Progress Energy

Serial: NPD-NRC-2010-070 10CFR52.79
August 30, 2010

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

LEVY NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 081 RELATED TO VIBRATORY GROUND MOTION

Reference: Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated February 16, 2010, "Request for Additional Information Letter No. 081 Related to SRP Section 2.5.2 for the Levy County Nuclear Plant, Units 1 and 2 Combined License Application"

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits our response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in the referenced letter.

A response to the NRC request is addressed in the enclosure. The enclosure also identifies changes that will be made in a future revision of the Levy Nuclear Plant Units 1 and 2 application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (727) 820-4481.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on August 30, 2010.

Sincerely,

John Elnitsky
Vice President
New Generation Programs & Projects

Enclosure/Attachments

cc : U.S. NRC Region II, Regional Administrator
Mr. Brian C. Anderson, U.S. NRC Project Manager

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P.O. Box 14042
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NRO

Levy Nuclear Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 081 Related to SRP Section 2.5.2 for the Combined License Application, dated February 16, 2010

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.05.02-22	L-0697	Response enclosed – see following pages

NRC Letter No.: LNP-RAI-LTR-081

NRC Letter Date: February 16, 2010

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.05.02-22

Text of NRC RAI:

FSAR Subsections 2.5.2.2.2.5 and 2.5.2.4.1 state that you used the South Texas Project (STP) approach in updating the EPRI-SOG seismic source parameters for the Gulf Coast seismic zones. The STP 3 & 4 FSAR incorporated contributions from seismic sources in the Gulf of Mexico through an update of the seismicity catalog and the maximum magnitude probability distributions of Gulf of Mexico source zones for five of the six EPRI-SOG Earth Science Teams (ESTs) based on the occurrence of two moderate 2006 earthquakes (mb 5.5 and 6.1) in the Gulf of Mexico. The original probabilities and updates are shown in Levy FSAR Table 2.5.2-209.

In response to STP RAI 2.5.2-21 (ADAMS Accession No. ML092170354), the staff received details of the process that resulted in the updates to Mmax. That RAI response (ML092710096) describes the STP approach and states that the SSHAC TI team's original recommendation was for a Mmax distribution that ranged from magnitude (mb) 6.1 to 7.2 (6.1 [0.1], 6.6 [0.4], 6.9 [0.4], 7.2 [0.1]). The weighted average of this Mmax distribution is mb 6.73. However, the SSHAC peer review panel did not approve of this Mmax distribution on the bases that "the Mmax value used by the USGS was not developed through a formal SSHAC process, was not intended to capture the 'legitimate range of technically supportable interpretations among the entire informed technical community' (NUREG/CR-6372, page 6), and was primarily developed to reflect hazard associated with the short return periods of building codes." Instead the SSHAC peer review panel recommended that the individual Mmax distributions for five of the six ESTs Gulf source zones be updated. The weighted average of the updated Mmax values for the five ESTs is mb 6.14.

Concerning the adopted Mmax distributions for the Gulf of Mexico source zones, the staff requests the following:

1. Please provide details and the basis for updating Mmax for the EPRI ESTs Mmax distributions, as shown in FSAR Table 2.5.2-209. Include a description of the updated information that will be incorporated into the FSAR.
2. Provide justification for rejecting the USGS Mmax value (mb 7.2) as representing a legitimate end member of the informed technical community.
3. Provide justification for not adopting the original TI team's Mmax distribution. The TI team's original recommendation was for a Mmax distribution that ranged from magnitude (mb) 6.1 to 7.2, not solely a single value mb 7.2, on which the USGS 2002 National Hazard Map places a weight of 1.0. There is a significant difference between the two weights (0.1 for TI team versus 1.0 for USGS) for the Mmax value of mb 7.2.
4. The weighted average of the adopted Mmax distributions for the five ESTs that had updated values is just mb 6.14. This is about the same magnitude (mb 6.1) as the September 10, 2006 Gulf earthquake. Considering this result, provide justification for the modest updates to the Mmax values for five of the six ESTs Gulf Coast models.
5. In view of the two 2006 Gulf Coast earthquakes, describe how the limited Woodward Clyde Consultant's source model adequately characterizes the hazard for the Gulf.

PGN RAI ID #: L-0697

PGN Response to NRC RAI:

Item 1 Response:

FSAR Section 2.5.2.3 discusses the correlation of the earthquake activity, including the 2006 Gulf of Mexico earthquakes, with seismic sources. The first conclusion reached is stated in the following excerpt from Section 2.5.2.3 of the LNP FSAR Revision 1:

> *The updated earthquake catalog does not show a pattern of seismicity within the site region different from that exhibited by earthquakes in the EPRI-SOG catalog that would suggest a new seismic source, in addition to those included in the EPRI-SOG characterizations.*

Restated, the occurrence of the 2006 Gulf of Mexico earthquakes does not indicate a need to change the interpretation of the seismic sources developed by the six ESTs. It is concluded in FSAR Section 2.5.2.3 that the size of the two largest earthquakes requires that some revision be made to the maximum magnitude distributions for those seismic source zones that encompass the locations of the earthquakes. The magnitude distribution adjustments adopted are presented in FSAR Tables 2.5.2-202 through 2.5.2-207. These were developed for the STP 3 & 4 COLA by applying the methodology for maximum magnitude assessment used by each of the ESTs considering the size of the two largest events. This approach is appropriate because no new data had been identified that would change the ESTs' tectonic interpretation of these sources as large background source zones.

The STP 3 & 4 COLA application used an expected estimate of the body wave magnitude, Emb, for the size of the two earthquakes. For the February 10 earthquake, an Emb of 5.5 was used based on a conversion from the reported M_S value of 5.2 for this earthquake. For the September 10 earthquake, an Emb of 6.1 was used based on an average of three conversions from the reported moment magnitude of **M** 5.8.

The values of Emb used to update the maximum magnitude distributions for the GOM sources are slightly conservative compared to the reported magnitudes obtained from recent review of the US Geological Survey database. The updated FSAR Table 2.5.2-201, given at the end of this response, lists the revised values of M_S and **M** for GOM earthquakes obtained from the NEIC database (accessed in June, 2010). The NEIC database also contains reported m_b magnitudes for the December 12, 2000, February 10, 2006 and September 10, 2006 GOM earthquakes.

The EPRI-SOG methodology for developing Emb was to use the reported m_b value if one was available. If one was not available, then Emb was assessed from other size measures using magnitude conversion relationships. A more complete assessment of Emb would at least include the reported m_b values of 4.2 and 5.9, leading to average m_b values of 4.9 and 6.0, for the February 10 and September 10, 2006 earthquakes, respectively. As described below, use of Emb values of 4.9 and 6.0 for the February and September 10 earthquakes, respectively, would lead to some differences in the updated maximum magnitude distributions for the EST Gulf of Mexico seismic source zones that encompass these earthquakes. The distributions presented in FSAR Tables 2.5.2-202, 2.5.2-205, and 2.5.2-206 are slightly conservative with respect to those developed using Embs of 4.9 and 6.0. Given the minor differences, a change to the distributions used in the probabilistic seismic hazard analyses (PSHA) calculation is not warranted. However, the text of the FSAR will be updated to reflect the revised Emb values of 4.9 and of 6.0 for the February 10 and September 10 earthquakes, respectively.

The updated maximum-magnitude distributions were developed by applying the maximum magnitude methodology developed by each EST to that EST's sources that contained one or both of the 2006 earthquakes. The STP 3 & 4 COLA used an Emb of 6.1 for the September 10, 2006, earthquake based on conversions from the reported **M** 5.8. As discussed above, a better estimate that is more consistent with the EPRI-SOG methodology is one that includes the reported m_b for the earthquake, resulting in an Emb of 6.0. Use of this value would lead to small differences in the updated maximum-magnitude distributions. Specifically, the distribution for the Bechtel Team's source BZ1 would change from 6.11 (weight 0.1), 6.4 (weight 0.4), 6.6 (weight 0.5) to 6.0 (weight 0.1), 6.3 (weight (0.4), 6.6 (weight 0.5). The distribution for the Rondout Team's source 51 would change from 6.11 (weight 0.3), 6.3 (weight 0.55), 6.5 (weight 0.15) to 6.1 (weight (0.3), 6.3 (weight 0.55), 6.5 (weight 0.15). The largest change would be for Weston Geophysical's source 107. The distribution would change from 6.6 (weight 0.89), 7.2 (weight 0.11) to 6.0 (weight 0.76), 6.6 (weight 0.21), 7.2 (weight 0.03). The change is due to the truncation of Weston Geophysical's discrete maximum-magnitude distribution at 6.0 instead of 6.6 because 6.0 would be the largest Emb event in the source. Overall, the changes in the maximum magnitude distributions are small and the values listed in FSAR Table 2.5.2-209 are conservative compared to those developed using an Emb of 6.0 for the September 10, 2006, earthquake. Therefore, no change to the values listed in FSAR Table 2.5.2-209 that was used in the updated PSHA calculation for the LNP site is proposed.

The COLA changes that will be made as a result of the response to Item #1 of this RAI are given at the end of this RAI response. The changes reflect the updated evaluation of the Emb values for the GOM earthquakes.

Item 2 Response:

FSAR Section 2.5.2.4.1.2 describes the updated maximum magnitude distributions for the GOM seismic sources. These updated distributions are given in FSAR Table 2.5.2-209. As indicated in FSAR Table 2.5.2-209, an m_b 7.2 is included within the maximum magnitude distributions for some of the EST Gulf of Mexico seismic sources. Therefore, an m_b of 7.2 was not rejected in the updated PSHA conducted for the LNP site.

No COLA revision is required as a result of the response to Item #2 of this RAI.

Item 3 Response:

The basis for the STP TI's initial distribution (values and weights) was not clearly reported in STP's response to their RAI 02.05.02-21 (ADAMS Accession No. ML092710096), other than to indicate the reasons for selecting the lower and upper values. Subsequently, STP in their response to RAI 02.05.02-28, Supplement 1 (ADAMS Accession No. ML101650101), has indicated that the distribution was a preliminary distribution developed before completion of their evaluations. Therefore, the merits of that distribution compared to the one derived from the updated EST distributions cannot be evaluated. However, it should be pointed out that the composite maximum-magnitude distribution for the three EST seismic sources that encompass the September 10, 2006, earthquake has the same range as that of the STP TI team's initial evaluation. This distribution is derived by averaging the updated distributions for Bechtel's source BZ1, Rondout's source 51, and Weston's source 107. The resulting distribution is 6.11 (weight 0.133), 6.3 (weight 0.183), 6.4 (weight 0.133), 6.5 (weight 0.05), 6.6 (weight 0.464), and 7.2 weight (0.037). The two distributions cover the same range of m_b 6.1 to 7.2 and the mean of the composite distribution is equal to 6.5, which is slightly lower than the mean of the STP TI's distribution, 6.7.

A sensitivity analysis was conducted in which the maximum magnitude distributions for the three EPRI-SOG seismic sources that encompass the September 10 earthquake were replaced by the distribution quoted in the text of the RAI: 6.1 (weight 0.1), 6.6 (weight 0.4), 6.9 (weight 0.4), 7.2 (weight 0.1). Probabilistic seismic hazard calculations were performed to compute the total hazard for the site finished grade elevation with the use of cumulative absolute velocity (CAV) and the site amplification functions. RAI 02.05.02-22 Table 1 lists the resulting change in calculated values for the LNP site. The table lists the change in the performance based surface response spectrum (PBSRS) computed for the finished grade level. The differences in the PBSRS motions are less than the 21 percent increase in the site ground motions used for SSI analysis that was applied to meet the requirements of 10 CFR Part 50 Appendix S for a minimum peak ground acceleration at the reactor foundation level of 0.1g (as described in the response to RAI 03.07.01-01).

RAI 02.05.02-22 Table 1

Percent Change in the Levy Site PBSRS Resulting from Use of Maximum Magnitude Distribution of 6.1 (weight 0.1), 6.6 (weight (0.4), 6.9 (weight 0.4), 7.2 (weight 0.1) for Bechtel Source BZ1, Rondout Source 51, and Weston Source 107.

Spectral Frequency (Hz)	**Percent Change in PBSRS Spectral Acceleration**
0.5	+2
1.0	+4
2.5	+4
5.0	+6
10.0	+6
25.0	+7
100.0	+7

On the basis that the distribution used in the PSHA for the Levy site represents an appropriate update of the EST's interpretations of seismic sources and the fact that use of the modified distribution listed in the text of this RAI leads to smaller changes than the increase in SSI input needed to meet the 0.1g minimum peak acceleration requirement, no COLA revision is required as a result of the response to Item #3 of this RAI.

<u>Item 4 Response</u>:

The updates to the maximum magnitude distributions for the ESTs' Gulf Coast source zones are based on the assumption that the recent moderate-size earthquakes that occurred in the Gulf of Mexico in 2006 are tectonic and representative of the type of earthquake that may occur in the Gulf Coast source zones as defined by the ESTs.

