50-269/270/287

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 14, 1994

Licensee: Duke Power Company

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

SUBJECT: SUMMARY OF OCTOBER 12, 1994, MEETING WITH DUKE POWER COMPANY ON KEOWEE PROBABILISTIC RISK ASSESSMENT PROJECT

On October 12, 1994, NRC staff members met with representatives of Duke Power Company (DPC) to discuss the status of the Probabilistic Risk Assessment (PRA) being performed for the Keowee hydrostation. A list of meeting attendees is included as Enclosure 1. Copies of licensee handouts are included as Enclosure 2.

The licensee's presentation opened with an overview of the project, including the purpose and objective of the analysis, a description of the project scope and level of detail, the project team organization, and the project schedule. In response to a staff question, the licensee explained that the analysis did not include external events, and that the external events would be covered under the IPE for External Events. The presentation also covered a brief description of the PRA process and the identification of data for the analysis. As a follow-up to a question from the previous meeting on the status of this project, the licensee stated that the decision had been made to integrate the results of this PRA study into the IPE. A number of other questions concerning clarification of the PRA process being used by DPC were also discussed. The licensee presented the preliminary results of the Keowee reliability study. The licensee then presented preliminary results for AC power reliability and the effect on core melt frequency from integrating the preliminary PRA results into the IPE. The Keowee reliability results were analyzed for the delivery of power to the startup transformer for the overhead path or transformer CT-4 for the underground path. The licensee's preliminary results indicated that the probability of core damage resulting from a loss of off-site power was comparable to the IPE results for this event.

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At the conclusion of the meeting, the NRC staff requested that the licensee provide the most recent fault tree base case models for both the systems and the integrated model. In addition, cut sets were requested to show results of the base case and sensitivity studies. The licensee was requested to perform an analysis and provide the cut sets for one Keowee unit in maintenance and the other unit paralleled to the electrical off-site grid. The licensee agreed to each of these requests.

/s/
Leonard A. Wiens, Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II

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

Enclosures:
1. List of Meeting Attendees
2. Licensee Handouts

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MEETING ATTENDEES

KEOWEE PROBABILISTIC SAFETY ASSESSMENT
STATUS MEETING

October 12, 1994

NAME	ORGANIZATION
Len Wiens	NRC/NRR/PDII-3
Duncan Brewer	Duke Power/PRA
Mike Barrett	Duke Power/PRA
P. M. Abraham	Duke Power/PRA
Duc Nguyen	EELB/NRR
Homayoon Dezfulz	SCIENTECH INC
V. Beaston	NRR/DE/EELB
Ken Canady	Duke Power/Nuclear Eng.
Fred Burrows	EELB/NRR
Ed Burchfield	Duke/ONS/Regulatory Compliance
Clay A. Little	Duke/ONS/Elec. Eng.
Warren Swenson	NRR/SPSB
Marty Virgilio	NRC/DSSA
Stacey Rosenberg	NRR/DSSA/SPSB
Frank Quinn	SCIENTECH Inc.
Herb Berkow	NRC/NRR\PDII-3
Jeff Shackelford	NRC/RII/DRS/OPS
Reed Severance	Duke Power/ONS/Mech. Sys. Eng.
Jeff Rowell	Duke Power/ONS/Elect. Power Sys.
Michael Bailey	Duke Power/ONS/Regulatory Compliance

ATTACHMENT 1

Keowee PRA

NRC-Duke Meeting

October 12, 1994

Agenda

8:30	Introduction (P. M. Abraham)
8:45	Overview of KPRA (Duncan Brewer)
9:15	KPRA Analysis And Results (Mike Barrett)
10:30	Break
10:50	AC Power Reliability Results (Duncan Brewer)
11:20	AC Power Core Melt Frequency Results (Duncan Brewer)
12:00	Break
1:00	Questions and Answers

Keowee PRA

Overview of Keowee PRA Process

By Duncan Brewer

Outline

- **Purpose and Objects of the Study**
- **Project Plan**
- **Project Team**
- **Identification of Data**
  - **Component Failure Data**
  - **Common Cause Data**
  - **Human Reliability Data**

Objectives of the Study

- To Develop An Analytical Model Of The Keowee Hydro Station
- *To Integrate the Keowee Model into the Oconee PRA Models for AC Power and Core Damage Frequency*
- To Obtain An Estimate Of The Reliability Of Keowee As An Emergency Power Source,
- *To Determine Keowee's Importance to AC Power Reliability,*
- *To Determine Keowee's Importance to Core Damage Frequency*

Objectives of the Study

- To Compare the Estimated Reliability to the Observed Reliability During Normal Operation, Emergency Tests and Functional Tests
- The Insights Gained From This Analysis Will Be Used To Complement Efforts Which Are Currently Underway To Address Keowee Reliability Concerns

Project Scope

- Utilized PRA Methods Such As Fault Trees, Reliability Data, Success Criteria, And Modeling Of Appropriate Human Actions.
- The Required Mission Of The Keowee Hydro Station was To Start And Run To Provide Emergency Power To Oconee For All Probabilistically Significant Scenarios Resulting From Internal Initiating Events.

Project Scope

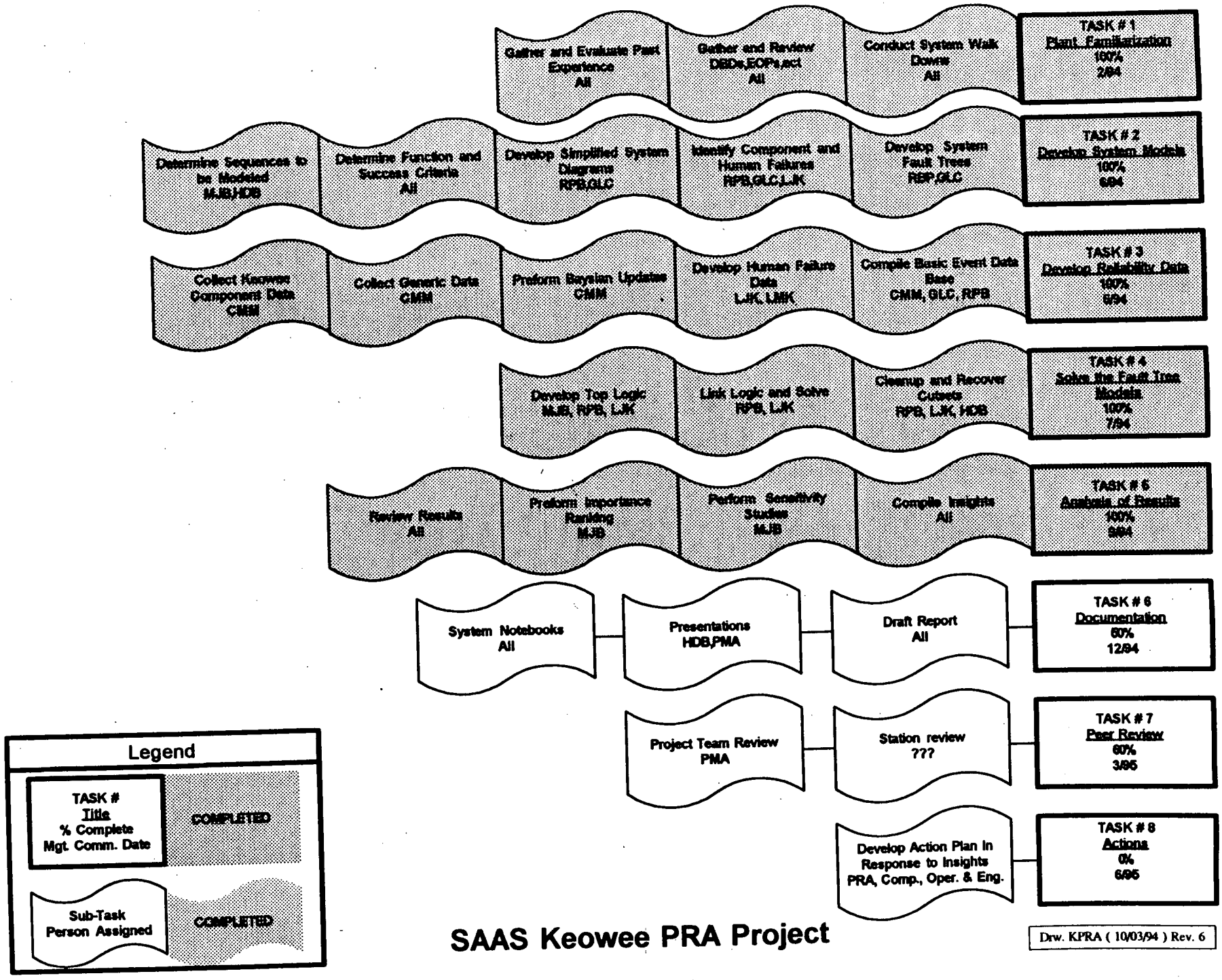
- The Model Includes All Important Components At A Level Appropriate For Gathering Statistically Significant Data.
- Support Systems Important To The Operation Of Keowee Were Also Modeled.

Project Team Organization

- Team Included System Analysts, Data Analysts, a Human Reliability Analyst, a Common Cause Analyst, and Plant Support Personnel
- 10 Members from Duke, One Outside Consultant Used for Independent Review

Task List and Schedule

• Plant Familiarization	2/94
• Develop System Models	6/94
• Develop Reliability Data	6/94
• Solve the Fault Tree Models	7/94
• Analysis of Results	9/94
• Documentation	12/94
• Peer Review	(Throughout Project)
• Actions	6/95


Gather and Evaluate Past Experience All
Gather and Review DBDs,EOPs,ect All
Conduct System Walk Downs All
TASK # 1 Plant Familiarization 100% 2/94
Determine Sequences to be Modeled MJB,HDB
Determine Function and Success Criteria All
Develop Simplified System Diagrams RPB,GLC
Identify Component and Human Failures RPB,GLC,LJK
Develop System Fault Trees RBP,GLC
TASK # 2 Develop System Models 100% 6/94
Collect Keowee Component Data CMM
Collect Generic Data CMM
Preform Bayesian Updates CMM
Develop Human Failure Data LJK, LMK
Compile Basic Event Data Base CMM, GLC, RPB
TASK # 3 Develop Reliability Data 100% 6/94
Develop Top Logic MJB, RPB, LJK
Link Logic and Solve RPB, LJK
Cleanup and Recover Cutsets RPB, LJK, HDB
TASK # 4 Solve the Fault Tree Models 100% 7/94
Review Results All
Preform Importance Ranking MJB
Perform Sensitivity Studies MJB
Compile Insights All
TASK # 5 Analysis of Results 100% 9/94
System Notebooks All
Presentations HDB,PMA
Draft Report All
TASK # 6 Documentation 60% 12/94
Project Team Review PMA
Station review ???
TASK # 7 Peer Review 60% 3/95
Develop Action Plan In Response to Insights PRA, Comp., Oper. & Eng.
TASK # 8 Actions 0% 6/95
Legend
TASK # Title % Complete Mgt. Comm. Date
COMPLETED
Sub-Task Person Assigned
COMPLETED
SAAS Keowee PRA Project
Drw. KPRA (10/03/94) Rev. 6

Identification of Data

Component Failure Data

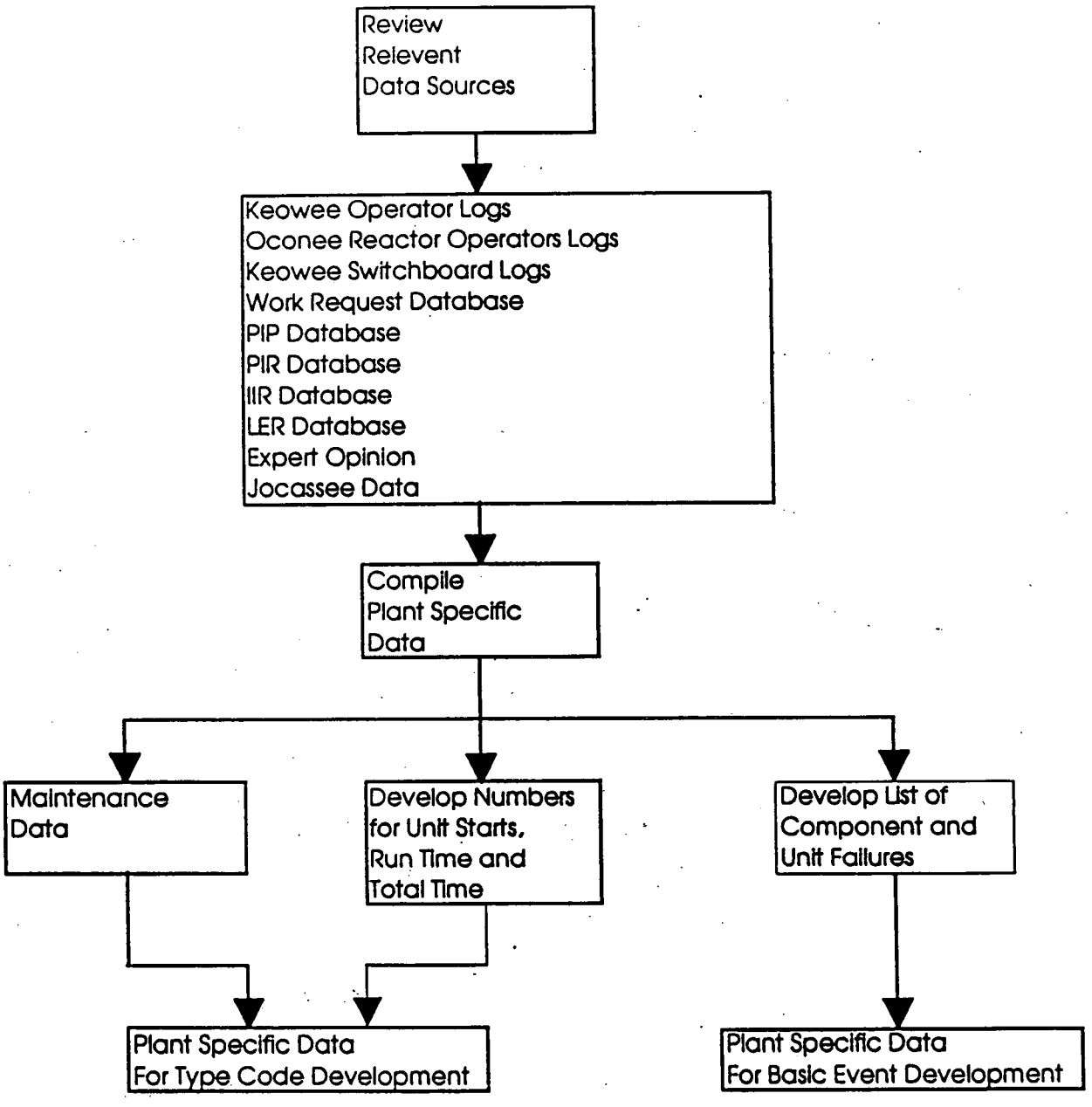
- Plant Specific Data was Collected for all Components in the Model
- Failure Data Was Collected by Review of Operator Logs and Keowee Work Requests
- Demands and Run Hours for the Period of Record Were Estimated by the System Analysts
- Generic Data was Developed from Multiple Sources of Generic Data

