of the SWS.

The licensee's docketed responses to the GL of January 26, 1990, and May 31, 1990, were broad in nature and not specific to each system addressed. Also, the licensee's response indicated the GL actions had been performed without taking exceptions.

However, the licensee's GL actions almost exclusively focused upon the LPSW system and its support systems. The licensee's actions in response to GL 89-13 did not address all the applicable GL systems. The SWS associated with the Keowee hydroelectric station was not considered. A number of GL actions were not considered for the ASW and the SWS portion of the SSF. Also, a number of GL actions were not performed by the licensee for the HPSW system due to the classification of the system as nonsafety-related. Failure to apply the GL actions to all the applicable systems is Deviation 50-269, 270, 287/93-25-01, "Failure to Adequately Perform SWS GL Actions."

The licensee had performed extensive corrective actions to the LPSW system, but one LPSW design deficiency identified during self-assessment activities was not properly rectified. Also, corrective actions associated with the support functions provided by the CCW system had not been performed in a timely manner and/or did not fully address the deficiencies identified.

Heat exchanger performance monitoring was adequate for the LPI coolers and the smaller LPSW system coolers. The RBCU performance monitoring had established relative changes in the fouling factor between monitoring intervals but had not determined the true fouling factor. Also, some of the inputs associated with RBCU performance monitoring were questionabl, in that the licensee was continuing to improve the hydraulic model for LPSW. See Appendix B for details on each GL 89-13 Action Item.

4. <u>Low Pressure Service Water System</u>

The LPSW system provided cooling to the RBCUs, LPI coolers, the motor and turbine driven EFW pump coolers, HPI pump motor coolers, the control room chilled water system, numerous room coolers, and nonsafety related turbine building loads. Units 1 and 2 shared three 15,000 gpm pumps with one pump capable of being powered from two separate safety related busses. The Unit 3 LPSW system had two 15,000 gpm pumps. The LPSW pumps took a suction from the 42" CCW discharge header within the turbine building. The Unit 1/2 LPSW pumps discharged into a common header that split into two supply lines; one supply line for each unit. The unit supply lines further divided into two separate headers supplying the two trains of safety related equipment. The two equipment supply lines then interconnected into a common line which entered containment. This common line then split into three parallel lines, each line supplying one RBCU. These three RBCU supply lines then reconnected into one line on the discharge side of the RBCUs before exiting containment. Also, branching from the common discharge header was a supply line to the turbine building loads. The turbine building supply line then split to provide cooling to each unit's turbine building equipment. The Unit 3 RBCU and turbine building cooling arrangement was similar. A normally closed crosstie line allowed either LPSW system to supply the discharge header of the other LPSW system.

Inspection findings related to the LPSW system were:

a. Turbine Building Isolation

(1) Design

The licensee's design for isolating the nonseismic turbine building line from the seismic portion of the LPSW system was inadequate. A single, motor operated butterfly valve was provided, even though the two LPSW trains were designed and operated as one interconnected system. The isolation valve for

Units 1/2 was LPSW-139, and LPSW-45 for Unit 3. The valves did not have an auto-closure feature, but could be electrically closed by operator action from a station just outside the control room. The isolation valves had not been originally specified as seismic but were seismically qualified as a resolution to a 1987 SITA finding on the LPSW system.

The licensee had performed calculations to determine the effect an earthquake would have on the LPSW systems. In the case of a nonseismically supported turbine building line failure without turbine building isolation, the calculation indicated the LPSW system would not be able to supply adequate cooling to the required safety related loads.

FSAR Section 9.2.2.2.3 stated in part, "The LPSW system provides sufficient flow to the Low Pressure Injection coolers and Reactor Building Cooling Units to ensure sufficient heat transfer capability following a design basis accident and a single active failure. The worst case design basis accident involves a LOCA/loss of offsite power with seismic event."

The licensee stated that failure of a seismic/non-seismic interface valve was outside the licensing basis for the facility. The team disagreed. This is Unresolved Item 50-269, 270, 287/93-25-02, "Turbine Building Isolation Single Failure Vulnerabilities."

(2) Testing

The isolation valves had not been VOTES tested in response to GL 89-13, "Safety Related Motor Operated Valve Testing and Surveillance." LPSW-45 was scheduled for VOTES testing at the next refueling outage. LPSW-139 was scheduled for VOTES testing at the next outage of both Units 1 and 2. In response to the team's request for design calculations supporting the closing capability of these valves, the licensee performed calculation OSC-6019, Valve LPSW-139 and 3LPSW-45, "Closure Against Maximum Delta P," indicating that adequate closing thrust could be developed.

Stroke testing of the valves had been limited. LPSW-45 was stroke tested once per refueling outage. Due to operating constraints associated with closing LPSW-139, it had been stroke tested only once since initial operation.

b. LPSW Pump NPSH Considerations

Calculations extrapolating system testing results identified several configurations involving loss of instrument air where LPSW flow demand was greater than design. The most severe configuration was simultaneous operation of both LPI coolers on a shutdown unit and a LOCA on the other unit with the LOCA unit's MTOTC temperature control valve bypassed. For this case, there was insufficient NPSH for the excessive LPSW flow demand causing significant cavitation of the LPSW pumps. The licensee established procedural controls to throttle LPSW flow within 30 minutes through operator actions, thereby eliminating the cavitation. The inadequate NPSH condition was evaluated by the licensee and considered acceptable.

(1) The licensee's NPSH acceptability evaluation was based upon accepting the manufacturer's best judgement that no significant pump degradation would occur during and following the inadequate NPSH condition. Neither the licensee nor the pump manufacturer performed any testing validating this judgement. Also, the pump manufacturer did not warrant the LPSW pumps for operation with insufficient NPSH. Therefore, the licensee failed to adequately validate this critical design assumption. 10 CFR 50, Appendix B, Criterion III, "Design Control," requires that adequate measures be established for the selection of equipment. Also, as committed through Duke Power Company Topical Report 1-A, Table 17.0-1; ANSI 45.2.11-1974, "Quality Assurance Requirements for the Design of Nuclear Power Plants," requires NPSH be considered as a design input in Section 3.2.11. This is considered an example of Violation 50-269, 270, 287/93-25-03A, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

(2) One of the operator actions to reduce flow demand within 30 minutes was throttling the LPI cooler isolation valves until reaching 3000 gpm. The cooler isolation valves were gate valves and, generically, not used for throttling. The licensee had evaluated and tested these valves for throttling flow and determined the valves could be throttled. However, after throttling, the valves may not go full open or closed due to internal damage suffered while throttled. This could result in the inability to isolate a leaking LPI cooler subsequent to the throttling activities.

c. The Hydraulic Model

(1) The licensee's hydraulic computer model for predicting LPSW system response during an accident used the manufacturer's pump curves. The manufacturer's pump curves did not include pump degradation. Quarterly inservice pump testing allowed for up to 10 percent pump degradation without declaring the pump inoperable. There were no procedural controls to evaluate the inservice pump test results against the hydraulic model's flow inputs. Although the situation was not identified during the inspection, an acceptable inservice pump test could invalidate the LPSW pump flow inputs to the hydraulic computer model.

Contrary to the requirements of 10 CFR 50, Appendix B, Criterion III, "Design Control," the licensee failed to provide the adequate procedural controls to ensure the LPSW hydraulic model was not invalidated. This is an example of Violation, 50-269, 270, 287/93-25-03B, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

(2) The manufacturer's pump curve indicated the possibility of deadheading a degraded pump when the LPSW pumps were operating in parallel. Trending of the one point flow/pressure check used in the IST program was not the most reliable method of detecting pump degradation. The development of an individual pump curve would more accurately predict this condition. However, the current testing method was consistent with regulatory requirements.

(3) In 1992, the licensee reviewed Unit 1 and 2 hydraulic computer model results and determined a waterhammer would occur during a design basis LOCA with a single failure. The hydraulic model predicted a LPSW pressure of -13.5 psig downstream of the RBCU discharge throttle valves. Containment temperature would exceed 200°F in response to the design basis LOCA. The combination of the low pressure (-13.5 psig) and the high temperature (200°F) would cause the LPSW water to flash to steam. Upon condensation of the steam, a waterhammer would ensue. Under condition adverse to quality report PIP 92-454, the licensee evaluated the effects the waterhammer would have on LPSW flow within the piping and the reduction in RBCU cooling in calculation OSC-4922, "LPSW Woods Model Flowrate Correction through RBCU's Due to Cavitation," issued September 25, 1992. The licensee did not evaluate the effects the waterhammer would have on the structural integrity of the RBCUs and the discharge piping. 10 CFR 50, Appendix B, Criterion XVI, "Corrective Actions," requires conditions adverse to quality to be promptly identified and corrected. This is considered an example of violation 50-269, 270, 287/93-25-04A, "Inadequate Evaluation of Conditions Adverse to Quality by Engineering."

d. RBCU Operability Determination

A combination of LPSW flow test data and computer modeling of RBCU air flow were used to determine if the RBCUs had adequate accident condition heat removal capability. There were two questionable inputs used in that determination as follows:

(1) Accuracy of the installed orifice used to measure LPSW flow

A reduction in the diameter of the piping in the area of the orifice would result in higher indicated LPSW flow than was actually occurring. Documentation and photographs showed fouling had occurred at various points within the LPSW piping. Anomalous results in previous flow testing, though possibly due to other reasons, could be explained by the flow instrumentation reading high. The licensee was aware of the potential problem and planned to replace the RBCUs and associated piping, including the section containing the flow orifice, at the next refueling outage for each unit.

(2) Validity of the RBCU non-uniform air flow distribution predicted by the computer modeling

The calculation of the air side fouling factor was highly sensitive to variations in the air flow distribution. The computer code had been benchmarked by a vendor. However, an airflow test performed in 1987, indicated airflow was substantially less than expected. When questioned about the results, the licensee stated this test was invalid due to significant air side fouling. Further testing was not conducted.

These two concerns placed RBCU results in question. Further licensee actions to determine the accuracy of these two inputs into AN RBCU operability determination is considered an Inspector Follow-up Item 50-269, 270, 287/93-25-05, "Additional Validation of RBCU Evaluation Inputs." Also, a detailed discussion of RBCU operability determination is contained in Appendix B, section II.

e. Use of Belzona for RBCU Leak Repair

The licensee had used Belzona to repair various plant components including the pressure retaining braze joints on the RBCUs. The commercial grade evaluation, CGD 2021.01-01-0001, specifically addressed the use of Belzona as a pressure retaining material for "pinhole" leak repairs on the Unit 2 RBCU coils. While the licensee's calculation found that the shear stress was acceptable; the licensee failed to evaluate or obtain test data to show that the RBCU repairs would withstand accident conditions. Failure of the Belzona presently installed in Unit 2 coincident with a LOCA would significantly increase containment leakage. 10 CFR 50, Appendix B, Criterion III, "Design Control," requires adequate suitability of application of materials reviews be performed. This is considered an example of Violation 50-269, 270, 287/93-25-03C, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

f. Simulator Observations

(1) During a LOOP/LOCA with failure of one LPSW pump on the shared Unit 1/2 system, the operator stopped one of the two operating LPSW pumps when no pump amperage was indicated. Redundant, independent instrumentation was not used prior to stopping the pump and was considered a performance weakness. Although

expected and consistent with the facility's design, LPSW pump suction valve position indication was lost. Indication was powered from a nonsafety related electrical bus which de-energizes in response to the LOOP. These valves were normally aligned open and do not receive an ESF signal. The lack of indication contributed to the operator's decision to stop the pump.

(2) With one operating LPSW pump supplying both units, the LPI cooler flows required by the emergency procedure could not be achieved. None of the licensee's procedures were applicable to this situation. The operators used their judgement and secured LPSW flow to the LPI coolers, isolated cooling to the control room, and isolated numerous nonessential loads. After transferring LPI pump suction to the containment sump due to depletion of the BWST, the LPI coolers were returned to service at flows less than required by the emergency procedure.

