January 19, 1996

LICENSEE: Duke Power Company

FACILITY: Oconee Nuclear Station, Units 1, 2, and 3

SUBJECT: SUMMARY OF MEETING ON DECEMBER 13, 1995, REGARDING ELECTRICAL SYSTEM ISSUES AND KEOWEE PROBABILISTIC RISK ASSESSMENT

Representatives from Duke Power Company (the licensee) met with members of the NRC staff on December 13, 1995, in Rockville, Maryland, to discuss (a) the issues related to the NRC staff's review of the emergency electrical system at the Oconee Nuclear Station, and (b) the licensee's December 12, 1995, letter providing information on previous initiatives taken to improve the reliability of the emergency electrical system, and the current status of this system. The list of attendees can be found as Enclosure 1.

The licensee presented an overview of the emergency a.c. electric power distribution system design with particular attention to the various power sources and associated distribution paths for providing power to the emergency busses. The background information also included a discussion of several key events or activities that have precipitated organizational, programmatic and equipment initiatives. In addition to a short discussion regarding risk insights and contributions, the licensee provided an overview of the Keowee probabilistic risk assessment (PRA) that included a description of the modeling, general analysis and methodology, and the conclusions. The licensee's discussions closely followed the presentation slides (Enclosures 2 and 3).

Following the licensee's presentation, the NRC staff asked a series of questions related to (a) the potential for an out-of-tolerance voltage or frequency condition to occur while a Keowee hydro unit is in operation, (b) concerns about the protection of equipment and components at the Oconee Station from out-of-tolerance voltage or frequency conditions, and (c) the maintenance and availability of the Lee Station combustion turbines and feeder line. The specific questions were provided in a letter to the licensee dated December 21, 1995.

Original signed by:

Patrick D. Milano, Sr. Project Manager
Project Directorate II-2
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket Nos. 50-269, 50-270
and 50-287

Enclosures: 1. List of Attendees
2. Briefing Slides on Electrical System
3. Briefing Slides on Keowee PRA

Distribution: See next page

cc w/enclosures: See next page
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 19, 1996

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3. Briefing Slides on Keowee PRA

cc w/enclosures: See next page

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MEMORANDUM DATED JANUARY 19, 1996

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MEETING ATTENDANCE LIST

Licensee: Duke Power Company Plant(s): Oconee, Units 1, 2, & 3

Subject: Electrical System Initiatives and Keowee Reliability Analysis

Location: NRC Offices, Conf. Room O-16-B-11 Date: December 13, 1995
Time: 12:30 p.m.

NAME	TITLE	ORGANIZATION
Leonard A. Wiens	Acting Director	NRR/PD II-2
Patrick D. Milano	Project Manager	NRR/PD II-2
Gus C. Lainas	Deputy Director	NRR/DE
Martin J. Virgilio	Deputy Director	NRR/DSSA
Charles E. Rossi	Director	AEOD/SPD
Jack E. Rosenthal	Branch Chief	AEOD/SPD/RAB
Dale Thatcher	Section Chief	NRR/DE/EELB
James J. Lazevnick	Sr. Engineer	NRR/DE/EELB
Harold L. Ornstein	Sr. Reactor Systems Engineer	AEOD/SPD/RAB
Stacey Rosenberg	Reactor Systems Engineer	NRR/DSSA/SPSB
Virgil Beaston	Electrical Engineer	NRR/DE/EELB
William LeFave	Sr. Systems Engineer	NRR/DSSA/SPLB
Stephen Dinsmore	Reliability Engineer	NRR/DSSA/SPSB
George Lanik	Section Chief	AEOD/SPD/RAB
William Raughley	Sr. Engineer	AEOD/SPD/RAB

ENCLOSURE 1

MEETING ATTENDANCE LIST

Licensee: Duke Power Company Plant(s): Oconee, Units 1, 2, & 3

Subject: Electrical System Initiatives and Keowee Reliability Analysis

Date: December 13, 1995 Time: 12:30 p.m.

NAME	TITLE	ORGANIZATION
Christopher Jackson	Reactor Systems Engineer	NRR/DSSA/SRXB
James H. Conran	CRGR Staff	AEOD/CRGR
Denwood Ross	Deputy Director	AEOD/OD
Laura Collins	Reactor Systems Engineer	AEOD/SPD/RRAB
Charles Hehl	Director	R-I/DNMS

MEETING ATTENDANCE LIST

Licensee: Duke Power Company Plant(s): Oconee, Units 1, 2, & 3

Subject: Electrical System Initiatives and Keowee Reliability Analysis

Date: December 13, 1995 Time: 12:30 p.m.

NAME	TITLE	ORGANIZATION
J. W. Hampton	Vice President Oconee Nuclear Sta. (ONS)	Duke Power Co.
B. L. Peele	Manager, Oconee Nuclear Station	Duke Power Co.
W. W. Foster	Manager, Oconee Safety Assurance	Duke Power Co.
J. M. Davis	Manager, ONS Engineering	Duke Power Co.
C. A. Little	Manager, ONS Electrical Systems	Duke Power Co.
J. E. Burchfield, Jr.	Manager, ONS Regulatory Compliance	Duke Power Co.
M. E. Bailey	ONS Regulatory Compliance	Duke Power Co.
H. T. Grant	ONS Electrical Systems	Duke Power Co.
R. L. McCoy	ONS Mechanical Civil Engineering	Duke Power Co.
W. K. Grayson	ONS Mechanical Systems	Duke Power Co.
W. R. Severance	ONS Mechanical Systems	Duke Power Co.
J. W. Rowell	ONS Electrical Systems	Duke Power Co.
G. E. Rothenberger	ONS Superintendent Operations	Duke Power Co.
P. M. Abraham	Nuclear Production Supr. Engineering	Duke Power Co.
M. J. Barrett	Nuclear Production Senior Engineer	Duke Power Co.

Duke/NRC Emergency Power Meeting

Jim Hampton, Site Vice President
Jack Peele, Station Manager

December 13, 1995

Oconee Nuclear Site

ENCLOSURE 2

Agenda

- Introduction
- Overview of Oconee AC Power Paths
- Historical Perspective
- Initiatives
  - » Organizational
  - » Programmatic
  - » Equipment
- Risk Insights
- Conclusion

Introduction

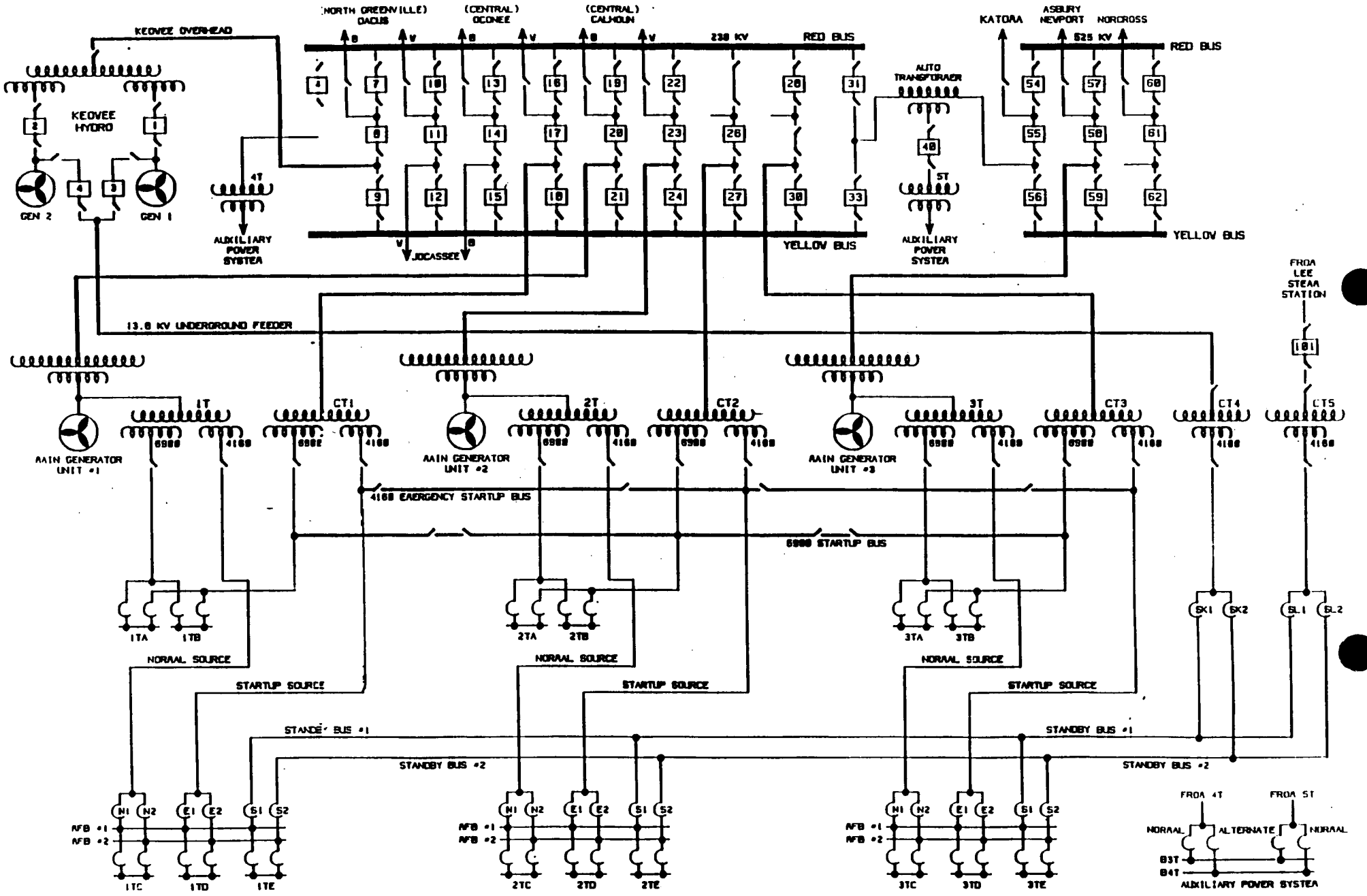
- Duke Power requested this meeting to respond to NRC interest in the Oconee emergency power system
- Important to recognize that Duke Power has implemented emergency power initiatives
- Focus has been on safety and enhanced reliability as well as to ensure all applicable licensing and design requirements continue to be satisfied
- Duke Power appreciates the opportunity to update the NRC on these initiatives