There remains considerable uncertainty regarding the source mechanism for the February 10, 2006, event as well as a later event in April 2006. As noted in the following excerpt from Section 2.5.2.1.2.2 of the LNP FSAR Revision 1, the source characteristics of the February and April 2006 events in the Gulf of Mexico are best explained as gravity-driven displacements occurring on a low-angle detachment surface within the sedimentary wedge. (FSAR Reference 2.5.2-221)

> *In contrast to the 1978 and September 2006 earthquakes, the February 10 earthquake is notable for the unusual characteristics of the teleseismic waveforms it generated (Reference 2.5.2-221). In particular, the teleseismic seismograms are depleted in high-frequency energy, and are not fit well by traditional double-couple source models typical of tectonic faulting mechanisms. A moment-tensor source can be used to model*

the surface waves generated by the February 10, 2006, earthquake if the earthquake centroid is placed within a few miles of the earth's surface in a medium with a very low shear modulus. The seismograms are fit well by a single-force source (that is, a model of sliding on a shallow, sub-horizontal surface). The depth of the source for the February 10 event was likely less than 6 to 8 km (3.7 to 5 mi.)

The February 2006 Emb 5.5 event, therefore, may be nontectonic in origin and representative of a geologic setting that is not present throughout the Gulf Coast region. In particular, the geologic setting of the northern Gulf of Mexico in which the February and April 2006 events occurred differs from the geologic setting of the Florida platform that underlies the LNP site region. Ewing (FSAR Reference 2.5.1-252) differentiates the northwest progradational margin of the Gulf of Mexico (from northwest Mexico to Alabama) that includes the epicentral region of the February 10, 2006, earthquake from the eastern carbonate margin (Florida and Yucatan platforms) that includes the LNP site (FSAR Figure 2.5.1-208).

The coastal zone of the northwest progradational margin (south of the Early Cretaceous carbonate shelf margin (FSAR Figure 2.5.1-208), is characterized by major "growth-fault" (syndepositional normal fault) trends of Cenomanian through Quaternary age, and salt diapir provinces that represent Jurassic subbasins that contained thick salt, which was later mobilized into diapiric structures. Lateral (basinward) movement of salt, as salt tongues or sheets due to shelf-margin loading and progradation, obscures the effects of Jurassic basins in this region. The February 10 event location is located within the Texas-Louisiana slope diapir province as designated by Ewing (FSAR Reference 2.5.1-252) (RAI 02.05.02-22 Figure 1).

As noted in FSAR Section 2.5.2.1.2.2 with regard to the causative mechanism for the February 10, 2006, event,

Peel (Reference 2.5.2-230) observes that a likely welded area can be mapped close to GC344, and concludes that the most likely mechanism for the earthquake was movement on the base of the Sigsbee Salt, with faulting occurring where a suprasalt basin is grinding against the base salt weld. The probable seismic expression of this mechanism would be low-angle faulting at a depth of about 8 to 10 km (5 to 6 mi.) subsea.

Comparable geologic settings and conditions may be restricted to regions in the Gulf of Mexico such as the Texas-Louisiana slope, where salt withdrawal basins associated with thick carapaces of sediment overlie autochthonous and allochthonous salt bodies. Therefore, events similar to the February 10, 2006, event may not occur throughout the Gulf Coastal region.

The September 10 earthquake, which had a deep hypocenter (22 km [13.6 mi.] per USGS solution and 31.7 km [19.6 mi.] per Harvard solution [FSAR Reference 2.5.2-223]), is recognized as a typical tectonic event (FSAR Reference 2.5.2-226). This event is located in oceanic crust as designated by both Johnston et al. (FSAR Reference 2.5.2-245) (RAI 02.05.02-22 Figure 2) and Sawyer et al. (FSAR Reference 2.5.2-227) (RAI 02.05.02-22 Figure 3). Therefore, this event may not be typical of stable continental crust that underlies the coastal regions of the Gulf of Mexico.

In light of these observations, it is not clear that updates to the ESTs' source models that were implemented in the LNP FSAR were required in all cases. The assumptions that the February 10, 2006, earthquake is tectonic and that the September 10, 2006, earthquake should be used to characterize continental crust are conservative.

With regard to the comparisons of the means of maximum magnitude distributions, a more appropriate comparison would be to consider the mean maximum magnitude for those EST sources that encompass the location of the September 10, 2006, event. As discussed in the response to item 3 above, the mean of the composite distribution for the three EST sources that encompass this earthquake is 6.5, which is larger then the Emb 6.0 derived in this response or 6.1 reported in the STP 3&4 FSAR.

No COLA revision is required as a result of the response to Item #4 of this RAI.

Item 5 Response:

The Woodward-Clyde Consultants (WCC) source model included background zones specific to each site for which hazard was computed rather than attempting to subdivide the entire Central and Eastern United States (CEUS). For the LNP site, the Woodward-Clyde background zone (WCC-B36), which was originally created to represent the background source zone for the Crystal River site (located approximately 18 km (11 mi.) southwest of the LNP site, is used. The WCC-B36 zone, which is represented by a two-degree-by-two-degree latitude-longitude rectangle approximately centered on the LNP site, does not include either of the two moderate earthquakes that occurred within the Gulf of Mexico in 2006. Therefore, these earthquakes were not used to update the maximum magnitude probability distribution for the zone.

The WCC-B36 zone is not intended to represent the hazard for the entire Gulf of Mexico region. Rather, the Woodward-Clyde source model background zones are defined to characterize the seismicity occurring on unrecognized faults or seismic sources within a region around the site that could contribute significantly to the hazard at the site.

The response to this RAI addresses the following issues:

1. Whether the earthquakes in the Gulf of Mexico are occurring in a similar tectonic setting and type of crust to that of the WCC-B36 zone such that these earthquakes should be used to update the maximum magnitude distribution for the background zone.
2. Whether a zone that includes the earthquake epicenters in the Gulf of Mexico should be added to the WCC source model.

As shown on RAI 02.05.02-22 Figure 2, the July 1978, February 2006, and September 2006 events all occurred within oceanic crust, as designated by Johnston et al. (Reference 2.5.2-245). This contrasts with the stable continental region crust (consisting largely of slightly extended crust) underlying the LNP site and surrounding WCC-B36 zone. Comparison of the locations of the recent Gulf of Mexico earthquakes to crustal-type boundaries as mapped by Sawyer et al. (Reference 2.5.2-227) also indicates that the recent Gulf of Mexico events occurred in different crust than what underlies the WCC-B36 zone (RAI 02.05.02-22 Figure 3). Sawyer et al. (Reference 2.5.2-227) map a more limited area of oceanic crust that includes the September 2006 earthquake. They classify the crust in the vicinity of the more northerly earthquakes (July 1978 and February 2006) as transitional crust rather than oceanic. The crust within WCC-B36 is mapped by Sawyer et al. as thick transitional crust (See FSAR Figure 2.5.2-209 and RAI 02.05.02-22 Figure 3).

As described under the Response to Item 4 above, the April and February 2006 events are located in the Texas-Louisiana slope diapir province of the coastal zone, which is characterized by growth faults, salt evacuation basins, and salt diapirs. In contrast, no salt diapirs are mapped under the Florida platform to the east. Offshore salt diapirs extend into the DeSoto Canyon diapir province and may be present at the base of the Florida escarpment.(RAI 02.05.02-22 Figure 1). Cross sections showing interpretation of seismic profiles in the northeastern Gulf of Mexico by Wu et al. (Reference RAI 02.05.02-22 01) illustrate the change from undeformed flat-lying strata underlying the Florida platform to the thicker and more deformed strata and allochthonous salt in the northern Gulf of Mexico (RAI 02.05.02-22 Figures 4 and 5). As discussed in the FSAR Section 2.5.2.1.2.2, Angell and Hitchcock (Reference 2.5.2-231) and Peel (Reference 2.5.1-230) postulate that the February 2006 earthquake may be due to seismic rupture of a growth fault where salt has been evacuated, resulting in a sediment-sediment contact at the base of the growth fault. These conditions could allow for both stick-slip and creep modes of displacement on a single fault surface.

The Woodward-Clyde background zone is confined primarily to the Florida platform and does not extend into the region of the Gulf of Mexico that is characterized by the thicker sediments and salt-related diapirs and growth faults.

Given the different type of crust in which the earthquakes occurred relative to the LNP site region, the earthquakes that occurred out in oceanic or more highly extended crust are not considered typical of the earthquakes that may be expected to occur within the less extended continental crust underlying the site region.

The issue of the extent of the Woodward-Clyde background source for the LNP site was previously addressed in the response to RAI 02.05.02-16. In that response it was stated that seismicity in the Gulf of Mexico at large distances from the LNP site have little contribution to the site hazard. In the response to RAI 02.05.02-16, the hazard result contribution for the Rondout Associates team's Gulf Coast Source 51, which encompasses both 2006 earthquakes, was deaggregated to identify the contribution from earthquakes at distances greater than 300 km from the LNP site. It was found that the contribution from earthquakes occurring in this source at distances greater than 300 km from the site contributed less than one percent of the total hazard. These events include both onshore Gulf Coast seismicity as well as offshore seismicity. This analysis was repeated for the Weston Geophysics Gulf Coast Source 107, for which the maximum magnitude distribution was updated to account for the occurrence of the 2006 Gulf of Mexico earthquakes. It was again found that seismicity occurring within this source at distances greater than 300 km from the LNP site contribute less that one percent to the total site hazard. Therefore the fact that the Woodward-Clyde LNP background source does not extend further into the Gulf of Mexico does not have a significant impact on the assessment of the LNP site hazard.

No COLA revision is required as a result of the response to Item #5 of this RAI.

References:

RAI 02.05.02-22 01 Wu, S., A. W. Bally, and C. Cramez, "Allochthonous Salt, Structure and Stratigraphy of the Northeastern Gulf of Mexico. Part II: Structure," Marine and Petroleum Geology, v. 7, pp. 334-370, 1990.

Associated LNP COL Application Revisions:

The following changes will be made to the LNP FSAR in a future revision:

1. FSAR Section 2.5.2.1.1, sixth paragraph will be changed from:

"In addition to these events, earthquakes that occurred in the Gulf of Mexico at greater distance from the LNP site were considered. In all, there are 17 additional earthquakes of mb ≥ 3 recorded from 1963 to January 1, 2007; 11 events of magnitude 3 ≤ mb < 4; 3 events of magnitude 4 ≤ mb < 5; 2 events of magnitude 5 ≤ mb < 6; and only 1 event, with a magnitude exceeding mb 6 (mb 6.08), which occurred at nearly 500 km (310 mi.) from the LNP site. Estimates of the MMI and strong motion records are not available for these earthquakes."

To read:

"In addition to these events, earthquakes that occurred in the Gulf of Mexico at greater distance from the LNP site were considered. In all, there are 17 additional earthquakes of $m_b \geq 3$ recorded from 1963 to January 1, 2007; 11 events of magnitude $3 \leq m_b < 4$; 5 events of magnitude $4 \leq m_b < 5$; and 1 event of magnitude $5 \leq m_b \leq 6$, which occurred at nearly 500 km (310 mi.) from the LNP site. Estimates of the MMI and strong motion records are not available for these earthquakes."

