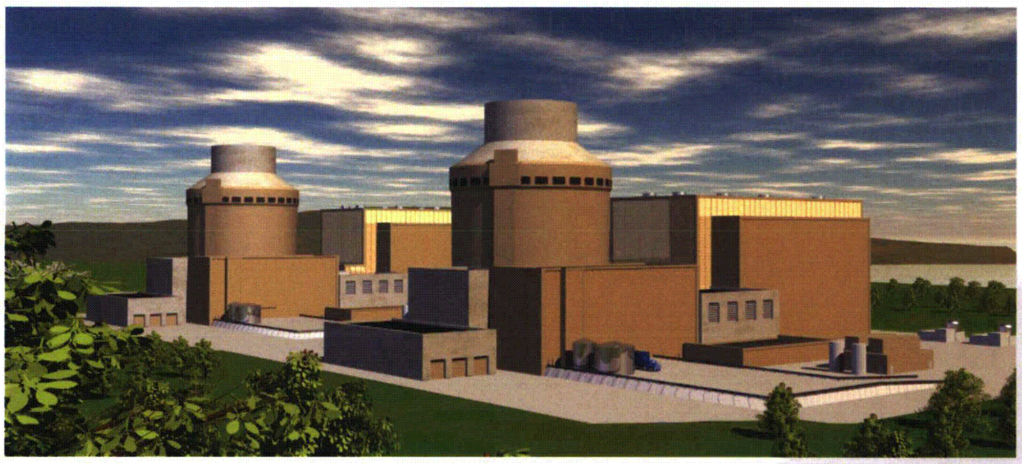
William States Lee III Nuclear Station
COL Application Review Schedule



Presentation to NRC Staff

March 19, 2008

Agenda

9:00	Introductions and Agenda	NRC
9:05	COL Scheduling Processes and Phases	NRC
9:30	WS Lee III COL Review Schedule	NRC
9:50	AP1000 Recirculation Screen	Peter Hastings (Duke Energy)
10:05	Ground Motion Methodology – RVT/Approach 3	Walt Silva (PEA)
10:55	Eastern Tennessee Seismic Zone Source Model	John Richards (Duke Energy)
11:15	Radwaste Building Fill Material Dynamic Response	Mike Gray (WLA)
11:40	Public Comment Opportunity	

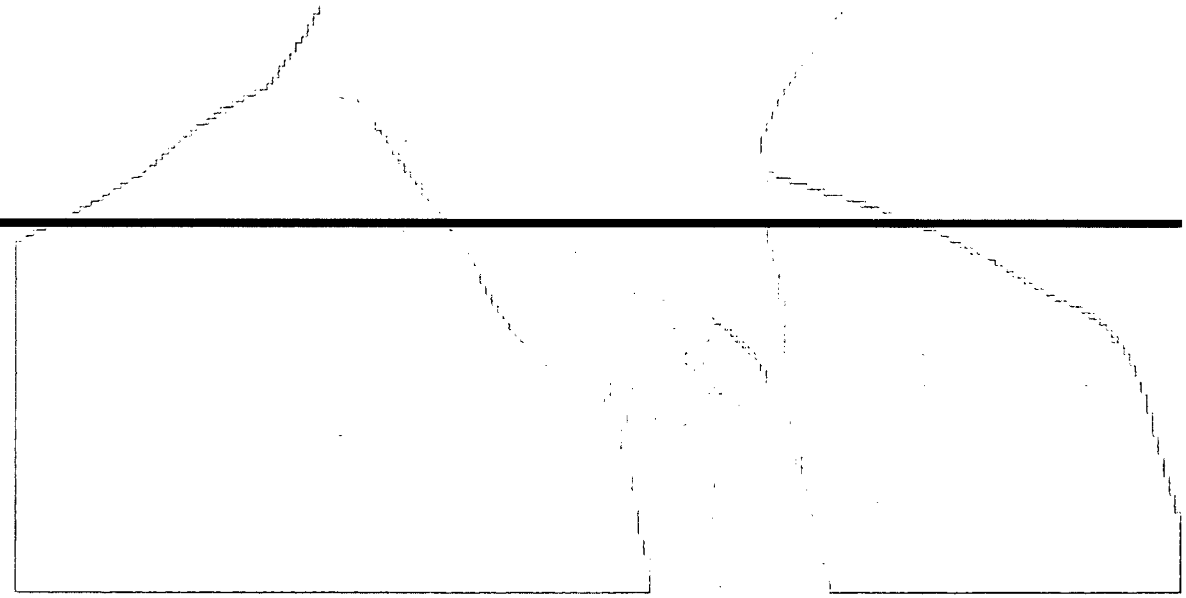
William States Lee III (Lee) Nuclear Station Combined License (COL) Application Timeline

▪ Duke Submittal of COL Application	12/12/07
▪ Presentation of COL Application to NRC	12/13/07
▪ NRC Acceptance Review Start	01/02/08
▪ NRC Docketing of Lee COL Application	02/25/08
▪ NRC Review Schedule Letter (planned)	03/26/08
▪ Duke Requested Deferral of NRC Review Schedule Letter	04/02/08

COL Application Review Observations

- Organizing along design centers provides effeciencies in the licensing process:
  - NuStart / DCWG / AP1000 Utilities
    - (TVA, Duke Energy, Progress Energy, SCE&G, Southern Company)
  - Standard (STD) Content
  - DCD / R-COLA / S-COLA
  - R-COLA ↔ S-COLA Coordination
  - Efficiencies Observed in the NRC Acceptance Review
- Generic Resolution of Non-STD Issues Offer Efficiencies
  - i.e., Eastern Tennessee Seismic Zone

AP1000 Recirculation Screen Design



Summary of Westinghouse Commitments to NRC

- Provide additional details on the Containment Recirculation and IRWST screen designs **(Complete: APP-GW-GLN-147 Rev 1 issued 3/3/08).**
- Demonstrate by test that the screen designs meet AP1000 screen pressure loss limits **(Complete: DCP/NRC2094, WCAP-16914 issued 3/3/08).**
- Demonstrate by analysis and evaluations that downstream effects do not adversely impact long term coolability of the core **(March 31, 2008).**
- Evaluate existing ITAAC (based on screen surface areas) to identify changes **(March 31, 2008).**
- Demonstrate by analysis that there is adequate margin between screen performance and AP1000 safety limits **(April 30, 2008).**

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Recirculation Screen Overview

- The Westinghouse submittals will confirm core cooling margins:
  - Detailed screen design
  - Screen performance testing
  - Ex-vessel downstream effects
  - In-vessel downstream chemical effects
  - Core cooling sensitivity to screen pressure drop
- Low amounts of debris and chemicals in the AP1000 design combined with large filtering areas provide substantial margins.
- The Westinghouse submittals (provided and planned) are intended to provide resolution of this issue under a Design Certification Amendment.

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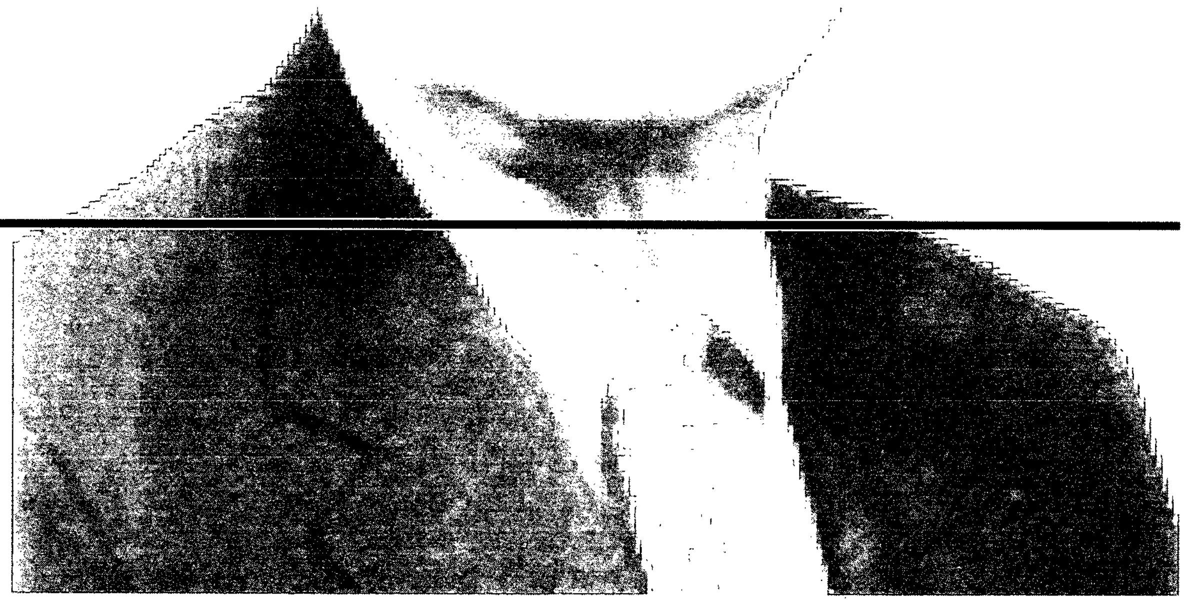
Conclusion

- NuStart/DCWG provides an effective forum for integration:
  - DCD / R-COLA / S-COLA
  - R-COLA ↔ S-COLA
  - Acceptance Review
  - RAI Process
- AP1000 Recirculation Screen is a generic issue for which Duke will implement the generic solution.
- Duke expects that this issue will be resolved by Westinghouse under a Design Certification Amendment.