Introduction

- We have devoted, and will continue to devote, the resources necessary to assure the system operates as designed
- Duke Power has invested over $6 million in the last few years on emergency power system initiatives
- We have full confidence that the emergency power system can perform its intended safety function

Overview of Oconee AC Power Paths

- Oconee generator through the normal auxiliary transformer
- 230kV Switchyard through the startup transformer
- One Keowee Unit through the startup transformer on the overhead path
- One Keowee Unit through the underground path and transformer CT4
- Dedicated 100kV path from a Lee Combustion Turbine through transformer CT5
- Central Switchyard through transformer CT5
- 230kV Switchyard through a backcharged main transformer
- 4160V and 6900V buses can be cross-tied between units



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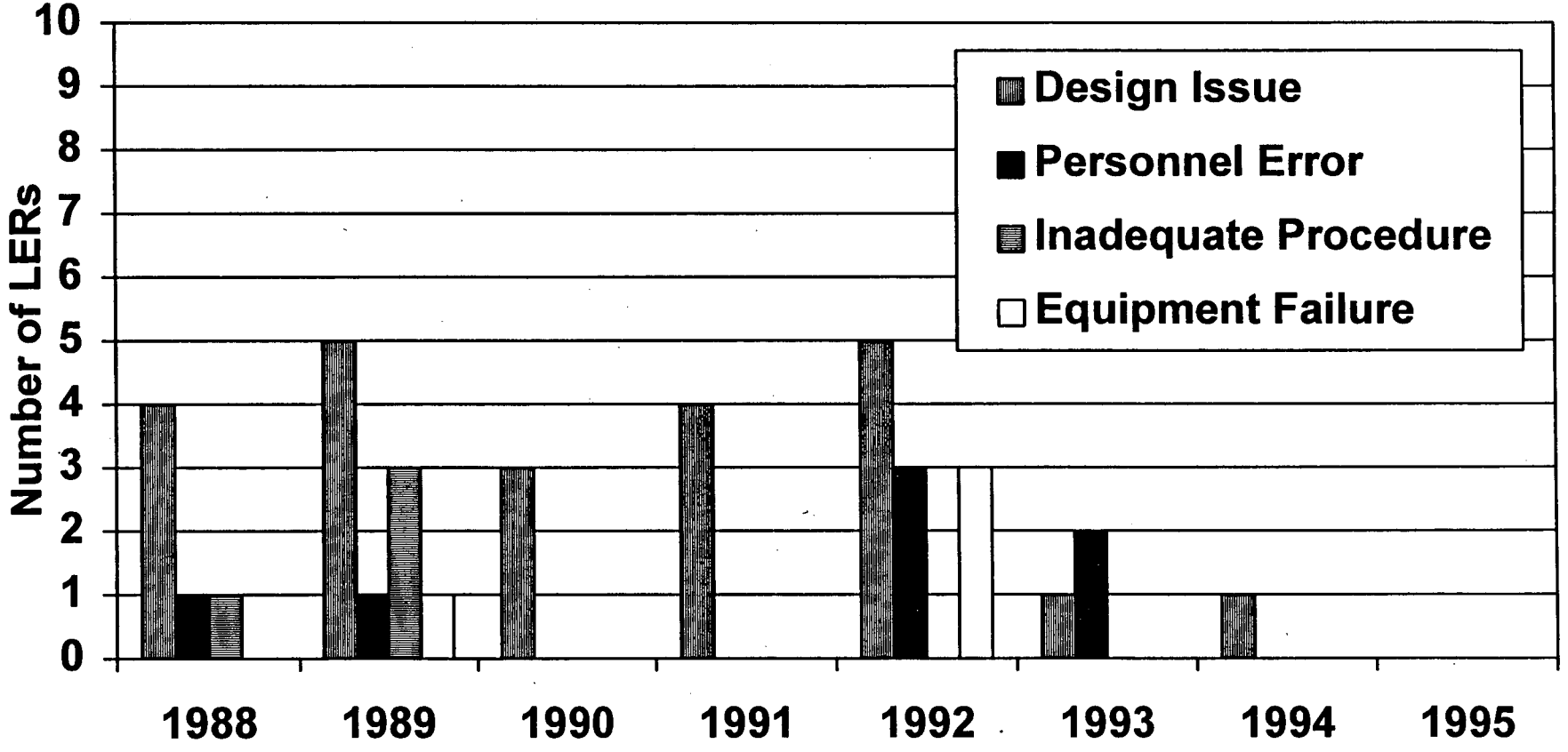
REFERENCES
CEE-117 SERIES

EMERGENCY POWER DISTRIBUTION

Historical Perspective

- Initiated Design Basis Documentation (DBD) Program in 1989
- Oconee Electrical Distribution Self Initiated Technical Audit (SITA) in April of 1992
- October 19, 1992 Oconee Unit 2 Loss of Offsite Power Event, followed by AIT and Management Meeting
- Oconee EDSFI in February of 1993

ONS Emergency Power-Related LERs



Organizational Initiatives

- Engineering resources redeployed to site in 1992
- Keowee personnel integrated into ONS Operations group in November of 1992
- Engineering resources reorganized in 1994
- Responsibility for switchyard transferred from Power Delivery to ONS
- Site assumed full responsibility for operation, maintenance, and testing of Keowee
- Emergency Power Project team was formed with a dedicated project manager

Programmatic Initiatives

- Established expectations for conduct of operations at Keowee Hydro Station
- Keowee Training Program enhanced
  - » Initial Operator and Technician Training Program
  - » Keowee Hydro Requalification Program
- Training enhancements for ONS operators
  - » Critical Keowee Job Performance Measures (JPMs)
  - » Keowee Emergency Start Abnormal Procedure
  - » Keowee Auxiliary Power System
  - » Loss of Power Abnormal Procedure

Programmatic Initiatives

- Human Performance
  - » Corrective Action Program
  - » Team skills in human error prevention
- Keowee reviewed against past NRC, OEP, and INPO items
- Created and upgraded maintenance and testing procedures
- Keowee instrument calibration program integrated into site

Programmatic Initiatives

- Continued to upgrade Design Basis Documents
- Established design basis test matrices for systems
  - » Defined design basis functions for systems
  - » Verified testing is adequate to ensure systems can perform design basis functions
  - » Where appropriate, new tests were performed
- Created and upgraded engineering calculations

Programmatic Initiatives

- Piping and supports for QA-1 mechanical systems at Keowee seismically qualified
- Inspected concrete expansion anchors on QA-1 and QA-4 pipe supports at Keowee
- SQUG
  - » Oconee
    - – 3, 115 of 4,283 contact devices qualified to date
    - – 1,130 of 1,532 equipment/cabinet items qualified to date
  - » Keowee/Switchyard
    - – 1, 034 of 1,260 contact devices qualified to date
    - – 213 of 276 equipment/cabinet items qualified to date