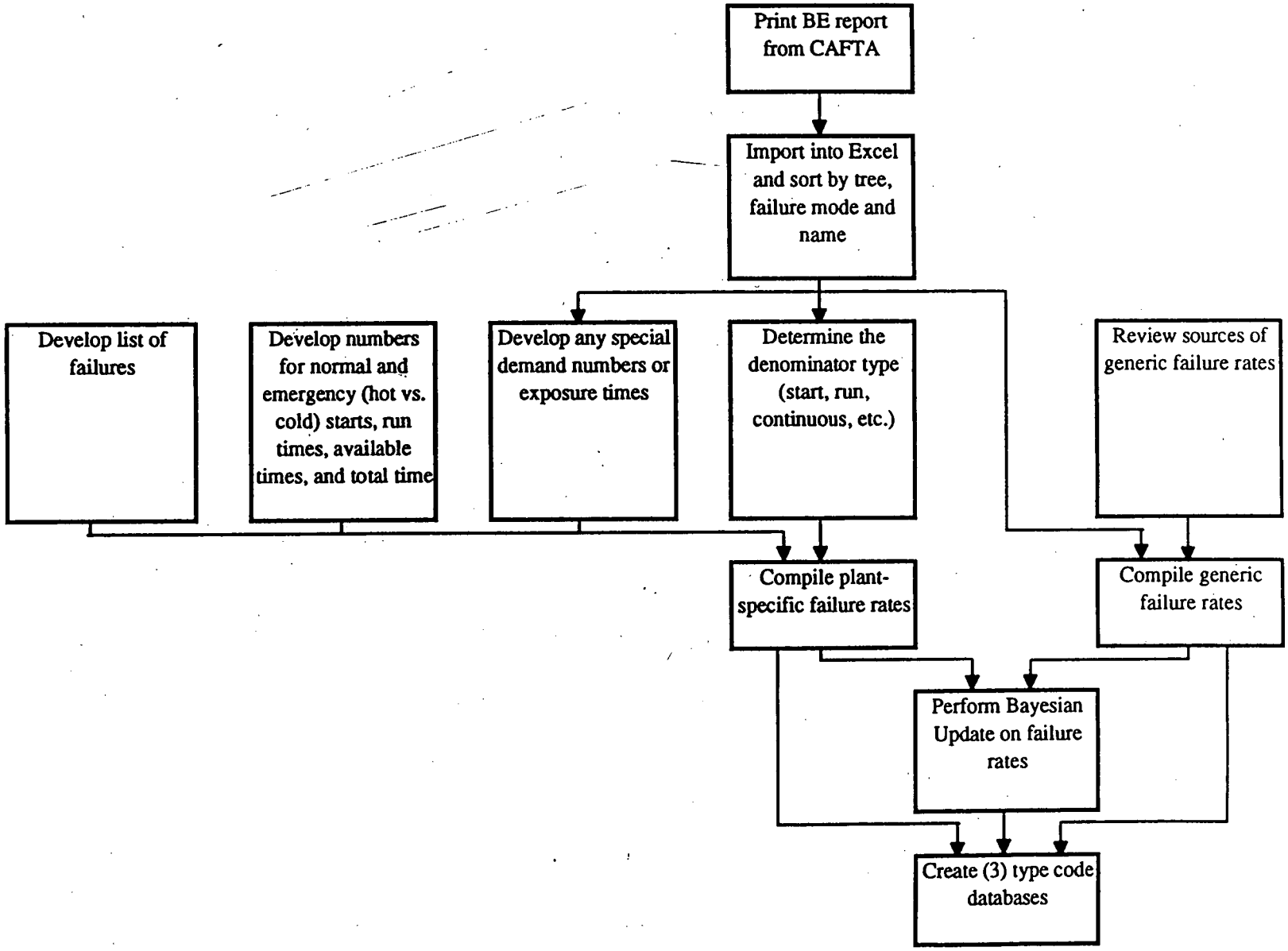
Identification of Data

Component Failure Data

- The Data Base Used For the Solution and Sensitivity Studies was a Bayesian Updated Combination of the Generic and Plant Specific Data
- We Retained the Ability to Calculate the Results with Generic Data, Plant Specific Data, or the Combined Data

Keowee PRA Plant Specific Data Collection Process





Keowee Reliability Assessment Type Code Development Flow Chart

Identification of Data

Common Cause Data

- Objective - Qualitatively And Quantitatively Evaluate Potential Common Cause Failure Modes Of Keowee
- Reviewed Operating Experience and System Models to Determine Appropriate Events
- Events Included at Both the System and Component Level
- Used EPRI CCDAT Software

Keowee PRA CCF Assessment Process

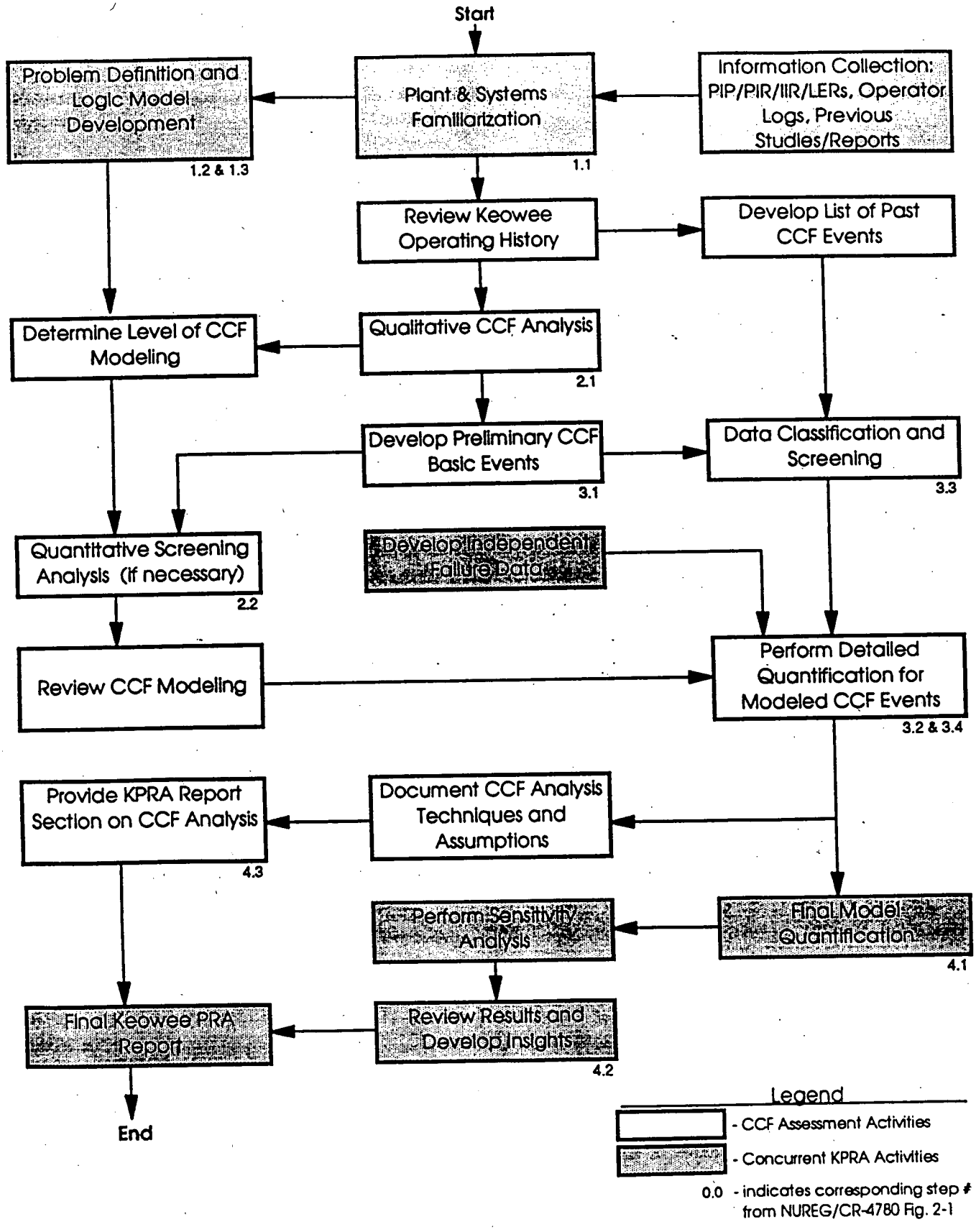


Figure X-1

Revised 5/19/94

Identification of Data

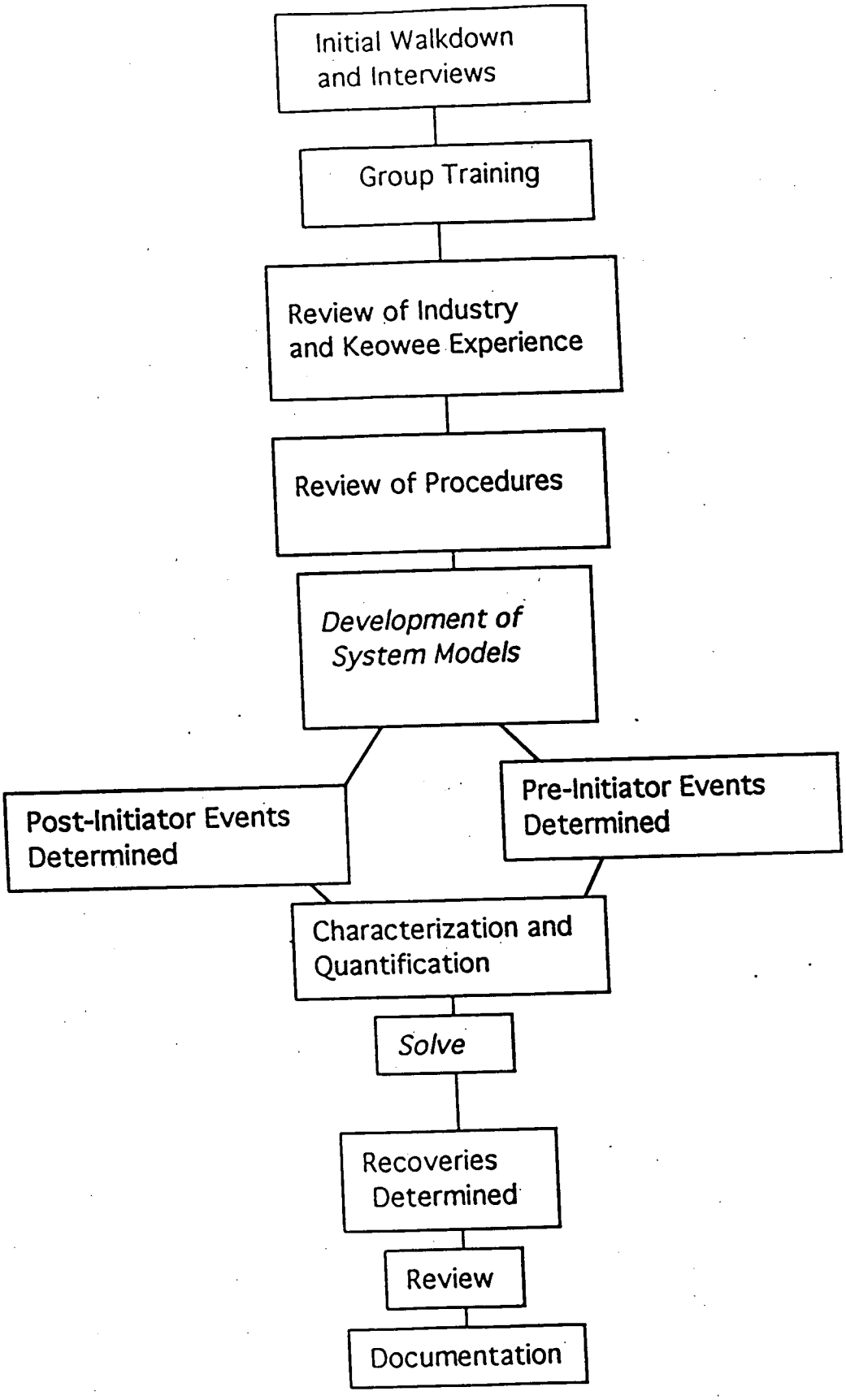
Human Reliability Data

- Reviewed Operating Experience
- Reviewed System Models
- Determined Appropriate Human Error Events
- Modeled Pre-initiator Errors , Post Initiator Errors and Recovery Errors
- Also, Performed a Qualitative Review for Errors of Commission

Identification of Data

Human Reliability Data

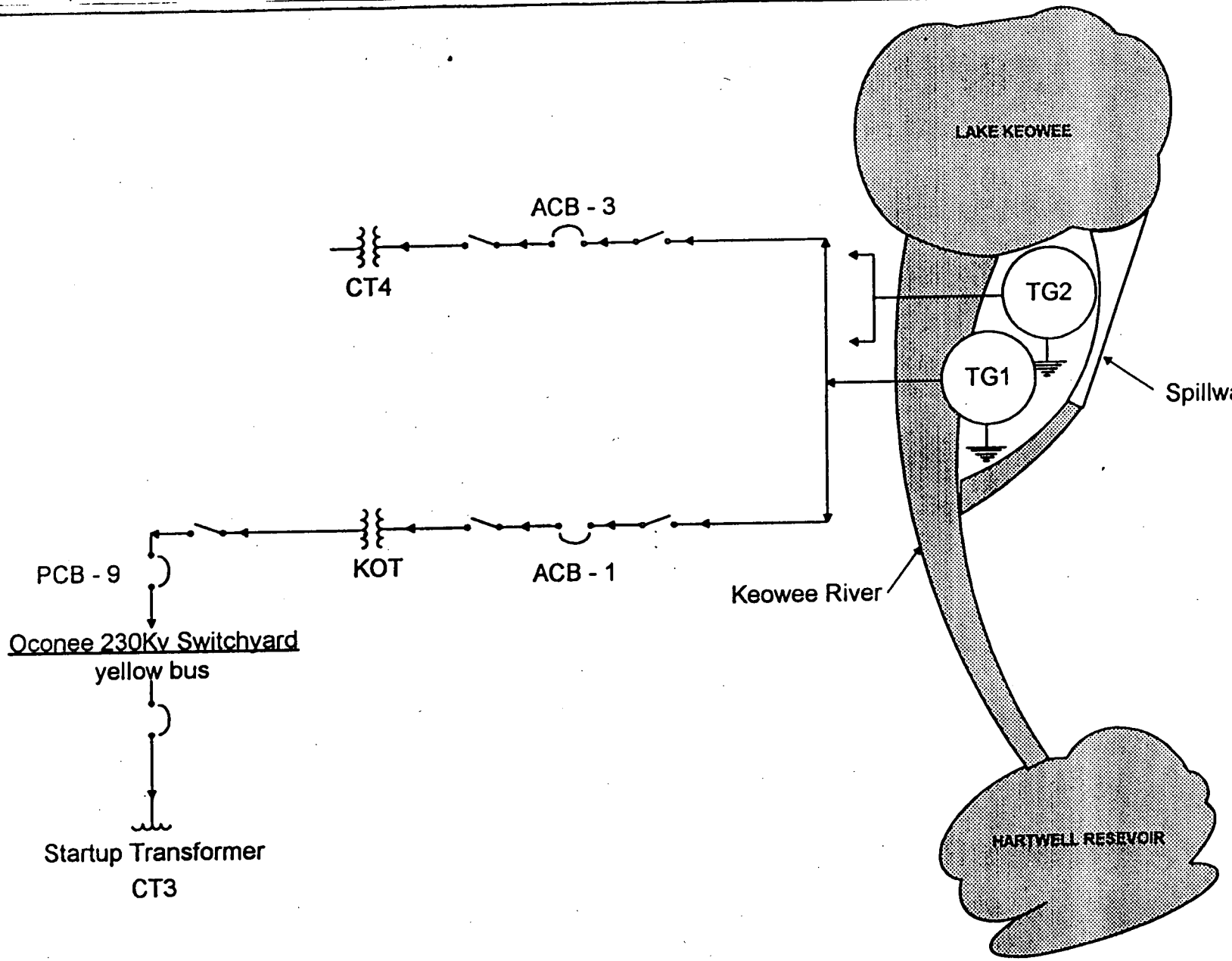
- Used NUREG/CR-1278 (THERP) Method to Quantify Pre-initiator Errors
- Used EPRI TR-100259 "Decision Tree" Method to Quantify Post Initiator Errors


Initial Walkdown and Interviews
Group Training
Review of Industry and Keowee Experience
Review of Procedures
Development of System Models
Post-Initiator Events Determined
Pre-Initiator Events Determined
Characterization and Quantification
Solve
Recoveries Determined
Review
Documentation

Keowee PRA

Reliability Analysis and Results

Mike Barrett



Keowee Generator System Schematic

Drw. PMA pg 1 (06/21/94) Rev. 4

Keowee Overview

Keowee Systems

- **Excitation System**
- **Air Circuit Breakers**
- **Auxiliary AC Power**
- **Auxiliary DC Power**
- **Generator**
- **Keowee Start-up Controls**

Keowee Overview (cont'd)