Near-Surface Site Ground Motion Effects Methodology



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Near-Surface Site Ground Motion Effects

- NRC expressed concerns with the level of detail provided for RVT and Approach 3
- Duke will supplement the application with a technical report providing additional details for RVT and Approach 3
  - Presentation will provide an outline of the report contents
  - Duke plans to submit the report on or before April 30
- The Duke technical report would focus on a site-specific application of Approach 3
- Duke would support a public meeting to discuss the report contents

Report Outline

- Objective of Site-Response
- Implementation of RVT
- Scaling Reference Site (Hard Rock) PSHA for Site-Specific Conditions
  - Parameter variabilities
  - Background of Approaches
  - Implementation of Approach 3
- Conclusions

Objective of Site-Response

- Develop Site-Specific Design Motions
  - Maintain Desired Hazard Levels
    - Annual Frequency of Exceedance (AFE) of Reference PSHA, Hazard Consistent
  - Incorporate Site-Specific Aleatory and Epistemic Variabilities in Dynamic Material Properties
    - Velocities, Depth to Basement, Modulus Reduction and Hysteretic Damping
      - Randomize, Parametric Aleatory Variability
      - Alternative Base Cases, Parametric Epistemic Variability
    - Alternative Site Response Models, Model Epistemic Variability

Overall Approach to Developing Site-Specific Design Ground Motions

- Two Distinct, Independent Analyses
  - Development of Transfer Functions (via RVT)
    - Horizontal Amplification Factors
      - Vertically Propagating Shear-Waves, Equivalent Linear
    - V/H Ratios
      - Verticals, Incident Inclined P-SV Waves
      - Empirical WNA V/H Ratios
  - Scale Reference Site PSHA to Reflect Site-Specific Conditions

RVT Site-Response

- Used in Two Distinct Places
  - Providing Estimates of Response Spectra (Oscillator Time Domain Peak Values)
  - Equivalent-Linear Site-Response
    - Providing Estimates of Time Domain Peak Shear Strain Values

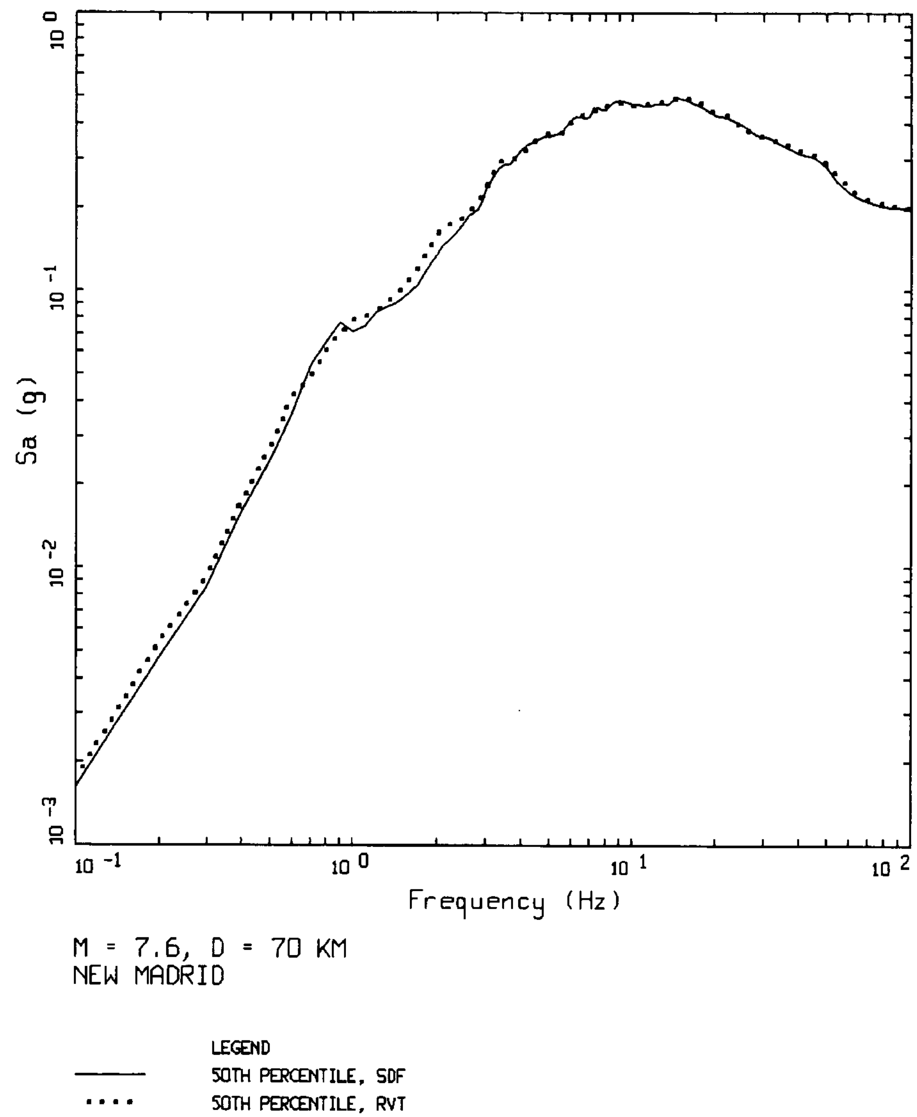
Considerations in RVT Implementation

- Stationarity
- RVT Duration
  - $1/F_C + 0.05\ R$
- Peak-to-RMS Ratio
  - Multiple Ratios, Functions
    - Degree of Approximation
      - ≈ 10% Range (Oscillator Response)
      - Selection Based on Comparison with SDF
- Integrate PSD, RMS
  - Frequency Range
    - 150 sec to 150 Hz, 25,000 points
      - Density, Capture Peaks/Valleys
    - Spectrally Match Target
    - Point-Source Model

Oscillator Response

- $F_O < F_C$
- Oscillatory Duration Longer Than Source/Path Duration
- Corrections: Empirical, Analytical
  - ≈ 10% Range
  - Selection Based on Comparison with SDF
  - Not an Issue for Ratios (Cancellation)

Comparison of median RVT and SDF (computed from acceleration time histories) 5% damped response spectra. RVT computed using Equation 24 in Boore (1983). Medians computed over 30 realizations.



Control Motions

- RVT Spectral Match to NUREG/CR-6728 Shapes
  - Extrapolate: 150 sec to 150 Hz
    - Point-Source
- Point-Source Simulations
- Spectral Shape Dependence on Site-Response (nonlinear)
  - M Not too Sensitive, ½ unit in M
  - 1 Verses 2 Corner, Sensitive
  - Loading Levels
    - PGA Grid
    - Vary Distance
      - Span Range in Reference PSHA Hazard Curves
    - Williams States Lee Not Issue, Linear Response
      - Distance Grid Important in V/H Ratios

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Scaling Reference Site PSHA to Reflect Site-Specific Conditions

- Two Primary Objectives
  1. Preserve Hazard Level of Reference Site PSHA Across Structural Frequency
     - Annual Frequency of Exceedance 10^{-4} and 10^{-5}
     - Horizontal and Vertical Motions
     - Hazard Consistent → Risk Consistent (Performance Goals)

Scaling Reference Site PSHA to Reflect Site-Specific Conditions

- Two Primary Objectives (continued)
  2. Incorporate Site-Specific Aleatory and Epistemic Variabilities in Dynamic Material Properties
     - Velocities, Depth to Basement, G/G_{max} and Hysteretic Damping
       - Parametric Aleatory, Random Variability Across Site
       - Parametric Epistemic, Uncertainty in Base Case Properties
     - Site Response Models
       - Model Epistemic, Uncertainty in Models
         - Multiple Models
         - Numerical and Empirical V/H Ratios

