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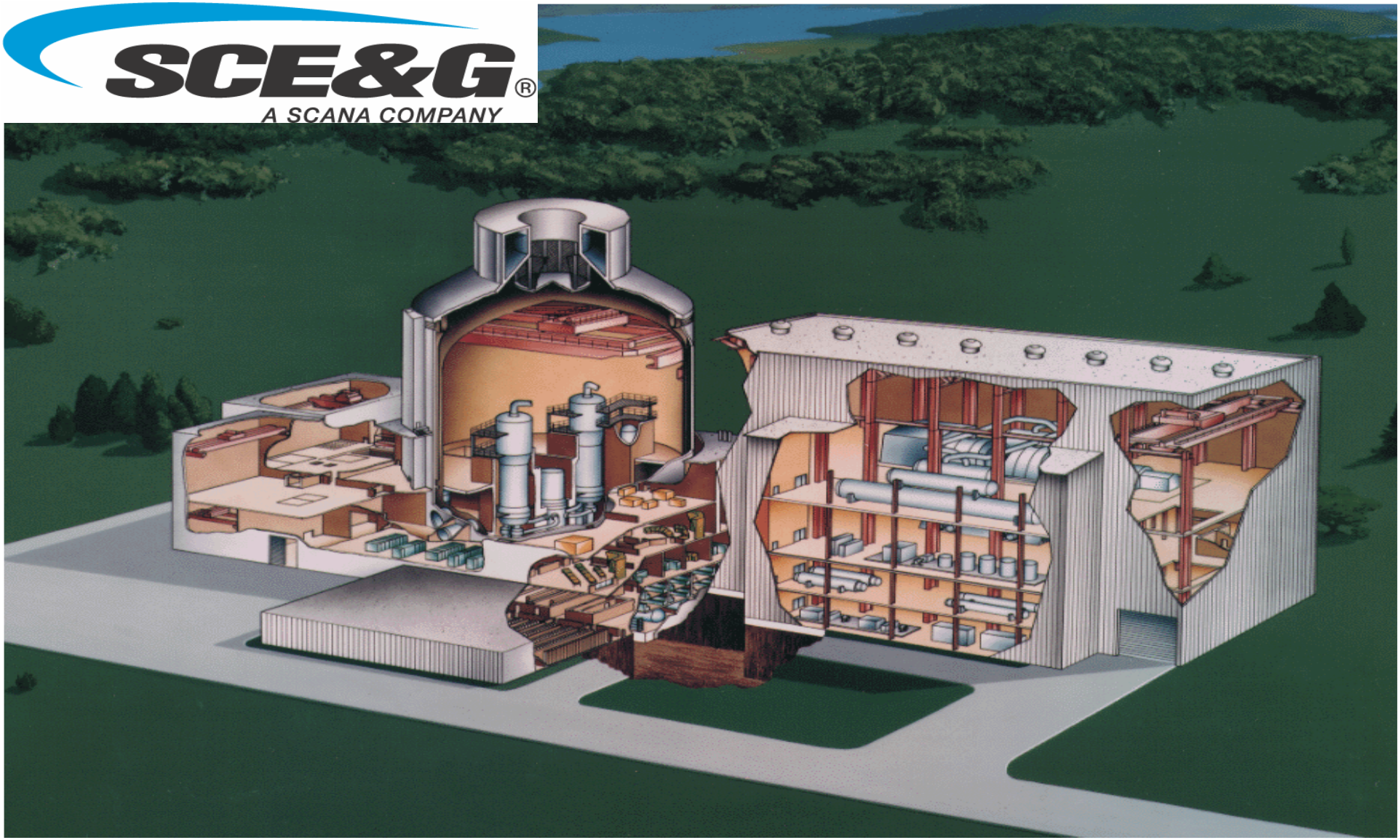


Virgil C. Summer Nuclear Station Units 2 & 3 (Westinghouse AP1000)

PROJECT OVERVIEW

VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNITS 2 & 3

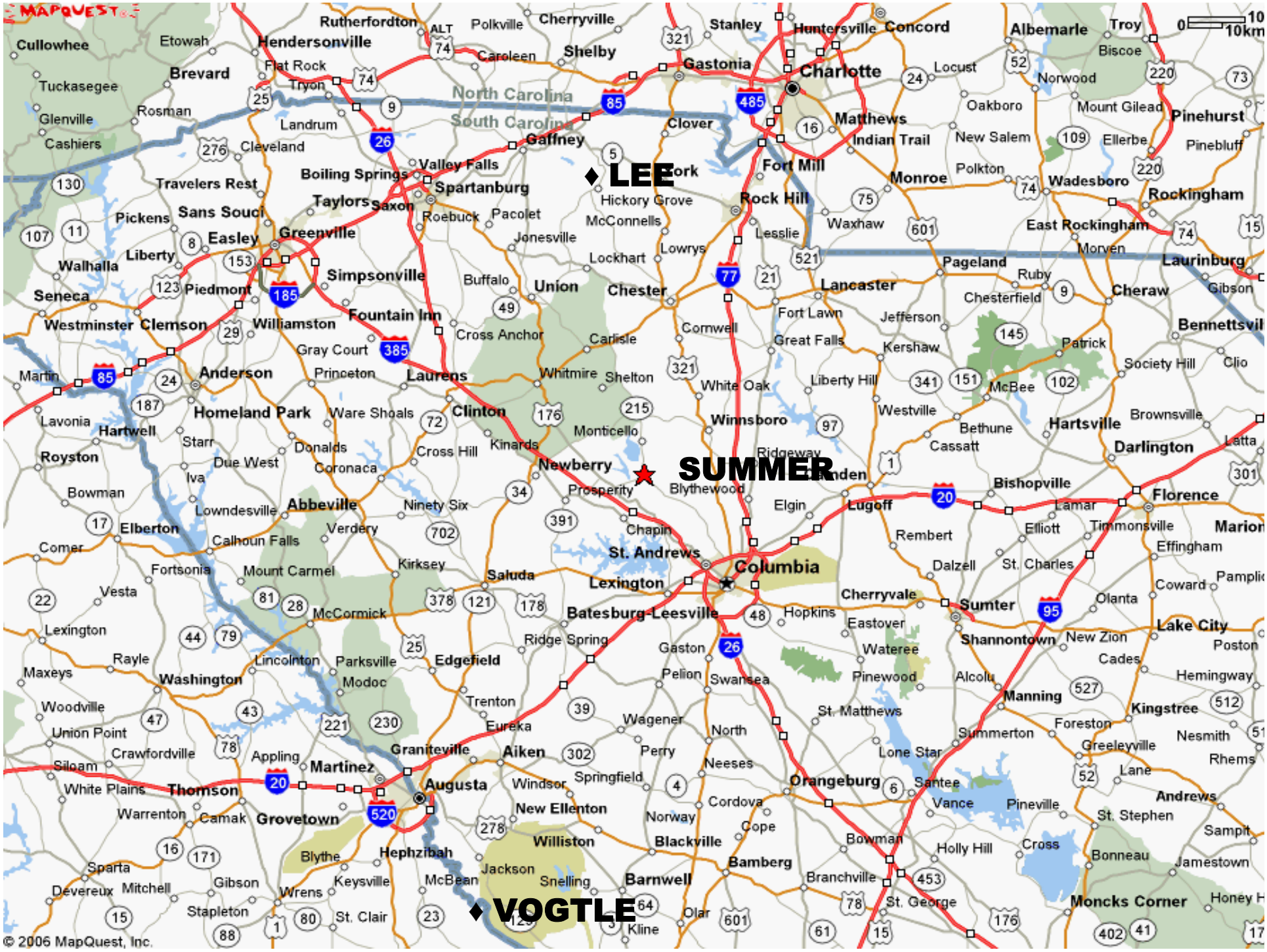
BOB WHORTON – SENIOR ENGINEER

SOUTH CAROLINA ELECTRIC & GAS COMPANY

OCTOBER 3, 2007

PURPOSE

- **Overview of SAR Section 2.5 (Prior to Submittal)**
- **Summary - Geology, Seismology and Geotechnical Investigations**
- **PSHA Process and Results**
- **Development of Site GMRS**
- **Summary – Seismic Issues (Existing Unit 1):**
  - **Bedrock Shear Fractures**
  - **Reservoir Induced Seismicity**


MAPQUEST
LEE
SUMMER
VOGTLE
North Carolina
South Carolina
Charlotte
Columbia
Augusta
Rutherfordton
Hendersonville
Polkville
Cherryville
Shelby
Stanley
Huntersville
Concord
Albemarle
Troy
Biscoe
Cullowhee
Etowah
Brevard
Flat Rock
Tryon
Caroleen
Gastonia
Locust
Norwood
Tuckasegee
Rosman
Glenville
Cashiers
Landrum
Cleveland
Gaffney
Clover
Matthews
Indian Trail
Oakboro
Mount Gilead
Pinehurst
New Salem
Ellerbe
Pinebluff
Travelers Rest
Boiling Springs
Valley Falls
Spartanburg
Fort Mill
Monroe
Polkton
Wadesboro
Rockingham
Pickens
Sans Souci
Taylors
Saxon
Roebuck
Pacolet
Hickory Grove
McConnells
Rock Hill
Waxhaw
East Rockingham
Easley
Greenville
Jonesville
Lesslie
Morven
Walhalla
Liberty
Simpsonville
Lockhart
Lowrys
Pageland
Laurinburg
Seneca
Piedmont
Buffalo
Union
Chester
Lancaster
Ruby
Chesterfield
Cheraw
Gibson
Westminster
Clemson
Williamston
Fountain Inn
Cross Anchor
Carlisle
Cornwell
Fort Lawn
Jefferson
Great Falls
Kershaw
Patrick
Bennettsville
Gray Court
Martin
Anderson
Princeton
Laurens
Whitmire
Shelton
White Oak
Liberty Hill
McBee
Society Hill
Clio
Lavonia
Hartwell
Homeland Park
Ware Shoals
Clinton
Monticello
Winnsboro
Westville
Bethune
Hartsville
Brownsville
Royston
Starr
Donalds
Cross Hill
Kinards
Ridgeway
Cassatt
Darlington
Latta
Due West
Coronaca
Newberry
Iva
Prosperity
Blythewood
Camden
Bishopville
Bowman
Lowndesville
Abbeville
Ninety Six
Elgin
Lugoff
Lamar
Florence
Elberton
Verdery
Chapin
Rembert
Elliott
Timmonsville
Marion
Comer
Calhoun Falls
St. Andrews
Effingham
Fortsonia
Mount Carmel
Kirksey
Saluda
Lexington
Dalzell
St. Charles
Vesta
Cherryvale
Sumter
Olanta
Coward
McCormick
Batesburg-Leesville
Hopkins
Eastover
Lake City
Lexington
Ridge Spring
Gaston
Shannontown
New Zion
Poston
Rayle
Lincolnton
Parksville
Edgefield
Wateree
Cades
Maxeys
Washington
Modoc
Pelion
Swansea
Pinewood
Alcolu
Hemingway
Woodville
Trenton
Manning
Kingstree
Union Point
Eureka
Wagener
St. Matthews
Foreston
Summerton
Nesmith
Crawfordville
Appling
Graniteville
Aiken
Perry
North
Lone Star
Greeleyville
Siloam
Martinez
Neeses
Rhems
White Plains
Thomson
Augusta
Windsor
Springfield
Orangeburg
Santee
Lane
Warrenton
Camak
Grovetown
New Ellenton
Norway
Cordova
Vance
Pineville
Andrews
St. Stephen
Williston
Cope
Blackville
Bowman
Holly Hill
Cross
Sampit
Sparta
Blythe
Hephzibah
Jackson
Bamberg
Bonneau
Jamestown
Devereux
Mitchell
Gibson
Keysville
McBean
Snelling
Barnwell
Branchville
Wrens
St. George
Moncks Corner
Honey H
Stapleton
St. Clair
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Kline
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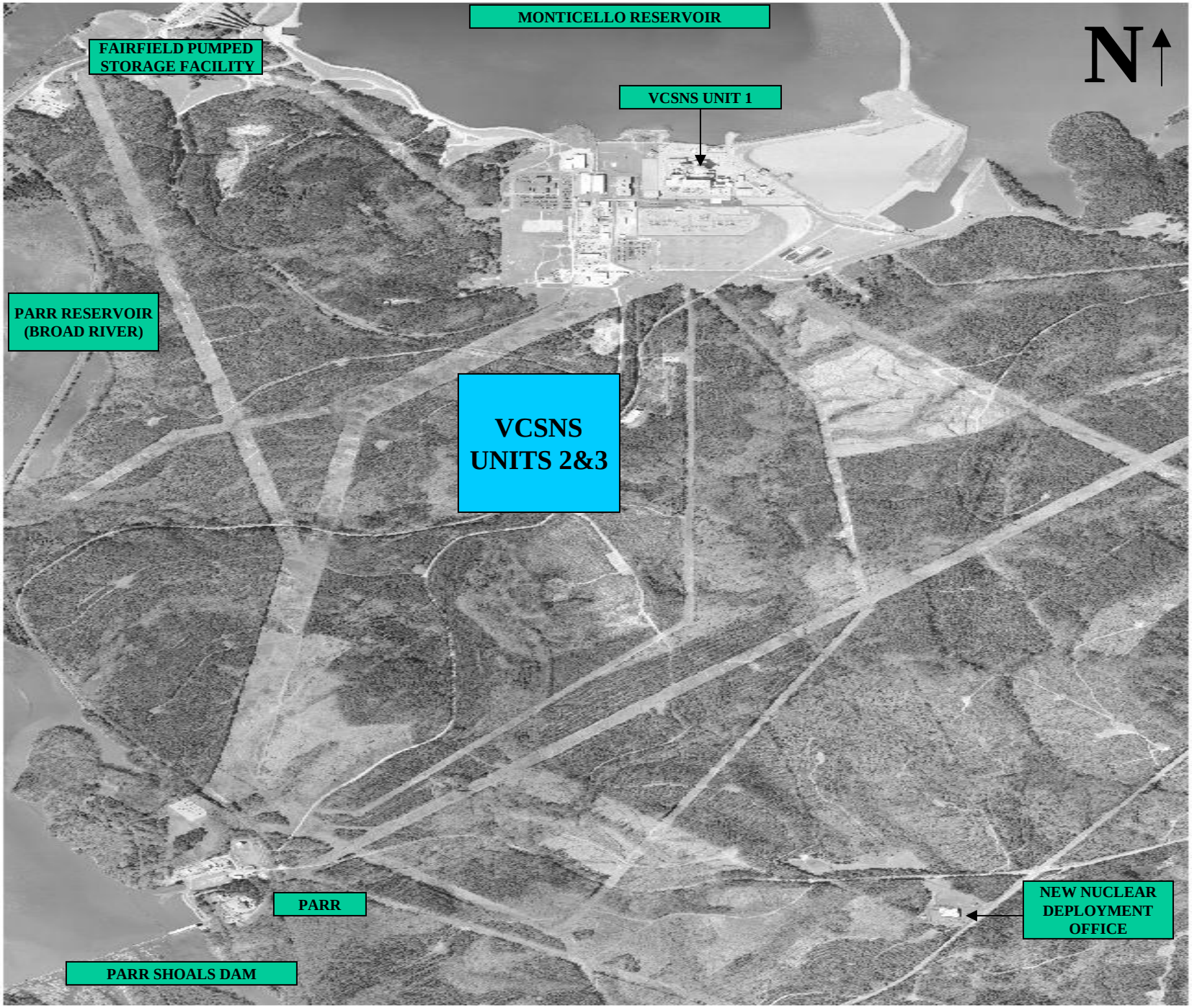
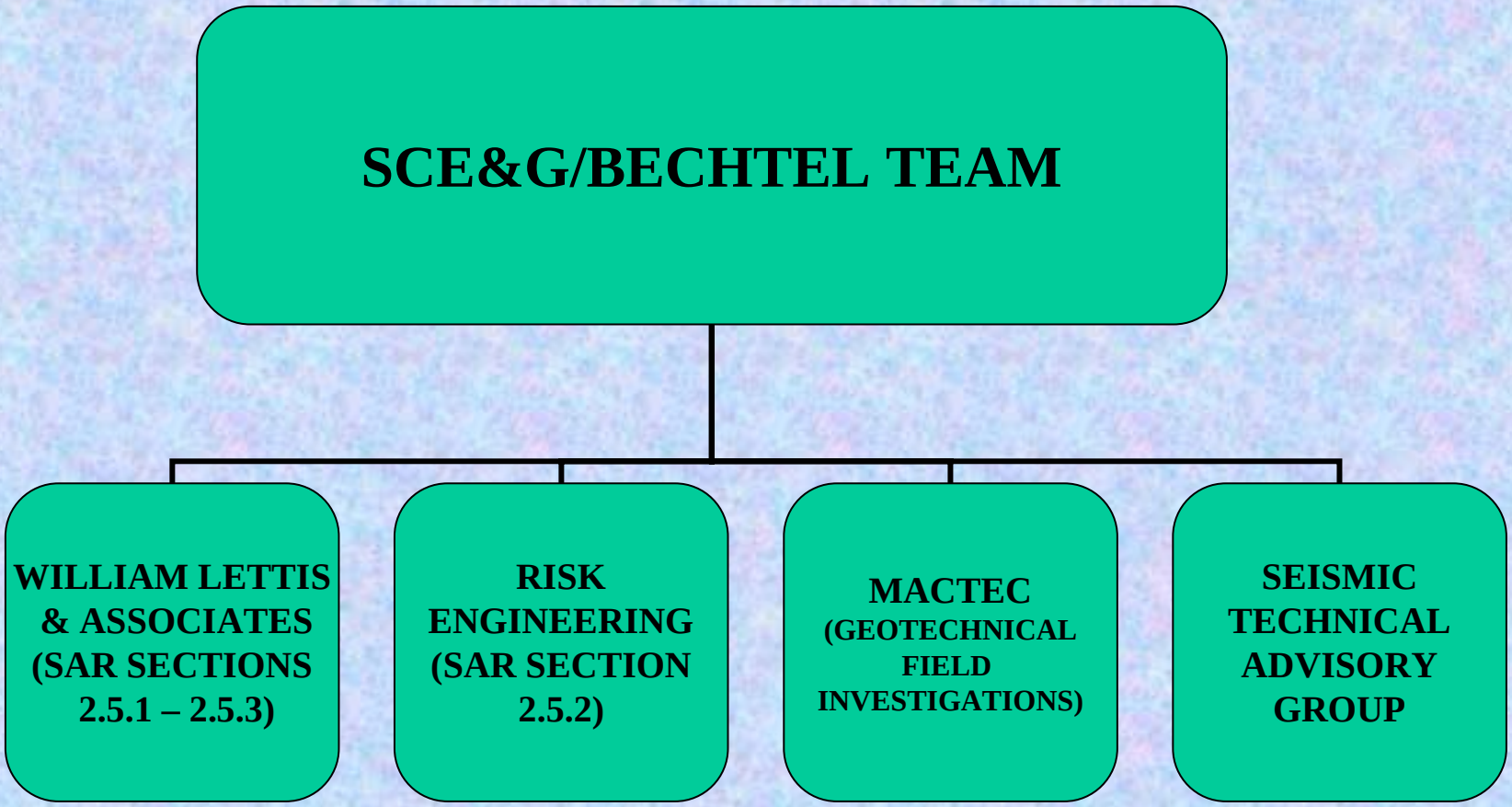

MONTICELLO RESERVOIR
N
FAIRFIELD PUMPED STORAGE FACILITY
VCSNS UNIT 1
PARR RESERVOIR (BROAD RIVER)
VCSNS UNITS 2&3
PARR
NEW NUCLEAR DEPLOYMENT OFFICE
PARR SHOALS DAM

09.29.2006 12:51

SAR SECTION 2.5
TECHNICAL DEVELOPMENT



SUMMER - SEISMIC TECHNICAL ADVISORY GROUP (TAG)

- **Dr. Martin Chapman – Virginia Tech**
- **Dr. Allin Cornell – Stanford**
- **Dr. Robert Kennedy – RPK S/M**
- **Mr. Don Moore – Southern Company**
- **Dr. Carl Stepp – EHS**

SUMMER TAG OVERVIEW

- **TAG #1 (June 6-7, 2006)**
  - **Project Orientation**
  - **Site Tour**
  - **Unit 1 Design Review**
  - **Unit 2&3 Geotechnical Investigations**
  - **Geological & Seismic Background**
  - **PSHA Review Process**
  - **TAG Recommendations & Technical Guidance**

AP1000 SEISMIC REVIEW COMMITTEE (APSRC)

- **Formed July 5, 2006 – Duke-Energy, Progress Energy, SCE&G, Southern Company, TVA (Technical Leads)**
  - **Provide Generic Oversight of Issues**
  - **Develop Common Approaches**
  - **Ensure Consistency of Evaluations / Results**
  - **Effectively Coordinate AP1000 Design Issues with NEI / SITF / EPRI / NRC**

SUPER TAG REVIEWS BELLEFONTE / LEE / SUMMER

- **TAG #2 (January 29 – February 1, 2007)**
  - **Duke Energy (Charlotte)**
- **TAG #3 (June 18 – 21, 2007)**
  - **Duke Energy (Charlotte)**
- **TAG #4 (August 31, 2007)**
  - **William Lettis & Associates (Walnut Creek)**

Comments

V. C. Summer Nuclear Station (VCSNS) Units 2 and 3

Geology (Regional and Site), Seismology, and Seismic Sources

(Highlights of Sections 2.5.1, 2.5.2, and 2.5.3)

Scott Lindvall

William Lettis & Associates, Inc.

NRC Presentation

October 3, 2007

2.5.1 Basic Geologic and Seismic Info.

- 2.5.1.1 Regional Geology
  - Site Region (200 miles)

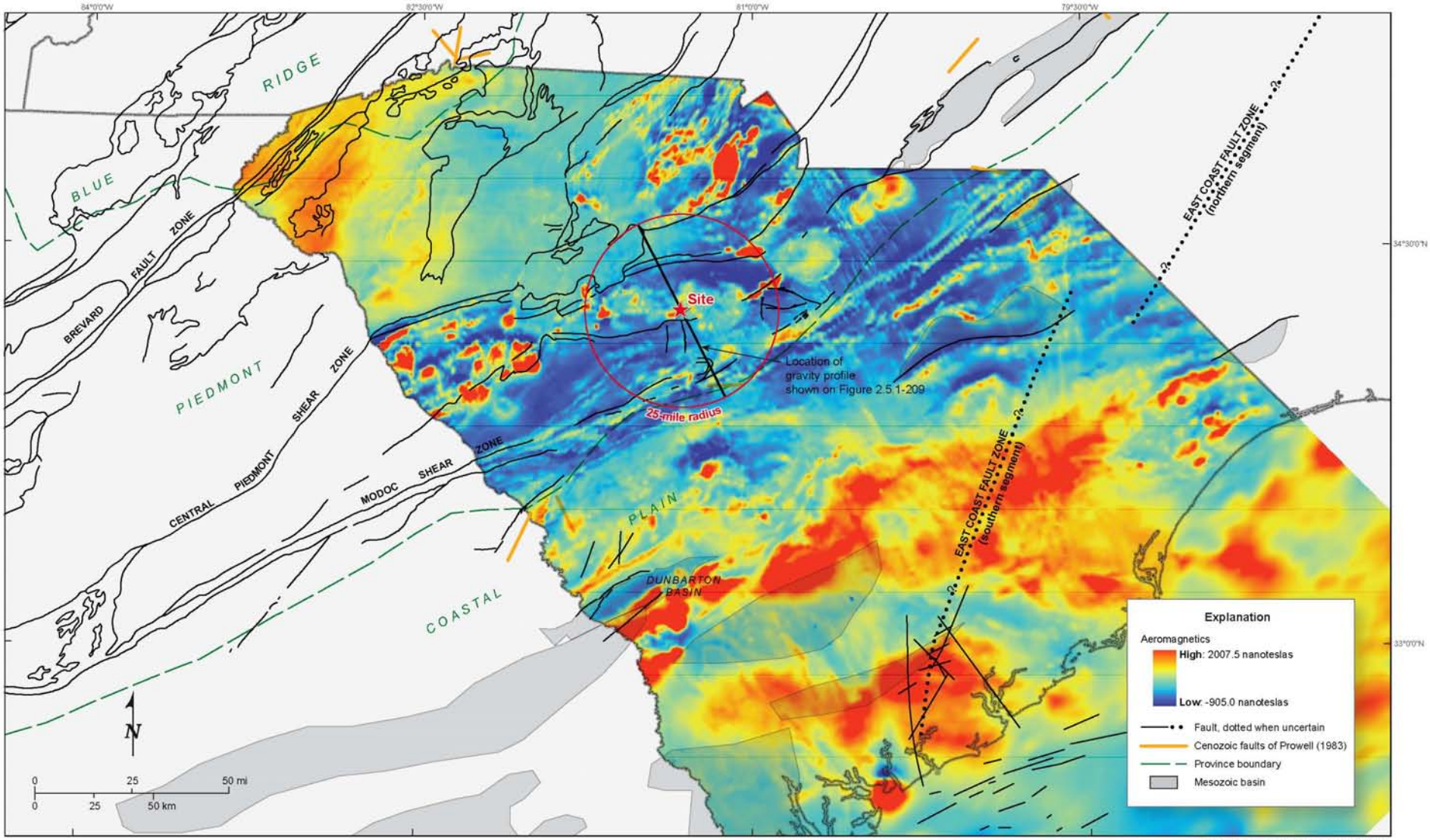
- 2.5.1.2 Site Geology
  - Site Vicinity (25 miles)
  - Site Area (5 miles)
  - Site (0.6 mile)

Potential Quaternary Features

None represent Capable Tectonic Sources

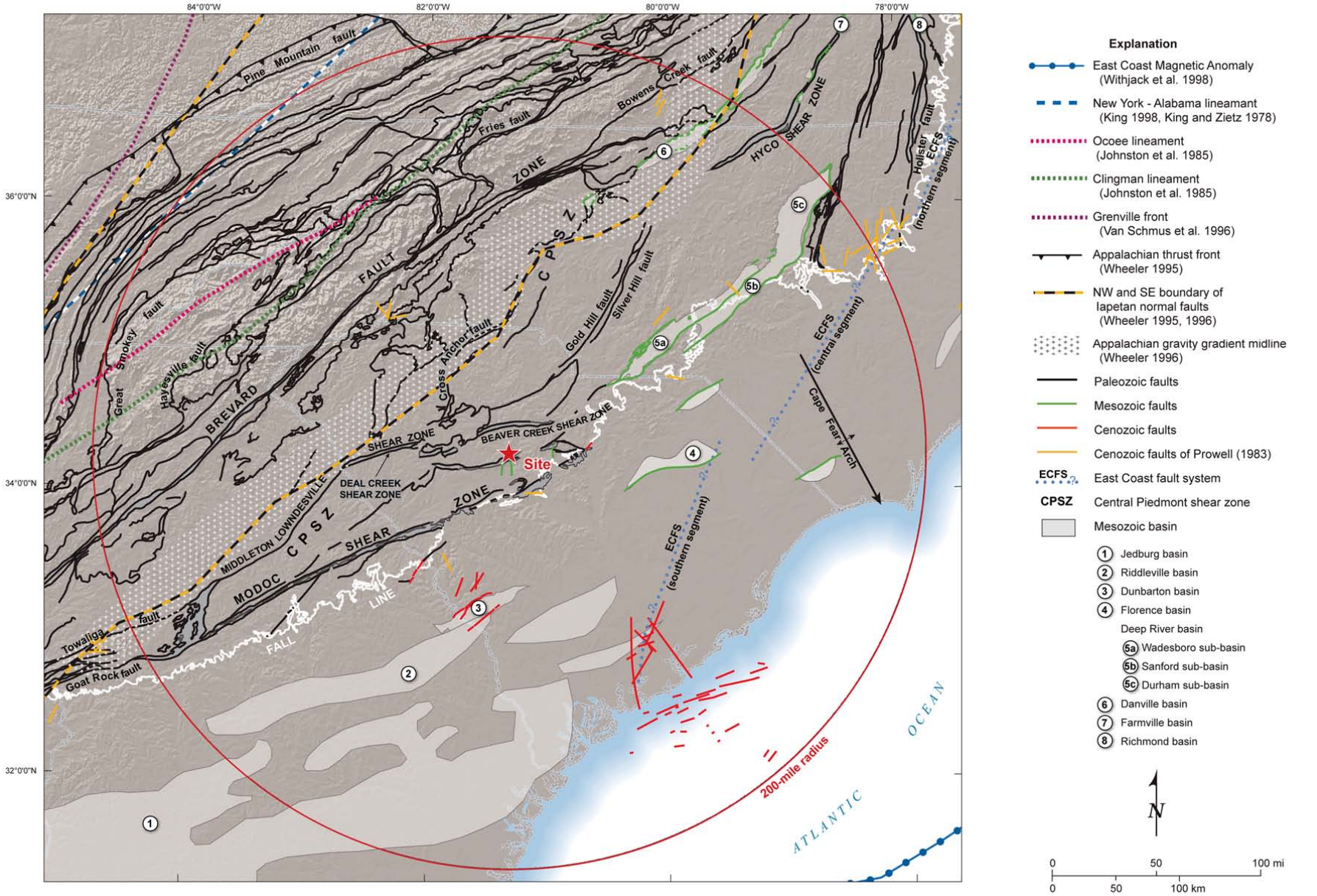
Charleston features and ETSZ are seismogenic sources

Aeromagnetic data illustrates buried structure, rock types, and Mesozoic dikes

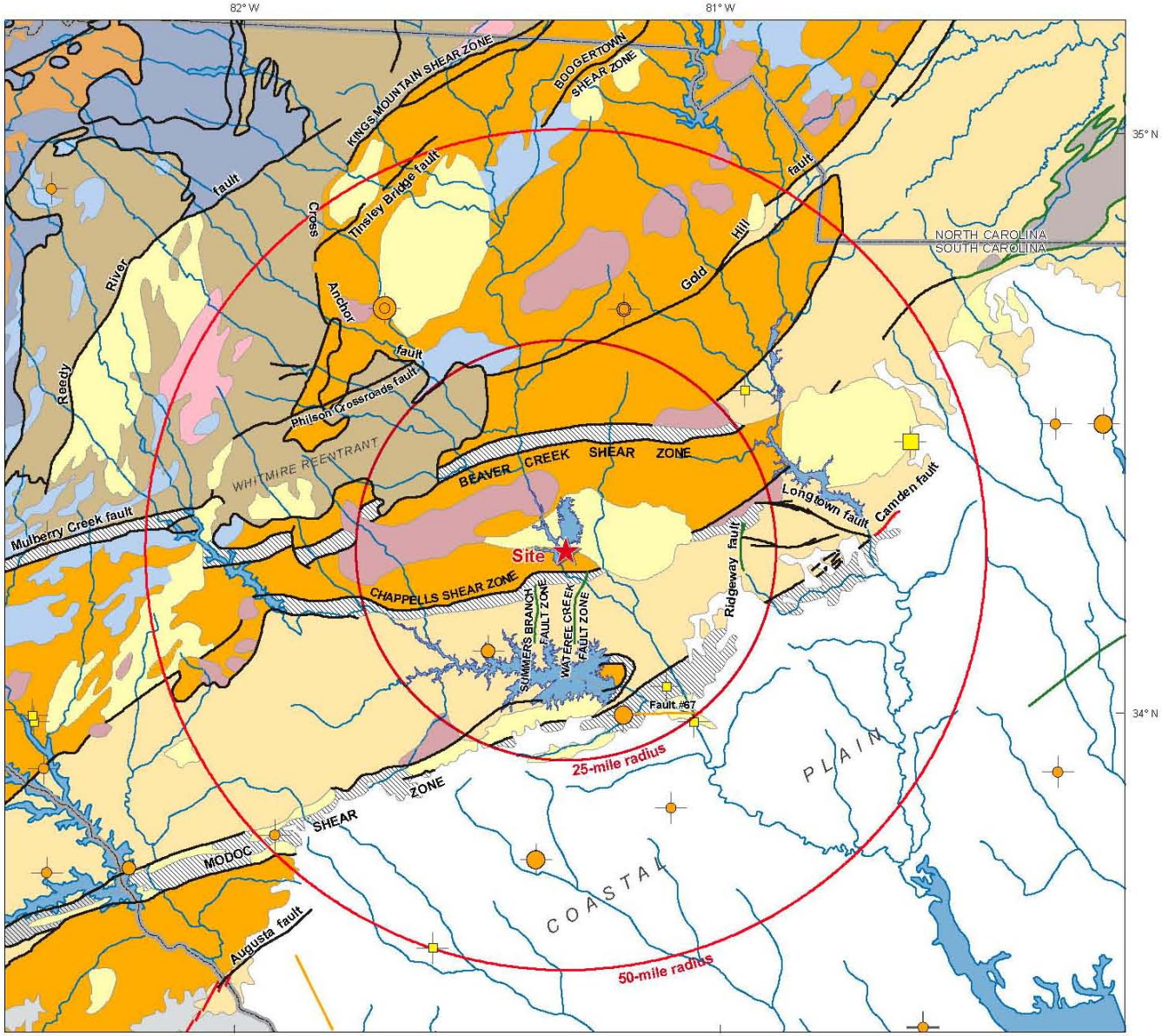


Aeromagnetic data from Daniels (2005)