Keowee Systems (cont'd)

- Turbine
- Governor
- High Pressure Oil System
- Governor Air System
- Governor Oil System
- Guide Bearing Oil System
- Turbine Sump System

Keowee Overview (cont'd)

Switchyard and Oconee Components and Systems

- Underground Cable
- Transformer CT4
- Switchyard DC Power System
- External Grid Trouble Protection System
- Switchyard Power Circuit Breakers
- Transformer CT3

Modeling

Objectives

- **Address all potential modes of operation of the Keowee units**
- **Include all components/systems necessary for the emergency operation of the Keowee units**
- **Include in the models the important failure modes that have been experienced**

Modeling (cont'd)

Scope

- Keowee components important for Keowee to provide emergency power to Oconee
- The underground path up to and including CT4
- The overhead path up to and including CT3
- Switchyard isolation logic

Modeling (cont'd)

14 Individual Fault Trees

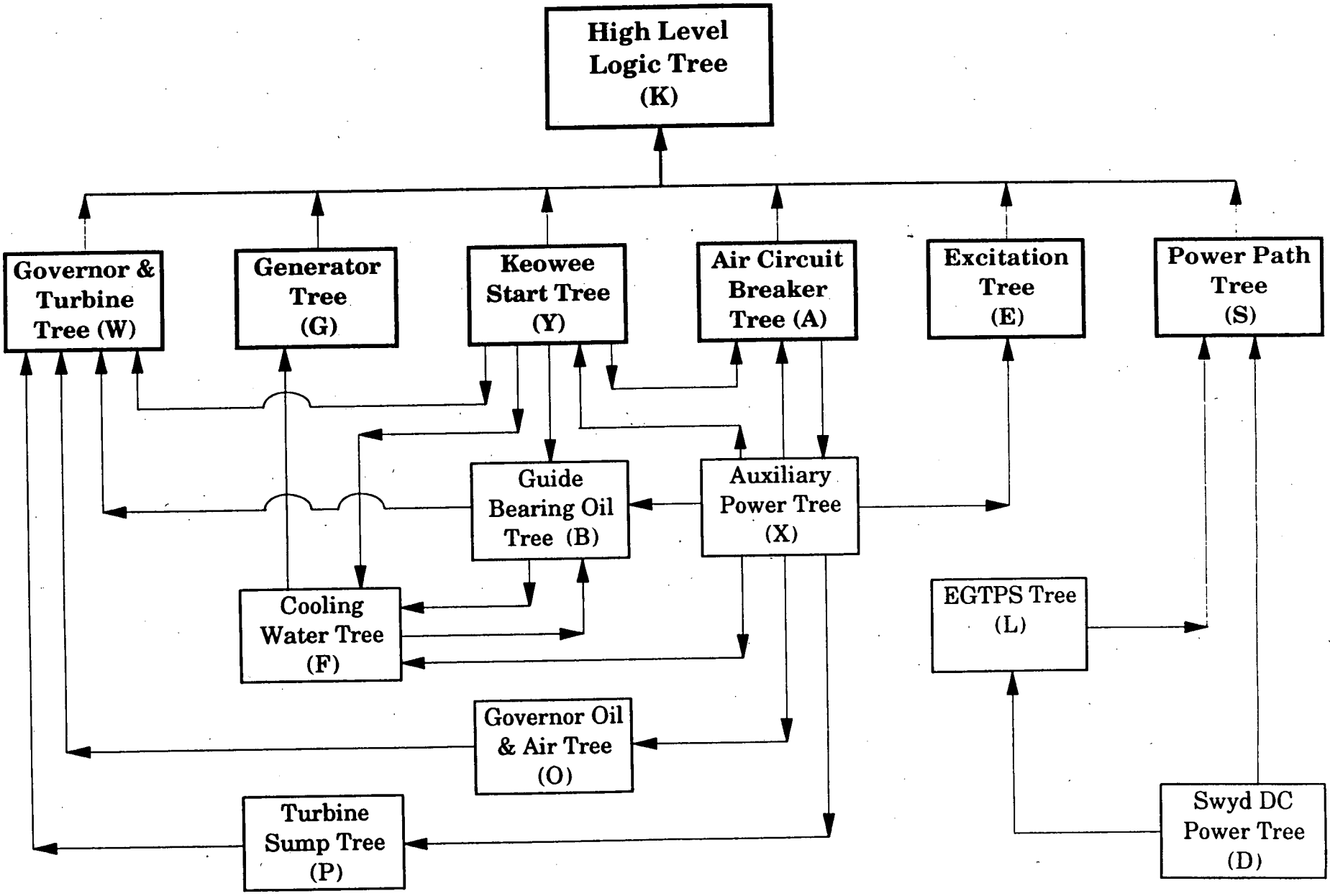
- **High Level Logic Model**
- **13 System/Component Trees**

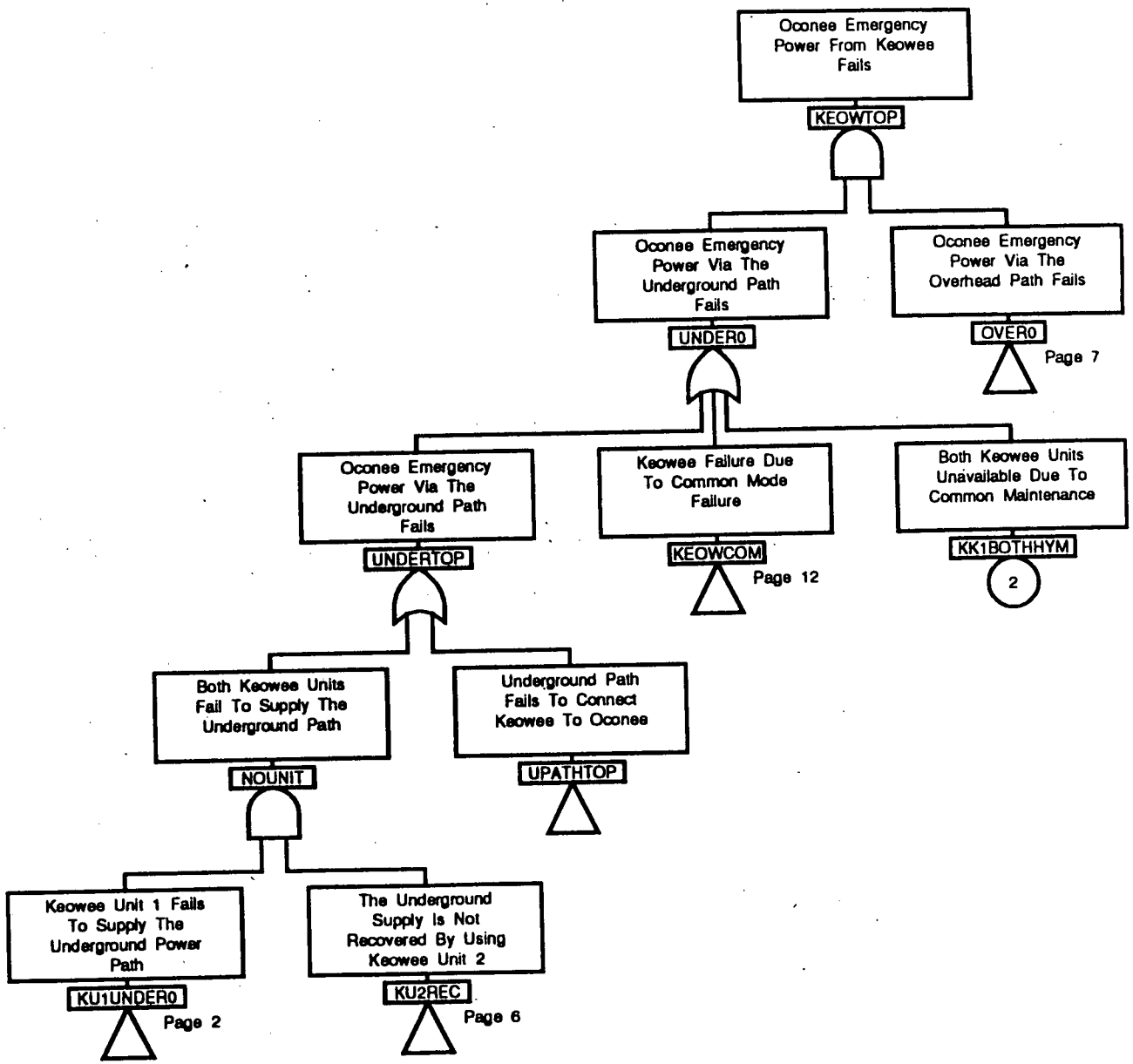
Modeling (cont'd)

High Level Logic Model

- Combines the individual sytem/component failures into an overall Keowee power supply failure
- Factors in the various operating configurations of the Keowee units
- Provides intermediate gate results for determining the reliability of individual units/paths

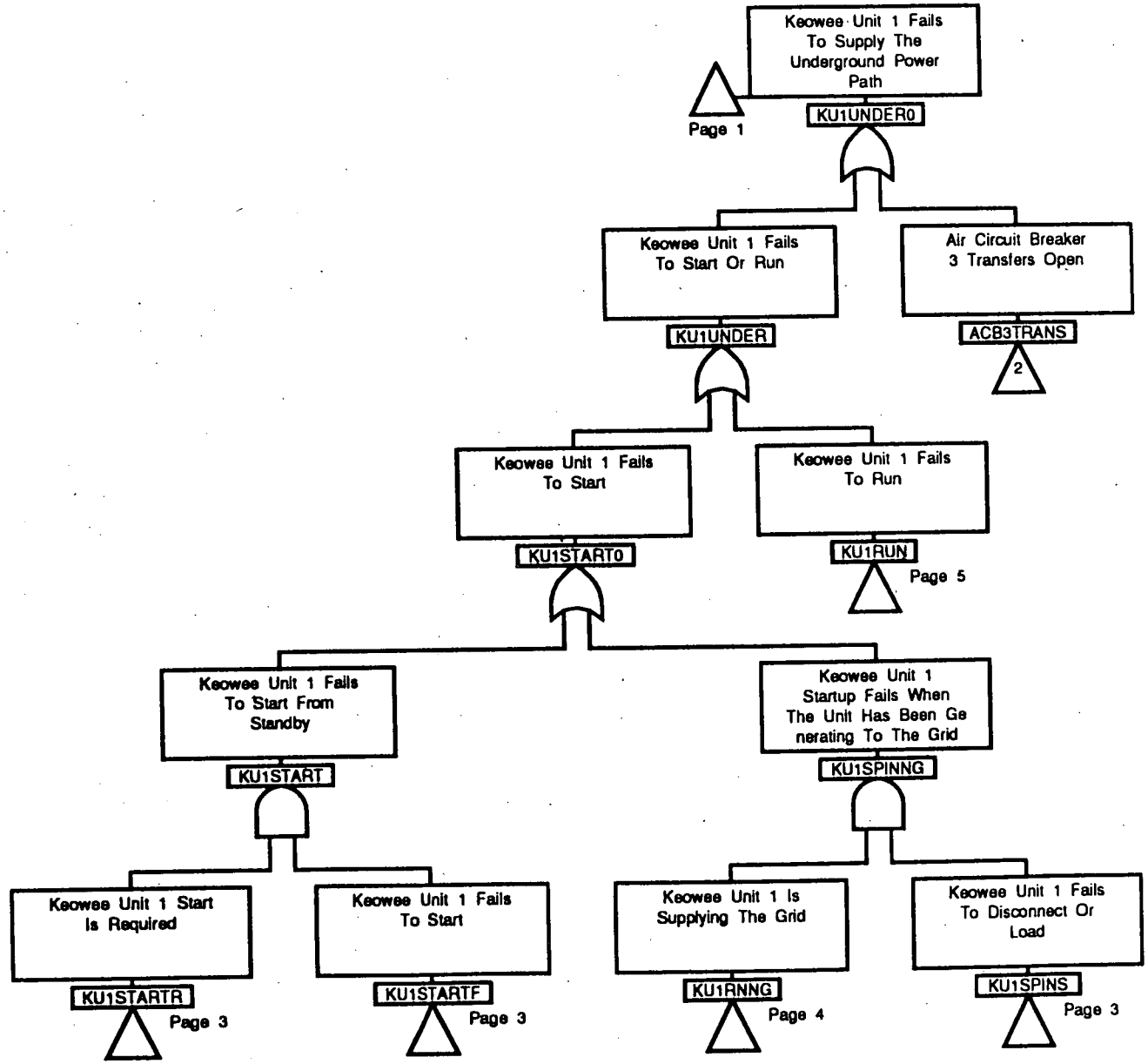
Keowee Fault Tree Overview





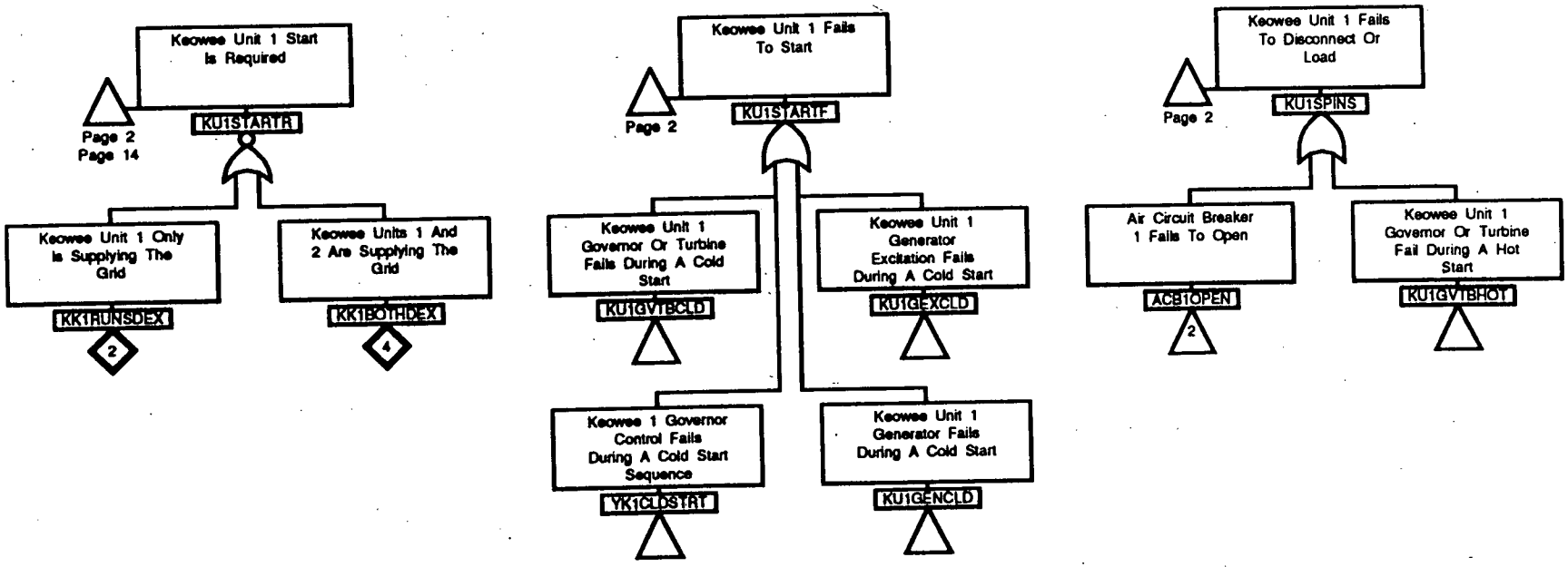
High Level Logic Model

Page 1



High Level Logic Model

Page 2



High Level Logic Model

Page 3

Modeling (cont'd)