Programmatic Initiatives

- Reviewed systems and equipment at Keowee for proper QA classification
- Implemented improved field process for determining QA classification of components
- Updated drawings

Programmatic Initiatives

- Implemented recommendations from the Keowee PRA
- Implemented risk matrix in Operations and Work Control
- Keowee, Switchyard, and Lee being incorporated into Maintenance Rule

Equipment Initiatives

- Keowee
  - » Uninterruptible power provided to statalarm panels, events recorder, and computer
  - » Modified auxiliary power system to automatically transfer to alternate power source
  - » Modification to eliminate zone overlap single failure vulnerability
  - » Modification and administrative controls to protect against overspeed and overfrequency

Equipment Initiatives

- Keowee
  - » Reblocked Keowee stepup transformer
  - » Replaced events recorder
  - » Replaced battery chargers and inverters

Equipment Initiatives

- Switchyard
  - » Inspected insulators on overhead power path
  - » Enhancing degraded grid protection logic
  - » Seismic ruggedness verified by IPEEE/A-46
  - » Replaced battery chargers

Equipment Initiatives

- Standby Shutdown Facility (SSF)
  - » Replaced SSF auxiliary service water control valve on each Oconee unit
  - » Minimized time required to activate the SSF
    - – Streamlined SSF activation procedure
    - – Improved operator training
    - – Enhanced SSF breaker configuration
  - » Added SSF submersible pump
  - » SSF RC letdown orifices replaced

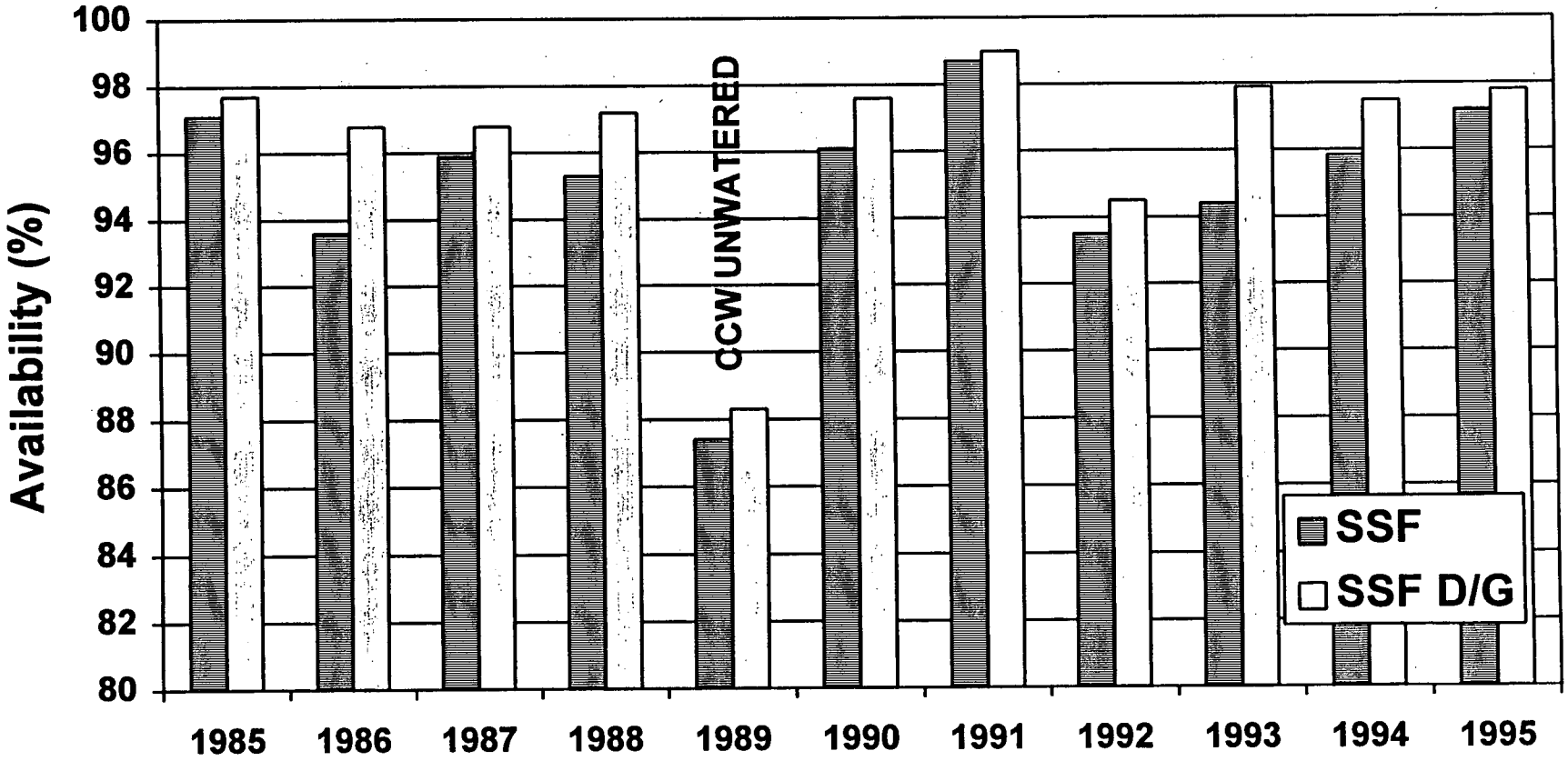
Risk Insights

- Reliability of Offsite Power
  - » IPE LOOP frequency based on industry data and Oconee experience through 1987 is 0.090 events/reactor year
  - » LOOP frequency based on industry data and Oconee experience through 1993 is 0.032 events/reactor year
  - » Oconee LOOP Data:
    - 0 grid failures in 65 reactor years
    - 2 Switchyard LOOP events in 65 reactor years
    - 0 severe weather LOOP events in 65 reactor years
- Keowee reliability confirmed by Keowee PRA

Risk Insights

- Station Blackout
  - » Probability of losing all ac power is low
  - » Coping duration of 4 hours
  - » SSF Diesel Generator is alternate ac power source