200-mi Map of Tectonic Features



50-mi Map of Tectonic Features and Earthquakes of mb ≥ 3.0



Explanation

- Paleozoic faults
- Mesozoic faults
- Cenozoic faults
- Cenozoic faults of Prowell (1983)
- Mesozoic basin

Earthquake Epicenters (by Magnitude, m_b)

EPRI catalog (1627 - 1984)	Eastern US seismicity (1985 - 2006)
3.00 - 3.50	3.00 - 3.50 *
3.51 - 4.00	3.51 - 3.90
4.01 - 4.50	
4.51 - 5.04	

* includes three events less than m assigned intensity of 4 or greater

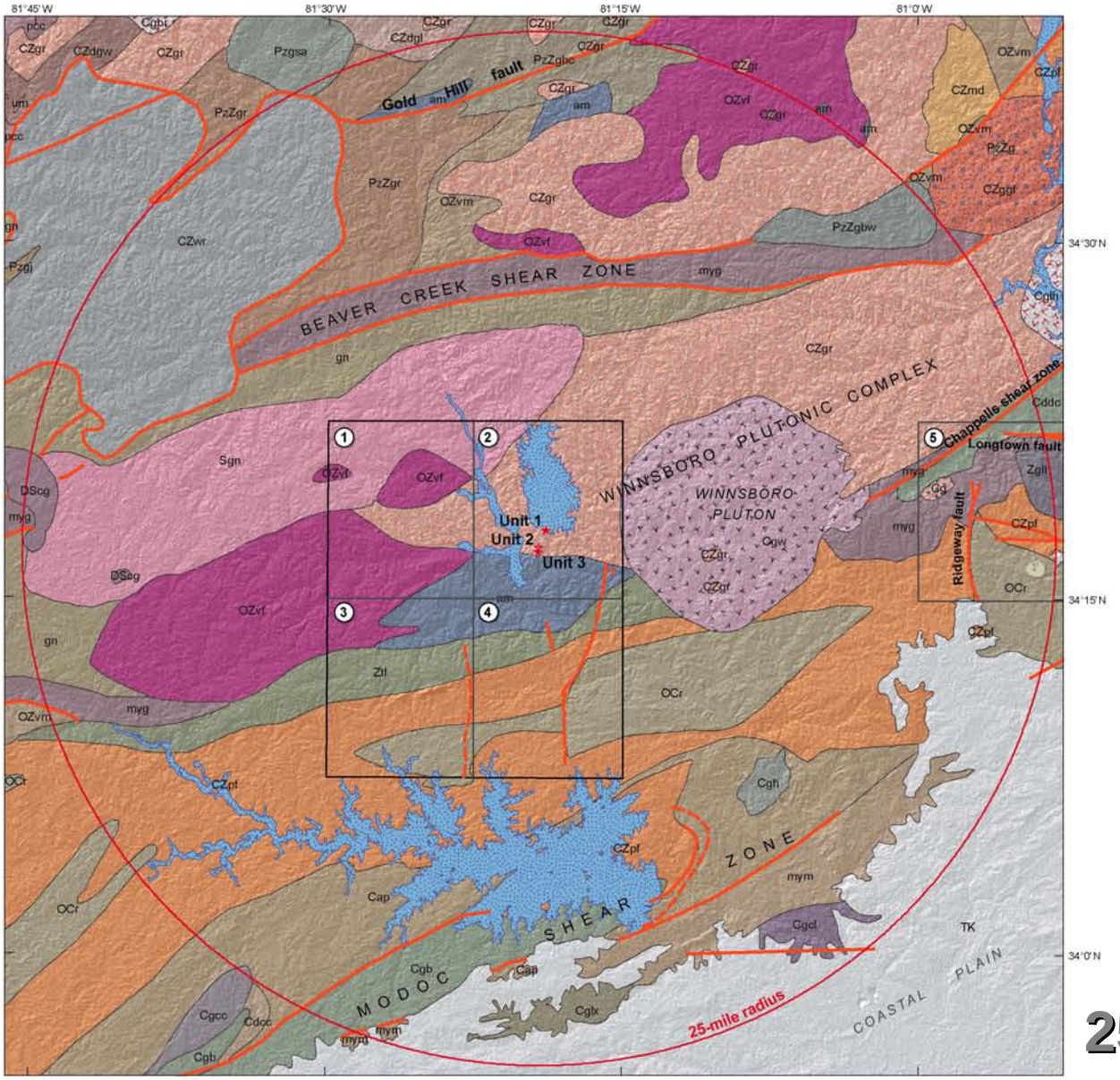
Tectonic features compiled and modified from Hibbard et al. (2006), Secor (2007), Secor et al. (1998), and Prowell (1983)

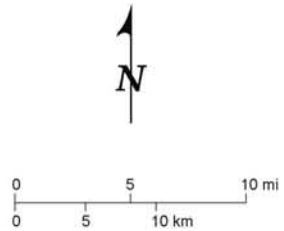
See Figure 2.5.1-204 for explanation of lithotectonic units

N

0 10 20 mi

0 10 20 km

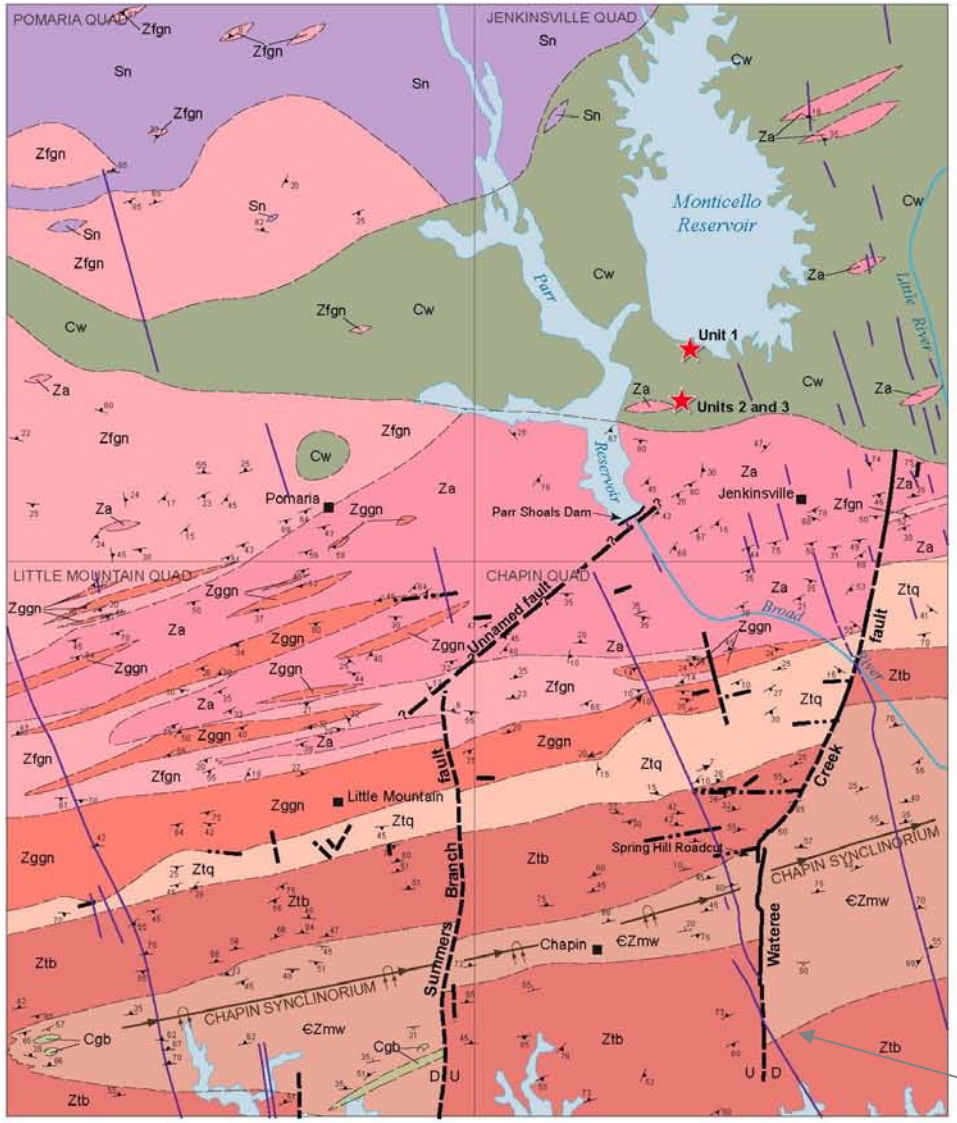


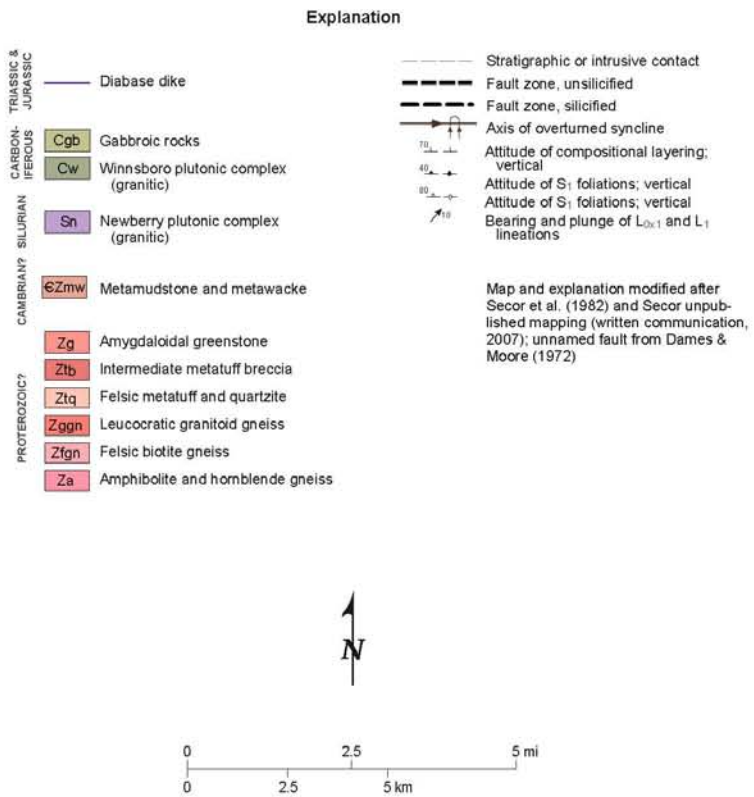


25-mi Geologic Map

Modified from Horton and Dicken (2001), Hibbard et al (2006), and Secor (2007)

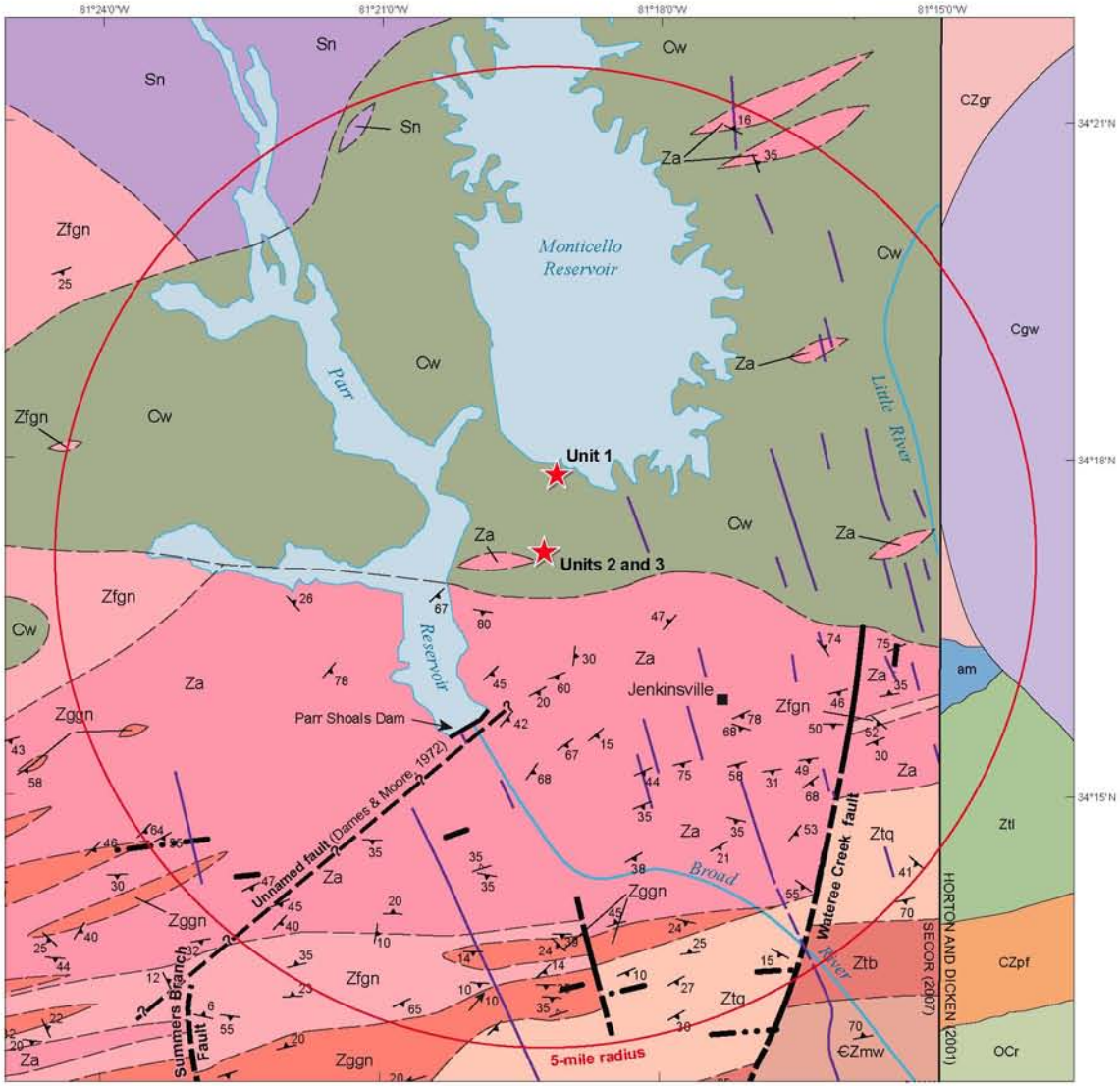
Secor et al (1982) mapping updated with Secor's more recent unpublished mapping; northern Wateree Creek fault has been revised





Fault cut by Mesozoic diabase dike

5-mi Geologic Map



Explanation

- Stratigraphic or intrusive contact
- Fault zone, unsilicified
- Fault zone, silicified
- Axis of overturned syncline
- 70 — Attitude of compositional layering; vertical
- 40 — Attitude of S_1 foliations; vertical
- 80 — Attitude of S_1 foliations; vertical
- 10 — Bearing and plunge of L_{0x1} and L_1 lineations

Secor (2007) 1:24,000 scale

TRIASSIC & JURASSIC
- Diabase dike

CARBONIFEROUS
- Cw — Winnsboro plutonic complex (granitic)

SILURIAN
- Sn — Newberry plutonic complex (granitic)

CAMBRIAN?
- €Zmw — Metamudstone and metawacke

PROTEROZOIC?
- Zg — Amygdaloidal greenstone
- Ztb — Intermediate metatuff breccia
- Ztq — Felsic metatuff and quartzite
- Zggn — Leucocratic granitoid gneiss
- Zfgn — Felsic biotite gneiss
- Za — Amphibolite and hornblende gneiss

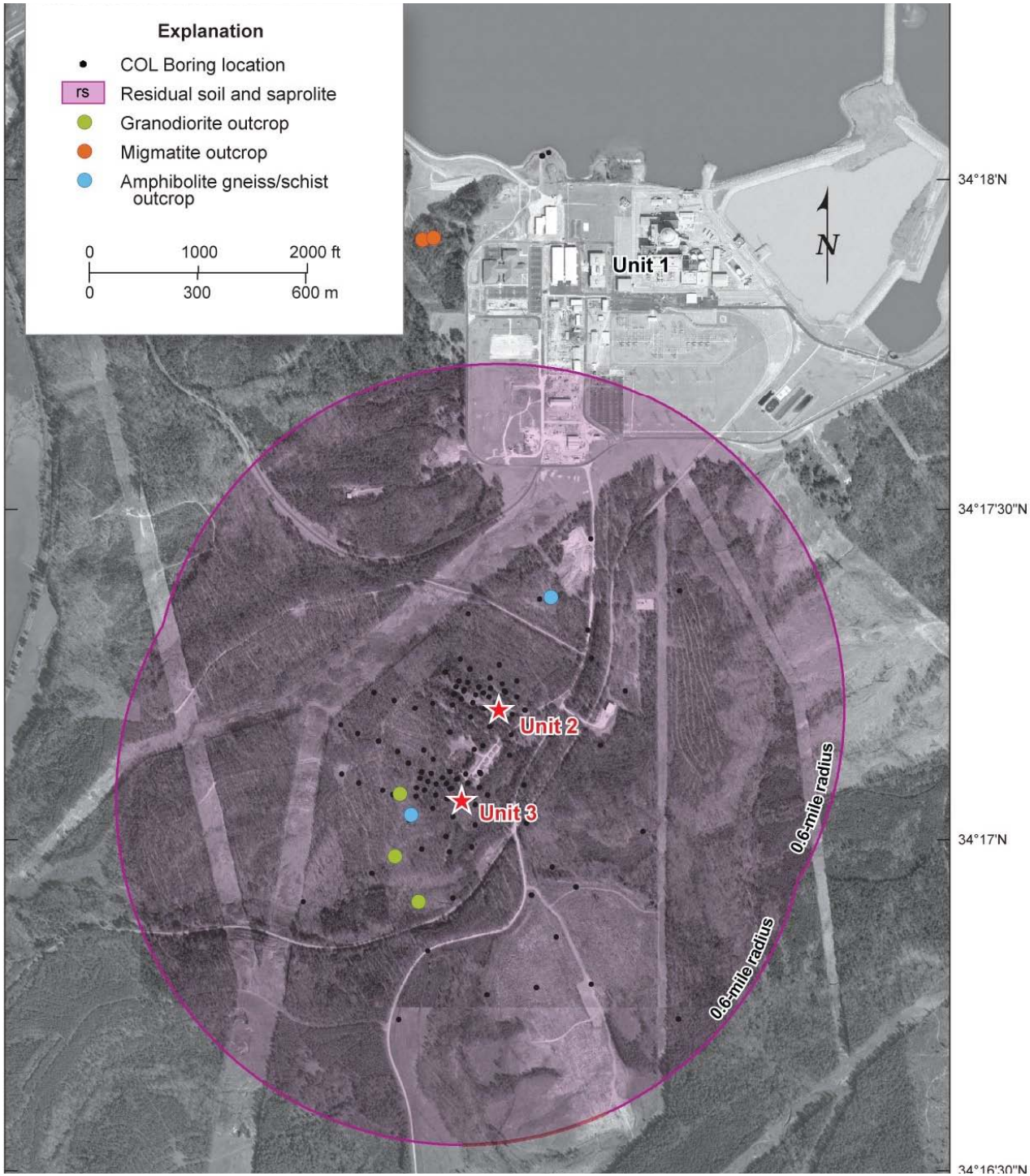
Horton and Dicken (2001) 1:500,000 scale

- Cgw — Winnsboro plutonic complex (granitic)
- CZgr — Metamorphosed granite to granodiorit
- am — Amphibolite and amphibole gneiss
- Ztl — Little Mountain metatonalite
- CZpf — Persimmon Fork Formation
- OCr — Richtex Formation

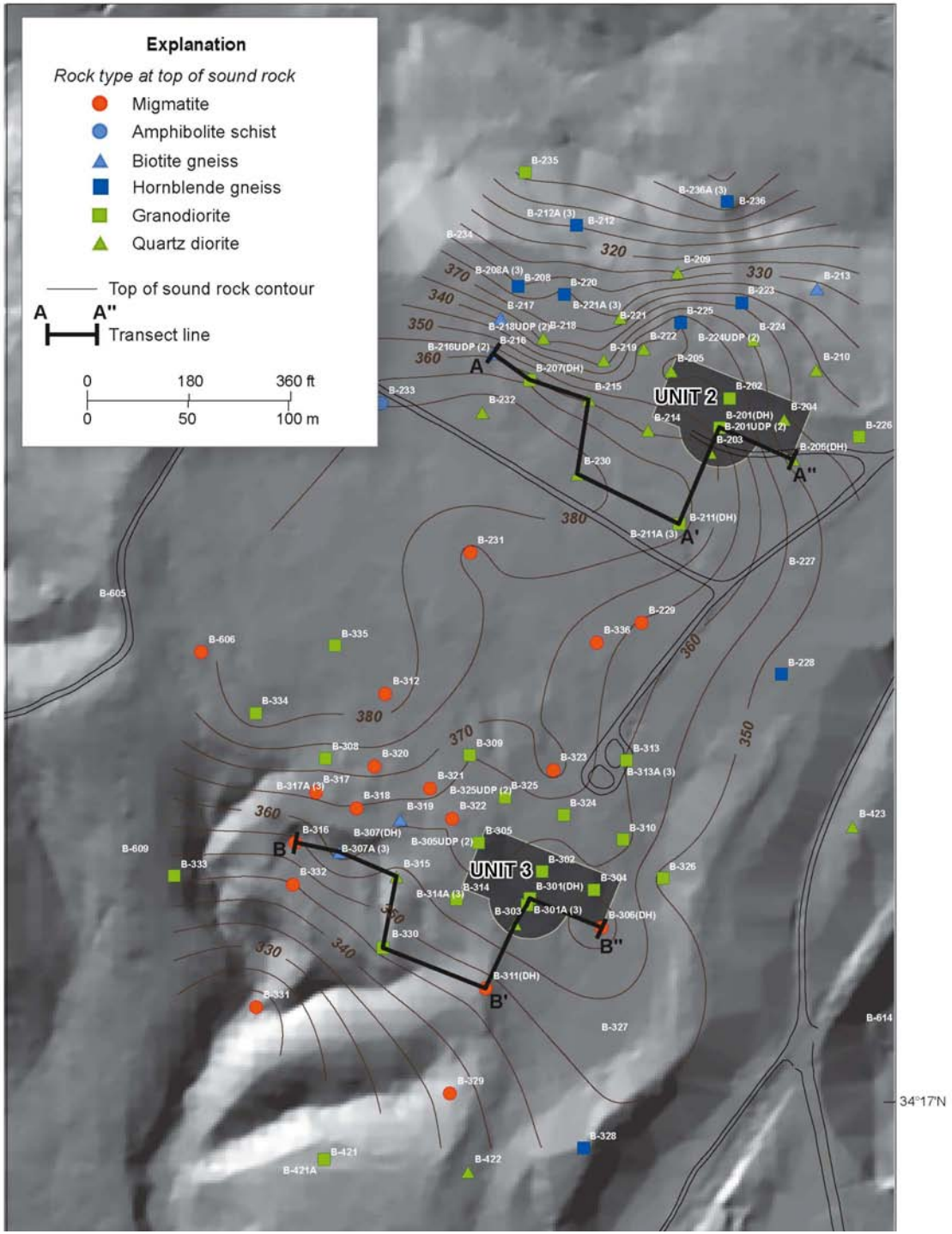
N

0 1 2 mi
0 1 2 km

0.6-mi Surficial Geologic Map



Top of Sound Rock Beneath Units 2 and 3



Potential Engineering Geologic Hazards at Site

- No surface faulting hazard
- No karst/dissolution hazard
- Human Activities:
  - No mining or fluid withdrawal hazards
  - Low hazard from Reservoir Induced Seismicity (high frequency, low energy motion)

Summary

- No Capable Tectonic Sources identified within Site Region
- New paleoseismic information (post-EPRI) requires update of Charleston source

2.5.2 Vibratory Ground Motion

- **2.5.2.1 Seismicity**
- **2.5.2.2 Geologic and Tectonic Characteristics of Site and Region**
- **2.5.2.3 Correlation of Earthquake Activity with Seismic Sources**
- 2.5.2.4 PSHA and Controlling Earthquake
- 2.5.2.5 Seismic Wave Transmission Characteristics of the Site
- 2.5.2.6 Ground Motion Response Spectrum

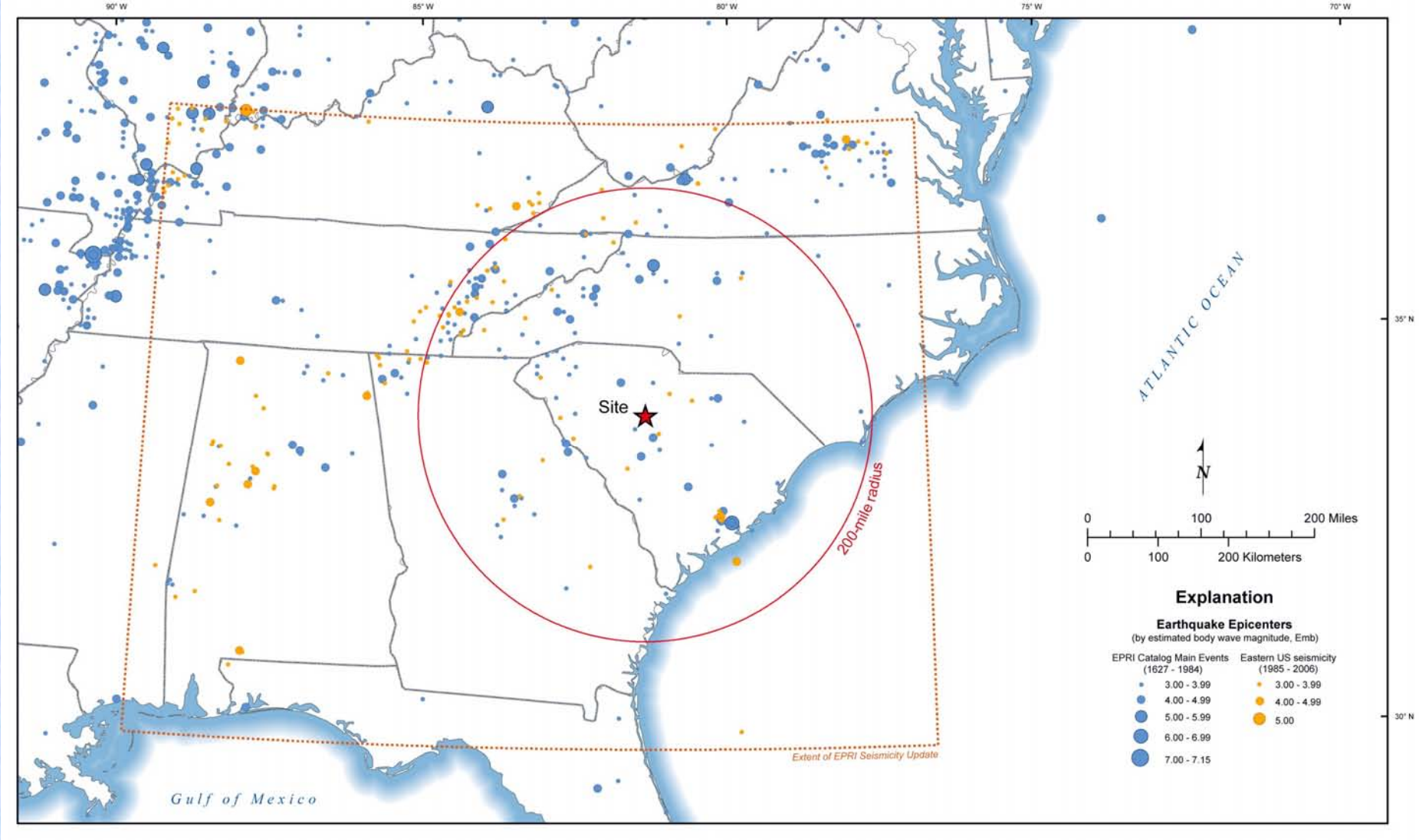
2.5.2.1 Seismicity

- Updated seismicity catalog
- Reservoir induced seismicity

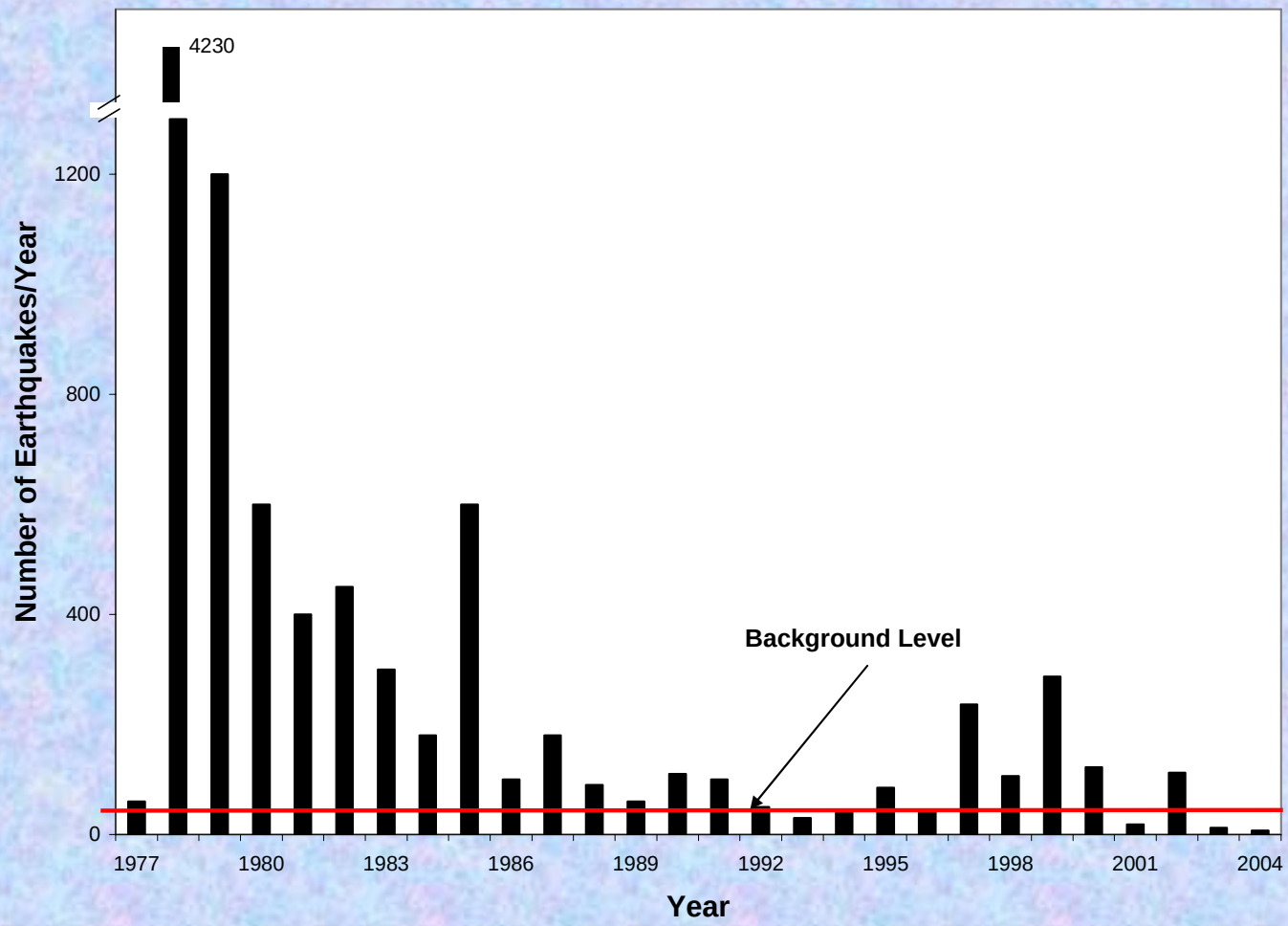
2.5.2.1 Seismicity: Updated Catalog

- RG 1.206: magnitude ≥ 3.0 or MMI ≥ IV within 200 miles
- Geographic window: 30°N to 38°N, 77°W to 89°W
- Chronologic update using SEUSSN and ANSS catalogs
- 207 earthquakes: 1985 – August 2006