Background of Approaches

- Four Approaches Described in NUREG/CR-6728
  - Presented in Increasing Levels of Accuracy and Complexity
  - Approaches 1 and 2 Are Deterministic
  - Approaches 3 and 4 Are Fully Probabilistic
- The Duke Lee application employed Approach 3
  - Includes Contributions to Site-Specific Hazard from Reference Hazard at All AFE
  - Proper Accommodation of Site Aleatory Variability
  - Unambiguous Accommodation of Site Epistemic Variability
  - Preserves Hazard Level of Reference Site PSHA Across Structural Frequency

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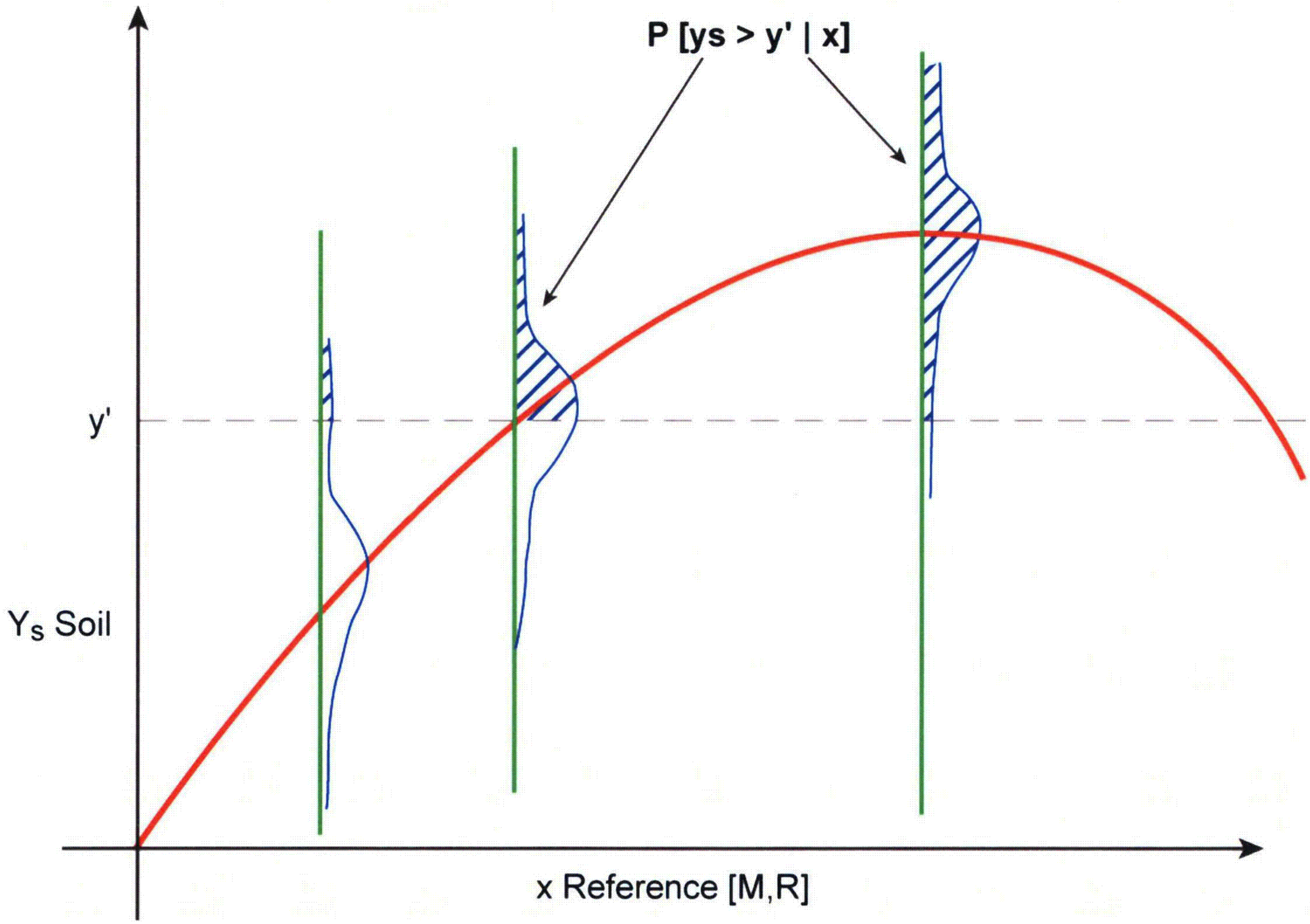
Development of Approach 3

$$-P[Y_S > Y' \mid M, R] \approx \sum_i P[Y_S > Y' \mid x_i] P[x_i \mid M, R]^*$$

- Full Integration Method
  - Soil Hazard Curve: Integration of Transfer Functions with Reference Hazard Curve
    - P [Y_S > Y'|x_i] CCDF of Transfer Functions Conditional on Reference Amplitude x_i
    - P [x_i|M, R] Probability of Observing Reference Amplitude x_i
      - Difference Reference Hazard Curve

*Tsai (2000)

Approach 3 Integration



Considerations

- Transfer Functions
  - M Deaggregations
    - Sensitivity to M
    - Horizontal, Nonlinear
  - R Deaggregations
    - Horizontal Not Sensitive
    - Vertical V/H Sensitive
  - Adequate Range in Loading Levels, Distance
    - Span Reference Hazard Levels for Horizontals (Equivalent-Linear)
    - Span Reference Hazard Distance for V/H Ratios
  - Interpolation
    - log

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Considerations (continued)

- $P[x_i]$, Numerical Differentiation
  - Scheme (Central)
  - Density of Points
- Integration
  - Scheme (Simpson's Rule)
  - Required Range in Reference Hazard
- Parametric and Model Epistemic Variability
  - Multiple Suites of Base Case Properties
  - Multiple Site-Response Models
  - Weight Resulting Hazard Curves

Illustrations of Approach 3, Horizontal Component

- Approximate Equation
  - $Y_S = X \cdot \bar{A} \, EXP \, \frac{\sigma^2}{2} \frac{\kappa}{1-c}$

