



## Oconee Nuclear Station

Pre-Submittal Meeting – November 18, 2015

10 CFR 50.55a(z) - Alternatives to Codes and Standards Requirements



- Scott Batson, Site Vice President
- Ed Burchfield, Engineering General Manager
- Todd Grant, Assistant Operations Manager
- Ray Price, Electrical Engineering Manager
- Chris Wasik, Regulatory Affairs Manager
- Chris Nolan, Director, Nuclear Fleet Regulatory Affairs
- Art Zarembo, Licensing Manager, Nuclear Fleet Regulatory Affairs
- Steve Kimbrough, Lead Analyst, Nuclear Fleet PRA

- Opening Remarks Scott Batson
- Background and Submittal Overview Chris Wasik
- Quality and Safety of Proposed Alternatives Ed Burchfield
- Closing Remarks Scott Batson

Scott Batson

Site Vice President

Chris Wasik

Regulatory Affairs Manager

### Background

- 2014 Component Design Basis Inspection (CDBI) Report
  - "...125 VDC control cables for train A of the ESPS [Engineered Safeguards Protective System] and cables for supervisory control of both KHUs [Keowee Hydro Units]...were installed in the same underground concrete raceway systems as the 4160 VAC auxiliary power cables, 13.8 kVAC power cables for both emergency power and protected service water (PSW), and were in close proximity to these power cables. The team was concerned that a short circuit...in the 13.8 kVAC cables could induce voltage and currents in the DC control system which could potentially impact the functionality of the emergency power system..."
  - "...A similar issue exists in Manhole 6 of the PSW underground raceway where the new power supply to the PSW (adjacent to the 125 VDC control emergency power system) could short circuit or fault to ground."
  - Unresolved issue (URI) opened to track the concern.

### Background (cont.)

- Task Interface Agreement (TIA) 2014-05
  - TIA seeks technical support as to whether or not the cable configuration in the noted underground raceways meets the existing Oconee licensing basis, design basis.
- In the interim, Oconee has conducted additional cable testing and is implementing plant modifications to address the concerns identified in the URI.
- For all 3 units, the existing cable configuration is considered operable but nonconforming with the current licensing basis.



### 10 CFR 50.55a(z) - Alternatives to Codes and Standards Requirements

- 10 CFR 50.55a(h)(2), Protection Systems

For plants with Construction Permits issued before 1/1/1971, regulation requires compliance with the licensing basis (IEEE Std. 279-1971 for Oconee).

- 10 CFR 50.55a(z), Alternatives to Codes and Standards Requirements

Alternatives...may be used...The applicant or licensee must demonstrate that:

- (1) Acceptable level of quality and safety. The proposed alternative would provide an acceptable level of quality and safety; or
- (2) Hardship without a compensating increase in quality and safety. Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.