The lack of specific procedural direction was due to a deficiency within the abnormal procedure for total loss of LPSW. The entry condition for using this procedure was no LPSW pump operating; instead of inadequate LPSW flow. The licensee acknowledged this deficiency. Actions to improve operator response to inadequate LPSW flow is considered part of Inspector Follow-up Item 50-269,270, 287/93-25-06A, "Actions to Improve Operator Responses to Abnormal Events."

(3) After the simulator demonstration, the ramifications of reduced LPI flow and the bases of the procedurally required 3000 gpm LPI cooler flow was discussed. This parameter directly involved maintaining containment temperature less than equipment environmental qualification temperature limits. Licensee responses were focused exclusively on reactor core cooling. The 3000 gpm bases for LPI cooler flow was not fully understood by the individuals. This was due to the limited training on containment temperature concerns during an accident. The licensee responded that containment temperature ramifications would be the responsibility of the Technical Support Center. This is considered a training weakness.

(4) The simulator was certified. However, there was no simulation of the HPI and LPI pump motor coolers, no deviation in LPSW flow to the RBCUs in response to the ESF actuation, and no simulation of the Unit 3 LPSW system crosstie.

g. SITA Actions

In 1987, the licensee conducted a technical audit of the LPSW system. The audit was thorough with a substantial number of findings. Some of the corrective actions directly associated with the LPSW system were adequately dispositioned. Examples included the replacement of the unreliable radiation monitoring system for effluents from the LPSW system, development of a hydraulic computer model, and the generation of a substantial number of calculations to support LPSW design. However, concerns by the licensee associated with some of the corrective action resolutions, especially dealing with support systems, prompted an October-November 1992 review of the SITA process and revisiting a number of these outstanding issues. Subsequently, a SWS Steering Committee was formed and charged with resolution of all SWS issues.

The team concurred with the licensee's assessment that there had been untimely progress of some critical SITA issues prior to the Fall, 1992. The SITA process review in the Fall, 1992, was a good initiative. Also, the resulting SWS Steering Committee had a number of positive aspects including centralization of the issues and the ability to focus the diverse sections of the Oconee organization on resolution of a particular issue. However, resolution of some of the outstanding issues was inadequately addressed. Examples included the LPSW turbine building isolation, and HPSW piping seismic capability.

h. System Availability

Recent system availability data compared favorably with the availability assumed in the IPE report. Also, the material condition of the LPSW system was good except for fouling of small diameter piping. Recent machinery history records indicated the majority of the repetitive corrective maintenance focused on unplugging fouled instrument impulse lines. Also, flow testing of the Unit 3 HPI pump motor cooler, the Unit 1 LPSW A pump's cooling line, and the TDEFW pump cooling lines indicated fouling resulting in stainless steel piping replacements in those areas.

5. Circulating Cooling Water System

The CCW system was common to all three units and took suction from the Lake Keowee intake canal. Twelve pumps (four per unit) supplied a common cross-connected 42-inch discharge header from which numerous other SWSs took suction. From this header, cooling water passed through the three condensers. Upon leaving the condensers, the water discharges through six lines (two per unit) and returns to Lake Keowee upstream of the intake canal.

A subsystem of CCW was the ECCW system. If the CCW pumps lost power ECCW actuated establishing siphon or gravity flow from the intake canal to the 42-inch header and through the condenser sections. Emergency condenser discharge lines connect the condensers with the Keowee hydroelectric station's tailrace and due to elevation differences. This was gravity/siphon flow operated. Prior to entering the tailrace all the discharge lines connected into one line. ECCW actuation involved the automatic closure of the condensers' normal outlet valves, opening of the condensers' emergency outlet valves and opening emergency discharge valve to the Keowee tailrace, CCW-8, located in the common discharge piping. The high points of the ECCW piping were connected to a vacuum priming system which would remove air entrapped within the system that could impede siphon operation. The licensee considered CCW supplying the LPSW pumps as the first siphon and CCW passing through the condensers as the second siphon.

The CCW system performed two distinct safety functions during the LOCA/LOOP event: First, it provided a suction source for other systems including the safety-related LPSW system, and second it provided cooling water to the condenser to remove decay heat in the emergency condenser cooling water (ECCW) mode. The CCW pumps contributed to these safety functions in two ways: First, when power is lost and they are not operating, they provided a siphon conduit from the intake canal to the CCW piping from which the LPSW takes suction, and to the condenser for the ECCW system. Second, at the time when the pumps can be restarted (up to 1/2 hours per emergency procedures), they continue to provide water for these same functions. Since dissolved air will tend to come out of solution when the system is in the siphon mode, at least one of the CCW pumps must be operated after power is restored in order for the water to continue to be supplied to the CCW piping.

Within the intake canal is an underwater dam which can trap approximately 67,000,000 gallons of water if Lake Keowee were to fall below the 770-foot level. With the CCW pumps operating the system is capable of recirculating water from this impounded area, through the condensers, through the condenser emergency discharge lines and through normally closed valve, CCW-9, which discharges into the intake canal.

Findings associated with the CCW system were:

a. The Siphons

(1) The 1987 SITA identified numerous support systems associated with the first siphon which did not meet safety related standards such as the non-seismically qualified vacuum priming system. The original SITA response did not refute the finding, but considered such requirements as outside the licensing basis of the facility. Eventually, the safety related aspects of these support systems were evaluated in a design study. Through a combination of the design study and a SWS steering committee the vacuum priming

issue was addressed by isolating the vacuum priming system in the Fall, 1993. Outgassing of air was addressed by establishing minimum CCW pump combinations for particular Lake Keowee levels. Licensee actions on this matter were untimely. Another support system, HPSW, for the first siphon is discussed in section 6.

(2) The CCW pump components necessary to support siphon operation to the LPSW system (the first siphon) performed a safety related function but, were not classified as safety related. For the first siphon to operate, the physical interface between the pump casing and the CCW piping must be leaktight, and the pump mounting/structural supports must be capable of withstanding an earthquake without allowing air inleakage. Examples of the effects of the improper classification were as follows:

(a) Following failure of an ECCW flow test the licensee determined the cause of the test failure to be air inleakage between the pump casing and the CCW piping. In response the licensee issued OE # 4072 dated 6/3/91 which authorized installation of a rubber seal at this interface. Though the design change appeared technically adequate, it was designated as nonsafety related.

(b) During the inspection period, the overhaul/repair of the 2B CCW pump was being performed using nonsafety related procedures.

(c) Whenever a CCW pump was disassembled, as with the 2B pump, the pump casing seal was disturbed. The subsequent post maintenance test to confirm leak tightness was performed without written procedural direction. Following discussions with the licensee the test method appeared adequate but, the conditions for testing, the instrumentation, the acceptance criteria, etc. were not being appropriately controlled.

Independently, the licensee recognized the error and was classifying the components as safety related in the most current draft revision to the Quality Standards Manual. The failure to properly classify the components is considered Violation 50-269, 270, 287/93-25-07, "Inadequate Classification of Siphon Support Equipment for LPSW Supply." However, based upon the corrective actions in progress, the licensee's self identification of the matter, no similar violations associated with the misclassification of the first siphon's support equipment, the lack of willfulness, and the nonescalated enforcement nature of the violation, this is considered a non-cited violation authorized under 10 CFR 2, Appendix C, Section VII.B.2.

(3) The licensee did not consider the equipment associated with the second siphon as safety-related. Therefore, some of the equipment associated with the condenser cooling mode did not meet safety-related design requirements.

The vacuum priming support system was not seismically supported. A number of valves were not powered from safety-related sources including some of the condenser emergency discharge valves, midpoint vent valves, and the emergency discharge valve to the Keowee tailrace.

Also, the single discharge valve to the Keowee tailrace was not seismically protected. This valve was located in a concrete and steel structure at elevation 730 feet. The top of this structure was covered with nonrestrained metal deck plates. In a seismic event, the plates could fall damaging the valve or the associated electrical cables below.

Unresolved Item, 269,270, 287/93-13-03, "ECCW System Design and Testing," had already been established on ascertaining the licensing basis of the ECCW system, including the condenser cooling mode. Therefore, the design aspects of the condenser cooling mode discussed above have been encompassed by this unresolved item. Resolution of this unresolved issue is contingent upon further NRC review.

(4) Nonconservatisms existed within the calculations supporting ECCW design and testing. Examples included:

(a) Calculation OSC-2349, "CCW Intake Piping Degassing in the ECCW Mode", Rev 1, May 21, 1990, was performed to show that the CCW system had the capability of providing the required flow rate even with air inleakage and outgassing of dissolved air from the water, both of which would tend to break the siphon. The calculation also provided the acceptance criteria for the intake piping water level for the "Emergency CCW System Flow Test," PT/1/A/0261/07, and the equivalent performance tests for Units 2 and 3.

The following discrepancies and nonconservatisms existed in this calculation:

- The maximum flowrate analyzed was 30,000 gpm. However, for the LOOP case, the maximum flowrate may include the maximum tailrace flow through the condenser and the CCW-8 emergency discharge valve (in the range of 30,000 gpm), plus the flows to the LPSW pumps (design flow of 15,000 gpm per pump, 5 pumps). The various LPSW pump combinations had not been analyzed, but initial evaluation indicated that as many as four pumps could be operating. Therefore, the actual flows could be significantly higher than what was analyzed, producing more outgassing due to the higher mass flow rate. Additionally, higher flow would require a higher minimum level in the piping to overcome the increased flow resistance.

- The atmospheric pressure used was 14.7 psia. Per "Atmospheric Pressure for Design Calculations," S. L. Nader, File OS-3C, 7/23/87, the correct atmospheric pressure for Oconee was 14.0 psia.

Conservatisms in the calculation and differences from the actual operating configuration which would tend to offset the non-conservatisms were as follows:

- The calculation assumed an outgassing rate of 100 percent. The actual rate would be less.

- Actual testing was done on one unit at a time with four CCW pump flow paths open. The calculation assumed only one open pump flow path.

- The duration of the analyzed SBO event was longer than the LOOP event (4 hours versus 1.5 hours).

It was not clear which will dominate, the conservatisms or the non-conservatisms, without rigorous re-performance of the analysis. Failure to reconcile the competing assumptions compromised the calculation on which the adequacy of the ECCW design requirements and test acceptance criteria were based in part.

(b) Calculation OSC-2346, "ECCW System Performance Evaluation," Rev 3, February 17, 1993, was generated to show that the condenser had the capacity to transfer the required decay heat without exceeding the condenser pressure limitations or causing flashing in the CCW piping which could cause loss of the siphon. This calculation formed the basis for the acceptance criteria of the Technical Specification required system flow test.

(1) The methodology used to derive the heat transfer capability of the siphon/condensers was nonconservative as follows:

- The calculation did not account for the potential for outgassing of the CCW which would tend to decrease the heat transfer capability of the condenser. Such outgassing would be driven by the decrease in pressure in the CCW system due to the siphon and by the increase in temperature of the CCW as it passes through the condenser tubes.

- The atmospheric pressure used in the calculation was 14.7 psia. Per "Atmospheric Pressure for Design Calculations," S. L. Nader, File OS-3C, July 23, 1987, the correct atmospheric pressure for Oconee was 14.0 psia.

- The calculation did not account for the decrease in heat transfer area as a result of condenser tubes that were presently plugged and may be plugged in the future.

- The calculation did not account for the decrease in heat transfer area due to plugging of the tubes by the Amertap balls. The balls were continuously recirculated through the condensers for tube cleaning during normal operation. Due to the very low differential pressure across the condenser during siphon operation, the balls would stick inside the tubes.

(2) The calculation did not address, as one of its acceptance criteria, the requirement that the condenser capacity in the ECCW mode should be such that the main steam relief valves would not be open except in the initial pressure spike transient. This criteria should have been included to show that the system could perform one of its primary functions, minimizing the release of radioactivity and conserving condensate inventory by condensing steam in the condenser rather than exhausting it to the environment through the relief valves. Although the calculation was deficient in this regard, the licensee was subsequently able to demonstrate this capability.