Y_S, Soil Amplitude

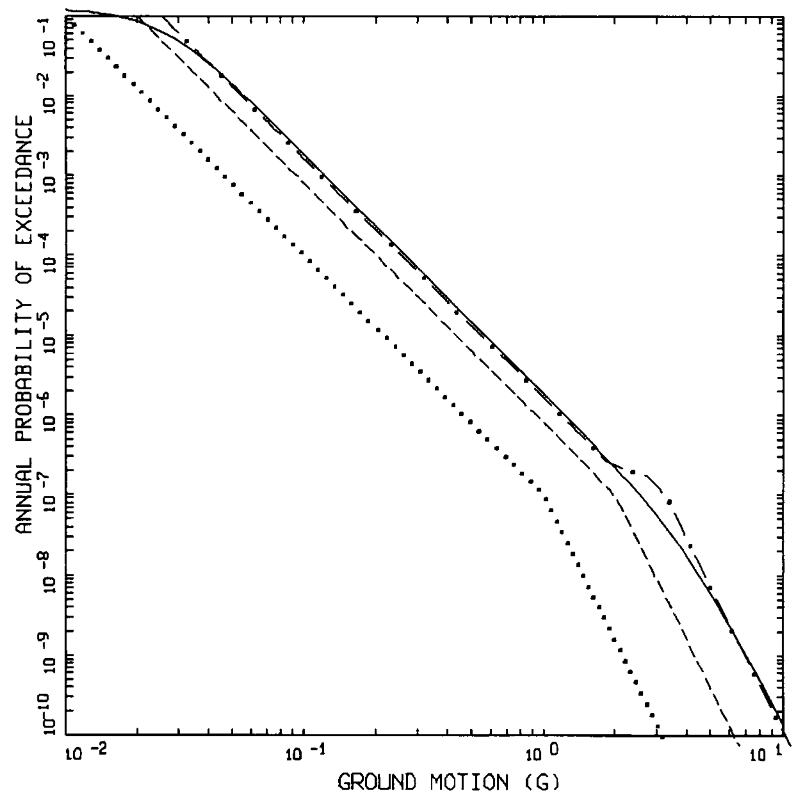
X, Reference Amplitude at Some AFE

Ā, Median Soil Amplification

σ, Aleatory Variability of Soil Amplification

c, Slope of Soil Amplification with X

K, Slope of Reference Hazard Curve



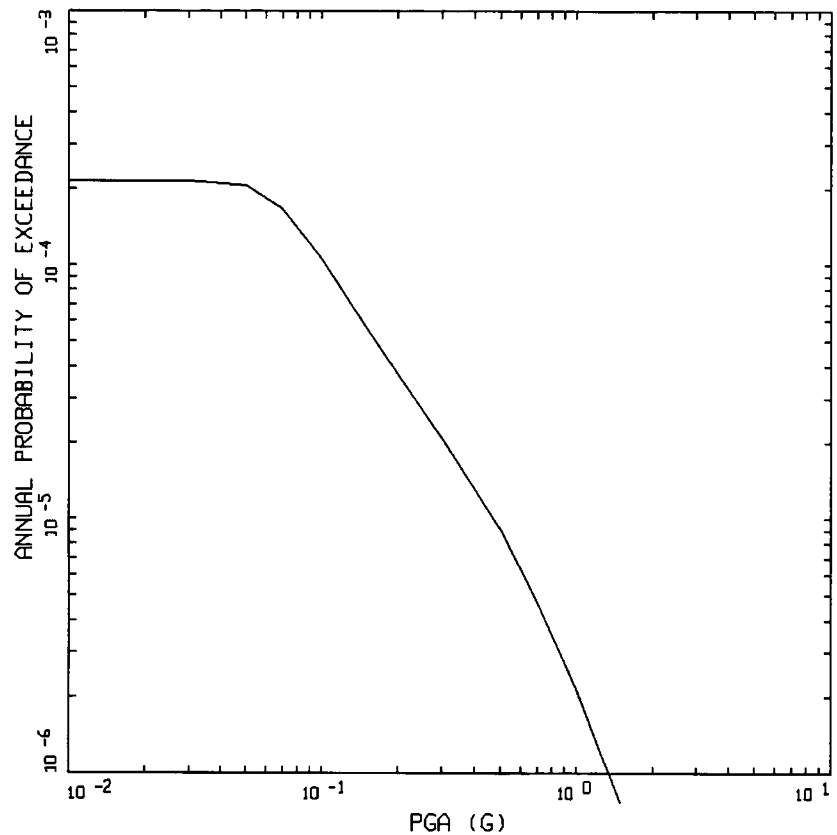
TEST EXAMPLE
AMP=2.0, SIGMA AMP=0.40

LEGEND

••••	INPUT ROCK HAZARD CURVE, SLOPES=3,6
----	INPUT ROCK HAZARD CURVE MULTIPLED BY AMP=2.0
—·—	OUTPUT SOIL HAZARD CURVE: APPROACH 3 APPROXIMATE
——	OUTPUT SOIL HAZARD CURVE: APPROACH 3 FULL INTEGRATION

Illustrations of Approach 3, Horizontal Component

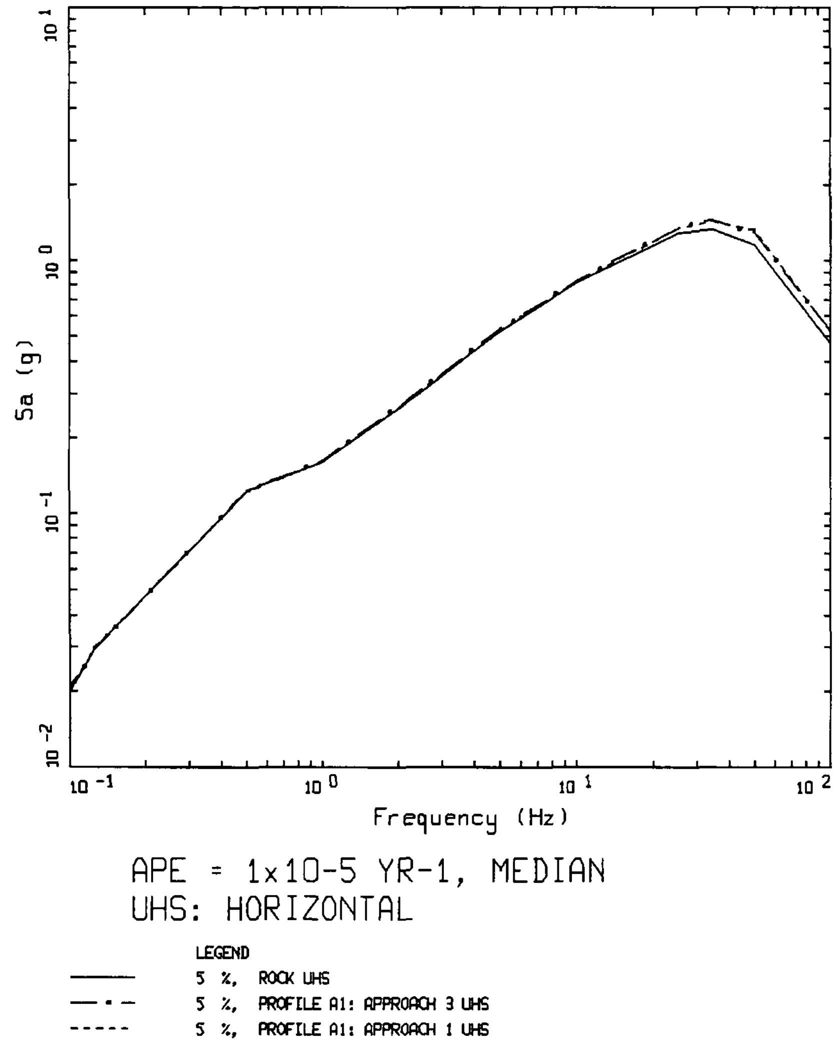
- Report Will Include Additional Test Cases
  - More Complex Case
  - Lee Specific Case



DUKE-LEE: HAZARD CURVE, MEAN
HARD ROCK, PGA

Duke-Lee Unit 1 AFE 10^{-5} UHRS

- Hard rock UHRS
- Approach 3 UHRS
- Approach 1 UHRS



Implementation of Approach 3, Vertical Components

- Vertical Motions at Same AFE as Horizontal, Hazard and Risk Consistent
- Apply Approach 3 (Full Integration) to Site-Specific Horizontal Hazard
- Transfer Functions
  - V/H Ratios

Considerations

- V/H Ratios Sensitive to Distance, Generally Vary Slowly
- V/H Ratios Sensitive to M
  - Horizontals Reflect Nonlinear Site Response
  - Verticals Reflect Linear Site Response
- Site-Specific V/H Ratios
  - No Universally Accepted Model
  - Incorporate Model Epistemic Variability
    - Combine Numerical and Empirical
    - WNA Applicability
  - Parametric Epistemic Variability
    - Multiple Base-Case Properties
    - Weight Resulting Hazard Curves