2. FSAR Section 2.5.2.1.2.2, first paragraph will be changed from:

"Two earthquakes having body-wave magnitudes greater than 5 (mb 5) and a smaller event occurred in the northern Gulf of Mexico during 2006 (Figure 2.5.2-203). A summary of the reported magnitudes for these and earlier events and distances from the LNP site is provided in Table 2.5.2-201. An unusual M_s 5.2 earthquake occurred off the coast of Louisiana, approximately 240 km (384 mi.) south of New Orleans on February 10, 2006 (References 2.5.2-220 and 2.5.2-221). This earthquake was the largest to occur in the Gulf of Mexico since the earthquake magnitude (**M**) 5 event of July 24, 1978 (Reference 2.5.2-222), which represents the best-recorded earthquake in the region prior to the February 10, 2006, event (Reference 2.5.2-221). Two previous earthquakes in 1994 (mb 4.2, according to the National Earthquake Information Center [NEIC]) and 2000 (M_s 4.3; according to NEIC) also occurred in the same area (within an error of ~50 km) of the February 10, 2006, event (Figure 2.5.2-203). Following the February 2006 event, another unusual event with source characteristics similar to the February event occurred on April 18, 2006, less than 100 km (30 mi.) offshore of the tip of Louisiana's Birdfoot Delta. This earthquake, which was not detected or located by the USGS (NEIC) using traditional P-wave[e] arrivals, generated surface waves of an amplitude typical for a shallow event of approximately **M** 4.6 (Reference 2.5.2-220). A larger **M** 5.8 occurred on September 10, 2006, approximately 419 km (260 mi.) west-southwest from Clearwater, Florida, (Reference 2.5.2-223) in an abyssal plain environment. This earthquake, which was felt in parts of Florida, Georgia, Alabama, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas, as well as in the Bahamas and the Yucatan Peninsula, Mexico, did not generate a significant tsunami (References 2.5.2-223 and 2.5.2-224). Felt reports at Crystal River, Florida, were intensity IV (Reference 2.5.2-223)

To read:

"One earthquake having a body-wave magnitude of approximately 6 (mb 6) and two smaller events occurred in the northern Gulf of Mexico during 2006 (Figure 2.5.2-203). A summary of the reported magnitudes for these and earlier events and distances from the LNP site is provided in Table 2.5.2-201. An unusual m_b 4.2, M_S 5.3 earthquake occurred off the coast of Louisiana, approximately 240 km (384 mi.) south of New Orleans on February 10, 2006 (References 2.5.2-220 and 2.5.2-221). This earthquake was the largest to occur in the Gulf of Mexico since the earthquake magnitude (**M**) 5 event of July 24, 1978 (Reference 2.5.2-222), which represents the best-recorded earthquake in the region prior to the February 10, 2006, event (Reference 2.5.2-221). Two previous earthquakes in 1994 (m_b 4.2, according to the National Earthquake Information Center [NEIC]) and 2000 (m_b 4.2, M_S 4.3; according to NEIC) also occurred in the same area (within an error of ~50 km) of the February 10, 2006, event (Figure 2.5.2-203). Following the February 2006 event, another unusual event with source characteristics similar to the February event occurred on April 18, 2006, less than 100 km (30 mi.) offshore of the tip of Louisiana's Birdfoot Delta. This earthquake, which was not detected or located by the USGS (NEIC) using traditional P-wave[e] arrivals, generated surface waves of an amplitude typical for a shallow event of approximately **M** 4.6 (Reference 2.5.2-220). A larger **M** 5.8-5.9, m_b 5.9, earthquake occurred on September 10, 2006, approximately 419 km (260 mi.) west-southwest from Clearwater, Florida, (Reference 2.5.2-223) in an abyssal plain environment. This earthquake, which was felt in parts of Florida, Georgia, Alabama, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas, as well as in the Bahamas and the Yucatan Peninsula, Mexico, did not generate a significant tsunami (References 2.5.2-223 and 2.5.2-224). Felt reports at Crystal River, Florida, were intensity IV (Reference 2.5.2-223).

The earthquake size measure used in the EPRI-SOG seismic source characterization is expected body wave magnitude, Emb. The EPRI-SOG methodology for obtaining Emb was to use the reported m_b if available. If no m_b value was reported, then Emb was assessed using conversions from other size measures. As indicated in Table 2.5.2-201, the estimate of m_b based on conversion from M_S is 5.6. For the LNP site evaluation a conservative value of Emb 4.9 is used, which is obtained by averaging the converted M_s value with the reported m_b of 4.2 for the February 10 earthquake. The September 10, 2006, earthquake had a reported m_b of 5.9 and a reported moment magnitude of **M** 5.8 to 5.9. Conversion of the moment magnitude to body wave magnitude using the relationships presented in FSAR Section 2.5.2.4.2.3 yields an average estimated m_b of 6.1. For the LNP site evaluation a slightly conservative value of Emb 6.0 is used, which is obtained by averaging the reported m_b and the value converted from **M** 5.8-5.9. The STP 3 & 4 FSAR reports an Emb of 6.1 for the September 10 earthquake, which is based solely on conversions from **M** 5.8."

3. FSAR Section 2.5.2.1.2.2, fifth sentence in the seventh paragraph, will be changed from:

"Peel (Reference 2.5.2-230) observes that a likely welded area can be mapped close to GC344, and concludes that the most likely mechanism for the earthquake was movement on the base of the Sigsbee Salt, with faulting occurring where a suprasal basin is grinding against the base salt weld."

To read:

"Peel (Reference 2.5.2-230) observes that a likely welded area can be mapped close to GC344, and concludes that the most likely mechanism for the earthquake was movement on the base of the Sigsbee Salt, with faulting occurring where a suprasalt basin is grinding against the base salt weld."

4. FSAR Section 2.5.2.3, 6^{th} item in bullet list will be changed from:

- "The updated catalog includes two earthquakes that are larger in magnitude than some of the upper- and/or lower-bound values used by EPRI-SOG teams to characterize the Mmax distribution of source zones within which these earthquakes occurred. These earthquakes are the February 10, 2006, body-wave magnitude (mb) 5.54 earthquake, and the September 10, 2006, m_b 6.08 earthquake. These events require revisions to some of the ESTs' Mmax distributions for background source zones, as described in FSAR Subsection 2.5.2.4.1.2."

To read:

- "The updated catalog includes two earthquakes that are larger in magnitude than some of the upper- and/or lower-bound values used by EPRI-SOG teams to characterize the Mmax distribution of source zones within which these earthquakes occurred. These earthquakes are the February 10, 2006, surface-wave magnitude (M_S) 5.3, body wave magnitude (m_b) 4.2 earthquake (Emb 4.9), and the September 10, 2006, moment magnitude (**M**) 5.8-5.9, m_b 5.9 earthquake (Emb 6.0). These events require revisions to some of the ESTs' Mmax distributions for background source zones, as described in FSAR Subsection 2.5.2.4.1.2."

5. FSAR Section 2.5.2.3, 7th item in bullet list will be changed from:

   - "As discussed above in FSAR Subsection 2.5.2.1.2.2, the February 10, 2006, mb 5.54 earthquake, which does not exhibit typical source characteristics of a tectonic earthquake has been potentially associated with specific geologic structures near the edge of the continental shelf."

   To read:

   - "As discussed above in FSAR Subsection 2.5.2.1.2.2, the February 10, 2006, m_b 4.2, M_S 5.3 earthquake, which does not exhibit typical source characteristics of a tectonic earthquake, has been potentially associated with specific geologic structures near the edge of the continental shelf."

6. FSAR Section 2.5.2.3, 8th item in bullet list will be changed from:

   - "The September 10, 2006, mb 6.08 earthquake, which has a tectonic signature, has not been tied to any unique geologic structure. This event occurred near the transition between oceanic and thin transitional crust, in extended basement crust having northwest-trending normal faults that are favorably oriented for reactivation in the present tectonic regime (see discussion in FSAR Subsection 2.5.1.1.4.5)."

   To read:

   - "The September 10, 2006, m_b 5.9, **M** 5.8-5.9 earthquake, which has a tectonic signature, has not been tied to any unique geologic structure. This event occurred near the transition between oceanic and thin transitional crust, in extended basement crust having northwest-trending normal faults that are favorably oriented for reactivation in the present tectonic regime (see discussion in FSAR Subsection 2.5.1.1.4.5)."

7. FSAR Section 2.5.2.3, 9th item in bullet list will be changed from:

   - "The February 10, 2006, mb 5.54 earthquake has been proposed to be the result of a gravity-driven displacement on a shallow, low-angle detachment surface within or at the base of a thick sedimentary wedge (Reference 2.5.2-221), possibly related to a sediment-sediment contact (weld) at the base of a growth fault at the edge of the continental shelf (References 2.5.2-230 and 2.5.2-231). The smaller-magnitude April 18, 2006, earthquake that exhibits similar source characteristics is also attributed to similar gravity-driven processes. This event was neither detected nor located by the USGS (NEIC) and thus is not included in the updated earthquake catalog. This hypothesis suggests a potential association between seismicity in the Gulf of Mexico and normal growth faults at the edge of the continental shelf; however, no other events within the updated catalog have been attributed to such mechanisms. The edge of the continental shelf generally is encompassed by the various EST areal source zones for the Gulf of Mexico and environs, and as such, increases in Mmax to account for the February 10, 2006, Emb[f] 5.5 (mb 5.54 this study), as well as the September 10, 2006, Emb 6.1 (mb 6.08 this study) earthquake adequately account for any potential association between earthquakes within the Gulf of Mexico and normal faults along the edge of the continental shelf. (Reference 2.5.2-244)."

   To read:

   - "The February 10, 2006, m_b 4.2, M_S 5.3 earthquake has been proposed to be the result of a gravity-driven displacement on a shallow, low-angle detachment surface within or at the base of a thick sedimentary wedge (Reference 2.5.2-221), possibly related to a sediment-sediment contact (weld) at the base of a growth fault at the edge of the continental shelf (References 2.5.2-230 and 2.5.2-231). The smaller-magnitude April 18, 2006, earthquake that exhibits similar source characteristics is also attributed to similar gravity-driven processes. This event was neither detected nor located by the USGS (NEIC) and thus is not included in the updated earthquake catalog. This hypothesis suggests a potential association between seismicity in the Gulf of Mexico and normal growth faults at the edge of the continental shelf; however, no other events within the updated catalog have been attributed to such mechanisms. The edge of the continental shelf generally is encompassed by the various EST areal source zones for the Gulf of Mexico and environs, and as such, increases in Mmax to account for the February 10, 2006 earthquake, as well as the September 10, 2006, m_b 5.9, **M** 5.8-5.9 earthquake adequately account for any potential association between earthquakes within the Gulf of Mexico and normal faults along the edge of the continental shelf. (Reference 2.5.2-244)."

8. FSAR Section 2.5.2.4.1.2, second paragraph, will be changed from:

"The maximum magnitude distributions for some of the GCSZs were updated in the STP 3 & 4 COLA (Reference 2.5.2-244) based on the occurrence of two earthquakes that occurred after the development of the EPRI 1986 source model. These two earthquakes, the February 10, 2006, Emb 5.5 earthquake and the September 10, 2006, Emb 6.1 earthquake, are of greater magnitude than the lower-, and in some cases upper-bound, Mmax values of some of the GCSZs in which the earthquakes occur or to which the earthquakes are in very close proximity (e.g., Figure 2.5.2-205). The STP 3 & 4 COLA updated the maximum magnitude distribution for a particular GCSZ only when two conditions are met: (1) one or both of the 2006 moderate-magnitude earthquakes cannot be determined to have occurred outside the source zone with reasonable certainty, and (2) the observed Emb magnitude for the largest earthquake in the zone is greater than the minimum mb magnitude of the EPRI 1986 source model maximum magnitude distribution. These criteria resulted in updates to five of the six EST GCSZs maximum magnitude distributions (Table 2.5.2-209)."

To Read:

"The maximum magnitude distributions for some of the GCSZs were updated in the STP 3 & 4 COLA (Reference 2.5.2-244) based on the occurrence of two earthquakes that occurred after the development of the EPRI 1986 source model. The STP 3 & 4 COLA updated the maximum magnitude distribution for a particular GCSZ only when two conditions are met: (1) one or both of the 2006 moderate-magnitude earthquakes cannot be determined to have occurred outside the source zone with reasonable certainty, and (2) the observed Emb magnitude for the largest earthquake in the zone is greater than the minimum m_b magnitude of the EPRI 1986 source model maximum magnitude distribution. These criteria resulted in updates to five of the six EST GCSZs maximum magnitude distributions (Table 2.5.2-209).

The updated maximum magnitude distributions were developed by applying the maximum magnitude methodology developed by each EST to that EST's sources that contained one or both of the 2006 earthquakes. The STP 3 & 4 COLA used an Emb of 5.5 for the February 10, 2006 earthquake based on conversion from the reported M_S magnitude and an Emb of 6.1 for the September 10, 2006, earthquake based on conversions from the reported moment magnitude. As discussed in FSAR Section 2.5.2.1.2.2 and indicated in Table 2.5.2-201, the reported m_b values for these two earthquakes are 4.2 and 5.9, respectively. Inclusion of the reported m_b values in the assessment of Emb results in values of 4.9 and 6.0 for the February 10 and September 10 earthquakes, respectively (Table 2.5.2-201). Use of these values to update the maximum magnitude distributions for the GCSZ would lead to small differences in the updated maximum magnitude distributions. Overall, the changes in the maximum magnitude distributions would be small and the values listed in Table 2.5.2-209 are slightly conservative compared to those that would be developed using Emb values of 4.9 and 6.0 for the February 10, 2006 and September 10, 2006, earthquakes, respectively. Therefore, the values listed in Table 2.5.2-209 were used in the updated PSHA calculation for the LNP site.

The maximum magnitude distributions for several other source zones were modified to account for the occurrence of another Emb 5.0 earthquake not associated with the GOM within their boundaries. These sources are Dames & Moore source 52 (Table 2.5.2-203), Law Engineering sources 107 and 108 (Table 2.5.2-204), Rondout source 49 (Table 2.5.2-205), and Woodward-Clyde Consultants source B38 (Table 2.5.2-207)."