SSF Availability

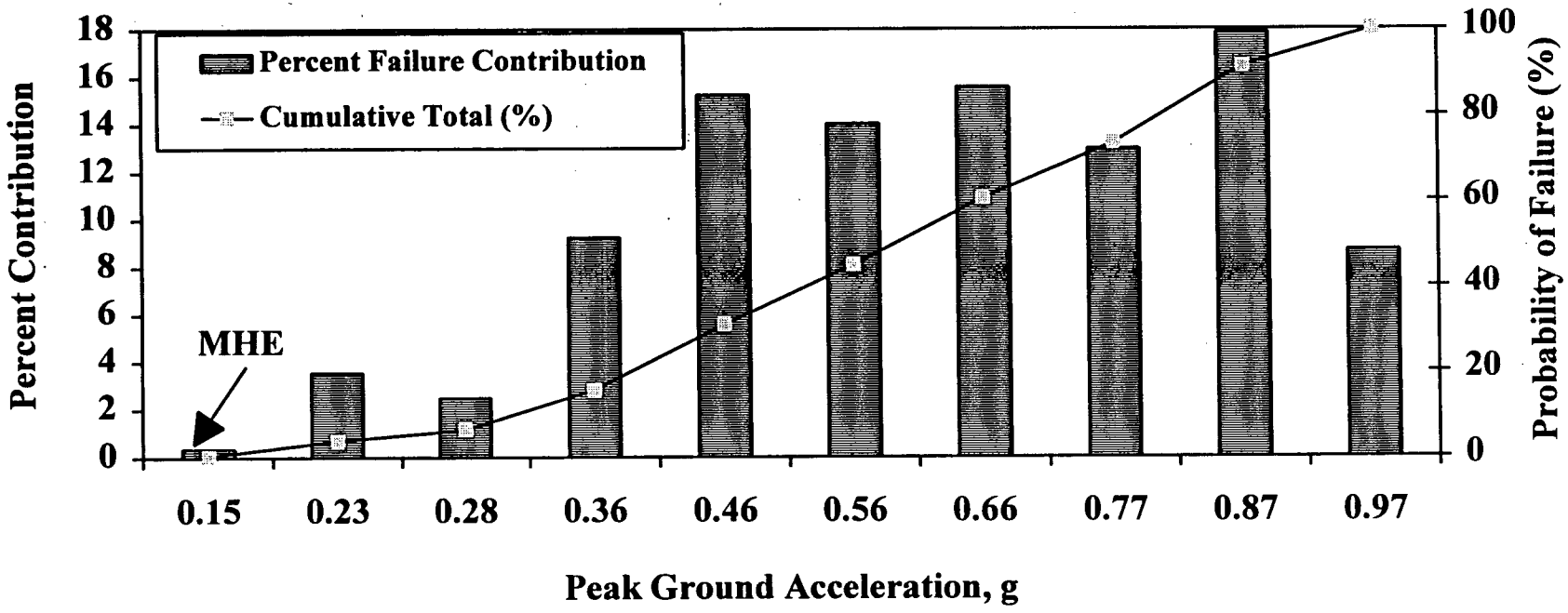


External Events

	IPE Report (12/90)		IPEEE Report (12/95)	
Initiating Event	Core Damage Frequency (per year)	Percent of Total	Core Damage Frequency (per year)	Percent of Total
Seismic	5.0E-05	57.5%	3.6E-05	58.9%
Fires	2.2E-05	25.3%	5.1E-06	8.3%
Tornadoes	9.7E-06	11.1%	1.3E-05	21.3%
External Flooding	4.9E-06	5.6%	7.0E-06	11.5%
Transportation and Nearby Facilities	--------	--------	--------	--------
Total External	8.7E-05		6.1E-05	

Oconee Seismic Core Damage Risk vs. Seismic Acceleration

- Seismic risk at ONS is predominately due to beyond design basis earthquakes



Ongoing Activities

- Fulfill few remaining NRC commitments related to the emergency power system
- Work with Staff to complete review of Tech Spec 3.7 rewrite
- Emergency Power Project Self-Initiated Technical Audit (SITA)
- Continued focus on human performance

Conclusions

- Keowee is integrated into the operations, maintenance, testing, and engineering programs at ONS
- Keowee personnel are part of ONS Operations group
- Emergency power system design features and system interactions are understood by operating staff
- Clear ownership exists for the emergency power system within site organizations
- IPE, Keowee PRA, and IPEEE confirm reliability of emergency power system

Duke - NRC Meeting

Keowee Reliability Analysis

(Keowee PRA)

12/13/95

By: M. J. Barrett

NGD - PRA Section

ENCLOSURE 3

Outline

- Motivation for Keowee PRA Study
- Overview of Scope, Objectives, and Tasks
- Description of Keowee
- Description of Methodology
- Results and Conclusions

Keowee PRA

Motivation

- Importance of Keowee to provide emergency ac power to each of the three Oconee units.
- A number of single failure vulnerabilities identified during the DBD process.
- A number of relay failures and Keowee unit failures occurred in the 1990 to 1992 period.
- Oconee Unit 2 LOOP - October 19,1992.
- These problems combined with Duke's interest in improving Duke/regulator confidence in Keowee led Duke to undertake the Keowee PRA study.

Project Objectives

- Develop an analytical reliability model of the Keowee Hydro Station.
- Obtain an estimate of the reliability of Keowee as an emergency power source for Oconee.
- Compare calculated reliability to the historical data.
- Develop insights and recommendations to complement ongoing initiatives.

Project Scope

- Develop fault trees for systems important to the emergency operation of Keowee.
- Include the important components at an appropriate level for collecting statistically significant data.
- Integrate the Keowee model into the Oconee PRA ac power model.

Keowee PRA

Project Team

- Project Leader
- Electrical Engineers
- Mechanical/Nuclear Engineers
- ONS Operations Support
- ONS Engineering Support
- Ongoing interaction with NRC personnel and contractor

Keowee PRA

Project Tasks

- Plant familiarization (drawing collection, PIP/LER studies & walkdowns)
- Collect plant specific failure and operating data
- Develop reliability data base
- Develop fault tree models
- Human reliability modeling
- Solution and analysis of results
- Reviews (team, consultants, NRC online, peers)

Keowee Function

Emergency power source for Oconee

- Overhead supply through the Oconee switchyard and startup transformers.
- Underground supply through a standby bus and associated transformer.