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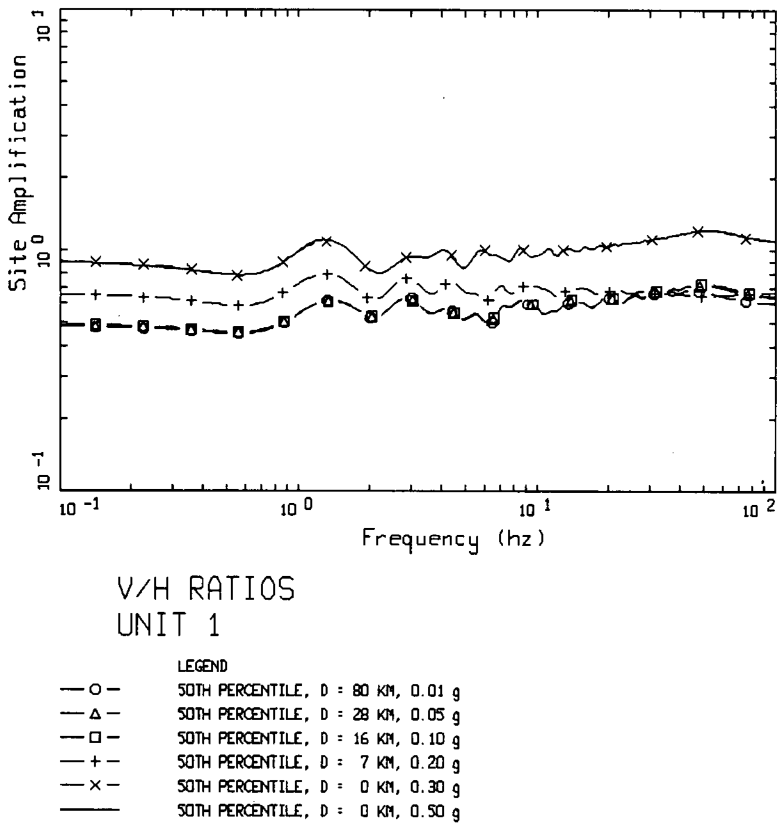
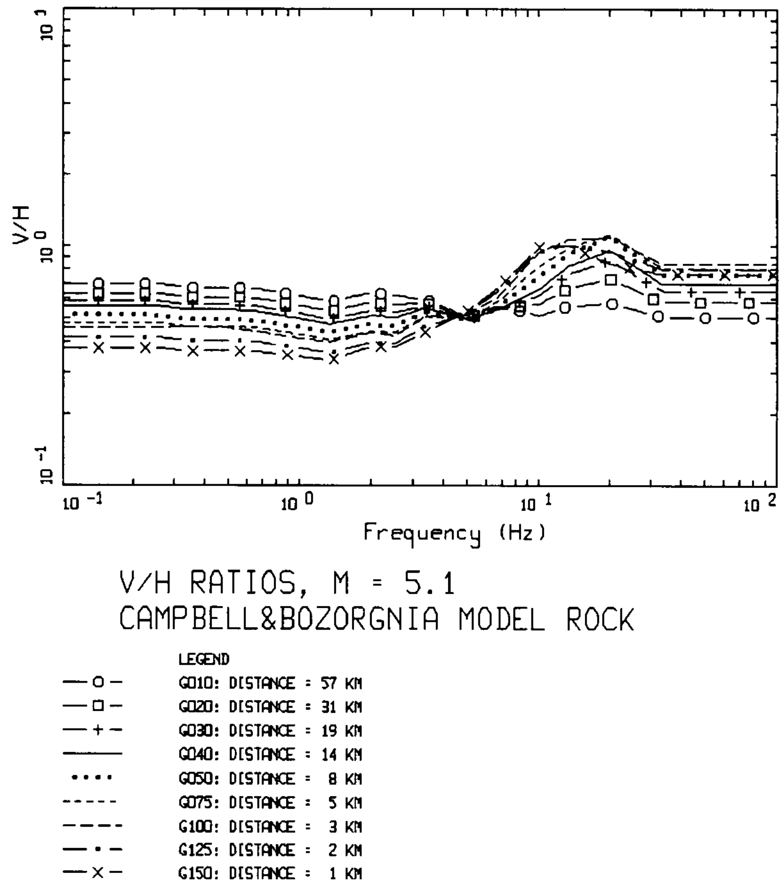
Considerations (continued)

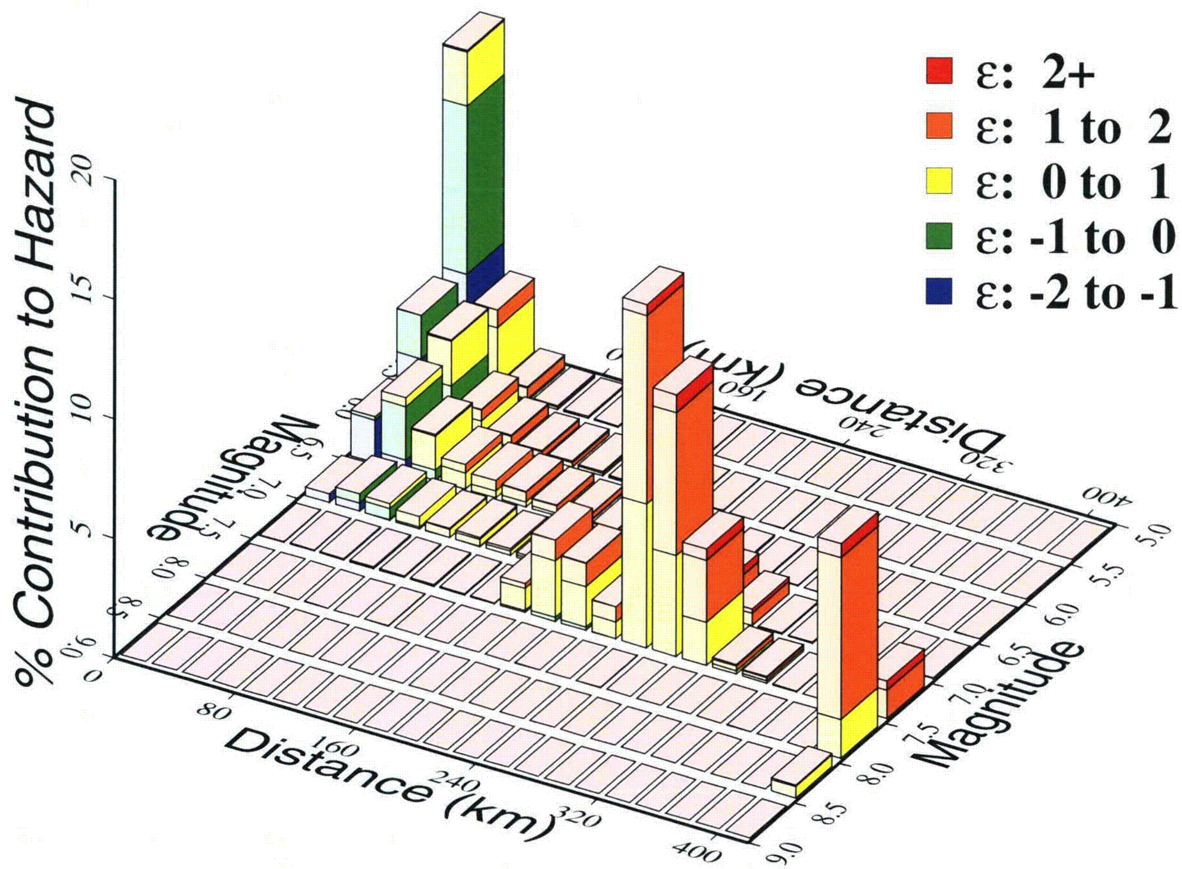
- Incorporate Parametric Aleatory Variability
  - Avoid Double Count
    - Already in Horizontals
- Verticals Slightly More Variable Than Horizontals

Numerical & Empirical Models





5Hz + 10Hz – 10^{-4} Deaggregation



Technical Report Conclusions

- Complete Development
  - RVT
  - Approach 3
- RVT
  - Description
  - Detailed Information on Parameters
- Approach 3
  - Derivation
  - Example Test Cases
  - Parameters Used
  - Incorporation of Aleatory and Epistemic Variabilities
  - Implementation in Developing Hazard Consistent Horizontal and Vertical Design Motions

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Report Outline

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Near-Surface Site Ground Motion Effects

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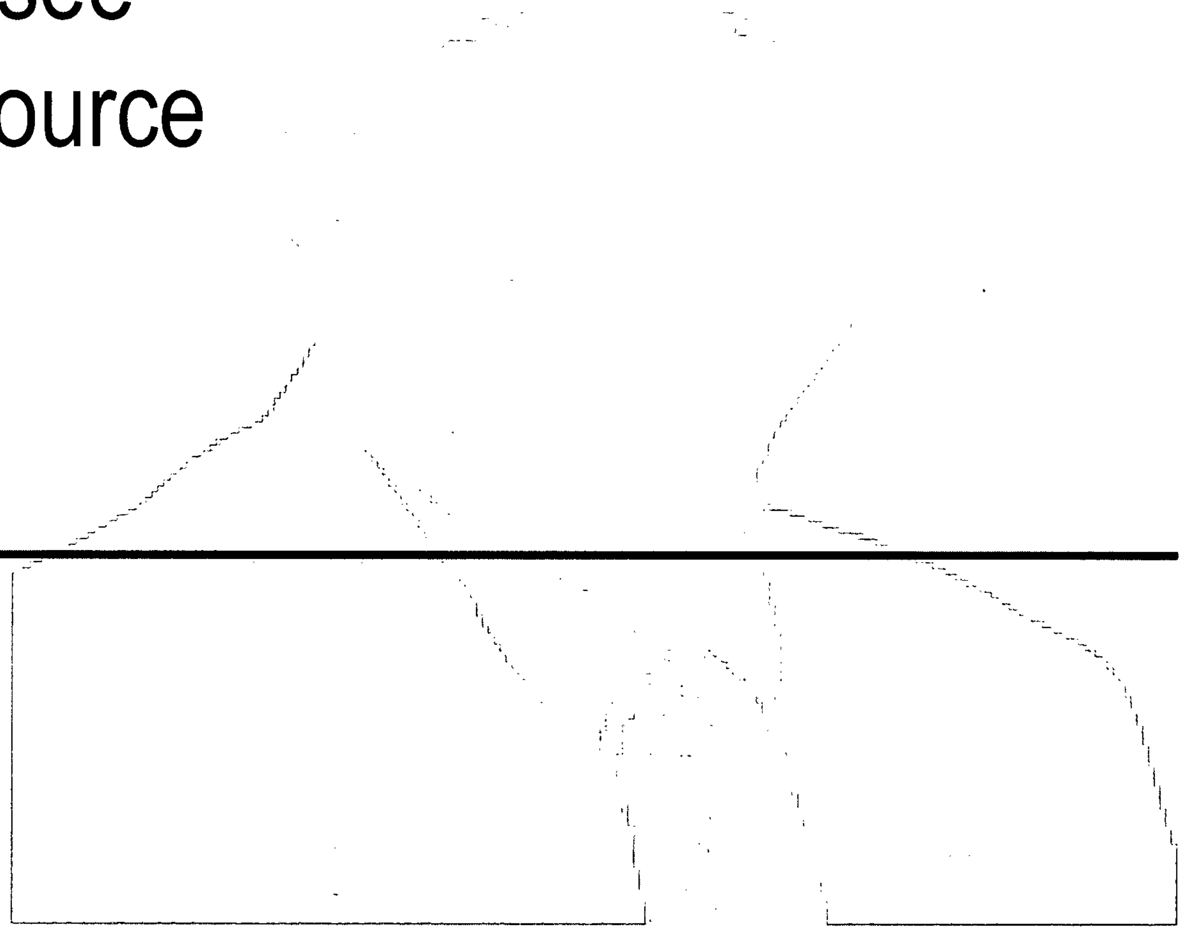
Eastern Tennessee Seismic Zone Source Model