9. The following figures will be revised to change the magnitudes for the February 10, 2006 and September 10, 2006, earthquake from m_b 5.5 and 6.1 to m_b 4.9 and 6.0 and to revise the legends to read "Emb" instead of "Final mb":

   2.5.1-232

   2.5.2-201

   2.5.2-202

   2.5.2-203

   2.5.2-204

   2.5.2-205

   2.5.2-206

   2.5.2-207

   2.5.2-208

   2.5.2-209

   2.5.2-210

10. FSAR Table 2.5.2-201 will be revised from:

Table 2.5.2-201
Parameters of Recent Gulf of Mexico Earthquakes

Date	Source	Original Magnitude	Type	Converted m_b	Distance to LNP Site	Comment
1994/6/30	NEIC	4.2	m_b	--	752 km (467 mi.)	
2000/12/9	NEIC	4.3	M_s	5.05	748 km (465 mi.)	
2006/2/10	ANSS	5.2	M_s	5.54	758 km (471 mi.)	
	NEIC	5.2	M_s			
2006/4/18		~4.6	**M**	NA	558 km (347 mi.)	Reported by Nettles (Reference 2.5.2-220; Reference 2.5.2-221). Not detected or located by USGS (NEIC). Therefore not included in the updated earthquake catalog. Moment magnitude estimated from surface wave recordings.
2006/9/10	ANSS	5.8	**M**	6.08	498 km (310 mi.)	
	NEIC	5.9	m_b			

Notes:

km = kilometer

mi. = mile

M = moment magnitude

m_b = body-wave magnitude

M_S = surface-wave magnitude

To Read:

Table 2.5.2-201
Parameters of Recent Gulf of Mexico Earthquakes

Date	Source	Reported Magnitude	Type	Converted m_b	Emb	Distance to LNP Site	Comment
1994/06/30	NEIC	4.2	m_b	--	4.2	752 km (467 mi.)	
2000/12/09	NEIC	4.3	M_S	5.0	4.6*	748 km (465 mi.)	
		4.2	m_b	--			
2006/02/10	NEIC	5.3	M_S	5.6	4.9*	757 km (470 mi.)	
		4.2	m_b	--			
2006/04/18		~ 4.6	**M**	NA	NA		Reported by Nettles (Reference 2.5.2-220; Reference 2.5.2-221). Not detected or located by USGS (NEIC). Therefore not included in the updated earthquake catalog. Moment magnitude estimated from surface wave recordings.
2006/09/10	NEIC	5.9	m_b	--		498 km (310 mi.)	
		5.9	**M**	6.1	6.0*		
		5.8	**M**				

Notes:
km = kilometer
mi. = mile
M = moment magnitude
m_b = body-wave magnitude
M_S = surface-wave magnitude
* Represents average of reported m_b and converted m_b magnitudes

Attachments:

1. RAI 02.05.02-22 Figure 1 [1 page]
2. RAI 02.05.02-22 Figure 2 [1 page]
3. RAI 02.05.02-22 Figure 3 [1 page]
4. RAI 02.05.02-22 Figure 4 [1 page]
5. RAI 02.05.02-22 Figure 5 [1 page]
6. Revised Figure 2.5.1-232 [1 page]
7. Revised Figure 2.5.2-201 [1 page]

8. Revised Figure 2.5.2-202 [1 page]
9. Revised Figure 2.5.2-203 [1 page]
10. Revised Figure 2.5.2-204 [1 page]
11. Revised Figure 2.5.2-205 [1 page]
12. Revised Figure 2.5.2-206 [1 page]
13. Revised Figure 2.5.2-207 [1 page]
14. Revised Figure 2.5.2-208 [1 page]
15. Revised Figure 2.5.2-209 [1 page]
16. Revised Figure 2.5.2-210 [1 page]

LNP COL 2.5-2

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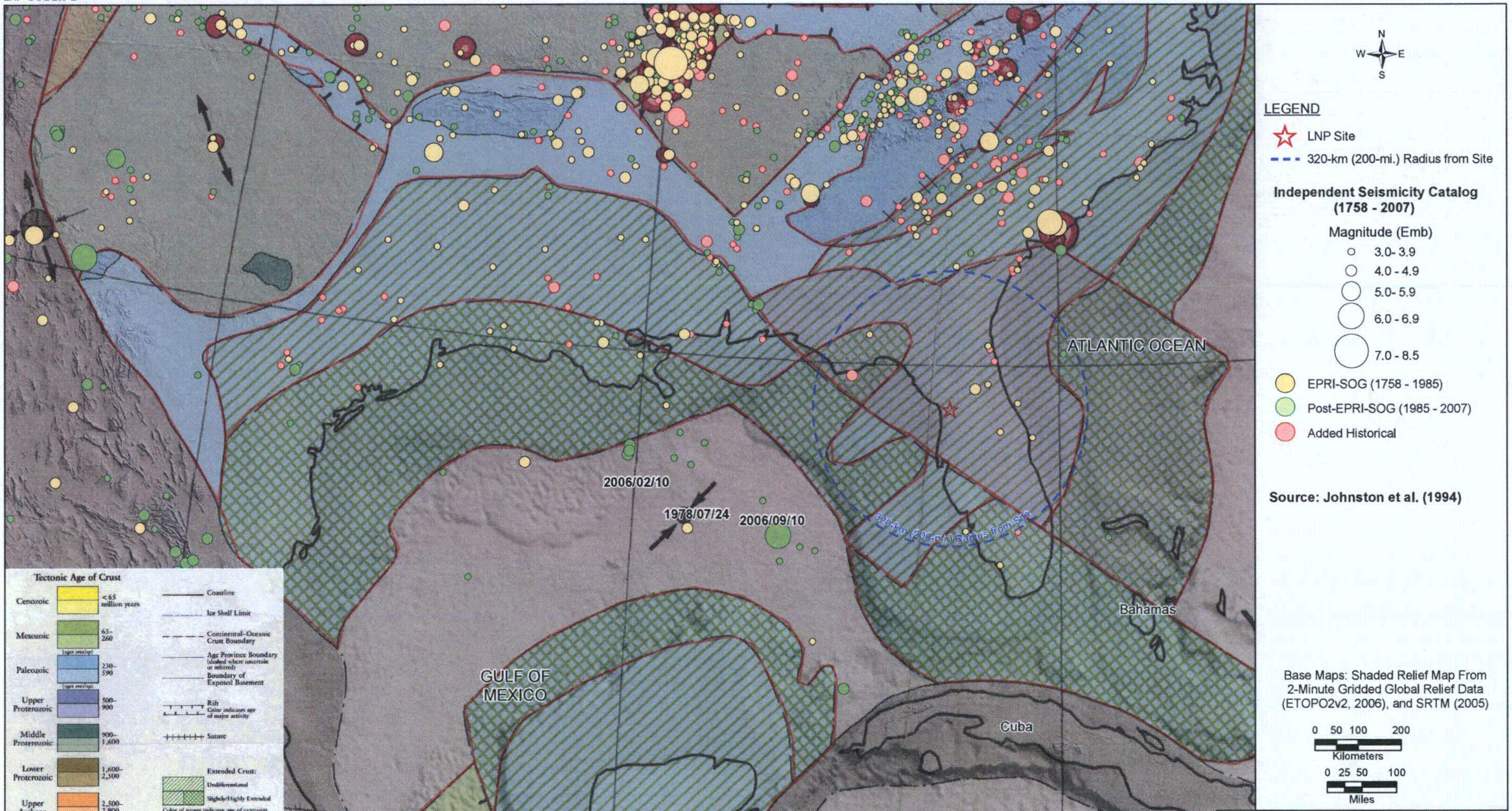
Salt Diapir Provinces of Northwestern Progradational Margin

RAI 02.05.02-22 FIGURE 1



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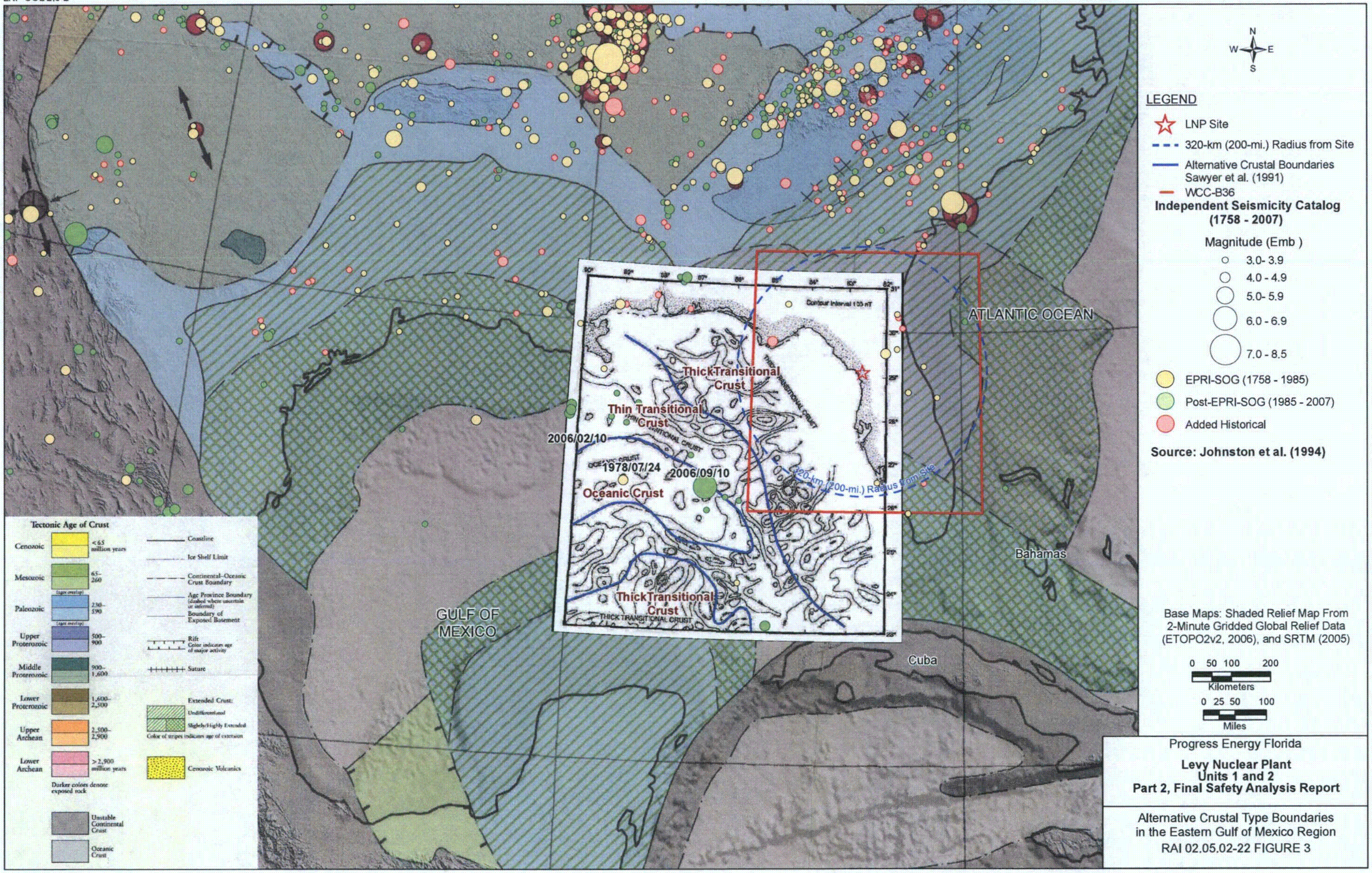
Types of SCR Crust in the Gulf of Mexico Region
RAI 02.05.02-22 FIGURE 2