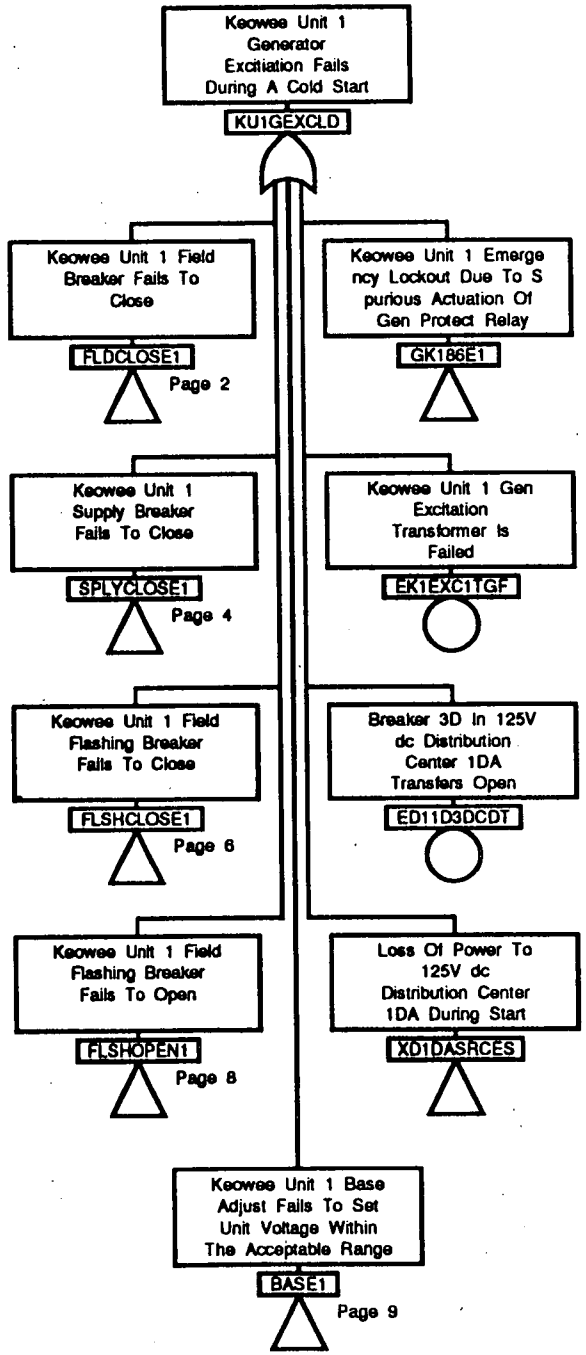
System/Component Fault Tress

- **Air Circuit Breakers**
- **Guide Bearing Oil**
- **Switchyard DC Power**
- **Generator Excitation**
- **Cooling Water**
- **Generator**
- **External Grid Trouble Protection System**

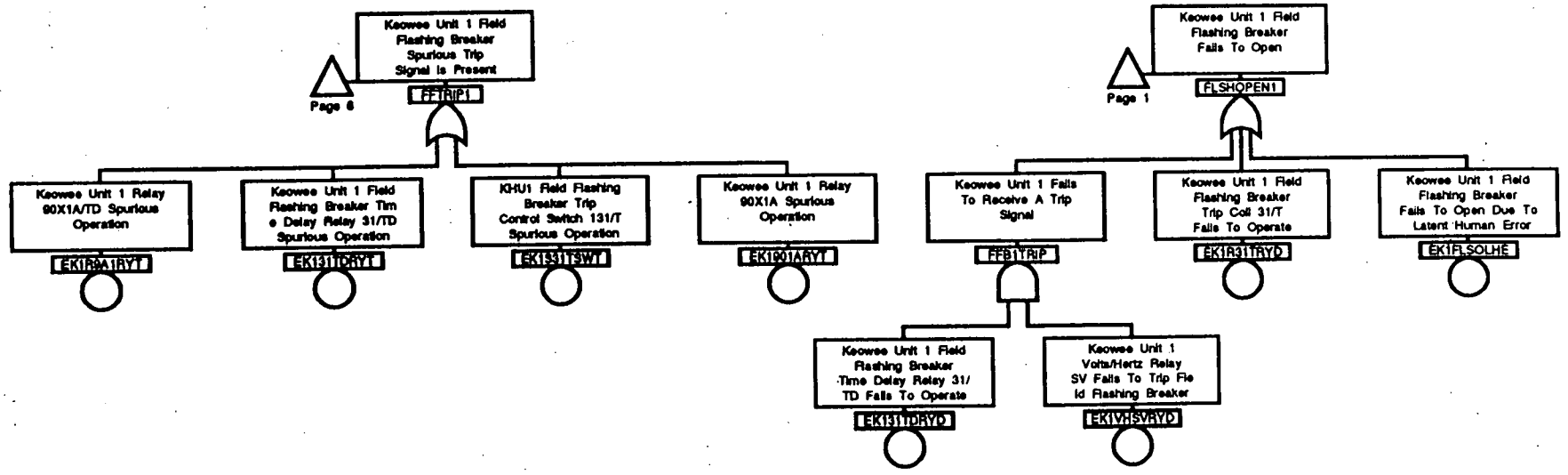
Modeling (cont'd)

System/Component Fault Tress (cont'd)

- Governor Oil and Air
- Turbine Sump
- Power Paths
- Governor and Turbine
- Auxiliary AC and DC Power
- Keowee Start



Generator Excitation | Page 1


Keowee Unit 1 Field Flashing Breaker Spurious Trip Signal Is Present
FFTRIP1
Page 6
Keowee Unit 1 Relay 90X1A/TD Spurious Operation
EK1R90A1RYT
Keowee Unit 1 Field Flashing Breaker Tim e Delay Relay 31/TD Spurious Operation
EK1311TDRYT
K1HU1 Field Flashing Breaker Trip Control Switch 131/T Spurious Operation
EK1S311TSWT
Keowee Unit 1 Relay 90X1A Spurious Operation
EK1R01ARYT
Keowee Unit 1 Field Flashing Breaker Fails To Open
FLSHOPEN1
Page 1
Keowee Unit 1 Fails To Receive A Trip Signal
FFB1TRIP
Keowee Unit 1 Field Flashing Breaker Trip Coil 31/T Fails To Operate
EK1R311TRYD
Keowee Unit 1 Field Flashing Breaker Fails To Open Due To Latent Human Error
EK1FLSOUHE
Keowee Unit 1 Field Flashing Breaker Time Delay Relay 31/ TD Fails To Operate
EK1311TDRYD
Keowee Unit 1 Volts/Hertz Relay SV Fails To Trip Fie ld Flashing Breaker
EK1VHSVRYD

Results

Base case analysis considers:

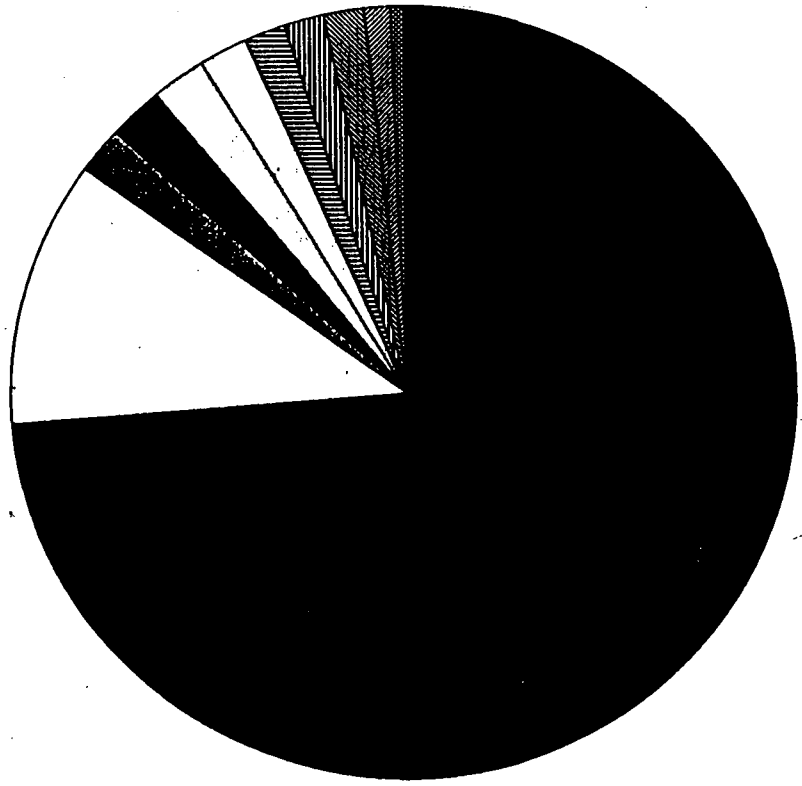
- **the current operating mode, restricted to one unit generating to the grid,**
- **operator recovery from certain unit failures.**

Probability that Keowee fails to supply power to Oconee **7.05E-03**

Results (cont'd)

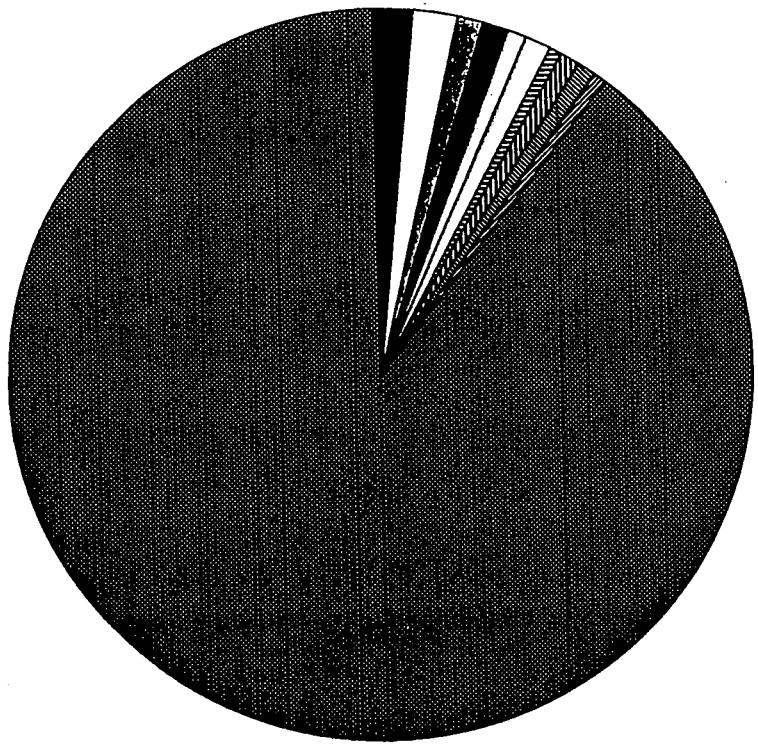
1)	Both Keowee Units Unavailable Due To Common Maintenance	5.23E-03	5.23E-03
2)	A Single Keowee Unit Is Unavailable Due To Maintenance	1-3.80E-02	1.55E-04
	Common Cause Failure Of Both Unit's WL Filters Due To Intake Debris	2.55E-03	
	Failure To Recover Flow Through Clogged Main Strainer	6.30E-02	
3)	A Single Keowee Unit Is Unavailable Due To Maintenance	1-3.80E-02	1.54E-04
	Keowee Unit 1 Only Is Supplying The Grid	1-0.0	
	Keowee Unit 2 Only Is Supplying The Grid	1-2.44E-02	
	Keowee Unit 1 and 2 Are Supplying The Grid	1-0.0	
	Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breaker	1.64E-04	1.64E-04

Relative Importance of the Top Ten Basic Events for "Oconee Emergency Power From Keowee Fails"



- Both Keowee Units Unavailable Due To Common Maintenance
- A Single Keowee Unit Is Unavailable Due To Maintenance
- Common Cause Failure Of Both Unit's WL Filters Due To Intake Debris
- Failure To Recover Flow Through Clogged Main Strainer
- Units 1 & 2 Excit Fail Due To Common Cause Failure Of The Breakers
- KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
- Keowee Unit 1 Generator Fault While the Unit Runs
- Failure To Recover Keowee Auxiliary Power Breakers
- Common Cause Failure Of All Keowee Auxiliary Power Breakers
- Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
- Remainder

Relative Importance of the Top Ten Basic Events for "Oconee Emergency Power From Keowee Fails" Excluding Common Cause, Maintenance and Recoveries



- KHU-1 Voltage Adjust Failure Drives Generator Output Too High/Low
- Keowee Unit 1 Generator Fault While the Unit Runs
- Air Circuit Breaker 7 Fails To Close Due To Mechanical Failure
- KHU-1 Base Adjust Fails To Maintain Generator Output Within Acceptable Range
- Keowee Unit 1 Gov. Fails to Position Wicket Gates With Unit Running
- Keowee Unit 1 Turbine Fails With the Unit Running
- Keowee Battery No. 1 Fails During Discharge
- KHU-2 Voltage Adjust Failure Drives Generator Output Too High/Low
- Keowee Unit 2 Generator Fault While the Unit Runs
- ACB Air Supply Fails Causing Low Pressure In All ACB Accumulators
- Remainder

Results (cont'd)

Overhead and Underground Supply Failure Probabilities

. Underground Power Supply	2.8E-02
. Overhead Power Supply	6.6E-02

Note: Common cause failures and double maintenance are not included in these results.

Results (cont'd)

Unit & Path Failure Probabilities

. Overhead path	9.4E-02
. Underground path	1.1E-03
. Operational unit (KU2)	1.9E-02
. Standby unit (KU1)	2.5E-02

Results (cont'd)

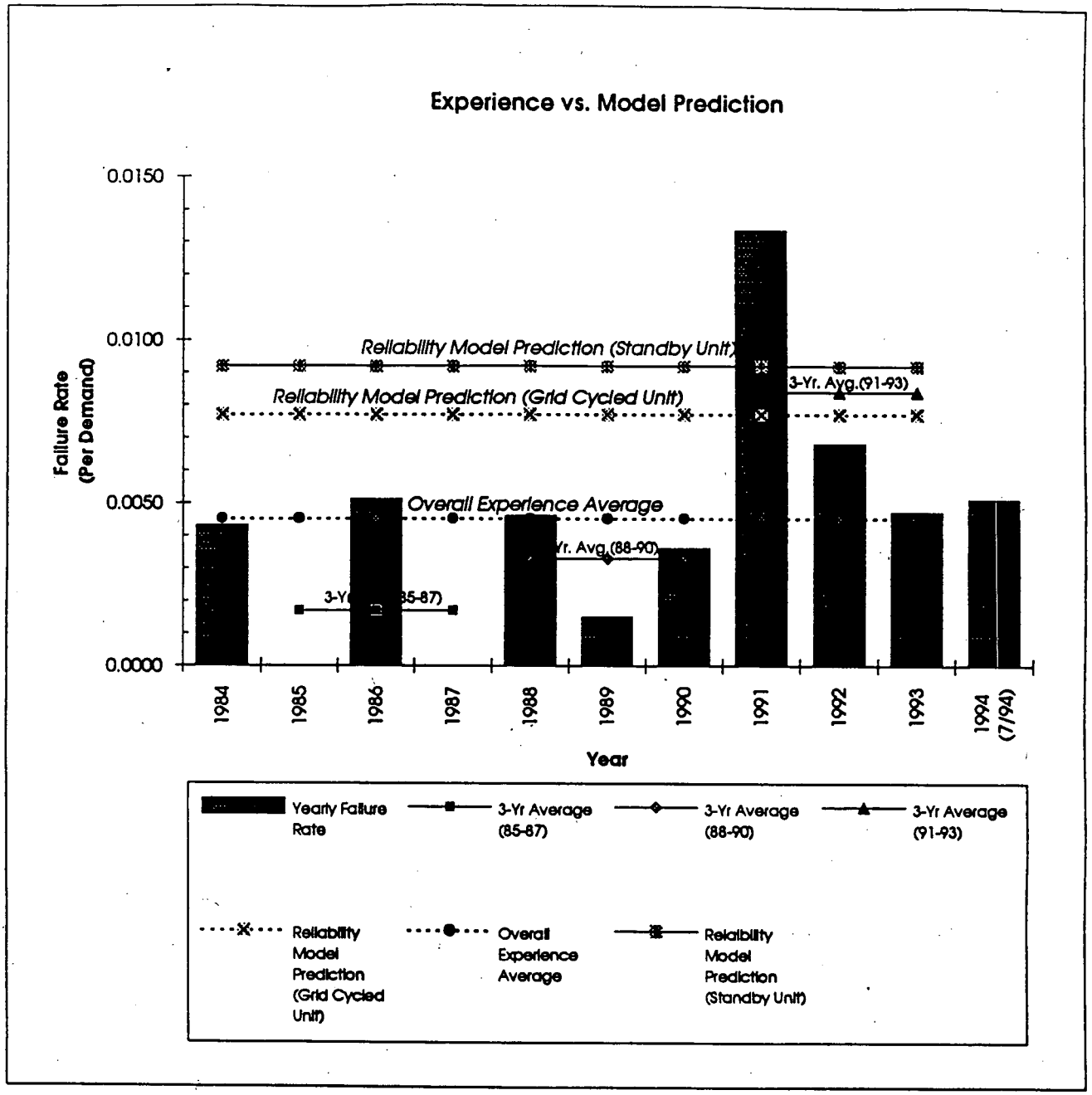
Gate Name	Result - Generic Data with no credit for recoveries	Result - Bayesian Updated Data with no credit for recoveries
KEOWTOP	1.3E-02	1.0E-02
KU1RUN	3.0E-02	1.6E-02
KU1STARTF	1.6E-02	9.2E-03
KU2RUN	1.8E-02	1.2E-02
KU2STARTF	1.1E-02	7.8E-03