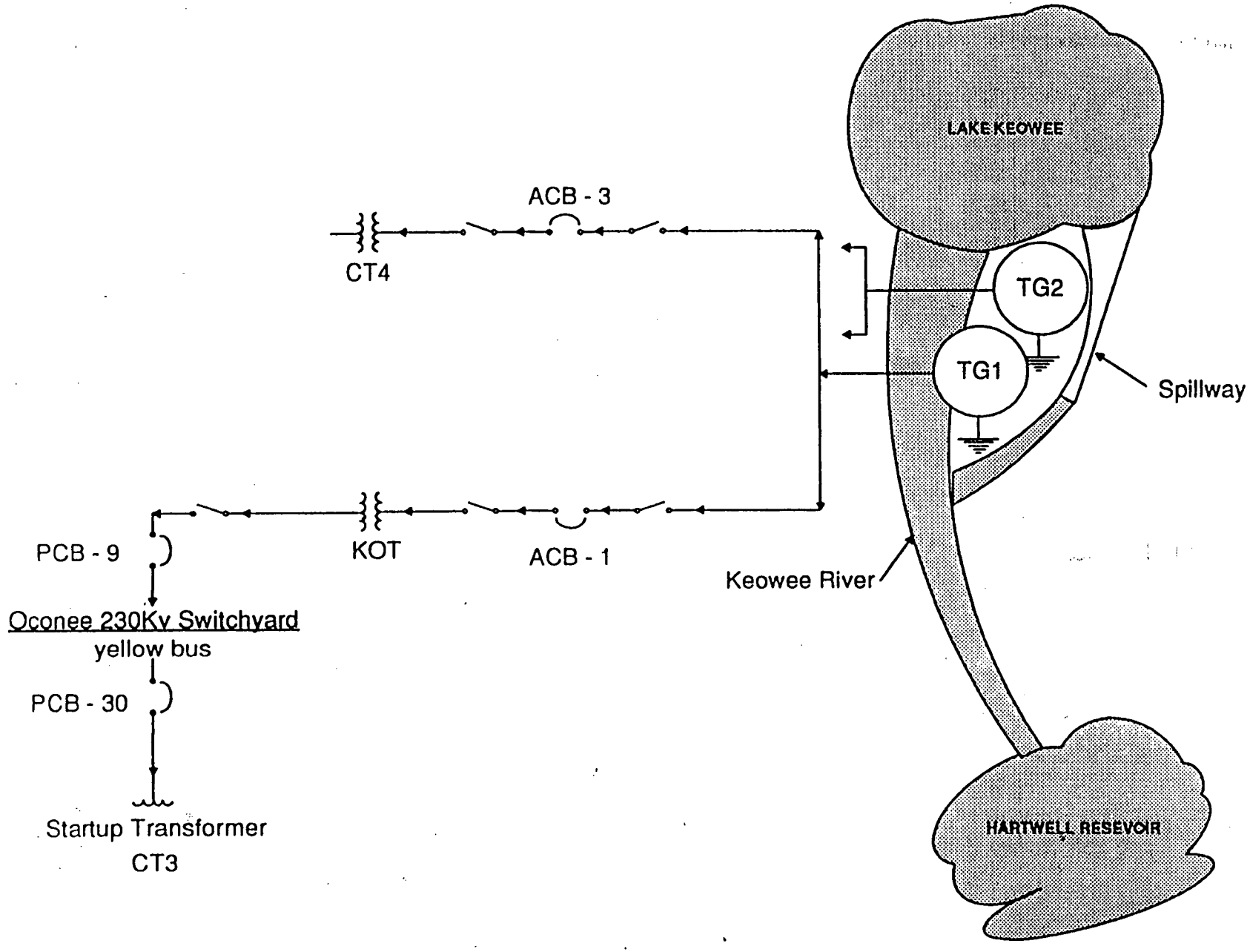


Figure 3.1-1 Keowee - Oconee AC Power Flowpath

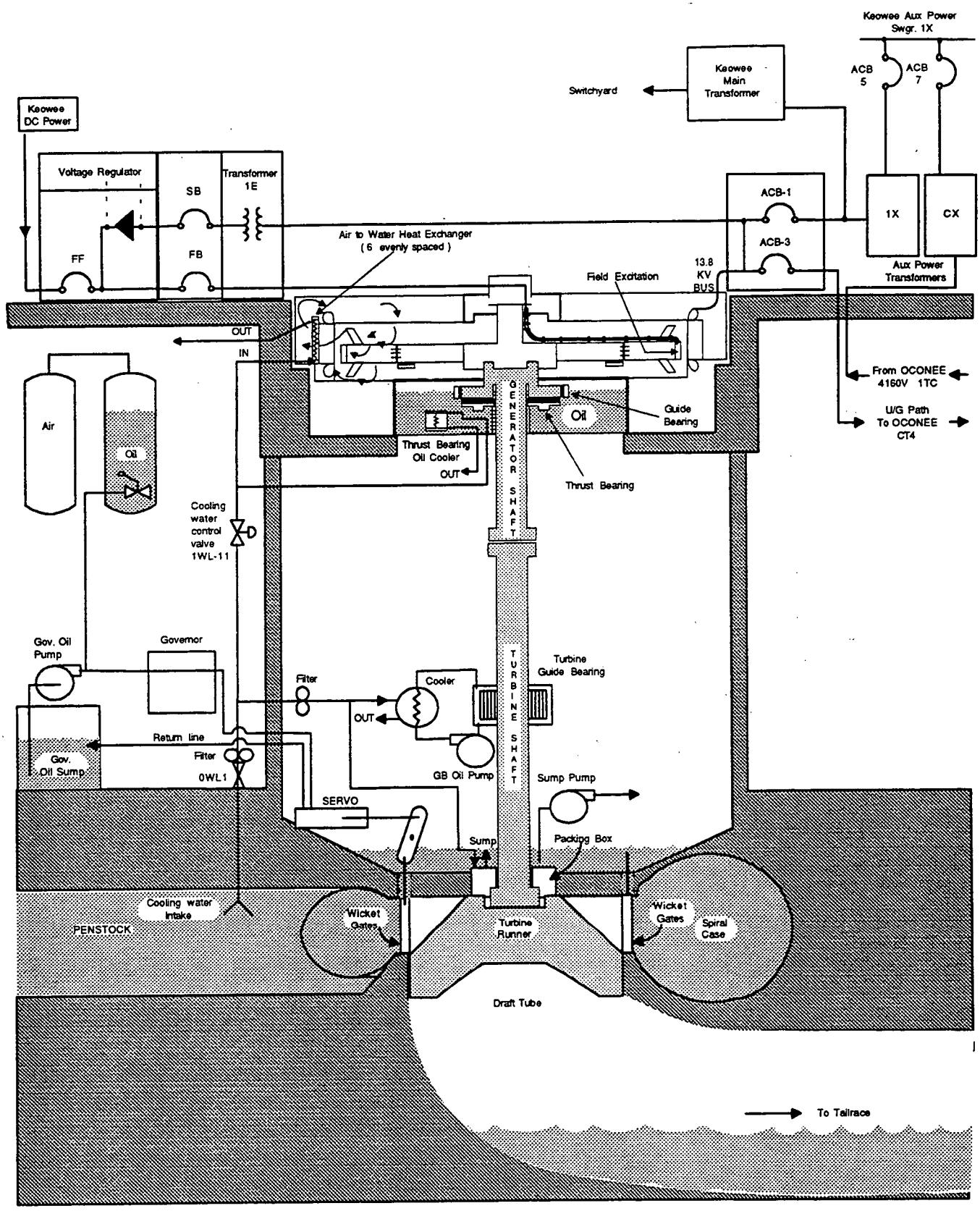


Figure 3.1-2 Keowee Subsystems Needed For Oconee AC Power

Modeling Objectives

- Identify and address all potential modes of Keowee operation.
- Develop models for components/systems required for the emergency operation of the Keowee units.
- Use plant experience to identify component-specific failure modes.
- Use plant experience to quantify failure rates of systems, subsystems, and components.

Modeling Scope

- Both Keowee units and the needed support systems.
- The underground path up to and including CT4.
- The overhead path up to and including CT3.
- Not intended to duplicate ONS IPE models.
- Modeling detail guided by the availability of data.

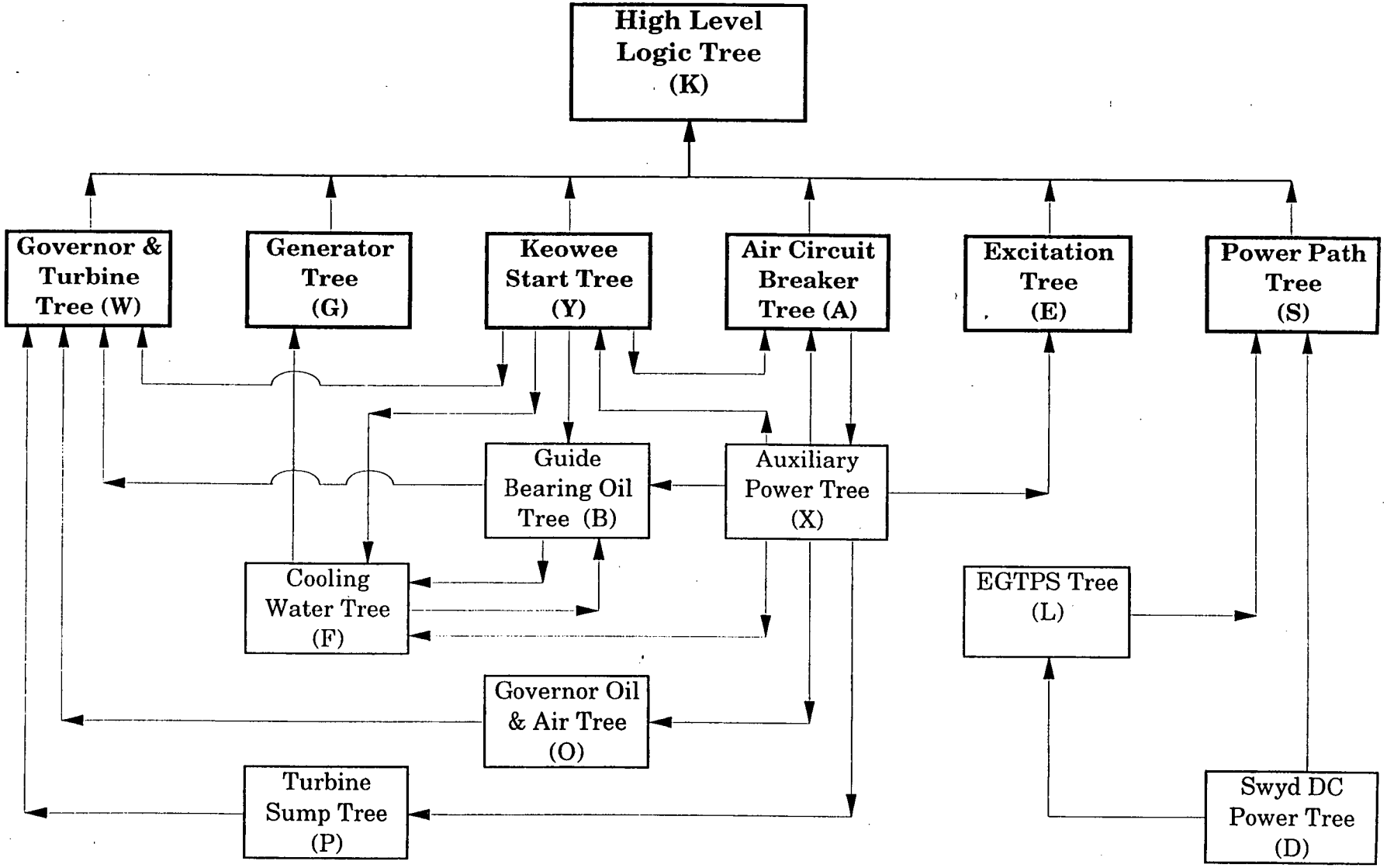


Figure 4.3-2 Keowee Fault Tree Overview

Keowee Model Attributes

- Considers all of the applicable operating modes of the Keowee Units.
- Considers the impact of human actions on Keowee reliability.
- Allows more detailed analysis of specific failures by determining results for subsections of the complete model.

General Analysis Description

- Base case considers past interim operating restriction on grid generation.
- Sensitivity study considers operation with two units available for grid generation:
  - includes the design change to protect against the zone overlap problem,
  - includes the design change to protect against the overfrequency concern.
- Other sensitivity studies (failure rates, human error rates, recoveries).