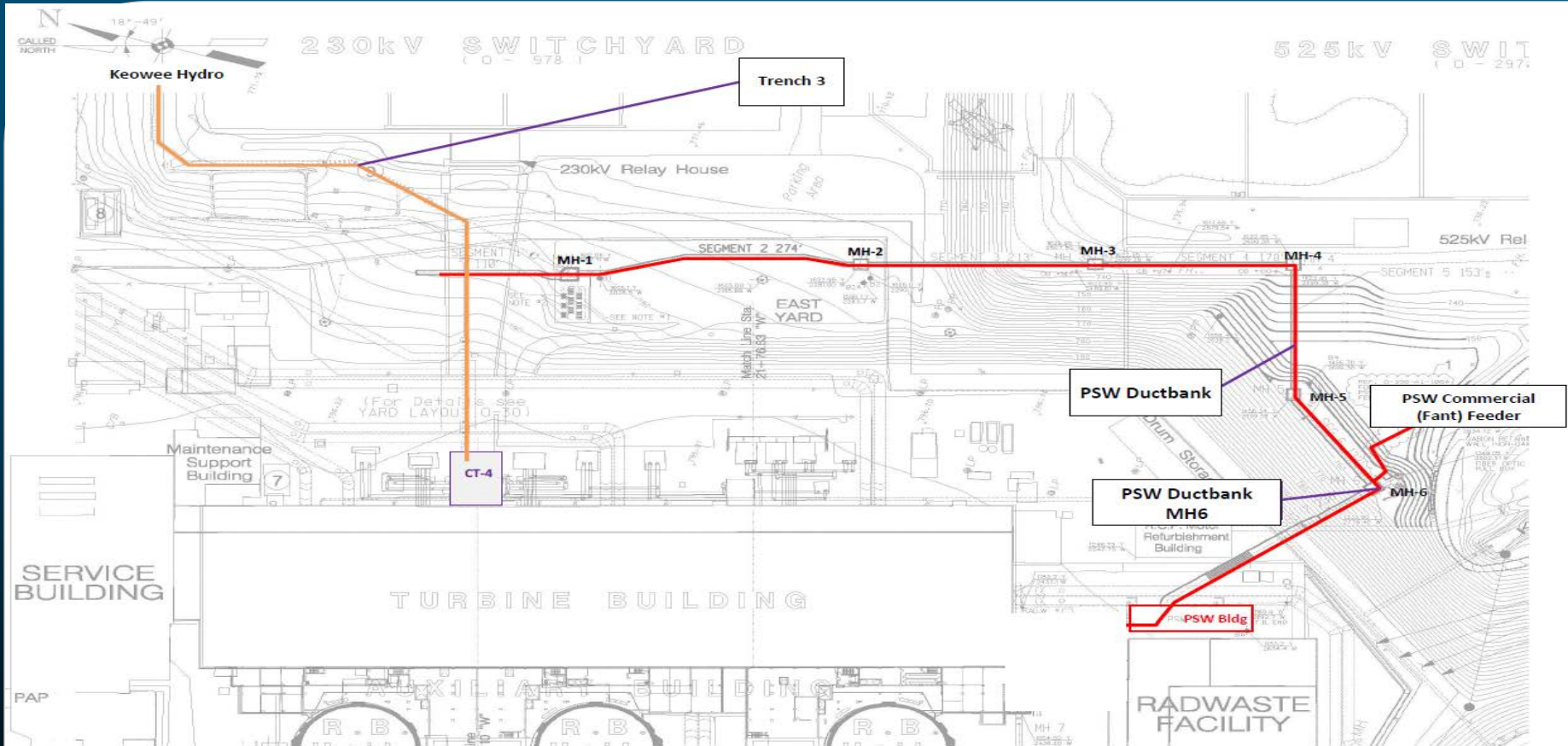
### 10 CFR 50.55a(z) - Alternatives to Codes and Standards Requirements (cont.)

- 10 CFR 50.55a(z) submittal will propose an alternative approach to meeting 10 CFR 50.55a(h)(2), (i.e., IEEE Std. 279-1971).
- Submittal will demonstrate that the proposed alternatives provide an acceptable level of quality and safety.
- NRC approval would revise and clarify the Oconee licensing basis and allow for resolution of the nonconforming condition.

Ed Burchfield

Engineering General Manager

# Quality and Safety of Proposed Alternatives



Trench 3 and PSW Ductbank Layout

For Information Only

This discussion on the bases for acceptability of the proposed alternatives is divided in to two (2) main sections:

1. Common Elements (applicable to all four plant areas)
  - Cable Crush Testing
  - Cable Fault Testing
  - Risk Insights
  
2. Proposed Alternatives and Bases for Each of the Plant Areas
  - Trench 3
  - PSW Ductbank Manholes 1-5
  - PSW Ductbank Manhole 6 and PSW Cable Spreading Area
  - Keowee Mechanical Equipment Gallery