(3) The calculation derived a minimum initial flow rate of 4,500 gpm to each unit's condenser to meet the heat transfer requirements. Flow through the three condensers was assumed to be equally split. Upon this assumption, acceptance criteria for the Technical Specification required flow test was derived. However, the unit specific flow paths (the piping from the condenser waterbox outlets to the common discharge line) were different in length and configuration. Also, there was not a flow analysis demonstrating the equal flow split. Therefore, the assumed equal flow distribution had not been validated.

10 CFR 50, Appendix B, Criterion III, "Design Control," requires that measures shall be established to assure that design bases are correctly translated into design documents and to verify the adequacy of design. Contrary to this requirement, the licensee did not adequately translate the requirements for the ECCW system into the analyses and test acceptance criteria which demonstrated the system's capability to meet these requirements. This is an example of Violation 50-269, 270, 287/93-25-03D, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

(5) ECCW Test Procedure

Procedure PT/1/A/0261/07, change 8, August 8, 1991, "Emergency CCW System Flow Test," was the periodic Technical Specification required test of the ECCW system flow capability. The flowrate of the siphon was determined by measuring the distance between the exit nozzle of the ECCW piping and the middle of the flume's impact point with the tailrace. There were distance markings at two feet increments painted on the tailrace for taking this measurement.

Through licensee interviews, the probable width of the flume at the point of impact was approximately three feet, and the center of the flume was estimated to the nearest foot. Therefore, determination of the flume's impact point entailed an error of as much as ± one foot, which represented an error of approximately ± 2,000 gpm in the acceptance criteria. This potential error was not accounted for in the test acceptance criteria. 10 CFR 50, Appendix B, Criterion XI, Test Control, requires that, "Test procedures shall include provisions for assuring that...adequate test instrumentation is available and used..." This is considered an example of Violation 50-269, 270, 287/93-25-08A, "Inadequate Testing Methods for Testing SWS Equipment."

(6) Although the ECCW calculations and the test procedure were inadequate, the most current test results of ECCW flow appeared to support system operability. This was due to:

(a) The current test procedure verifying the ECCW mode capability, PT/1/A/0261/07, change 8, August 8, 1991, was based on the more conservative analysis in Rev. 2 of the calculation which required an initial flow rate of 6,000 gpm per unit instead of 4,500 gpm per unit. This procedure's acceptance criteria started at 18,000 gpm flow and decreased with time based on an implied assumption that flow through the three unit condensers would be evenly distributed.

(b) Total ECCW flow was approximately 30,000 gpm.

(7) Under Minor Modification OE # 5514 dated September 16, 1993, the licensee deleted the condenser cooling water mode or the "second siphon" from the CCW system design basis document, Specification OSS-0254.00-00-0003, Rev 2, March 31, 1992. The licensee's safety evaluation justifying the deletion, considered the condenser cooling mode of decay heat removal as only required for the total loss of power (onsite and offsite) event discussed at original licensing. In the more recent SBO submittal approved by the NRC (SER dated January 28, 1992), the decay heat removal pathway described was via lifting main steam relief valves, and not the condenser cooling mode. Therefore, the licensee considered the SBO submittal as superseding the original requirements.

Deletion of the condenser cooling mode was not justified because:

- Technical Specifications 3.4.5 required the ECCW system. The Technical Specification bases stated "Normally, decay heat is removed by steam relief through the turbine bypass system to the condenser. Condenser cooling water flow is provided by a siphon effect from Lake Keowee through the condenser for final heat rejection to the Keowee Hydro Plant tailrace." It also stated that, "Decay heat can also be removed from the steam generators by steam relief through the main steam safety relief valves." Therefore, both the ECCW condenser cooling mode and the SBO submittal method were credited for decay heat removal.

- Section 9.2.2 of the current FSAR, "Cooling Water Systems," stated that the CCW system, "...serves as the ultimate heat sink for decay heat removal during cooldown of the plant. Following a design basis event involving loss of the CCW pumps, the Emergency Condenser Circulating Water System...provides flow through the condenser for decay heat removal." It further stated, "The CCW system has an emergency discharge line to the Keowee hydro tailrace... Under a loss-of-power situation, the emergency discharge line will automatically open and the CCW system will continue to operate as an unassisted siphon system supplying sufficient water to the condenser for decay heat removal and emergency cooling requirements." Additionally, it stated, "...the "second siphon" provides flow through the condenser to remove decay heat." And finally it stated, "In a loss of off-site power situation, the ECCW System is required to function until a CCW pump can be manually restarted by the control room operator."

- The licensee's SBO submittal did not request elimination of the ECCW condenser cooling mode from the licensing basis. The NRC's SBO SER did not state relief was granted from previous condenser cooling mode licensing requirements, nor did it state that the condenser cooling mode was only required for a total loss of power event.

- On page 9, item 6, of a May 23, 1993, Notice of Violation, the NRC stated, "The ECCW system is required to provide both a suction source to the Low Pressure Service Water (LPSW) pumps and cooling water through the main condenser for decay heat removal if the Condenser Circulating Water (CCW) pumps are unavailable."

- In a February 11, 1987, letter concerning an enforcement conference for failure of an ECCW system test, the NRC's position was summarized on Page 3 of Enclosure 1 as, "The NRC discussed the event in detail with DPC and expressed concern that the load shed test had not been appropriately conducted in the past to insure that the required gravity flow (which relies upon a siphon) for the ECCW System was available and effective upon demand." On this page, the siphon referred to was defined as the "second siphon" in a statement that, "The ECCW System relies upon a siphon effect to lift water from Lake Keowee and then exit by gravity flow to Lake Hartwell at a lower elevation."

The licensee stated that present practices (operation, maintenance, testing, etc.) were not changed as a result of deleting the condenser cooling mode from the design basis document. However, the team considered that at a minimum, future modifications could be impacted. Also, the minor modification's safety evaluation became the basis for a licensee request to delete ECCW from the Technical Specifications. The Technical Specification change request was under review by NRR. Resolution of the team's concerns associated with the licensing bases of the condenser cooling mode and the prudence of the licensee's actions are contingent upon NRR's decision (either approval or denial) of the Technical Specification change request and completion of NRC's review of Unresolved Item 50-269, 270, 287/93-13-03, "ECCW System Design and Testing."

b. The CCW Pumps

(1) The active components associated with CCW pumps were not classified as safety-related. However, the licensee credited CCW pump operation 1/2 hour after accident occurrence to provide the suction supply to the LPSW system. Therefore, the pumps were improperly classified. Independently, the licensee recognized the error and was classifying the pumps as safety related in the most current draft revision to the Quality Standards Manual.

Unresolved item 50-269, 270, 287/93-13-03, "ECCW System Design and Testing," already identified concerns regarding the licensing basis of the CCW pumps.

(2) The only documentation discussing CCW NPSH requirements was a letter from the pump vendor which stated that the pump "...will operate satisfactorily at a low water condition of elevation 770 feet." This letter did not address the temperature of the water on which this judgement was made. The design temperature for the CCW pumps at the time of this letter is given in Table 9-12 of the original FSAR as 75°F. Since then, the design maximum lake temperature was raised to 85°F by Calculation OSC-2568, Revision 0, July 24, 1987. Also, the letter did not discuss operation below the 770 feet elevation, the top of the intake canal's underwater weir, which would be the initial conditions for the loss of Keowee Dam event. Subsequently, the intake canal level would decrease due to leakage and evaporation. Finally, the intake canal temperature would steadily increase due to decay heat and other heat input from the three units.

Prior to and during the inspection the licensee was attempting to acquire the necessary information from the pump manufacturer. Acquisition of the information is Inspector Follow-up Item 5-269, 270, 287/93-25-09, "CCW Pump NPSH Information." The lack of CCW pump performance evaluation during the loss of Keowee Dam event is another facet of the inadequate Keowee Dam failure analysis discussed in paragraph d. below.

(3) The power and control cables for all of the CCW pumps and the pump discharge valves as well as all of the piping for the HPSW supply to the pump seals and coolers were located in a common trench at the CCW structure. This trench was covered with heavy steel deck plates which were not bolted in place. In response to a seismic event the plates in the horizontal portions of the trench would not dislodge due to stiffeners welded to the plates. However, there were sections of the trench running at approximately 45° from horizontal, and the plates covering these sections could be dislodged by a seismic event potentially damaging the cables below. The licensee was able to demonstrate that only the cables in the upper cable tray (powering the Unit 3 CCW pumps), and the cables in the bottom of the trench (powering and controlling the CCW pump discharge valves) could be damaged. Due to armored sheathing on the cables, damage could not spread to adjacent cables from the resultant electrical faults. Although CCW pump performance could be degraded, the total CCW function of supplying water to the LPSW system and the condensers would not be lost. The licensee initiated a work request to bolt the covers in place.

c. Keowee Loss of Dam Event

Part of the licensing bases for Oconee involved the ability to withstand a loss of Lake Keowee as an ultimate heat sink. Section 10.4 of the original FSAR, "Condenser Circulating Water System" stated, "In the unlikely event that the water level in Lake Keowee should fall below 770 feet, an underwater weir in the intake canal would act as a dam capable of retaining a large amount of water [67 million gallons] to serve as an emergency cooling pond. By operator action, the condenser circulating water system normal discharge paths would be closed and an emergency discharge conduit, provided for this contingency, would be opened, permitting cooling by recirculation of the cooling pond water. The capacity of this cooling pond is adequate to provide core decay heat cooling indefinitely as long as electric power is available to run the condenser cooling pumps in the intake structure." Therefore, for the dam break event, the impounded intake canal would become the plant's ultimate heat sink.

Numerous weaknesses in the licensee's ability to respond to the Keowee Dam failure were identified as discussed below.

(1) The licensee did not have analyses demonstrating the "...capacity of this cooling pond is adequate to provide core decay heat cooling indefinitely..." Such analyses should have addressed the heatup rate, the water inventory losses due to leakage, evaporation, etc., and the effects of the increased temperature and the decreased water inventory on the CCW system and the various systems being served. Therefore, the licensee failed to demonstrate the ability of the intake canal to perform as the ultimate heat sink as described in the FSAR.

10 CFR 50, Appendix B, Criterion III, "Design Control," requires in part that measures shall be established to assure that design bases are correctly translated into design documents and procedures. This is considered an example of violation 50-269, 270, 287/93-25-03E, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

(2) Case B of Abnormal Procedure AP/1/A/1700/13, "Loss of Condenser Circulating Water Intake Canal/Dam Failure," described the actions to be taken in the event of a failure of the Keowee Dam <u>without</u> loss of the CCW intake canal. In Step 5.5.1, the operator was directed to align the LPSW system to recirculate the water back to the CCW crossover header between the units from which it also takes suction in order to conserve circulating water inventory.

In this closed loop condition, the temperature of the system would rise very rapidly to the point where its ability to perform its decay heat removal safety function would significantly degrade. The licensee had no analyses supporting operation in this recirculation condition. Without such an analysis LPSW system operation was inconsistent with system design requirements.

10 CFR 50, Appendix B, Criterion III, "Design Control," requires in part that measures shall be established to assure that design bases are correctly translated into design documents and procedures. This is considered an example of Violation 50-269, 270, 287/93-25-03F, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

(3) Procedure AP/1/A/1700/13, Case B, "Dam Failure Without Loss of Intake Canal", required the operator to actuate ECCW by pressing the "CCW DAM FAILURE" pushbutton. This action tripped the CCW pumps and opened the emergency discharge valve to the Keowee tailrace, CCW-8, to establish the ECCW flow. Upon restoration of power to the CCW pumps the operator was directed to start a CCW pump, verify that CCW-8 closed, and verify the emergency discharge to the CCW intake canal structure valve, CCW-9, opened.