Updated Seismicity Catalog



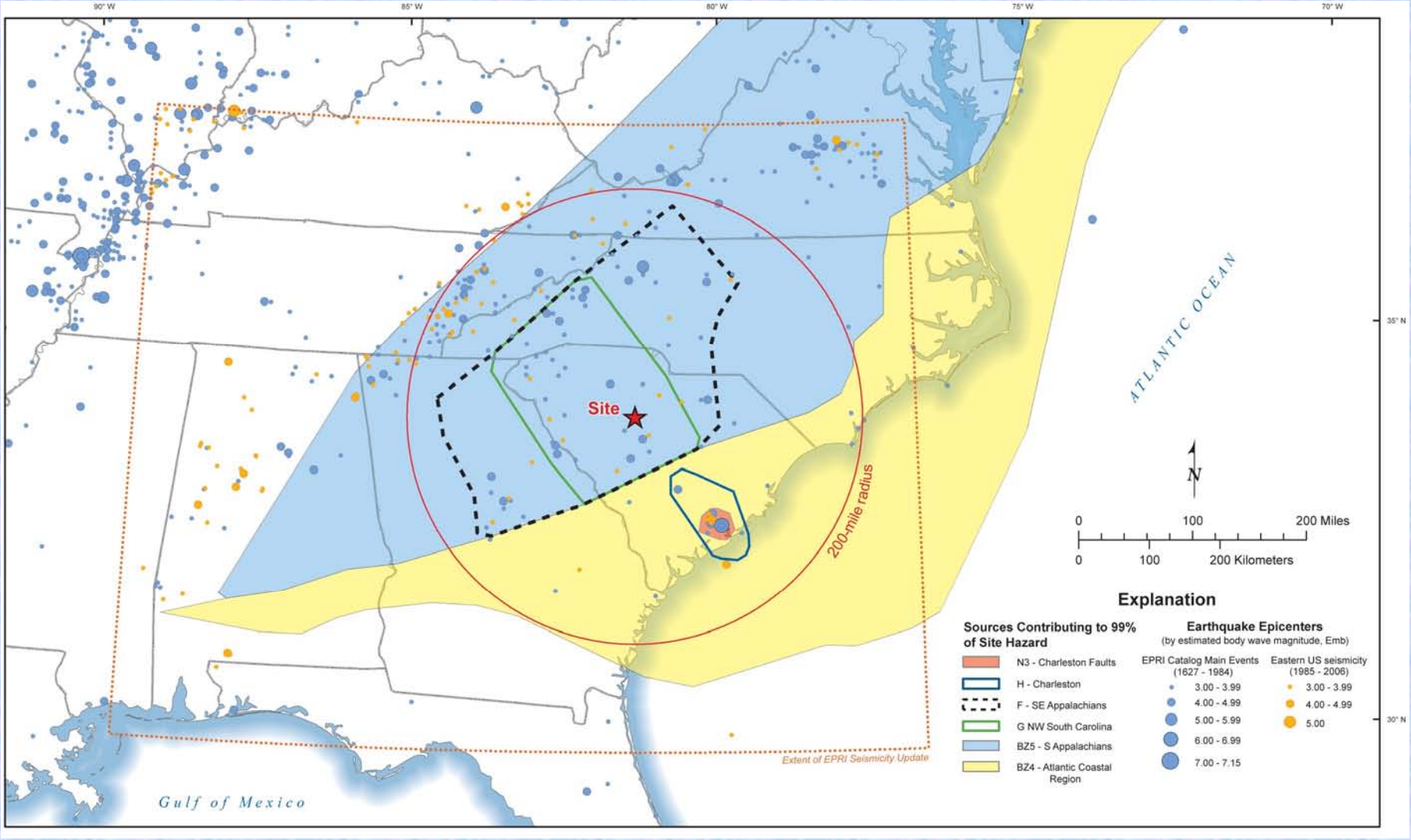
Reservoir Induced Microseismicity



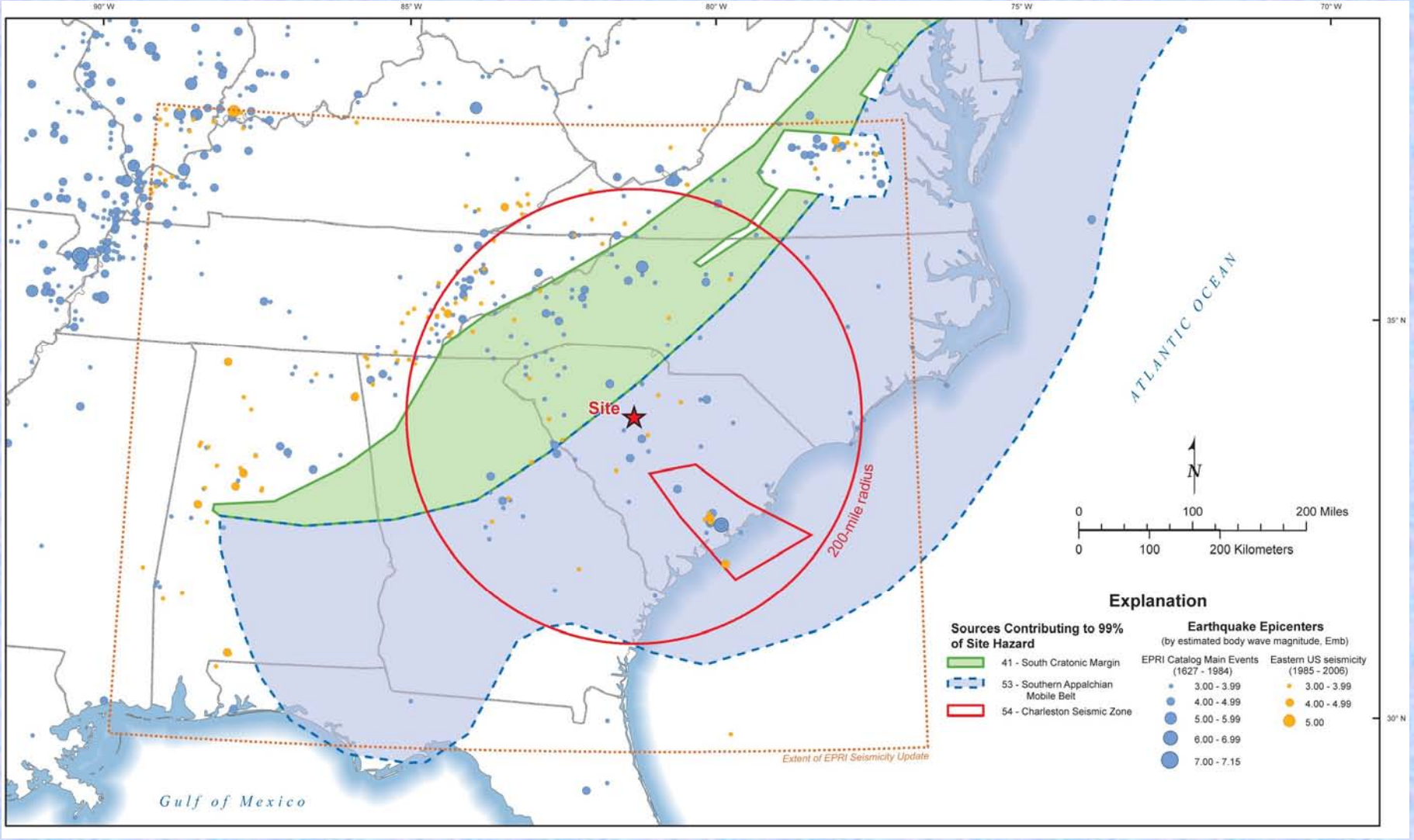
CONCLUSION

RIS does not pose any risk or safety issue for the Units 2 and 3 site.

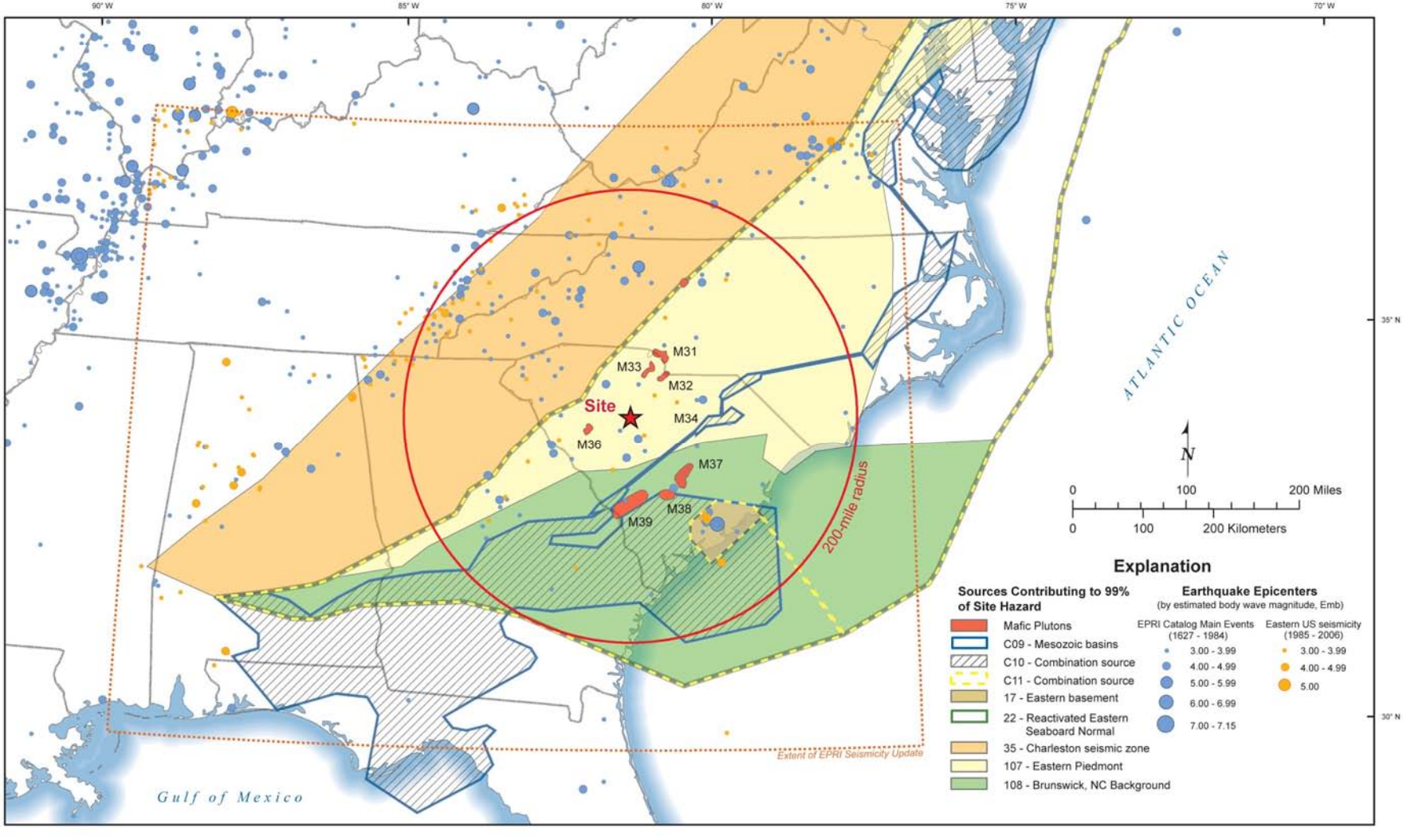
Bechtel EPRI Sources



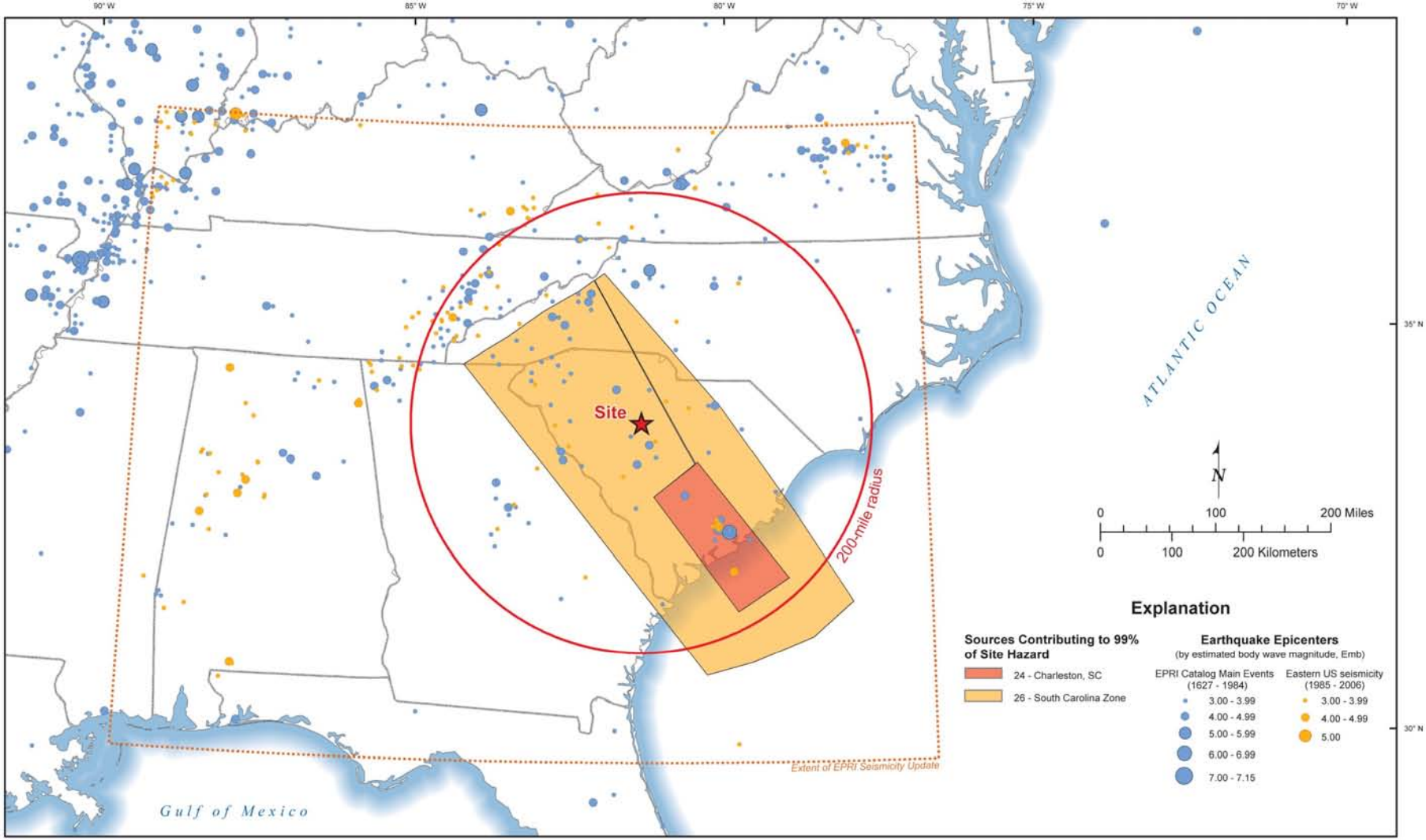
Dames & Moore EPRI Sources



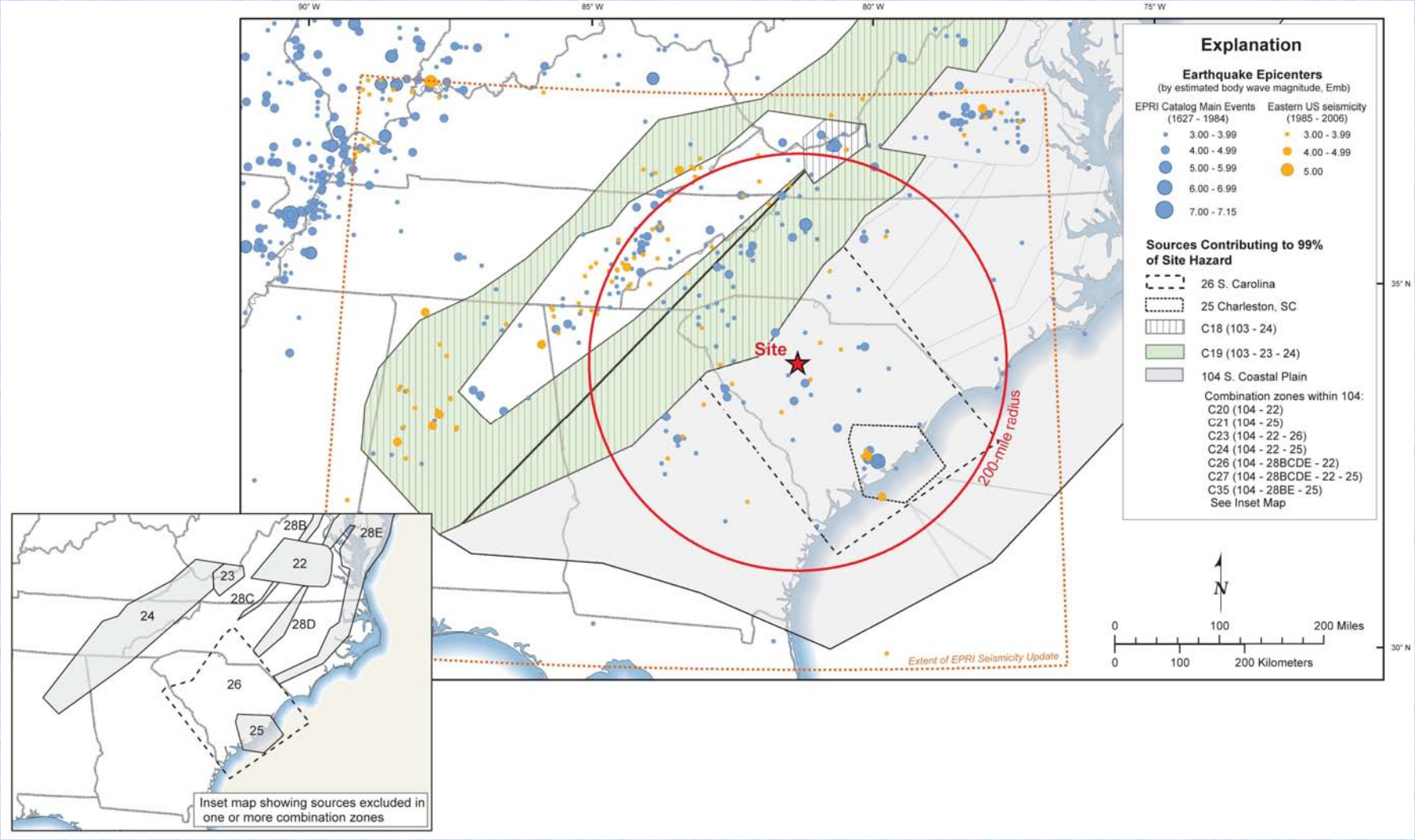
LAW EPRI Sources



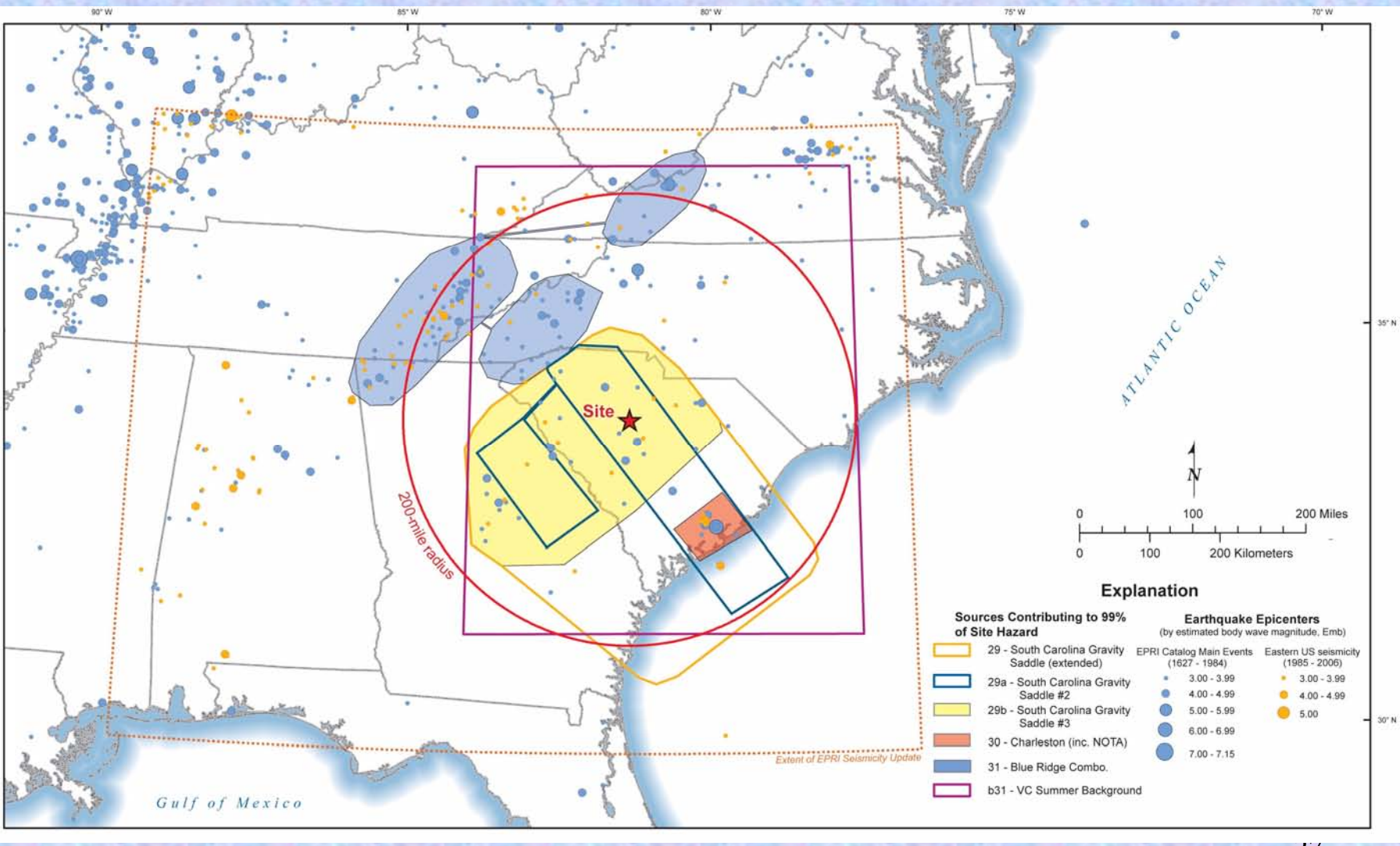
Rondout EPRI Sources



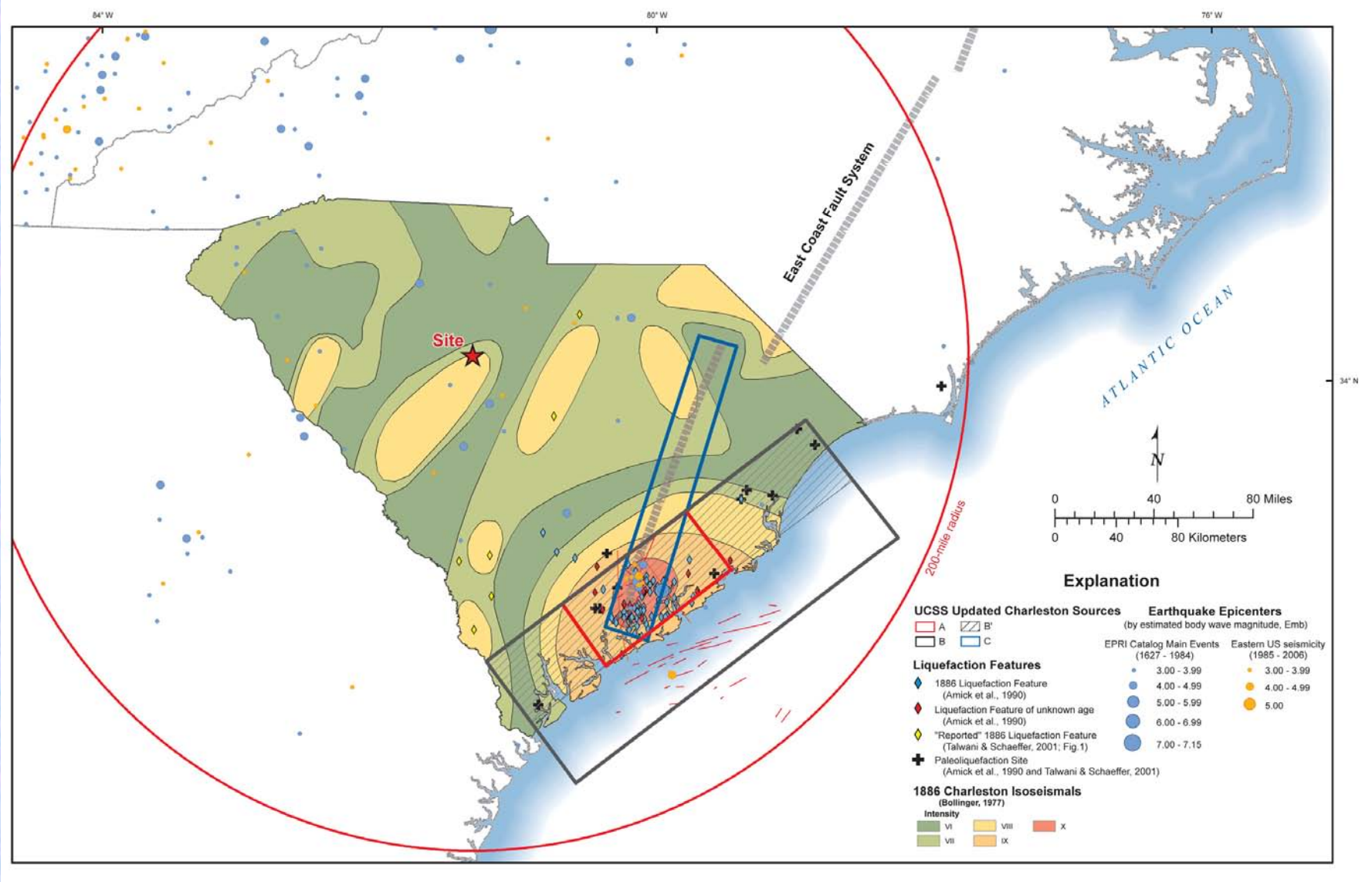
Weston EPRI Sources



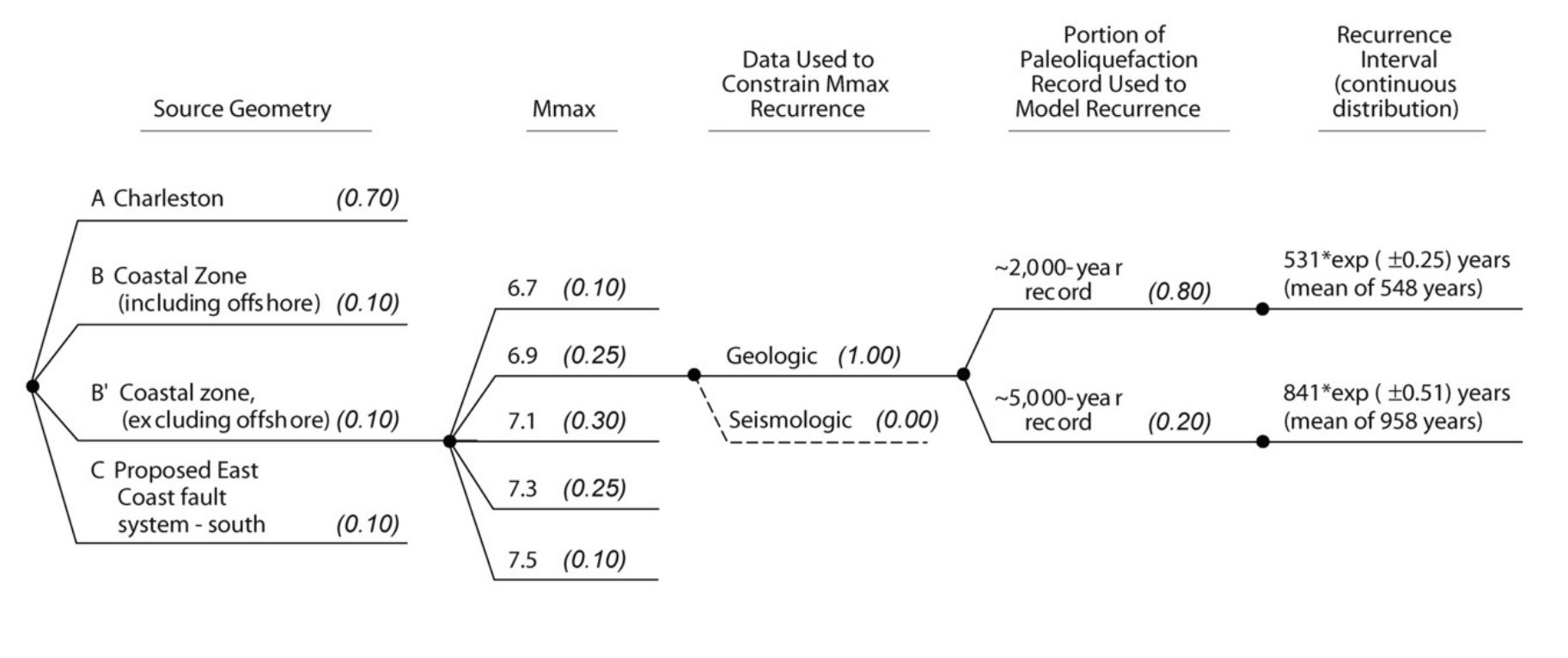
Woodward-Clyde EPRI Sources



Updated Charleston Seismic Source (UCSS)



Updated Charleston Seismic Source Logic Tree



Summary of VC Summer Seismic Source Model

- No new Capable Tectonic Sources identified within site region
- Use significant EPRI sources (99%)
- No modifications to ETSZ.
- Updated Charleston model to replace EPRI sources (adopted from Vogtle)
- New Madrid Source added (adopted Clinton characterization)

2.5.3 Surface Faulting

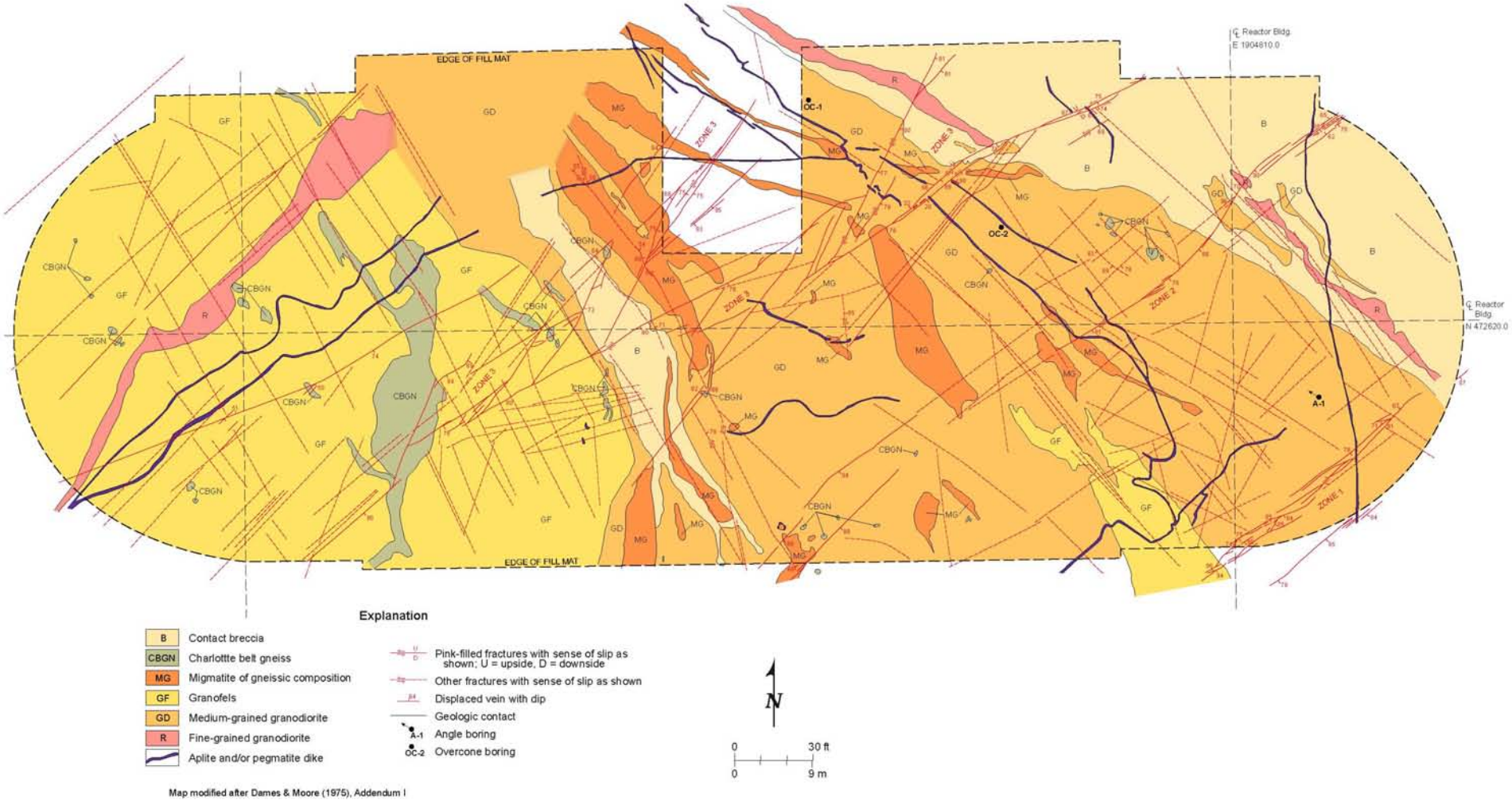
- 2.5.3.1 Geological, Seismological, and Geophysical Investigations
- 2.5.3.2 Geological Evidence, or Absence of Evidence, for Surface Deformation
- 2.5.3.3 Correlation of EQs with Capable Tectonic sources
- 2.5.3.4 Age of Most Recent Deformations
- 2.5.3.5 Relationship of Tectonic Structures in the Site Area and Region
- 2.5.3.6 Characterization of Capable Tectonic Sources
- 2.5.3.7 Designation of Zones of Quaternary movement
- 2.5.3.8 Potential for Surface Tectonic Deformation