### Cable Crush Testing

- Testing performed to confirm the mechanical properties of the bronze tape cable design employed at Ocone.
- 13.8 kV and 4.16 kV single conductor power cables tested.
- Testing was conducted at Okonite's High Voltage Laboratory in February 2015.
- Performed impact, increasing crush and crush tests based on Underwriters Laboratories (UL) Standard 1569, Metal Clad Cables.
- Test report is documented in Ocone letter to NRC dated March 27, 2015 (ML15139A050).
- Test results demonstrated the cable design with a bronze tape shield provides mechanical protection to perform as armored cable based on UL Test 1569, Sections 24, 25, and 26.

### Cable Fault Testing - Overview

- Between November 2-6, 2015, tests were conducted at the KEMA Laboratories outside of Philadelphia, PA.
- The primary purpose of the cable fault testing was to determine if a single cable failure (line-ground fault) on a single medium voltage power cable would propagate to a multi-phase fault and damage adjacent cables.
- A secondary purpose was to determine if low voltage control cables installed near the faulted cable would be damaged and if unacceptable voltage would be induced on the low voltage conductors.
- Four (4) different configurations tested, five (5) times each (20 tests total).
- No single cable failure resulted in propagation to a multi-phase fault.
- No damage or adverse impacts on control cables.

### Cable Fault Testing - Setup

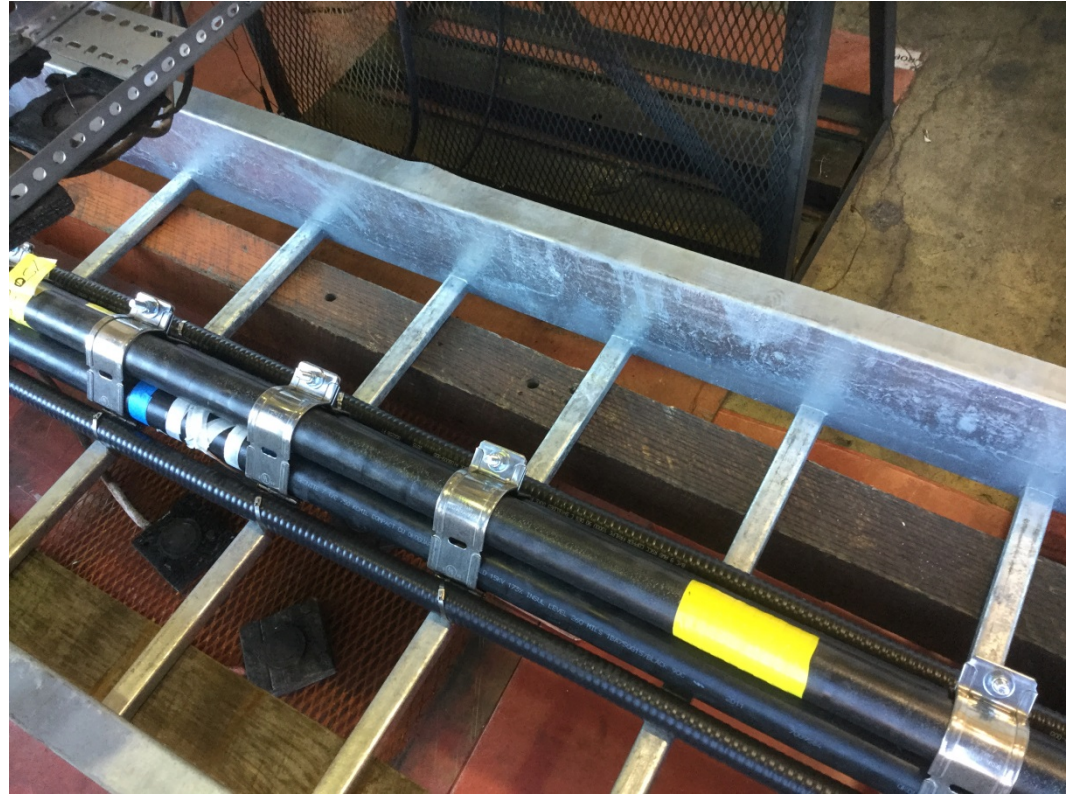
- The test setups used were configured in a manner to maximize the potential for a single cable phase to ground fault to propagate into a multi-phase fault.
- Test fault currents and associated durations bound the Oconee plant fault currents and associated durations for cables of concern.
  - Oconee configuration does not utilize breaker reclosure feature.
- The tests were conducted on cables identical to existing plant cables installed in the following plant locations:
  - 13.8 kV Keowee Underground Path (Keowee to Transformer CT-4),
  - 4.16 kV Keowee Underground Path (Breaker 1TC-04 to Keowee Transformer CX),
  - 13.8 kV Fant Path (Manhole 6 to PSW Switchgear),
  - 13.8 kV PSW Underground Path (Keowee to PSW Switchgear).