Eastern Tennessee Seismic Zone (ETSZ) Generic Study

- Purpose:
  1. To evaluate sensitivity of ground motion hazards and GMRS to more recent ETSZ characterizations compared to the EPRI-SOG model
  2. Use the results of the generic study to answer NRC questions raised in individual COL applications

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Development of Generic ETSZ Study

- Proposed generic study initially discussed with NRC at NEI meeting on February 13
- More detailed proposals submitted to NRC through NEI on February 27 and March 2
- Industry believes the Generic Study will be responsive to NRC Concerns

Proposed Analysis

- Select generic "site" near middle of ETSZ to maximize contribution of ETSZ
- Calculate seismic hazard for EPRI-SOG representations
- Develop updated EQ catalog
- Calculate hazard from updated seismicity parameters (recurrence) for the EPRI-SOG representations of ETSZ
- Calculate the seismic hazard for EPRI-SOG sources with Mmax values modified to reflect TIP and TVA Study Mmax distributions
- Document the hazard sensitivity for EPRI-SOG teams

ETSZ Seismic Hazard Calculations to Include

- EPRI-SOG sources with original EPRI Mmax values with both original and updated recurrence parameters
- EPRI-SOG sources modified to reflect Mmax values from both TIP and TVA Dam Safety studies
- Hazard from Charleston and New Madrid sources
- EPRI (2004) attenuations with updated sigmas
- With and without Cumulative Absolute Velocity (CAV) filter
- UHRS and GMRS at 7 frequencies (PGA, 25, 10, 5, 2.5, 1, and 0.5 Hz)

ETSZ Generic Study Submittal

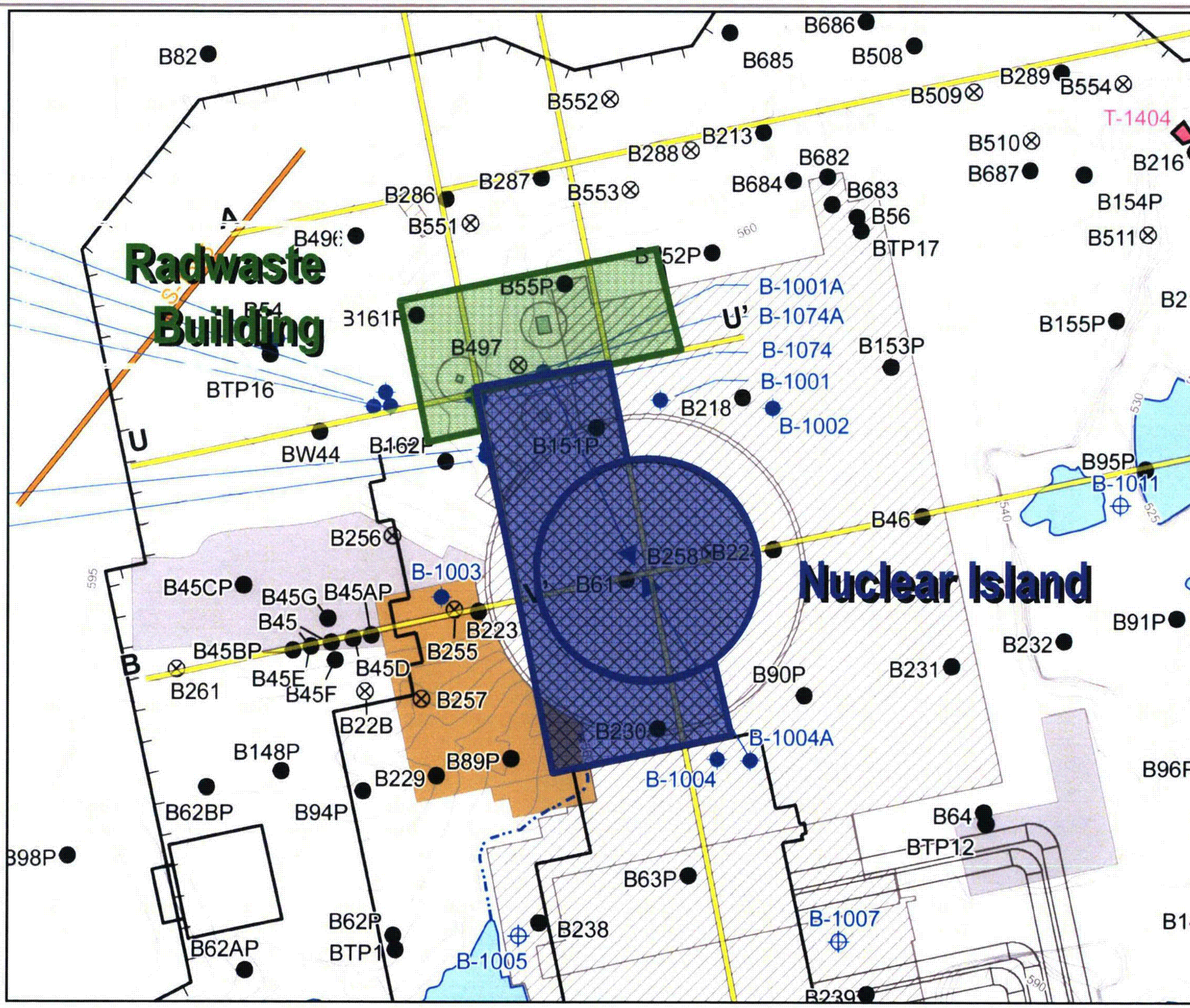
- Determine the impact on hazard from more recent characterizations of ETSZ since the EPRI-SOG model
- To be submitted by industry to NRC on May 14, 2008
- Duke will incorporate this effort into its COL Application in a future submittal

Radwaste Building Fill Material Dynamic Response

Radwaste Building Fill Material

- NRC had a concern about the fill materials under the Radwaste Building (i.e. liquefaction)
- Duke will supplement the application with information summarizing the results of a liquefaction analysis of Group I engineered fills under the Radwaste Building
  - Perform analysis consistent with RG 1.198 as described in the following slides
  - Presentation will provide an outline of the analysis
  - Submit a summary report on or before May 23, 2008
- FSAR provides an explanation of foundation materials and soil backfill outside the nuclear island
- Review the Radwaste Building design criteria specified in the AP1000 DCD

AP1000 Configuration



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Approach to Evaluate Liquefaction Potential (RG 1.198)

- Screening-level analysis - using COLA-derived data
  - Geologically-based liquefaction assessment on naturally-occurring deposits (saprolite and weathered rock)
    - Past performance or evidence of historic or paleoliquefaction, deposit type/age, percent granular material, and SSE PGA range
  - Soil-texture based liquefaction assessment on naturally-occurring deposits and engineered fill
    - Fines content (clay and silt) content, Plasticity Index (PI), Liquid Limit (LL), and in situ water content
  - Derive qualitative assessment of liquefaction hazard (e.g., very low, low, moderate, high, or very high)
    - Forms the basis of the conclusions in the COLA

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Approach to Evaluate Liquefaction Potential (RG 1.198)