Faults Within 25 Miles of Site

Feature Name	Proximity to VCSNS Site (mi)	Mapped Length (mi)	Orientation	Reference(s)	Assigned Age
Beaver Creek shear zone	10	>50	ENE-NE	Hibbard et al. (2006)	Paleozoic
Chappells shear zone	2	60	NE-ENE	Hibbard et al. (2006)	Paleozoic
Cross Anchor fault	10	>60	variable	Hibbard et al; (2006) West (1998)	Paleozoic
Fault #67 of Prowell (1983)	20	18	E	Prowell (1983)	Eocene-Pliocene? (non-tectonic?)
Gold Hill fault extension	20	75	NE	West (1998)	Paleozoic
Longtown fault	25	20	WNW	Secor et al. (1998) Barker and Secor (2005)	Mesozoic
Modoc shear zone	>12	20	NE	Hibbard et al. (2006)	Paleozoic
Ridgeway fault	20	>9	N	Secor et al. (1998) Barker and Secor (2005)	Mesozoic (minimum age)
Summers Branch fault	5	8	N	Secor et al. (1982) Secor (2007)	Mesozoic (minimum age) (non-existent?)
Unnamed fault near Parr, SC	3	--	--	Dames & Moore (1972)	Paleozoic (minimum age) (non-existent?)
Unnamed fault near Ridgeway, SC	20	9	E	Secor et al. (1998) Barker and Secor (2005)	Mesozoic (minimum age)
Wateree Creek fault	2	>8	N	Secor et al. (1982) Secor (2007)	Mesozoic (minimum age)

No Quaternary Fault or Capable Tectonic Source within 25 Miles of the Site

Unit 1 Foundation Map



Map modified after Dames & Moore (1975), Addendum I

Surface Faulting Summary

- Nearest faults are Mesozoic and Paleozoic and are about 2 mi from the site
- Excavation mapping of Unit 1 found small, bedrock shears. These minor features were demonstrated to have last moved between 300 and 45 Ma.
- Minor bedrock shears likely exist throughout site, but these <u>do not</u> represent a surface rupture hazard
- Negligible potential for tectonic or non-tectonic deformation at the site

Comments

SCE&G VC Summer COL

FSAR Sections
2.5.4 and 2.5.5

Site Geotechnical Characterization/ Foundations

David F. Fenster, Bechtel Corporation

Meeting with NRC
October 3, 2007

Section 2.5.4

"Stability of Subsurface Materials and Foundations"

Use Format of RG 1.206

2.5.4.1 Geologic Features – Refer to Sections 2.5.1.1 and 2.5.1.2

2.5.4.2 Properties of Subsurface Materials

2.5.4.3 Foundation Interfaces – New Section

2.5.4.4 Geophysical Surveys

2.5.4.5 Excavations and Backfill

2.5.4.6 Groundwater Conditions – Refer to Section 2.4.12

2.5.4.7 Response of Soil and Rock to Dynamic Loading

2.5.4.8 Liquefaction Potential

2.5.4.9 Earthquake Site Characteristics –Refer to Section 2.5.2.6

2.5.4.10 Static Stability

2.5.4.11 Design Criteria

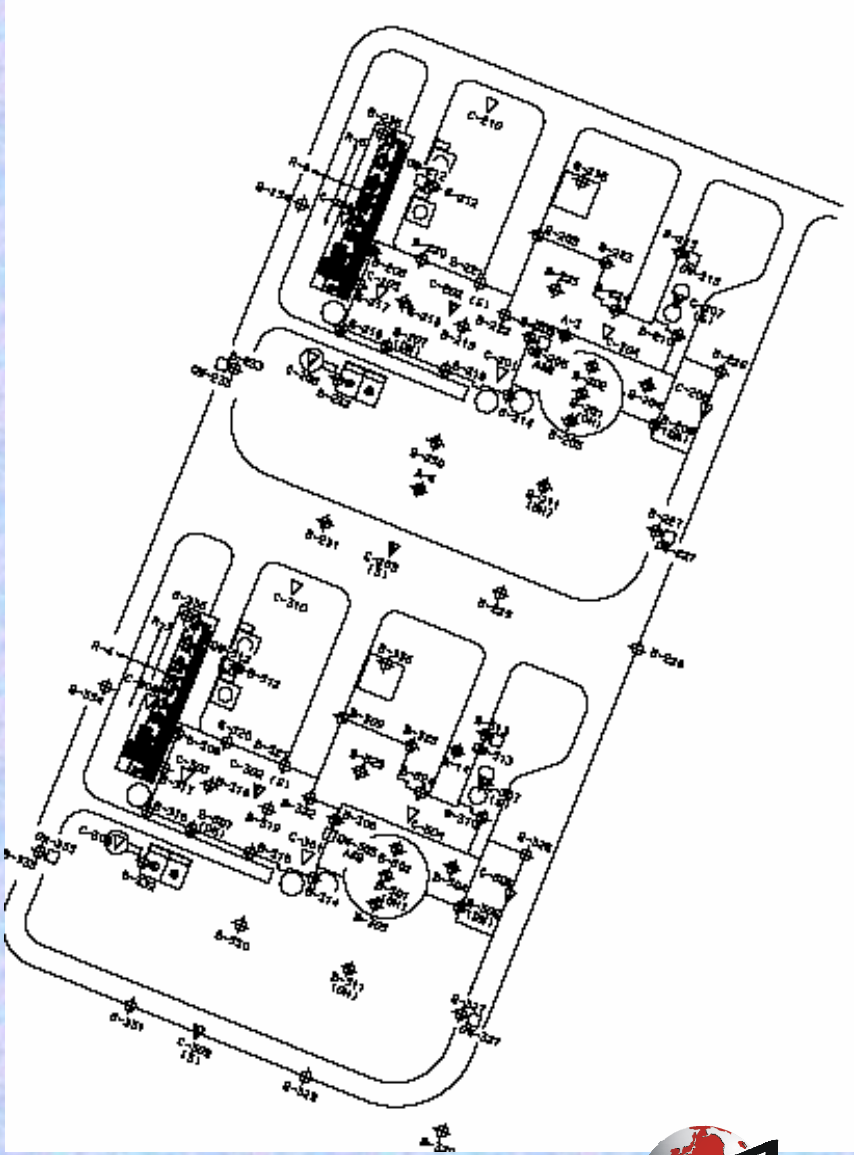
2.5.4.12 Techniques to Improve Subsurface Conditions

Section 2.5.4.2.2 Description of Subsurface Materials

- **Residual Soil –** reddish silty sands and sandy silts with variable clay content
- **Saprolite –** completely weathered rock but w/preserved relict rock structure, mainly silty sands
- **Partially Weathered Rock (PWR) –** decomposed rock matrix mixed w/semi-hard rock fragments
- **Moderately Weathered Rock (MWR) --** >50% by volume of sound rock interspersed w/decomposed zones
- **Sound Rock –** Hard fresh to slightly discolored rock (granodiorite, quartz diorite, gneiss, schist, migmatite)

Section 2.5.4.2.3 Field Investigations

- Boreholes
  - Soil and Rock Drilling (111 Total)
- Observation Wells (31 Total)
  - Slug and Packer Tests
- CPTs (36 Total)
- Test Pits (4 Total)
- Geophysical Testing
  - Downhole Testing (8 Total):
    - (P-S Suspension Logging, Gamma, Resistivity, Televiewer, Caliper, and Deviation)
  - Seismic CPTs (7 Total)
  - Electrical Resistivity (6 Total)



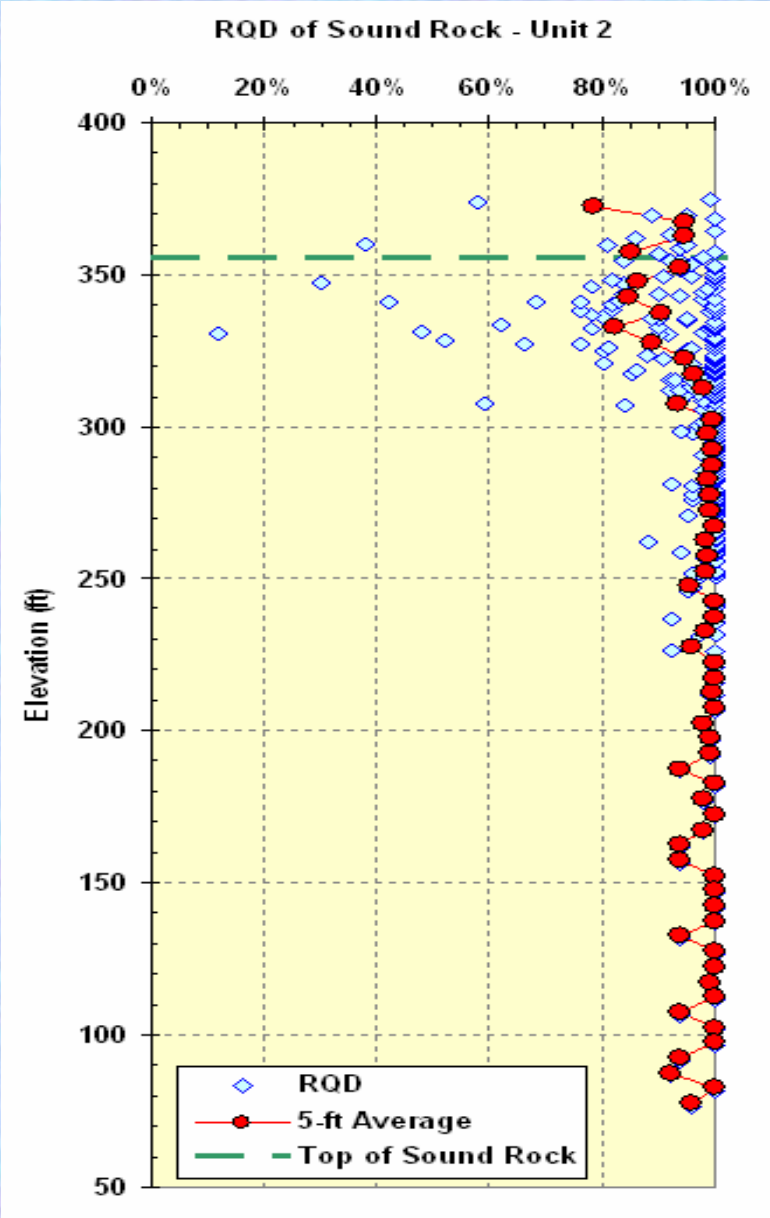
Section 2.5.4.2.4 Laboratory Testing - Soil

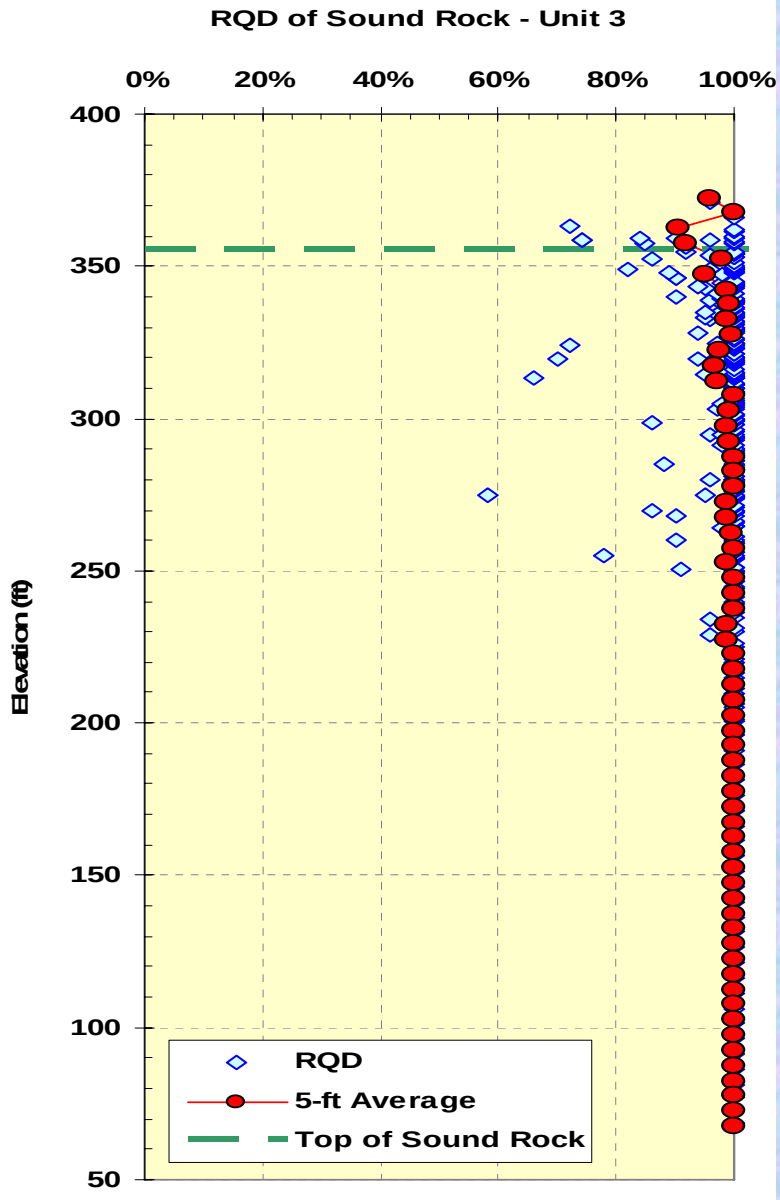
- **Moisture content (237)**
- **Unit weight (55)**
- **Specific gravity (16)**
- **Sieve and hydrometer analysis (95)**
- **Grain size analysis (93)**
- **Atterberg limits (74)**
- **Chemical analyses (pH, chloride, sulfate) (22)**
- **Moisture – density (6)**
- **California bearing ratio (6)**
- **Unconsolidated undrained triaxial compression (11)**
- **Consolidated undrained triaxial compression (10)**
- **Direct shear (5)**
- **Torsional shear resonant column (5)**
- **Consolidation (16)**

2.5.4.2.5 Summary of Engineering Properties

Stratum[1]	**I-II** [4]	**III**	**IV**	**V**	**Fill**
Description	Residuum/ Saprolite	PWR	MWR	**Sound Rock**	**Sandy Fill**
Elevation to top of layer (ft)	+418	+375	+370	**+355**	**+395**
USCS symbol	ML-MH-SM	-	-	**-**	**SW**
Total unit weight γ (pcf)	110	145	160	**182**	**125**
Natural water content, w, (%)	25	-	-	**-**	**-**
Fines content (%)	32	-	-	**-**	**-**
SPT N_{60}-value (blows/ft)	20	-	-	**-**	**30**
Drained properties					
Effective cohesion, c′ (ksf)	0.25	-	-	**-**	**-**
Effective friction angle, ϕ'(deg)	30	-	-	**-**	**36**
Rock core recovery (%)	-	-	0-90	**90-100**	**-**
RQD (%)	-	-	0-50	**80-100**	**-**
Unconfined compressive strength, U (ksi)	-	2.2	10	**25**	**-**
Elastic modulus (high strain)	720 ksf	500 ksi	3,300 ksi	**9,500 ksi**	**1,080 ksf**
Elastic modulus (low strain)	7,350 ksf	750 ksi	3,300 ksi	**9,500 ksi**	**9,700 ksf**
Shear modulus (high strain)	270 ksf	185 ksi	1,250 ksi	**3,800 ksi**	**400 ksf**
Shear modulus (low strain)	2,750 ksf	280 ksi	1,250 ksi	**3,800 ksi**	**3,600 ksf**
Shear wave vel., avg (ft/sec)	900	3,000	6,000	**10,000**	**960**
Comp. wave vel., avg. (ft/sec)	1,800	6,000	12,000	**17,500**	**2,000**

2.5.4.2.5 RQD - Sound Rock

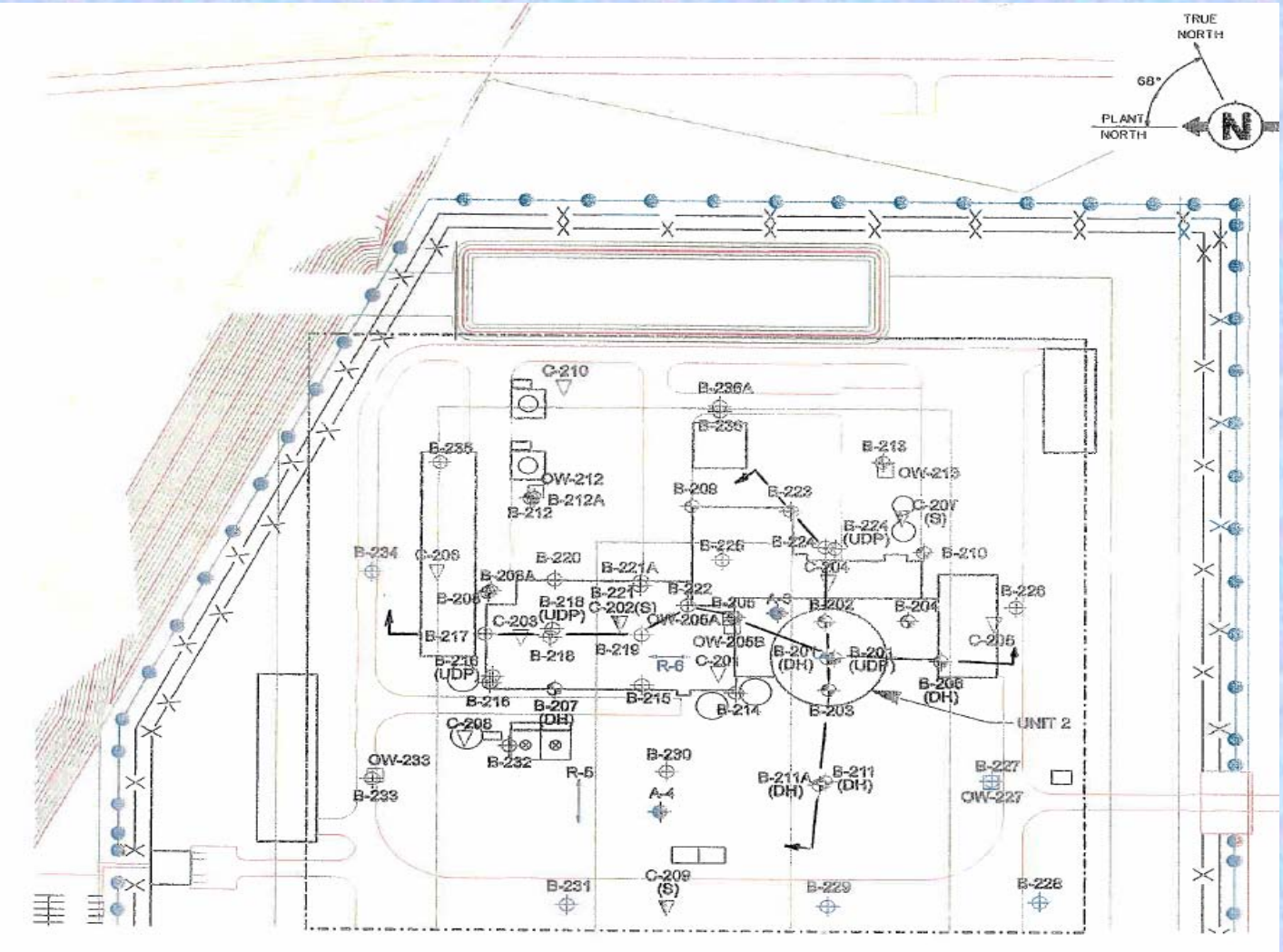




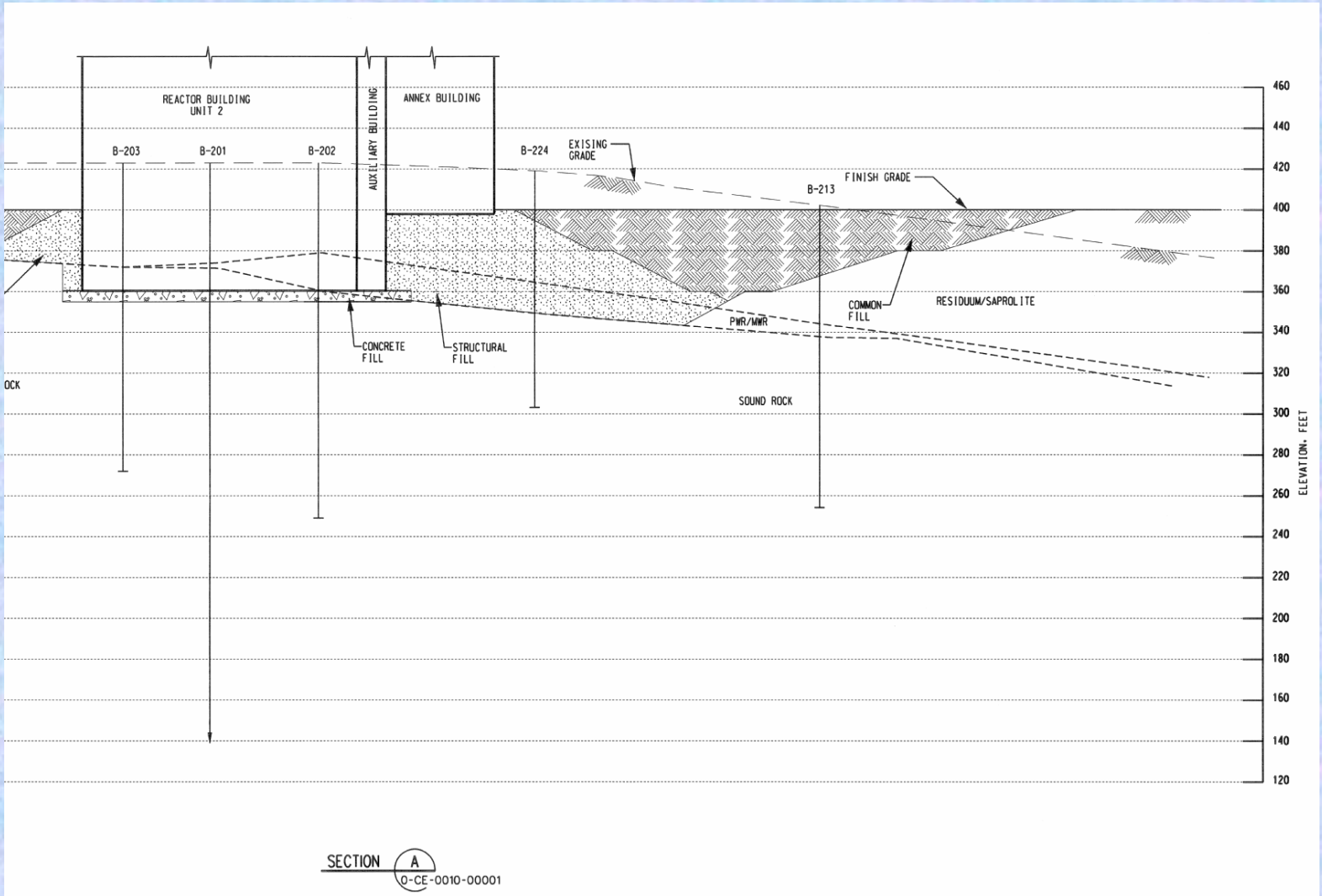
Section 2.5.4.3 Foundation Interfaces

- Boring location plans
- Profiles showing detailed relationship of safety-related facilities to subsurface materials

Section 2.5.4.3.1 Unit 2 Boring Location Plan Showing Cross-Section Locations



Section 2.5.4.3.2 Typical Cross-Section



Section 2.5.4.4 Geophysical Surveys

- Down-hole Geophysical Logs
- Seismic CPTs
- Field electrical resistivity

Section 2.5.4.4.1 Down-Hole Testing

Suspension P-S velocity logging

Natural gamma

Resistivity

Spontaneous potential

Borehole acoustic televiewer

3-arm caliper

Borehole deviation

4 boreholes in each power block

1 to 350 ft, 1 to 215 ft, 2 to 175 ft

Section 2.5.4.5.1 Sources & Quantities of Backfill Material

- Martin Marietta Aggregate's North Columbia Quarry (about 20 miles from site)
- Granitic sand from rock crushing operation
- Hundreds of thousands of tons stockpiled, 30 year's supply available

Section 2.5.4.5 Compaction & Testing of Backfill

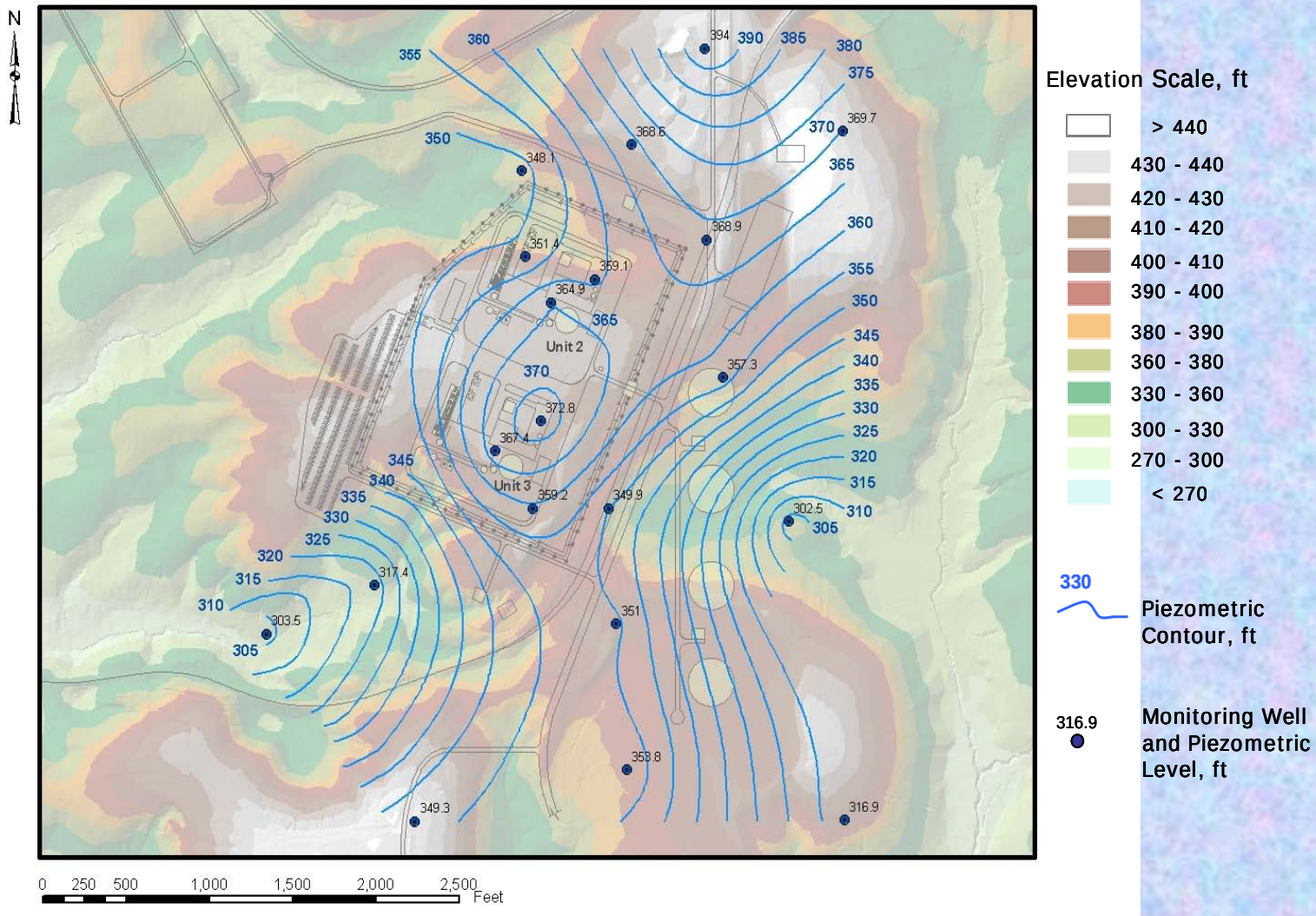
- Minimum 95% of modified Proctor maximum dry density
- Within 3% of optimum moisture content
- Thin lifts with heavy vibratory steel drum roller
- Independent testing firm onsite during compaction and testing
- Minimum 1 field density test every 10,000 ft^2
- Light compaction equipment within 5 ft of wall

Section 2.5.4.6 Groundwater Conditions

Refer to Section 2.4.12 “Groundwater”

Groundwater is mainly sitting above sound rock within the PWR, but was recorded in the lower part of the saprolite at some locations.