### Cable Fault Testing - Setup (cont'd)

- The cable fault was created by drilling a small hole into the cable, installing a small piece of wire, and orienting the hole directly at an adjacent power cable.
  - This is a conservative arrangement in terms of directing the energy release into the adjacent phase power cable.
  - Drilling the hole in the shield to induce the fault is conservative in that the 'barrier' to help contain the fault currents is breached on purpose, thus creating a weak link.
- Un-bonded cable tray utilized as specimen support with cable cleats to maintain minimal separation of power cables at the fault location and to minimize adjacent current paths.

## Quality and Safety of Proposed Alternatives



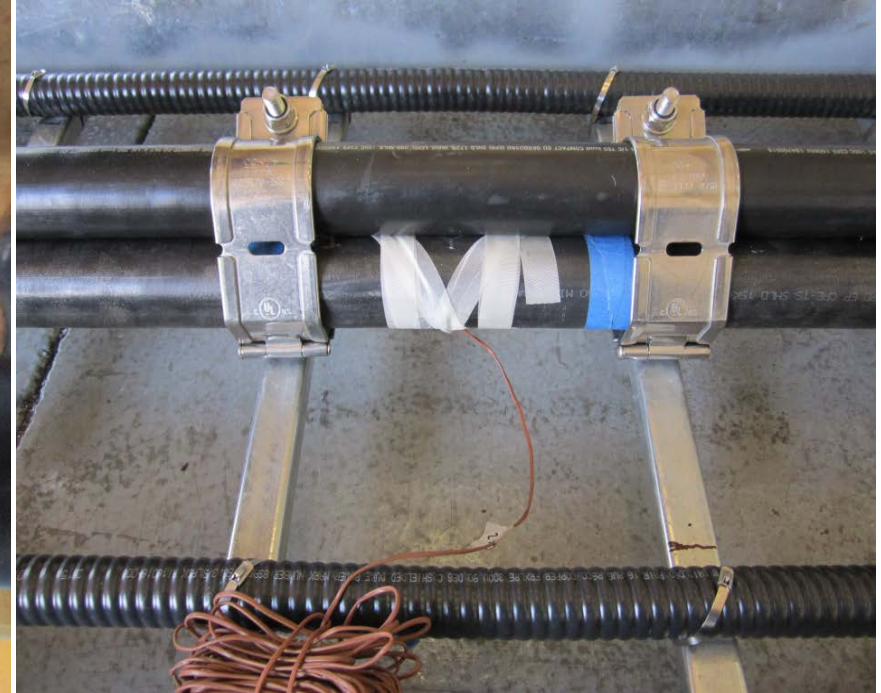
Test Arrangement Examples

For Information Only

## Quality and Safety of Proposed Alternatives



Typical Faulted Cable Prep



Typical Test Configuration  
(Pre-test)

### Cable Fault Testing – Results

- None of the 20 test cases resulted in cable damage that propagated to a multi-phase fault.
- In some of the tests, the adjacent cable was indented slightly at the fault location but no jacket or shield damage occurred.
- In one of the five 4 kV cable fault tests, there was damage to one of the adjacent power cable's outer jacket and bronze tape shield; however, the internal insulation remained intact and no phase to phase fault occurred.