Keowee PRA

Sensitivity Studies

- generic versus bayesian updated data
- grid-cycled versus standby unit reliability
- recovered versus unrecovered results
- human error sensitivity studies
  - -latent human errors
  - -human error probabilities prior to the 10/92 loss of offsite power
- infrequently tested/demanded components challenged during emergency starts
- mg-6 relay failure rate
- uncertainty analysis
- one versus two units generating to the grid
- sensitivity to fraction of time that 2 units generate to the grid

Results Of The Keowee Reliability Model

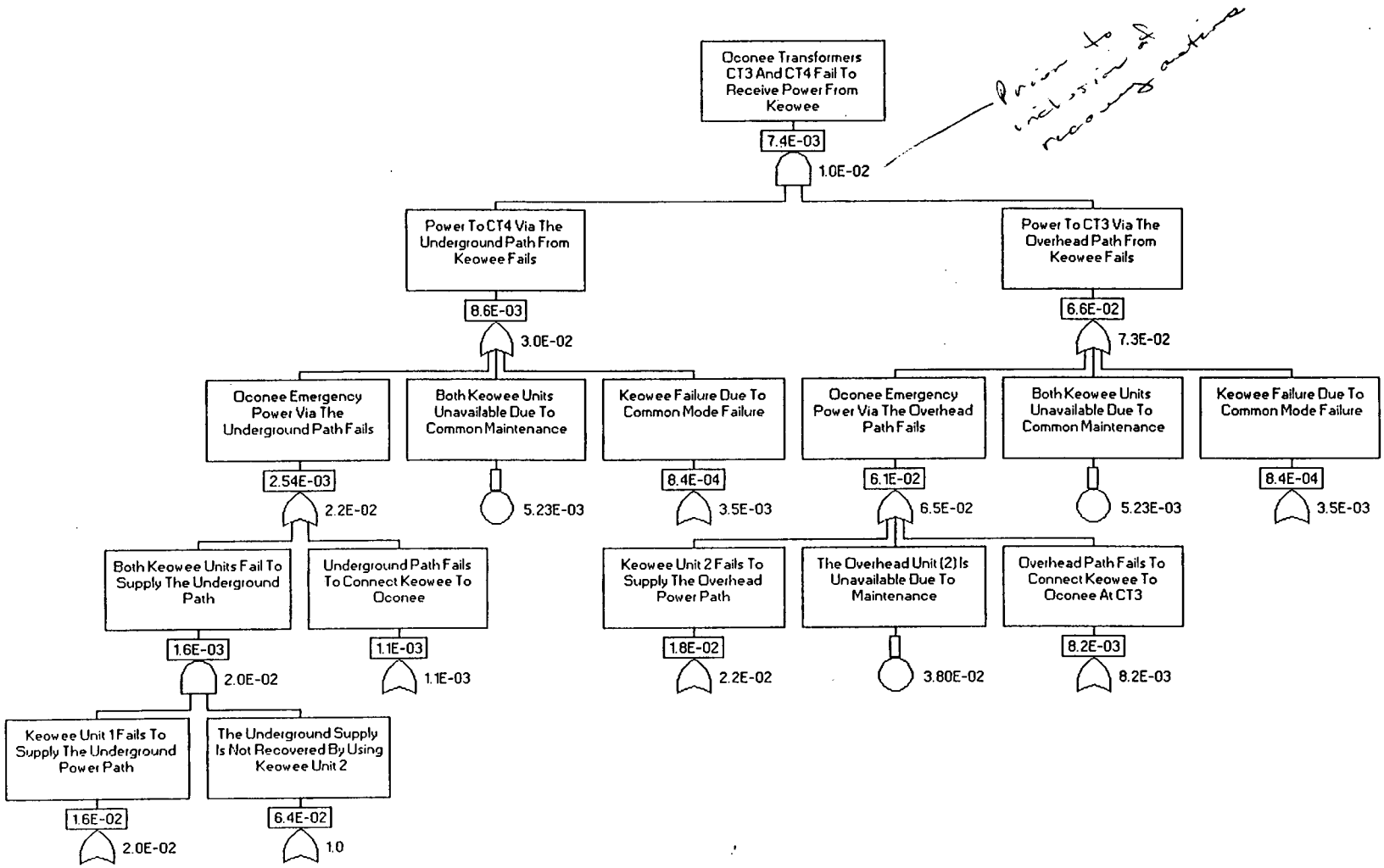
- The probability of Keowee station failure is calculated to be 0.0074 for the base case.
- Keowee unit reliability values: Model/Op data
  - Start failure probability 0.0081/0.0045
  - Run failure probability 0.012/0.012
- Overhead/Underground Supplies
  - UG supply failure probability 0.027
  - OH supply failure probability 0.070

Results Of The Keowee Reliability Model (Contd.)

- The Keowee station failure probability is dominated by the Keowee unavailability due to maintenance.
- Components of the auxiliary ac power system and the voltage regulator are also important.
- Keowee station failure probability is not affected by Keowee alignment for grid generation.
- Model results compare well to the historical data.

Oconee Transformers CT3 And CT4 Fail To Receive Power From Keowee - 7.4E-03

1)	**Both Keowee Units Unavailable Due To Common Maintenance**	**5.23E-03**
2)	**With Both Keowee Units Available** **Common Cause Failure Of ACBs 5, 6, 7, and 8** **Failure To Recover From ACB Failures By Manual Operation**	**3.22E-04**
3)	**The Overhead Unit (2) Is Unavailable Due To Maintenance** **Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure**	**2.66E-04**



Simplified Fault Tree Visualization Of The Keowee Reliability Results

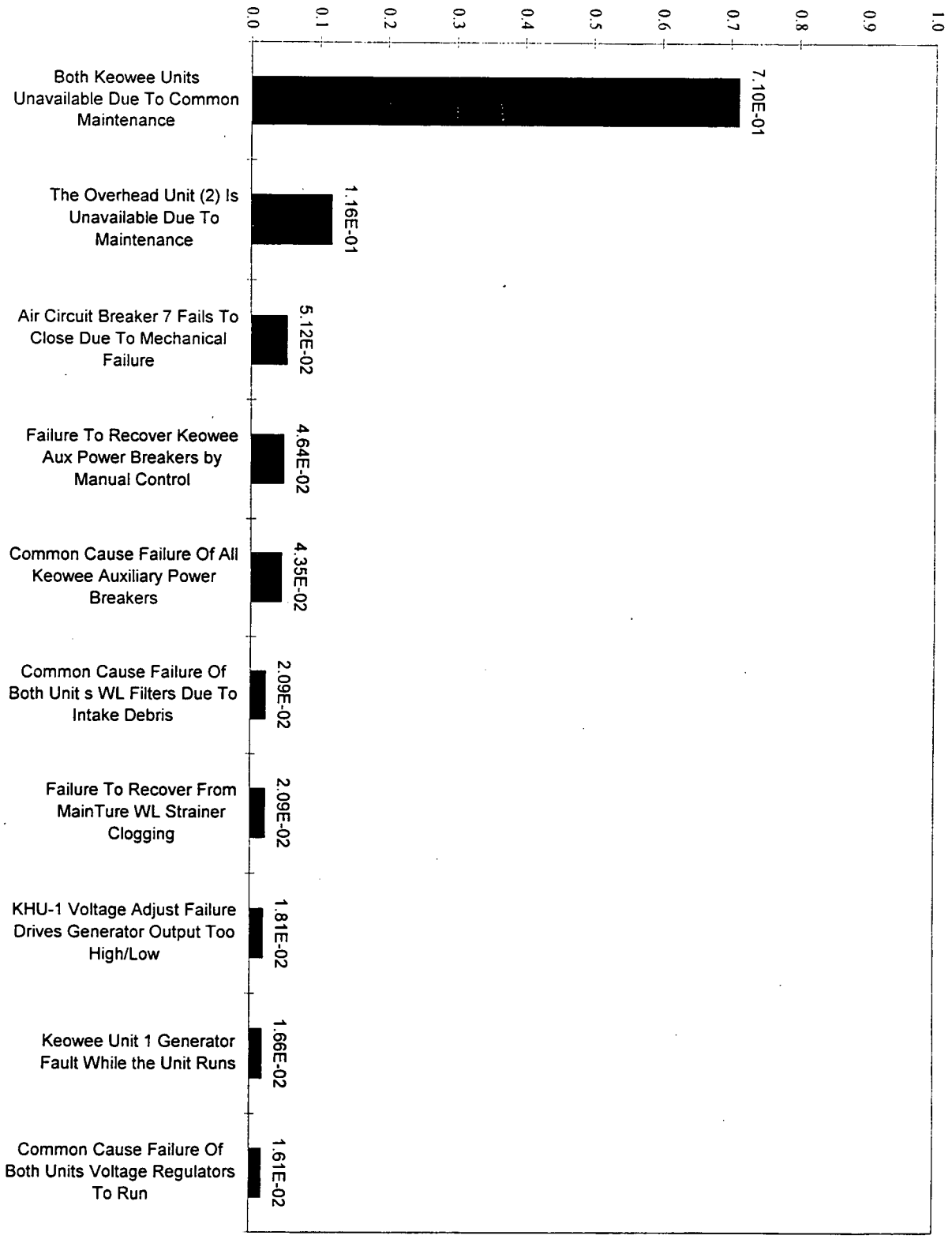


Figure 7.2-1 Dominant Contributors To Keowee Unavailability as Ranked by Importance Measure