However, as a consequence of the Keowee Dam failure valve CCW-8 would be submerged. Per Calculation FERC Project Number 2503 dated December 18, 1992, "Final Summary of Analysis to Determine the Extent of Inundation Due to Catastrophic Dam Failure for Keowee Hydro Project," for the dam failure event, the water level at the valve would reach a maximum of 776 feet for the "sunny day" failure and 785 feet for the "postulated maximum flood" failure. Valve CCW-8 was located within the flooded area in a concrete and steel enclosure. According to this calculation, the valve would be submerged by as much as 55 feet, and 12 hours would elapse before the water would recede below the valve. Even with the receding water, the water, mud and debris trapped within the enclosure could impact valve operation.

The licensee's analysis had not considered the consequences of the dam failure affecting valve CCW-8. Subsequent licensee review concluded that all operator actions associated with the valve's cycling would be accomplished prior to the flood water reaching the valve. However, the procedure and previous operator training did not indicate that these actions were time dependent. Also, the calculation establishing the time available for operator action was not very precise. Therefore, the ability to perform the necessary actions without such procedural direction/training was questionable.

(4) Procedure AP/1/A/1700/13, "Loss of Condenser Circulating Water Intake Canal/Dam Failure," had other weaknesses including:

- Pressing the "CCW DAM FAILURE" pushbutton without considering CCW pump power availability in Case B. This action tripped the CCW pumps and opened the emergency discharge to the Keowee tailrace valve, CCW-8, to establish the ECCW flow. However, tripping the CCW pumps with power available was not necessarily the most appropriate action at that time.

- Not providing a caution to ensure a CCW pump was ready for immediate restart prior to closing the CCW discharge valves. Closure of the discharge valves would break the ECCW siphon. Therefore, the CCW pumps must be immediately ready for starting to maintain a viable decay heat removal path through the condenser.

The licensee stated that procedure AP/1/A/1700/13 would be reviewed to ensure procedural content was appropriate. Review and revision of this procedure is considered part of Inspector Follow-up Item, 50-269,270, 287/93-25-06B, "Actions to Improve Operator Responses to Abnormal Events."

6. High Pressure Service Water System

The HPSW system was the site's fire protection system and constantly supplied cooling and sealing water to the CCW pumps. The system was capable of supplying cooling water to specific components normally cooled by the LPSW system, such as the HPI pump motor coolers and the TDEFW pump coolers. The system could also provide backup cooling to the Unit 1, 2, and 3 LPSW systems, though at reduced capacity, through interconnections at the discharge of the LPSW pumps.

The system was composed of three pumps, an elevated water storage tank (EWST), and interconnecting piping to fire protection deluge valves throughout the site and to the CCW pumps. The three HPSW pumps, two with 6000 gpm capacity each and one jockey pump, took suction from the 42 inch CCW discharge header. The jockey pump was normally in service maintaining HPSW system pressure. The other two pumps were in standby to automatically makeup lost water inventory in the 100,000 gallon capacity elevated storage tank.

HPSW must remain operational for the CCW system to accomplish its safety related function of supplying water from the intake canal to the suction of the LPSW pumps. The CCW system relied upon HPSW as a necessary support system in both the siphon mode and CCW pump operating mode. The interface between the CCW pumps and the CCW piping must be leaktight to prevent air inleakage which would break the siphon. Seal water from HPSW performed this function. Also, in order for the CCW pumps to operate, cooling water must be supplied to pump motor bearing coolers. Cooling water from HPSW performed this function. This sealing and cooling water was supplied by the HPSW system normally through operation of the HPSW jockey pump, and during accident conditions involving a loss of power, from the elevated water storage tank. The HPSW pumps also performed an accident mitigation support function since EWST replenishment would be necessary to maintain long term cooling and sealing flow to the CCW pumps.

The original NRC Safety Evaluation Report discussed the HPSW as a backup to the LPSW system and "...concluded that the LPSW and HPSW systems will provide all needed normal and emergency services and are acceptable." Neither the SER nor the original FSAR discussed the HPSW support function for the CCW system. In the more recent licensee SBO submittal and the subsequent NRC SER, HPSW gravity flow cooling of CCW from the EWST for up to four hours was assumed. Without continual gravity flow, air inleakage would form voids requiring extensive fill and venting actions prior to CCW pump restart. Therefore, to allow immediate pump restart after four hours, the assumed duration of the SBO, HPSW gravity flow had to be maintained.

Inspection findings associated with HPSW were:

a. The HPSW system was not classified, constructed, tested or maintained commensurate with its importance to safety. This determination was based upon:

   (1) The HPSW system was not designated or constructed to the seismic standards of the FSAR, but to conventional commercial fire protection structural standards of the late 1960s. Failure in virtually any portion of the system in a loss-of-power event would cause loss of CCW sealing and cooling water due to diversion of flow out the faulted piping section depleting the EWST water source. Consequently, through the loss of the siphon or the CCW pumps, the LPSW and CCW decay heat removal capabilities to all three units would be lost.

   (2) The safety function of critical HPSW valves were not tested following maintenance.

   During a LOOP/LOCA, SBO or any LOOP, the HPSW pump check valves, HPSW-2, 5, and 8, must not leak or the EWST inventory would drain into the CCW suction header. Such leakage would directly impact the duration of EWST cooling and sealing flow to the CCW pumps.

   Maintenance records indicated that the only post maintenance testing on these check valves was an external leakage observation and did not include a reverse flow test. Normal system operation would only indicate gross leakage of the main HPSW pumps' valves and would not indicate any leakage of the jockey pump valve since it operated continuously.

Maintenance records for the last 13 years contained 5 work requests associated with the check valves. Three involved the HPSW jockey pump valve, HPSW-8. The first of these three was written in 1982 to repair a seat leak on HPSW-8. Although the original work request was lost, a replacement work request was closed out on November 10, 1986, with a note to the effect that the valve was checked out by Operations, and no problems were found. However, on the next day, the second work request was written to investigate and repair HPSW-8 because of indications it was not seating. Under this work request, the disk was found installed backwards and the disk nut and washer found to be broken off. Since there were no replacement parts available, the valve was reassembled and placed back into service on November 18, 1986, without a disk "...to enable [sic] the sys. to be used." Under the third work request, a replacement valve was installed on January 23, 1987. Therefore, EWST cooling/sealing capability to the CCW pumps was questionable for an extended period of time. It also appeared that during the last two months of this period, the inoperable status of this valve was recognized by plant personnel without any compensatory measures taken.

The other two work requests in the maintenance records were to disassemble, inspect, and refurbish valves HPSW-5 and HPSW-2 respectively in 1990. A responsible Maintenance Supervisor was asked if this work were being done today, would current procedural requirements have specified post-maintenance back-leakage testing for these valves. He responded that it would not have.

(3) Although the system performed a safety-related function, it was not classified as safety-related in the licensee's safety classification document, the Quality Standards Manual.

One of the ramifications of the lack of safety-related designation was not including HPSW within the IST program. Therefore, the stringent, periodic reverse flow testing of the HPSW check valves was not required. Also, the HPSW system was not included in much of the SWS GL actions since the GL was only applicable to safety-related SWSs.

(4) CCW pump sealing flow indication was not properly maintained. Consequently, operators may not be alerted to a low flow condition jeopardizing siphon operation when required. Also, one of the indications of inadequate motor bearing cooling flow was not properly maintained.

Each of the 12 CCW pumps was instrumented with 2 rotameters. A larger rotameter with a scribe mark was installed for sealing flow and a smaller one without a scribe mark for cooling flow.

These rotameters were input devices to low flow annunciators in the control room. Also, operators took local rotameter readings as part of their normal rounds.

Examples of improperly maintaining the rotameters were:

(a) The instrument procedure, IP/0/B/0261/004, used to calibrate the low seal and cooling flow alarms, directed setting the alarms nonconservatively with respect to the applicable vendor information. The procedure directed setting the low seal water alarm setpoint at 2.5 gpm $\pm$ 0.5 gpm decreasing, but the CCW pump vendor manual required a seal water flow of 3 to 5 gpm. The procedure directed setting the low bearing cooling water alarm setpoint at 1.6 gpm $\pm$ 0.2 gpm decreasing, but the pump motor vendor drawing required a bearing cooling water flow of 2.5 gpm.

Additionally, inconsistent with the rotameter's vendor document, OM 267-0179, the procedure directed reading the float from the bottom instead of from the scribe line on the float or from the top if there was no scribe line.

(b) The material condition of some of the rotameters was poor. Pump 2C's bearing cooler flow meter tube was installed backwards with the scale in a difficult place to read. Pumps 2A and 2D flow tubes, float, and guide rod for the seal water flow meters were heavily coated with organic contamination (slime). This would tend to reduce the accuracy of the instruments.

(c) The operator rounds sheet for taking local rotameter readings contained no guidance on how to read the reference marks. The Shift Manager was asked how the operators read these gauges. He responded consistent with vendor guidance on the larger rotameters with a scribe mark. However, he stated that "It was the consensus of opinions of the unlicensed operators that the float should be read to the center of the cylindrical portion" for the smaller non-scribe mark types. As discussed earlier this was not the correct reference point.

The seismic and safety classification concerns of the HPSW system were encompassed in an outstanding unresolved item documented in NRC inspection report 50-269, 270, 287/93-13. This unresolved item concerned the licensing bases of the CCW pumps, the ECCW subsystem, and their support systems. Resolution of this unresolved issue is contingent upon further NRC review.

b. Through various means (DBD effort, attempts to resolve outstanding SITA issues on ECCW, and SBO submittal preparation) the licensee's engineering organization recognized the safety significance of the HPSW system. This was evident by the licensee's decision to evaluate HPSW for seismic acceptability, adding the HPSW valves necessary for CCW pump cooling and sealing to the most current draft revision of the safety classification document and establishing a periodic disassembly and inspection of the HPSW pump discharge check every fourth refueling outage.

However, based upon interviews with operations and maintenance personnel, this heightened safety emphasis on the HPSW system had yet to be fully conveyed to the rest of the organization. Also, two of the engineering actions associated with HPSW were not adequate or of sufficient scope. The two actions are discussed below.

(1) In the licensee's most current draft revision to the Quality Standards Manual, the safety classification document, some HPSW components were included, but not the HPSW pumps or their discharge check valves.

(2) The licensee recognized the lack of seismic qualification while attempting to resolve ECCW siphon support system concerns during design study ONDS 327 and PIP 92-084. The licensee concluded that the HPSW system was structurally adequate because it was "inherently rugged." Inherently rugged was defined by the licensee to mean that the system, in general, conformed to the criteria in EPRI Report NP-5617, "Recommended Piping Seismic Adequacy Criteria Based on Performance During and After Earthquake," January 1988, which had yet to be endorsed or accepted by the NRC. The licensee's evaluation criteria from the EPRI report were:

- A system walkdown has verified qualitatively that piping and equipment in the system are adequately supported.
- A system walkdown has verified that no large pipes are restrained by small pipes.
- A qualitative evaluation of the system has concluded that corrosion does not threaten its structural integrity.

However, the licensee's evaluation failed to consider the actuation of any of the fire deluge functions of the system due to a seismic event, which would have the same effect as a pipe break with regard to loss of water. Therefore, full identification of the adverse condition and assurance of adequate corrective action was not accomplished. 10 CFR 50, Appendix B, Criterion XVI, "Corrective Actions," requires conditions adverse to quality be promptly identified and corrected. This is considered an example of violation 50-269, 270, 287/93-25-04B, "Inadequate Evaluation of Conditions Adverse to Quality by Engineering."

Also, the licensee's evaluation involved these weaknesses:

- The determination of adequate support was of a qualitative nature. The team observed some of the HPSW piping at the CCW intake structure to be supported by simple threaded rod hangers at relatively long intervals, and the hangers were attached to the concrete by simple expansion bolts.

- The conclusion by the licensee that corrosion did not threaten the structural integrity of the system was inferred from observations made in the similar LPSW system, and can be challenged by direct evidence of corrosion deterioration in the HPSW system. Although through wall leakage had not been observed, excessive flow restriction in the small bore HPSW piping to the CCW pumps caused the piping material to be upgraded to stainless steel in Exempt Change OE 4625. The licensee's safety evaluation for this change stated, "Recently failures have occurred in the small diameter piping, showing that the corrosion has reached the condition of causing us to question the integrity of the pipe." Also, though it did not render the system inoperable, corrosion had been identified in the LPSW system.