## Quality and Safety of Proposed Alternatives



Fant Line -13.8 kV Faulted Cable  
(typical)



KUG to CT4 / PSW - 13.8 kV Feed Faulted Cable  
(typical)

## Quality and Safety of Proposed Alternatives



Feed to Keowee CX XFMR – 4.16 kV Faulted Cable  
(typical)



Feed to Keowee CX XFMR- Adjacent 4.16 kV Cable  
(Only instance of breached cable jacket in adjacent cable)

### Cable Fault Testing - Results (cont'd)

- In each test case, the bronze tape performed its function of protecting the conductors and not allowing a fault to propagate.
- In each test case there was no observable damage to the control cables in the tray section adjacent to the faulted power cables (control cable separation from power cables varied from 5" to no gap spacing between them and the power cables).
- Low induced voltage levels observed on control cables was determined to be inconsequential.
- Length of cable tested has negligible impact on the results due to cable design and installation.



### Risk Insights

- A risk analysis was performed to determine the potential risk impact of the current plant configuration with respect to cable separation in the locations of concern.
  - Risk is different for each location based on specific cabling in each location.
- The analysis considered the following aspects:
  - Frequency of cable faults,
  - Probability that a fault is a multi-phase or high energy arc fault (HEAF),
  - Probability of a large imposed voltage on one or both Oconee vital 125 VDC trains,
  - Probability of failure of one or both Oconee vital 125 VDC trains, given an imposed voltage,
  - Probability of failure of mitigation strategies.

### Risk Insights (cont'd)

#### Analysis Results

Location	CDF
Trench 3	2E-10
PSW Ductbank Manholes 1 through 5	< 1E-13
PSW Ductbank Manhole 6, and PSW Cable Spreading Area	2E-11
Keowee Equipment Gallery	5E-12
Total	3E-10

### Risk Insights (cont'd)

- The analysis shows that the overall core damage frequency (CDF) increase for the five (5) cable locations is approximately  $3\text{E-}10/\text{year}$ , using conservative values.
  - Conservative likelihood of a large imposed voltage on DC control cables was assumed.
  - Conservative likelihood of a loss of one or both trains of Oconee vital 125 VDC was assumed.
- Risk values are low due to system design and mitigating capabilities.
  - Grounding scheme reduces the likelihood of a severe fault.
  - Failure of DC control cables (i.e., open circuit) does not impact normal power to Oconee.
  - Mitigation strategies are still available in the event of a loss of offsite power and both vital 125 VDC trains.
    - Standby Shutdown Facility (SSF) is designed for standalone operation (i.e., has its own AC and DC power).
    - PSW power can be provided to the SSF in the event of failure of dedicated diesel generator (for some locations).

### Risk Insights (cont'd)

- Differences in risk between locations are mostly driven by fault frequency.
  - Number of energized AC power cables
  - Length of exposed cable
- The CDF increase for Trench 3 is  $2E-10$ /year.
  - Three normally energized AC power cables and significant cable length (approximately 4100 feet)
  - PSW power available to SSF
- The CDF increase for Manholes 1 through 5 is less than  $1E-13$ /year.
  - Very limited fault exposure due to normally de-energized power cables and short length of cable
  - PSW power available to SSF

### Risk Insights (cont'd)

- The CDF increase from Manhole 6 and the PSW cable spreading area is  $2E-11$ /year.
  - These locations have relatively short lengths of cable, but contain the normally energized Fant power feed.
  - SSF available, but PSW power NOT available to SSF
- The CDF increase for the Keowee Equipment Gallery is  $5E-12$ /year.
  - This location has a relatively short length of cable
  - PSW power available to SSF
- CDF is the bounding metric.
  - Oconee has a large, dry, containment, such that LERF is driven by bypass sequences (S/G tube ruptures, ISLOCAs) and isolation failure sequences.
  - Loss of AC and/or DC does not create a bypass sequence.
  - Most containment isolation valves fail closed on loss of AC/DC power.
  - Large Early Release Frequency (LERF) is expected be at least an order of magnitude less than CDF.

