

RAS 6864

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September 26, 2003

DOCKETED
USNRC

September 30, 2003 (3:21PM)

Rules and Adjudications Branch
Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

SUBJECT: *Filing in MOX CAR Proceeding, No. 70-3098*

Dear Madam/Sir,

Enclosed for filing please find the original and two copies of Georgians Against Nuclear Energy's Response to New Facts and Arguments in NRC Staff's Response to Duke Cogema Stone & Webster's Motion for Summary Disposition of Contention 3. Please note that the signature page of the supporting Supplemental Declaration of Dr. Leland Timothy Long has an electronic copy of Dr. Long's signature, which he sent by e-mail. I did not receive his original signed declaration in time for this filing, but will forward it when I receive it.

Sincerely,



Diane Curran

Cc: Service list

Template = SECY-041

SECY-02

September 26, 2003

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Thomas S. Moore, Chairman
Charles N. Kelber
Peter S. Lam

In the Matter of)

DUKE COGEMA STONE & WEBSTER)

(Savannah River Mixed Oxide Fuel)
Fabrication Facility))

Docket No. 0-70-03098-ML

ASLBP No. 01-790-01-ML

**GEORGIANS AGAINST NUCLEAR ENERGY'S
RESPONSE TO NEW FACTS AND ARGUMENTS
IN NRC STAFF'S RESPONSE TO DUKE COGEMA STONE & WEBSTER'S
MOTION FOR SUMMARY DISPOSITION OF GANE CONTENTION 3**

I. INTRODUCTION

Pursuant to 10 C.F.R. § 2.749(a), Georgians Against Nuclear Energy ("GANE") hereby responds to NRC Staff's Response to Motion for Summary Disposition Submitted by Duke Cogema Stone & Webster (September 16, 2003) (hereinafter "NRC Staff Response").¹ This response is supported by the Supplemental Declaration of Dr. Leland

¹ The Staff filed its Response in support of Duke Cogema Stone & Webster's Motion for Summary Disposition on Consolidated Contention 3 (August 22, 2003) (hereinafter "DCS's Motion"). On September 16, 2003, GANE filed Georgians Against Nuclear Energy's Opposition to DCS's Motion for Summary Disposition of Contention 3 (hereinafter "GANE's Opposition"). GANE's Opposition was supported by the Declaration of Dr. Leland Timothy Long Regarding GANE Contention 3 (September 16, 2003) (hereinafter "Long September 16 Declaration").

Timothy Long Regarding GANE Contention 3 (September 25, 2003) (hereinafter “Long Supplemental Declaration”). GANE is also attaching the complete transcript of Dr. Long’s deposition on June 25 and 26, 2003.²

In support of its Response, the Staff attaches the Declaration of Dr. John Stamatakos. The Atomic Safety and Licensing Board (“ASLB”) should disregard Dr. Stamatakos’ assertions, because he lacks the requisite professional qualifications to testify regarding the issues raised by Contention 3. Even if the ASLB credits Dr. Stamatakos’ statements, they should be given little weight.

In any event, Dr. Stamatakos provides little new information in support of DCS’s Motion. Most of his declaration consists of statements that he agrees with DCS’s expert, Dr. Carl Stepp. GANE will not address these arguments, because they are not new. To the limited extent that Dr Stamatakos offers new facts or arguments, they are controverted by the attached Long Supplemental Declaration.

II. DR. STAMATAKOS LACKS SUFFICIENT QUALIFICATIONS TO EVALUATE THE ISSUES RAISED BY CONTENTION 3.

Pursuant to 10 C.F.R. § 2.749(b), an affidavit submitted in support of a summary disposition motion must “show affirmatively that the affiant is competent to testify to the matters stated therein.” As discussed in paragraph 3 of the attached Long Supplemental Declaration, Dr. Stamatakos lacks any significant experience with the subject matter of Dr. Long’s deposition testimony on Contention 3: evaluating the location and frequency

² Both DCS and the NRC Staff have made many references to Dr. Long’s deposition testimony. DCS has attached only the cited portions of the deposition transcript, and the NRC Staff has not attached any pages at all. GANE provide the entire transcript in order to provide the Board with a complete reference. Dr. Long’s corrections to his deposition transcript are attached, in their entirety, to DCS’s Motion.

of Charleston-type earthquakes, wave propagation in the earth's crust, or computation of a Probabilistic Safety Hazards Assessment ("PSHA"). Instead, his career has focused on paleomagnetism, deformation features of sedimentary rocks, and geological perspectives of large faults and of fault systems which exhibit both ductile and/or brittle failure. Thus, Dr. Stamatakos has given no indication that he is qualified to evaluate the technical information and opinions that Dr. Long has given in his deposition testimony.³

To deny GANE a hearing, based on a summary disposition affidavit by an unqualified NRC Staff witness, would be a "harsh" and unfair remedy. *Cleveland Electric Illuminating Co.* (Perry Nuclear Power Plant, Units 1 and 2), ALAB-443, 6 NRC 741, 755 (1977). Thus, his testimony regarding Contention 3 should be disregarded. *Id.*, *Florida Power & Light Co.* (Turkey Point Nuclear Generating Plant, Units 3 and 4), ALAB-950, 33 NRC 492, 500-01 (1991). Even if Dr. Stamatakos' testimony is allowed on the basis of his general knowledge as a geologist, it should be given little weight against the particularized knowledge of Dr. Long. *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), LPB-00-12, 51 NRC 247, 267 note 9 (2000).⁴

³ While GANE considers the structural integrity of the proposed MOX Facility to be irrelevant to Contention 3, Dr. Stamatakos has also failed to demonstrate that he has the necessary professional qualifications to support his comments on the structural integrity of the proposed MOX Facility, in paragraphs 6-9 and 12. These opinions would appear to require the expertise of a structural engineer.

⁴ Dr. Stamatakos concedes that Dr. Long is "a well-qualified researcher in seismology issues," but questions Dr. Long's qualifications to comment on the issues raised by Contention 3, because Dr. Long has admitted that he is not closely familiar with NRC regulations or regulatory guidance. Stamatakos Declaration, par. 4. As discussed in the Long Supplemental Declaration, par. 4, Dr. Long does not claim to be an expert on NRC regulations. He is highly qualified, however, to evaluate the adequacy of DCS's analysis of the seismic hazard to the proposed MOX Facility. Neither Dr. Stamatakos nor Dr. Stepp possesses equivalent qualifications in this regard.

III. THE NRC STAFF HAS FAILED TO DEMONSTRATE THE LACK OF A GENUINE AND MATERIAL FACTUAL DISPUTE REGARDING CONTENTION 3.

Assuming for purposes of argument that Dr. Stamatakos is qualified to make the assertions in his declaration, he has failed to provide new facts or arguments showing the lack of a genuine and material dispute regarding Contention 3. To the extent that Dr. Stamatakos does offer new arguments or information, his assertions are controverted by the attached Supplemental Declaration of Dr. Leland Timothy Long.

A. DCS's Historical Check Was Inadequate.

The only new information that NRC Staff offers regarding the adequacy of DCS's historical check on its PSHA is the emphasis placed by Dr. Stamatakos on the Campbell attenuation relation calculation. *See* Stamatakos Declaration, par. 23. This emphasis is misplaced, because Campbell's attenuation relation is a generalized calculation for the eastern United States that would not be appropriate for the South Carolina-Georgia Coastal Plain. Long Supplemental Declaration, par. 11.

In its Response, the NRC Staff also makes the new argument that it doesn't matter whether the attenuation relation calculation is incorrect, because the structural design of the proposed MOX Facility is conservative enough to withstand an earthquake much stronger than the design basis earthquake. NRC Staff Response at 9; Stamatakos Declaration, pars. 6-9, 11-12. This argument is without merit, for several reasons. First, 10 C.F.R. § 70.64(a)(2) provides that the MOX Facility design "must provide for adequate protection against natural phenomena *with consideration of the most severe documented historical events for the site.*" (emphasis added). This requirement is

independent of any structural design requirements for the buildings on the site. It is not enough to guess at the risk posed by the most severe documented historical events for the site, and then over-design the building based on that guess. Instead, 10 C.F.R. § 70.64(a)(2) specifically requires reasoned consideration of the severity of the hazard. In this case, DCS has chosen to perform a PSHA to fulfill that requirement. As demonstrated in Dr. Long's September 16 Declaration, the PSHA is fundamentally inadequate to meet the task.

Second, the Staff misuses the concept of a conservatism. As discussed in GANE's Opposition at 12, it is not possible to add a conservatism to a fundamentally defective analysis, because there is no way to determine how big the conservatism should be, other than to perform the calculation correctly in the first place. The design of a major facility deserves a through analysis and update of pertinent data, not the injection of errors of unknown magnitude that arbitrarily increase the hazard in hopes that they are greater than the effects of the errors and omissions. Long Supplemental Declaration, pars. 5 and 7; Long September 16 Declaration, paragraphs 9(e), 29, 57.

Finally, as discussed above, Dr. Stamatakos is a geologist, not a structural engineer. As such, he lacks the professional qualifications to testify that the MOX Facility is adequately designed to withstand a much stronger earthquake than the design basis earthquake. Long Supplemental Declaration, par. 3.

B. The NRC Staff Fails to Justify Direct Application of the LLNL and EPRI Studies to the MOX Facility PSHA.

The NRC Staff argues that Dr. Long has provided no support for his argument that the Lawrence Livermore National Laboratories ("LLNL") and Edison Electric Power

Institute (“EPRI”) studies were never intended for general application, because he cannot remember the name of the individual who told him that, or when. Dr. Long has testified, however, that at the time the EPRI and LLNL studies were done, the prospective use of the studies concerned him enough to ask the study managers how the studies would be applied. Long September 16 Declaration, par. 9(a)(iv). While, twenty years later, he may not remember the name of the individuals that he consulted, he does remember (a) that the issue concerned him at the time of the EPRI and LLNL studies, (b) that he made the inquiry at that time, and (c) that the individuals he consulted were in a position to know the answer. His recollection is sufficient to demonstrate a genuine and material dispute between the parties.

In any event, even if the LLNL and EPRI studies *were* intended for general application, the underlying data base has changed significantly in several key respects during the past twenty years, and should be revised. Long Supplemental Declaration, par. 5.⁵ *See also* Long September 16 Declaration, par. 9(a)(1)-(iv). His view is supported by Regulatory Guide 1.165, which anticipates that the LLNL and EPRI studies will be revised every ten years. *See id.*, Appendix E.

⁵ As Dr. Long explains, new information about the characteristics of the Carolina Coastal Plain shows that the attenuation functions used in the LLNL and EPRI studies, which were taken from the interior of the U.S., do not apply to the region around the MOX facility. *Id.* Moreover, much more is known today about the distribution and magnitude of historical earthquakes. Finally, magnitude statistics are better understood today than they were twenty years ago. Consideration of any of these factors could lead to a higher seismic risk for the proposed MOX Facility. The critical analysis has not been performed by DCS to ascertain the impact of these developments. Because the true hazard is unknown, DCS does not know if the added conservatism is sufficient. *Id.*

C. Consideration of Floating Earthquakes Is Justified.

In paragraphs 16 and 17, Dr. Stamatakos states that Dr. Long has offered no explanation as to how or why the spatial variability of Kafka's small earthquakes should be extrapolated to include earthquakes with larger magnitudes. *See also* NRC Staff Response at 10. He also asserts that Dr. Long over-interprets or even misinterprets the results of the Kafka paper. *Id.* As Dr. Long states in paragraph 8 of his Supplemental Declaration, Dr. Stamatakos' Declaration reflects either a lack of appreciation of the inherent scale invariance of magnitude statistics, or a lack of understanding that in a scale invariant system, it is not significant whether the largest events are 4.5 or 6.5. Dr. Long's reliance on the Kafka study is reasonable and appropriate.