Results (cont'd)

Sensitivity Studies

	1 Unit Operational	2 Units Operational
Recovered	7.05E-03	6.88E-03
Unrecovered	1.01E-02	9.75E-03

KEOWEE START FAILURE PROBABILITY



DATA SUMMARY

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994•(7/94)
Yearly Failure Rate	0.0043	0.0	0.0051	0.0	0.0046	0.0015	0.0036	0.0134	0.0068	0.0047	0.0051
3-Yr Average (85-87)			0.0017								
3-Yr Average (88-90)						0.0033					
3-Yr Average (91-93)									0.0084		
Reliability Model Prediction (Grid Cycled Unit)						0.0077					
Reliability Model Prediction (Standby Unit)						0.0092					
Overall Experience Average						0.0045					

KEOWEE 24 Hr. RUN FAILURE PROBABILITIES

Reliability Model Prediction (Standby Unit)	***0.016***
Reliability Model Prediction (Grid Cycled Unit)	***0.012***
Overall Experience (10 Year Average)	***0.012***

Modifications

Part AL1

Deal with the single failure concern over the differential relaying zone overlap (ACB-1)

Automatically transfer the available overhead unit to the underground path

Modifications (cont'd)

Part BL1

Prevent connecting Keowee To Oconee when the Keowee unit is generating at too high a frequency

- **overspeed on load rejection**
- **governor failure**

Open and reclose the underground breaker if that unit is generating to the grid

Modifications (cont'd)

BL1 (cont'd)

ACB-3 fail to close probability ~ 8.7E-03

Applicable only when unit is generating to the grid
~6% of the time

Failure contribution ~5.2E-04

Modifications (cont'd)

BL1 (cont'd)

Prevent closure of ACBs 1 through 4 if frequency is too high

Prevent closure of breakers SK1 and SK2 if frequency is too high, most significant new failure mode is on the order of 7.0E-06

Trip ACBs 1 through 4 if governor failure is detected

Keowee PRA

AC Power Reliability Results

By Duncan Brewer

Outline

- Objectives
- Oconee AC Power System Overview
- Method
- Fault Tree
- Application of Recoveries
- Results

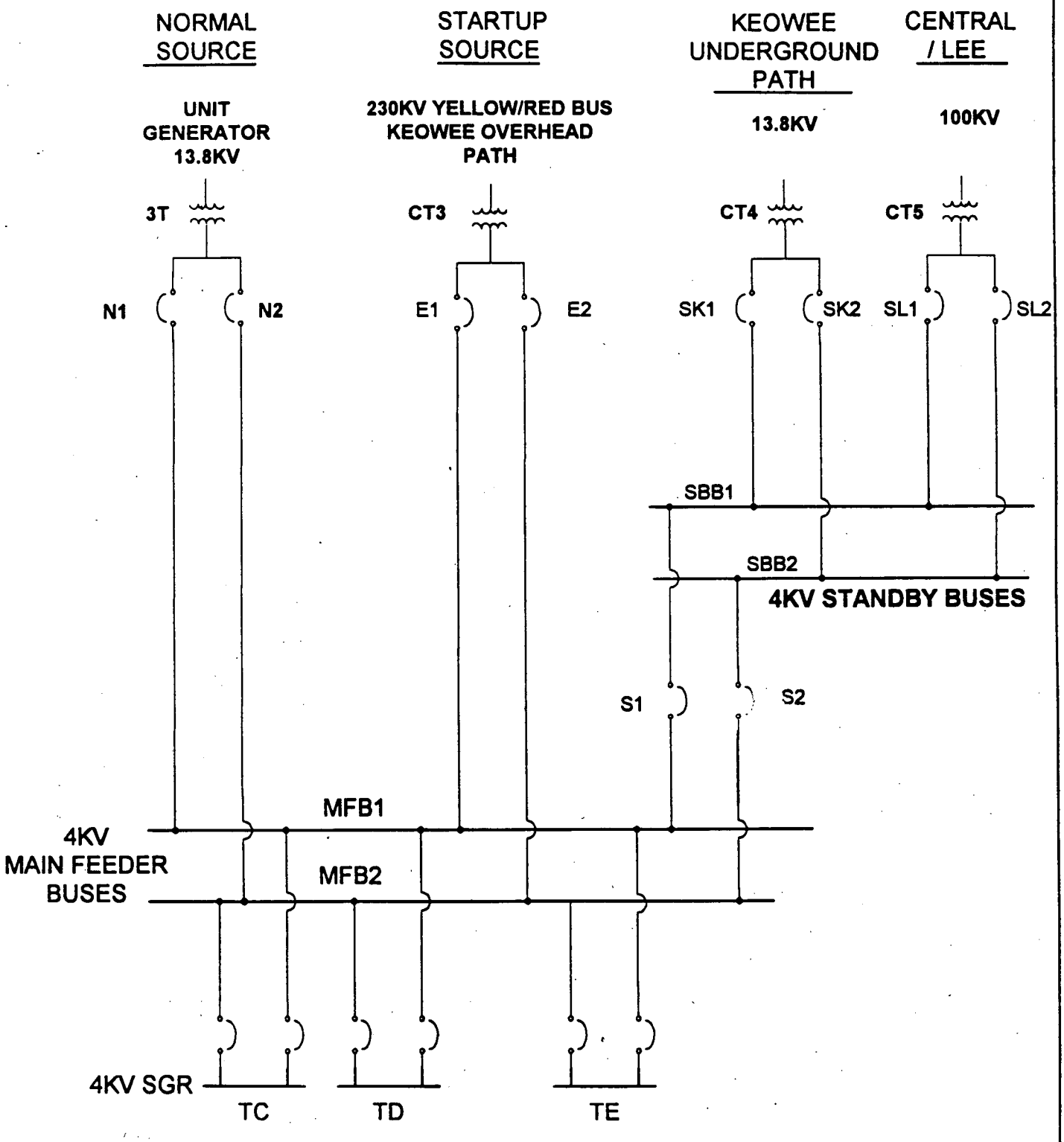
Objective

- To Determine the Reliability of the Oconee AC Power System
- To Allow Importance Ranking of Keowee Systems and Components Relative to the Complete Oconee Power System
- To Account for the Impact of Initiating Events on the Overhead Path

Oconee AC Power System Overview

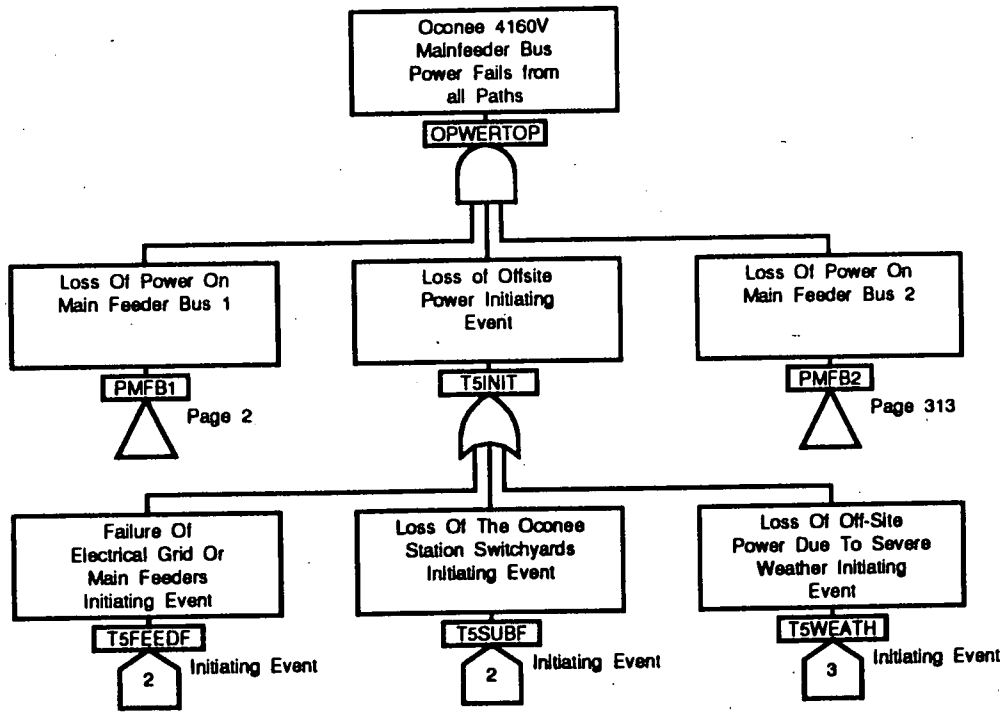
- One Keowee Unit Aligned to Overhead Path
- One Keowee Unit Aligned to the Underground Path
- The 100 kV Path from Lee Combustion Turbine Through Central Switchyard and CT5 Transformer
- Any One Can Power Both Main Feeder Busses

OCONEE AC POWER SYSTEM

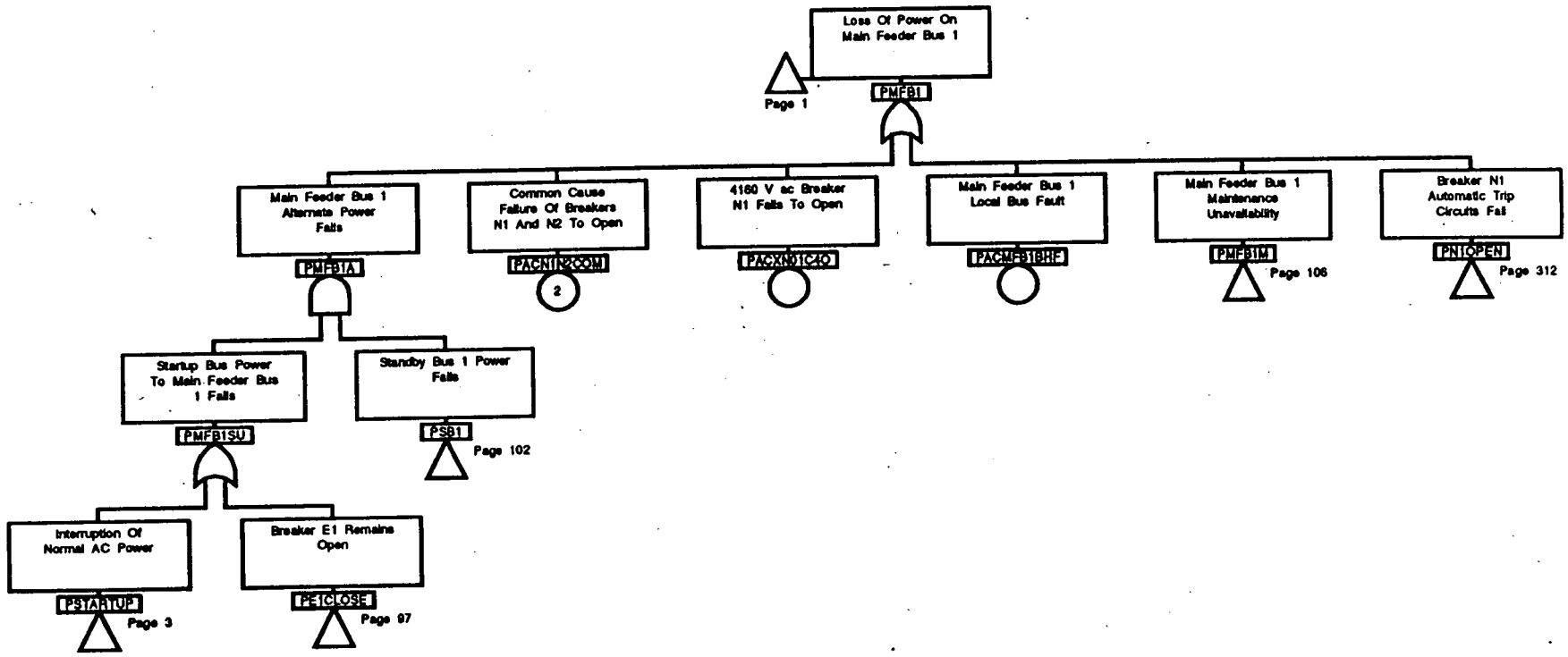


Method

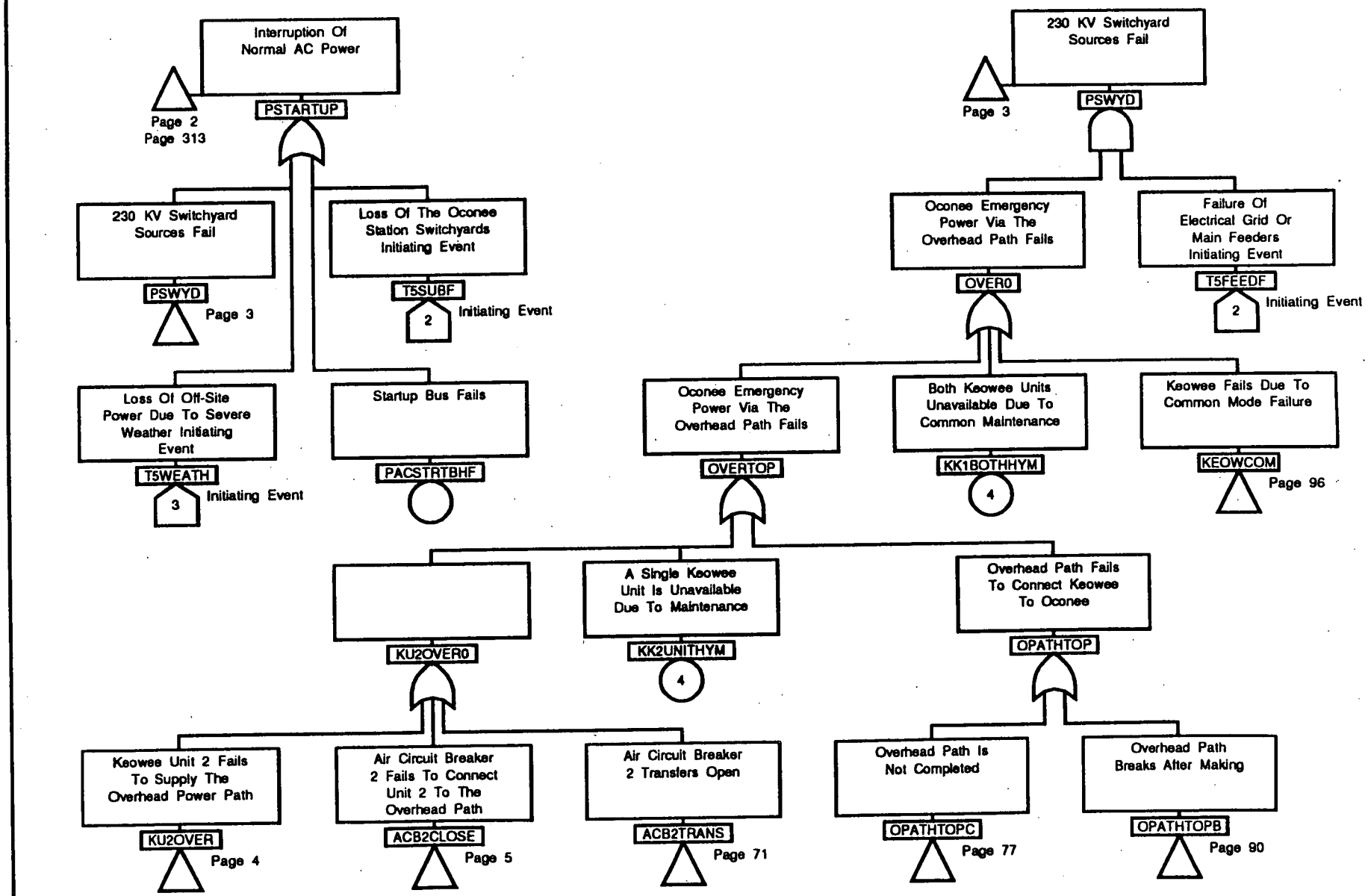
- Started with Oconee IPE Model for AC Power System
- Linked with DC Power System from Oconee IPE
- Cut Out Old Keowee Model
- Linked in the New Keowee Model
- Combined the Keowee and Oconee Data Bases
- Solved the New Tree
- Applied Keowee and Oconee Recoveries