2.5.4.6.5 Groundwater Contours

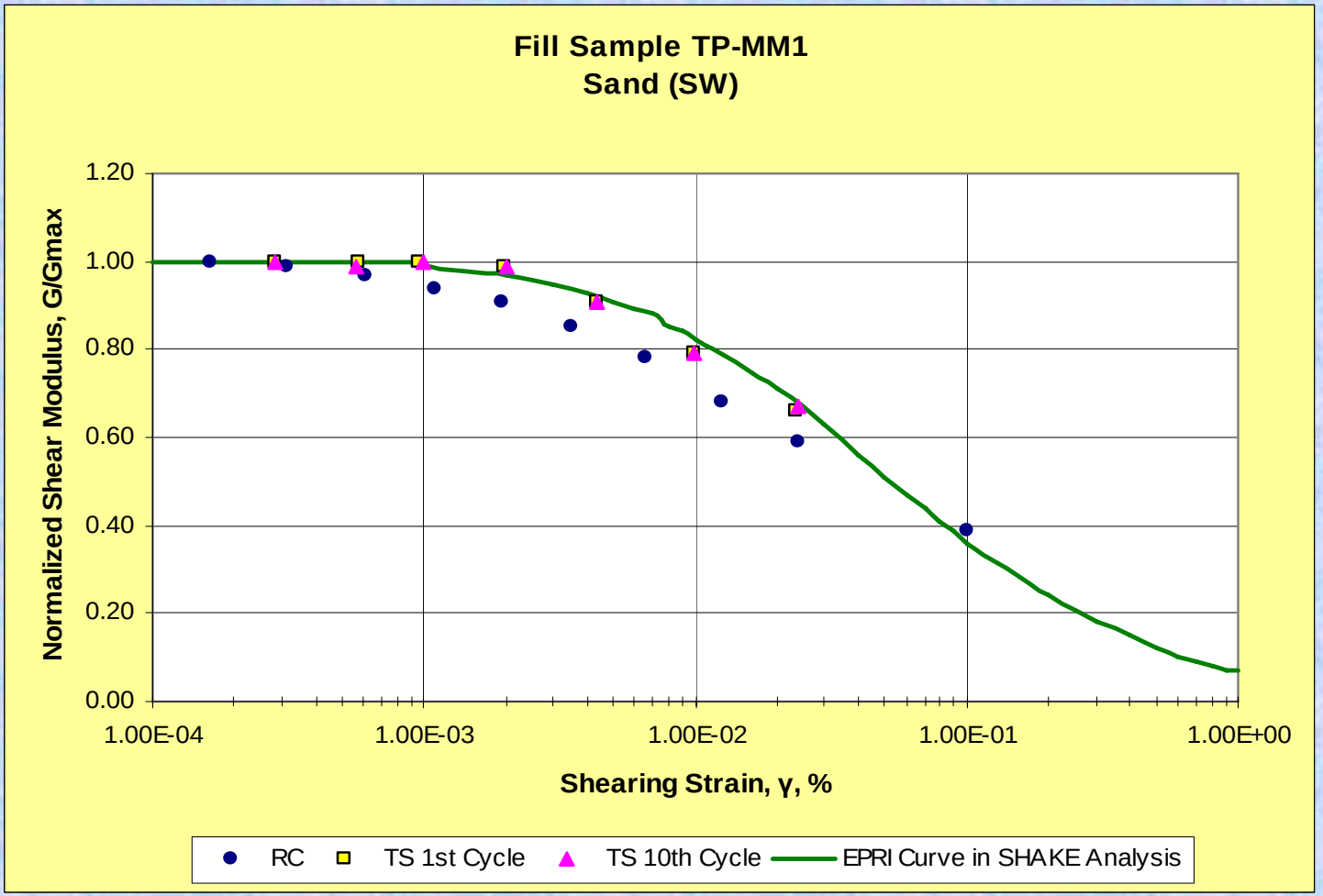


Section 2.5.4.7 Response of Soil and Rock to Dynamic Loading

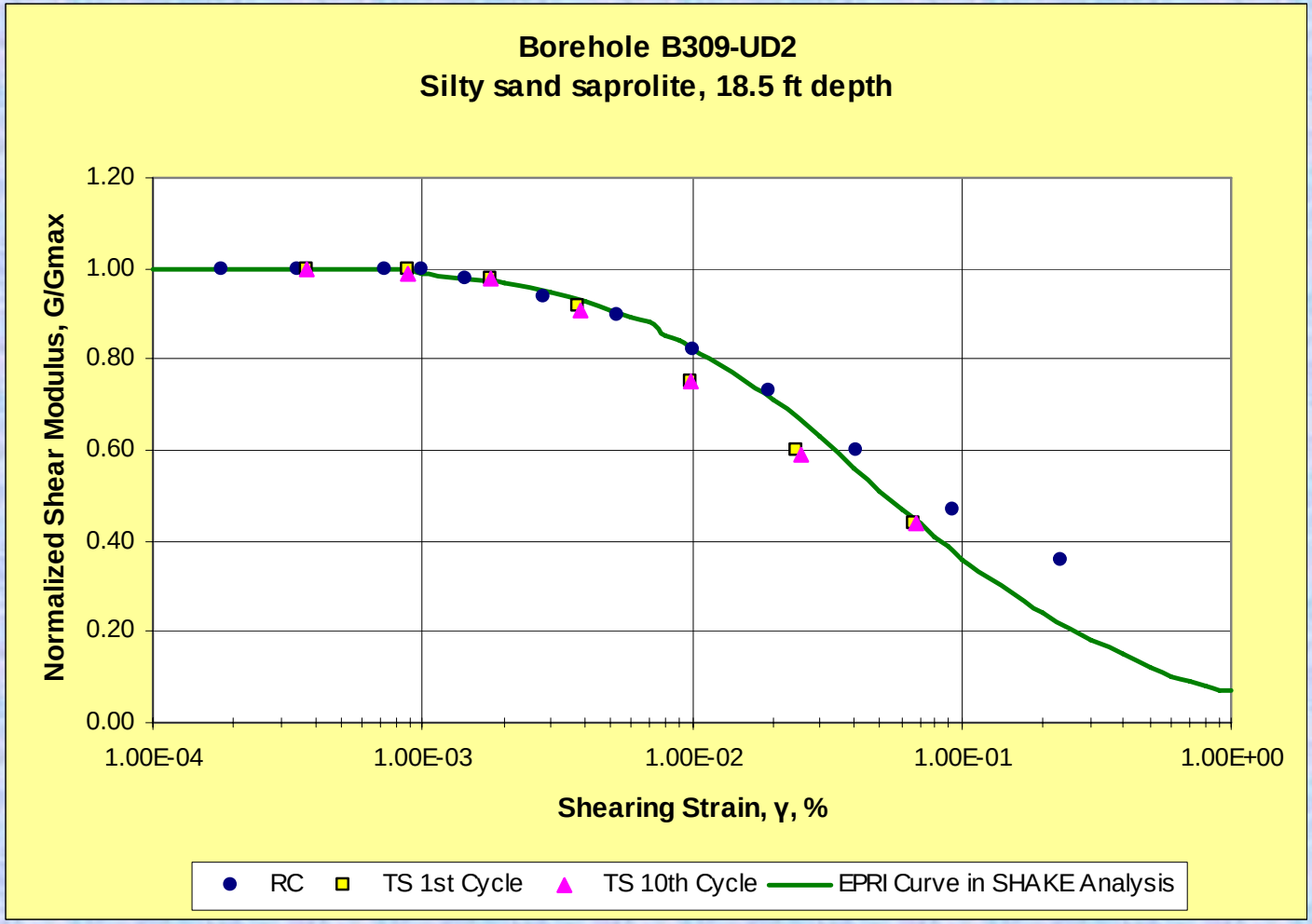
RG 1.206:

- Investigations to determine effects of earlier earthquakes on soils and rocks in vicinity of site, e.g. liquefaction – Sections 2.5.1.and 2.5.2
- P and S wave velocity profiles
- Results of dynamic lab tests – RCTS testing, Section 2.5.4.2.4

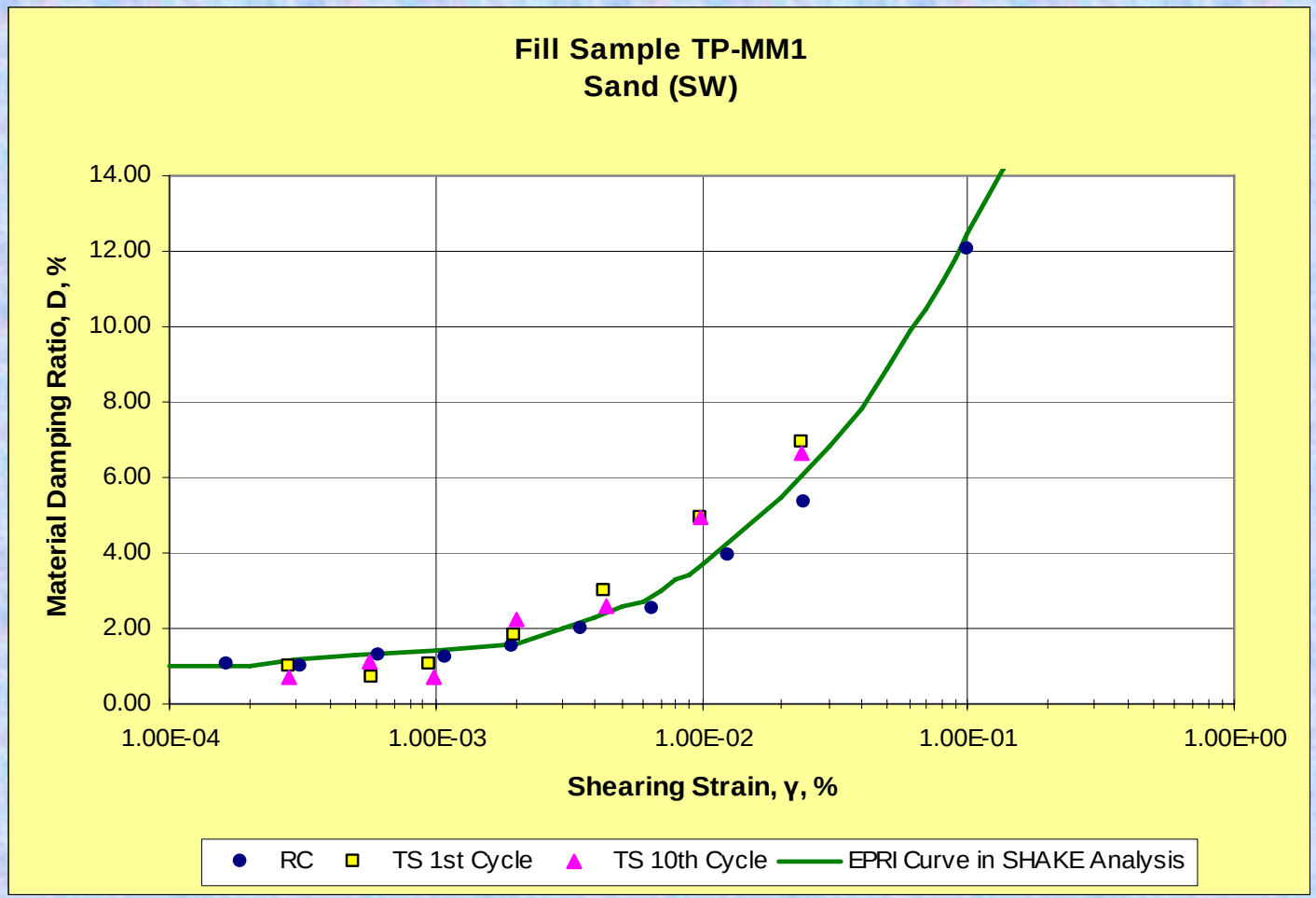
Section 2.5.4.7.2 Laboratory Testing
RCTS Test on Structural Fill



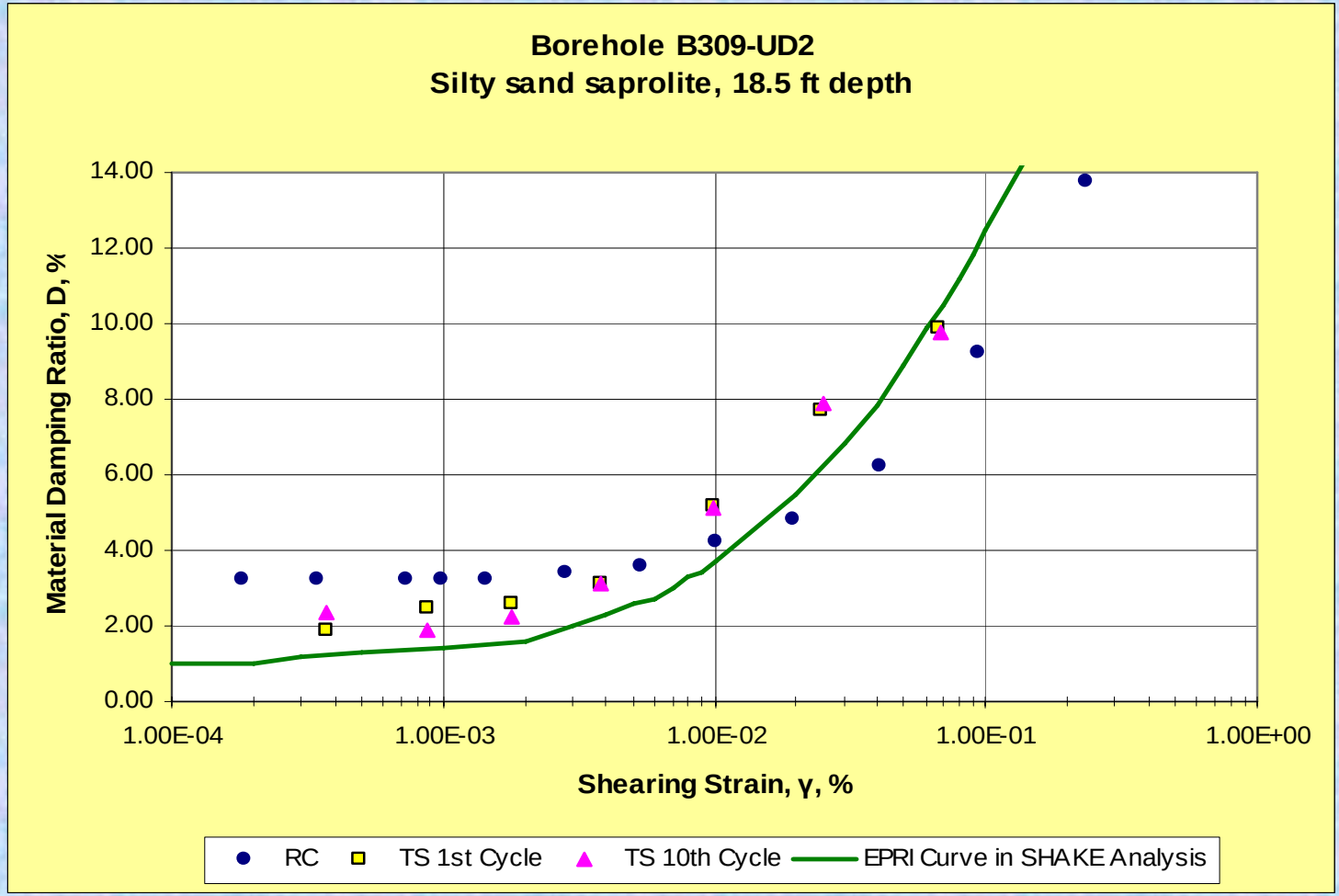
Section 2.5.4.7.2 Laboratory Testing
RCTS Test on Saprolite



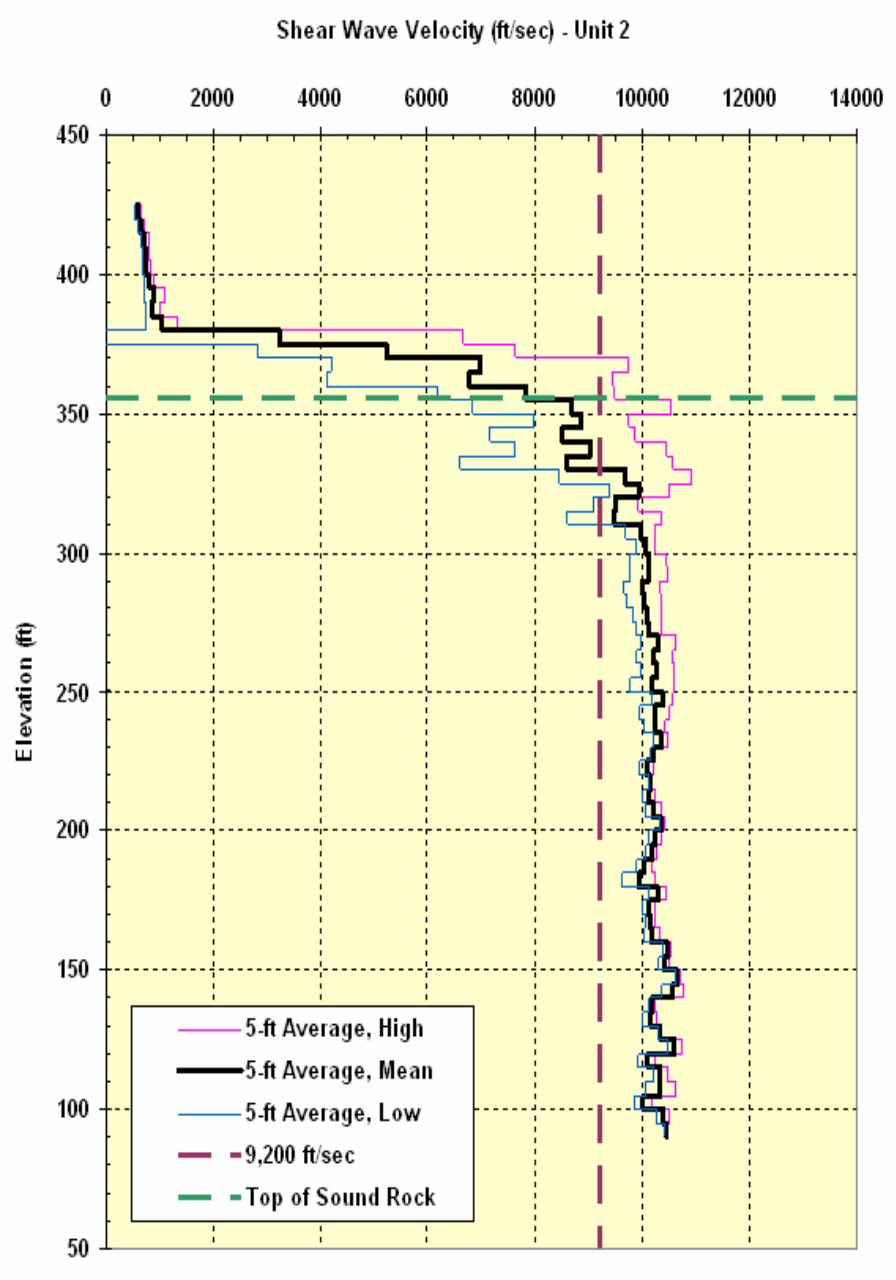
Section 2.5.4.7.2 Laboratory Testing
RCTS Test on Structural Fill

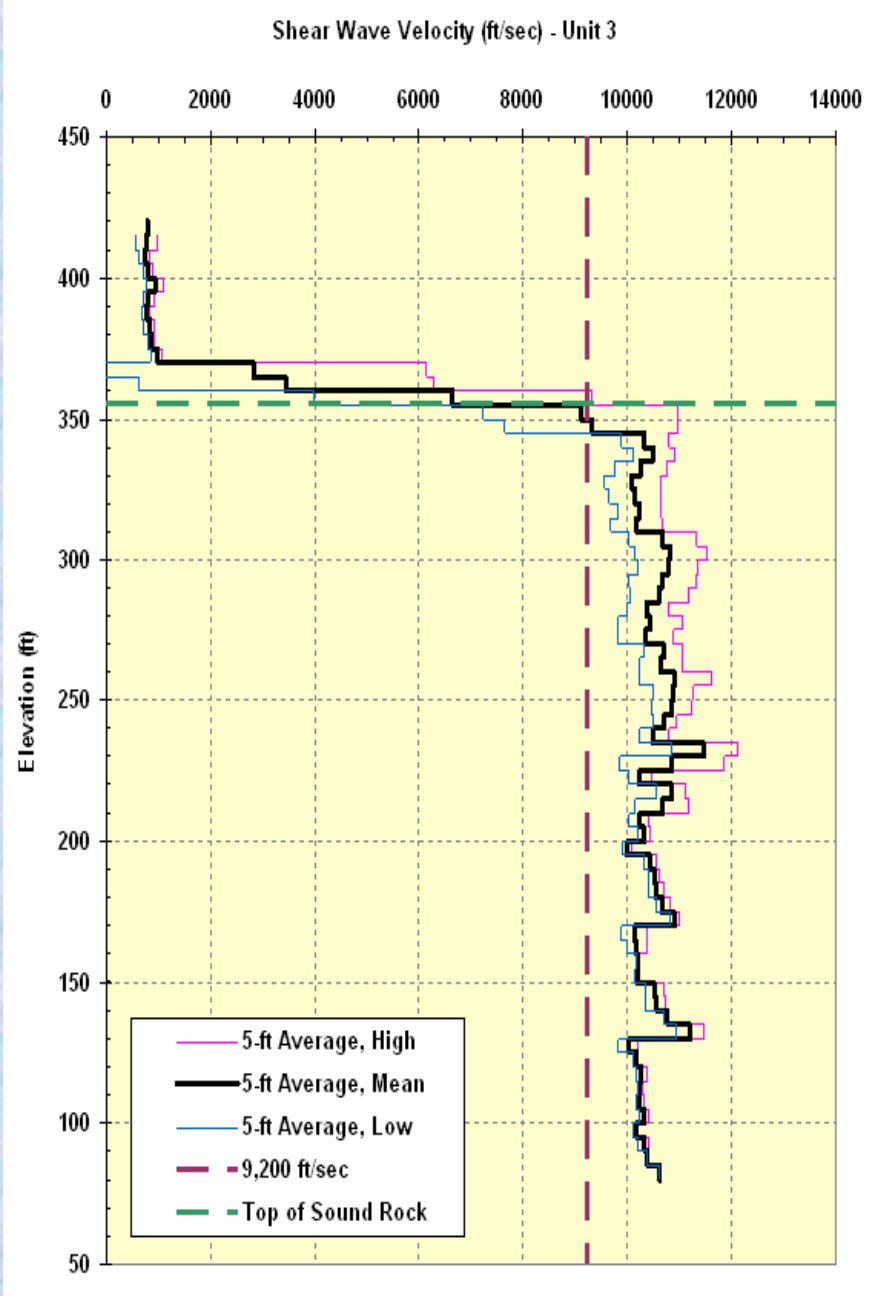


Section 2.5.4.7.2 Laboratory Testing
RCTS Test on Saprolite



2.5.4.7.2 Vs Averaging at 5 Ft Intervals





Section 2.5.4.8 Liquefaction Potential

If the site soils are potentially liquefiable, can this impact plant safety?

- Nuclear island is on sound rock or on concrete on sound rock.
- Seismic Category II Annex Bldg is on compacted structural fill.
- No saprolite is within the zone of influence of the foundation loading.

<u>Liquefaction can't impact plant safety.</u>

Conclusion: Isolated small zones of granular saprolite could liquefy under design seismic conditions. Any such saprolites are beyond the zone of influence of seismic Category I and II structures.

Section 2.5.5 Stability of Slopes Conclusions

The permanent perimeter slopes are at least 600 ft away from the nearest point on the nuclear islands. Thus, failure of these slopes, under any of the conditions to which they could be exposed during the life of the plant, could not adversely affect the safety of the nuclear power plant facilities.

The temporary slopes that will be installed for plant construction will not adversely affect the safety of the nuclear power plant facilities.

Comments

Seismic Hazard for Summer Nuclear Station Units 2 & 3

Technical Presentation
Rockville, MD

Robin K. McGuire
Risk Engineering, Inc.
Boulder, Colorado

October 3, 2007

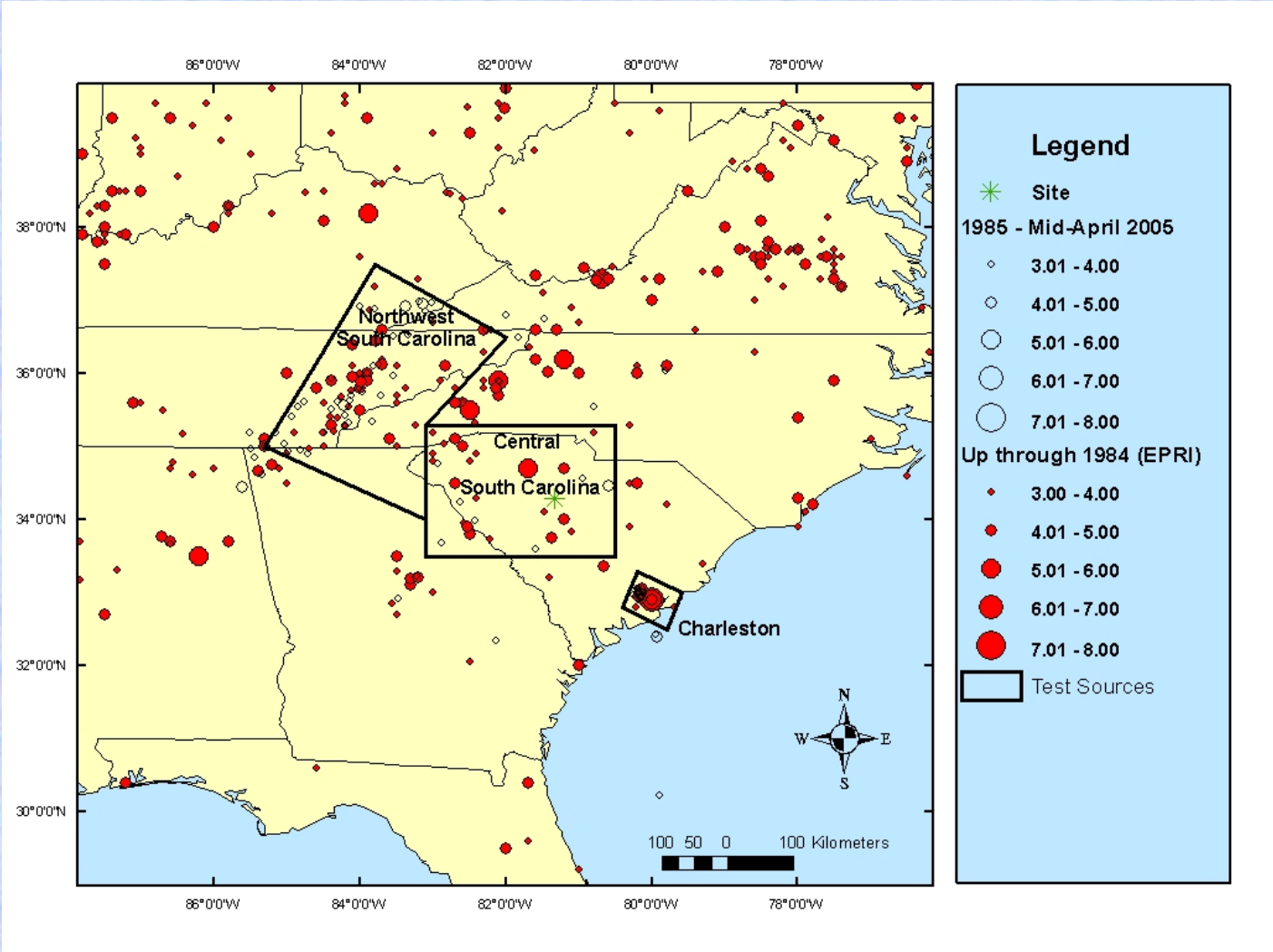
Topics for Probabilistic Seismic Hazard Analysis

- Replication of 1989 hazard results
- Effect of updated seismicity
- Updating of Charleston source
- Seismic hazard and UHRS (hard rock)
- V/H ratios and GMRS (hard rock)

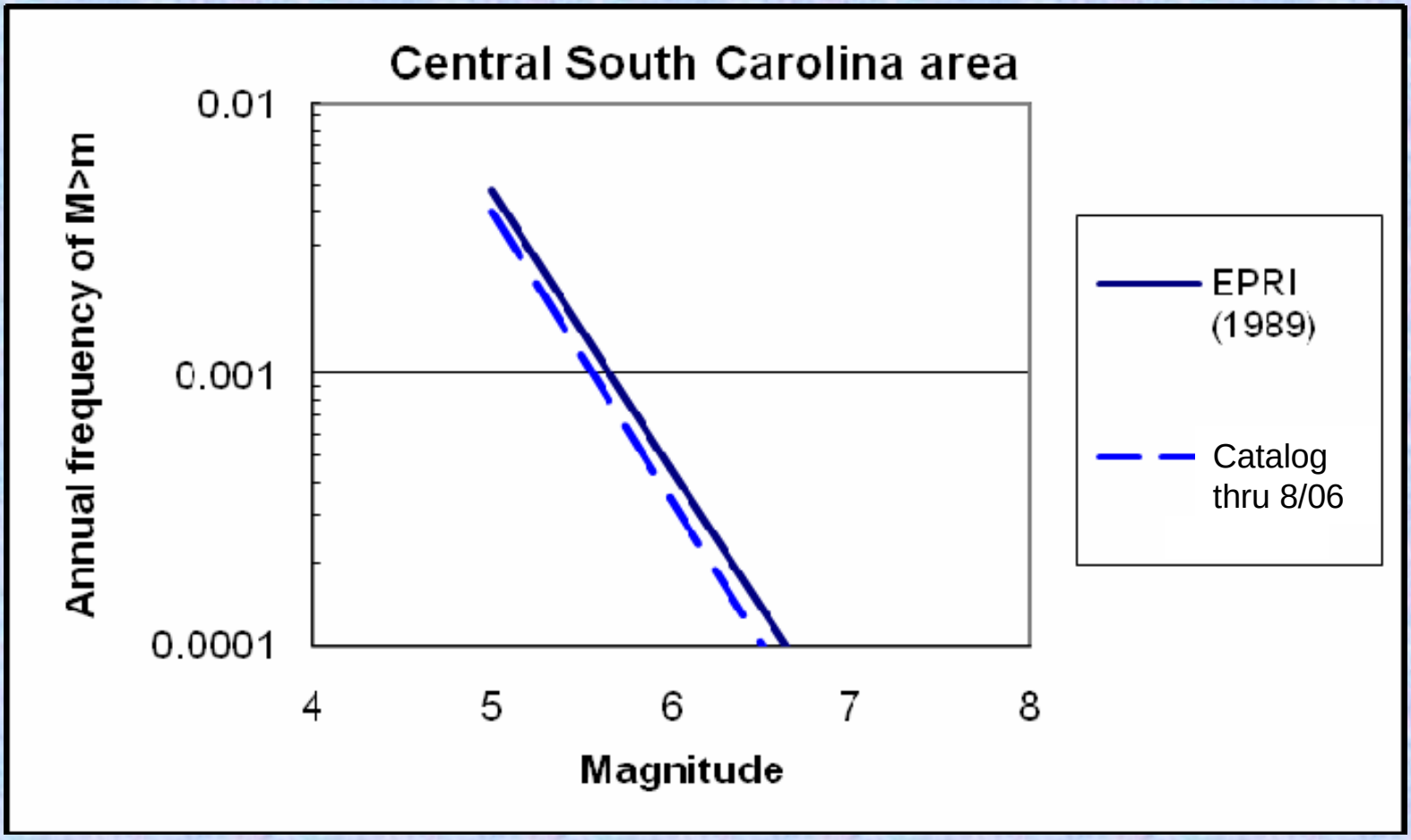
Comparison of EPRI (1989) and current hazard results using EPRI (1989) assumptions
Mean hazard comparison

PGA	EPRI (1989)	Current results	
amp, cm/sec^2	hazard	hazard	% diff
50	9.15E-04	9.32E-04	1.81%
100	2.69E-04	2.74E-04	1.82%
250	3.65E-05	3.74E-05	2.47%
500	5.19E-06	5.37E-06	3.45%
700	1.73E-06	1.81E-06	4.39%
1000	4.79E-07	5.08E-07	6.10%

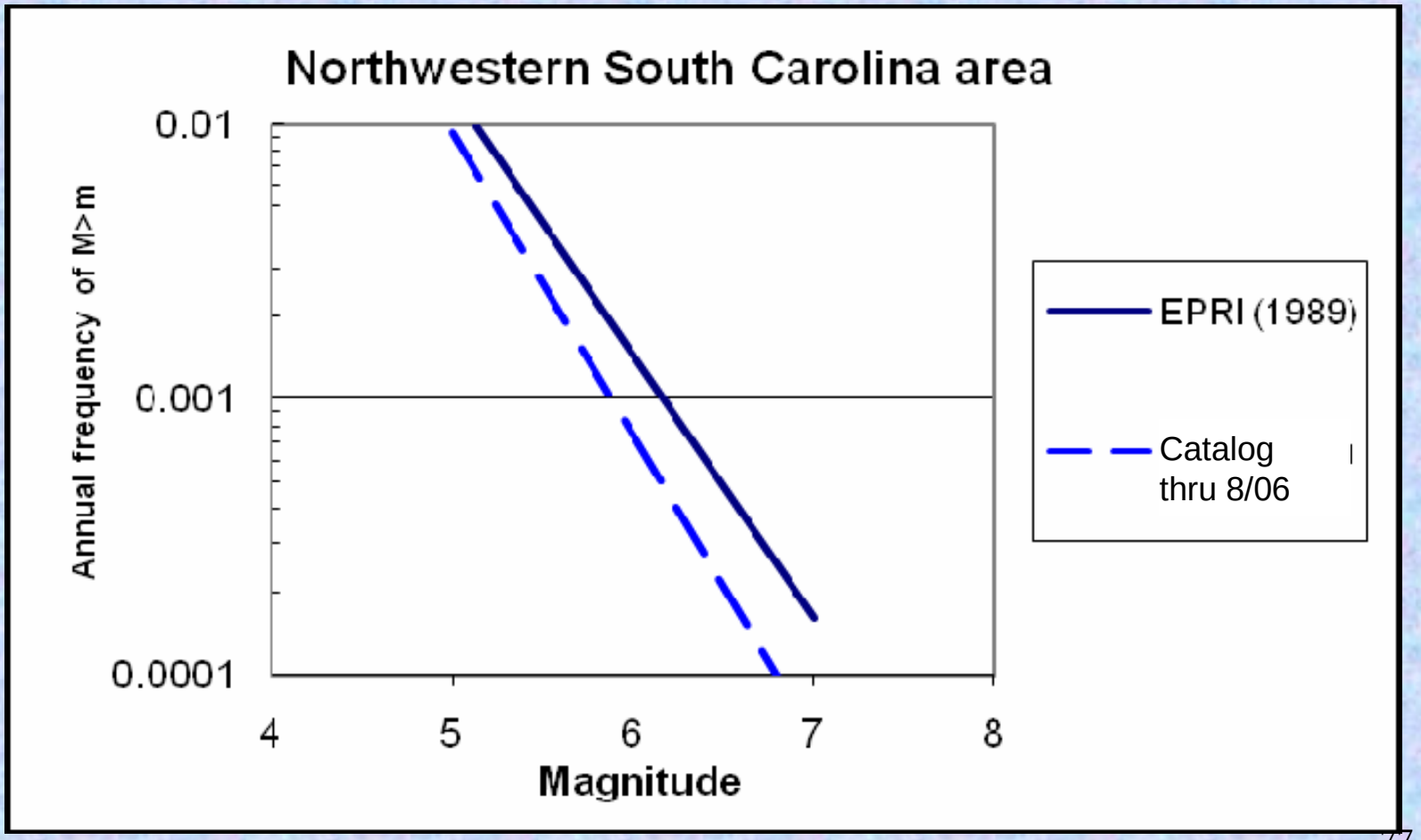
Historical seismicity in vicinity of Summer site and three areas used to test the effects of additional seismicity