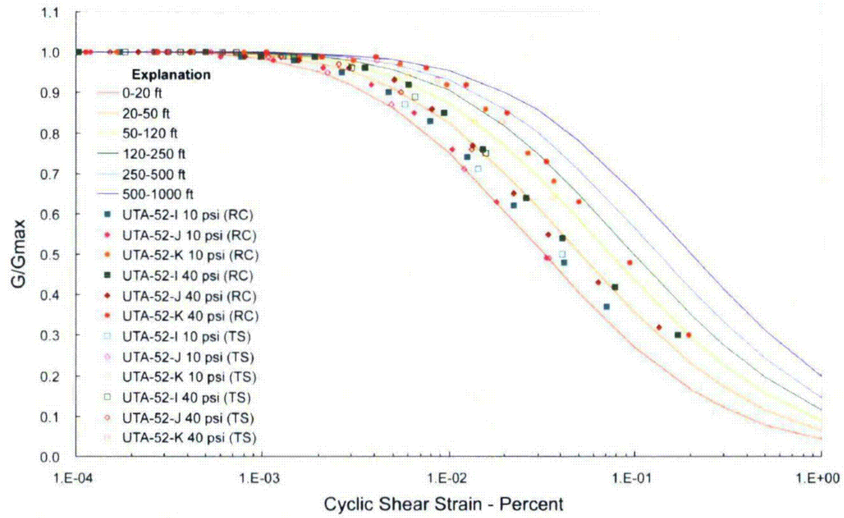
- Quantitative analysis - using COLA-derived data (SPT, CPT, and Vs measurements)
  - Deterministic approach
    - Derive factor of safety against liquefaction
  - Probabilistic approach – consistent with seismic hazard
    - Derive factor of safety against liquefaction

Characterization of Group I Engineered Fills

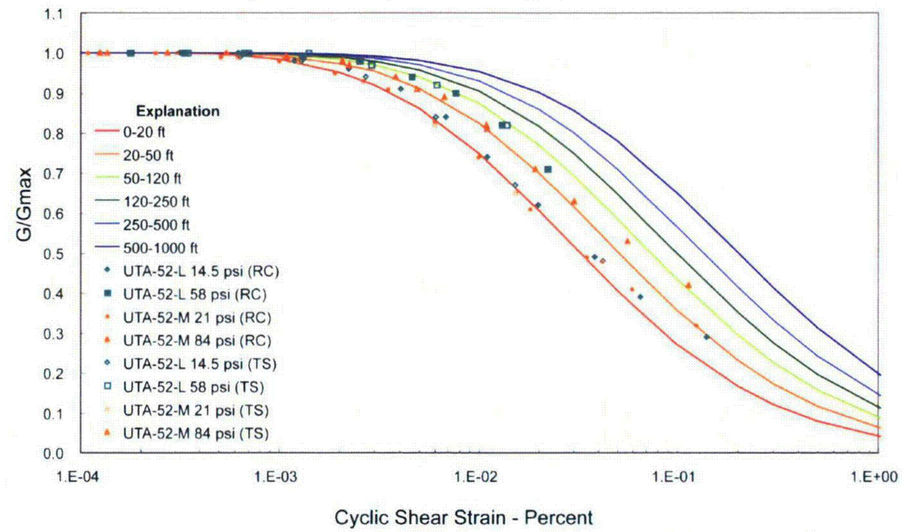
- Evaluate properties using extensive field and laboratory testing program
  - Existing Group I engineered fills including Test Fills 1 and 2
  - Proposed Borrow Areas
- Field testing - SPT, CPT/SCPT, P-S Suspension, and SASW
  - Borings - 15 in Group I Fill and 14 in Borrow Areas
  - CPT/SCPT - 13 in Group I Fill and 1 in Borrow Areas
  - Test Pits - 1 in Group I Fill and 8 in Borrow Areas
- Laboratory testing includes static tests (index and strength) and dynamic RCTS
  - RCTS - 13 total
    - 2 Existing Group I Fill (Test Fill 1)
    - 3 Remolded Borrow Area Samples
- Evaluations define epistemic variability (uncertainty in the mean) in soil and rock properties

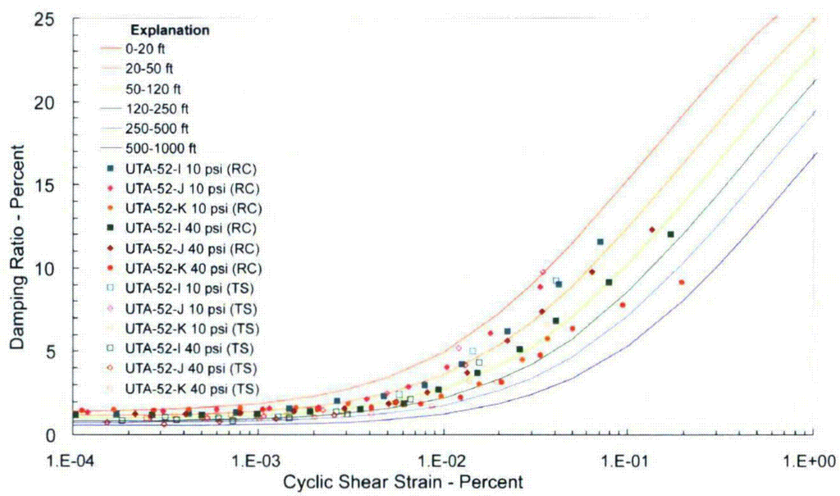
Shear Modulus and Damping Ratio Plots for RCTS Fill Samples at 1x and 4x Confining Stress

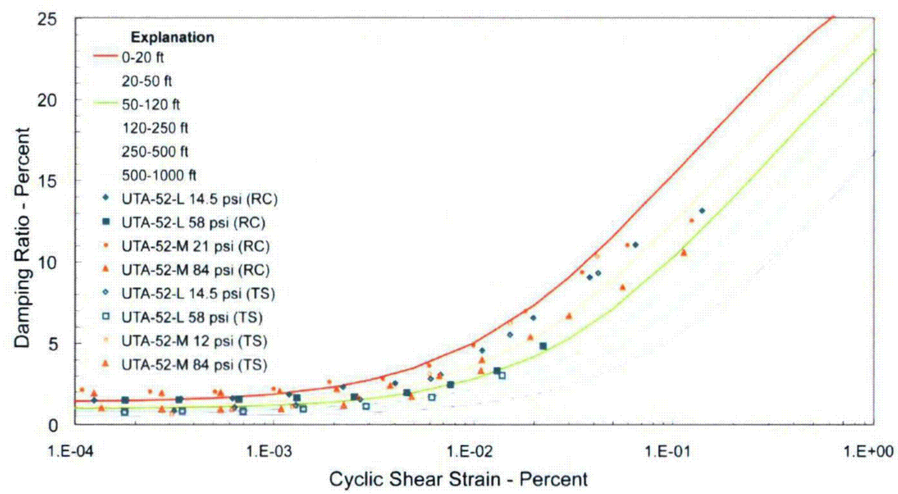
Remolded Samples (3)



Existing Group 1 Fill (2)