In paragraph 18 of his declaration, Dr. Stamatakos also states that past large earthquakes which would be relevant to the Savannah River Site were not randomly located. Dr. Long explains the basis for his disagreement with this assertion in paragraph 9 of his declaration. In Dr. Long's professional opinion, Dr. Stamatakos does not have an adequate statistical basis to support a firm conclusion that a major earthquake cannot occur outside the South Carolina-Georgia Coastal Plain. Dr. Long does find statistically significant the fact that two (i.e. approximately 33%) of the approximately six large earthquakes in the past 6,000 years occurred in locations other than Charleston, whereas the catalog of felt or instrumentally documented earthquakes would identify Charleston

as the only potential source of a large earthquake in that area.⁶ Clearly, the parties have a genuine and material dispute regarding this factual issue.

D. The NRC Staff Fails to Show That There Is No Potential for a Large Earthquake In the Eastern Tennessee Seismic Zone.

The NRC Staff argues that in his deposition, Dr. Long did not provide any basis for suggesting that a magnitude 7.5 earthquake could occur in the Eastern Tennessee Seismic Zone. This is simply incorrect. *See Long Deposition Transcript at 23, 92-93, 166, 207, 375-76.*

Dr. Stamatakos also argues that the eastern Tennessee zone lacks any historical or geological evidence for geologically recent, large-magnitude earthquakes. Stamatakos Declaration, paragraph 20. Dr. Stamatakos concedes, however, that he is unfamiliar with the geophysical structure underlying the southeastern Tennessee Seismic Zone. Thus, he is not competent to make his assertion. As Dr. Long explains in paragraph 10 of his Supplemental Declaration, without studying the area, one could easily overlook the similarities between southeastern Tennessee and the New Madrid seismicity. The southeastern Tennessee seismic zone is in a remote area where many older events have gone undetected and a major event would likely have occurred prior to recorded history. The lack of any historical or geological evidence for geologically-recent, large-magnitude

⁶ These two earthquakes occurred at Bluffton and Georgetown. According to the NRC Staff, because neither of these locations is any closer to the Savannah River Site than the 120 kilometer distance used by DCS in the modeled historic check, they lack materiality. NRC Staff Brief at 11. While the Staff cites paragraph 25 of the Stamatakos Declaration for this proposition, the declaration does not support, or even address, that particular proposition. As Dr. Long states, the statistical significance of these earthquakes is that they show the potential for major earthquakes in the region, in locations other than Charleston. Long Supplemental Declaration, par. 9.

earthquakes in the southeastern Tennessee Seismic Zone could simply be a matter of timing. *Id.* Accordingly, there is a genuine and material factual dispute between the parties regarding this issue.

E. The NRC Staff Has Failed To Demonstrate That Key Seismic Factors Were Given Quantitative Consideration.

In numerous instances, Dr. Stamatakos argues that the new and site-specific information identified by Dr. Long as missing from the LLNL and EPRI studies was, in fact, known and included in the LLNL and EPRI studies. *See, e.g.,* Stamatakos Declaration, paragraphs 10, 11, 19, 21, 22, 24, and 26. *See also* NRC Staff Response at 10, 11. The important question in determining the impact of these factors on the hazard is not whether they were considered in a qualitative sense, but the degree to which they contributed to the original quantitative analysis. DCS should have performed a critical analysis to assess the significance of the new data. Long Supplemental Declaration, par. 6; Long September 16, Declaration, par. 9(a).

IV. CONCLUSION

For the foregoing reasons, the ASLB should find that the NRC Staff's Response does not lend support to DCS's motion for summary disposition of Contention 3, and therefore should deny the motion.

Respectfully submitted,



Diane Curran

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September 26, 2003

CERTIFICATE OF SERVICE

I hereby certify that on September 16, 2003, copies of the foregoing GEORGIANS AGAINST NUCLEAR ENERGY'S REPLY TO NRC STAFF'S RESPONSE TO DUKE COGEMA STONE & WEBSTER'S MOTION FOR SUMMARY DISPOSITION OF CONTENTION were served on the following by e-mail and first-class mail:

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Diane Curran

September 24, 2003

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Thomas S. Moore, Chairman
Charles N. Kelber
Peter S. Lam

| | | |
|---|---|--------------------------|
| In the Matter of |) | |
| |) | |
| DUKE COGEMA STONE & WEBSTER |) | Docket No. 0-70-03098-ML |
| |) | |
| (Savannah River Mixed Oxide Fuel Fabrication Facility) |) | ASLBP No. 01-790-01-ML |
| |) | |

**SUPPLEMENTAL DECLARATION OF DR. LELAND TIMOTHY LONG
REGARDING CONTENTION 3**

Under penalty of perjury, I, Dr. Leland Timothy Long, depose and say:

1. My name is Leland Timothy Long. I am Professor of Geophysics at the Georgia Institute of Technology in Atlanta, Georgia. A description of my professional qualifications is provided in my declaration of September 16, 2003, which was submitted by Georgians Against Nuclear Energy ("GANE") in support of its opposition to Duke Cogema Stone & Webster's ("DCS's") motion for summary disposition of GANE Contention 3.
2. The purpose of this supplemental declaration is to respond to new information and arguments made in Affidavit of Dr. John Stamatakos, which was submitted by the Nuclear Regulatory Commission ("NRC") Staff in support of NRC Staff's Response to Motion Summary Disposition Submitted by Duke Cogema Stone & Webster (September 16, 2003). To the extent that Dr. Stamatakos simply expresses his agreement with assertions that previously were made by Dr. Carl Stepp, or repeats assertions that were made by Dr. Stepp, I will rely on my September 16 declaration.
3. My concerns about the adequacy of the seismic analysis for the proposed MOX Facility relate to the location and frequency of Charleston type earthquakes, the propagation of seismic waves in relation to the MOX Facility, and the adequacy of the

Probabilistic Safety Hazards Assessment (“PSHA”) conducted by DCS. These concerns were also the subject of my deposition testimony on June 25 and 26, 2003. Dr. Stamatakos’ qualifications to evaluate my opinions on these subjects appear to be very limited. As demonstrated by the resume that he refers to in paragraph 3 of his affidavit, Dr. Stamatakos lacks any significant experience with evaluating the location and frequency of Charleston-type earthquakes, wave propagation in the earth’s crust, or computation of a PSHA. Instead, his career has focused on paleomagnetism, deformation features of sedimentary rocks, and geological perspectives of large faults and of fault systems which exhibit both ductile and/or brittle failure. Thus, Dr. Stamatakos does not appear to be qualified to evaluate the information and opinions I have given in discovery responses and in my deposition testimony. He also appears to lack the necessary professional qualifications to support his comments on the structural integrity of the proposed MOX Facility, in paragraphs 6-9 and 12.

4. In paragraph 4, Dr. Stamatakos concedes that I am “a well-qualified researcher in seismology issues.” But he questions my qualifications to comment on the issues raised by Contention 3, because I have admitted that I am not closely familiar with NRC regulations or regulatory guidance. I do not claim to be an expert on NRC regulations. I am highly qualified, however, to evaluate the adequacy of DCS’s analysis of the seismic hazard to the proposed MOX Facility. I do not consider Dr. Stamatakos or Dr. Stepp to have equivalent qualifications in this regard.

5. Contrary to Dr. Stamatakos’s assertion in paragraphs 5 and 25, direct application of the PSHA computed in the Lawrence Livermore National Laboratories (“LLNL”) and Electric Power Research Institute (“EPRI”) studies to the hazard evaluation for the MOX facility is not appropriate. As I pointed out in my September 16 declaration, the database that was used for the EPRI and LLNL studies has changed significantly in several key respects during the past twenty years. First, new information about the characteristics of the Carolina Coastal Plain shows that the attenuation functions used in the LLNL and EPRI studies, which were taken from the interior of the U.S., do not apply to the region around the MOX facility. Moreover, much more is known today about the distribution and magnitude of historical earthquakes. Finally, magnitude statistics are better understood today than they were twenty years ago. Consideration of any of these factors could lead to a higher seismic risk for the proposed MOX Facility. The critical analysis has not been performed by DCS to ascertain the impact of these developments. Because the true hazard is unknown, DCS does not know if the added conservatism is sufficient.

6. In many instances (*see, e.g.*, pars. 10, 11, 19, 21, 22, 24, and 26), Dr. Stamatakos argues that the factors listed in paragraph 5 above were known and included in the LLNL and EPRI studies. The important factor in determining the impact of these factors on the hazard is not whether they were considered in a qualitative sense, but the degree to which they contributed to the original quantitative analysis. DCS should have performed a critical analysis to assess the significance of the new data.

7. In paragraphs 6, 7, 8, 9, and 12, Dr. Stamatakos asserts that the seismic ground motion performance goals for PC-3 and PC-4 facilities like the MOX Facility are 1×10^{-4} and 1×10^{-5} , which corresponds to 10,000 and 100,000 year return periods, respectively. In other words, he argues that DCS has built in extra conservatism in the design, and hence the seismic hazard criteria can be ignored. I strongly disagree. As stated above in paragraph 5, unless and until DCS makes a reasonably accurate assessment of the true seismic hazard at the MOX Facility, it has no valid means of determining the degree of conservatism that should be applied.

8. In paragraphs 16 and 17, Dr. Stamatakos states that I have offered no explanation as to how or why the spatial variability of Kafka's small earthquakes should be extrapolated to include earthquakes with larger magnitudes. He also asserts that I over-interpret or even misinterpret the results of the Kafka paper. Like Dr. Stepp, Dr. Stamatakos either does not appreciate the inherent scale invariance of magnitude statistics, or he does not understand that in a scale invariant system, it is not significant whether the largest events are 4.5 or 6.5. Kafka's study is a study of statistics of earthquake occurrences. It points out that the fraction of new large events outside of known seismic zones in any region can be quantified. In my professional opinion, it is reasonable to extrapolate Kafka's results to what they would be if he had a complete catalog for a long time period including the Charleston Earthquake. Kafka evaluated such catalogs for other areas with similar results. It is not necessary to consider a specific hypothesis and its converse to see that earthquake statistics like these simply demonstrate that in any area, a certain percentage of the large earthquakes will occur in new areas. If the proportion of new epicenters for large events occurring in a region is different from the proportion of events assigned to the background zones (or the equivalent of background zones) in the studies by LLNL and EPRI, a critical assessment of the impact of these statistics should be performed.

9. In paragraph 18, Dr. Stamatakos states that past large earthquakes which would be relevant to the Savannah River Site were not randomly located. In support of his position, he cites the fact that the approximately six magnitude 7.0 earthquakes that occurred during the past 6,000 years happened in the South Carolina-Georgia Coastal Plain. I do not think such a small data base affords a basis for a firm statistical conclusion that a major earthquake cannot occur outside the South Carolina-Georgia Coastal Plain; nor do I find there is any statistical basis for concluding that a large earthquake could not occur outside the South Carolina-Georgia Coastal Plain. I do find statistical support in the fact that two (i.e. approximately 33%) of the large earthquakes in the past 6,000 years occurred in locations other than Charleston. The catalog of felt or instrumentally documented earthquakes would identify Charleston as the only potential source of a large earthquake in that area.

10. In paragraph 20, Dr. Stamatakos states that he is unfamiliar with the geophysical structure underlying the southeastern Tennessee Seismic Zone. Without studying the area, one could easily overlook the similarities between southeastern Tennessee and the

New Madrid seismicity. The southeastern Tennessee seismic zone is in a remote area where many older events have gone undetected and a major event would likely have occurred prior to recorded history. Thus, Dr. Stamatakos does not have a valid basis for his conclusion that a large earthquake is unlikely in the southeastern Tennessee Seismic Zone. The lack of any historical or geological evidence for geologically-recent, large-magnitude earthquakes in the southeastern Tennessee Seismic Zone could simply be a matter of timing.