LNP COL 2.5-2



LEGEND
LNP Site
320-km (200-mi.) Radius from Site
Alternative Crustal Boundaries Sawyer et al. (1991)
WCC-B36
Independent Seismicity Catalog (1758 - 2007)
Magnitude (Emb)
3.0- 3.9
4.0 - 4.9
5.0- 5.9
6.0 - 6.9
7.0 - 8.5
EPRI-SOG (1758 - 1985)
Post-EPRI-SOG (1985 - 2007)
Added Historical
Source: Johnston et al. (1994)
ATLANTIC OCEAN
GULF OF MEXICO
Bahamas
Cuba
Thick Transitional Crust
Thin Transitional Crust
Oceanic Crust
Thick Transitional Crust
2006/02/10
1978/07/24
2006/09/10
320-km (200-mi.) Radius from Site
Tectonic Age of Crust
Cenozoic
Mesozoic
Paleozoic
Upper Proterozoic
Middle Proterozoic
Lower Proterozoic
Upper Archean
Lower Archean
Coastline
Ice Shelf Limit
Rift
Suture
Extended Crust:
Cenozoic Volcanics
Unstable Continental Crust
Oceanic Crust
Base Maps: Shaded Relief Map From 2-Minute Gridded Global Relief Data (ETOPO2v2, 2006), and SRTM (2005)
0 50 100 200
Kilometers
0 25 50 100
Miles
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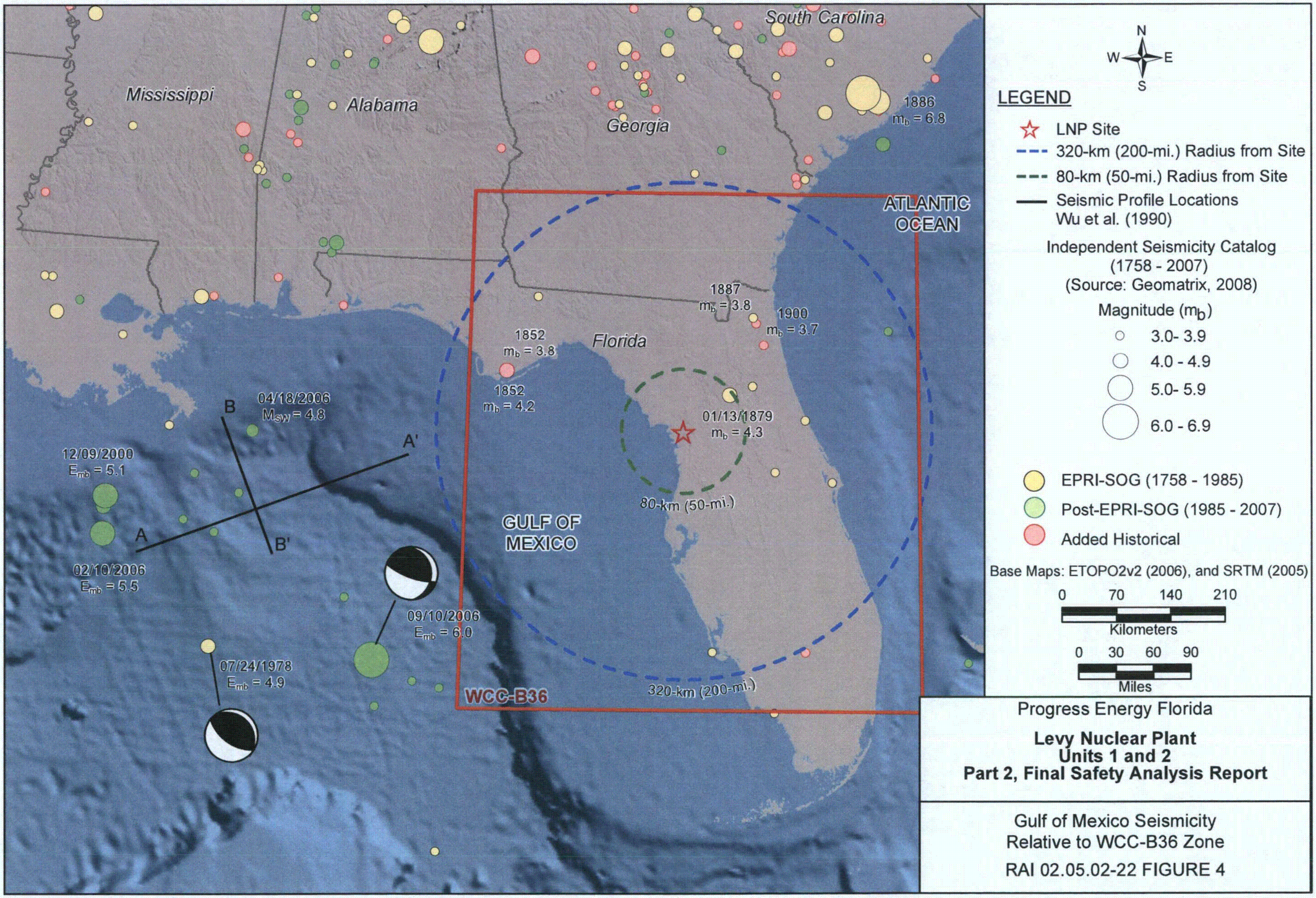
Alternative Crustal Type Boundaries in the Eastern Gulf of Mexico Region
RAI 02.05.02-22 FIGURE 3



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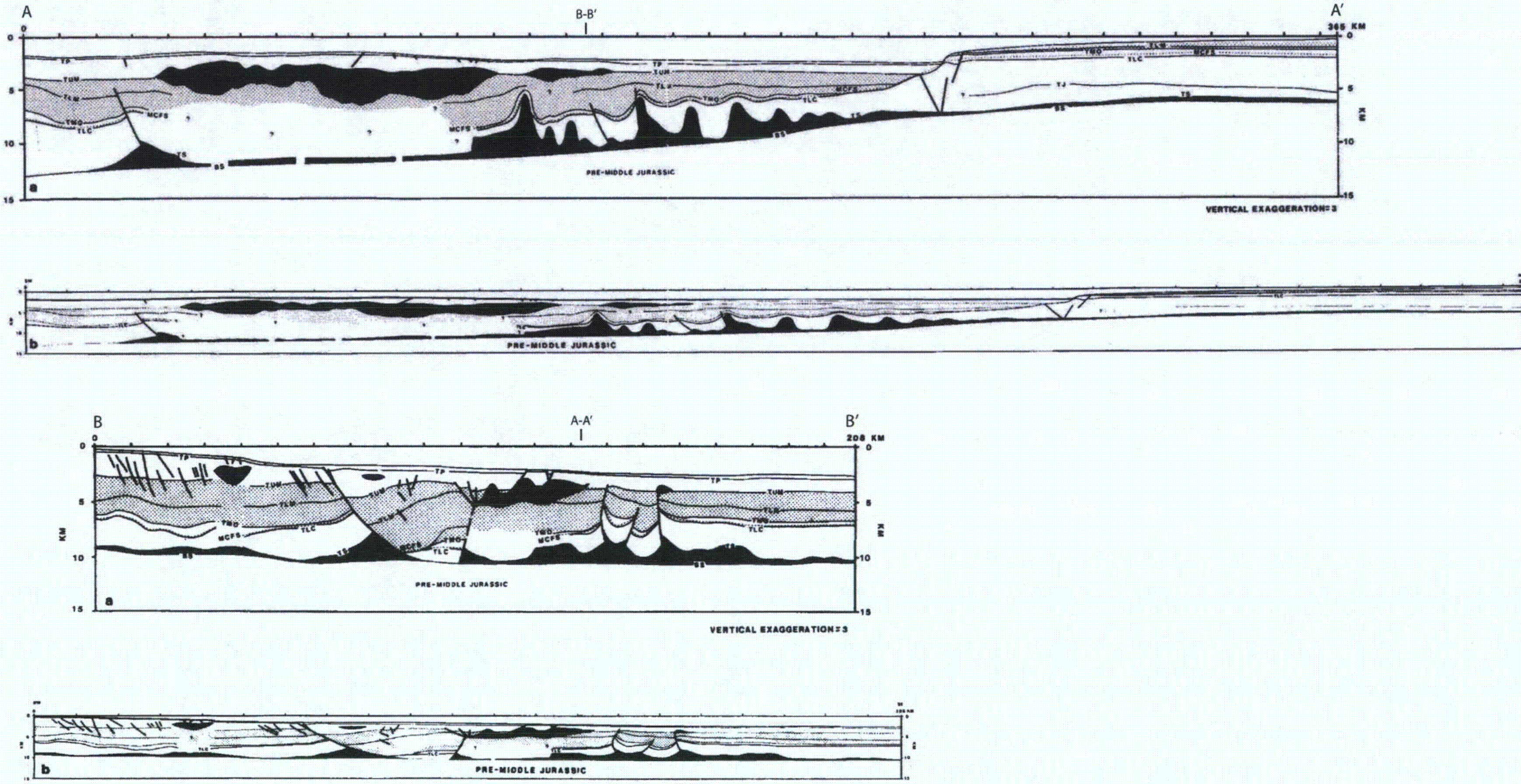
Gulf of Mexico Seismicity
Relative to WCC-B36 Zone

RAI 02.05.02-22 FIGURE 4



Source: Wu et. al. (1990)

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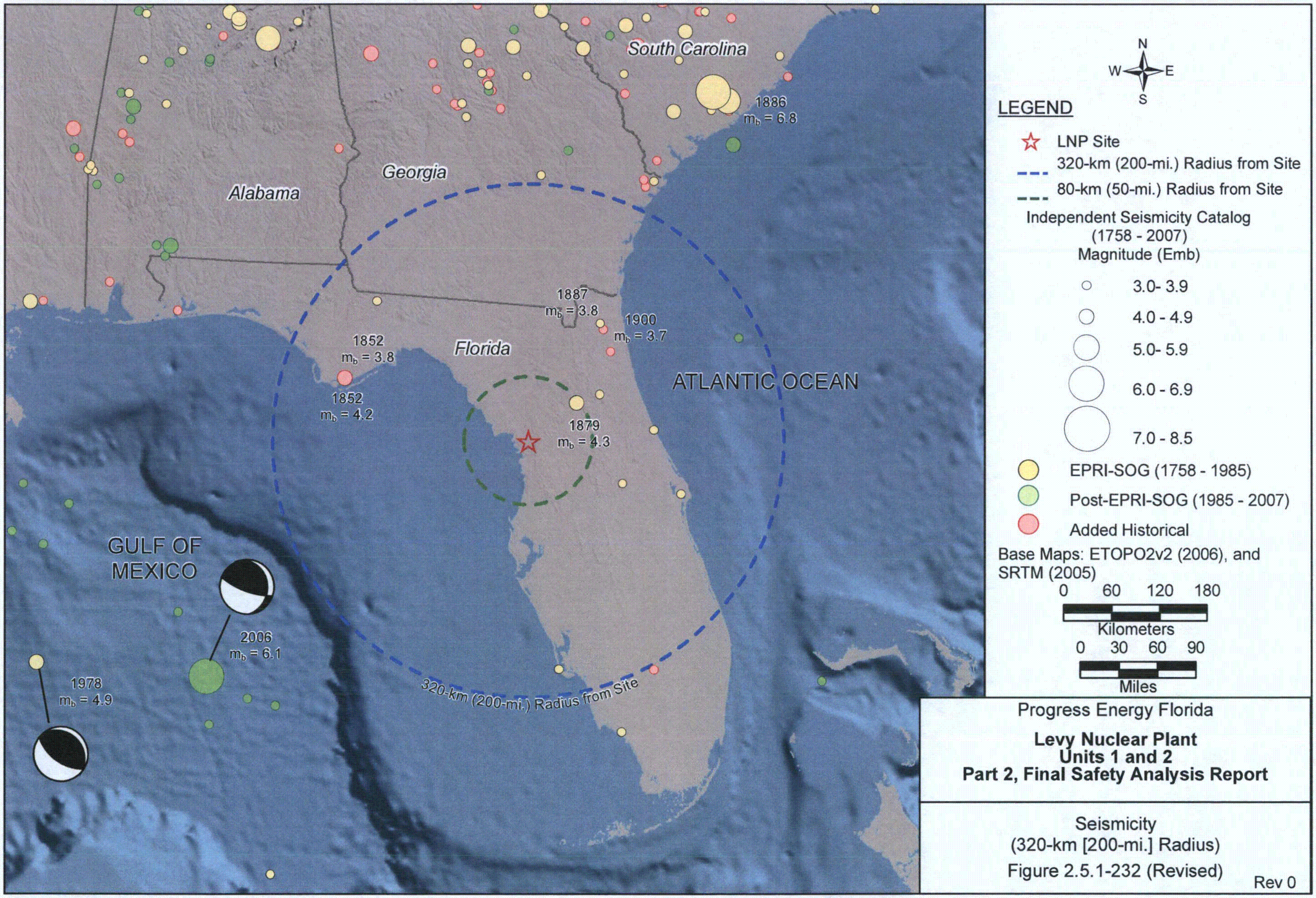
Interpretation of Seismic Profiles
A-A' and B-B'