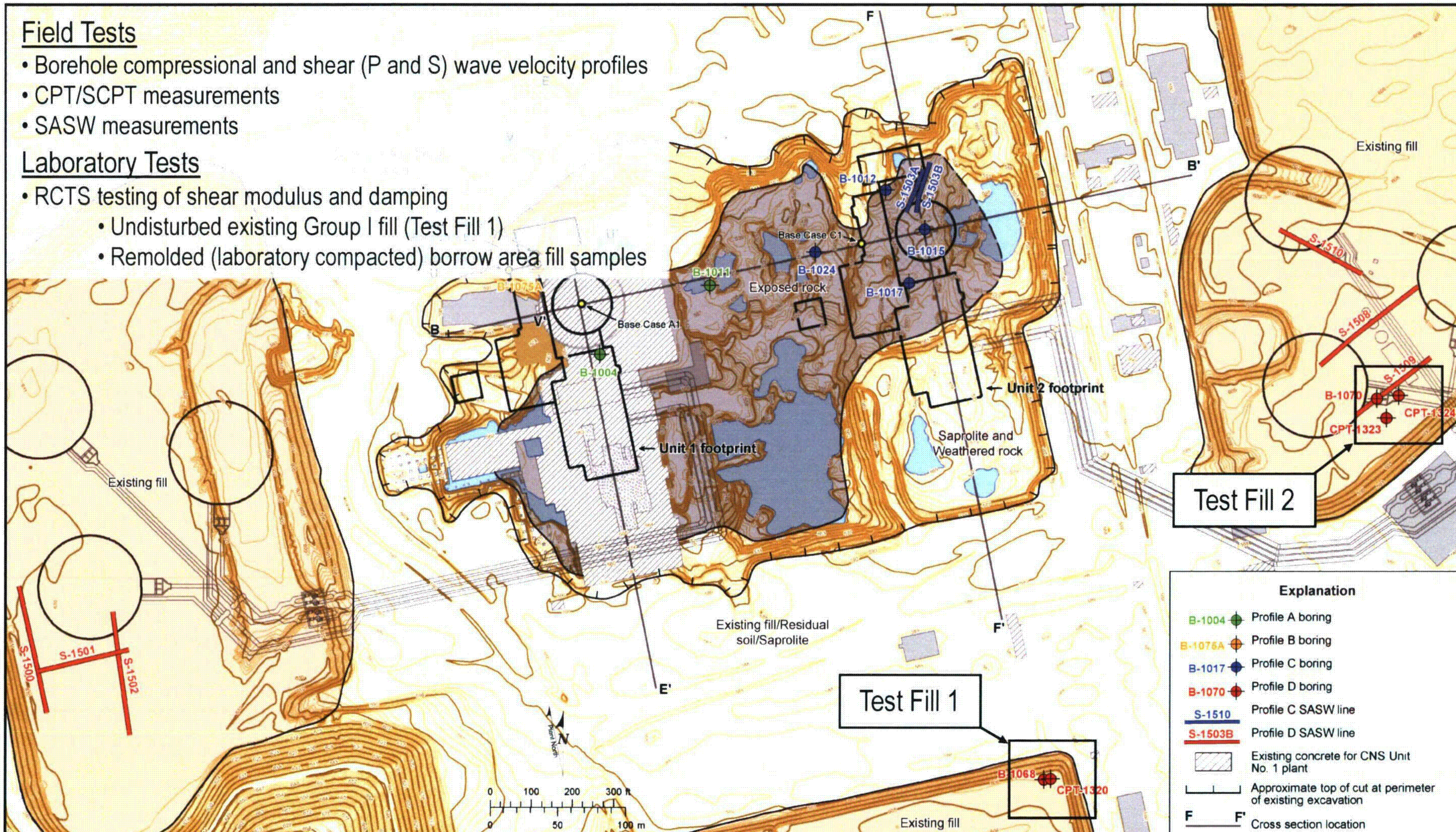
COLA Field Investigations – Group I Fill Properties

<u>Field Tests</u>

- Borehole compressional and shear (P and S) wave velocity profiles
- CPT/SCPT measurements
- SASW measurements

<u>Laboratory Tests</u>

- RCTS testing of shear modulus and damping
    - Undisturbed existing Group I fill (Test Fill 1)
    - Remolded (laboratory compacted) borrow area fill samples



Foundation Materials and Soil Backfill Outside the Nuclear Island

- FSAR provides an explanation of foundation materials and soil backfill outside the nuclear island
- FSAR 2.5.4.5.3.3 Foundation Materials Outside the Nuclear Island
  - Defines criteria to determine the presence of suitable foundation materials prior to placement of backfill materials beneath the non safety-related structures
- FSAR 2.5.4.5.3.5 Soil Backfill Outside the Nuclear Island
  - Soil backfill is from Borrow Areas 1, 6A, and CT1 or comparable

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Radwaste Building Design Criteria

- DCD 3.7 states that 'Seismic Category II and non-seismic structures are designed or physically arranged (or both) so that the safe shutdown earthquake could not cause unacceptable structural interactions with or failure of Seismic Category I structures, systems, and components'
- Radwaste Building seismic design criteria defined in DCD 3.7.2.8.2
  - Non-seismic classification
  - Structure designed to UBC, Zone 2A with Importance Factor of 1.25
  - Small steel frame building

Radwaste Building Fill Material

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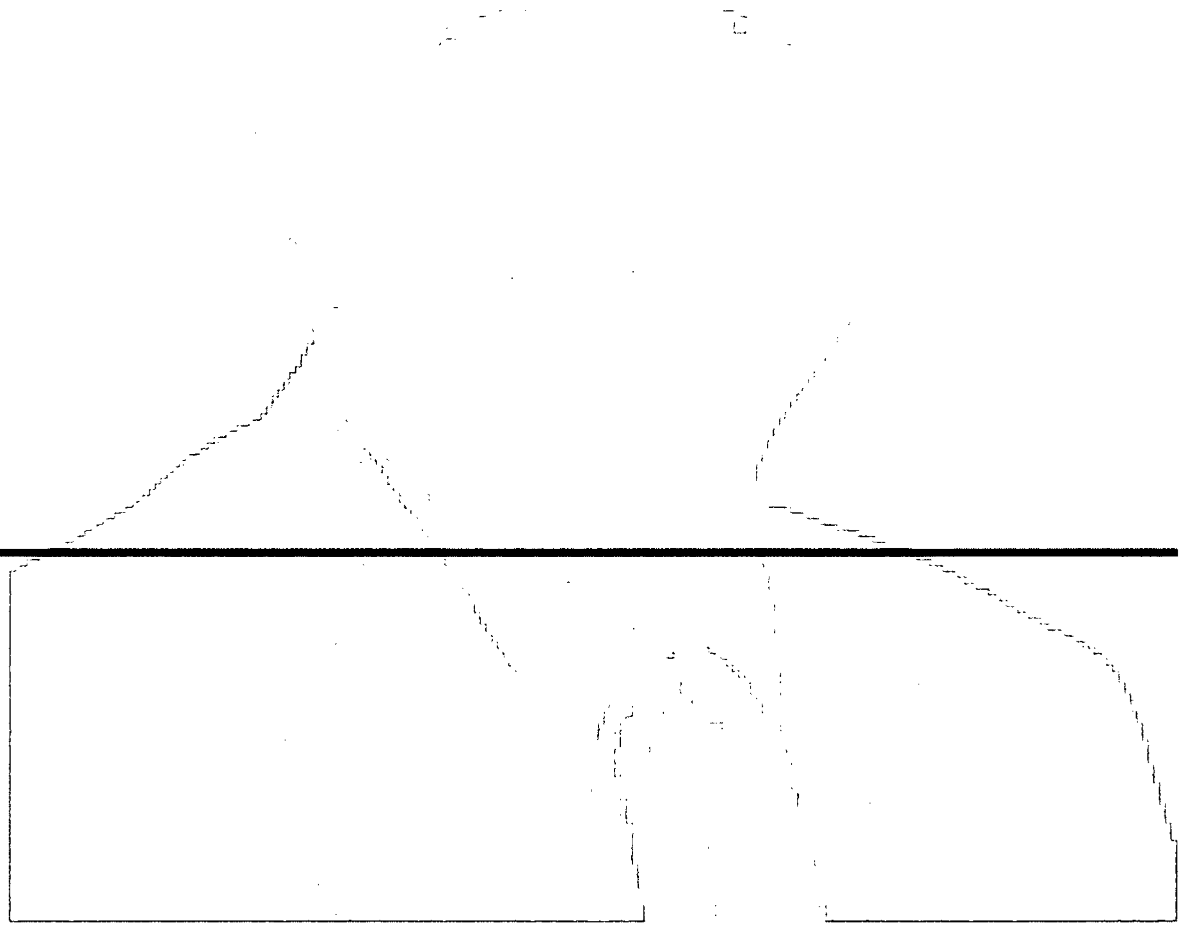
Summary and Conclusion



Summary

- AP1000 Recirculation Screen Design
  - Westinghouse submittals intended to resolve issue under a Design Certification Amendment
- RVT and Approach 3
  - Submittal planned for April 30, 2008
  - Duke would support an NRC request for a future public meeting
  - Duke is requesting a Lee specific review
  - Duke will consider generic activities to further this effort

Summary (continued)

- Eastern Tennessee Seismic Zone
  - Generic industry approach to be submitted on May 14, 2008
  - Duke will incorporate this effort in its COL application in a future submittal
- Dynamic Response of Fill Material (Radwaste Building)
  - Submittal planned for May 23, 2008
  - Submittal will address liquefaction
- Other Planned Submittals
  - Concrete Basemat Test Report planned for April 1, 2008

Conclusion

- Efficiencies can be realized through the design center
  - STD content
  - Duke realized efficiencies in the NRC Acceptance Review
- NuStart/DCWG provides an effective forum for integration
  - DCD / R-COLA / S-COLA
  - R-COLA ↔ S-COLA
  - RAI Process
- AP1000 Recirculation Screen & ETSZ are generic issues for which Duke will implement the generic solution

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Conclusion (continued)

- Duke expects that the schedule impacts for the Radwaste Building are bounded by the generic seismic issues.
- Duke expects that RVT and Approach 3 will have minimal impact on the review schedule.

Questions