11. I disagree with Dr. Stamatakos's assertion in paragraph 23 that the Campbell attenuation relation would be appropriate for the Coastal Plain of South Carolina. The Campbell attenuation relation is a generalized calculation for the eastern United States. The geological characteristics of the Coastal Plain of South Carolina are notably different from the major portion of the rest of the eastern United States. For example, the thickness of the crust in the Coastal Plain is only about 30 km, in comparison to an average thickness of 40 km for the continental eastern United States. As discussed in my September 16, declaration, crustal thickness and structure have an effect on attenuation relations.



Leland Timothy Long

September 24, 2003

In The Matter Of:

Duke Cogema Stone & Webster

Deposition of Leland T. Long, Dr.

Vol. 2, June 25, 2003.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of :
DUKE COGEMA STONE & WEBSTER : Docket No.:
 : 0-70-03098-ML
(Savannah River Mixed Oxide : ASLBP No.:
Fabrication Facility) : 01-790-ML
Washington, D.C.
Wednesday, June 25, 2003
The deposition of DR. LELAND TIMOTHY
LONG, called for examination by counsel for
Plaintiff in the above-entitled matter, pursuant to
Notice, in the offices of Morgan, Lewis & Bockius,
1111 Pennsylvania Avenue, N.W., Washington, D.C.,
convened at 9:41 a.m., before Cathy Jardim, a
notary public in and for the District of Columbia,
when were present on behalf of the parties:

APPEARANCES:

On behalf of Georgians Against
Nuclear Energy:
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LAWRENCE A. SALOMONE
CARL STEPP
JEFF KIMBALL
JOHN STAMATAKOS

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EXAMINATION BY COUNSEL
WITNESS FOR DCSW
LELAND TIMOTHY LONG
By Mr. Polonsky 4
EXHIBITS
LONG DEPOSITION MARKED
No. 1 230

PROCEEDINGS

(1) [REDACTED]
(2) Whereupon,
(3) DR. LELAND TIMOTHY LONG
(4) was called for examination by counsel for DCS and,
(5) having been first duly sworn by the notary public,
(6) was examined and testified as follows:

(7) EXAMINATION BY COUNSEL FOR DCSW
(8) BY MR. POLONSKY:

(9) Q: Just for everyone's reference, we have
(10) drinks on the end. Feel free at any time to get up
(11) and help yourself. If we need to take a break, we
(12) will take a break.
(13) My name is Alex Polonsky. I am with the
(14) law firm of Morgan, Lewis and Bockius, here in
(15) Washington, D.C. We have been retained by Duke
(16) Cogema Stone and Webster, LLC to represent them in
(17) the mix oxide fuel fabrication construction
(18) authorization licensing request before the NRC's
(19) Atomic Licensing and Safety Board.
(20) I am going to refer to my client as the
(21) DCSW. I will refer to the facility as the MOX
(22) facility and the construction authorization request

(1) as the CAR.
(2) Could you please identify yourself for
(3) the record by name and address?
(4) A: Leland Timothy long. I work at Georgia
(5) Tech, Atlanta, Georgia.
(6) Q: You have been already sworn. Do you
(7) understand that your testimony is under oath and
(8) that you have been sworn to tell the truth?
(9) A: Yes.
(10) Q: I will be asking you a series of
(11) questions today relating to Georgians Against
(12) Nuclear Energy contention number three entitled
(13) inadequate seismic design. For purposes of the
(14) deposition I will refer to Georgians Against
(15) Nuclear Energy as GANE.
(16) So the court reporter can create a clear
(17) record, we should not talk at the same time so I
(18) would ask if you wait until I am finished, and I
(19) will do my best to wait until you have finished
(20) your response. Also, please give a response orally
(21) as opposed to physical gesture.
(22) If you don't hear a question, please say

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[1] so. I will repeat it again. If you don't
[2] understand a question, please let me know. I will
[3] rephrase it. If you realize that an answer that
[4] you gave earlier is not accurate or complete for
[5] any reason, please let me know. I will be happy to
[6] go back and revisit that question or that response.

[7] If you want to stop to take a break for
[8] coffee or use the restroom, please let me know and
[9] we will do so.

[10] If I ask you a question and you don't
[11] know the answer or you do not recollect the
[12] necessary information, just simply say that.

[13] If you answer my question, I will assume
[14] that you have heard it and that you understand it.
[15] You can talk to Diane, your attorney, but I would
[16] ask that you finish your answer, if there was a
[17] question pending and that only after that, you can
[18] confer.

[19] Do you understand the instructions?

[20] A: Yes, I do.

[21] Q: Is there anything that would prevent you
[22] from testifying fully and accurately today?

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[1] A: No.

[2] Q: Are you feeling well?

[3] A: Yes.

[4] Q: Are you taking any medications that would
[5] impair your ability to testify today?

[6] A: No.

[7] Q: Do you understand that during today's
[8] deposition that you are speaking as GANE's
[9] proffered expert?

[10] A: I am speaking as an expert on the seismic
[11] conditions or evaluation.

[12] Q: Regarding intraplate seismic theories,
[13] what do you think are the three most valuable
[14] hypotheses for explaining the origins of intraplate
[15] earthquakes?

[16] A: That is two questions. What do I think
[17] the scientific community considers the three most
[18] and what do I consider the three most. I have one
[19] theory. Scientific community has a bunch of
[20] theories. The paradigm that comes out of
[21] California is that faults exist and they create
[22] earthquakes. That is the standard explanation for

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[1] earthquakes. Californians seem to explain
[2] earthquakes without having faults as blind faults
[3] or perhaps they didn't map the fault.

[4] In the east, it seems just about
[5] everything is a blind fault or an intraplate
[6] setting. Everything seems to be a blind fault.
[7] They tend to occur in areas very often where
[8] historically seismic hazard hasn't been observed.
[9] Although paleo seismic data today seems to indicate
[10] that areas of — many areas of large earthquakes
[11] have had pre-historical seismicity.

[12] So what do I think are the main theories?

[13] In the Charleston area, in the New Madrid area, my
[14] opinion is that the area has experienced a local
[15] weakening of some type and that local weakening has
[16] resulted in a deformation or compression of the
[17] crust, earth's crust, that creates a stress
[18] amplification in the stronger portions of the crust
[19] and that stress application is failed in an
[20] earthquake. It is failed perhaps because of stress
[21] amplification but also perhaps because of weakening
[22] along new or perhaps existing zones of weakness or

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[1] fractures. That theory has been expounded in a
[2] couple of articles that have my name on them.

[3] I will have to admit that that theory has
[4] not been entirely accepted, although I believe a
[5] number of studies are coming closer to it.

[6] Q: Could we go off the record.

[7] (Discussion off the record.)

[8] BY MR. POLONSKY:

[9] Q: The question on the table is what were
[10] the three most viable hypotheses for explaining
[11] intraplate earthquakes. I believe you have
[12] identified, and correct me if I am wrong, the
[13] theory that you believe is the most viable
[14] hypothesis.

[15] A: That is correct. I have identified that
[16] theory for major earthquakes. I have another
[17] theory for minor incidental earthquakes that are
[18] very shallow.

[19] Q: Let's stick with the explanation for
[20] major earthquakes. You stated it is not entirely
[21] accepted. Do you mean in the scientific community?

[22] A: I mean that people don't reference it and

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[1] they continue to try to explain major earthquakes
[2] by associating them with active faults.

[3] Q: Are you aware of any other paper that
[4] references your theory for major intraplate
[5] earthquakes?

[6] A: I have not checked the reference citation
[7] index on that.

[8] Q: Would it surprise you if there weren't
[9] any articles that referenced your —

[10] A: No —

[11] Q: It would not surprise you if there were
[12] none — I am sorry. Let rephrase the question.
[13] Again, for the court reporter, if you would wait
[14] until I am done.

[15] A: I would be surprised if there were no
[16] references to it.

[17] Q: So you believe there are articles out
[18] there that reference your theory on major
[19] intraplate earthquakes?

[20] A: Yes.

[21] Q: Who would those articles be authored by?

[22] A: I would not know. I would have to

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[1] speculate on that.

[2] Q: What are the most viable hypotheses that
[3] are out there for explaining origins of major
[4] intraplate earthquakes that the scientific
[5] community stands behind?

[6] A: We will restrict this to the eastern
[7] U.S. —

[8] Q: Yes.

[9] A: For intraplate. Most of the theories
[10] that have been developed revolve around ideas with
[11] respect to New Madrid seismicity and that is
[12] generally accepted as a fault zone that has
[13] repeated earthquakes. The belief in general is
[14] that there exists for many of these earthquakes a
[15] fault which is considered a zone of weakness in the
[16] crust and that the stresses accumulate and are
[17] released along that fault. That is the major idea,
[18] that stresses increase and cause failure along an
[19] existing zone of weakness or fault.

[20] Q: Is there any reason why you don't believe
[21] that the theory you just discussed which, as I
[22] understand it, is not your own theory, would not

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[1] equally apply to Charleston?

[2] A: Primary reason is that it is a high
[3] stress event, that it is a small focus area, that
[4] there is not a pervasive fault that exists in spite
[5] of numerous attempts to identify an active fault in
[6] the region. The seismicity in that area from
[7] after-shock studies generally defines a volume or a
[8] curve surface of failure, not necessarily a linear
[9] surface, and that in general, when one looks at the
[10] distribution of seismicity in areas like
[11] Charleston, then you see a volume of activity that,
[12] when you look at the seismicity in New Madrid, you
[13] do identify a number of failure zones or faults,
[14] that failed in the large three or four earthquakes
[15] that occurred in 1811 and '12. The failure zone in
[16] the New Madrid area is generally explained by
[17] traditional mechanisms, by the failure of the
[18] faults under intraplate stress.

[19] Q: Are there other viable theories out there
[20] other than your theory, the theory you just
[21] identified, associated primarily with New Madrid?

[22] A: You used the term viable. The Lawrence

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[1] Livermore/EPRI studies went through multiple,
[2] multiple hypotheses and there are lists from viable
[3] to the absurd and where you want to draw that line
[4] is very questionable. I would say, in those days,
[5] and this was 10 or 20 years ago, I was proposing
[6] that one viable hypothesis is that matric materials
[7] were of higher elastic strengths than others and in
[8] a compressing crust they would contract or
[9] concentrate stresses. I would not today say that
[10] was a viable hypothesis. Another viable hypothesis
[11] associated with those earthquakes is that the
[12] earthquakes occurred along existing edge faults.
[13] That has been proposed by many people in those days
[14] but I would not say that that was viable today, and
[15] none of the seismicity nor the characteristics have
[16] shown a correlation. There are many, many
[17] Triassic-base edge faults without earthquakes.
[18] There are many hypothesis. We could go on all day,
[19] as the Lawrence Livermore/EPRI studies did, arguing
[20] hypothesis.

[21] Q: I appreciate you identifying for me the
[22] inappropriateness of viable.

[1] What weight would the scientific
[2] community place on the second theory you discussed,
[3] the theory focusing on New Madrid and the repeat
[4] earthquakes being associated with some type of
[5] fault condition?

[6] A: I would say there are two groups, those
[7] that believe there is something mechanically going
[8] on with the crust in the New Madrid area and those
[9] that still accept the California paradigm of an
[10] active fault being responsible for earthquakes. I
[11] think U.S. Geological Survey personnel are to some
[12] extent still doing models on — based on active —
[13] an active fault or fault zone that fails and trying
[14] to explain the motion. There are a couple of
[15] instructors who have — investigators who have
[16] taken — have looked at the data from New Madrid
[17] and said there are anomalous features that perhaps
[18] suggest that the zone is a zone of weakness and not
[19] one of a fault response. And like the word viable,
[20] there is a gradational zone between investigators
[21] from one polarization to the other.

[22] Q: You believe that some scientists are in

[1] the camp that there is a California model that
[2] earthquakes — sorry, faults cause earthquakes and
[3] that the USGS is primarily in that camp.