Proposed Alternatives

### Keowee Underground Power Path (Trench 3)

#### Proposed Alternative

Until modifications are completed, temporary acceptance pursuant to 10 CFR 50.55a(z)(1) of the existing Trench 3 configuration is requested as an alternative to meeting the requirements of 10 CFR 50.55a(h)(2) to allow for the completion of modifications to relocate the safety related control cable functions outside of Trench 3, thereby eliminating the potential for any adverse effects from a cable fault.



### Keowee Underground Power Path (Trench 3) (cont'd)

#### 10 CFR 50.55a(z)(1) Acceptable Level of Quality and Safety

- Robust power cable design and cables procured to QA-1 standards
- High impedance grounding system limits fault current
- Satisfactory cable crush test results
- Satisfactory cable fault test results
- Station power cables are periodically tested and inspected as described in UFSAR Section 18.3.14, "Insulated Cables and Connections Aging Management Program."
- Protection from the environment. The cables are enclosed in a steel-reinforced concrete trench engineered to withstand earthquakes, tornado missiles, and to minimize water entry. Passive drains and inspection ports are provided at trench low points.
- Calculated negligible CDF risk increase from a damaging cable fault (2E-10/year)

### PSW Ductbank Manholes 1 through 5

#### Proposed Alternative

Modification of the Oconee licensing basis pursuant to 10 CFR 50.55a(z)(1) & (2) to accept, pursuant to 10 CFR 50.55a(z), the “as-is” configuration as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2).

### PSW Ductbank Manholes 1 through 5 (cont'd)

#### 10 CFR 50.55a(z)(1) Acceptable Level of Quality and Safety

- Satisfactory cable crush test results
- Satisfactory cable fault test results
- The potential for power cable to control cable interaction in the manholes represents a significantly small portion of the overall cable run (approximately 150 feet out of 5200 feet).
- Cables not normally energized
- Station power cables are periodically tested and inspected as described in UFSAR Section 18.3.14, "Insulated Cables and Connections Aging Management Program."
- Protection from the environment - the cables are housed in a steel-reinforced concrete ductbank engineered to withstand earthquakes, tornado missiles, and to minimize water entry.
- Robust power cable design and cables procured to QA-1 standards
- High impedance grounding system limits fault current
- Calculated negligible CDF risk increase from a damaging cable fault ( $< 1\text{E-}13/\text{year}$ )

### PSW Ductbank Manholes 1 through 5 (cont'd)

#### 10 CFR 50.55a(z)(2) Hardship without a Compensating Increase in the Level of Quality and Safety

- There are several rigging and lifting concerns associated with opening the manholes, including concerns for overhead 230 kV and 525 kV power lines, special crane requirements, potential for damage to the manhole cover seal and concrete edges.
- Work activities within the confined space of a manhole (e.g., drilling, rebar scanning, expansion anchor installation, ingress and egress of personnel and materials, modification implementation) could damage cables.
- Manholes outside the protected area are required to be fenced (Security). Any cranes would need to be moved/disassembled/locked every evening.
- PSW system is unavailable during work in manholes.