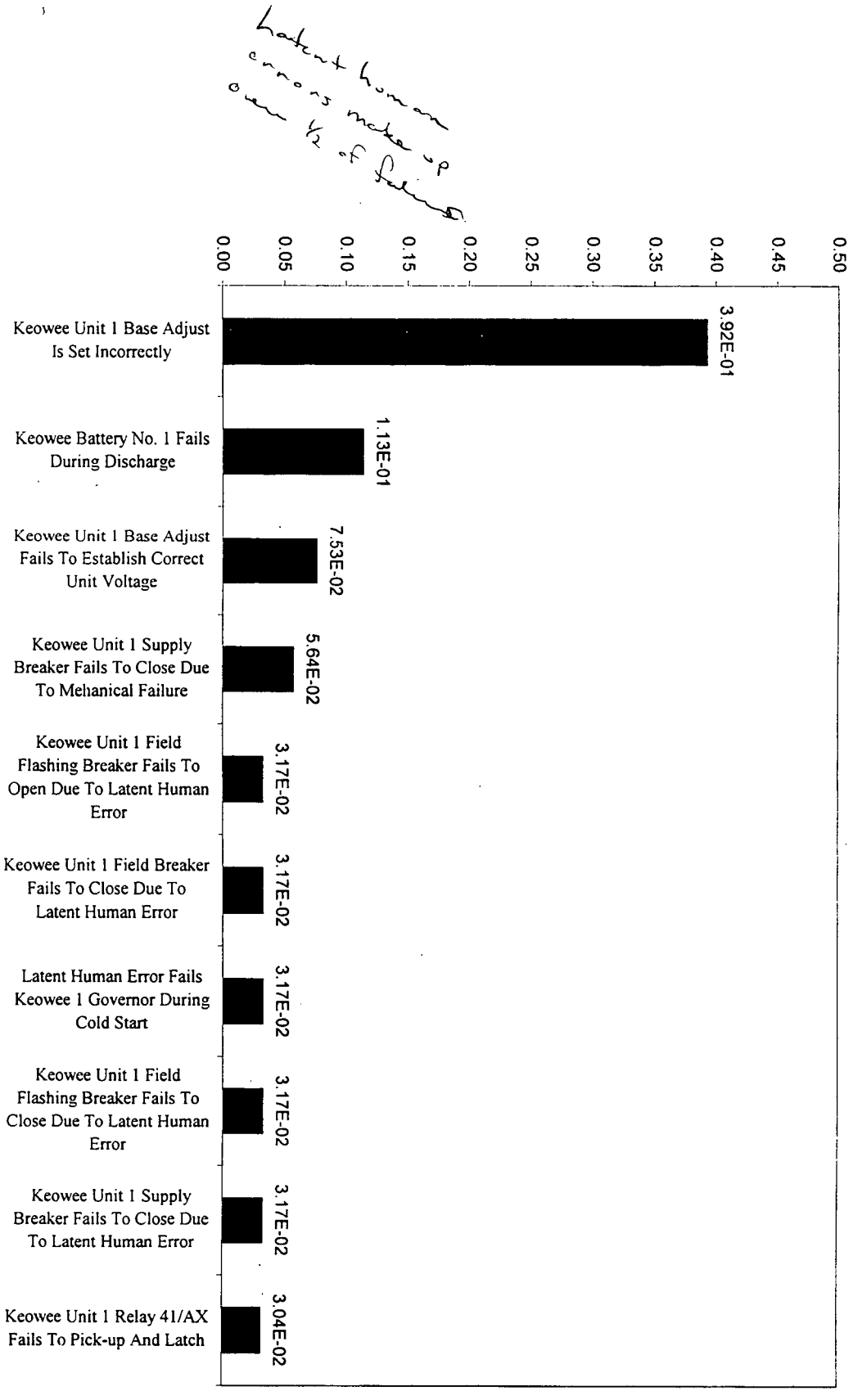


Figure 7.2-3 Dominant Contributors to Keowee Unit 1 Start Failure as Ranked by Importance Measure

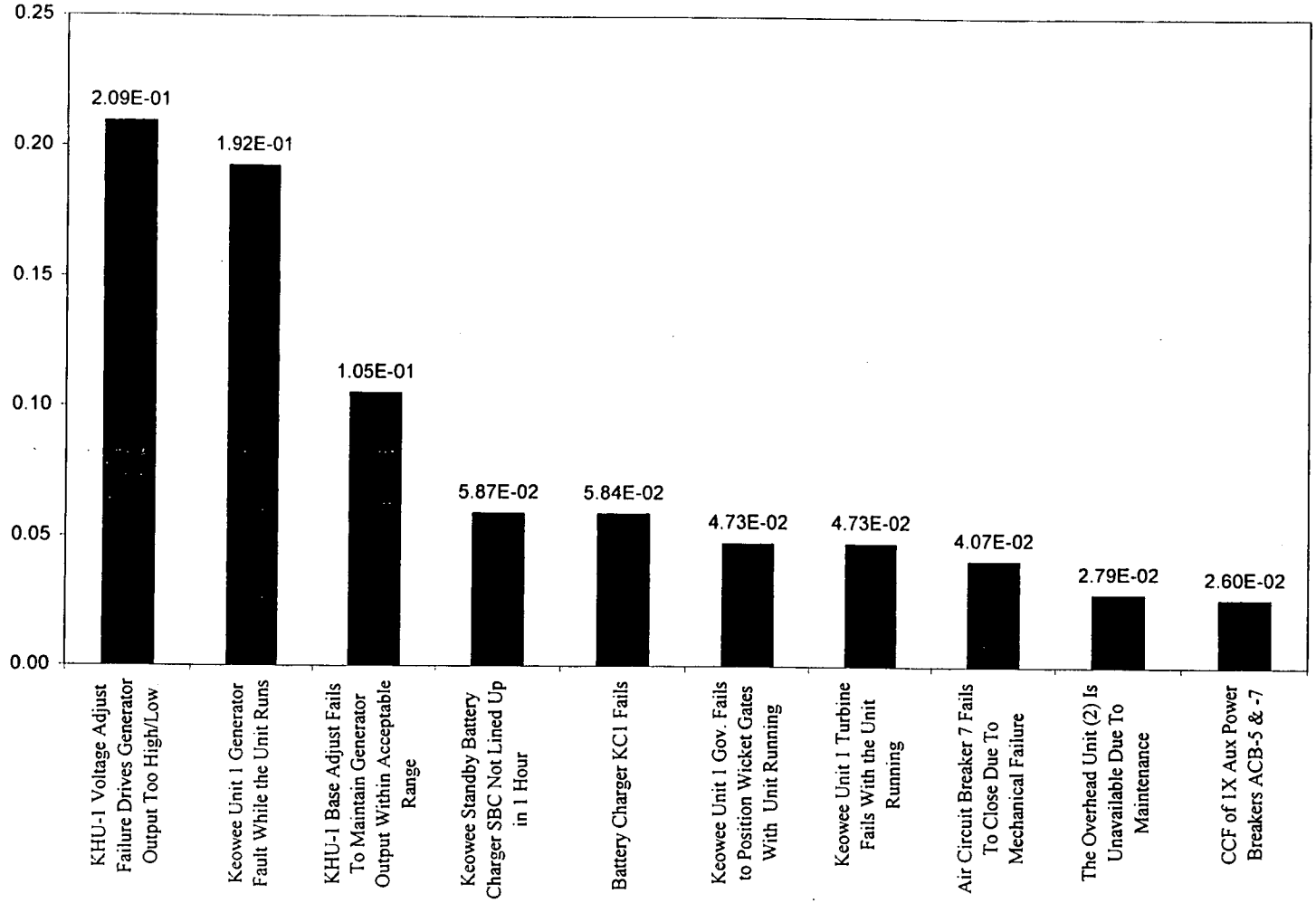


Figure 7.2-4 Dominant Contributors to Keowee Underground Unit (Unit 1) Run Failures as Ranked by Importance Measure