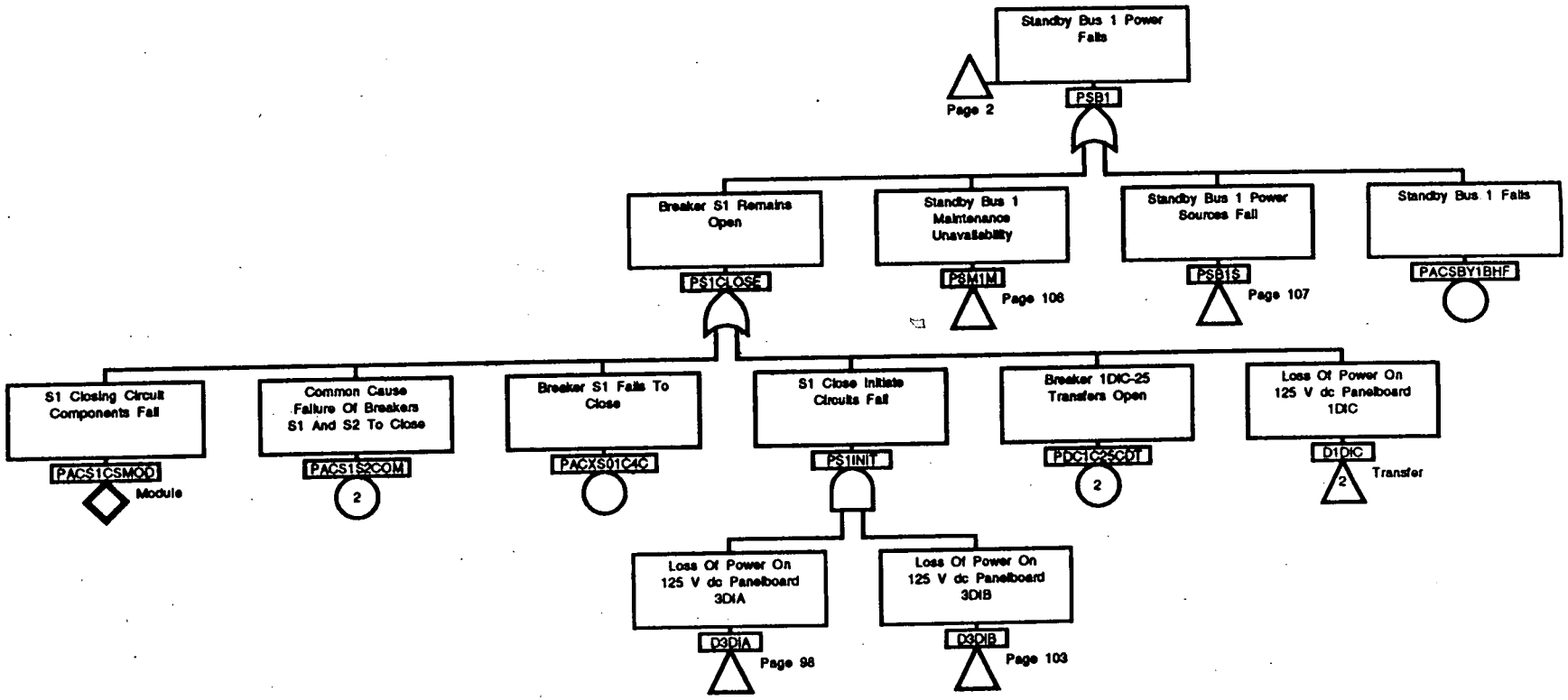
Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 1

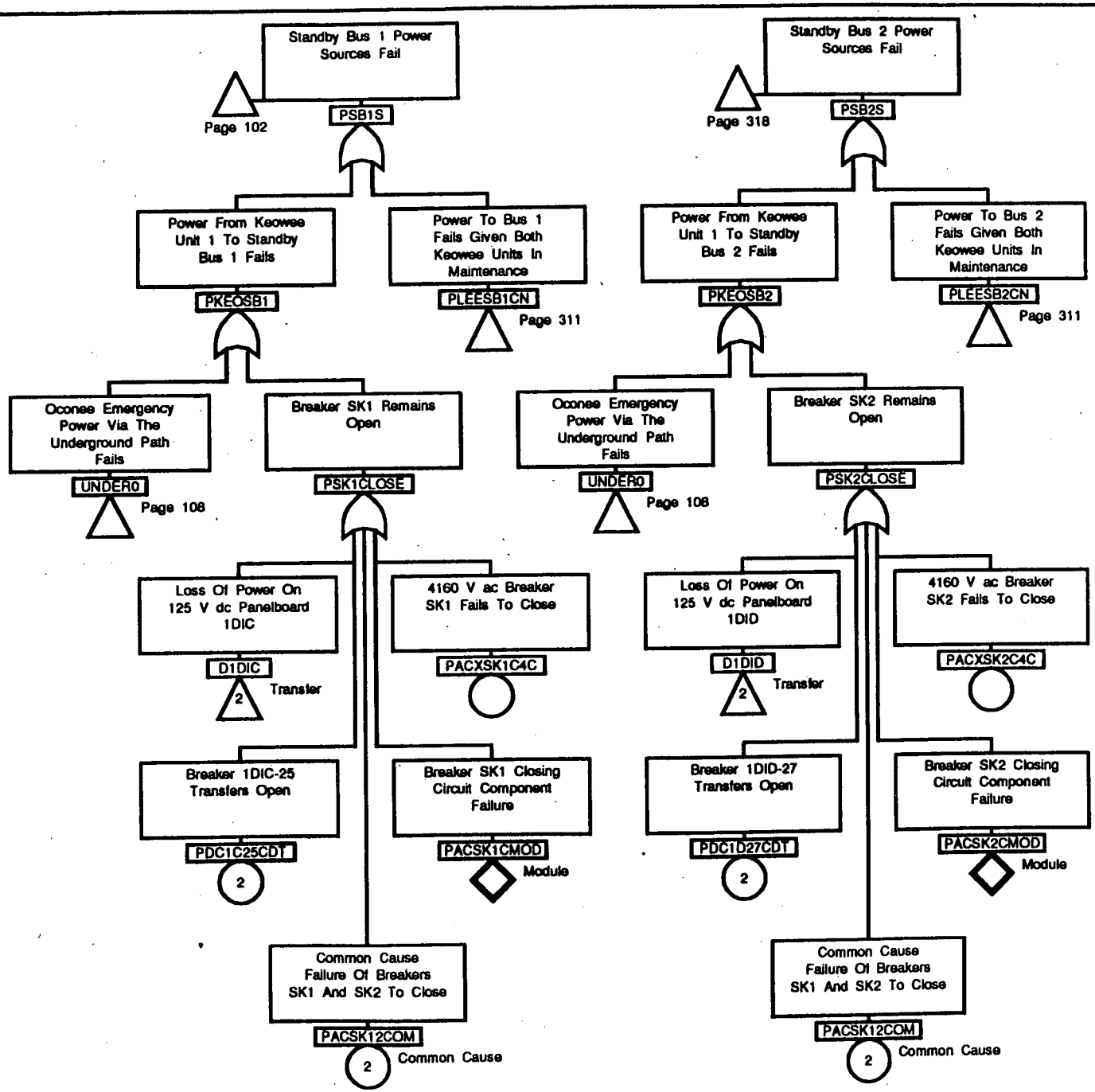


Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 2

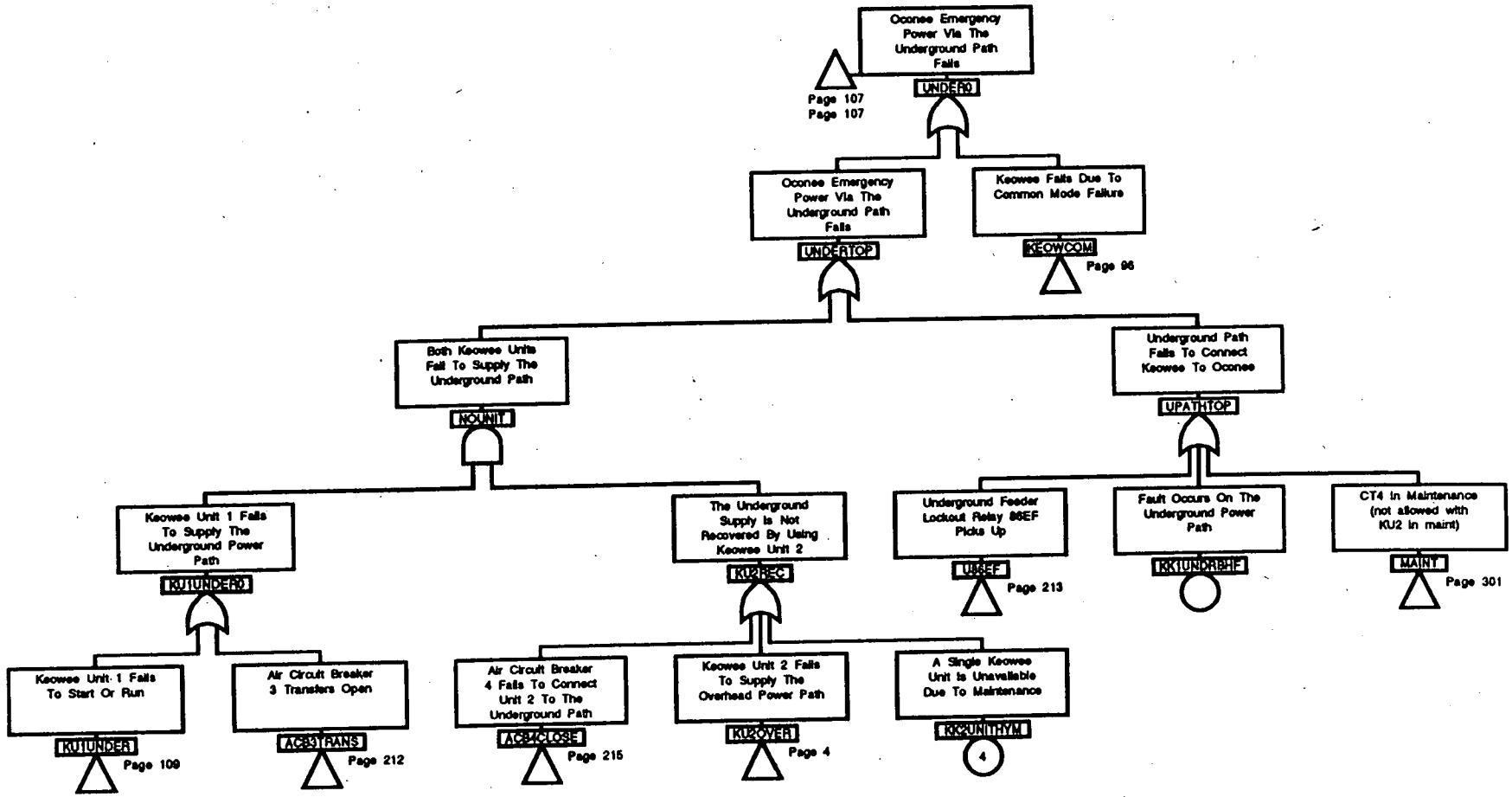


Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 3

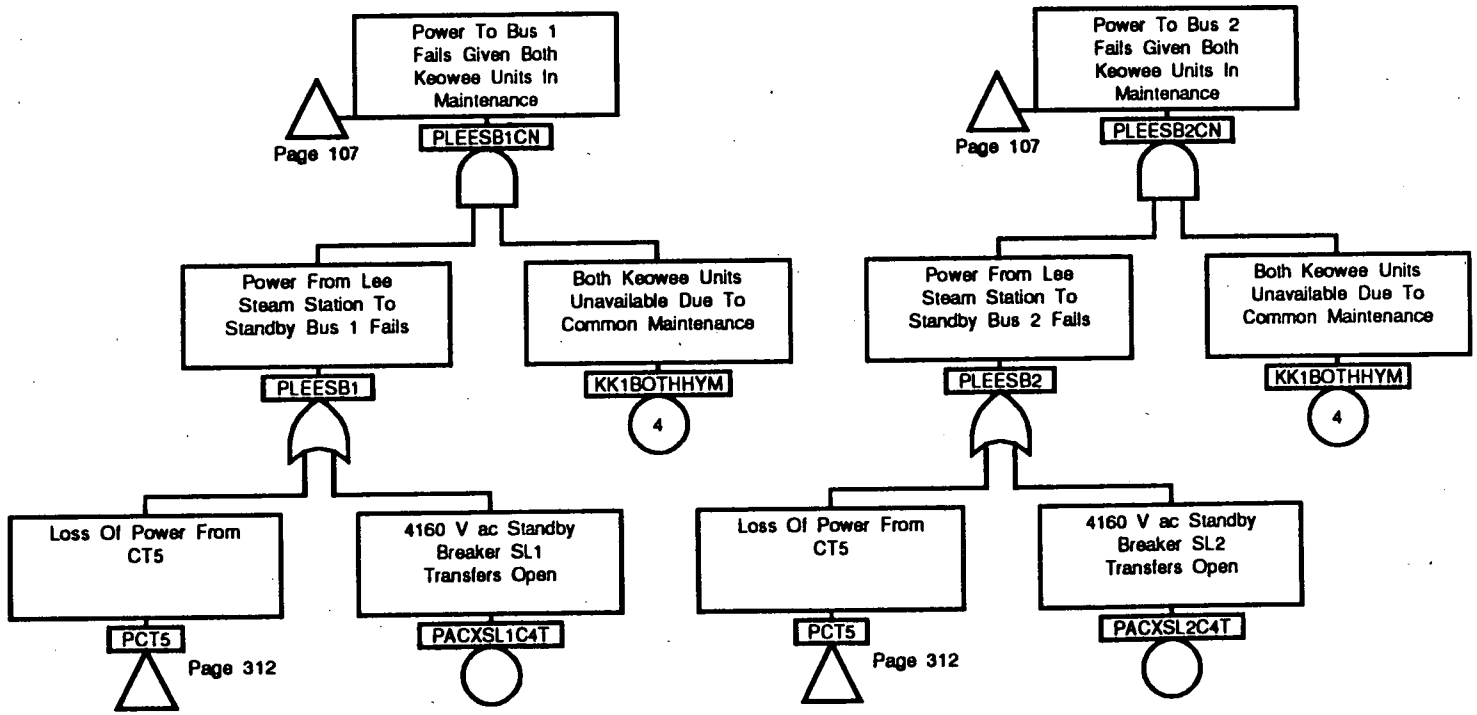

Standby Bus 1 Power Fails
PSB1
Page 2
Breaker S1 Remains Open
PS1CLOSE
Standby Bus 1 Maintenance Unavailability
PSM1M
Page 106
Standby Bus 1 Power Sources Fail
PSB1S
Page 107
Standby Bus 1 Fails
PACSBY1BHF
S1 Closing Circuit Components Fail
PACS1CSMOD
Module
Common Cause Failure Of Breakers S1 And S2 To Close
PACS1S2COM
2
Breaker S1 Fails To Close
PACXS01C4C
S1 Close Initiate Circuits Fail
PS1INIT
Breaker 1DIC-25 Transfers Open
PDC1C25CDT
2
Loss Of Power On 125 V dc Panelboard 1DIC
D1DIC
2
Transfer
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 98
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
Page 103