RAI 02.05.02-22 Figure 05



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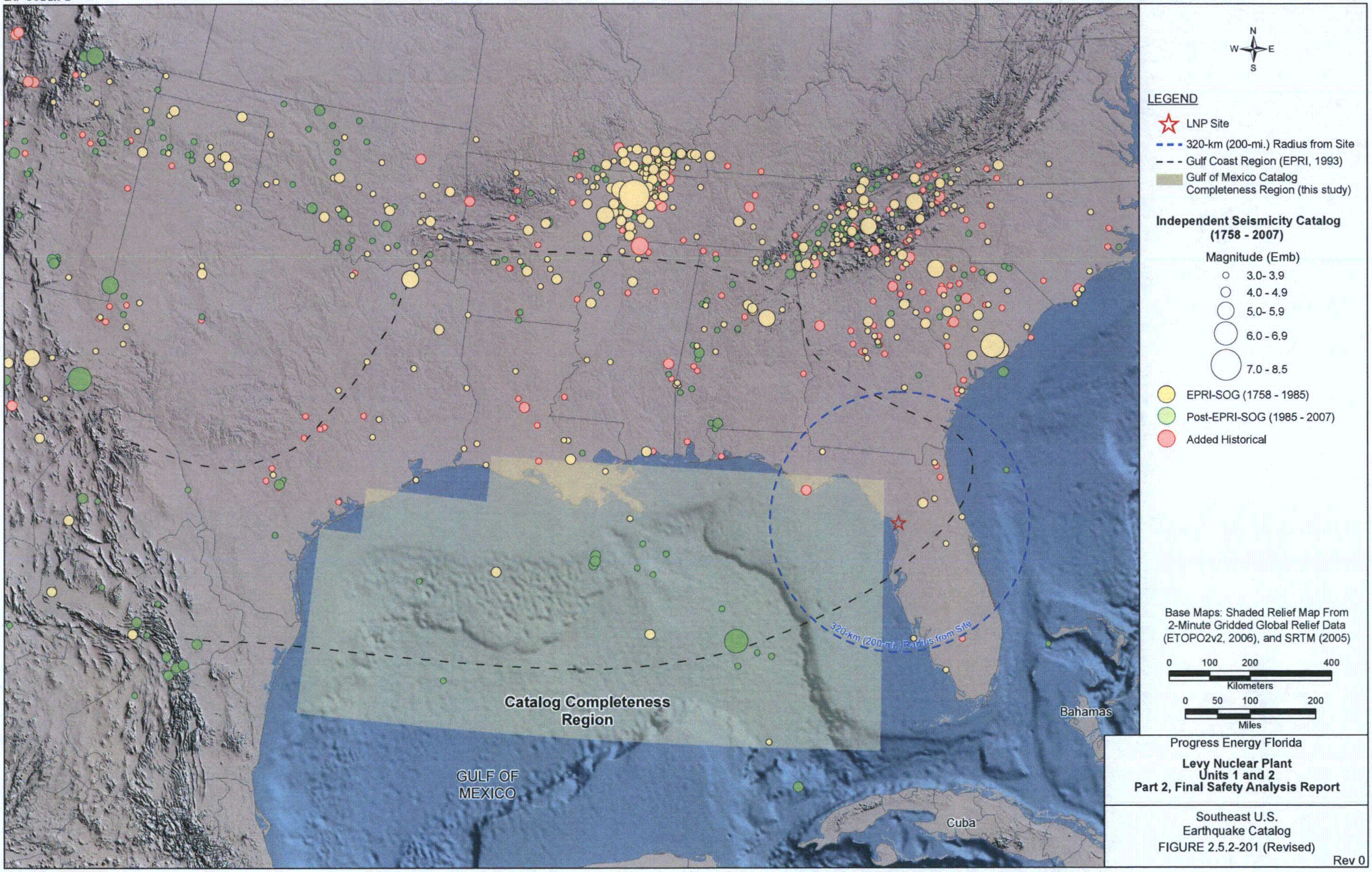
Seismicity
(320-km [200-mi.] Radius)
Figure 2.5.1-232 (Revised)

Rev 0

LNP COL 2.5-2



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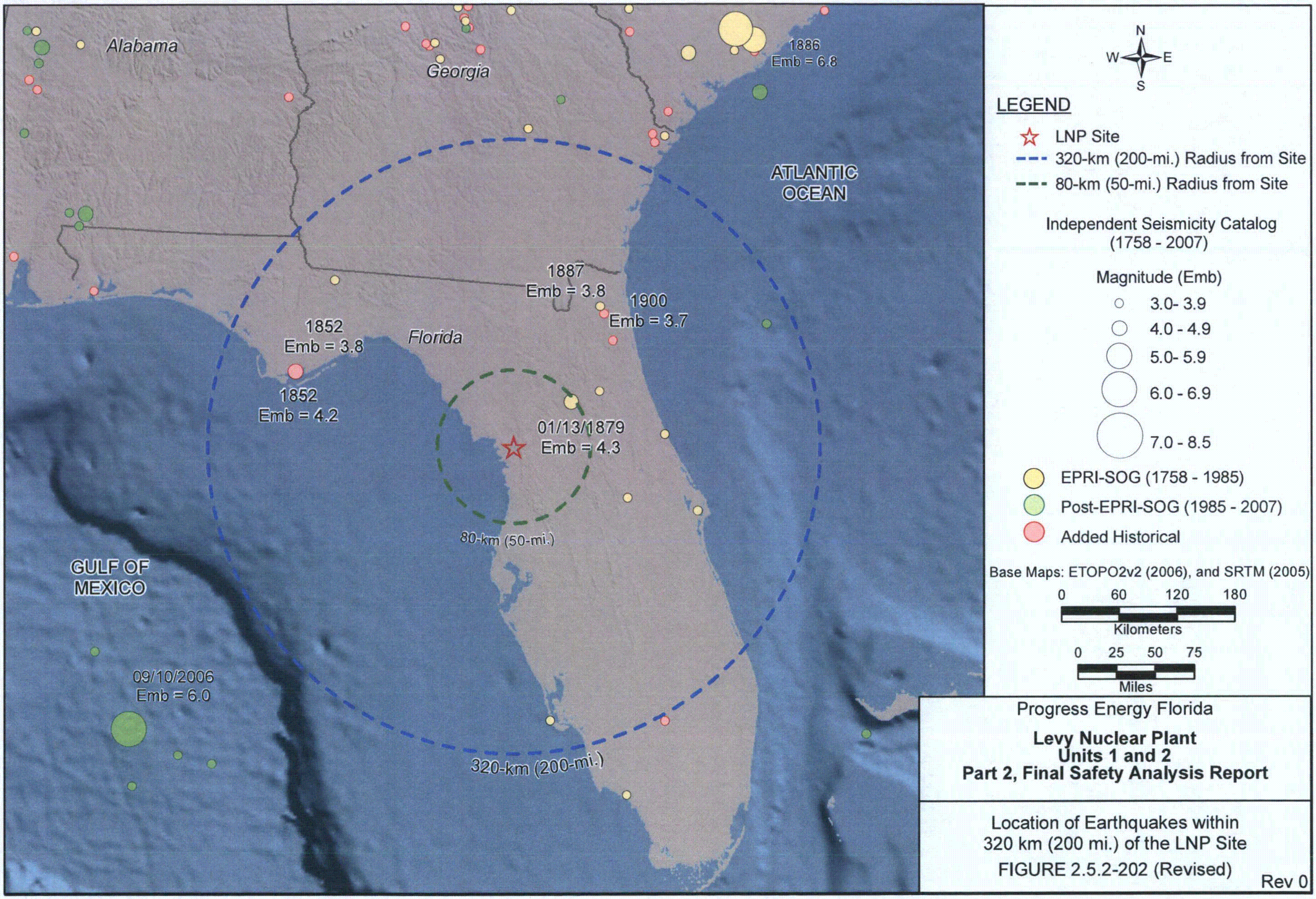
Southeast U.S. Earthquake Catalog
FIGURE 2.5.2-201 (Revised)

Rev 0

LNP COL 2.5-2



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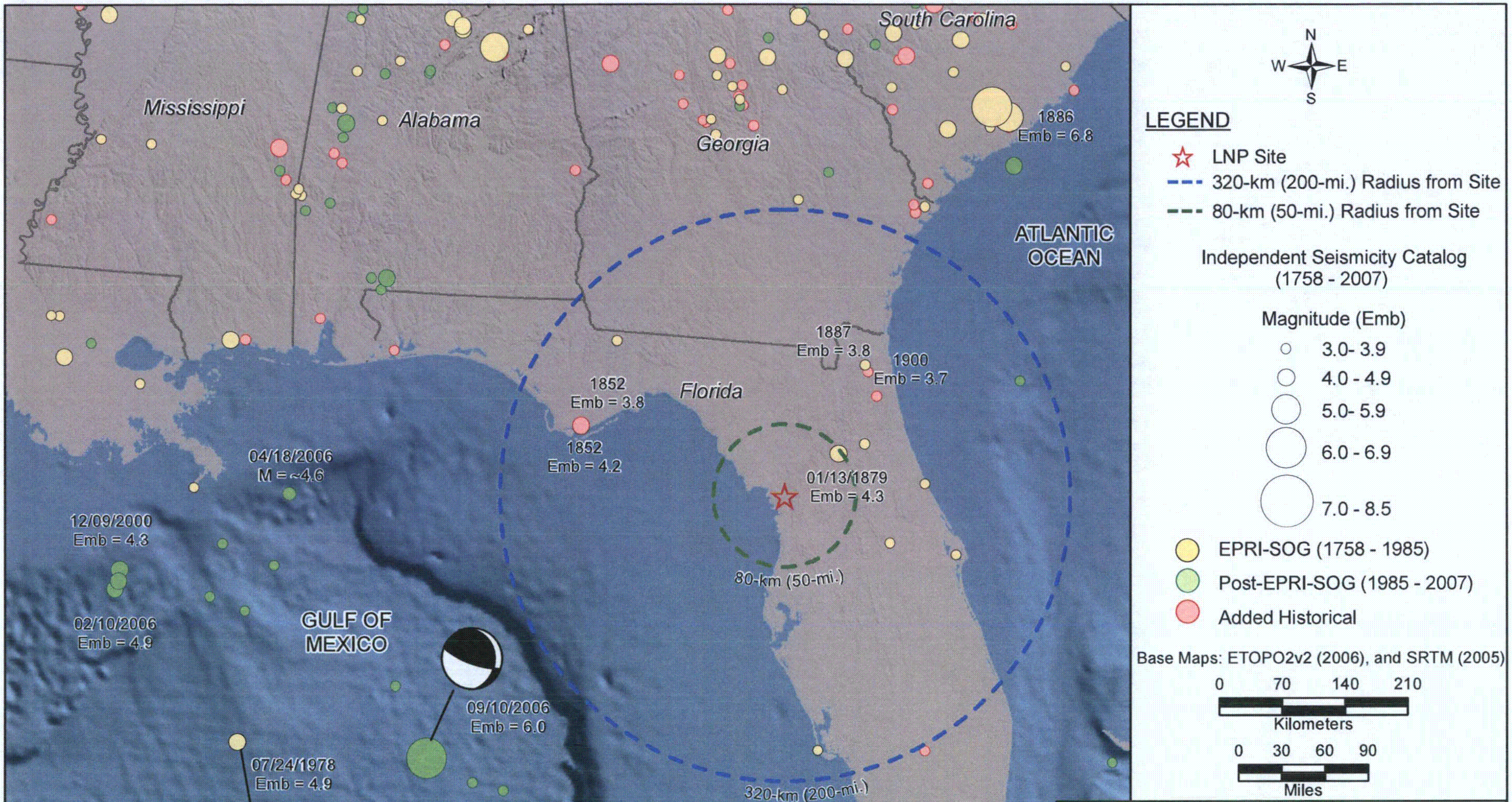
Location of Earthquakes within
320 km (200 mi.) of the LNP Site
FIGURE 2.5.2-202 (Revised)

Rev 0



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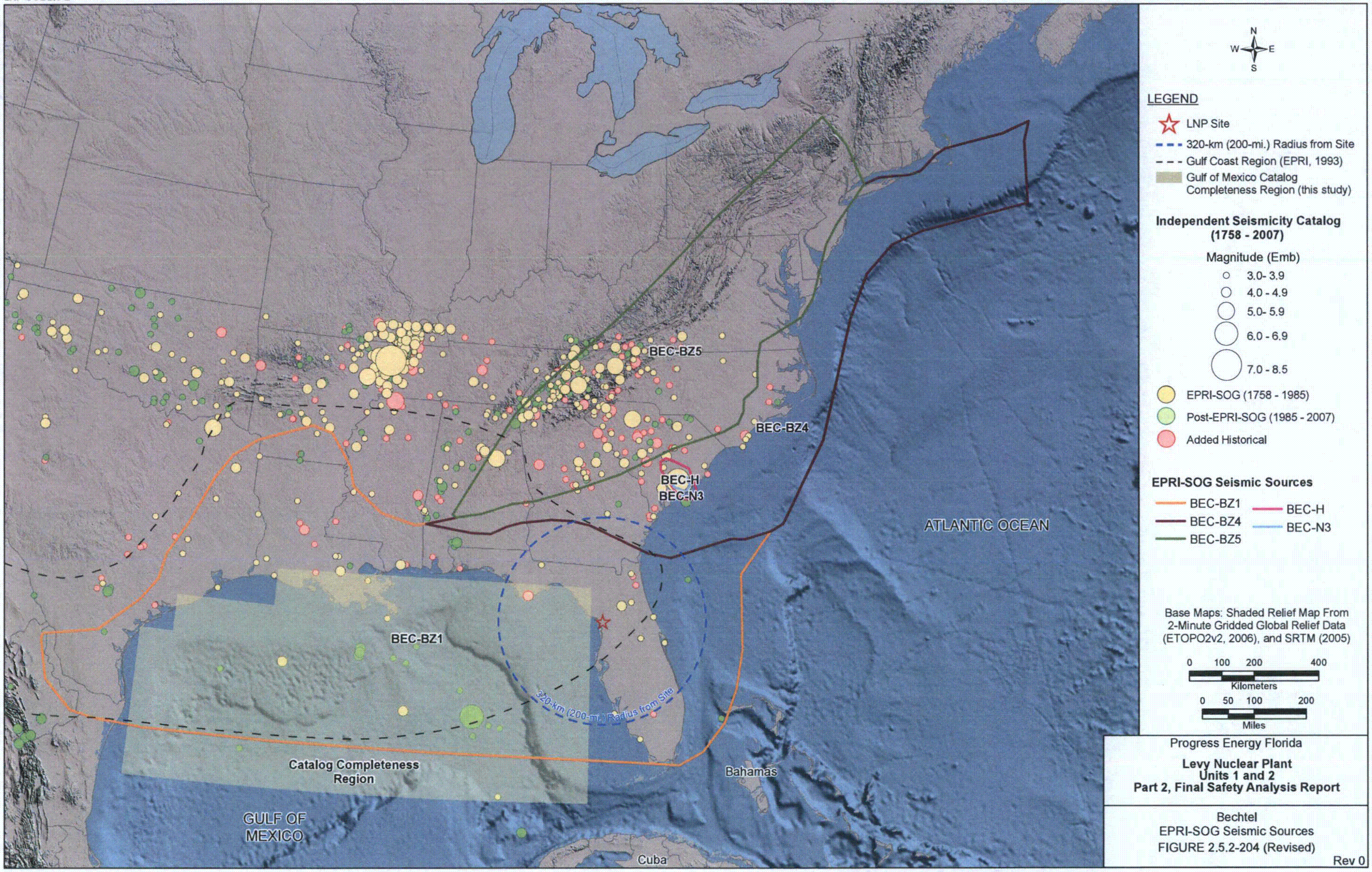
Gulf of Mexico Seismicity