- Only the portion of the system from the HPSW water source to the CCW pumps was included in the walkdown.

The seismic and safety classification concerns of the HPSW system were encompassed in an outstanding unresolved item documented in NRC inspection report, 50-269, 270, 287/93-13. This unresolved item centered around the licensing bases of the CCW pumps, the ECCW subsystem, and their support systems. The lack of seismic qualification for the HPSW system was specifically discussed in the report. The concept of "inherently rugged" as an acceptable substitute for seismic qualification is another aspect of this unresolved issue. Resolution of this unresolved issue is contingent upon further NRC review.

c. There were numerous weaknesses in the management controls that assured the HPSW system was capable of performing as indicated in the licensee's SBO submittal.

The SBO submittal discussed gravity flow cooling of the CCW pumps from the EWST for up to four hours so the CCW pumps could be restarted immediately upon restoration of offsite power. Without continual gravity flow, air inleakage would form voids requiring extensive fill and venting actions prior to starting the CCW pumps.

The management control weakness are discussed below.

(1) The ability to perform cooling via the EWST to the CCW pumps and other necessary equipment for four hours was tested annually using test procedure PT/0/A/250/38, "Elevated Water Storage Tank Drain Test." Per Section 8.2 of the procedure and the design specification for HPSW, OSS-0254.00-00-1002, the normal level of the EWST was 90,000 gallons or greater. Per Enclosure 13.3 of the procedure, Step 5.0, the capacity of the tank in minutes was calculated by dividing the EWST level at the beginning of the test by the adjusted HPSW outleakage flow rate. The result must be greater than 240 minutes (4 hours) to be acceptable. However, using the level at the beginning of the test for the calculation rather than the minimum full level of 90,000 gallons, only verified that the tank had sufficient capacity at that particular time, not for any other time when the level may be lower but still in the normal range above the "full" 90,000 gallons level. For the last six tests (March 21, 1987-August 7, 1993) the tank level varied between 87,500 gallons and 99,100 gallons. Therefore, the procedure failed to establish the appropriate initial test conditions. The licensee's submittal of January 26, 1990, states that adequate test procedures will be established to ensure system performance during a SBO. This is Deviation 50-269, 270, 287/93-25-10, "Inadequate HPSW SBO Test."

(2) The EWST drain test procedure had additional problems including:

- It allowed test re-performance if the original test failed due to HPSW discharge check valve leakage. Prior to test re-performance the procedure directed the applicable pump be isolated (closing its discharge valve) thus isolating the leaking check valve. Following completion of this second test, the isolated pump could be returned to service with an annotation on the operator turnover sheets to isolate the applicable pump on a loss of power event to prevent excessive losses of the EWST.

  This method of assuring EWST cooling capability by isolating the pump was not directed by emergency procedures, did not provide for verification of the completed action and could be forgotten or overlooked due to the numerous other tasks associated with a LOOP or SBO event. Also, assuming the operator action was performed, there was no provision in the test's acceptance criteria to account for the EWST inventory lost through the leaking check valve prior to isolating the pump. Therefore, the procedure allowed an equipment deficiency that directly affected the test's acceptance criteria to be excluded without proper compensation.

- It directed the user to inform the operating manager for leakage rates greater than 500 gpm, rather than the maximum acceptable leakage rate of 375 gpm. Also, there was no direction as to what action the operating manager was to take upon being notified of the excessive flowrate. In an interview with an operating manager, he did not know what the appropriate response would be.

(3) For over seven months, the four hour gravity feed capability lacked validation. On February 27, 1993, PT/0/A/250/3 was performed and the system failed to meet the 240 minute acceptance criteria by 45 minutes. Subsequently, the licensee recognized that the procedure did not account for several water loss points from the system which automatically isolate for a loss-of-power event. The procedure was revised to account for these inventory losses on April 27, 1993. However, even when accounting for these losses, the test on February 27, 1993, would not have met the acceptance criteria. On August 7, 1993, the test was successfully re-performed. The team could not ascertain what (system maintenance, improper recording of data, change in equipment performance, etc.) caused the difference between the adjusted test results of February 27th and August 7th test results. The licensee was unable to provide any insights.

(4) Five of the CCW seal water rotameters and all of the bearing cooling water flows (3A's was solid against the upper stop at 8+ gpm) were greater than the values used to calculate the four hour availability of the EWST. Also, the operator rounds sheets contained no upper limit for these flows.

7. Standby Shutdown Facility

The SSF was a separate onsite building housing the necessary equipment to maintain all three units in a safe shutdown condition following turbine building flood, fire, sabotage, certain classes of tornados or station blackout. The SWS portion of the SSF was composed of a high head, low capacity pump and interconnecting piping to all steam generator EFW discharge lines, solenoid operated flow control valves in the discharge lines to the steam generators, a pump and piping to cool a tandem diesel with a common generator, two pumps with a condenser unit to cool the HVAC within the SSF and a moveable submersible pump. The SSF ASW, HVAC and EDG pumps took suction from the Unit 2's CCW pumps discharge header. The HVAC and EDG pumps discharged to the CCW header. There was an option to divert the EDG pump discharge water to the yard drainage system when high temperature constraints warranted. The submersible pump allowed replenishment of the CCW header from the intake canal.

a. Jocassee Dam Failure

In the licensee's IPE submittal for an event outside the facility's licensing bases, the SSF was discussed as the system to mitigate the consequences of a Jocassee Dam failure. This dam was located upstream of the Oconee site and formed the uppermost boundary of Lake Keowee. The IPE flood evaluation concluded that the Oconee site would be under 4.71 feet of water. With the exception of the SSF, this would render all decay heat removal cooling systems inoperable. To assure the SSF would not be affected by the flood, a 5-foot (4.71-foot plus 0.29-foot) high waterproof flood wall was constructed around the ground level entrances to the SSF. The review of the SSF to withstand this postulated flood was as follows:

(1) Contrary to the IPE submittal, the SSF could not withstand the postulated flood. Therefore, core damage of all reactor units would occur as a consequence of such a postulated flood.

In response to questions from the team regarding initial lake height assumptions, the licensee stated that a recently completed reanalysis of the Jocassee Dam failure for another regulatory agency resulted in a flood height at least 10 feet above the SSF wall. The change in flood height was due to modeling a bridge abutment downstream of the Keowee tailrace in the most recent flood analysis. The abutment acted as a flow constriction causing the flood waters to backup over the Oconee site. From a PRA perspective the probability of core melt from the Jocassee Dam failure as calculated by the team increased ten fold to 1.58E-05.

Licensee correction of the this error and subsequent corrective actions as a result of the error are considered a part of Inspector Follow-up Item 50-269, 270, 287/93-25-11A, "Jocassee Dam Failure IPE Inaccuracies."

(2) Another aspect of the IPE submittal was in error. IPE Submittal report, Section 3, Subsection 13, indicated there was an 8-foot waterproof flood wall around the SSF ground level entrances. The wall was 5-foot in height.

Licensee correction of the this error and subsequent corrective actions as a result of the error is considered a part of Inspector Follow-up Item 50-269, 270, 287/93-25-11B, "Jocassee Dam Failure IPE Inaccuracies."

(3) A watertight gate was installed in the flood wall to allow access to and from the SSF. The gate was observed on more than one occasion with the watertight dogs not properly secured.

b. SSF Calculations

(1) Following plant modifications performed in previous years, some of the applicable calculations were not updated. Examples included:

- OSC-2030, Standby Shutdown Facility HVAC Load Calculations

  The calculation conclusion section stated:

  "The SSF Air Conditioning System can maintain design conditions in the safety related areas (Control Room and Battery Rooms) with the following actions:

  (A) Start second condenser circulating water pump to provide 41 GPM condenser water flow with both pumps operating.

  (B) Shed security computer load by the time control room temperature reaches 85 F or temperature of condenser water reaches approximately 93 F."

  However, an electrical interlock had been installed preventing simultaneous operation of the two condenser circulating water pumps. The condenser circulating water pumps were of different sizes, and their simultaneous operation would cause flow instability and eventual pump runout. This interlock could not be bypassed. Also, the SSF HVAC system had been modified excluding portions of the security complex and portions of the HVAC had been rerouted.

  Prior to the conclusion of the inspection the licensee re-performed the HVAC calculation with acceptable results. The design document had not reflected the as-built condition of the facility at the time of the inspection.

- OSC-3233, SSF Service Water System Hydraulic Model

  The last revision of the model was January 23, 1989. Since then, the HVAC pump motors had been changed from 1750 rpm to 3600 rpm motors, pressure breakdown orifices had been installed, the 3 way valves located upstream of the SSF HVAC condensers had been replaced, and the SSF ASW impellers had been changed twice. Other calculations were performed which partially encompassed the changes to the hydraulic model but, did not reconcile those results with the total hydraulic model. Therefore, this design document did not reflect the as-built condition of the facility.

The administrative controls for updating calculations, EDM-101, Engineering Calculations/Analysis, Section 2.4.4 only required these calculations be updated in a timely manner, rather than establishing a definitive length of time. 10 CFR 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," require appropriate acceptance criteria for determining that quality related activities have been satisfactorily accomplished. This is an example of Violation 50-269, 270, 287/93-25-12A, "SWS Procedure/ Drawing Content or Procedure Implementation Inadequacies."

(2) Calculation OSC-4171, "SSF ASW Pump Minimum Flow Line Design Inputs Calculation," contained invalidated or nonconservative assumptions as follows:

- Each unit or steam generator pair had only one flow instrument associated with it. Calculation OSC-3303, "SSF ASW Flow and SSF ASW Pump Suction Pressure, Instrument Accuracy Calculation: CCW FT0225," determined the methodology for calculating the instrument loop error for the flow instruments. The result was +/- 54 gpm for an individual flow instrument. The three flow instruments errors were averaged through the square root sum of the squares method resulting in an error of +/- 31 gpm. The instrument error used in calculation OSC-4171 was +/- 31 gpm.

  However, if just one of the flow instruments were at or near it's negative maximum error that particular unit's minimum required flow would be inadequate. According to accepted industry methodology, the square root sum of the squares methodology is used to combine dependent and independent variables to calculate loop uncertainties. In this instance the methodology was misapplied, in that it was used to reduce an individual error contribution and not calculated loop uncertainties. The use of this nonconservative assumption resulted in a flow to a pair of steam generators that was 23 gpm below the minimum analyzed flow. During the inspection period the licensee indicated that a calculation was being prepared that would lower the minimum required flows such that the 23 gpm difference would not invalidate the conclusion of OSC-4171. However, the calculation was not ready for NRC review. 10 CFR 50, Criterion III, "Design Control," requires the design basis and applicable regulatory requirements be translated into appropriate documents. This is considered an example of Violation 50-269, 270, 287/93-25-03G, "Failure to Perform Adequate Calculations and Evaluations to Support Facility Design."

- Calculation OSC-4171 assumed the flows were equally balanced between all six generators. That assumption had never been validated.

- Calculation OSC-4171 and numerous other calculations assumed certain flow distributions among the three SWS operating pumps (SSF ASW, HVAC, and EDG cooling water pump). Also, the discharge flow of the operating HVAC pump was assumed to equally split between the two parallel SSF HVAC condenser coolers. These two assumptions had not been validated.

c. SSF Testing

(1) Post-construction Testing

Post-construction SSF testing in the mid-1980s did not adequately confirm critical functional requirements of the SSF design and was not performed in accordance with committed quality standards. Examples included:

(a) The flushing procedure provided by the licensee for the discharge lines was a gravity fill and drain from HPSW prior to the piping being connected at the SSF ASW pump discharge or in the penetration rooms. There was no acceptability criteria for the flush in the procedure. This fill and drain did not provide assurance that the lines were not blocked or partially restricted.