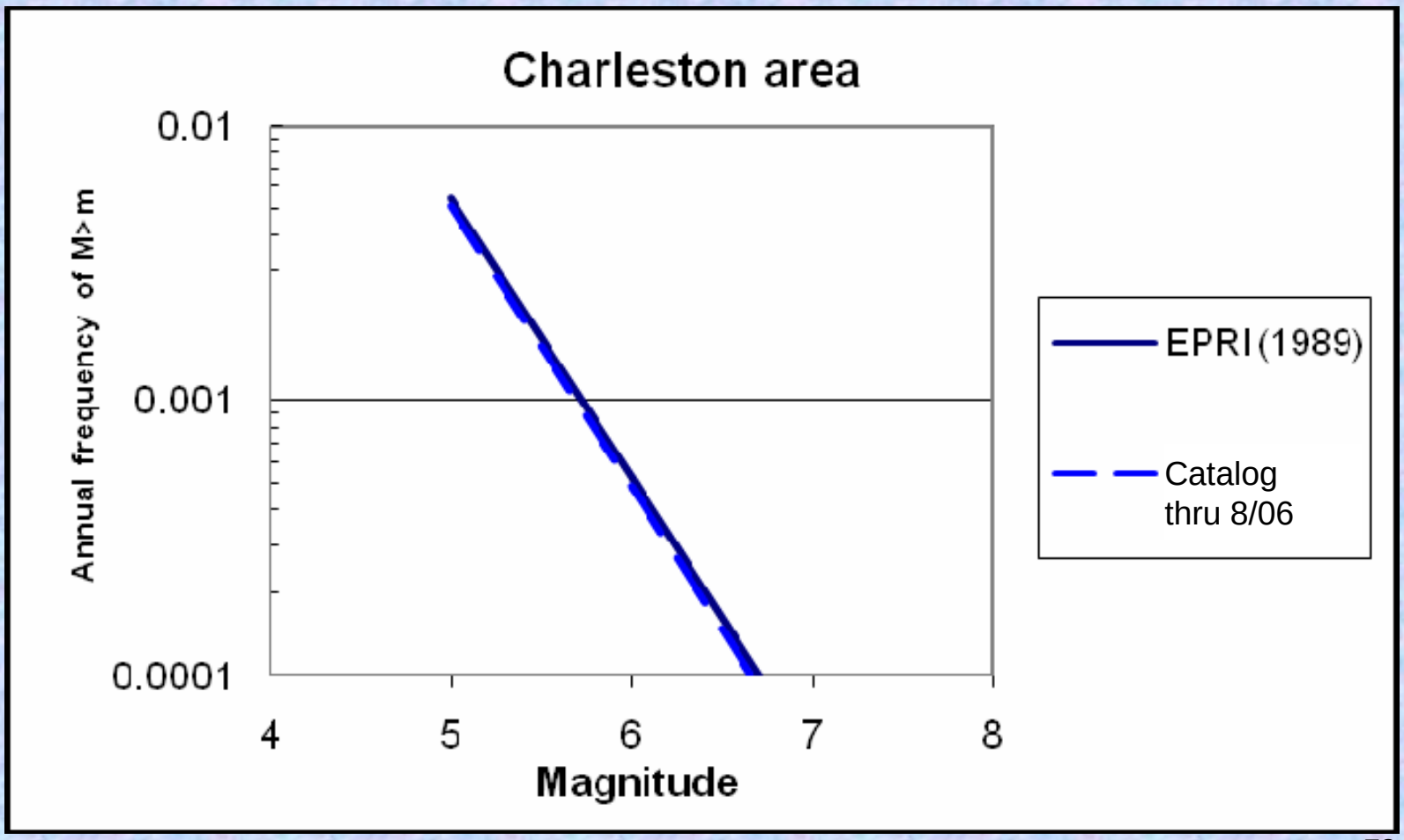
Earthquake occurrence rates for EPRI (1989) catalog and for catalog extended through 8/06, for central South Carolina area



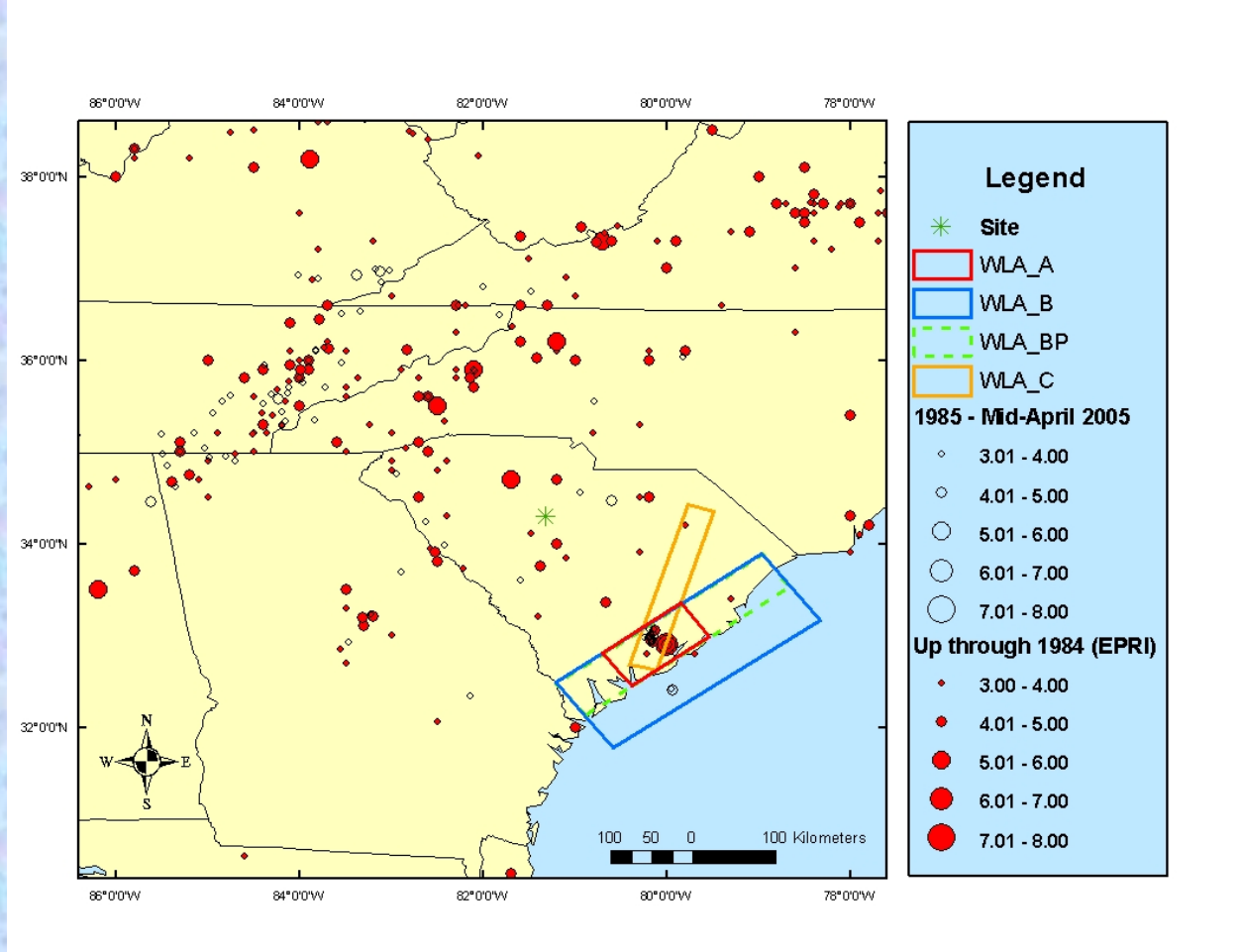
Earthquake occurrence rates for EPRI (1989) catalog and for catalog extended through 8/06, for northwestern South Carolina area



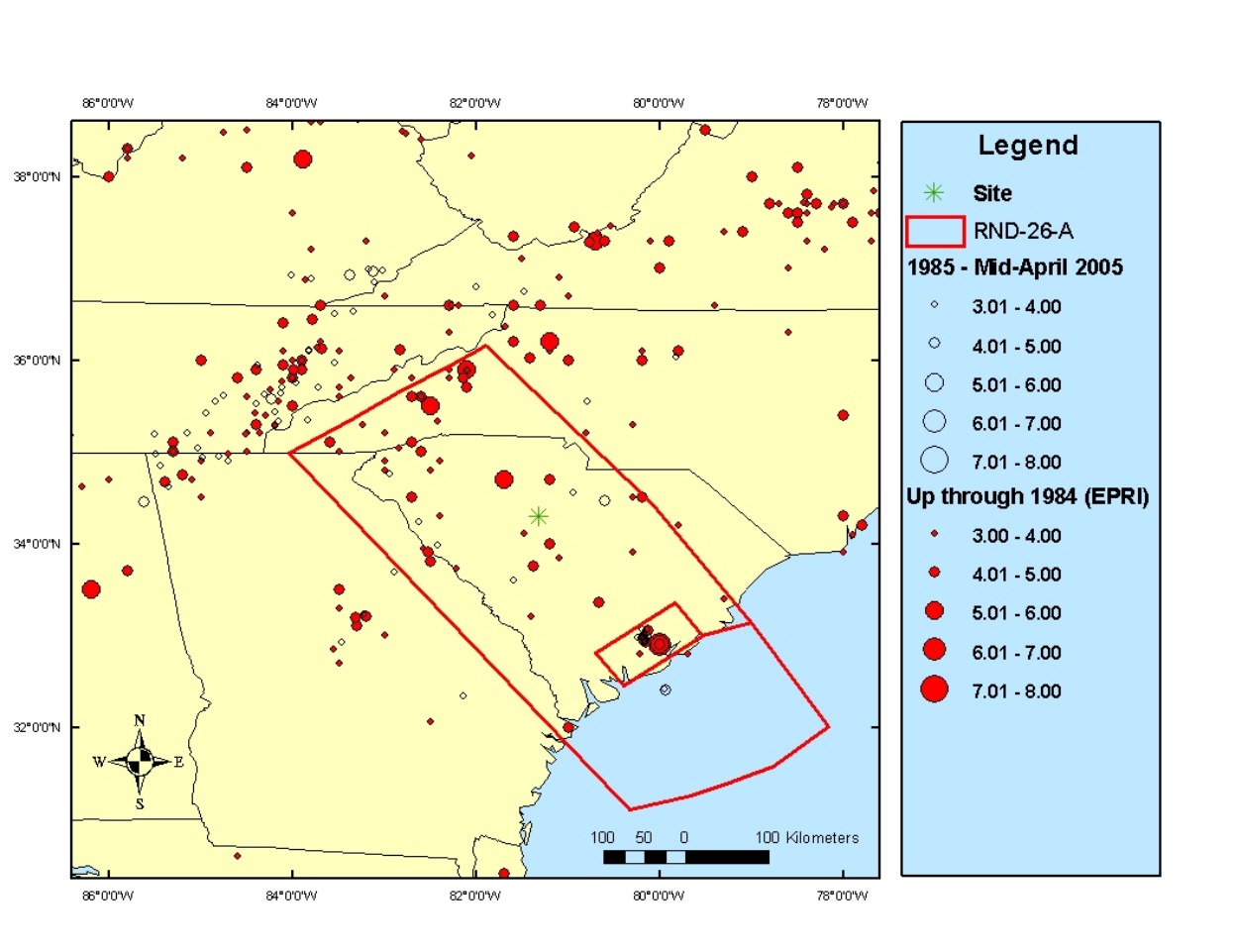
Earthquake occurrence rates for EPRI (1989) catalog and for catalog extended through 8/06, for Charleston area



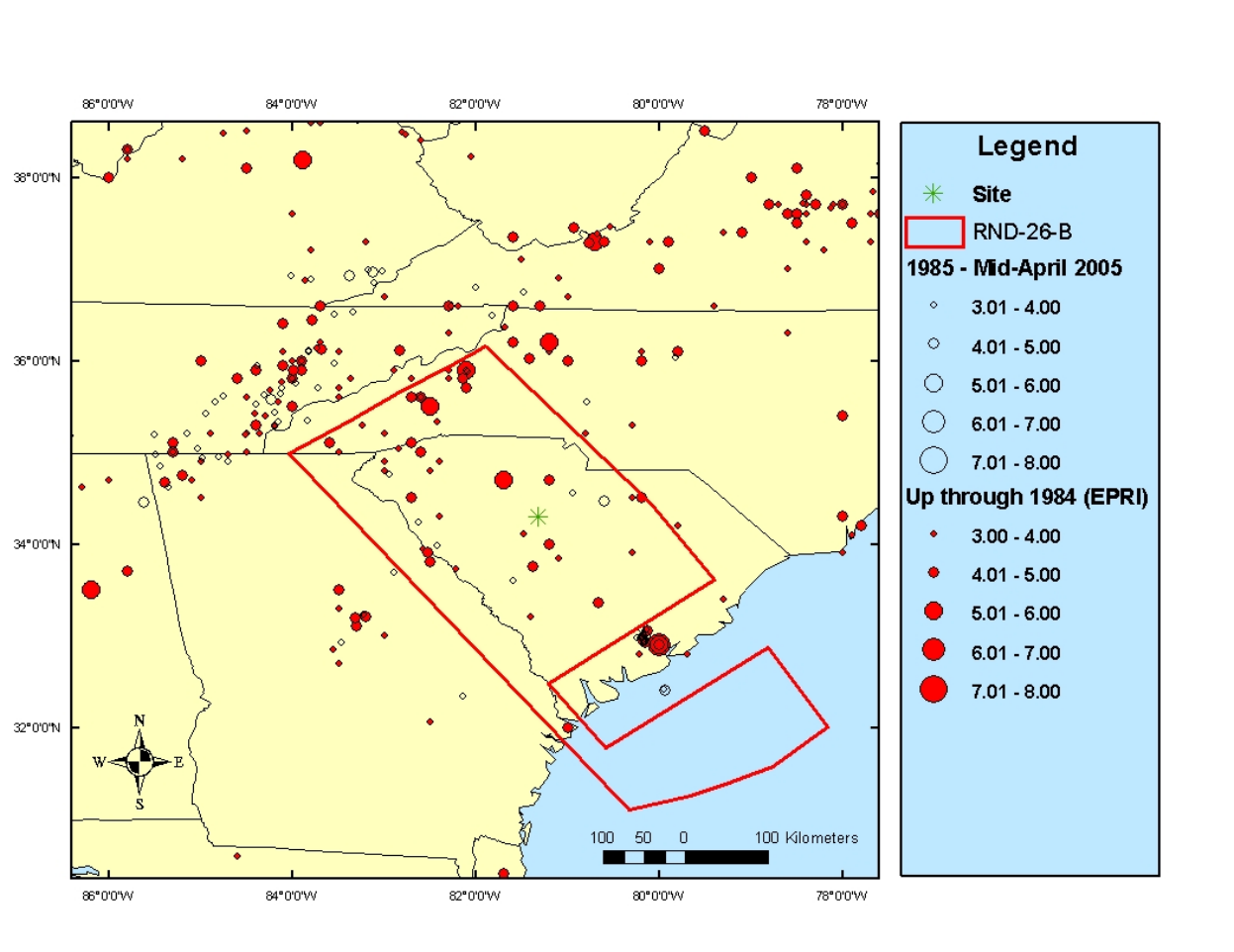
Geometry of four sources used in UCSS model



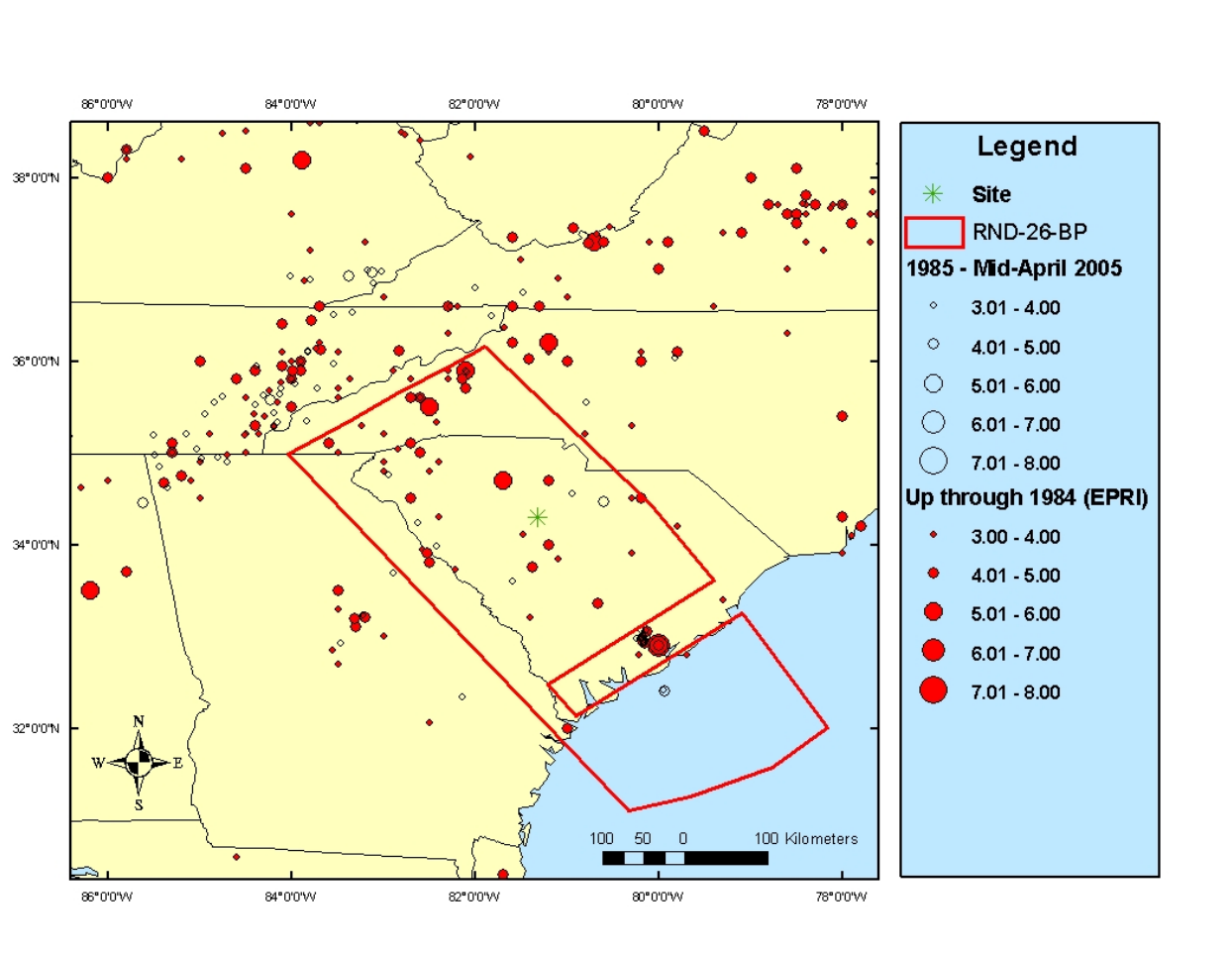
Geometry of revised Rondout source RND-26-A



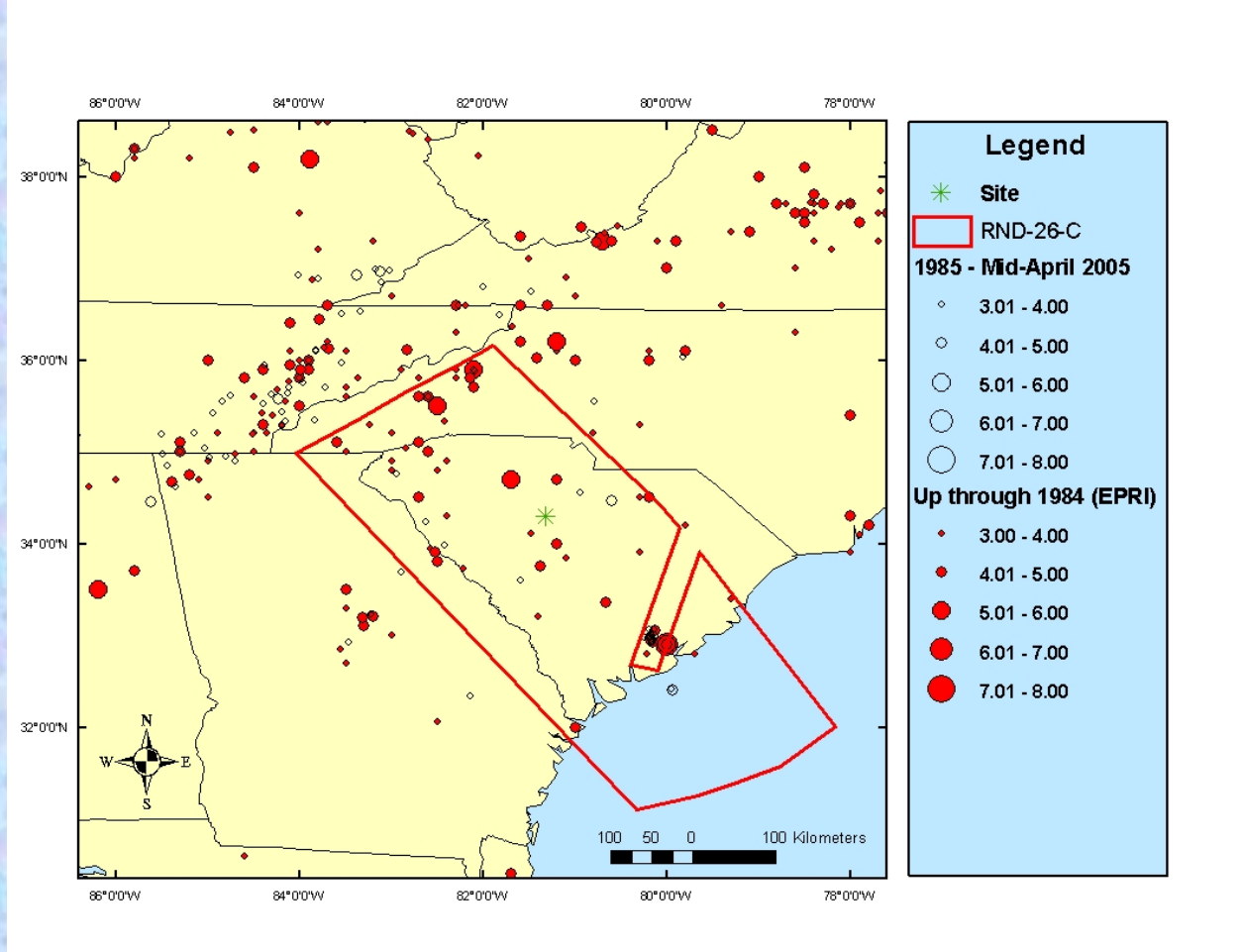
Geometry of revised Rondout source RND-26-B



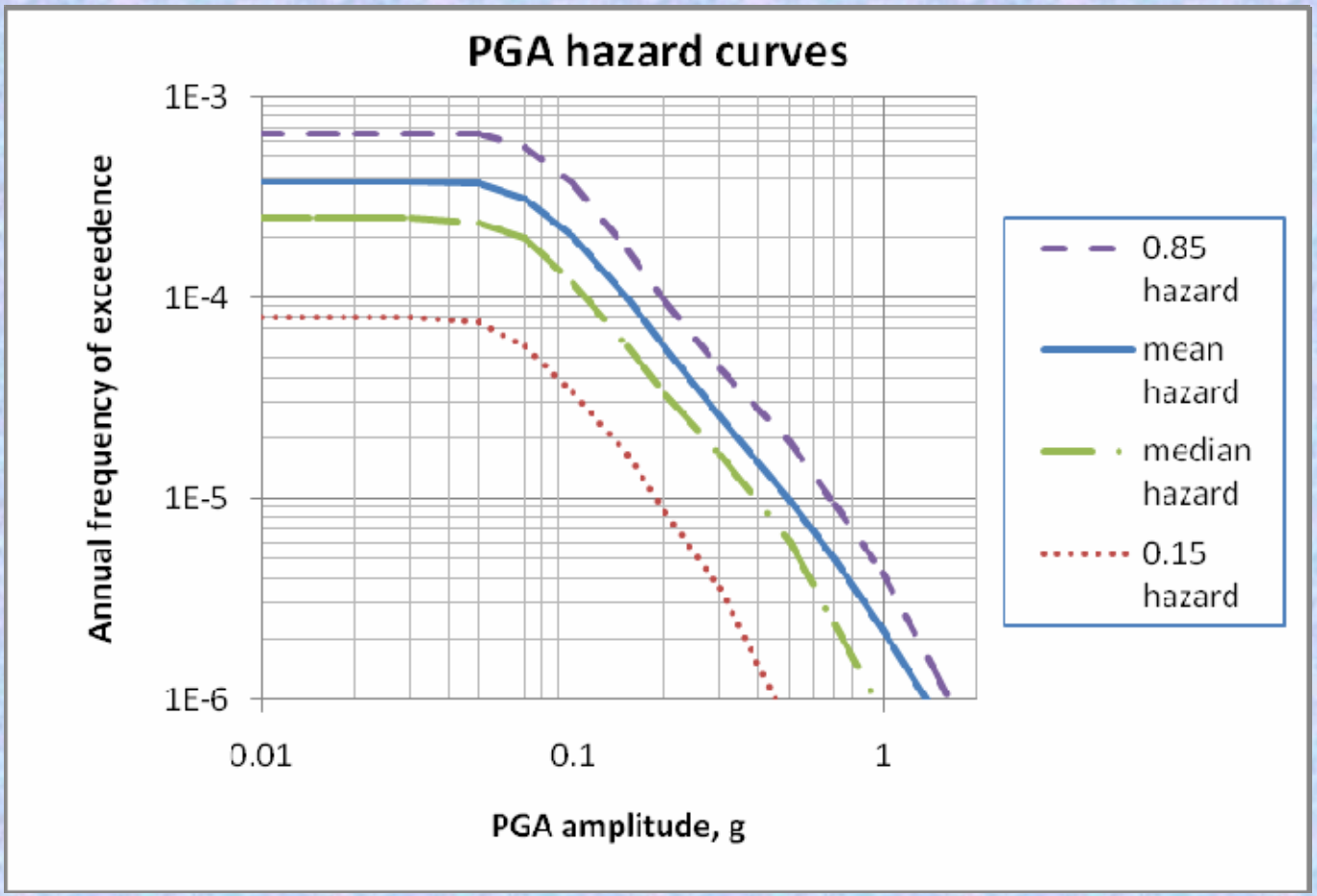
Geometry of revised Rondout source RND-26-BP



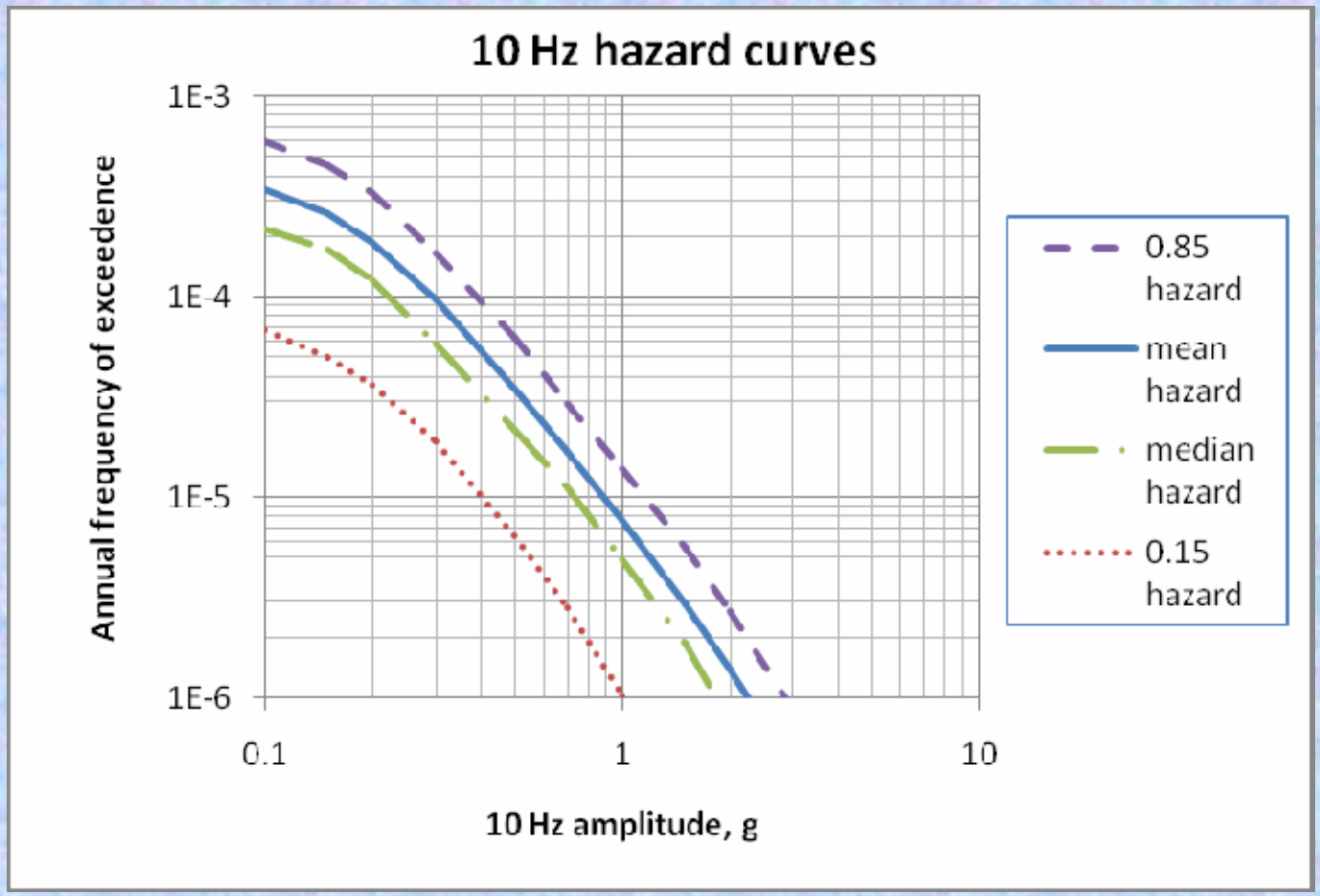
Geometry of revised Rondout source RND-26-C



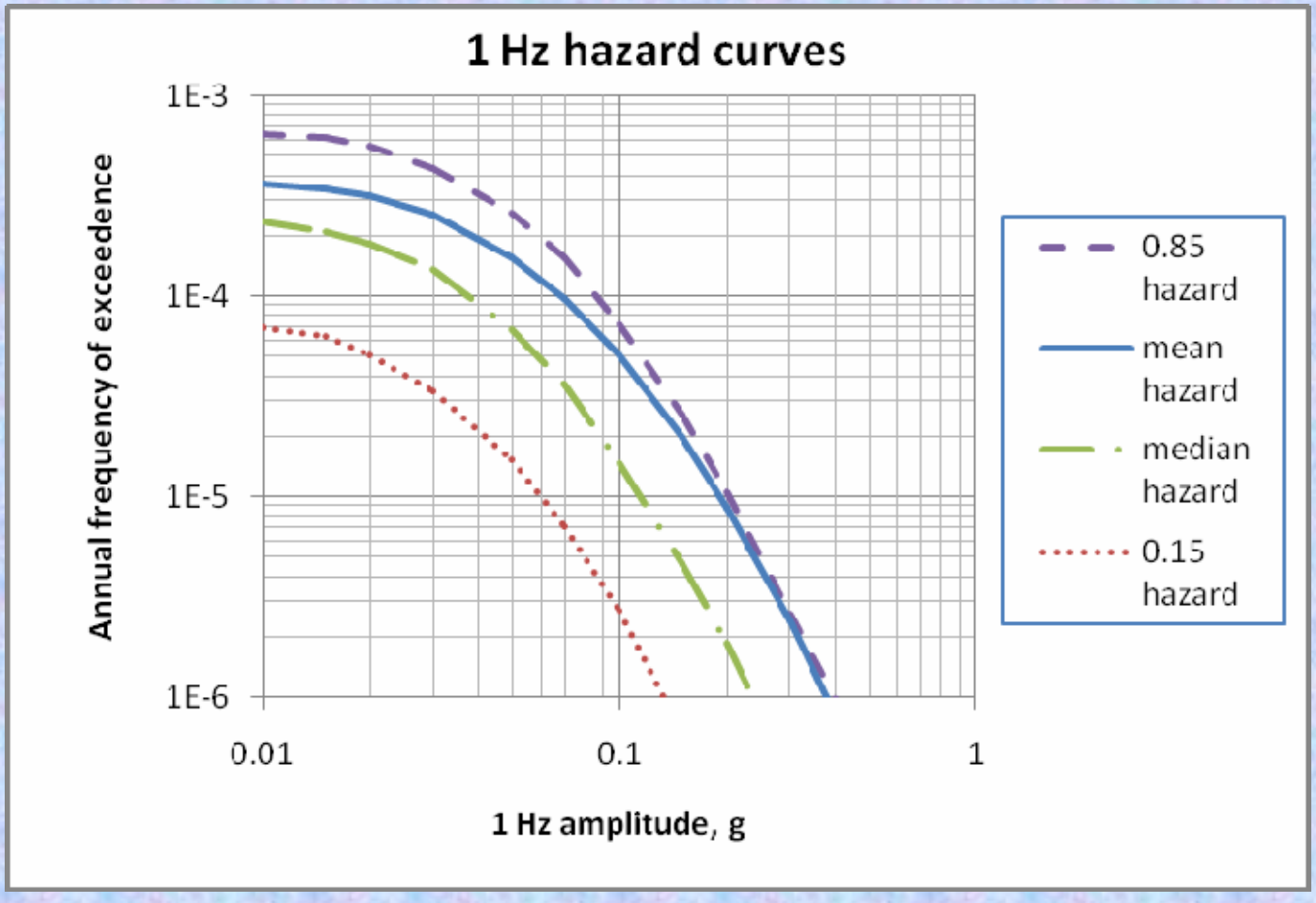
Mean and fractile PGA seismic hazard curves