[4] A: I would say many investigations in New
[5] Madrid that come out of the USGS are in that camp.
[6] I am not saying that all of the individuals in USGS
[7] are.

[8] Q: Would you say that the USGS — let me
[9] back up. Are you familiar with the USGS seismic
[10] hazard maps?

[11] A: Yes.

[12] Q: Are you familiar with the 2002 revision
[13] of those maps?

[14] A: Not in detail but I have looked at them.

[15] Q: Are you familiar with the 1996 maps?

[16] A: I have looked at those too.

[17] Q: Would you say that the 2002 USGS hazard
[18] maps follow the California model for New Madrid?

[19] A: The USGS maps are — the Lawrence
[20] Livermore studies pulled in a lot of information on
[21] proposed and hypothesized mechanisms with experts
[22] varying from a large earthquake can occur anyplace

[1] for any reason to very specific zones, other
[2] experts saying very specific zones were
[3] responsible. There was a lot of ambiguity in
[4] accepting this multiple hypothesis. USGS perhaps
[5] were developed from the fact — from the
[6] observation that many scientists were not content
[7] with the 1960-70, Elgin Mercer risk maps which were
[8] based on fairly distinct zones which — in 1960 the
[9] zones were not well known so some of those zones
[10] have turned out to be unrealistic by today's
[11] seismic standards. So USGS maps were developed
[12] based on purely seismicity, existing earthquakes,
[13] so they represent a point source for New Madrid
[14] because that is where the earthquakes occurred. A
[15] wider zone around there, where earthquakes
[16] occurred, Charleston is a bull's eye on the map in
[17] South Carolina, because that is where most of the
[18] earthquakes have occurred, not all, but most. So
[19] the USGS hazard maps are based to a large extent
[20] primarily on existing knowledge of seismic
[21] earthquakes and also knowledge of earthquakes that
[22] are above magnitude of three, three and a half,

[1] something like that. So they represent — they are
[2] based on earthquakes and seismicity that is
[3] reasonably well documented by eliminating smaller
[4] magnitudes, they eliminate the possibility that in
[5] many areas of the country the smaller quakes have
[6] not been documented to the same extent as they have
[7] been in others.

[8] The 2000 maps represent improvements in
[9] their knowledge of things like attenuation and
[10] seismicity. The 2000 maps included an
[11] Ackerman/Boore relationship, which is perhaps a
[12] little more appropriate for the eastern U.S. than
[13] the earlier attenuation relationships.

[14] (The witness consulted with counsel.)

[15] THE WITNESS: Atkinson. Excuse me. I am
[16] not sure I know an Ackerman.

[17] BY MR. POLONSKY:

[18] Q: The New Madrid seismic source zone,
[19] again, you stated that there was a California model
[20] that faults cause earthquakes and that there was a
[21] second model for explaining the origins of
[22] earthquakes in that area and that would be

[1] anomalous in the crustal structure. Is that an
[2] accurate statement?

[3] A: Anomaly in the physical properties of the
[4] crust in the area, yes.

[5] Q: What weight would the scientific
[6] community place on the theory of anomalies in the
[7] physical properties in the crust for New Madrid
[8] originated earthquakes?

[9] A: What is my opinion as to the scientific
[10] community?

[11] Q: Of course, what is your opinion.

[12] A: I can't say what they would say. I
[13] always — and obviously my view of what the
[14] scientific community thinks is biased by my own
[15] opinions so that is not an easy thing to judge.

[16] This has to be a pure guess. I would say at this
[17] time it is on the order of 25 percent. I would say
[18] that is up from what it was sometime back.

[19] Q: So in your opinion, approximately a
[20] quarter of the experts, seismic experts out there,
[21] would say that the origin of New Madrid earthquakes
[22] is from anomaly of physical properties of the

[1] crust?

[2] A: We have a problem with experts. Because
[3] experts can be seismological experts but they may
[4] know about Turkey earthquakes and they may not know
[5] about intraplate or eastern earthquakes. If you
[6] pick experts, you would say fault mechanism is the
[7] ideal. If you take Eastern United States experts,
[8] you would get a larger percentage.

[9] Q: In your opinion what percentage of
[10] experts with expertise in Southeastern United
[11] States seismicity or central and eastern seismicity
[12] would say that the physical properties —

[13] A: I think we can count the experts on the
[14] Southeastern United States on one hand.

[15] Q: How many are there?

[16] A: Well, I think Perdita Uani, Gil
[17] Bollinger, myself and that is about it.

[18] Q: Who was the second one?

[19] A: Gil Bollinger.

[20] Q: And yourself?

[21] A: Yes. There are people who have
[22] concentrated their studies on the Southeastern

[1] United States, have looked at this problem over a
[2] number of years.

[3] Q: And where do you believe Perdita Uani
[4] falls in that camp?

[5] A: In a concentrated zone.

[6] Q: That would be the anomalies in physical
[7] properties?

[8] A: I don't know if he understand that but he
[9] believes in the concentrated zones.

[10] Q: And Gil Bollinger?

[11] A: I don't know exactly where he would stand
[12] on that. He retired a few years ago. He hasn't
[13] seen the latest data. I think he would be
[14] concentrated zone and I believe it is anomalous
[15] features that develop over short time periods that
[16] create these earthquakes.

[17] Q: What data would you need to evaluate the
[18] potential for the occurrence of a large to major
[19] earthquake?

[20] A: With the occurrence of a —

[21] Q: Let me back up. What is your definition
[22] of a major earthquake?

[1] A: A major earthquake is an earthquake that
[2] ruptures at depth with significant fault size to
[3] cut across the major strength on the U.S. across,
[4] which is anywhere from five to 15 kilometers. So
[5] we are looking at an earthquake with seismic fault
[6] of anywhere from five to 15 kilometers.

[7] Q: What moment magnitude would you consider
[8] a major earthquake?

[9] A: Knees type of earthquakes — the crustal
[10] conditions that support these types of earthquakes
[11] would imply earthquakes of magnitude of probably
[12] five, five and a half and above. There is a very
[13] well known Gutenberg-Richter recursion relationship
[14] that says if you have an earthquake of magnitude
[15] six, you have about 10 magnitude fives, 100
[16] magnitude fours, so other levels of seismicity will
[17] be observed in general in seismic areas. We are
[18] talking here about what is the largest earthquake
[19] that could be supported.

[20] Q: Maybe you are going beyond my question.
[21] I was just asking for your definition of what major
[22] earthquake means to you?

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[1] A: My definition of a major earthquake may
[2] not — you can define it many ways.
[3] Q: I am just asking for your definition.
[4] A: I consider a major earthquake one that
[5] actually occurs in a portion of the crust where it
[6] can break the earth's crust and so we are looking
[7] at a mechanism and size of event that could support
[8] a very large event even though a major event for
[9] that area might be smaller than the very largest.
[10] Q: I am a little confused by your answer.
[11] Is there a simple way of bounding, what you consider
[12] major?
[13] A: My definition is based on a mechanism and
[14] not a size.
[15] Q: Your mechanism is a crustal break between
[16] five and 15 kilometers?
[17] A: We didn't delve into the smaller
[18] earthquakes for which I said I have another theory.
[19] I believe in the Southeast, what I have observed is
[20] that we have many earthquakes that occur that are
[21] very shallow, half a kilometer to one kilometer.
[22] Other people locate them as deep as four or five

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[1] kilometers. So we probably max out at magnitude of
[2] five, five and a half.
[3] Then there are areas in the Southeastern
[4] United States, like Charleston, New Madrid, not
[5] Southeastern but Southeastern Tennessee seismic
[6] zone where we have earthquakes that occur in the
[7] depth range of four to five kilometers down to 15
[8] and in some cases in Southeastern Tennessee the
[9] zone is as deep as 25 or 30. That indicates
[10] seismicity which can go through the earth's crust.
[11] It is not a surficial feature and I would say a
[12] major earthquake can occur in any zone where we
[13] have earthquakes occurring at substantial depth,
[14] and that a major event to me would be one that
[15] actually ruptures the crust with a substantial size
[16] of the fault zone being five to 15 kilometers, I
[17] believe I said.
[18] Q: I am going to hold off on additional
[19] questions of Southeast Tennessee and take you back
[20] to your theory of minor earthquakes. What is your
[21] hypothesis for explaining minor intraplate
[22] earthquakes?

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[1] A: Many people associate minor seismicity
[2] with dams in the reservoir and call them
[3] reservoir-induced seismicity and very often that
[4] seismicity is expunged from the catalogs as not
[5] being representative of tectonic events. My
[6] indication is that reservoir-induced seismicity and
[7] many of the earthquakes we see in the Georgia,
[8] Piedmont and all the way up into Virginia and New
[9] England, where the crystalline rocks crop out at
[10] the surface, many of these earthquakes are due to
[11] movements on existing faults, and that that
[12] movement may be triggered by some mechanism
[13] involving fluids in the rocks. There have been
[14] many perturbations on the theory, most of them
[15] relate to the same mechanism for reservoir-induced,
[16] in part, that the fluids increase from the
[17] reservoir, that puts pressure on the falls so
[18] fractures separating them, causing them to weaken
[19] and fail.
[20] Q: At what depth are these earthquakes
[21] occurring, in your opinion?
[22] A: The distribution of earthquakes I have

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[1] observed, and I believe I have adequate seismic
[2] coverage, are in the range of .25 to 2 kilometers.
[3] Most of them .5 to 1 kilometer, and I think I could
[4] argue that everybody who finds them deeper doesn't
[5] have adequate station coverage.
[6] Q: What is in your opinion the perception of
[7] your minor earthquake origin theory?
[8] A: Those that recognize that there is a
[9] difference I think accept it. Those that look at
[10] seismicity and say that is an earthquake, probably
[11] don't go far enough into it to decide whether they
[12] accept it or not.
[13] Q: Would you say your minor earthquake
[14] theory is well accepted in the scientific
[15] community?
[16] MS. CURRAN: I am going to object because
[17] I think Dr. Long has already told you that requires
[18] him to speculate and I think you are asking him to
[19] speculate about what other people think.
[20] BY MR. POLONSKY:
[21] Q: I would like an answer. You can answer
[22] the question.

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(1) A: In my opinion by the time I finish
(2) publishing the papers, everybody will agree,
(3) doesn't mean they will agree with every earthquake
(4) but they will agree on the mechanism.

(5) Q: Does this minor theory work only where
(6) there are crystalline rock crops out at the
(7) surface?

(8) A: It works where there are fractures of
(9) crystalline rocks with fairly — rocks of fairly
(10) substantial strength.

(11) Q: The crystalline rock doesn't mean to —

(12) A: It doesn't need to crop out at the
(13) surface. I think the induced seismicity in Denver
(14) was fluids pumped into crystalline rocks in the
(15) basement and there the fluid pressure was increased
(16) significantly, triggering the sequence of
(17) earthquakes.

(18) Q: How is increasing fluid pressure
(19) occurring in your opinion between 0.25 and 2
(20) kilometers other than a man-induced fluid pressure?

(21) A: Rainfall. Rainfall and time variability
(22) in the fluid conductiveness of the rock, the

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(1) ability of the rock to transmit fluids.

(2) Q: GANE contention three is entitled
(3) Inadequate Seismic Design. Do you have any
(4) opinions as to how the seismic design of the MOX
(5) Facility is inadequate?

(6) A: Sounds like the whole contention. What I
(7) did is I looked over, in the limited time I had, I
(8) looked over the design or set up the analysis and
(9) have stated opinions as to whether the techniques
(10) that were used represented either the most recent
(11) developments in understanding or whether they were
(12) in some way — under estimate or over estimate the
(13) hazard at the site. I found, as the contention
(14) states, that there are a number of issues that lead
(15) to uncertainties and to conclusions.

(16) Q: Are there any other issues in your
(17) opinion of where the MOX Facility seismic design is
(18) inadequate other than that stated in the contention
(19) or in interrogatory responses?