(b) The calculations supporting SSF design assumed certain flowrates and flow distributions to the steam generators. No documentation existed validating that flow could be achieved to any of the steam generators. The licensee verbally confirmed that there was no flow testing performed which involved the discharge lines beyond the test line connection. Therefore, flow control valve capabilities were not verified, and assumptions associated with equalizing flow to units and steam generator pairs were not verified.

(c) The calculations supporting SSF design assumed certain flow distributions among the three SWS operating pumps (SSF ASW, HVAC and EDG cooling water pump). The three pumps were not tested simultaneously to confirm the assumed flow distributions and that the equipment would perform as predicted.

The preoperational testing portion of ANSI N45.2.8-1975, Section 5.2, dealing with assurance of operation in accordance with SSF design and proper flow alignments was also applicable to this aspect of the facility's design.

10 CFR 50, Appendix B, Criterion XI, "Test Control," requires a preoperational testing program demonstrating facility acceptability to the design requirements. Also, the licensee was committed to ANSI N45.2.8-1975 and ANSI N45.2.1-1973 through Duke Power Company Topical Report 1-A, Table 17.0-1. ANSI N45.2.8-1975 and ANSI N45.2.1-1973 requires in part that flushing procedures with velocities and acceptance criteria based on filter, turbidimetric or chemical analyses. The preoperational testing portion of ANSI N45.2.8-1975, Section 5.2, states in part "This testing involves the operation of all items in a system ... to assure that operation is in accordance with the design criteria and functional requirements. The testing shall include, but not be limited to, ... service requirements for initial operation such as flow alignments ..." Therefore, critical aspects of the SSF's design were not demonstrated prior to placing the facility into service. This is an example of Violation 50-269, 270, 287/93-25-08B, "Inadequate SSF and ECCW Testing."

(2) Periodic Testing

(a) The periodic testing program for the SSF was accomplished through component specific testing. There were specific tests for the SSF ASW pump, HVAC pump, etc., which were performed at different test intervals. The periodic SSF ASW pump test discharged through a test line connection and not through the full extent of the steam generator discharge lines. Therefore, the deficiencies of the post-construction testing previously discussed in paragraph c.1 above were not rectified by the periodic test program.

b. Beyond the post-construction testing deficiencies discussed in paragraph c.1, the sum of the component specific periodic testing did not constitute an integrated test. Certain aspects of system design could only be provided by the licensee through the completion of actions during emergency response drills. An example of this was the unwinding and connecting of the submersible pump's electrical cable to its emergency bus and operating the pump. These actions were not part of any periodic test program and had only been accomplished once during an emergency response drill.

c. Emergency Procedure AP/0/A/1700/25, Standby Shutdown Facility Emergency Operating Procedure, Enclosure 6.1, Step 2.5 and 2.12 instructed the operator to start the SSF ASW

Pump with no preparatory action beyond aligning a flow path to the designated unit. The periodic pump operability test, PT/0/A/0400/05, directed an additional action of pump venting in Step 12.2 just prior to starting the pump in Step 12.4. This action preconditioned the pump, possibly masking air entrapment within the pump which would affect pump performance. 10 CFR 50, Appendix B, Criterion XI, "Test Control," requires test procedures direct the establishment of suitable environmental conditions when performing the test. This is considered an example of Violation 50-269, 270, 287/93-25-08C, "Inadequate SSF and ECCW Testing."

d. Other Observations

(1) There were few material condition deficiencies observed. Preventive and corrective maintenance was effective. Repetitive corrective maintenance actions were not evident. Most work requests were completed in one to three months.

(2) Operator training met normal industry standards and emphasized strict adherence to procedures. The information supplied by training matched the information in the procedure.

8. <u>Auxiliary Service Water System</u>

ASW was originally designed for a non-design bases event, the loss of the intake canal/structure. However, following NUREG 0737 review of the facility for tornado vulnerabilities, the system was discussed in the July 28, 1989, NRC Safety Evaluation Report to mitigate the consequences of the most severe classes of tornadoes. For these severe tornados the ASW system in conjunction with the HPI system were required to maintain the units in a safe shutdown condition by providing adequate decay heat removal via the steam generators and RCS makeup.

ASW was a shared system common to all three units. It consisted of a suction connection at the Unit 2 CCW pump discharge piping, a low head, high capacity pump, piping with manual valves connected to the EWF discharge piping of all three units for cooling all the steam generators, and piping with manual valves connected to the LPSW piping for cooling the HPI pump motor coolers. The ASW pump was operated from the tornado protected, safety related AuxService Water Switchgear.

The only other actions necessary in the severe tornado event was operation of the HPI pump. Since normal HPI pump power was not tornado protected, one HPI pump motor per unit could be manually connected to the AuxService Water Switchgear through spare power cables staged for this purpose.

Inspection findings associated with the ASW system were:

a. Emergency Procedure EP/1,2,3/A/1800/01, Section 502, Step 10.1

required approximately 200 gpm be provided to each steam generator by the ASW pump. The step further stated that if one steam generator was isolated, flow should be increased to approximately 400 gpm to the un-isolated steam generator. The ASW discharge lines or the interconnection with the EFW system to the steam generators did not contain any flow instruments. Therefore, there was no way to verify the directed actions had been accomplished. 10 CFR 50, Appendix B, Criterion V, "Instructions, Procedures and Drawings," requires adequate written procedures be provided for activities affecting quality. This is an example of Violation 50-269, 270, 287/93-25-12B, "SWS Procedure/Drawing Content or Procedure Implementation Inadequacies."

b. To support the licensee submittal that ultimately led to the tornado SER, Calculation OSC-2262, Tornado Protection Analysis, was generated. The calculation indicated that ASW system operation must be accomplished in about 40 minutes to prevent core uncovery.

(1) Job performance measures existed for the alignment of ASW to the steam generators, alignment of ASW to the HPI pump motor coolers, and establishment of electrical power to a HPI pump motor. Documentation indicated that the tasks could be accomplished in approximately 30 minutes after the operators recognized the need for ASW. No integrated drill/test verifying that all the tasks could be accomplished within the requisite time had been performed.

(2) There was no abnormal procedure specifically for a tornado event. Entrance into the emergency operating procedures for inadequate secondary side heat transfer would eventually direct use of the ASW system. These procedures attempted to establish normal feedwater, emergency feedwater, and SSF service water prior to initiation of ASW. However, there was only 10 minutes available for the operator to direct initiation of ASW in lieu of these other systems (10 minutes to decide to use ASW + 30 minutes to initiate ASW from training documentation = 40 minutes before core uncovery). The procedure provided the system options, but system selection was based on operator judgement depending upon the extent of the tornado damage. No test or drill had been devised confirming the operator's ability to make this judgement within the 10 minutes available.

(3) Other procedures associated with flow through the EFW header to the steam generators included a caution to limit flow to less than 1000 gpm to reduce tube vibration. Procedures associated with ASW operation did not contain such cautions and the hydraulic model indicated that flow to the Unit 3 steam generators would exceed 1000 gpm in certain conditions. The licensee indicated that flows of this magnitude would be for a short period and the tube integrity concerns due to vibration

were only a factor in extended operation. However, the licensee decided to review this item and determine if procedural guidance should be included.

Licensee initiatives to improve operator guidance for response to a severe tornado are considered a part of Inspector Follow-up Item, 50-269,270, 287/93-25-06C, "Actions to Improve Operator Responses to Abnormal Events."

c. Certain equipment associated with the ASW system were not included within a periodic testing program. However, licensee actions associated with the DBD effort identified the situation and appropriate corrective actions were being taken. Examples included:

- Cooling water flow to the HPI pump motors had never been established using the ASW system. However, a test procedure was being developed to establish and verify flow to the HPI motor coolers.

- Certain check valves within the LPSW system which must close to establish HPI flow were not tested in the closed direction per the IST program. This lack of reverse flow check valve testing had been previously identified by the licensee. Corrective actions were in progress to revise the IST program and develop testing procedures for the valves. This is Violation 50-269, 270 287/93-25-13, "Omissions of LPSW Check Valves from IST Program." However, based upon the corrective actions in progress, the licensee's self identification of the matter, no similar violations associated with omissions in the IST program, the lack of willfulness, and the nonescalated enforcement nature of the violation, this is considered a non-cited violation authorized under 10 CFR 2, Appendix C, Section VII.B.2.

- The discharge check valves to the steam generators were being incorporated into a test/inspection program for the first time.

d. Some of the calculations associated with the ASW system lacked rigor. Examples included:

(1) Calculation OSC-4989, Auxiliary Service Water Flow Model, did not model cooling water flow to the HPI pump motors. The licensee performed preliminary calculations indicating flow would be sufficient. Also, complete bench marking of the ASW hydraulic flow model had not been performed.

(2) In the formal ASW pump NPSH analysis and in a subsequent informal analysis the licensee used incorrect assumptions. These were:

(a) Calculation OSC-5125, ASW NPSH Analysis, assumed siphon flow from the intake canal to the ASW pump suction would be in operation following the tornado. Consequently, an administrative minimum level, 780', associated with Lake Keowee was selected as the minimum suction height for the NPSH calculation. However, the ECCW siphon lacked tornado protection, and would not be operational. Therefore, the minimum suction height was contingent upon the inventory losses in the CCW piping as a result of ASW pump operation.

(b) Once the incorrect assumption was identified to the licensee, the licensee re-evaluated the situation and determined the minimum NPSH for the ASW pump was -2.22 psig and NPSH considerations did not restrict pump operation. A required NPSH of -2.22 psig meant that the pump could draw water from 5.12 feet below the pump's impeller eye and still have adequate NPSH. However, the licensee failed to consider the actual configuration of the CCW piping going to the suction of the ASW pump. Therefore, when the water in the CCW piping dropped to a height of 770.46 feet, inadequate NPSH would occur.

Subsequently, the licensee performed preliminary calculations of the water volume between 791 feet, the assumed initial suction height of the calculation, and 770.46 feet. Results indicated that a substantial amount of water inventory still existed allowing ASW operation for an extended period. Therefore, the assumed replenishment of the ASW supply source before reaching 770.46 feet appeared reasonable. Issuance of a revised calculation is considered an Inspector Follow-up Item 50-269, 270,287/93-25-14, "Review of Revised ASW Pump NPSH Calculation."

(3) Abnormal Procedure AP/1,2,3/A/1700/11, Loss of Power, Enclosure 6.3, Aux Service Water to HPI Pump Motor Coolers, required the recirculation test line valve, CCW-247, be opened approximately 2 turns prior to starting the ASW pump. This flow path through the test line was also the minimum flow pathway to prevent deadheading the pump. No data or calculations existed showing that enough flow could be achieved with CCW-247 throttled to protect the pump. Subsequently, the licensee performed preliminary calculations indicating a flow between 400 and 450 gpm could be achieved with valve CCW-227 in the throttled position. The 400 gpm flow appeared acceptable for minimum flow protection. However, the licensee decided to completely open CCW-247, fully assuring minimum flow protection, prior to starting the ASW pump.

9. Keowee Hydroelectric Station

Lake Keowee was the motive and cooling source for the two hydroelectric generators which functioned as Oconee's onsite emergency power. Water flowed from a common penstock, through the turbines and into the tailrace. Cooling flow came from a single pipe located in the penstock. Once the line entered the building housing the hydroelectric units it split into two lines, one for each unit. Cooling flow for the turbine bearing oil cooler, the stuffing box, eight thrust bearing heat exchangers and six generator air coolers came from the unit specific main line.

Inspections findings associated with Keowee were:

a. Corrective Actions

Previous NRC inspections identified that numerous aspects of the quality assurance program had been omitted from Keowee. In response to NRC observations the licensee established an integrated corrective action plan entitled the "Emergency Power Management Plan." Prior to the management plan, the licensee had initiated design study ONDS 258 to correct design document deficiencies at Keowee. ONDS 258 was not part of the committed Emergency Power Management Plan.