Mean and fractile 10 Hz seismic hazard curves



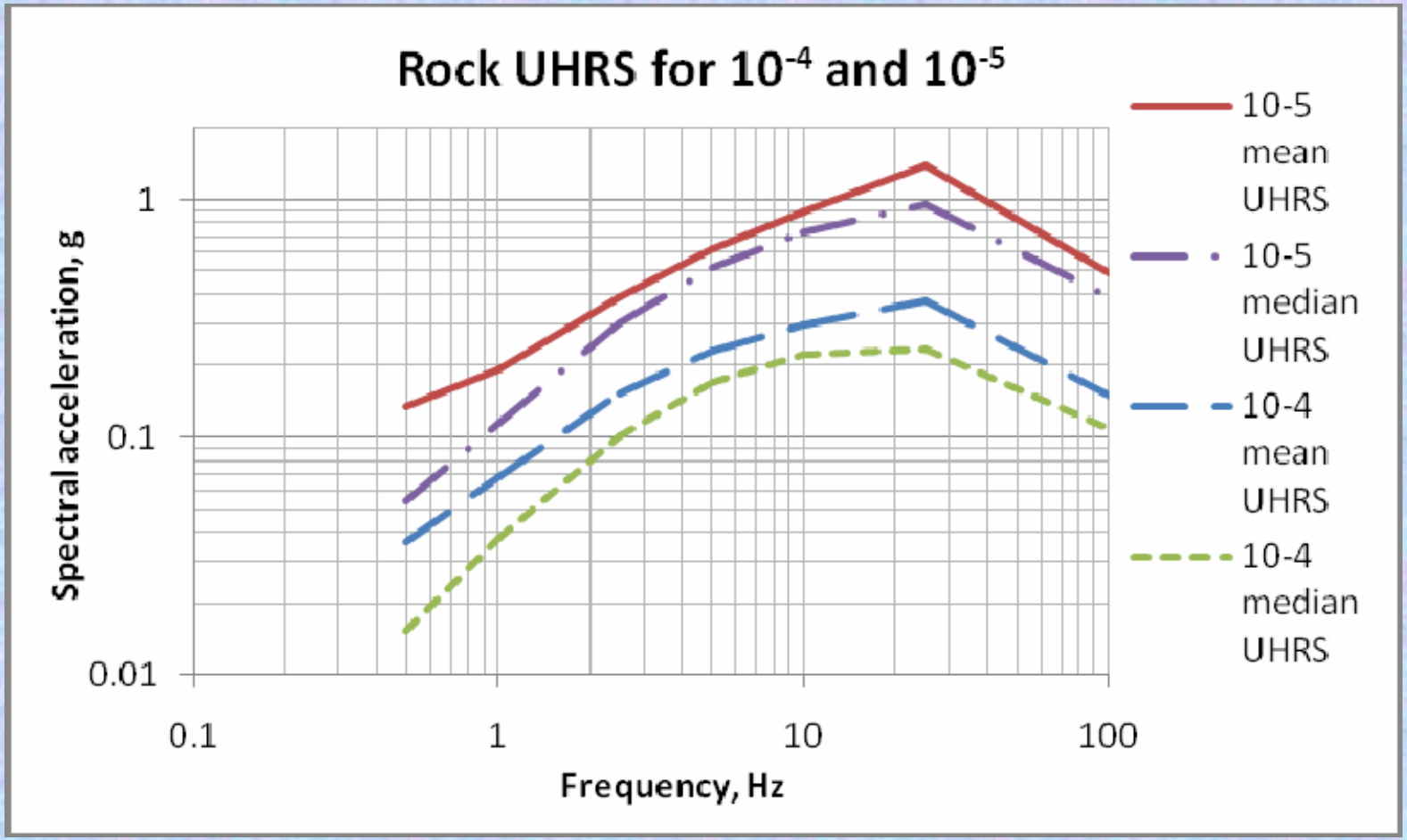
Mean and fractile 1 Hz seismic hazard curves



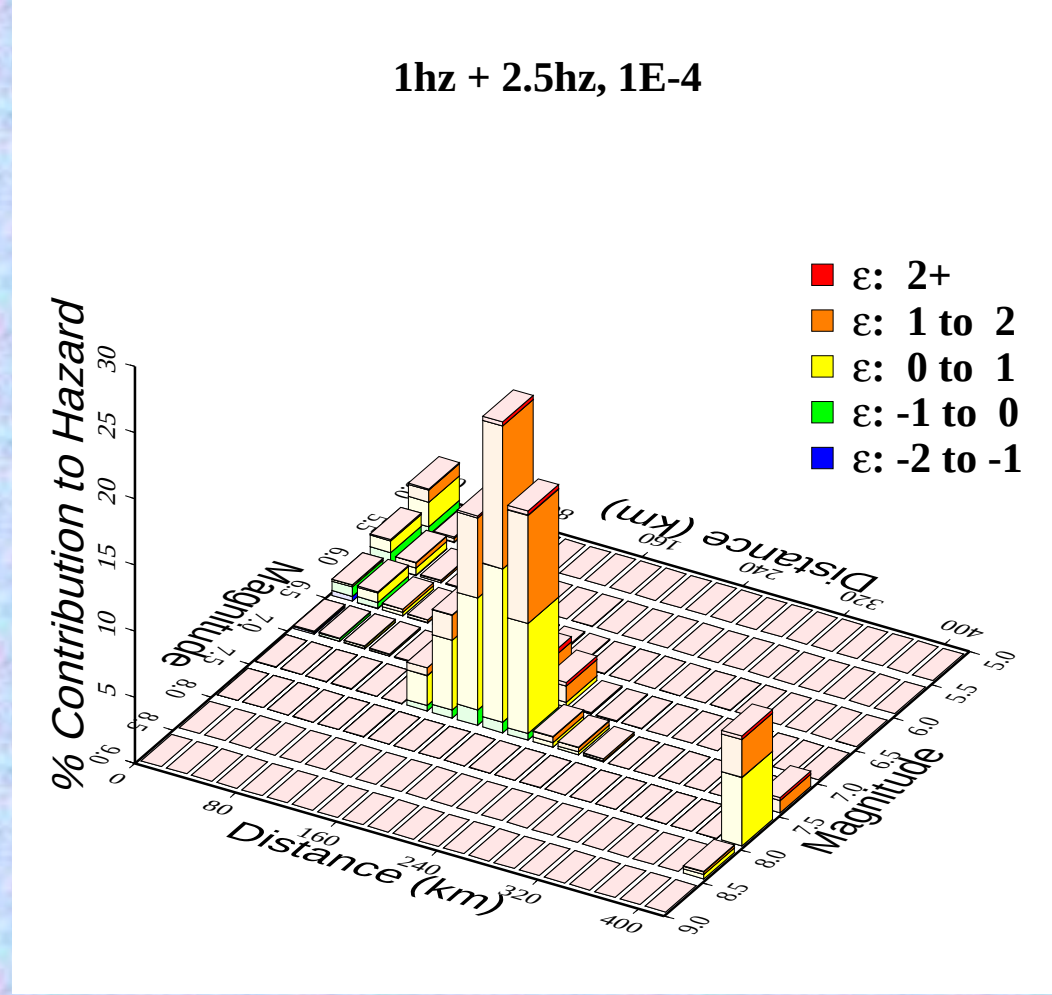
Mean rock uniform hazard response spectral accelerations (g)

UHS results, g			
ground motion frequency	mean 10^{-4}	mean 10^{-5}	mean 10^{-6}
0.5 Hz	0.0366	0.136	0.295
1 Hz	0.0687	0.192	0.381
2.5 Hz	0.152	0.390	0.797
5 Hz	0.230	0.618	1.40
10 Hz	0.295	0.890	2.25
25 Hz	0.373	1.40	4.01
PGA	0.150	0.493	1.38

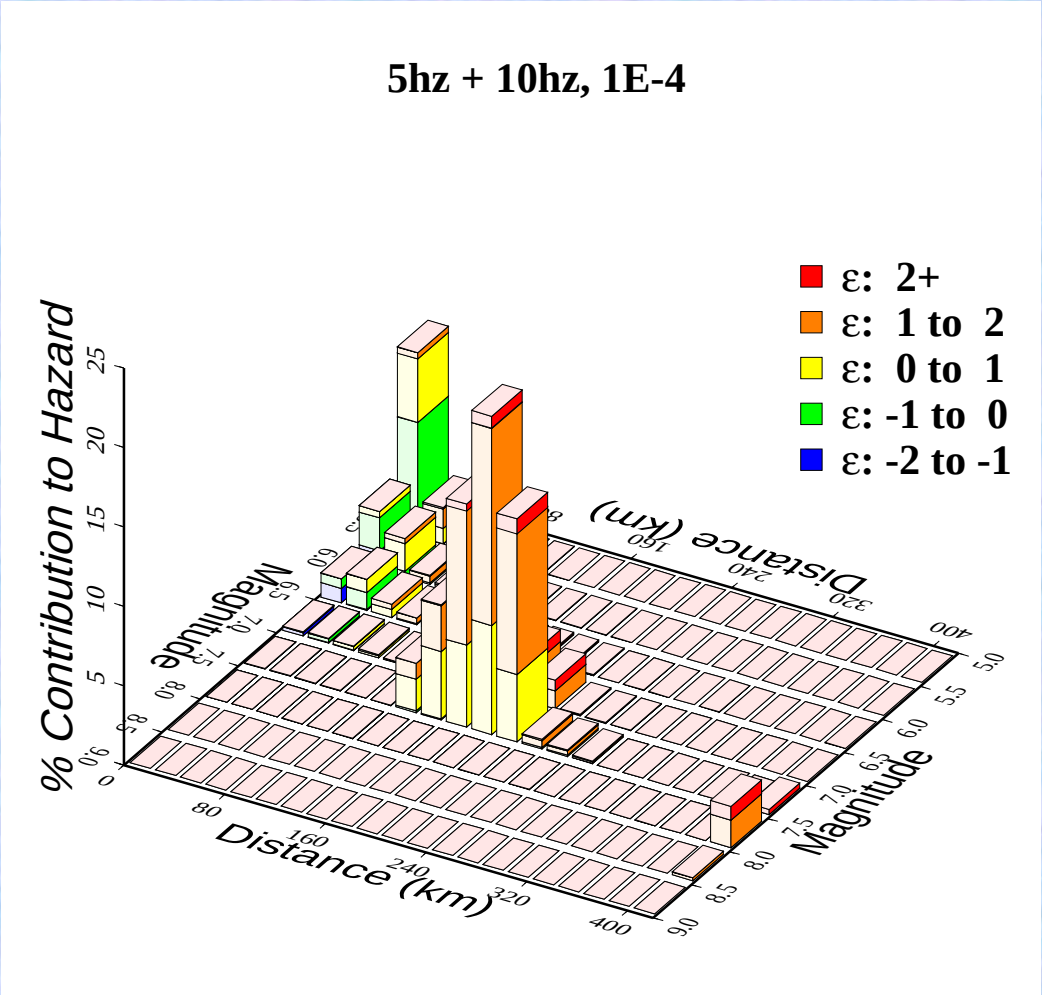
Mean and median uniform hazard response spectra



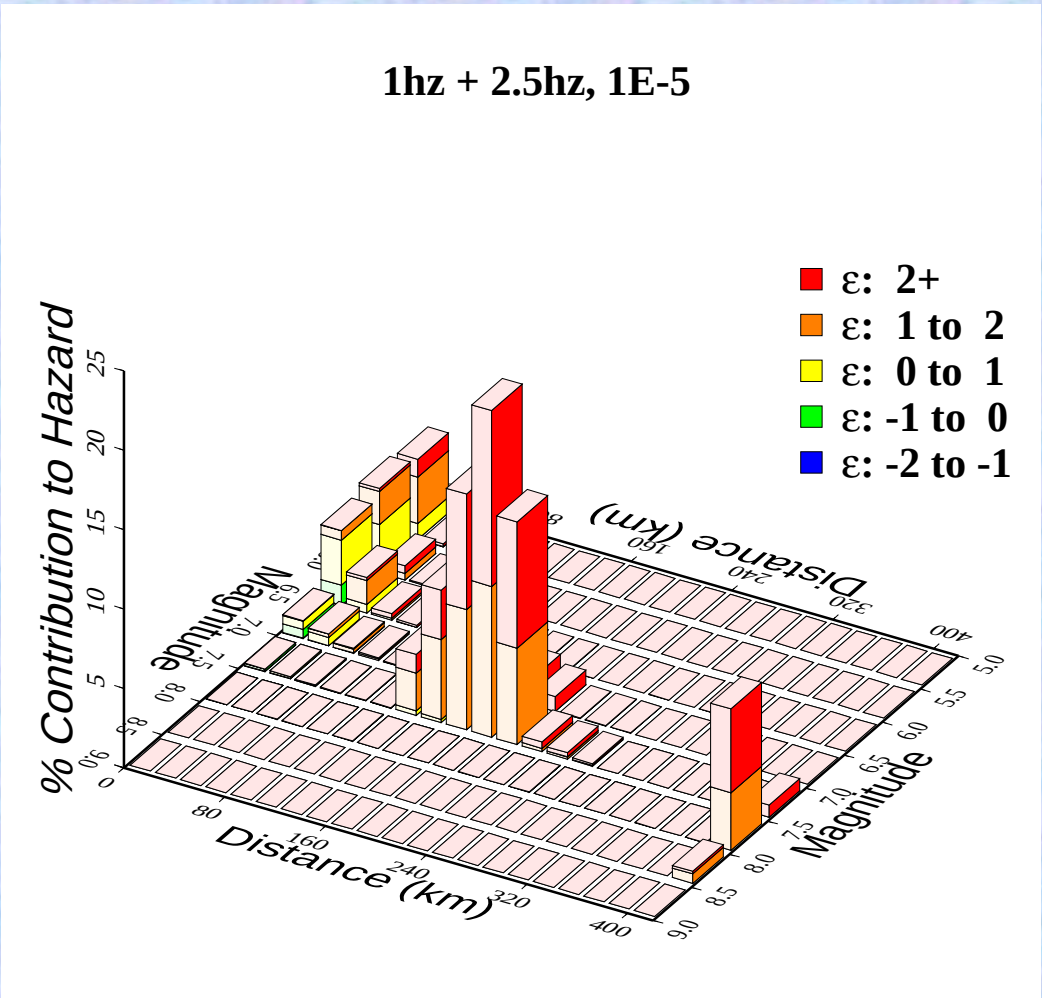
M and R deaggregation for 1 and 2.5 Hz at 10^{-4} annual frequency of exceedence



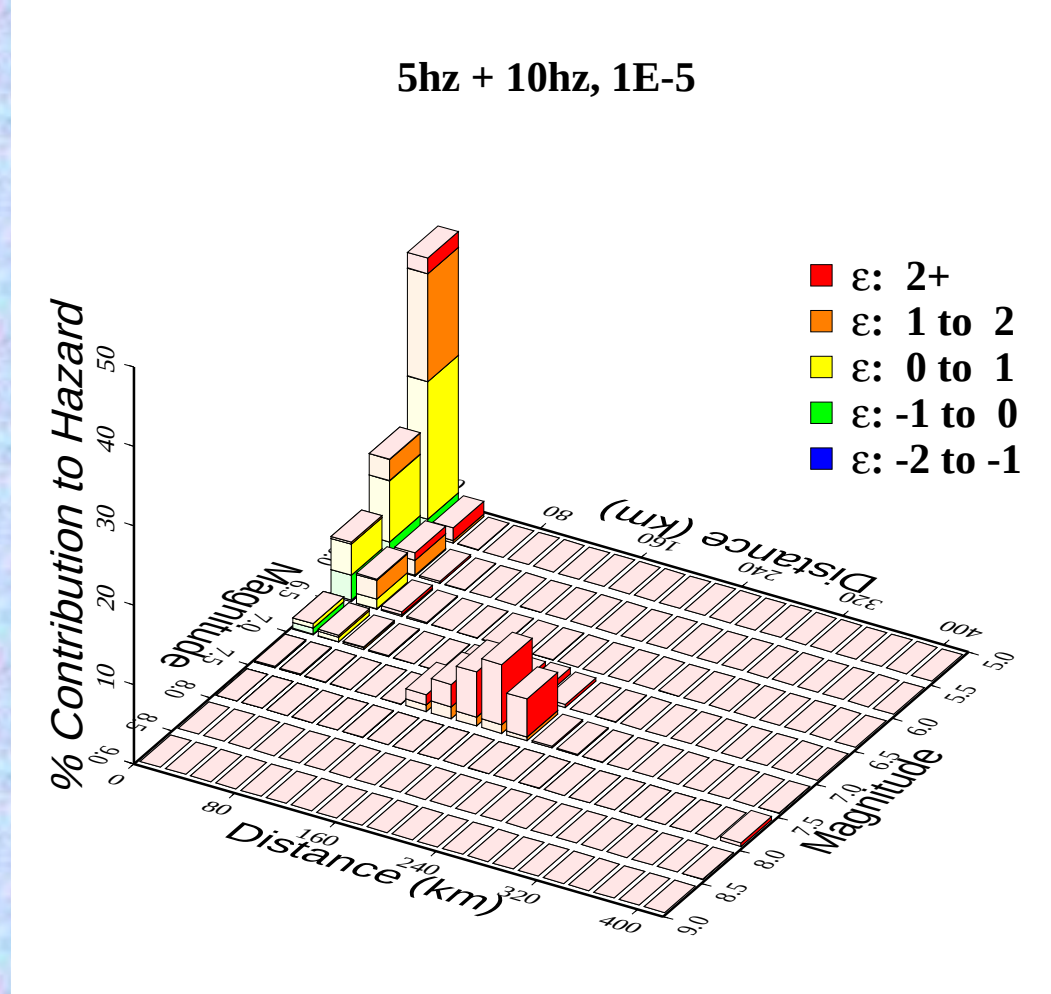
M and R deaggregation for 5 and 10 Hz at 10^{-4} annual frequency of exceedence



M and R deaggregation for 1 and 2.5 Hz at 10^{-5} annual frequency of exceedence



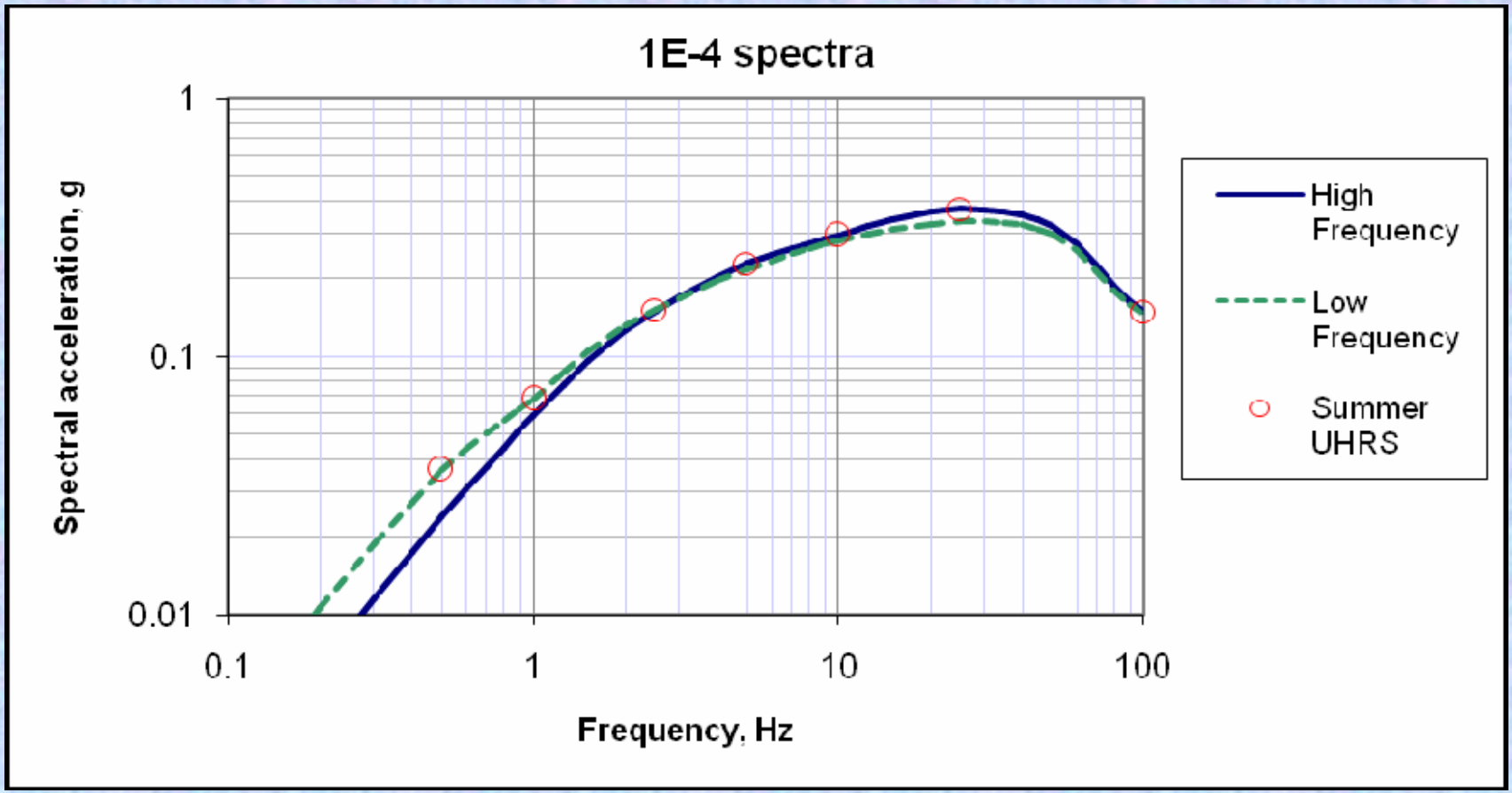
M and R deaggregation for 5 and 10 Hz at 10^{-5} annual frequency of exceedence



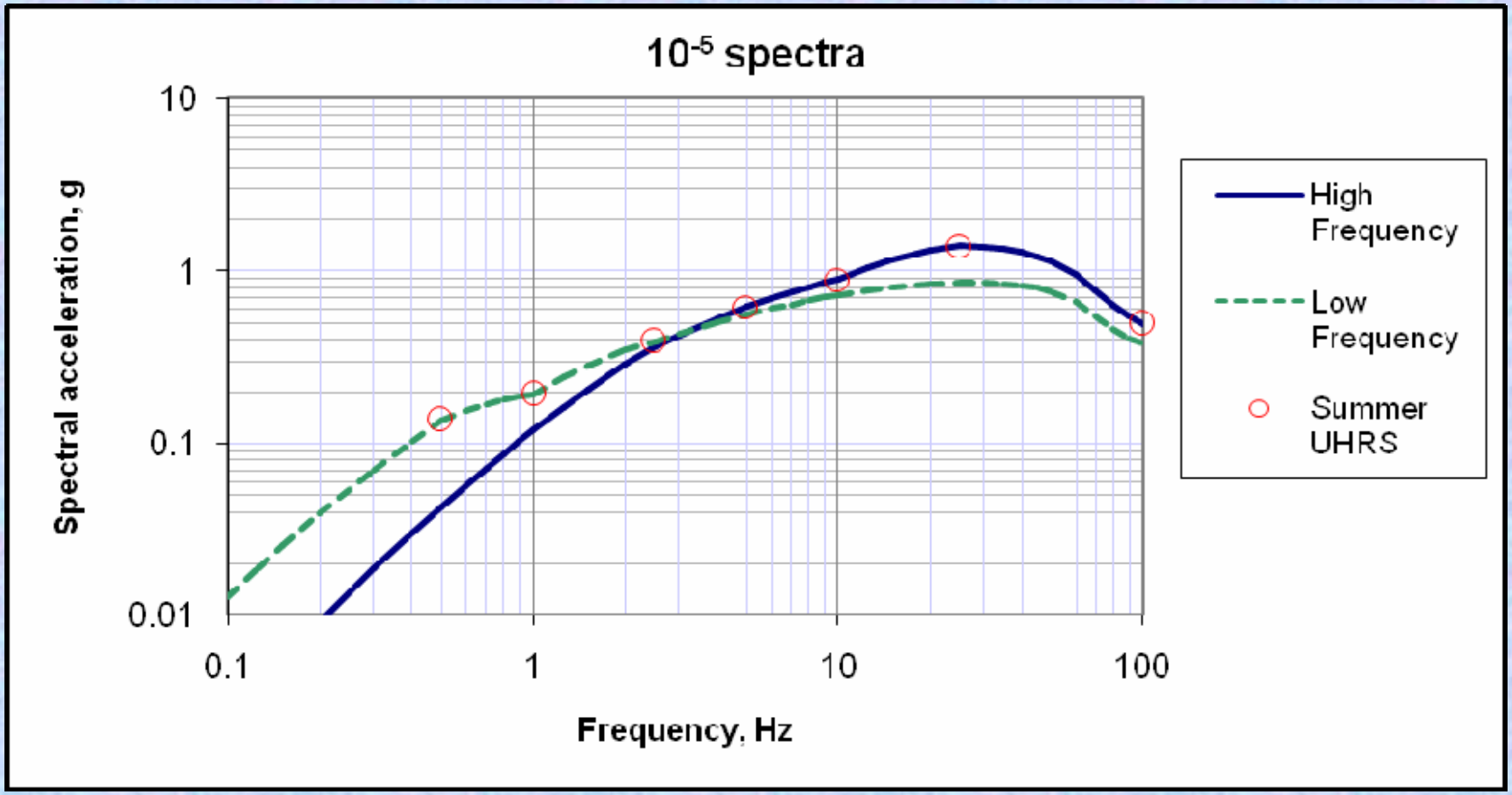
Controlling magnitudes and distances from deaggregation (shaded cells indicate values used to construct UHRS)

Struct. frequency	Annual Freq. Exceed.	Overall hazard		Hazard from R>100 km	
		M	R, km	M	R, km
1 & 2.5 Hz	1E-4	7.1	220	7.3	250
5 & 10 Hz	1E-4	6.8	160	7.2	210
1 & 2.5 Hz	1E-5	7.1	210	7.3	260
5 & 10 Hz	1E-5	6.1	70	7.2	190
1 & 2.5 Hz	1E-6	6.9	160	7.3	265
5 & 10 Hz	1E-6	5.8	26	7.2	180

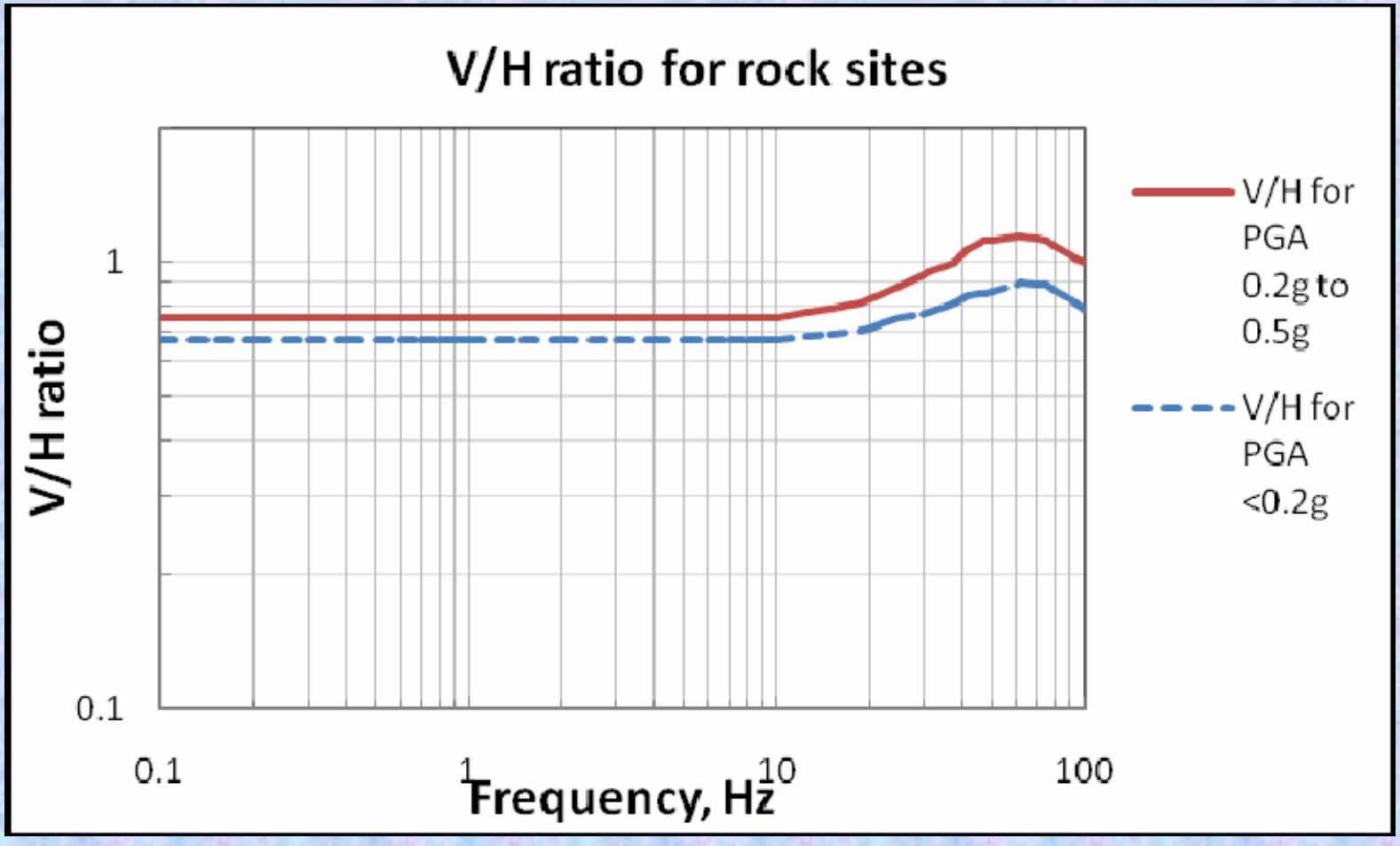
Smooth 10^{-4} UHRS for HF and LF earthquakes