### PSW Ductbank Manhole 6 (MH-6) & PSW Cable Spreading Area

#### Proposed Alternative

- Modification of the Oconee licensing basis pursuant to 10 CFR 50.55a(z)(1) to accept a proposed modification to meet the separation requirements for a Limited Hazard Area as noted by IEEE 384-1992, Paragraph 6.1.4 with respect to the normally energized Fant line power supply feeder and adjacent control cables is requested as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2). Oconee will install industry standard designs to address the power and control cable separation concerns.
- Modification of the Oconee licensing basis pursuant to 10 CFR 50.55a(z)(1) to accept the as-is configuration of the normally de-energized 13.8 kV power feed from Keowee to the PSW building as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2).
- Until modifications are completed, temporary acceptance of the “as-is” configuration pursuant to 10 CFR 50.55a(z)(1) of the Fant line feeder and adjacent Keowee control cables is requested as an alternative to meeting the requirements of 10 CFR 50.55a(h)(2) until the above proposed modification is complete.

### PSW Ductbank Manhole 6 (MH-6) & PSW Cable Spreading Area (cont'd)

#### 10 CFR 50.55a(z)(1) Acceptable Level of Quality and Safety

- Satisfactory cable crush test results
- Satisfactory cable fault test results
- Modification of Fant and adjacent control cable raceway to meet enclosed raceway separation requirements for a Limited Hazard Area as noted by IEEE 384-1992, endorsed by NRC RG 1.75
- Station power cables are periodically tested and inspected as described in UFSAR Section 18.3.14, "Insulated Cables and Connections Aging Management Program."
- Protection from the environment - the cables are housed in a steel-reinforced concrete ductbank engineered to withstand earthquakes, tornado missiles, and to minimize water entry.
- Robust power cable design and cables procured to QA-1 standards
- Calculated negligible CDF risk increase from a damaging cable fault (2E-11/year)

### Keowee Mechanical Equipment Gallery

#### Proposed Alternative

- Modification of the Oconee licensing basis pursuant to 10 CFR 50.55a(z)(1) to accept a proposed modification to meet the separation requirements for a Limited Hazard Area as noted by IEEE 384-1992, paragraph 6.1.4 with respect to the auxiliary power feed to Keowee, the Keowee underground emergency power feeder, the PSW KPF switchgear line side bus power cables and adjacent control cables is requested as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2). Oconee will install industry standard designs to address the power and control cable separation concerns.
- Until modifications are completed, temporary acceptance pursuant to 10 CFR 50.55a(z)(1) of the "as-is" configuration in the Keowee Mechanical Equipment Gallery as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2) until the above proposed modification is complete.
- Modification of the Oconee licensing basis pursuant to 10 CFR 50.55a(z)(1) to accept the "as-is" configuration of the normally de-energized 13.8 kV power feed from Keowee to the PSW building as an alternative configuration to meeting the requirements of 10 CFR 50.55a(h)(2).



### Keowee Mechanical Equipment Gallery (cont'd)

#### 10 CFR 50.55a(z)(1) Acceptable Level of Quality and Safety

- Satisfactory cable crush test results
- Satisfactory cable fault test results
- Modifications to meet enclosed raceway separation requirements for a Limited Hazard Area as noted by IEEE 384-1992, paragraph 6.1.4
- Station power cables are periodically tested and inspected as described in UFSAR Section 18.3.14, "Insulated Cables and Connections Aging Management Program."
- Robust power cable design and cables procured to QA-1 standards
- Protective environment, cables are below grade in the Keowee powerhouse not exposed to environmental hazards.
- Calculated negligible CDF risk increase from a damaging cable fault (5E-12/year)

### Summary

- Oconee is taking action to address the NRC's concerns.
- Submittal seeks to clarify the Oconee licensing basis with respect to the cables noted in this presentation.
- Submittal seeks NRC approval per 10 CFR 50.55a(z).
- Submittal demonstrates an acceptable level of quality and safety for the proposed alternatives based on several factors, including:
  - Cable Crush Test Results
  - Cable Fault Test Results
  - Modifications per Accepted Standards
  - Environmental Factors
  - Aging Management Program
  - Risk Significance

Scott Batson

Site Vice President