(1) Under the design study the licensee revised the Keowee Turbine Generator Cooling Water System drawings, KFD-100A-1.1 and KFD-100A-2.1. However, errors were still present on the drawings including an inconsistent piping class break in the supply line to the thrust bearing coolers, the connection of the supply line to the air compressor coolers on Unit 1 was indicated in the 12 inch portion of the main line instead of the 8" portion, a valve downstream of valve 2WL-3 for Unit 2 was not indicated even though one was present, and the piping downstream of WL 76 in both units was indicated as carbon steel instead of copper. Subsequently, the licensee initiated a condition adverse to quality report to correct drawing errors. 10 CFR 50, Appendix B, Criterion V, "Procedures, Drawings, and Instructions," requires in part that drawings reflect the as-built condition of the facility. This is considered an example of Violation 50-269, 270, 287/93-25-12C, "SWS Procedure/Drawing Content or Procedure Implementation Inadequacies."

(2) Numerous errors existed in the I&C portion of drawings KFD-100A-1.1 and KFD-100A-2.1 and other related I&C drawings. The I&C drawing update portion of the design study was in progress and the licensee had already identified these same discrepancies for resolution. It was noted that the I&C drawing update portion of design study had not been met. As stated previously, the design study was not part of the committed Emergency Power Management Plan. Also, there was no definitive mechanism to assure the I&C drawings (part of the design study) were correct prior to

transferring instrument calibration responsibilities from the Keowee staff to the Oconee staff (part of the Emergency Power Management Plan). Prior to the end of the inspection period the two organizations involved discussed the situation and the licensee indicated that the appropriate integration would occur.

(3) Although the valve positions observed at Keowee were consistent with design requirements, no operating procedures existed for the mechanical systems reviewed. Therefore, no specific procedural controls existed for the throttled, manual valves in the generator air and thrust bearing discharge lines. The Keowee staff was aware of this deficiency and planned to generate procedures in the future. Also, the safety significance of this situation was reduced since these valves were locked throttled and rarely manipulated. However, the creation of these procedures was not identified as a corrective action under the management plan or the design study.

b. Turbine Bearing Oil Cooler Maintenance

During the inspection period, the licensee removed the Unit 2 safety related turbine bearing oil cooler from service to perform the triennial cleaning and inspection. While reinstalling the cooler, a coupling was broken and required replacement prior to completing the installation. Subsequently, a condition adverse to quality report was initiated.

(1) As part of the response to the adverse condition report, engineering personnel discussed Unit operability without the turbine bearing oil cooler installed. Engineering personnel verbally determined that the cooler was only needed during extended high ambient temperature conditions (the summer) and unit operability was not effected. However, Nuclear Generation Department Directive 2.8.1, "Problem Investigation Process," step 3.4 directed that adverse conditions requiring engineering assistance be processed as an upper tier adverse quality report which receive a written operability evaluation. Subsequently, the cooler was reinstalled in the unit for emergency operation and PIP 93-0994 initiated for not performing the written operability evaluation. 10 CFR 50, Appendix B, Criterion V, "Drawings, Procedures and Instructions," requires in part that established procedures be followed. This is considered an example of Violation 50-269, 270, 287/93-25-12D, "SWS Procedure/ Drawing Content or Procedure Implementation Inadequacies."

(2) The work request for oil cooler maintenance specified housekeeping zone 4 for the cleanliness requirements. However, Oconee Nuclear Site Directive 1.4.1, "Cleanliness in Safety Related Areas," Section 3.1, stated the highest level zone designation allowed for safety related equipment was 3. The

difference between level 3 and 4 was zone 4 lacked personnel and tool accountability. A review of numerous completed safety related work requests on other equipment revealed that zone 4 was routinely designated. Contrary to the 10 CFR 50, Appendix B, Criterion V, "Instructions, Procedures and Drawings," requirements for procedure adherence, the licensee did not designate the correct housekeeping zones on safety related work requests. This is an example of Violation 50-269, 270, 287/93-25-12E, "SWS Procedure/Drawing Content or Procedure Implementation Inadequacies."

c. Other Observations

(1) The scope of the calibration program was weak. Annunciator actuation was not verified in any of the calibration procedures reviewed and the licensee stated that this was generally the case with all calibration procedures at Keowee. Generator and thrust bearing cooling flow setpoints and the associated timers were not checked. The transmitter for the packing box's local pressure indicator was not being calibrated. The licensee indicated that these procedures would be reviewed for improvement. However, the description of the instruments being calibrated and how they affected system operation in individual calibration procedures was complete, accurate and well written.

(2) Historically, the mechanical systems at Keowee performed well. Little corrective maintenance was needed. Preventative maintenance was appropriate and consistent with operating experience and vendor manual recommendations where applicable. The hydroelectric station was operated almost daily. The daily operation functioned as a performance test in many respects and placed much of the mechanical systems under no worse conditions than would be experienced when operating as an emergency power source. However, no equipment performance trending, especially of the safety related heat exchangers, was being performed.

(3) One common mode failure vulnerability was identified. Within the common stretch of piping for cooling both units' mechanical support systems was a manual gate valve. Prior to the end of this inspection the licensee locked the valve open.

(4) Minimal housekeeping and material condition discrepancies were observed. Personnel were knowledgeable of their safety-related duties.

10. Miscellaneous Matters

Findings not tied to a particular system were:

a. The DBD concept and the associated testing acceptance criteria was a good initiative by the licensee. Generally, the DBDs provided the best description of the system, the system's function, the licensee's understanding of the licensing bases and the design requirements. There were, however, some implementation weaknesses resulting in errors and discrepancies in the DBDs. Also, the licensee partially attributed the lack of reconciliation and failure to update the SSF calculations to the lack of a completed DBD for the SSF.

b. There were FSAR omissions which could have clarified and more completely explained the actual design parameters for select components. An example was the flow to the RBCUs which the FSAR discussed as 1400 gpm whereas, certain testing configurations only exhibited 800 gpm flow and the system was considered as performing its design function.

c. Offsite review committee minutes contained the proper content, indicated that a proper quorum was present and met within the required frequency. Resumes indicated that personnel qualification requirements were met. Committee performance was consistent with regulatory requirements.

d. Design calculation OSC-3528, Establish an Administrative Minimum Lake Level for Keowee, contained unsubstantiated and nonconservative assumptions, and a variety of other calculational irregularities. The licensee indicated that the calculation was a theoretical "look see" calculation and the title was misleading. There were no other calculations associated with minimum Lake Keowee water volume. Further licensee initiatives to perform an actual analytical calculation to establish a minimum Lake Keowee level to assure adequate water volume is maintained is Inspector Follow-up Item 50-269, 270, 287/93-25-15, "Administrative Controls for Lake Keowee."

11. Follow-up on Previously Identified Items

(Open) Unresolved Item 50-279, 270, 287/93-13-03, "ECCW System Design and Testing": Sections 5.a.3, 5.a.7, 5.b.1, 6.a., and 6.b.2 discussed different aspects of this matter. However, further NRC review is necessary to ensure any regulatory action taken is consistent with the original licensing requirements.

12. Exit Interview

The team conducted an exit meeting on December 14, 1993, at the Oconee Nuclear Power Station to discuss the major areas reviewed during the inspection, the strengths and weaknesses observed, and the inspection results. Licensee representatives and NRC personnel attending this exit meeting are documented in Appendix A of this report. The team also discussed the likely informational content of the inspection report. The licensee did not identify any documents or processes as proprietary.

There were dissenting comments at the exit meeting associated with recommended regulatory action concerning the inadequate NPSH conditions in the LPSW pumps and the possible regulatory action involving the lack of dual turbine building isolation in the LPSW system. The licensee indicated a thorough review of the inspection findings would be necessary to ascertain the appropriate responses or corrective actions to the issues identified. Also, on February 3, 1994, NRC management discussed the unresolved LPSW turbine building isolation issue with the licensee via telephone.

ITEM NUMBER	STATUS	PARAGRAPH	DESCRIPTION
93-25-01	Open	3	DEV - Failure to Adequately Perform SWS GL Actions
93-25-02	Open	4.a.1	UNR - Turbine Building Isolation Single Failure Vulnerabilities
93-25-03	Open	4.b.1, 4.e, 5.a.4, 5.c.1, 5.c.2, 7.b.2	VIO - Failure to Perform Adequate Calculations and Evaluations to Support Facility Design
93-25-04	Open	4.c.3, 6.b.2	VIO - Inadequate Evaluation of Conditions Adverse to Quality by Engineering
93-25-05	Open	4.d	IFI - Additional Validation of RBCU Evaluation Inputs
93-25-06	Open	4.f.2, 5.c.3, 8.b.3	IFI - Actions to Improve Operator Responses to Abnormal Events
93-25-07	Closed	5.a.1	NCV - Inadequate Classification of Siphon Support Equipment for LPSW Supply
93-25-08	Closed	5.a.5, 7.c.1.c, 7.c.2.c	VIO - Inadequate SSF and ECCW Testing
93-25-09	Open	5.b.2	IFI - CCW Pump NPSH Information

93-25-10	Open	6.c.1	DEV - Inadequate HPSW SBO Test
93-25-11	Open	7.a.1, 7.a.2	IFI - Jocassee Dam Failure IPE Inaccuracies
93-25-12	Open	7.b.1, 8.a	VIO - SWS Procedure/Drawing Content or Procedure Implementation Inadequacies
93-25-13	Closed	8.c	NCV - Omissions of LPSW Check Valves from IST Program
93-25-14	Open	8.d.2	IFI - Review of Revised ASW Pump NPSH Calculation
93-25-15	Open	10.d	IFI - Administrative Controls for Lake Keowee
93-13-03	Open	11	UNR - ECCW System Design and Testing

APPENDIX A

Duke Nuclear Power Plant

Persons Contacted

* L. Azzarello, Mechanical/Nuclear Engineering
* S. Baldwin, Systems Engineer - Raw Water
* H. Barron, Station Manager - Oconee Nuclear Station
* R. Colainanni, Nuclear Licensing - General Office
* D. Coyle, Systems Engineering Manager
* J. Davis, Safety Assessment
* B. Dolan, Mechanical/Nuclear Engineering Manager
* P. Farish, Nuclear Engineer - PRA
* K. Grayson, Mechanical/Nuclear Engineering
* J. Hampton, Vice President - Oconee Nuclear Station
* H. Harling, Mechanical/Nuclear Engineering
* R. Harris, Senior Engineer - Systems Engineering
* J. Hemminger, Mechanical/Nuclear Engineering
* M. Hipps, Mechanical Maintenance
* D. Hubbard, Component Engineer
* D. Kelley, Civil Engineering
* R. Ledford, Instrumentation and Controls
* T. Ledford, Electrical Engineering
* E. LeGette, Operations
* G. McAninch, Systems Engineer
* S. Nader, Mechanical/Nuclear Engineering
* M. Patrick, Regulatory Compliance Manager
* D. Patterson, Regulator Compliance - Oconee Nuclear Station
* B. Peele, Engineering
* M. Tuckman, Senior Vice President - Nuclear Generation
* J. Weir, Component Engineer

U.S. Nuclear Regulatory Commission

  L. Mellen, Reactor Inspector
  D. Prevatte, Powerdyne Corporation
  C. Rapp, Reactor Inspector
* W. Rogers, Team Leader
  L. King, Reactor Inspector
* A. Gibson, DRS Division Director
* M. Lessor, DRP Section Chief
* L. Weins, NRR Licensing Project Manager
* P. Harmon, Senior Resident Inspector
* K. Portner, Resident Inspector
* L. Keller, Resident Inspector

* Indicates those present at the exit meeting on December 14, 1993

APPENDIX B

Generic Letter 89-13 Action Items

I. Biofouling Control and Surveillance Techniques

Action I of GL 89-13 requested licensees to implement and maintain an ongoing program of surveillance and control techniques to significantly reduce the incidence of flow blockage problems as a result of biofouling. The actions requested included intake structure inspections, periodic SWS flushing/flow testing and chemical treatment of the SWS.