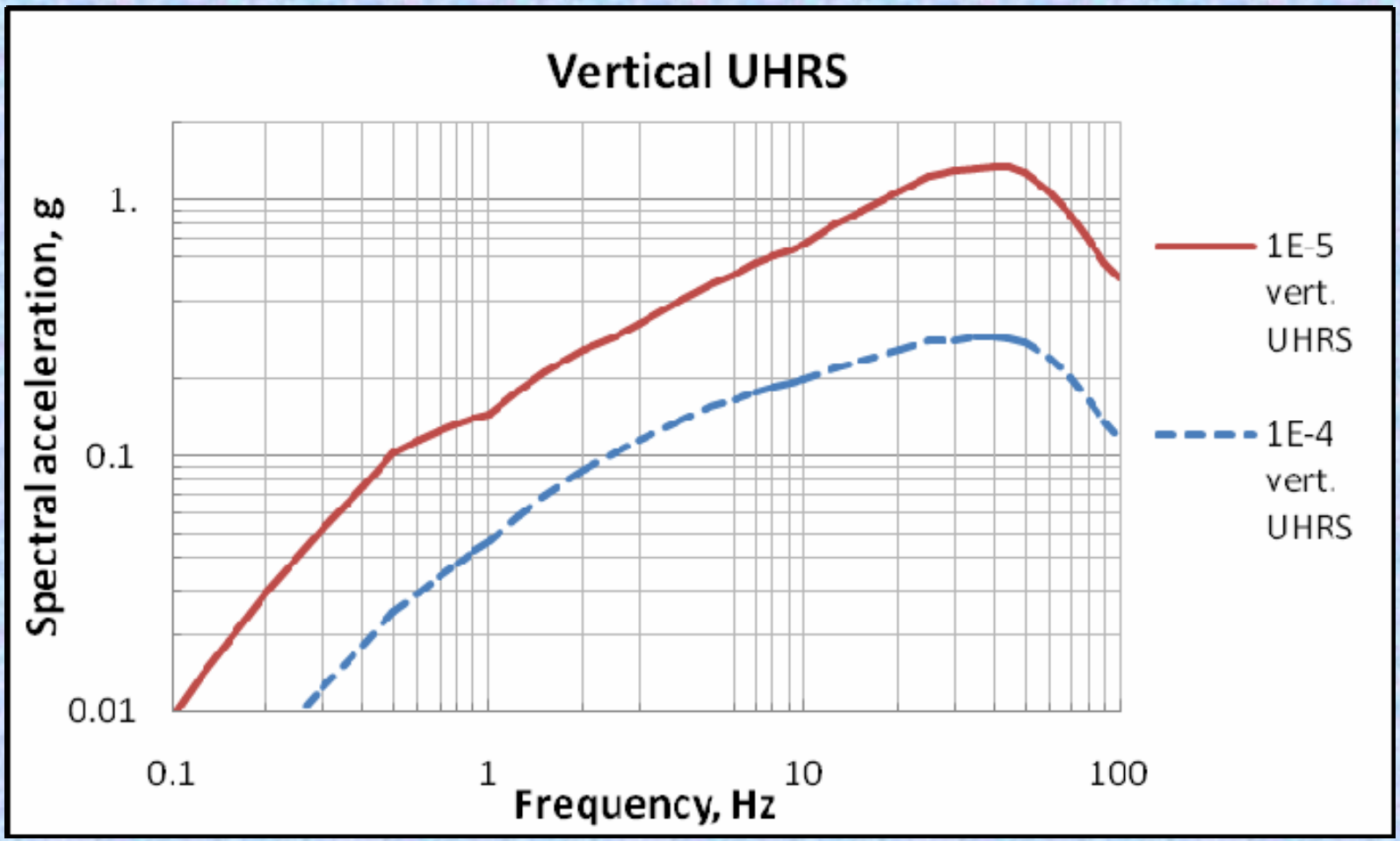
Smooth 10^{-5} UHRS for HF and LF earthquakes



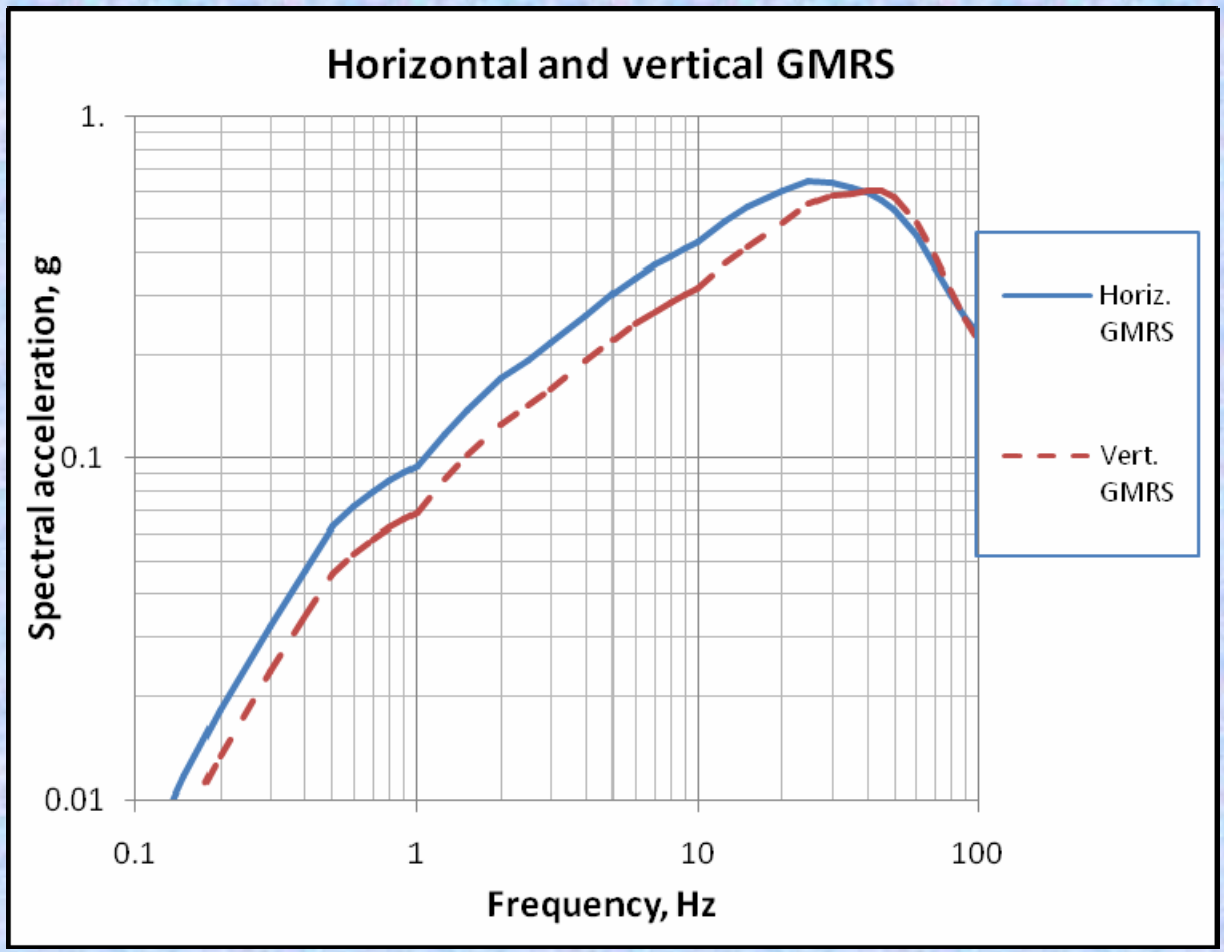
V/H ratios for hard rock sites for PGA<0.2g and for 0.2g≤PGA<0.5g



Vertical 10^{-4} and 10^{-5} UHRS



Horizontal and vertical GMRS



Comments

VCSNS UNIT 1 EXCAVATION SHEAR FRACTURES

- **Late 1973 - Unit 1 Excavations Removed Overburden Material to Competent Rock**
- **Dames & Moore Resident Geologist Identified Shear Fractures at Rock Surface**
- **Early 1974 - NRC Issued Stop-Work-Order**
- **SCE&G Mobilized Team of Regional Experts for Further Evaluations**

EXPERT REVIEW TEAM

- **Dr. Robert Butler – UNC**
- **Dr. Gil Bollinger – Virginia Tech**
- **Dr. Robert Carpenter – Georgia**
- **Dr. Villard Griffin – Clemson**
- **Dr. Jasper Stuckey – NC State**

Geological Investigation – Dames & Moore

GEOLOGICAL INVESTIGATION

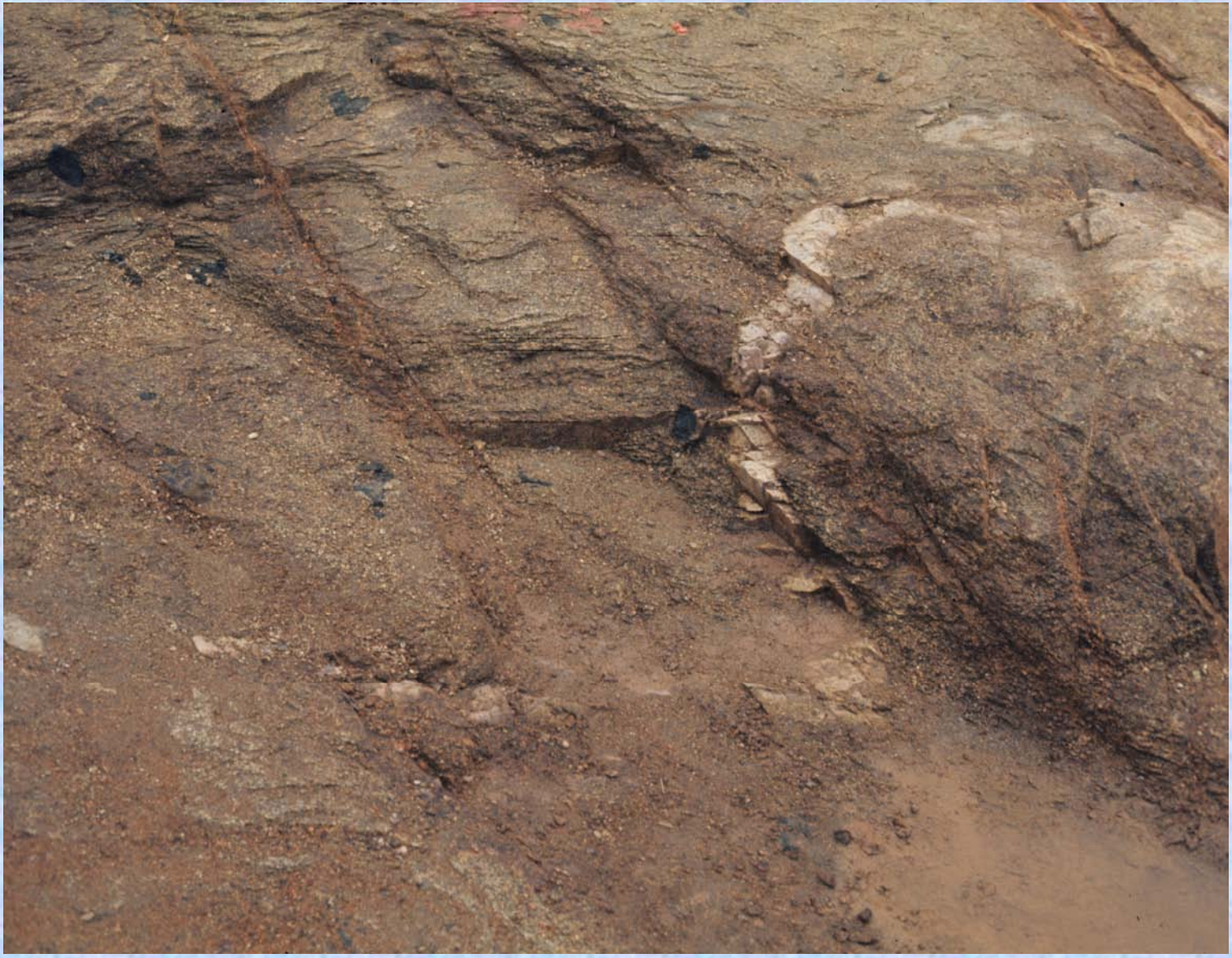
- **Detailed Geologic Mapping & Sampling**
- **Excavation of Trenches**
- **Drilling Inclined Boring**
- **Petrofabric & Structural Analysis**
- **Radiometric Age Dating**
- **X-Ray Defraction Analysis**

GEOLOGICAL INVESTIGATION

- **Literature Search (Tectonic Movement)**
- **Aerial Photo & ERTS-1 Imagery**
- **Gravity & Magnetic Data Analysis**
- **In-Place Stress Measurement**
- **Review of Local Microseismic Data**
- **Off-Site Geological Reconnaissance**

SHEAR FRACTURE DESCRIPTION

- **Near Vertical Shears – Oblique Slip (Left-Lateral) & Normal Displacement (South Side Down)**
- **General Orientation: Northeast / Southwest**
- **Maximum Net Displacement: ~ 7 Feet with Individual Shear Thickness - Fraction Inch to Less Than One Foot**
- **Shears did not Penetrate through the Soil Profile to the Ground Surface**
- **Shears Subjected to Hydrothermal Activity with Emplacement of Laumontite Crystals (Zeolite)**
- **Crystals not Deformed, Sheared or Strained**



UNIT 1 CONCLUSIONS

- **The Unit 1 Rock Structure Characteristics Considered Typical of Piedmont Conditions – With Similar Fractures Likely to be Found Anywhere in the Surrounding Region**
- **Documentation of Recent Tectonic Displacement (within 100 Miles of the Site) Does Not Exist**
- **Shear Orientation is Consistent with Regional Joint Pattern and Not Integral with Any Known Fault System**

UNIT 1 CONCLUSIONS

- **A Hydrothermal Event Occurred Subsequent to Termination of All Shear Movement with Emplacement of Zeolite Laumontite (which has not deformed)**
- **Age Dating Indicates that Movement Along the Shears could not have Occurred Later than 45 MYBP and Probably Inactive for 150-300 MYBP**
- **In-Situ Rock Stresses are Relatively Low with the Direction of Principal Stress in the Horizontal Plane ~ Normal to the Shear Plane**

UNITS 2 & 3 CONCLUSIONS

- **Consistent with the results of the Unit 1 investigation, we expect excavations for Units 2 & 3 will have similar shear fractures**
- **Current Geological Investigations have not Identified any New Data to Change our Current Interpretations**
- **Units 2 & 3 Excavation will be geologically mapped and results documented**
- **SAR Section 2.5.1 Concludes that the Shear Fractures are not Capable Tectonic Sources and do not Represent Ground Motion or Surface Rupture Hazards to the Site**

Comments

UNIT 1
RESERVOIR INDUCED SEISMICITY

- **1974-76 – Prior to Construction of Monticello Reservoir, Background Microseismic Activity ~ 1 Event Every 6 Days [Jenkinsville (JSC)]**
- **Mid-1977 – SCE&G Installed 4-Station Microseismic Network (Recommended by Dr. Gil Bollinger)**
- **December 1977 - March 1978 Monticello Reservoir Filled**
- **Late December 1977 – Microseismic Activity Dramatically Increases (Peaking at 800 Events During February 1978)**

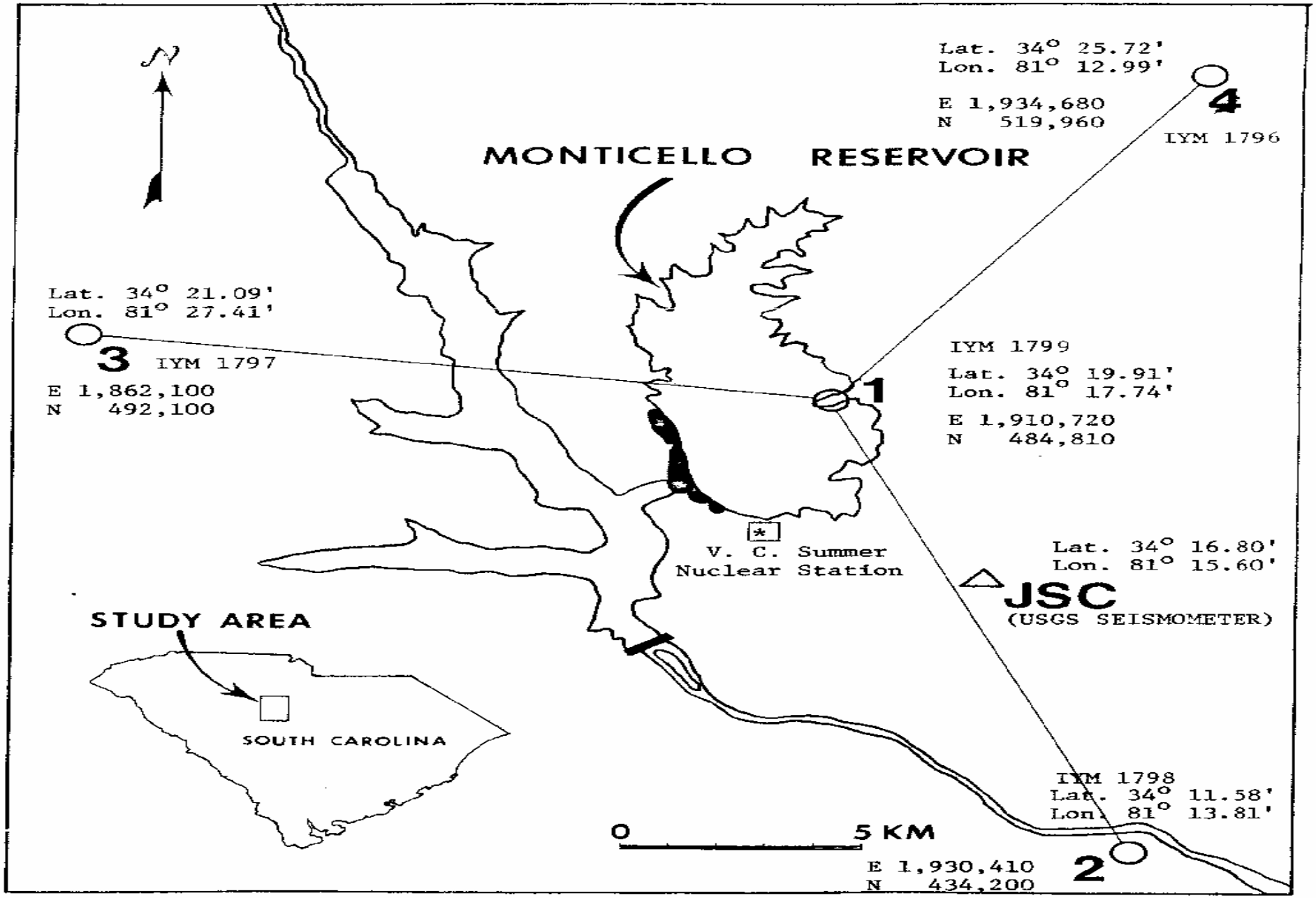
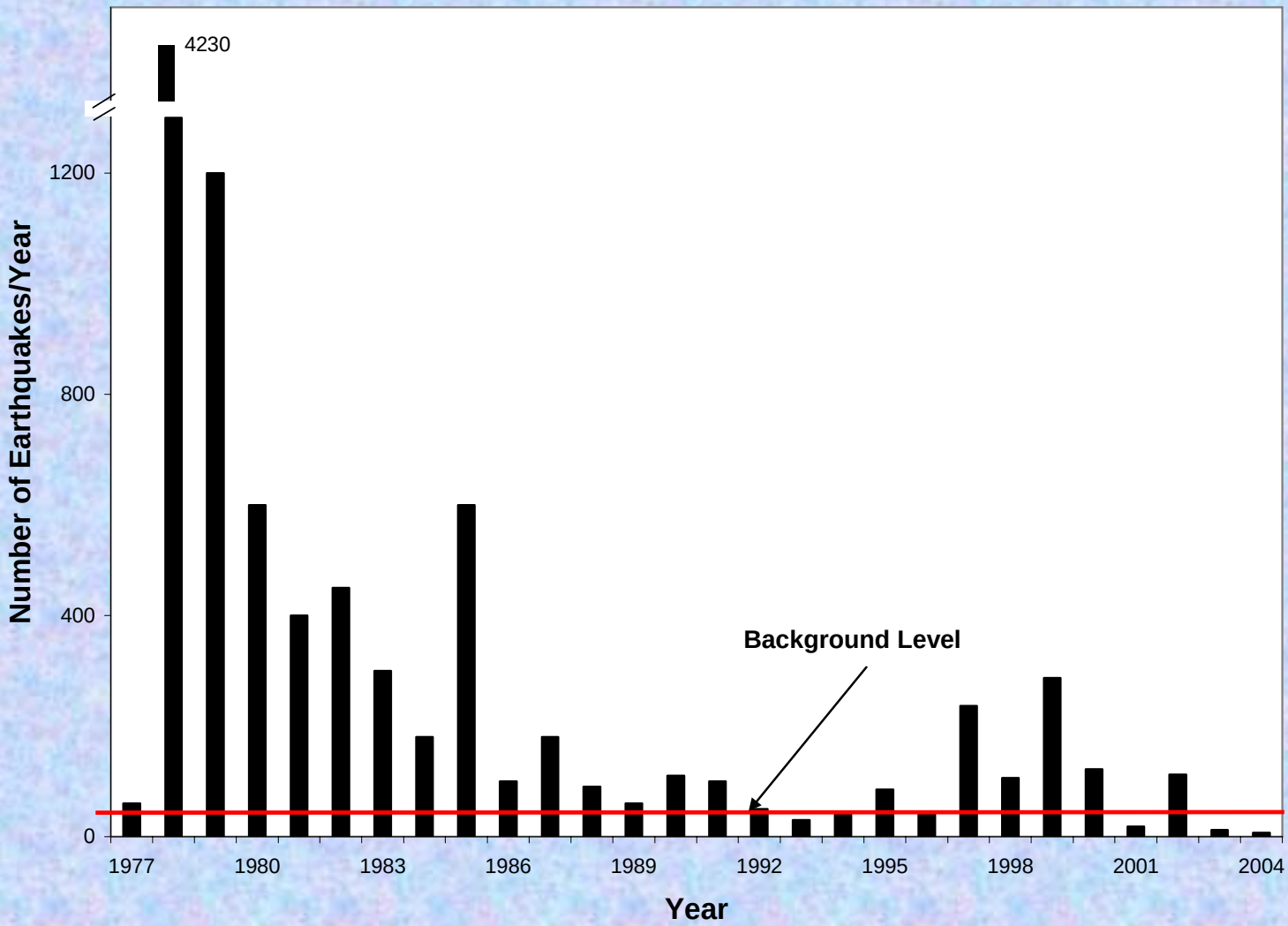


Figure 3
ORIGINAL LOCATIONS OF SCE&G 4-STATION MICROSEISMIC NETWORK

RIS Histogram

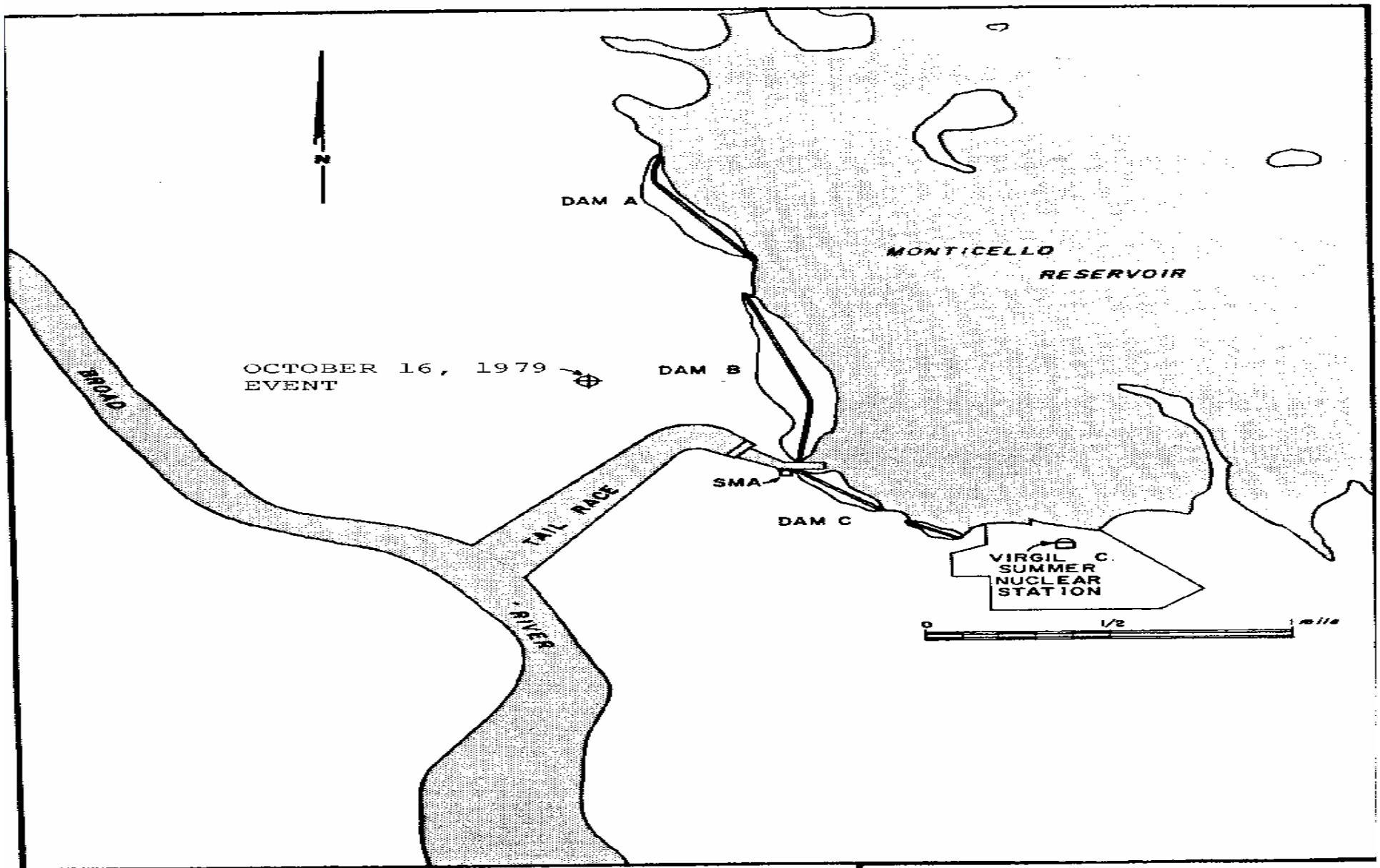


SEISMIC MONITORING PROGRAM

- **1974 – SC Network Seismometer at Jenkinsville (JSC) Installed Nearby (approximately 2.5 miles SE of Unit 1)**
- **1977 - SCE&G Microseismic Monitoring Network (4-Station) Installed, with Data Evaluated by Dr. Pradeep Talwani (USC)**
- **1995 – NRC Approved the SCE&G Request for Discontinuation of the Seismic Monitoring Network**
- **1996 – SCE&G Donates Network Instrumentation to USC (along with providing supplemental funding)**
- **2004 – USC Terminates Network Operation due to Equipment Age and Failures**
- **2007 – Jenkinsville Seismometer (JSC) Continues operation as part of the SC Seismic Network**

RESERVOIR INDUCED SEISMICITY

- **Early-1978 - USGS Installed a Strong Motion Accelerometer at a Free-Field Dam Abutment of Monticello Reservoir**
- **August 27, 1978 – M_L 2.8 – PGA: 0.25g**
- **October 16, 1979 – M_L 2.8 – PGA: 0.36g**



LEGEND:

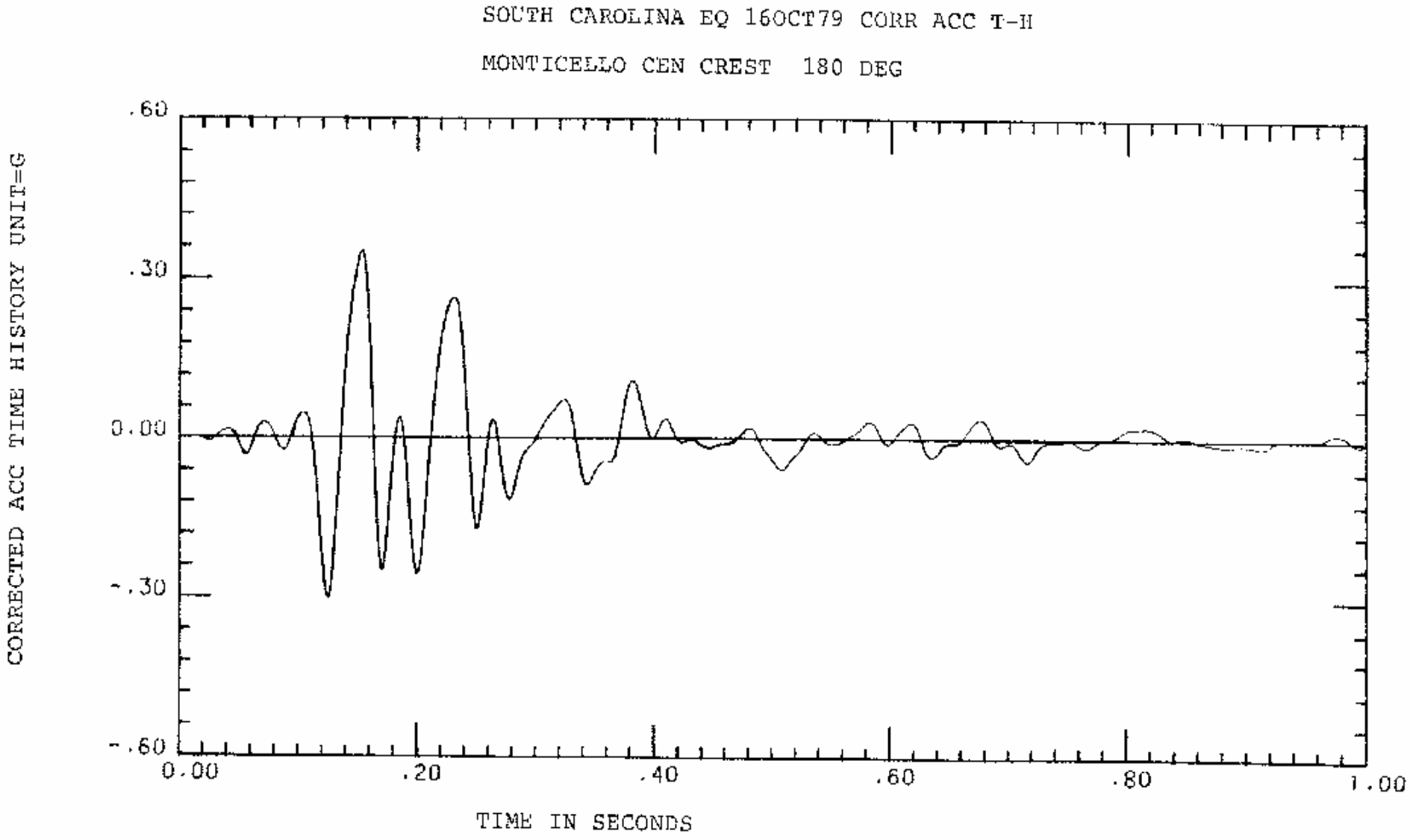
COMPUTED LOCATION OF EPICENTER OF 0.36g EVENT OF OCTOBER 16, 1979

SMA LOCATION OF STRONG MOTION ACCELEROGRAPH

South Carolina Electric & Gas Co.
Virgil C. Summer Nuclear Station

OCTOBER 16, 1979
EARTHQUAKE

Figure 9



TIME HISTORY OF CORRECTED 180° RECORD WITHOUT CLIPPING

Figure 10

UNITS 2 & 3 CONCLUSIONS

- **SAR Section 2.5.2 Documents RIS Associated with Monticello Reservoir**
- **Microseismic Activity has diminished to the Pre-Impoundment Background Rate with Occasional Spurts of Activity**
- **RIS does not Increase Ground Motion Hazards for the Site**

Comments

SEISMIC TECHNICAL ADVISORY GROUP REVIEW
VIRGIL C. SUMMER NUCLEAR STATION UNITS 2 & 3 COLA

PRESENTATION TO
NUCLEAR REGULATORY COMMISSION

October 3,2007

Seismic Technical Advisory Group (TAG)

Prof. Martin C. Chapman – Virginia Tech

Prof. C. Allin Cornell – Stanford University

Dr. Robert P. Kennedy – Consultant

Mr. Donald P. Moore – Southern Nuclear

Dr. J. Carl Stepp – Consultant

TAG Review Process

- Participatory Peer Review Process
- Coordination
  - Seismic generic issue resolution/updating of seismic regulatory guidance
  - AP1000 foundation interface issue resolution
  - Other COLA preparation activities

Participatory Peer Review

- **TAG review meetings**
  - **Four meetings at selected COLA preparation completion stages**
  - **Review draft technical results**
  - **Joint TAG meetings with parallel COLA preparation activities; AP1000 foundation interface issues**

Coordination

- **AP1000 Seismic Review Committee (APSRC) - SCE&G, Duke, Entergy, TVA**
  - **New Plant Seismic Issues Resolution Program - EPRI, NEI**
    - **Updating seismic regulatory guidance**
  - **AP1000 foundation interface issues - NuStart**
  - **COLA preparation joint TAG meetings**
    - **Bellefonte Nuclear Station (BNS)**
    - **William States Lee Nuclear Station (WSLNS)**
    - **Virgil C. Summer Nuclear Station (VCSNS)**
    - **Grand Gulf Nuclear Station (GGNS)**

Conclusions

- **Preparation of the VCSNS Units 2 & 3 COLA properly implemented state of practice methods and procedures in compliance with NRC's updated seismic regulatory guidance and interim staff guidance.**

- **Coordination with concurrent preparation of COLA for BNS, WSLNS, and GGNS and with Industry-NRC generic seismic issue resolution was particularly effective and productive.**

- **The TAG concurs with the results and conclusions presented in the Safety Analysis Report supporting the VCSNS Units 2 & 3 COLA and consider them to be appropriately and adequately supported by the data and analysis.**

- **These endorsements will be included in the TAG letter to accompany the COLA submittal.**