FIGURE 2.5.2-203 (Revised)

Rev 0



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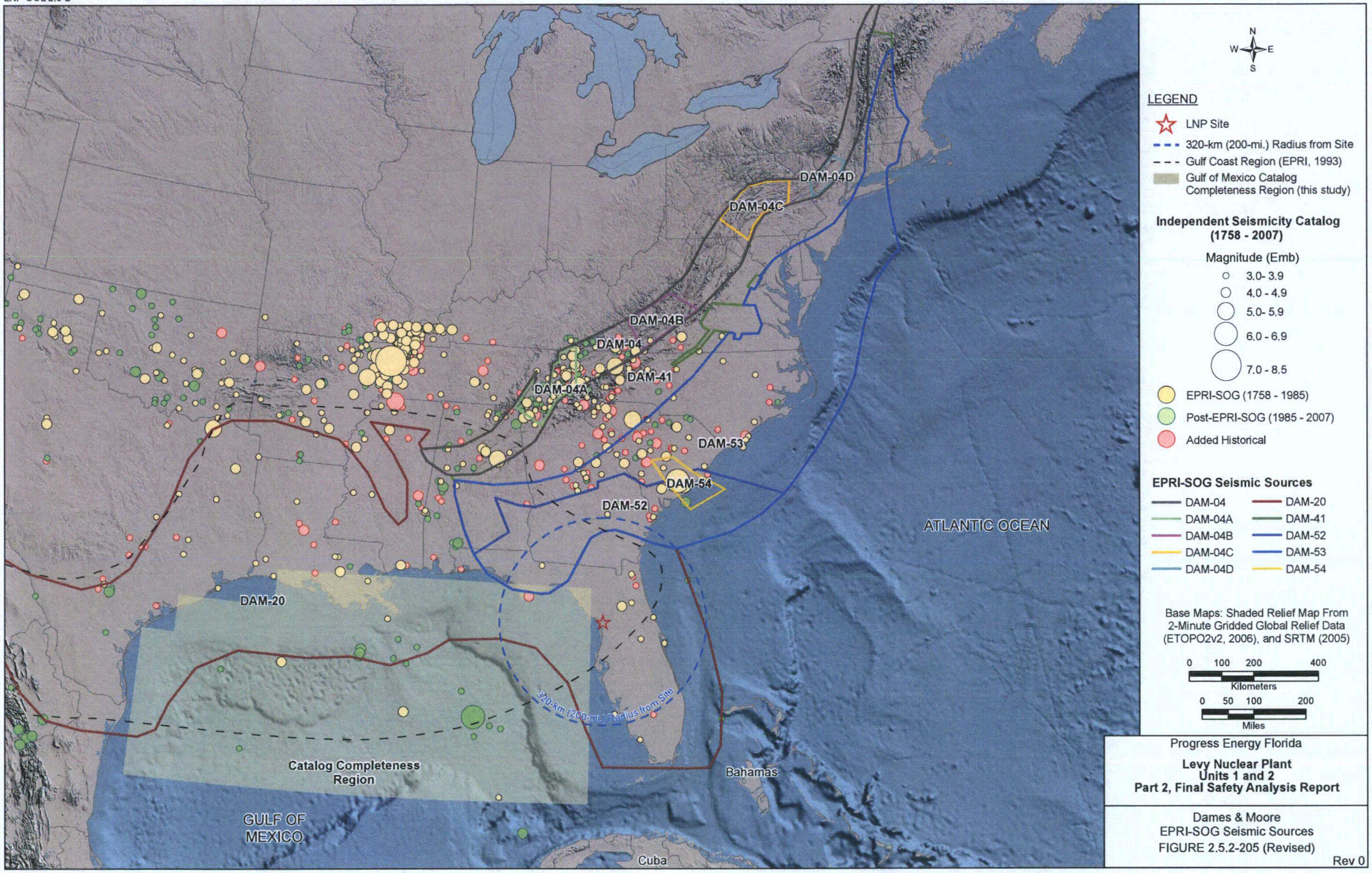
Bechtel

EPRI-SOG Seismic Sources

FIGURE 2.5.2-204 (Revised)

Rev 0

LNP COL 2.5-2



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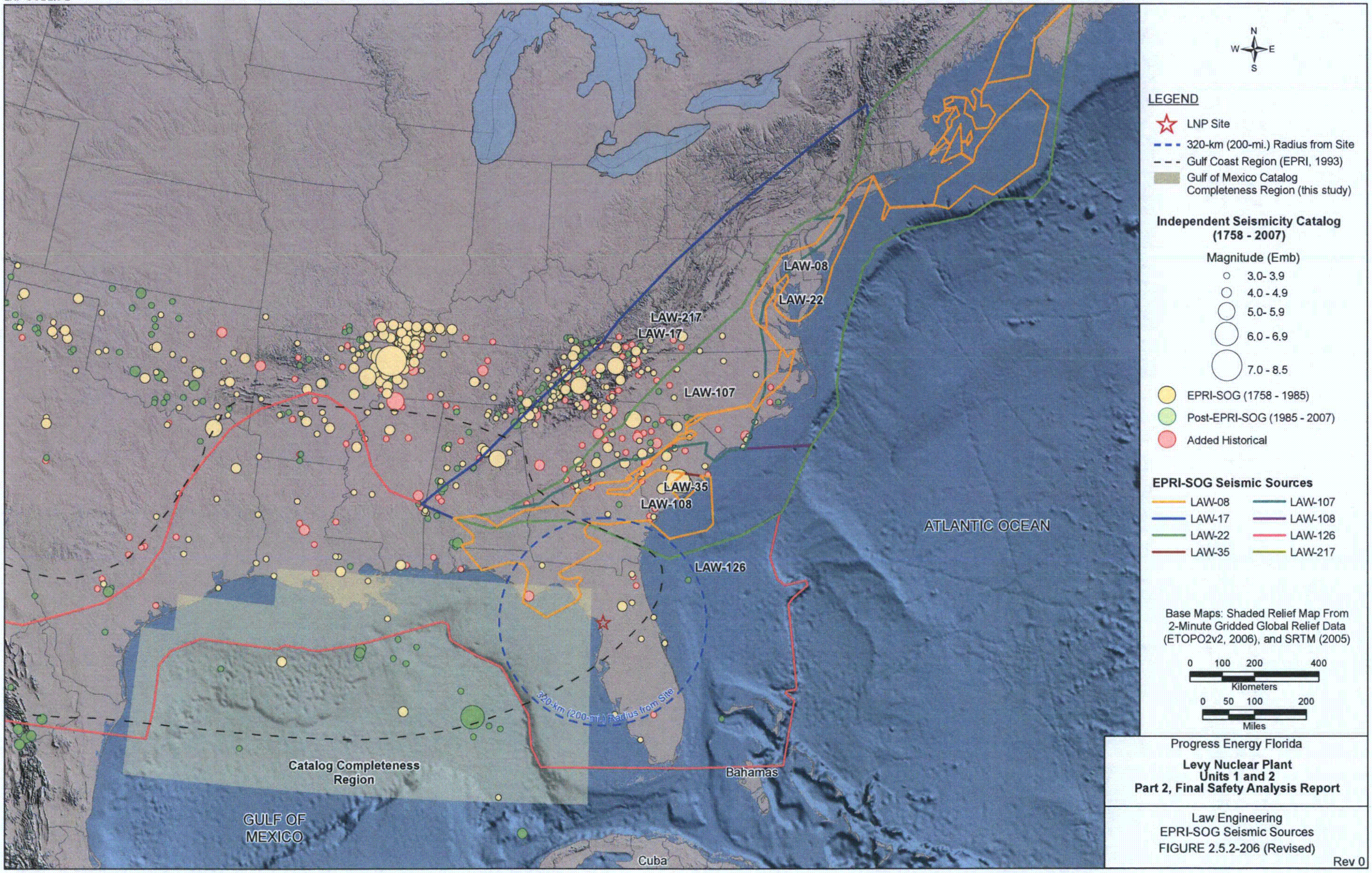
Dames & Moore EPRI-SOG Seismic Sources
FIGURE 2.5.2-205 (Revised)

Rev 0

LNP COL 2.5-2



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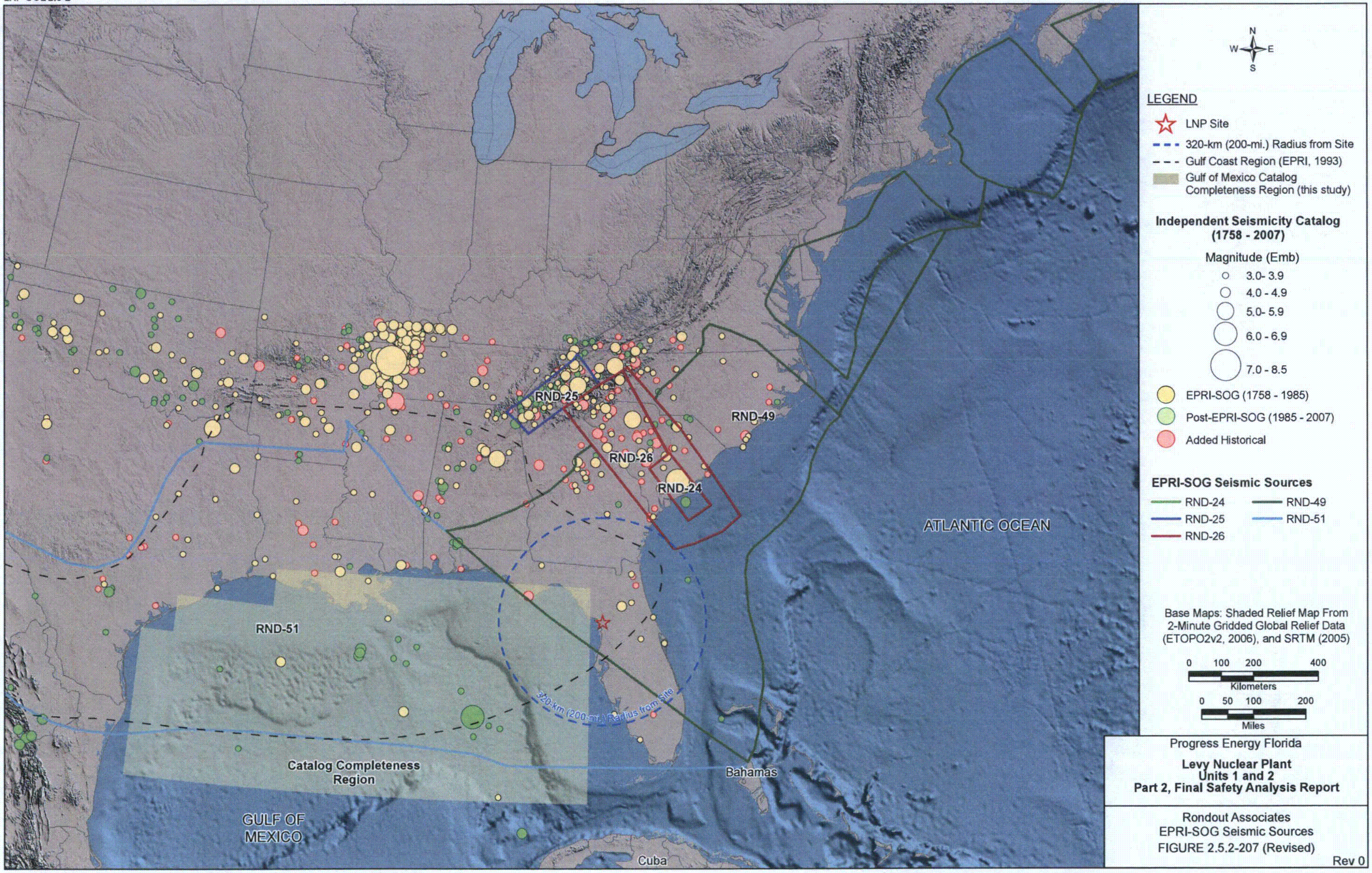
Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report