(20) A: I am sure that a qualified person dealing
(21) with various aspects of analysis could find that,
(22) I have only tried to emphasize those that I felt

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(1) fairly confident about.

(2) Q: Can you identify for me the specific
(3) things that you believe are inadequate in the MOX
(4) Facility?

(5) A: One of the things that they have done is
(6) to accept that Lawrence Livermore and EPRI
(7) evaluations for the site. It is my opinion that
(8) the attenuation relationships that were used to
(9) derive the hazard should be updated. I think that
(10) the studies, Atkinson and Boore and her more recent
(11) studies, document what I have felt for a long time,
(12) and that is in the distance range of around 100
(13) kilometers, the so-called mobile bounce post
(14) critical reflection enhances the amplitude of
(15) vibration, and that was not taken into account in
(16) the hazard computation, at least not properly taken
(17) into account in the hazard computation.

(18) It has always been my understanding,
(19) based on a question I asked a long time, and I have
(20) forgotten who, that the individual sites that were
(21) analyzed by Lawrence Livermore/EPRI as test sites
(22) were never meant to be used for citing purposes,

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(1) they were meant largely as a test, that any citing
(2) should be done in the future by considering local
(3) conditions, local properties, and a more detailed
(4) analysis of both the seismicity and the
(5) transmission in that feature. I don't believe that
(6) was done in this case.

(7) Q: Regarding EPRI and Livermore studies, do
(8) you have any other issues of how they were used in
(9) incorporating the seismic design of the MOX
(10) Facility or in generating the seismic design of the
(11) MOX Facility?

(12) A: Let me see if I understand that. It is
(13) my understanding that the results of the
(14) EPRI/Lawrence Livermore studies were accepted with
(15) the hard rock spectral properties, and then the
(16) amplitude was fixed, .2 G —

(17) Q: I am sorry, I can't hear you?

(18) A: The amplitude was fixed at .2 Gs, is my
(19) understanding. I think to the extent that they
(20) actually used those studies — the question is is
(21) the .2 or the value that comes out of the EPRI and
(22) Lawrence Livermore studies appropriate and whether

[1] it is appropriate or not would depend on whether a
[2] revision or update of seismicity and attenuation
[3] relationships indicated that it was appropriate.
[4] **Q:** Are there any other opinions that you
[5] have as to how the seismic design of the MOX
[6] Facility other than the Livermore and EPRI studies
[7] used inappropriate attenuation and they should be
[8] updated using Atkinson and Boore?
[9] **A:** A supplemental check study was the
[10] propagation of the Charleston earthquake to the
[11] site. That study utilized a crustal model which
[12] was derived from an old study by Hermann. The
[13] crustal model that Hermann came up with does not
[14] apply to the path of the Charleston site. Hermann
[15] came up with a two-layer crustal model based on
[16] dispersion data which really is an average of
[17] distance from Bowman — excuse me, there was a
[18] Bowman earthquake used, from the Bowman central
[19] area to the Atlanta seismic station and in crustal
[20] structure varies significantly and when you average
[21] it out, it looks like a two-layer crustal model but
[22] there is not a two-layer crustal model either

[1] anyplace along the line. It is a fact that the
[2] crustal thickness varies. So the model really of a
[3] two-layer model is not appropriate.
[4] When propagating, using the theory to
[5] propagate waves through a two-layer model, it
[6] disturbs and perturbs the attenuation of the
[7] distance functions and I believe in such a way that
[8] it would have released the amplitude of the mobile
[9] bounce and put in longer amplitudes and shorter
[10] distances. That is a relationship which should be
[11] checked by using a proper crustal model, not
[12] speculating.
[13] **Q:** Do you have any opinions as to any other
[14] inadequacy in the seismic design of the MOX
[15] Facility other than what you have just told us?
[16] **A:** Lots of small details here. I think I
[17] would want to go through the contention point by
[18] point and look at it to see whether — what those
[19] issues were in detail. There are small details
[20] like how many earthquakes are there at Charleston
[21] of large magnitude, where could a Charleston type
[22] earthquake occur, is it limited to Charleston or in

[1] a significantly long time period in the future
[2] could one occur some place else, the probability of
[3] that, I don't know has been fully addressed. I
[4] think there are a lot of details but most of it
[5] falls in the category of what I am talking about.
[6] (The witness consulted with counsel.)
[7] **MR. POLONSKY:** Diane, is there a document
[8] I should bring out?
[9] **MS. CURRAN:** I wrote some words on a
[10] piece of paper to remind myself.
[11] **THE WITNESS:** We mentioned earlier that
[12] the national seismic program produced maps and I
[13] believe the numbers that come out of that are
[14] somewhat higher. I would have to refer to the
[15] actual map to see what the numbers are for the
[16] area. The letter you wrote stated — 379(g) and
[17] the numbers I observed are between .40 and .60
[18] contour lines.
[19] **Q:** If you could just clarify, USGS numbers?
[20] **A:** Those numbers are the two percent
[21] probability in 50 years.
[22] **Q:** You are referring to the return period?

[1] **A:** Yes.
[2] **Q:** Do you have any other concerns with USGS
[3] other than return period?
[4] **A:** The question you asked is do I have
[5] concern with USGS maps other than return period?
[6] **Q:** Let me rephrase. I am sorry. Do you
[7] have an opinion as to how, looking at the seismic
[8] designs of the MOX Facility, the USGS suggests some
[9] inadequacy other than an inadequacy in the
[10] development of the return period?
[11] **A:** USGS is a different type study. It is a
[12] purely seismically controlled — historically
[13] seismicity controlled, without speculation on
[14] whether events have occurred over long time period
[15] or whether they could occur in other areas. The
[16] utilization is something like — it is possible.
[17] There is a study by Kafka in New England that
[18] looked at a number of occurrences of the larger
[19] earthquakes and found that the existing seismicity
[20] was able to predict — not predict, but to provide
[21] a good estimate of what 70 percent might occur. 30
[22] percent occurred in areas where there hadn't been

[1] any historical seismicity there. So that is a
[2] statistical property of the seismicity that the
[3] USGS had not incorporated in and could have been
[4] incorporated in the MOX study.

[5] Q: I understand you have now identified an
[6] issue that you believe USGS could have considered
[7] something but my question was whether DCS in
[8] preparing the seismic design for the MOX Facility
[9] should have contained anything and you have
[10] identified return period.

[11] A: I think the design for the MOX Facility
[12] should have been based on a recomputation of the
[13] hazard for the site using up-to-date attenuation
[14] relationships and the best estimate of the seismic
[15] rate of occurrence, and I think the USGS study is
[16] really based purely on — almost entirely on
[17] seismicity and on attenuation relationships which
[18] are one-third Atkinson and Boore and two-thirds the
[19] other two studies of attenuation relationships that
[20] were used.

[21] Q: Did you mean to say that the USGS study
[22] is —

[1] A: The USGS study used attenuation
[2] relationships that were one-third Atkinson Boore
[3] and two-thirds other — the original — the 2000
[4] USGS study was one-third Atkinson/Boore and
[5] two-thirds relationships used in the '95 study, and
[6] in my opinion the study for the region, where the
[7] Charleston earthquake should have used a past
[8] specific attenuation relationship which would have
[9] been similar to the Atkinson/Boore but should have
[10] been corrected and adjusted for very likely
[11] possibility that the mobile bounce is going to give
[12] you a larger signal. For seismicity in the other
[13] direction, which is probably not as significant, a
[14] different attenuation relationship should be used.

[15] Q: So you disagree with the way USGS was
[16] preparing for the 2000 maps because they used
[17] one-third Atkinson/Boore and two-thirds other
[18] studies left over from the 2000 maps?

[19] A: I disagree with using their maps for a
[20] specific site, when their technique although
[21] appropriate for getting an estimate for the whole
[22] eastern United States, was an appropriate

[1] technique, it may not be appropriate for a specific
[2] area. Specific areas may have sufficiently
[3] anomalous features to cause a change in what the
[4] estimate should be.

[5] MR. POLONSKY: Let's take a short break.
[6] (Discussion off the record.)
[7] (Recess.)

[8] BY MR. POLONSKY:

[9] Q: Before we broke we were discussing GANE
[10] contention three and its title, Inadequate Seismic
[11] Design. Everything you have listed so far where
[12] you have an opinion as to how it is inadequate
[13] appears to deal with what is commonly referred to
[14] as the design basis earthquake or the spectral
[15] shape that was generated for the facility. Do you
[16] have any opinion whether there are any inadequacies
[17] in the design other than in the design spec?

[18] A: There is a big issue of how the waves are
[19] propagated from the base of the sediments to the
[20] surface. I have not addressed that because I don't
[21] feel like I am an expert and I also understand that
[22] the variability and the constants and the programs

[1] are such that one can get a large variation in
[2] numbers and I couldn't see there was anything
[3] substantially incorrect about the way it was done.

[4] Q: Are you referring here, and tell me if I
[5] am reading into this, the issue of liquefaction in
[6] soils?

[7] A: I hadn't thought of liquefaction. I was
[8] thinking of the generation of surface motion from
[9] the base. Liquefaction is an issue of its own. It
[10] is usually limited to shallow layers and requires
[11] an understanding of the conditions of the materials
[12] and their specific type and that is not information
[13] I have gone into.

[14] Q: I thought we had an agreement that we had
[15] withdrawn that and I wanted to make sure that when
[16] you were discussing propagation from the base to
[17] the surface, that you were not still saying —
[18] that liquefaction is not on the table.

[19] MS. CURRAN: I think we can stipulate
[20] that it is not on the table. He is trying to be
[21] responsive as an expert.

[22] MR. POLONSKY: I am trying to make sure I

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[1] understand when you say waves from the base to the
[2] surface, you are discussing how it was propagated
[3] to the surface and not liquefaction.

[4] BY MR. POLONSKY:

[5] Q: Do you have any challenge to the vertical
[6] spectrum?

[7] A: No, I did not look in detail at the
[8] spectrum, or variations in the spectrum.

[9] Q: Do you have any plans to look at the
[10] vertical spectrum?

[11] A: Not on my own. As a request, perhaps,
[12] but not on my own.

[13] Q: Have you been requested as of today to
[14] look at the vertical spectrum?

[15] A: No.

[16] Q: Do you have a concern with the bedrock
[17] spectra at the MOX Facility?

[18] A: Not really. The spectra itself is fairly
[19] generic. I think the concern is with the
[20] amplitude, not the spectral shape. The factors
[21] that will affect the spectral shape are the stress
[22] drop from the Charleston earthquake, or the major

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[1] earthquakes and the attenuation along the path. I
[2] didn't see anything in there that was terribly out
[3] of line. I think that the path, propagation path,
[4] the geometrical attenuation could be a concern but
[5] that relates to the amplitude and not the spectral
[6] content.

[7] Q: When you said you did not see anything in
[8] there that was terribly out of line, you are
[9] referring to the bedrock spectra?

[10] A: To the spectra, yes.

[11] Q: Do you have any concerns regarding the
[12] surface spectra of the MOX Facility?

[13] A: I really didn't go into detail on that.

[14] Again, the reason for that was to propagate from
[15] the base to the top contains a lot of assumptions
[16] about the base properties and although I could have
[17] looked at that, I did not. A complete analysis of
[18] that would require one to look at the propagation
[19] through the sediments as well as the vertical
[20] response from the typical program like SHAKE. I
[21] believe they simply used the SHAKE program in that.
[22] I think that there is enough ambiguity in the SHAKE

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[1] program and in the definition of the velocity
[2] structure to where I didn't feel I could contribute
[3] to it. I know that some studies were done with
[4] observed data. I don't know that those results
[5] were included in this.

[6] Q: In this, are you referring to the surface
[7] spectra?

[8] A: In the surface spectra, yes.

[9] Q: Do you have any concerns at all with the
[10] shape or wear — let me ask it in parts.