SWS Intake Structure Biofouling Inspections - The licensee had developed a program to monitor, sample, and analyze the intake structure for Asiatic clams. This program was conducted once per refueling cycle or annually. The program had identified the presence of clams but at a low population density. There was no increasing trend in the number of clams. Also, some minor corrective maintenance in the LPSW, SSF and HPSW systems had been due to clam presence. The team considered the program adequate.

Periodic SWS Flushing/Flow Testing - The licensee had implemented a flow testing and piping inspection program to identify reduced and blocked flow to equipment. Hydraulic models had been developed for the ASW, SSF and LPSW systems. No periodic flushing program was established.

LPSW - The licensee's efforts had been very effective in identifying inadequate flow to numerous pieces of LPSW equipment through small bore piping. The hydraulic model had been fully benchmarked. However, instrument impulse lines had been excluded from the program. The corrective maintenance history indicated repeated instrument failures due to flow blockage. Subsequent actions under the SWS Steering Committee recognized the situation and prompted revision to the instrument calibration procedures to include flushing. Revision of the procedures was scheduled for completion in March, 1994. Also, without a flush program the LPSW crosstie line between Units 1/2 and 3 received no evaluation. As a result of other regulatory correspondence this section of stagnant piping was to be inspected and flushed at the next refueling outage.

Other Systems - The benchmarking of the SSF hydraulic model was incomplete with respect to the SSF diesel service water pump portion of the flow model and the SSF ASW pump discharge piping to the steam generators. The hydraulic model of the ASW system excluded the piping to the HPI pump motor coolers. Also, the flow downstream of the discharge valves to the steam generators had not been benchmarked. No program had been developed for the Keowee SWSs.

SWS Chemical Treatment - The licensee's biofouling monitoring program did not indicate a level of clam infestation that would warrant chemical treatment.

II. Monitoring Safety Related Heat Exchanger Performance

Action II of GL 89-13 requested licensees to implement a test program to periodically verify the heat transfer capability of all safety related heat exchangers cooled by the SWS. The test program was to consist of an initial test program and a periodic retest program.

In response to this item, the licensee established a performance monitoring program for LPSW heat exchangers. The program was a combination of inspections, performance tests and computer modeling. The program specifics and the team assessment were:

Low Pressure Injection Coolers - These coolers were tested during each refueling outage when the coolers were placed in service for decay heat removal. This test was conducted at a heat load less than would be experienced during accident conditions. A fouling factor was developed based on the test results and compared to historical data to identify any adverse trend that would indicate increasing fouling.

The team considered the LPI cooler performance monitoring as adequate.

Reactor Building Cooling Units - To determine operability of the RBCUs, the licensee used a computer code to predict the heat removal under accident conditions based on heat removal data taken during normal operations.

The team had two concerns with this process. The first concern was the ability of the computer code to predict RBCU heat removal under accident conditions. This computer code was divided into two separate calculations. First, a fouling factor was calculated based on data taken during normal operations. The fouling factor was then used to predict the heat removal during accident conditions. Because the airflow distribution was non-uniform, the licensee used another computer code that predicted the airflow distribution based on the data taken during normal operating conditions. This computer code was obtained from a vendor and the licensee relied on the vendor's benchmarking of the computer code. A non-regulatory required airflow test performed in 1987, indicated the airflow was substantially less than assumed in the computer code; however, the licensee stated this test was invalid due to significant air side fouling. The ability of this computer code to accurately predict the air flow distribution has a direct effect on RBCU operability.

The second concern was the accuracy of LPSW flow measurement. The determination of RBCU heat removal capability relied on the accuracy of the LPSW flow measuring device which was an installed orifice. The inspectors reviewed documentation and photographs that showed the LPSW piping had fouled at various points. A reduction in the diameter of the piping in the area of the orifice would result in higher indicated LPSW flow. The licensee had performed a special test to determine the accuracy of the LPSW flow instrumentation by subtracting the indicated flows from other LPSW supplied components from the total LPSW flow; however, this resulted in unrealistically high LPSW flow to the RBCUs. The licensee also performed testing of the LPSW pumps using ultrasonic flow measurements which indicated substantially lower flows than the installed instrumentation. The licensee stated this was a special test for gathering data and did not constitute a valid performance test.

The team concluded that without field validation of the RBCU airflow distribution and stronger assurance of flow element accuracy, the RBCU computer results were questionable.

Small LPSW Heat Exchangers - Periodic flow verifications were performed. The team had no concerns.

The Main Condensers - The main condenser were cleaned and inspected each refueling outage. The team had no concerns.

SSF Diesel Engine Jacket Water Heat Exchangers - The ISI requirements for the SSF diesel lube oil and jacket water coolers was on a 10 year cycle verses the 5 year criteria in the GL. No other monitoring program was in place. The team considered the performance monitoring of these heat exchangers inadequate.

SSF HVAC Condensers - A semiannual preventive maintenance activity for the SSF air handling unit required cleaning of the condenser tubes if the head saturation temperature was more than 10°F higher than the outlet temperature. The licensee stated the condenser tubes had not been cleaned based upon the above conditions. The team had no concerns.

Keowee - No formal performance monitoring of the SWS heat exchangers had been established. In the licensee's informal SWS Program Manual the Keowee heat exchangers were discussed indicating that normal operation of Keowee by operators would identify any problems. The team considered the present monitoring methods as inadequate. First, the instrumentation that would be relied upon to inform the operators of a problem was not being fully maintained as discussed in Section 9.c.1. Second, there was no documented trending or operator rounds program in place for the SWS heat exchangers.

In summary the heat exchanger performance monitoring program had been inadequately implemented, mainly due to a lack of scope.

III. Routine Inspection and Maintenance

Action III of GL 89-13 requested that licensees implement a routine inspection and maintenance program for open-cycle SWS piping and components. This program was to ensure that corrosion, erosion, protective coating failure, silting, and biofouling would not degrade the performance of the safety related systems supplied by the SWS.

In response to this action item, the licensee had established periodic inspections, cleaning as needed, and piping replacements.

Piping - Design Study ONDS-252 evaluated SWS piping configurations for the sections with the highest potential for corrosion. The criteria for determining the most probable area of corrosion was piping material, piping diameter, duration of flow through the pipe and velocity of flow. Corrective action in the form of stainless steel piping replacements was accomplished in a number of the potential corrosion areas. Also, an aggressive program of pipe section inspections were in place. With the help of the SWS Steering Group a Service Water Piping Corrosion Management Program Manual dated October 29, 1993, had been developed to assure appropriate management control and attention were maintained for this effort. This piping inspection program did not include the Keowee SWSs. No other program encompassed Keowee.

The team considered the piping inspection and replacement program excellent except in terms of scope. This caused the licensee's actions to be inadequate due to the omission of the Keowee SWS piping from the program. For the systems where licensee actions were applied the maintenance program was adequate except in select equipment associated with the HPSW system and the CCW pumps. These pieces of equipment suffered from inadequate safety classification that reduced the rigor of assurance that the materials used in repair activities were proper and the work was performed properly. This also included the rigor used in post maintenance testing.

Pumps and Valves - Following the 1987 SITA a preventive maintenance schedule for the LPSW pumps was established. However, pump rebuild and refurbishment could not be accomplished within the TS LCO time allowed which caused maintenance constraints on the shared Unit 1/2 LPSW system. Pump performance deficiencies had centered around high temperatures in the stator of the motors. The CCW pumps were experiencing long term vibration/fatigue with adequate corrective actions being taken to address the issue. Valves were being adequately maintained.

Heat Exchangers - Periodic inspections and cleaning frequencies had been established for a number of heat exchangers.

IV. Design Function Verification and Single Failure Analysis

Action IV of GL 89-13 requested to licensees confirm that the SWS would perform its intended function in accordance with the licensing basis for the plant. This confirmation was to include a review ensuring requisite safety functions were accomplished even with the failure of a single active component.

In response to this action item, the licensee utilized the 1987 self-assessment of the LPSW system and the ECCW support (first siphon) to the LPSW system. Also, design calculations were performed to verify that safety functions were accomplished with a single failure occurring.

The team considered the LPSW design review of the 1987 self-assessment as thorough and comprehensive. However, some of the corrective actions did not adequately address the issues identified such as isolation of the LPSW turbine building header. Resolution to problems identified while implementing corrective actions to the self-assessment were occasionally inadequate as with the inadequate NPSH for the LPSW pumps and the postulated waterhammer in the RBCU discharge piping. Also, a number of corrective actions were untimely such as safety classification of the CCW pumps and, seismic suitability of the vacuum priming and HPSW systems which support ECCW (first siphon) operation. The self-assessment did not include the ASW, SSF SWS, Keowee, HPSW, and the other operating modes of the CCW system (second siphon and loss of Keowee Dam). In summary the licensee's corrective actions to this action item were inadequate.

V. Training

Action V of GL 89-13 requested licensees to confirm that maintenance practices, operating and emergency procedures, and training involving the SWS were adequate to ensure safety related equipment cooled by the SWS would function as intended.

In response to this action item the licensee evaluated LPSW maintenance practices, all LPSW operating (normal and abnormal) procedures, and LPSW training, as part of the 1987 self-assessment. Beyond this specific review, the licensee considered the established personnel qualification 2 year procedure review, 10 CFR 50.59 safety evaluation, qualified reviewer, operating experience and operator requalification programs as adequate to address this action item.

The team identified LPSW weaknesses which were within the scope of this aspect of the 1987 self-assessment. Examples of these weaknesses included the lack of an abnormal procedure addressing inadequate LPSW flow and, limited operator training on containment temperature concerns during an accident. Also, beyond the specific self-assessment, the established generic programs did not identify numerous weaknesses. Examples of these weaknesses included the lack of operating procedures for Keowee SWSs, weak operator direction in response to the Keowee Dam failure, the inability to verify flow to the steam generators from the ASW system and incomplete verification that ASW actions could be accomplished within the 40 minute required timeframe. A review, similar to that performed on the LPSW system, of Keowee would almost certainly have identified the lack of key quality assurance elements in the operation, maintenance and training associated with the Keowee hydroelectric station years before operational events in 1992 brought them to light. In summary the licensee's corrective actions to this action item were inadequate.

APPENDIX C

Acronyms and Abbreviations

ANSI	American National Standards Institute
ASW	Auxiliary Service Water
BWST	Borated Water Storage Tank
CCW	Condenser Circulating Water
CC	Component Cooling Water
CGD	Commercial Grade Dedication
DBD	Design Basis Document
DEV	Deviation
DPC	Duke Power Company
ECCW	Emergency Circulating Cooling Water
EDG	Emergency Diesel Generator
EFW	Emergency Feedwater
EP	Emergency Procedure
EPRI	Electric Power Research Institute
ESF	Engineered Safety Feature
EWF	Emergency Feedwater
EWST	Elevated Water Storage Tank
FSAR	Final Safety Analysis Report
GL	Generic Letter
GPM	Gallons per Minute
HPI	High Pressure Injection
HPSW	High Pressure Service Water
HVAC	Heating, Ventilation, and Air Conditioning
IFI	Inspector Follow-up Item
IPE	Individual Plant Examination
ISI	Inservice Inspection
IST	Inservice Test
LCO	Limiting Condition for Operation
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LPI	Low Pressure Injection
LPSW	Low Pressure Service Water
MTOTC	Main Turbine Oil Temperature Control
NCV	Noncited Violation
NPSH	Net Positive Suction Head
PRA	Probabilistic Risk Assessment
PSIA	Pounds per Square Inch Absolute
PSIG	Pounds per Square Inch Gauge
RBCU	Reactor Building Cooling Unit
RCS	Reactor Coolant System
SBO	Station Blackout
SER	Safety Evaluation Report
SSF	Safe Shut Down Facility
SWS	Service Water System
SWSOPI	Service Water System Operational Performance Inspection
TDEFW	Turbine Driven Emergency Feedwater
TDH	Total Developed Head
TS	Technical Specification
UNR	Unresolved
VIO	Violation