Law Engineering EPRI-SOG Seismic Sources FIGURE 2.5.2-206 (Revised)

Rev 0

LNP COL 2.5-2



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Units 1 and 2
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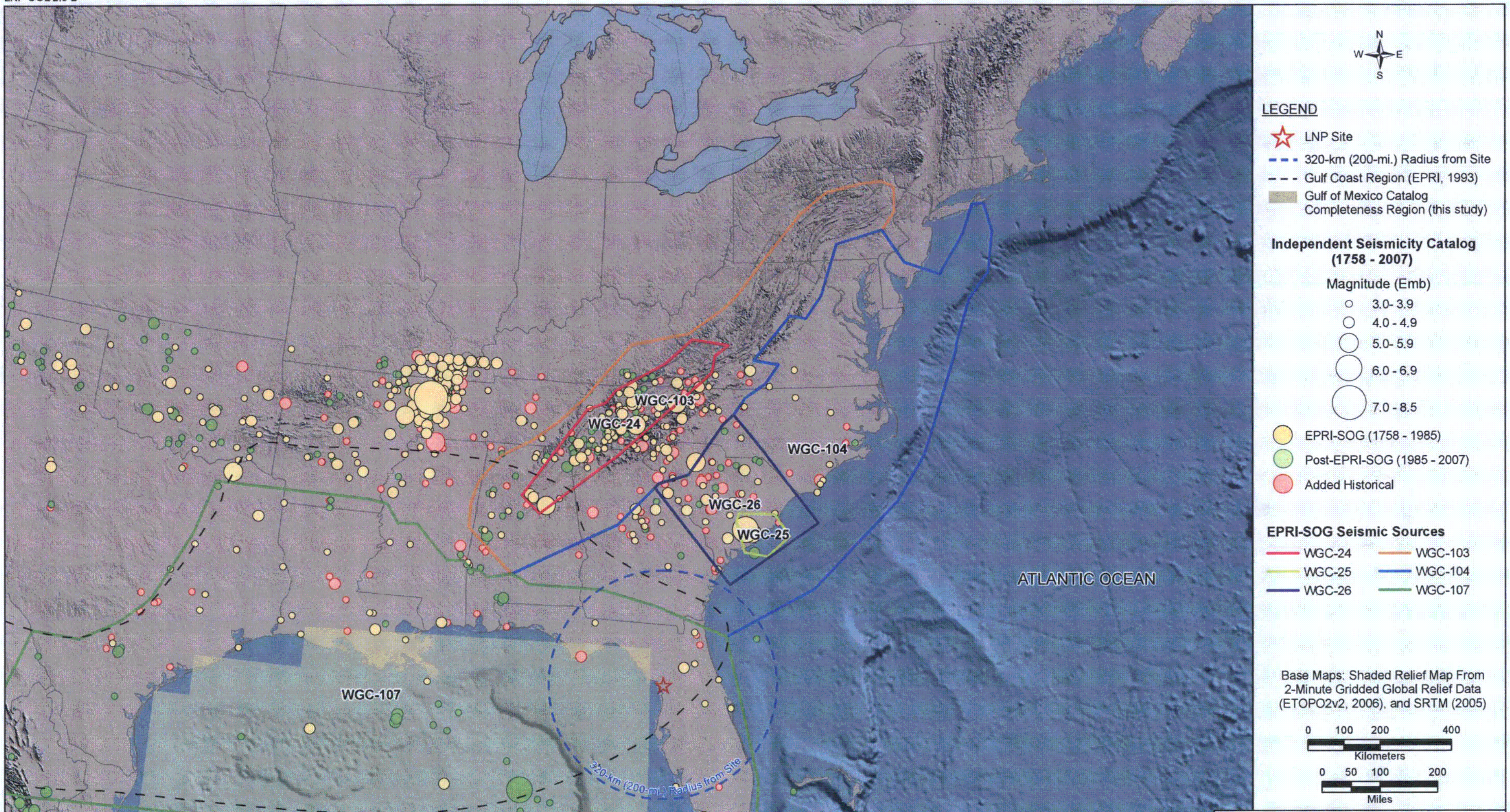
Rondout Associates
EPRI-SOG Seismic Sources
FIGURE 2.5.2-207 (Revised)

Rev 0



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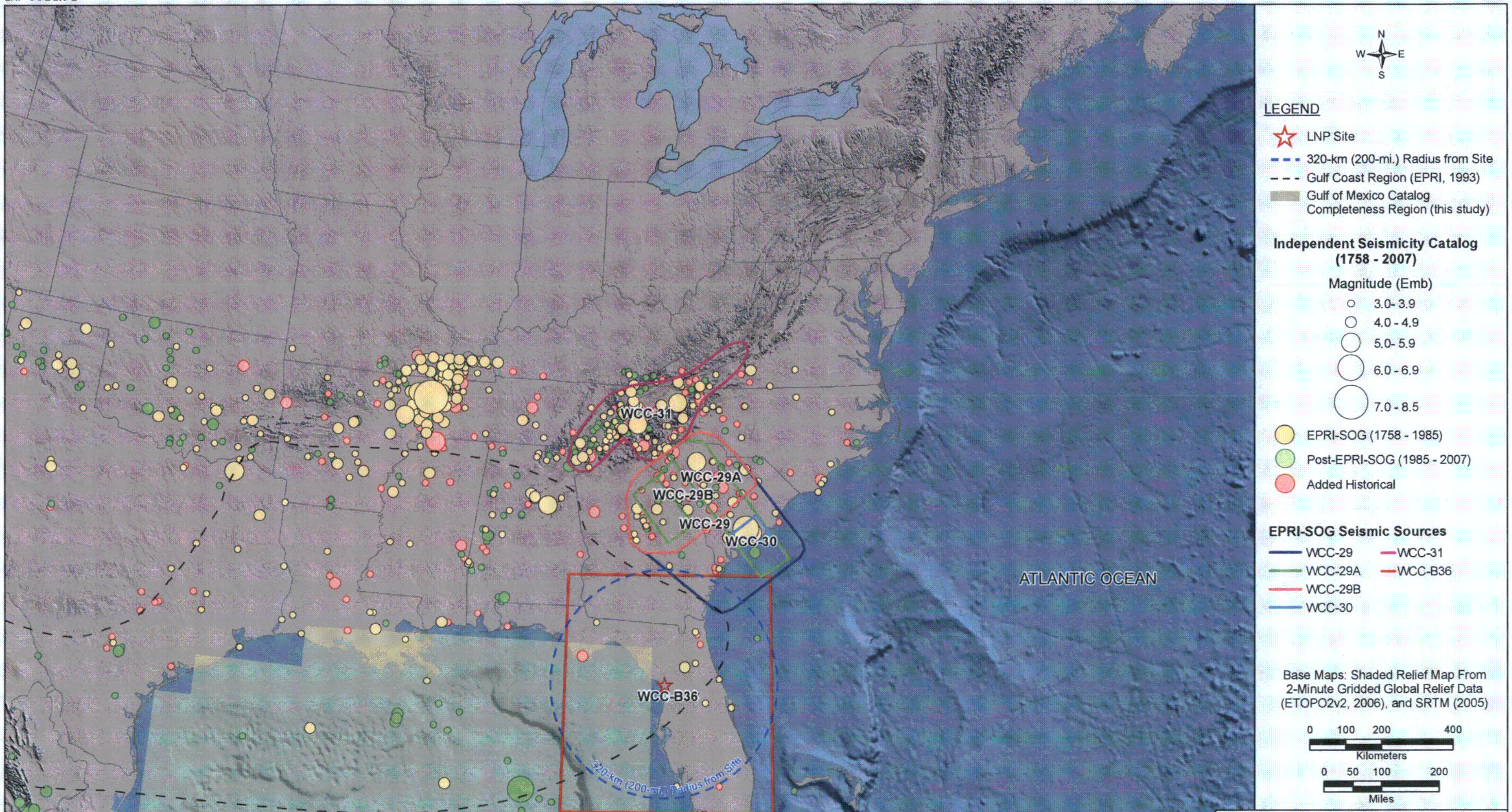
Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report

Weston Geophysical
EPRI-SOG Seismic Sources
FIGURE 2.5.2-208 (Revised)

Rev 0



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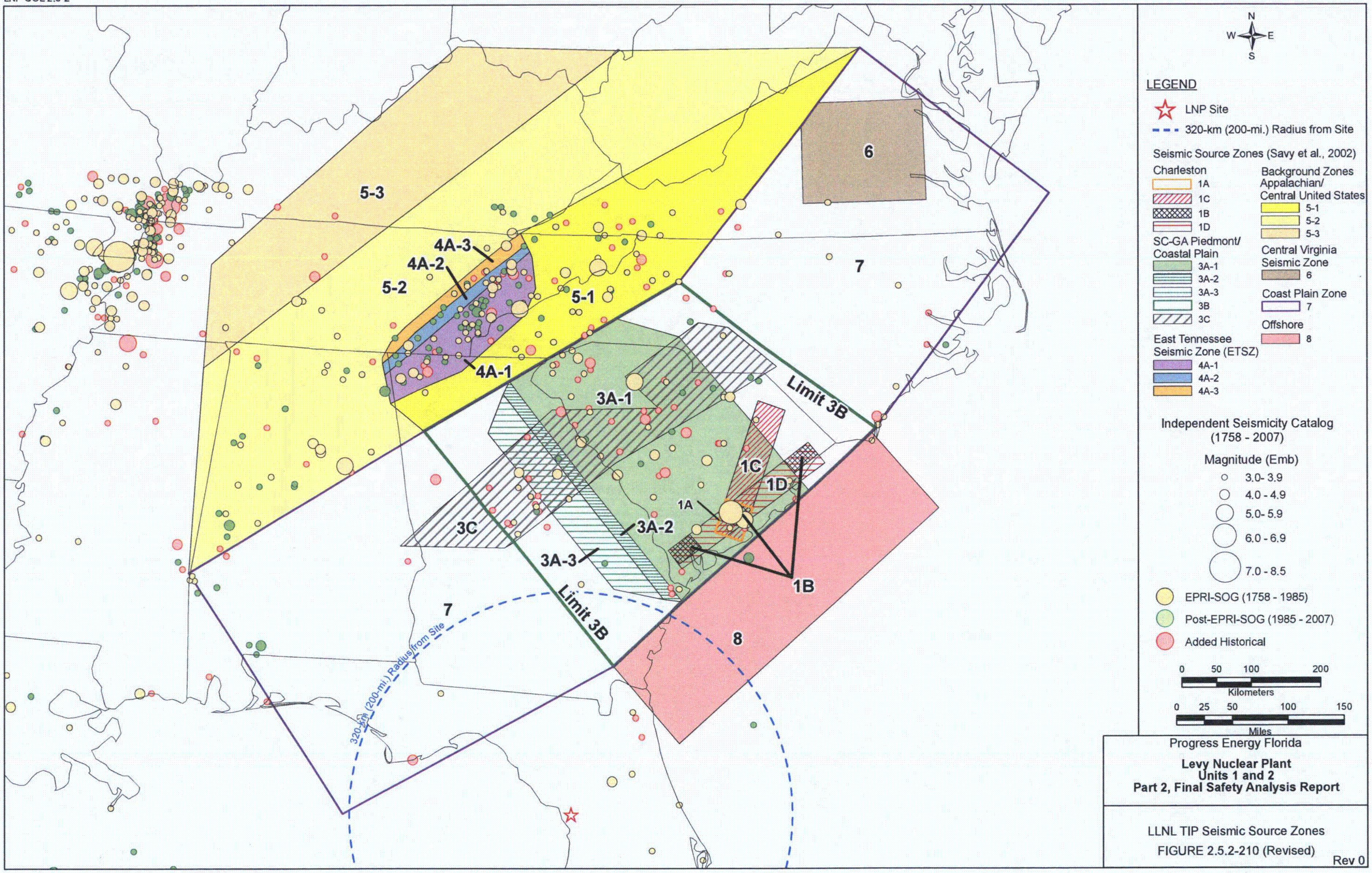
Levy Nuclear Plant
Units 1 and 2
Part 2, Final Safety Analysis Report

Woodward-Clyde Consultants
EPRI-SOG Seismic Sources
FIGURE 2.5.2-209 (Revised)

Rev 0

LNP COL 2.5-2



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Levy Nuclear Plant Units 1 and 2 Part 2, Final Safety Analysis Report

LLNL TIP Seismic Source Zones

FIGURE 2.5.2-210 (Revised)

Rev 0