[11] Do you have any concern with the shape of
[12] the surface spectra for the MOX Facility?

[13] A: In general, no.

[14] Q: Do you have any concern with where that
[15] shape was anchored at deep ground acceleration?

[16] A: With amplitude, yes. We anchored the
[17] shape at a given amplitude.

[18] Q: What was that amplitude?

[19] A: My understanding was it was anchored at
[20] .2 hard rock and it was at a given frequency. I
[21] would have to look it up.

[22] Q: When you say .2 hard rock, what do you

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[1] mean?

[2] A: The amplitude as defined by the
[3] spectral — the probabilistic seismic hazard
[4] assessment for hard rock conditions.

[5] Q: Would that be also at bed — when you
[6] state that it is 0.2 G hard rock, are you referring
[7] to where it was anchored at bedrock or at surface
[8] because I was referring to the surface spectra and
[9] I am confused —

[10] A: I have always been confused because
[11] engineers talk about hard rock being something you
[12] can't pound through and seismologists think of hard
[13] rock as the seismicity. I am not surprised you are
[14] confused.

[15] My first reference is when I talk about
[16] hard rock it is at the base of the sediments but
[17] that I understand is not necessarily correct in
[18] this context so I have to say oops, I am talking to
[19] engineers as well so I have to say that is the
[20] position at which the seismic energy would be — it
[21] is the position in the column where the seismic
[22] energy would represent a sort of pseudohard rock

(1) response as defined by the — both the
(2) EPRI/Lawrence Livermore and USGS. All of those
(3) have hard rock definitions. Where that occurs in
(4) the column, I am not too sure.

(5) Q: Let me go over basics at the Savannah
(6) River Site. Are you aware there is approximately
(7) 1,000 feet of soil sediment?

(8) A: Yes, coastal plain sediments.

(9) Q: Are you aware that there is a thousand
(10) feet of sediments between the surface in the F area
(11) and where we would refer to as bedrock?

(12) A: That is approximately correct.

(13) Q: When we refer to the surface spectrum,
(14) are you referring to the top of that thousand foot
(15) layer of soil?

(16) A: Yes.

(17) Q: When you refer to hard rock conditions,
(18) are you referring to somewhere around the bedrock?

(19) A: Somewhere around the bedrock or up in the
(20) sediments.

(21) Q: But somewhere below 1,000 feet —

(22) A: I don't know about thousand feet but

(1) below the surface.

(2) Q: Would it be many hundreds of feet?

(3) A: That would be a thousand. I would have
(4) to talk to some engineers and say where do you
(5) think the hard rock is and where does it occur, and
(6) that definition is different among the two groups
(7) of scientists.

(8) Q: Go back to the surface spectrum. You
(9) said, I think, that you don't have any concerns
(10) with the shape of the surface spectrum but that you
(11) have a concern with the amplitude of that spectrum;
(12) is that correct?

(13) A: I have a concern with the hard rock
(14) spectral amplitude. I haven't gone into details of
(15) propagation from the base to the top, to know
(16) whether the shape or amplitude of the surface
(17) spectra is appropriate. I haven't stated an
(18) opinion on that.

(19) Q: Do you plan to do any work —

(20) A: No.

(21) Q: — to have an opinion —

(22) A: Not unless asked.

(1) Q: And have you been asked?

(2) A: No.

(3) Q: What do you believe should be the
(4) amplitude for the horizontal surface spectra?

(5) A: Not having done it it is hard to say what
(6) it should be. I have looked at the engineering
(7) studies in many cases and typically they use a
(8) program like SHAKE which vibrates a column of
(9) sediments to come up with the surface and they put
(10) everything from the real surface on down and the
(11) results come up very often with almost outlandish
(12) vibrations at the surface which will get wiped out
(13) during construction. The question is where is the
(14) relevant motion and how much should it be and
(15) without running numbers and putting in
(16) qualifications, I couldn't tell you.

(17) Q: What studies have you done to provide
(18) assistance to GANE in this contention?

(19) A: Actual studies have been limited. Most
(20) of the work has simply been taking over the — I
(21) think the first one was prepared by someone else
(22) and I went through those concerns and gave my

(1) opinion to GANE as to whether they were appropriate
(2) or not.

(3) (The witness consulted with counsel.)

(4) THE WITNESS: Is that the interrogatory
(5) answer, I believe, I was referring to? The first
(6) interrogatory was not something I put together. So
(7) most of the work — I have not done computations
(8) for this. I have simply looked at the data and
(9) expressed opinions based on my experience and
(10) background, I guess back-of-the-envelope
(11) calculations I have done, but not actual analyses.

(12) BY MR. POLONSKY:

(13) Q: You started off by saying actual studies
(14) have been limited. That implies that you have done
(15) some studies. What are those studies?

(16) A: Later on I said I have done
(17) back-of-the-envelope studies. I have done a lot of
(18) studies but not with respect to this specifically
(19) and I have been able to draw on those to say
(20) whether or not the contentions were viable.

(21) Q: What kind of back-of-the-envelope studies
(22) have you done?

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[1] A: Just estimating numbers and
[2] calculations — by that I mean just small
[3] estimates, nothing that involved computer
[4] simulation.

[5] Q: When you say estimating numbers and
[6] calculations, we have spoken a lot — spoken about
[7] many different types of relationships —

[8] A: I can give you an example —

[9] Q: I would actually like all of the
[10] examples, if you could recall them?

[11] A: There is no way I could recall all the
[12] examples. This has gone on for a year or two, at
[13] various times. This is not something — when you
[14] do back-of-the-envelope calculation you don't
[15] necessarily keep track of it. One example is when
[16] I looked at the 1995 Atkinson/Boore article and
[17] looked at their observed attenuation relationships
[18] and at the end of the article they plot a
[19] comparison data with their composite or theoretical
[20] curves which has utilized by the USGS. Then if you
[21] look at the 100 kilometer distance range you see a
[22] note — that they note in the article that there

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[1] are some anomalous features there, that the
[2] amplitudes that are observed vary from a factor of
[3] two to a factor of four above their theoretical
[4] curves.

[5] Q: Have you documented any of your
[6] back-of-the-envelope calculations?

[7] A: No. That is why they are
[8] back-of-the-envelope.

[9] Q: Are they recorded in paper form anywhere?

[10] A: Probably not.

[11] Q: Do you intend to at any point to put them
[12] to paper?

[13] A: None of them were extensive enough to
[14] warrant publication and that would be putting them
[15] to paper, yes. There are a number of things that
[16] have come out of this that I think probably should
[17] be published.

[18] Q: Are there any back-of-the-envelope
[19] calculations that you have done, in the literal
[20] sense, without meaning publications, have been
[21] reduced to a piece of paper?

[22] A: All of the documentation — all of the

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[1] paperwork I have done has been submitted as part of
[2] the documentation to GANE or as part of these
[3] interrogatories.

[4] Q: When you say back-of-the-envelope and I
[5] mean someone takes a piece of paper, they write
[6] down what they are doing. Did you, at the time you
[7] were doing these calculations, put down with a pen
[8] or pencil, whatever medium, on to a written piece
[9] of paper?

[10] A: In some cases, but that paper, usually,
[11] because it is back-of-the-envelope, is thrown away.

[12] Q: Did you retain any of those?

[13] A: No.

[14] Q: Is there anything that you intend to rely
[15] upon for your opinions that you have reduced to
[16] paper that is not already contained in an
[17] interrogatory response?

[18] A: There is a recent article by Atkinson and
[19] a student that just came out which actually
[20] reinforces the attenuation relationship for eastern
[21] U.S. that contains this normal amplitudes at 100
[22] kilometers.

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[1] Q: And you intend to rely on this paper for
[2] your opinions in this case?

[3] A: Yes. Solomon, L.R. Solomon.

[4] Q: Where is that paper published?

[5] A: Seismological Research Letters.

[6] MS. CURRAN: You can have a copy, if you
[7] would like.

[8] BY MR. POLONSKY:

[9] Q: Have you begun any studies other than
[10] back-of-the-envelope calculations to support GANE
[11] in this contention?

[12] A: Specifically at the request to support
[13] GANE, no. My work over the last 20 or 30 years has
[14] involved these topics and in most cases it is not
[15] something I needed to do.

[16] Q: Briefly for the record, since you brought
[17] up your background, could you provide for us an
[18] educational background, briefly, from college to
[19] the present?

[20] A: Okay. My undergraduate is in geology at
[21] the University of Rochester in upstate New York. I
[22] have a master's degree in physics from New Mexico

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(1) Tech where I wrote a thesis on — New Mexico
(2) Institute of Mining and Technology, full name,
(3) where I wrote a thesis on seismic noise, largely
(4) from trains and trucks, and I also did work there
(5) on micro earthquakes, small earthquakes in the
(6) seismic zone and on recording of larger mine
(7) blasts.

(8) I went from there to Oregon State where I
(9) worked with Joe Burke. This was on — my thesis
(10) at Oregon state was on transmission and attenuation
(11) of seismic waves or P waves in distance range of
(12) 100 to 300 kilometers — excuse me, 100 to 600
(13) kilometers.

(14) I went from there to Georgia Institute of
(15) Technology where I have worked on all aspects of
(16) seismicity and coastal structure in the
(17) Southeastern United States.

(18) Q: What year did you graduate from — your
(19) Ph.D.?

(20) A: I will have to count back. '66 or '67, I
(21) forget. I went to Georgia Tech in '67 and I think
(22) the degree was formally — I formally graduated in

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(1) June of that year.

(2) Q: Is it correct that your master's thesis
(3) was on seismic noise?

(4) A: Ground noise, yes, micro seisisms.

(5) Q: You said largely from trains and trucks,
(6) were any of those from actual earthquakes?

(7) A: My research assignment there was to work
(8) with micro earthquakes. I have a paper on that
(9) showing reflections from an intermediate level in
(10) the crust that we discovered for the first time. I
(11) was able to document that there was in fact a magna
(12) chamber down below the Rio Grande River.

(13) Q: Your Ph.D., is that the looking at
(14) seismic attenuation of P waves in the range of 100
(15) to 600 kilometers?

(16) A: Yes.

(17) Q: Can you give a little more detail about
(18) that?

(19) A: We had a number of refraction lines from
(20) nuclear tests. They were — I was supported by the
(21) VALA uniform program for a year or two and we had
(22) data recorded by the USGS along refraction lines.

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(1) We looked in detail at the wave form and the
(2) character of the P waves as it propagates away from
(3) the nuclear test site. One was in new Mexico, and
(4) the other in Nevada, and I related the travel
(5) times — I related the character of the arrivals to
(6) the attenuation — absorptive attenuation in the
(7) crust and to the geometrical spreading in the
(8) crust, and I came up with a gradient model for both
(9) the crust and for the layers below the Moho, which
(10) I felt explained the propagation much better and I
(11) used various computer programs that I wrote to
(12) generate attenuation versus distance functions for
(13) those.

(14) Q: Veil —

(15) A: V A L A.

(16) Q: What is that?

(17) A: It was — the main thrust of the program
(18) was to learn more about propagation so one could
(19) detect nuclear explosions.

(20) Q: When you say P wave, is that short for
(21) primary —

(22) A: Primary compression wave.

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(1) Q: And my understanding is that is the first
(2) wave to hit a recording instrument?

(3) A: Yes. It is the fastest.

(4) Q: So you came up with a gradient model for
(5) both the crust and the layers below. What was that
(6) model?

(7) A: What was it? I had two. One for New
(8) Mexico and one for northern Nevada, and in the New
(9) Mexico one, it was fairly flat layer, but in Nevada
(10) it was basin layer which has a fairly shallow Moho
(11) and then at the end it thickens. A gradient model
(12) layer — a gradient model is one in which the
(13) velocity is a function of depth. So it increases
(14) gradationally with depth. The program you all
(15) used, the Hermann model used constant velocity
(16) layers which is an approximation to what is
(17) actually there. I justified the gradient model on
(18) the basis of the amplitudes and the arrival time of
(19) the waves.