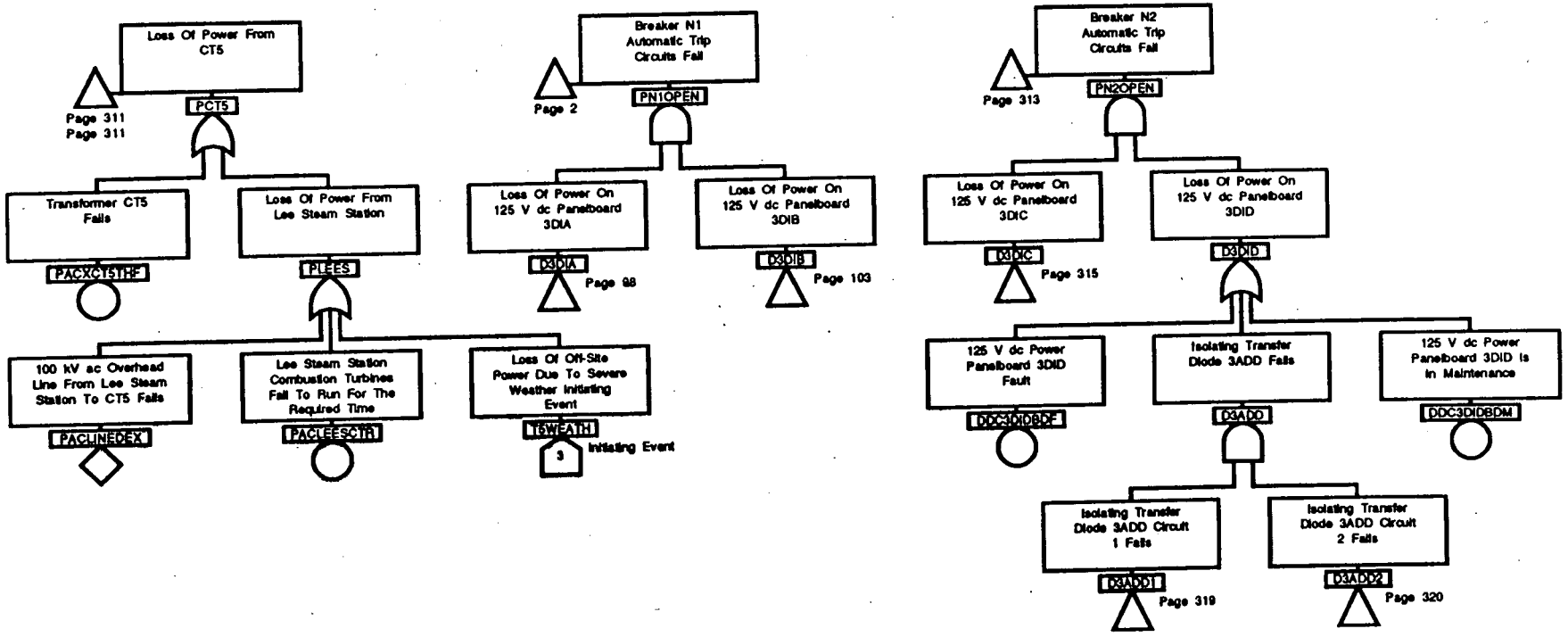
Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 107



Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 108



Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-AC1.CAF	10-10-94	Page 311


Loss Of Power From CT5
Page 311
Page 311
PCT5
Transformer CT5 Fails
PACXCT5THF
Loss Of Power From Lee Steam Station
PLEES
100 kV ac Overhead Line From Lee Steam Station To CT5 Fails
PACLINEDEX
Lee Steam Station Combustion Turbines Fail To Run For The Required Time
PACLEESCTR
Loss Of Off-Site Power Due To Severe Weather Initiating Event
T6WEATH
3
Initiating Event
Breaker N1 Automatic Trip Circuits Fail
Page 2
PN1OPEN
Loss Of Power On 125 V dc Panelboard 3DIA
D3DIA
Page 98
Loss Of Power On 125 V dc Panelboard 3DIB
D3DIB
Page 103
Breaker N2 Automatic Trip Circuits Fail
Page 313
PN2OPEN
Loss Of Power On 125 V dc Panelboard 3DIC
D3DIC
Page 315
Loss Of Power On 125 V dc Panelboard 3DID
D3DID
125 V dc Power Panelboard 3DID Fault
DDC3DID8DF
Isolating Transfer Diode 3ADD Fails
D3ADD
125 V dc Power Panelboard 3DID Is In Maintenance
DDC3DID8DM
Isolating Transfer Diode 3ADD Circuit 1 Fails
D3ADD1
Page 319
Isolating Transfer Diode 3ADD Circuit 2 Fails
D3ADD2
Page 320

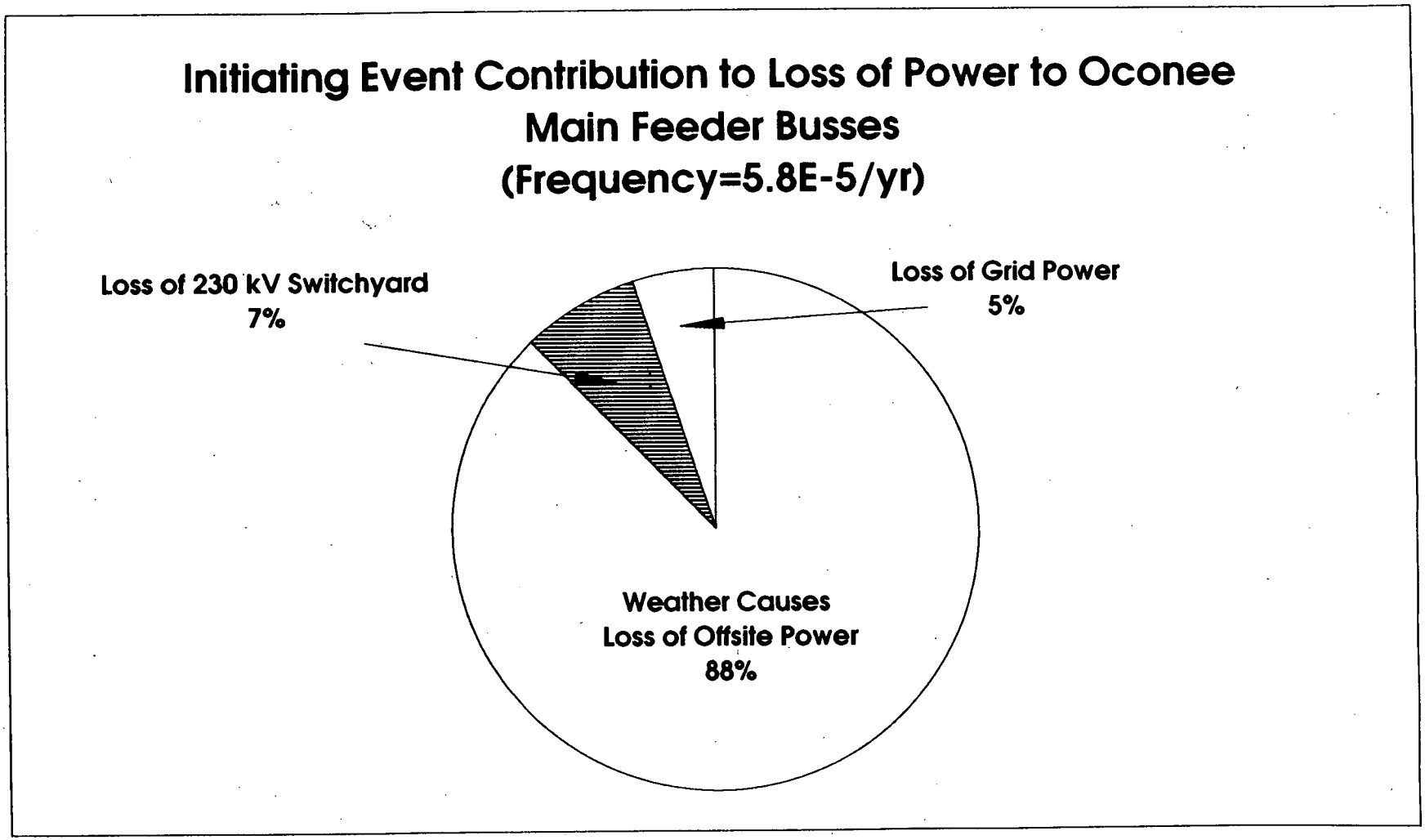
Recoveries

- Applied Keowee Recoveries - Only One Allowed per Cut Set
- Applied Oconee Recoveries
- Did Not Apply Offsite Power Recovery

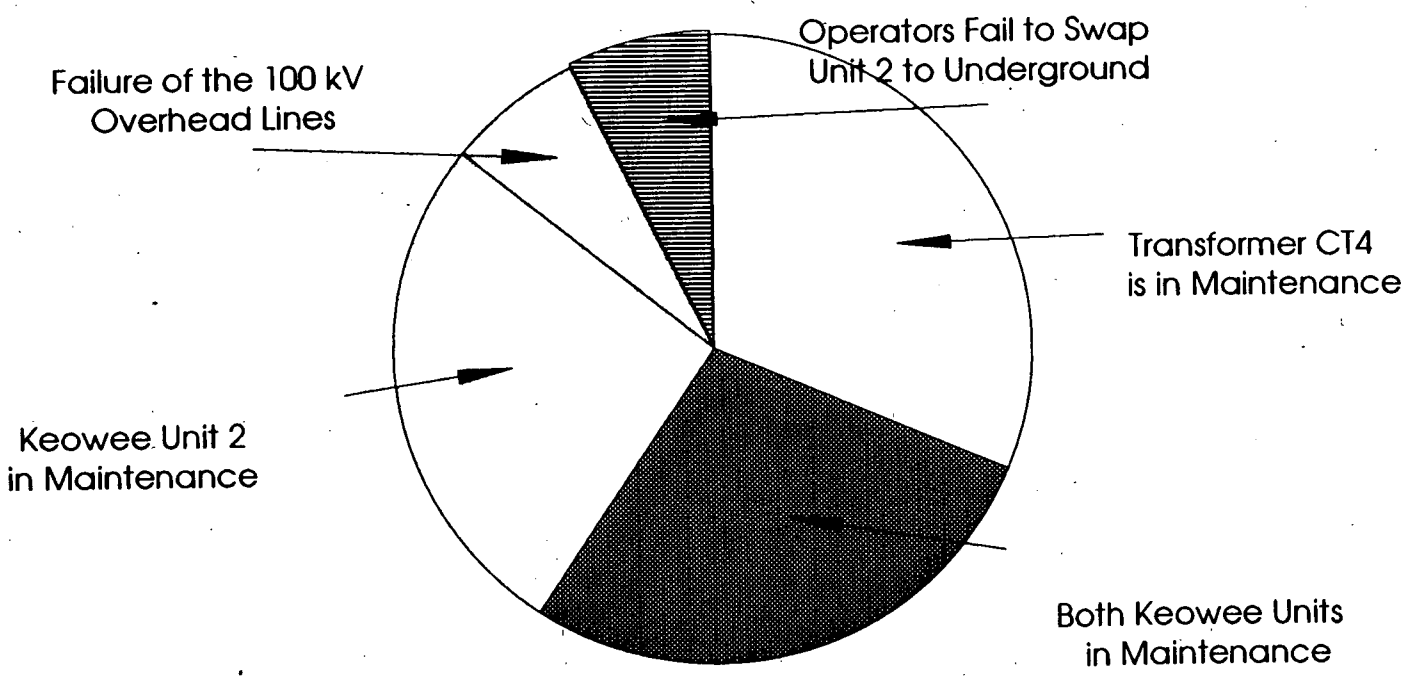
Results

- Three Loss of Offsite Power Initiating Events are Modeled
  - Loss of the Grid (T5FEEDF) = 2.73E-2 / YR
  - Loss of the Switchyard (T5SUBF) = 4.86E-2 / YR
  - Weather Related LOOP (T5WEATH) = 1.44E-2 / YR

- Frequency of Loss of all AC Power to the Main Feeder Buses = 5.8E-5 / YR


Initiating Event Contribution to Loss of Power to Oconee
Main Feeder Busses
(Frequency=5.8E-5/yr)
Loss of 230 kV Switchyard
7%
Loss of Grid Power
5%
Weather Causes
Loss of Offsite Power
88%

Basic Event Contribution to Loss of Power to Oconee Main Feeder Busses (Frequency=5.8E-5/yr)



Keowee PRA

AC Power - Core Melt Frequency Results

By Duncan Brewer

Outline

- Objectives
- Overview
- Method
- Fault Tree
- Application of Recoveries
- Results

Objectives

- To Determine the Oconee Core Damage Frequency for Sequences Involving Keowee
- To Allow Importance Ranking of Keowee Systems and Components Relative to the Contribution to Core Damage
- To Compare to the "Black Box" Representation of Keowee in the Oconee IPE Submittal

ONS Core Damage Model Overview

Core Damage Sequences Involving Keowee that Result from a LOOP Initiating Event Take Two Forms:

- RCP Seal LOCA without Primary System Makeup Capability
- Failure of SSHR without the Ability to Perform Feed and Bleed Cooling

ONS Core Damage Model Overview

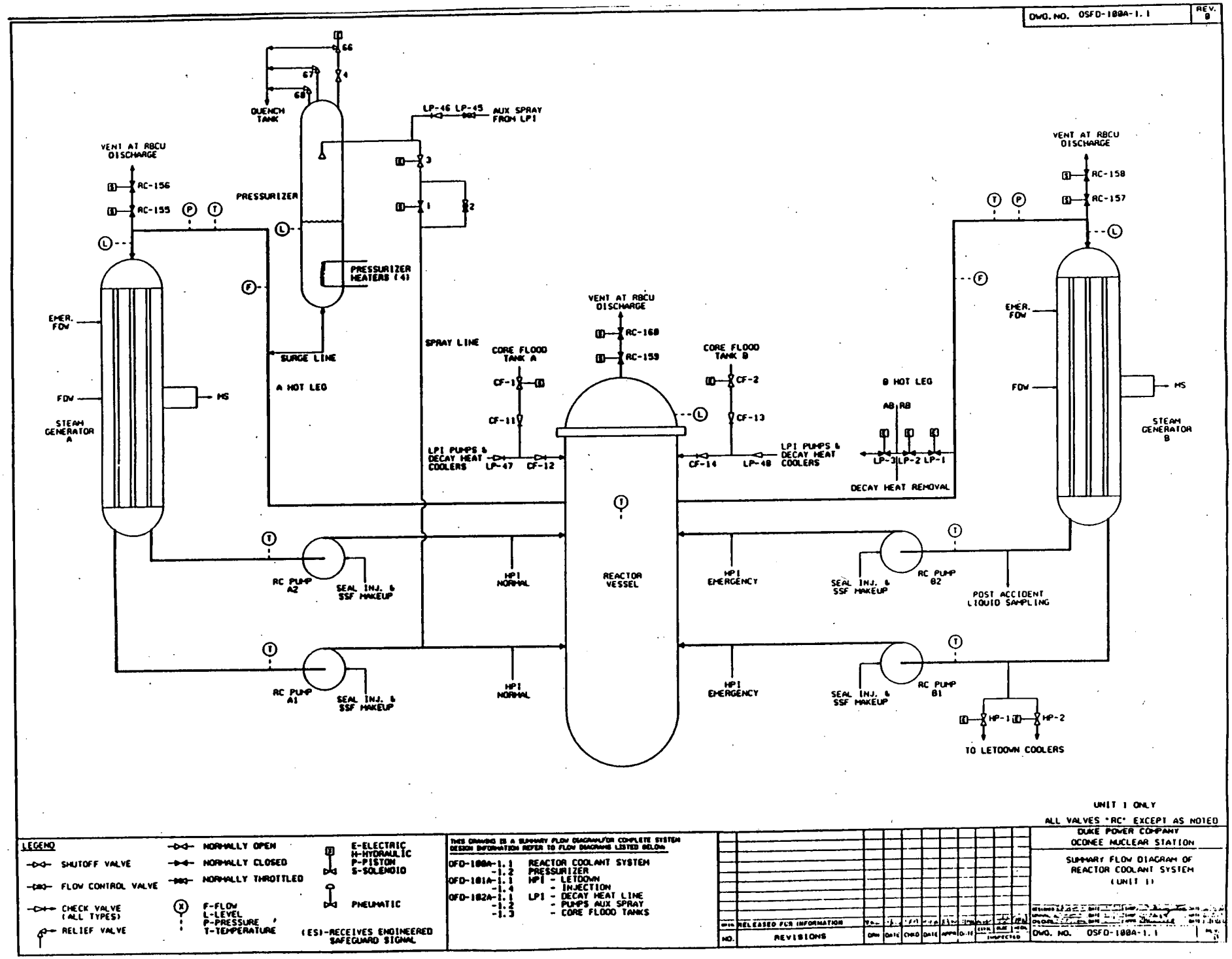
The "RCP Seal LOCA without Primary System Makeup Capability" Sequence Requires the Following Failures:

- All AC Power (HPI Cooling to the RCP Seals)
- SSF Fails to Provide RCP Seal Cooling

ONS Core Damage Model Overview

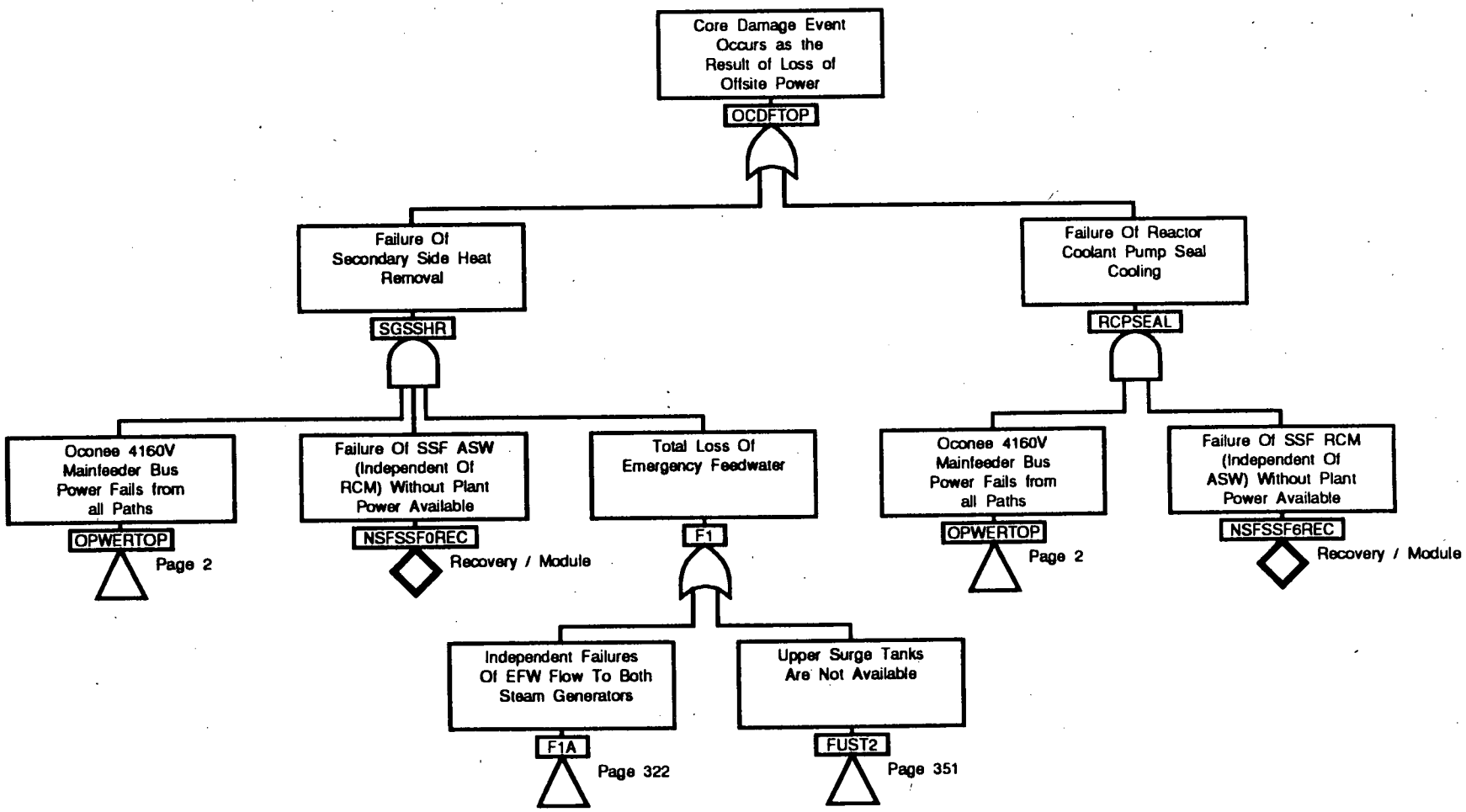
The "Failure of SSHR without the Ability to Perform Feed and Bleed Cooling" Sequence Requires the Following Failures:

- All AC Power (Fails the Motor Driven Em. Feedwater Pumps and HPI Cooling)
- Failure of the Turbine Driven Em. Feedwater Pump
- Failure of the SSF Aux. Service Water Pump

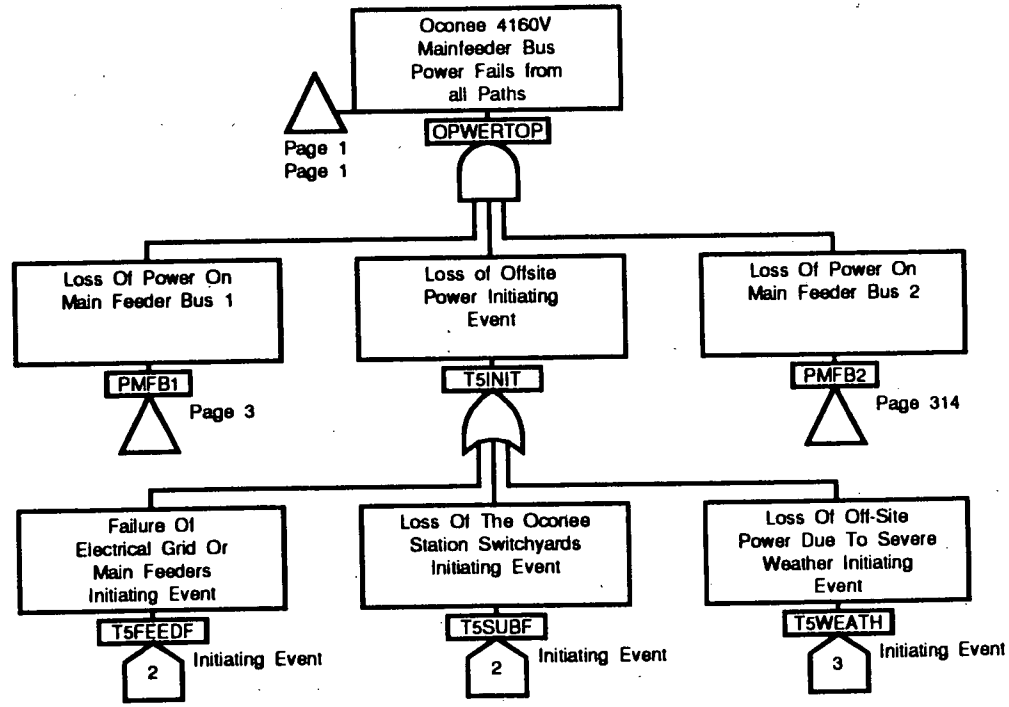

DWG. NO. OSFD-100A-1.1
REV. 0
QUENCH TANK
LP-46 LP-45 AUX SPRAY FROM LPI
VENT AT RBCU DISCHARGE
RC-156
RC-155
PRESSURIZER
PRESSURIZER HEATERS (4)
SURGE LINE
A HOT LEG
EMER. FDW
FDW
MS
STEAM GENERATOR A
SPRAY LINE
CORE FLOOD TANK A
CF-1
CF-11
LPI PUMPS & DECAY HEAT COOLERS
LP-47
CF-12
VENT AT RBCU DISCHARGE
RC-160
RC-159
REACTOR VESSEL
CORE FLOOD TANK B
CF-2
CF-13
CF-14
LP-48
LPI PUMPS & DECAY HEAT COOLERS
B HOT LEG
AB
RB
LP-3
LP-2
LP-1
DECAY HEAT REMOVAL
VENT AT RBCU DISCHARGE
RC-158
RC-157
EMER. FDW
FDW
MS
STEAM GENERATOR B
RC PUMP A2
SEAL INJ. & SSF MAKEUP
HPI NORMAL
HPI EMERGENCY
SEAL INJ. & SSF MAKEUP
RC PUMP B2
POST ACCIDENT LIQUID SAMPLING
RC PUMP A1
SEAL INJ. & SSF MAKEUP
HPI NORMAL
HPI EMERGENCY
SEAL INJ. & SSF MAKEUP
RC PUMP B1
HP-1
HP-2
TO LETDOWN COOLERS
UNIT 1 ONLY
ALL VALVES "RC" EXCEPT AS NOTED
LEGEND
SHUTOFF VALVE
FLOW CONTROL VALVE
CHECK VALVE (ALL TYPES)
RELIEF VALVE
NORMALLY OPEN
NORMALLY CLOSED
NORMALLY THROTTLED
F-FLOW
L-LEVEL
P-PRESSURE
T-TEMPERATURE
E-ELECTRIC
H-HYDRAULIC
P-PISTON
S-SOLENOID
PNEUMATIC
(ES)-RECEIVES ENGINEERED SAFEGUARD SIGNAL
THIS DRAWING IS A SUMMARY FLOW DIAGRAM FOR COMPLETE SYSTEM DESIGN INFORMATION REFER TO FLOW DIAGRAMS LISTED BELOW
OFD-100A-1.1 REACTOR COOLANT SYSTEM
-1.2 PRESSURIZER
OFD-101A-1.1 HPI - LETDOWN
-1.4 - INJECTION
OFD-102A-1.1 LPI - DECAY HEAT LINE
-1.2 - PUMPS AUX SPRAY
-1.3 - CORE FLOOD TANKS
RELEASED FOR INFORMATION
NO. REVISIONS
DUKE POWER COMPANY
OCONEE NUCLEAR STATION
SUMMARY FLOW DIAGRAM OF REACTOR COOLANT SYSTEM (UNIT 1)
DWG. NO. OSFD-100A-1.1

Method

- Started with Oconee IPE Model for AC Power System
- Linked with the ONS DC Power System Model, the ONS Emergency Feedwater Model, and SSF Model from Oconee IPE
- Cut Out Old Keowee Model
- Linked in the New Keowee Model
- Combined the Keowee and Oconee Data Bases
- Solved the New Tree
- Applied Keowee and Oconee Recoveries



Oconee-Keowee Core Damage Fault Tree	C:\CAFTA\TREE\OPRA\KEON-CD1.CAF	10-10-94	Page 1

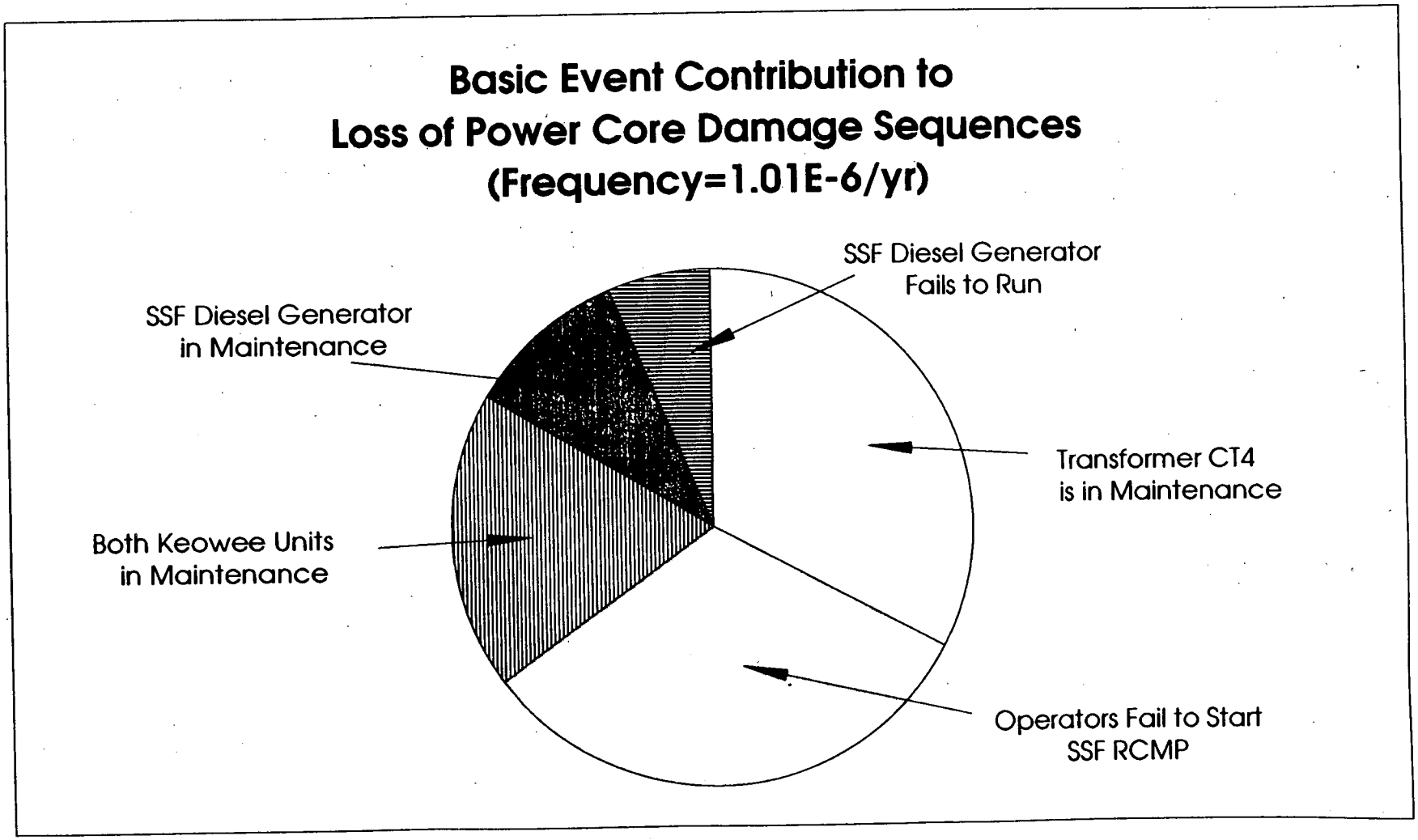

Oconee 4160V
Mainfeeder Bus
Power Fails from
all Paths
OPWERTOP
Page 1
Page 1
Loss Of Power On
Main Feeder Bus 1
PMFB1
Page 3
Loss of Offsite
Power Initiating
Event
T5INIT
Loss Of Power On
Main Feeder Bus 2
PMFB2
Page 314
Failure Of
Electrical Grid Or
Main Feeders
Initiating Event
T5FEEDF
2
Initiating Event
Loss Of The Oconee
Station Switchyards
Initiating Event
T5SUBF
2
Initiating Event
Loss Of Off-Site
Power Due To Severe
Weather Initiating
Event
T5WEATH
3
Initiating Event

Recoveries

- Applied Keowee Recoveries - Only One Allowed per Cut Set
- Applied Oconee Recoveries
- Applied Offsite Power Recoveries

Results

- **Frequency of Core Damage Resulting From Loss of Offsite Power = 1.01E-6 / YR**
- **This is Comparable to the Oconee IPE Results of 3.2E-6 / YR (Higher Maintenance and Common Cause Values in IPE Study)**


Basic Event Contribution to
Loss of Power Core Damage Sequences
(Frequency=1.01E-6/yr)
SSF Diesel Generator
Fails to Run
SSF Diesel Generator
in Maintenance
Transformer CT4
is in Maintenance
Both Keowee Units
in Maintenance
Operators Fail to Start
SSF RCMP