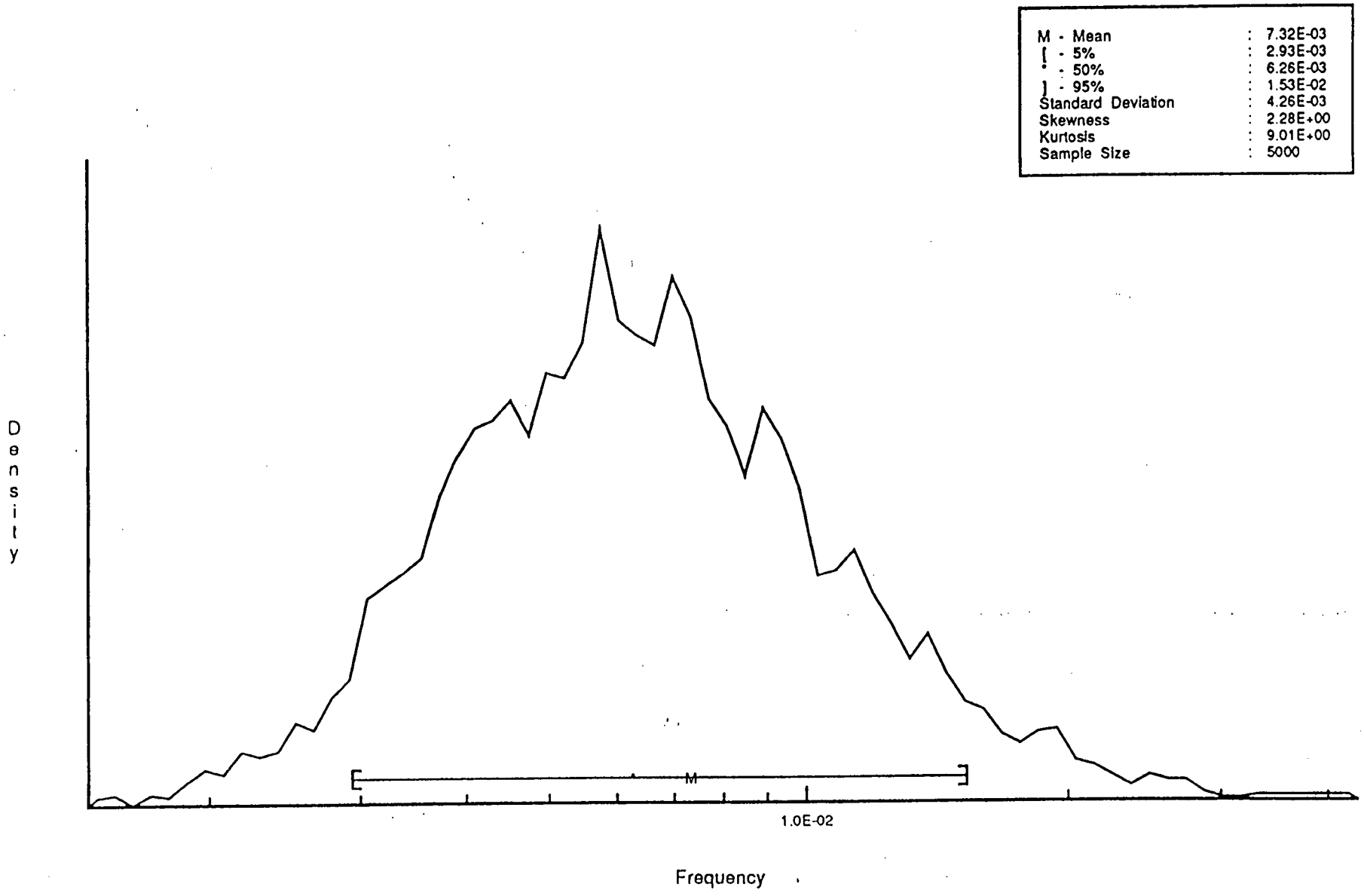


Figure 7.5-1: Probability Distribution For Model Top Gate KEOWTOP

Results Of The Keowee/Oconee ac Power Integrated Model

- The probability of losing all ac power at Oconee is calculated to be 6.4E-05/year.
- This result is mostly influenced by the occurrence of a severe weather event:
  - assumed loss of the overhead path,
  - assumed loss of the CT5 feed.
- Other important events are the maintenance unavailabilities for the Keowee units and transformer CT4.

Oconee 4160V Main Feeder Bus Power Fails from all Paths - 6.35E-05

1) With Both Keowee Units Available Transformer CT4 Is In Maintenance Loss Of Off-Site Power Due To Severe Weather Initiating Event	**1.26E-05**
2) Both Keowee Units Unavailable Due To Common Maintenance Loss Of Off-Site Power Due To Severe Weather Initiating Event Modifier For Keowee Maintenance Scheduled For Mild Weather	**7.53E-06**

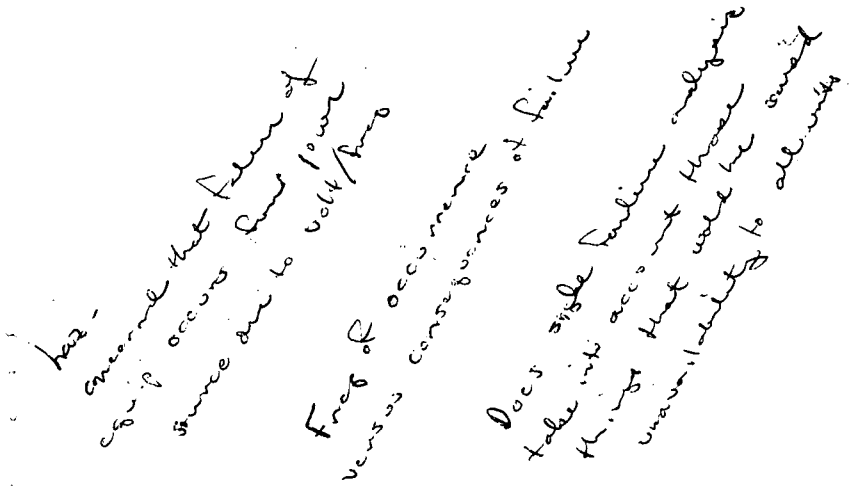
Oconee 4160V Main Feeder Bus Power Fails from all Paths (Contd.)

3) With Both Keowee Units Available 4.63E-06
Loss Of Off-Site Power Due To Severe Weather Initiating Event
Common Cause Failure Of ACBs 5, 6, 7, and 8
Failure To Recover From ACB Failures By Manual Operation

Keowee PRA

Results Of The Keowee/Oconee ac Power Integrated Model (Contd.)

- Core Melt Frequency due to loss of all ac power events is 1.0E-06/year
  - low probability of loss of all ac power
  - mitigation capability of the SSF



Core Damage Event Occurs as the Result of Loss of Offsite Power - 1.04E-06

1) With Both Keowee Units Available — 2.77E-07
Transformer CT4 Is In Maintenance
Loss Of Off-Site Power Due To Severe Weather Initiating Event
Operators Fail To Align The SSF RCM System For Operation
Offsite power not recovered

Core Damage Event Occurs as the Result of Loss of Offsite Power(Contd.)

2) Both Keowee Units Unavailable Due To Common Maintenance Loss Of Off-Site Power Due To Severe Weather Initiating Event Modifier For Keowee Maintenance Scheduled For Mild Weather Operators Fail To Align The SSF RCM System For Operation Offsite power not recovered	**1.66E-07**

Core Damage Event Occurs as the Result of Loss of Offsite Power(Contd.)

3) With Both Keowee Units Available **Transformer CT4 Is In Maintenance** **Loss Of Off-Site Power Due To Severe Weather Initiating Event** **SSF Diesel Generator Is In Maintenance** **Offsite power not recovered**	**9.69E-08**

Conclusions

- Keowee is a very reliable source of emergency power for Oconee.
- Simultaneous loss of both Keowee units, due to concurrent maintenance or common cause failure, is the principal cause of Keowee failure.
- The high reliability of the underground path and the ability to align the overhead unit to the underground path make the probability of losing all ac power small.

Recommendations

- Procedure enhancements.
- Some important maintenance activities should consider other maintenance activities in progress or the potential for severe weather.
- Use the Maintenance Rule Program to perform systematic monitoring of the equipment and performance of the ac power system.