(20) Q: What do you consider to be fairly shallow
(21) for depth of the Moho?

(22) A: In continental areas in the area of 18 to

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(1) 20 kilometers. 50, 45, 55, is fairly deep.

(2) Q: What would the SRS be?

(3) A: Around 30, 30 to 33.

(4) Q: Somewhere in between shallow and deep?

(5) A: Yes. Closer to the coast it gets a

(6) little bit shallower, 28, 27.

(7) Q: What exactly does a degree in geophysics

(8) give you as it pertains —

(9) A: Besides 50 cents and a cup of coffee —

(10) Q: As it applies — I will narrow the

(11) question. As it applies to the seismic design of

(12) any building, let's keep it that simple.

(13) A: A degree in geophysics like many degrees

(14) depends on who you work with and what your

(15) experience is. In geophysics, it implies that you

(16) have developed a background which includes

(17) understanding many aspects of the earth's —

(18) physics of the earth, extending from the core to

(19) the very shallow surface but most importantly you

(20) should understand the principles that are used to

(21) explore and study the earth. So I have had course

(22) work and training in the magnetic field of the

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(1) earth, in the gravitational field of the earth, I

(2) have done some work with gravity data and in

(3) seismic training you have interpretation of seismic

(4) refraction data, theory of wave propagation or

(5) theoretical seismology so you get a broad

(6) background and depending on the institution you may

(7) have more exposure to the engineering side. At

(8) Georgia Tech there are many engineers working there

(9) so I have had more exposure there than I did for my

(10) degree.

(11) Q: Have you written any papers or reports

(12) that specifically relate to nuclear regulatory

(13) requirements governing seismic design?

(14) A: In terms of the requirements, no. Almost

(15) all my work has dealt with the science, not the

(16) regulatory — or regulation side.

(17) Q: Have you written or published any papers

(18) or reports that specifically relate to seismic

(19) design of nuclear facilities?

(20) A: I probably have participated in a number

(21) of them. Some may or may not be available. I have

(22) over the years been a consultant to Law

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(1) Environmental Services. They have prepared

(2) documents which I have contributed to concerning

(3) the citing or the various aspects of a number of

(4) nuclear facilities in the Southeast, either

(5) proposed or constructed. It would not be possible

(6) to give you a list of those.

(7) Q: Would it be possible for you to just

(8) identify in your work through Law Engineering

(9) Services the facilities that you assisted in

(10) preparing seismic design or seismic hazard for?

(11) A: Some were small pieces of work. Some

(12) were larger. Plant in south Georgia. I did an

(13) early refraction survey to give them sheer wave

(14) velocity. I believe it was a large bar in

(15) Tennessee where I did work with them on trying to

(16) interpret — this was the definition of a

(17) consulting job, actually. They had not — I could

(18) not get the right answer so the night before they

(19) called me in and said, you have this data, we need

(20) the report tomorrow and the problem was in that

(21) area the layers are tilted at a 45 degree and they

(22) were looking at cross whole data and they couldn't

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(1) figure out why the velocity was different in one

(2) direction than the other and the engineers didn't

(3) know what to do with the material where you have

(4) velocities being different. They said we want a

(5) sheer wave velocity, not two of them. But I did

(6) the engineering. Law Engineering did a number of

(7) reports for Duke Power which I contributed to for

(8) the siting.

(9) Q: What was your role for the work done by

(10) Law for Duke Power?

(11) A: Mostly as a seismic consultant.

(12) Q: That is very broad?

(13) A: Yes, it is a very broad topic and the

(14) questions were very broad. Sometimes it was

(15) regional seismic. Sometimes it was solving a local

(16) problem like a cross whole study. Where you drill

(17) two drill holes and you shoot across to see if you

(18) can get the velocity. There are a lot of problems

(19) associated with that and sometimes the engineers

(20) use a calculator with limited precision and you get

(21) strange answers.

(22) Q: For any of those facilities, either Duke

(1) Power or southern Georgia, were you involved at all
(2) with the seismic design of any of the components or
(3) the building itself?

(4) A: Not the design of the components of the
(5) building itself. I have been asked about problems
(6) a couple of times but I refrain from engineering
(7) aspects of seismic design.

(8) Q: Were you asked or have you done
(9) engineering aspects of seismic design at any time
(10) in the past?

(11) A: No, not really.

(12) Q: Any other work other than the work you
(13) did for Duke Power, the facility in southern
(14) Georgia and Watts' bar?

(15) A: With respect to facilities, that is
(16) probably it. That is a big area and that is my
(17) area of experience. I wouldn't be expected to do a
(18) seismic study outside of the area.

(19) Q: Do you belong to any professional
(20) societies that relate in any way to seismic design
(21) of facilities — that are specific to seismic
(22) design of facilities?

(1) A: I don't believe so. Seismological
(2) Society of America. All seismologists pretty much
(3) belong to that.

(4) Q: Have you done any consulting with respect
(5) to NRC requirements governing seismic design?

(6) A: I don't believe so. Again, I have stayed
(7) pretty much on the science end of it, not the
(8) regulatory end.

(9) Q: What is your current title?

(10) A: Professor of geophysics.

(11) Q: What are your duties and responsibilities
(12) in that position?

(13) A: Teach and research.

(14) Q: What research are you involved in?

(15) A: Right now my major point is tomographic
(16) conversion of surface waves for shallow —
(17) detection of shallow structures.

(18) Q: What is tomographic conversion?

(19) A: It is what we use to — if you have data
(20) outside of an area, you use tomography to get an
(21) image of what is inside the area.

(22) Q: What equipment is used to get that image?

(1) A: I have used a simple refraction
(2) seismograph on that project — actually put the
(3) whole thing together rather than pay 15,000 for a
(4) new one.

(5) Q: What other research are you currently
(6) involved in?

(7) A: At this point that is my major project.
(8) I have other work going and other interests. I
(9) have an interest right now on a DARPA-sponsored
(10) project for — trying to describe this — as a
(11) sensor unit including a seismograph.

(12) Q: Did you say —

(13) A: DARPA, D A R P A, Defense Advanced
(14) Research Projects Agency. That is armed forces;
(15) and I have an interest going now in what we refer
(16) to as educational seismology, programs to put
(17) seismographs in high schools and if you go on the
(18) Web site you can see recommendations for various
(19) seismographs.

(20) Q: You say you teach and do research. What
(21) courses do you currently teach?

(22) A: I have taught quite a few. On a regular

(1) basis I teach the seismology course. I have taught
(2) exploration geophysics. I have taught — lately I
(3) have taught inverse theory course and next fall I
(4) shall for the first time teach beginning geology.

(5) Q: What is inverse theory?

(6) A: That relates to the theory behind
(7) everything scientists do — all the computations
(8) scientists do to convert data to a model. Not all
(9) our students take it.

(10) Q: How long have you held that position as a
(11) professor?

(12) A: About a third of a century, about 34, 35
(13) years — 36 — '67.

(14) Q: What was your position before you were a
(15) professor?

(16) A: I was a research assistant with Oregon
(17) State University and working on my Ph.D. The last
(18) year of that, year and a half, I spent in
(19) Alexandria, Virginia, at the nuclear test detection
(20) contracting people.

(21) Q: You went straight from —

(22) A: Basically I went from Oregon State to

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[1] Georgia Tech.

[2] Q: When did Law Engineering occur in that
[3] timeframe?

[4] A: A gentleman who is now up at the vice
[5] presidential level took my seismology course the
[6] first time I offered it, first or second year. I
[7] gave him a D. I don't know if that was a mistake
[8] or not but he hired me.

[9] Q: So the consulting that you have been
[10] doing for Law Engineering has been while you have
[11] been at Georgia Tech?

[12] A: Yes.

[13] Q: And what period were you doing that
[14] engineering consulting for Law Engineering?

[15] A: Up to about seven or eight years ago. It
[16] is off and on. Consulting is off and on.

[17] Q: Have you done any consulting in the past
[18] five years?

[19] A: Yes.

[20] Q: Who for?

[21] A: I think I have that list. I will try
[22] to —

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[1] Q: Is it on your biographical sketch?

[2] A: Yes, it should be. There was a mine
[3] collapse case in Alabama. It would be on a
[4] separate listing of consulting activities.

[5] MR. POLONSKY: Off the record.

[6] (Discussion off the record.)

[7] (Recess.)

[8] BY MR. POLONSKY:

[9] Q: For the record, we are looking at an
[10] attachment to GANE's second supplemental response
[11] to applicants first set of interrogatories. It is
[12] entitled biographical sketch of Leland Timothy Long
[13] and we are on page five. Is that right, Dr. Long?

[14] A: That is where it is listed.

[15] Q: You were saying — we were talking about
[16] some of the consulting projects you have done in
[17] the past five years?

[18] A: Yes. The first one listed under
[19] consulting projects is the location of a mine
[20] collapse in Alabama.

[21] Q: And that says for litigation?

[22] A: That has actually settled.

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[1] Q: What was that case about?

[2] A: There were two — the mine was using a
[3] long-haul technique at a couple thousand feet deep.
[4] That technique, if the rocks don't agree with the
[5] theory perfectly, can create earthquakes of
[6] magnitude three, three and a half, and there was a
[7] restaurant located fairly nearby that claimed
[8] damage from the earthquake, and rather than admit
[9] fault and pay for damage, the coal company wanted
[10] to prove that it wasn't their mine that was causing
[11] the earthquakes. I used a location technique which
[12] I am actually preparing for publication to show
[13] that the events actually occurred at the mine and
[14] they were very likely responsible for the damage.
[15] They finally settled probably for more money than
[16] it would cost to rebuild the restaurant.

[17] Q: Who did you do the work for?

[18] A: It was a lawyer, Lighthouse, Incorporated
[19] or something like that. I would have to go back to
[20] check notes.

[21] Q: Do you recall the law firm involved?

[22] A: No. There were actually two firms. The

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[1] name was Slotnick.

[2] Q: And do you recall his first name?

[3] A: No. Something like Joe.

[4] Q: When did you do this consulting work?

[5] A: That went over about a two-year period.

[6] Q: From when until when?

[7] A: Up until about a year ago that it
[8] settled.

[9] Q: Where was this located in Alabama?

[10] A: North Birmingham, in the coal mining
[11] district. Restaurant was on one of the reservoirs.

[12] Q: What was your role in the case? Were you
[13] designated an expert witness, were you an expert
[14] for both parties?

[15] A: I provided an analysis of seismic data
[16] and a report showing a location of the
[17] earthquake — of the event that caused damage. So
[18] I provided evidence for the fact that this was —
[19] in essence this was a mine collapse event, and that
[20] it occurred at the time the damage was incurred and
[21] that it was located at their mine site.

[22] Q: Did you provide this analysis for the

[1] plaintiffs in that case?

[2] A: For the restaurant, yes.

[3] Q: Who was seeking damages?

[4] A: Yes.

[5] Q: Was there an expert that represented the
[6] other side in that case?

[7] A: Yes. They had someone — I did not
[8] interact with them and in this case I didn't
[9] evaluate his work. I provided data. I was deposed
[10] on that.

[11] Q: Do you recall the name of the person who
[12] provided analysis for the other side in that case?

[13] A: No, I don't.

[14] Q: Was it a person you were familiar with at
[15] the time?

[16] A: No.

[17] Q: Were you deposed as an expert witness in
[18] that case?

[19] A: Yes.

[20] Q: How much were you paid to prepare your
[21] analysis in that case?

[22] A: I would have to go back to records to

[1] give you an accurate figure on that.

[2] Q: Do you have a guess or an estimate?

[3] A: It is the same rates we have here. Total
[4] project was anywhere from three to 8,000. Some
[5] place in that range.

[6] Q: When you say the same rates as here, what
[7] do you mean by that?

[8] A: Hourly rate.

[9] Q: What is your hourly rate?

[10] A: 200 for deposition, 100 for analysis and
[11] preparation. Relatively cheap.

[12] Q: In the same second supplemental response,
[13] you have identified Burrell, et al., versus Rahaise
[14] and Hanson Aggregate as another case where you were
[15] an expert?

[16] A: That is the Waldon County Environmental
[17] Group.

[18] Q: Let me take you back to the Lighthouse
[19] case. How were you first retained in that case,
[20] how did they learn about you?

[21] A: I am pretty well known. It was a case of
[22] contacting — finding the Web site. Either by

[1] referral or calling up and asking. I think in this
[2] case because I have data from Georgia, a lot of
[3] people just to see whether there is data there.

[4] Q: And then Burrell, how did you come to be
[5] contacted in that case?

[6] A: I had done a number of consulting jobs
[7] with a gentleman who used to be at Georgia Tech who
[8] worked in acoustics and he was called in on that
[9] case and he referred me to them.

[10] Q: And who were you providing expert
[11] analysis for, Burrell or —

[12] A: Burrell.

[13] Q: How did you describe Burrell et al., what
[14] are they?

[15] A: Burrell was the person in charge of the
[16] organization, Waldon County Environmental Group.

[17] Q: What did you do for them?

[18] A: I provided an estimate of the size blast
[19] vibrations that would be created by a proposed
[20] quarry and I provided a critical analysis of a
[21] report from the quarry's consultant.

[22] Q: And what were your conclusions?

[1] A: That the consultant from the quarry had
[2] not properly analyzed data and grossly
[3] underestimated amplitude.

[4] Q: What was the outcome of that case?

[5] A: I do not know.

[6] Q: Still going on?

[7] A: I would have to ask. I don't know. I
[8] testified in January at a hearing. That was to be
[9] continued and I have not been contacted.

[10] Q: Before whom did you testify, agency or
[11] court?

[12] A: It was in downtown Atlanta at a court.
[13] That would have had something to do with the
[14] licensing bureau and I don't know the exact name.
[15] I would have to go back to papers on that.

[16] (The witness consulted with counsel.)

[17] A: She pointed out that this testimony was
[18] September 25 on that. It was to be continued in
[19] January and was not.

[20] Q: Thank you for the clarification because
[21] the interrogatory response shows September. Have
[22] you provided any deposition testimony or otherwise

[1] since January 1, 2003?
[2] A: No.
[3] Q: How much were you paid to provide
[4] analyses for Burrell?
[5] A: That is also on the order of three to
[6] 8,000.
[7] Q: And were the same rates in effect there?
[8] A: Yes.
[9] Q: Were you in fact actually paid those
[10] amounts from that organization?
[11] A: Yes — one exception to that. There is
[12] one small bill that I wrote off. Under
[13] questionable circumstances the building they were
[14] trying to preserve was burned down and at that time
[15] I said, this kind of ends it so forget it.
[16] Q: And you wrote that off?
[17] A: Yes.
[18] Q: Other than these two events, after 2000,
[19] were there any other instances where you have been
[20] deposed?
[21] A: I believe that is it, for depositions.
[22] Q: Other than these two cases, have you ever

[1] A: Yes.
[2] Q: Why did you agree to provide that
[3] testimony?
[4] A: I was doing research in the middle of
[5] having to do with location of regional events and
[6] computing their magnitudes and I was the
[7] appropriate seismologist. I was recommended for
[8] that position by a gentleman at Virginia
[9] Polytechnic who retired at that time. I was
[10] recommended for that position by a gentleman at
[11] VPI, Virginia Polytechnic Institute, a state
[12] university.
[13] Q: Were you paid for that?
[14] A: Yes, and I have no idea of the amount.
[15] Was I paid enough? Probably not.
[16] Q: You also said that you have submitted
[17] some reports that have been used by an agency or
[18] legislative body. I don't want to misquote you but
[19] you indicated in answer to a question have you ever
[20] testified before a court or legislative body, that
[21] you had prepared reports. Can you explain that?
[22] A: I have been involved with environmental

[1] provided testimony in any forum, court, agency,
[2] legislative body?
[3] A: I have provided a number of reports which
[4] have gone into the record, and I did provide a
[5] court appearance early in the '70s on a mine
[6] collapse location.
[7] Q: Let's start with the Court appearance in
[8] the 1970s for the mine collapse. Can you tell me
[9] more about that?
[10] A: This was also a long-wall coal mining
[11] operation that was a case where a house had been
[12] damaged by some of the resulting events and I was
[13] snuck into town right before the hearing, provided
[14] testimony concerning the fact that the seismic data
[15] indicates that the mine was responsible for these
[16] particular events, that is, the data I had located
[17] the events at the mine and that perhaps more
[18] importantly the size of the event was sufficient to
[19] cause damage and then I left. I had also prepared
[20] a report for that.
[21] Q: This was while you were at Georgia
[22] Institute of Technology?

[1] impact statements.
[2] Q: In what role?
[3] A: My master's thesis was on seismic noise
[4] vibration and there was some concern in Atlanta
[5] when they were planning a new freeway called the
[6] Stone Mountain Freeway that the vibrations from
[7] vehicles on that highway would be detrimental in
[8] particular to a telescope that was operated by a
[9] science center. So I was brought in to give them
[10] an estimate of the magnitude of the level of
[11] vibrations and the potential detriment to images
[12] and visual capabilities of the telescope.
[13] Q: Other than the environmental impact
[14] statement for that road construction in Atlanta,
[15] any other instances?
[16] A: That led to eight or 10 very similar type
[17] studies, all very, very much alike. Probably the
[18] one that was the most fun was the impact for the
[19] Cape Canaveral site for vibration, to ride around
[20] in elevators in the swamp and make some
[21] measurements.
[22] Q: All of these were in relation to the

[1] environmental impact —

[2] A: Of ground vibration generated by trucks,
[3] vehicles, trains, et cetera.

[4] Q: And when was the last time you provided a
[5] report for that kind of work?

[6] A: Probably mid '80s, late '80s. That was
[7] written in a small paper in my biographical sketch
[8] there — the results of most of those studies.

[9] Q: Other than two instances, you haven't
[10] actually testified in court and those were in 1970
[11] for a mine collapse and one of the most recent
[12] litigation where you provided court testimony?

[13] A: In court, yes, two. Deposition, for
[14] Lighthouse, before we went to court.

[15] Q: And you were not deposed in the Burrell
[16] case, you just went straight to the Court
[17] proceeding?

[18] A: That is right.

[19] Q: Have you provided any kind of support to
[20] GANE in the past other than in connection with this
[21] proceeding?

[22] A: No.

[1] Q: Have you provided any support to any
[2] individual opposed to constructing any kind of
[3] facility other than the ones we have mentioned?

[4] A: I don't believe so.

[5] Q: Let's go back to your consulting projects
[6] list, since the location of the mine collapse
[7] litigation got us off. Georgia Management Service.
[8] Assist in preparation of earthquake video.

[9] A: Never saw it. I think the contractor
[10] defaulted on it.

[11] Q: What did you do to assist them with the
[12] preparation?

[13] A: Provided basic materials, provided an
[14] outline and went through general background and
[15] organization. Got ready to shoot and never got
[16] called in.

[17] Q: Was there a particular theme in the
[18] earthquake video other than the presentation of
[19] earthquakes in Georgia?

[20] A: I don't think it was ever produced.
[21] Other projects for GEMA, they were concerned with
[22] preparation for seismic hazard and if you go on my

[1] Web site you will see a paper that is emergency
[2] managers guidance to earthquakes in Georgia. That
[3] was prepared with their assistance.

[4] Q: DOE, project evaluation for bore hole
[5] geophysics. Can you give me a timeframe for that,
[6] first — again, mid to — decade would be
[7] sufficient?

[8] A: Quarter of the last century. Probably in
[9] the '80s, I guess.

[10] Q: What is that study?

[11] A: Where they bring in the principal
[12] investigators and they give a song and dance and
[13] the evaluators say whether they are doing what they
[14] should be doing.

[15] Q: Were these for specific structures that
[16] were being constructed?

[17] A: These were for projects which are
[18] developmental ideas. Basic research. Not specific
[19] projects.

[20] Q: GEMA, estimation of seismic hazard, what
[21] was the timeframe for that?

[22] A: I think the GEMA work started in the mid

[1] '80s and every couple, three years, would do a
[2] little more.

[3] Q: When is the last time you did anything
[4] for GEMA?

[5] A: For pay?

[6] Q: Sure. Let's start there.

[7] A: For pay, goes about three years. I have
[8] talked to them. I have helped them out but I don't
[9] always bill them.

[10] Q: What does estimation of seismic hazard in
[11] relation to GEMA mean?

[12] A: To a large extent, it is preparing the
[13] emergency management organization for an
[14] earthquake, assisting them. Each emergency
[15] management group has to have a plan to respond to
[16] various disasters. Earthquakes are not high on
[17] Georgia's list but they are on the list. So I have
[18] given talks to a couple of regional GEMA meetings
[19] of managers for emergency management groups. I
[20] worked with a number of others. Probably the most
[21] recent contacts have been in the last few weeks
[22] because of the earthquake. There was an earthquake

[1] in Northeastern Alabama. Raised a lot of
[2] questions. I have talked with them about that and
[3] we are talking about doing more about what GEMA is
[4] doing to not only be prepared for an earthquake,
[5] but to help prevent damage and hazards caused by an
[6] earthquake.

[7] **Q:** Estimation of seismic hazard, I don't
[8] understand that. I understand your interplay with
[9] GEMA. Were you doing studies for them or
[10] consulting overview?

[11] **A:** The U.S. Geological Survey's 1995 maps
[12] were the result of a number of studies over four or
[13] five years that they put together. Around 1989,
[14] 1988, 1990, a number of investigators, including
[15] myself, I know it was done for Arizona, done for
[16] New England, individual people who had been
[17] discussing the existing hazard maps, came up and
[18] generated their own version, and I think this
[19] perhaps was one of the instances where I did some
[20] of that and we did it with cooperation with GEMA
[21] and presented it to them and then we utilized that
[22] in programs to help emergency managers cope with

[1] were part of the expert panel.

[2] **A:** Right.

[3] **Q:** There was also a ground motion panel?

[4] **A:** As far as I understand. I did not get
[5] involved with that.

[6] **Q:** What other panels were there?

[7] **A:** I don't know.

[8] **Q:** But you only provided input to the
[9] seismology expert panel?

[10] **A:** That was my main responsibility on that
[11] project, yes.

[12] **Q:** What other responsibilities did you have
[13] in what I will now call the Livermore work?

[14] **A:** The seismology panel experts like myself,
[15] went through a process of evaluating the data,
[16] looking at the seismicity, drawing zones if one
[17] wants to for different areas, and in the end trying
[18] to make some assessment of whether you thought you
[19] were an expert in this area or that area, where
[20] your end should apply. It was a whole process
[21] where if you go back through the documentation you
[22] can see what was done. All the panelists did the

[1] earthquakes. I think a lot of those efforts like
[2] mine were dropped because the USGS finally did what
[3] they should have.

[4] **Q:** Next item is Lawrence Livermore lab —

[5] **A:** LLNL.

[6] **Q:** What was the timeframe for that?

[7] **A:** You are the expert. Those were the '70s,
[8] late '70s, around there. This was the contract by
[9] NRC to Lawrence Livermore to come up with a
[10] probabilistic estimate and I served as an expert on
[11] seismology.

[12] **Q:** On one of those panels?

[13] **A:** The panel was a seismology panel and then
[14] they had a ground motion panel. I was a singular
[15] expert on the seismology. I was given a code
[16] number. One to 12, and one of those is mine.

[17] **Q:** There were 12 other seismology experts on
[18] the same panel?

[19] **A:** I think on that order, 11 or 12, and, of
[20] course, the definition of expert comes in here.
[21] You might not agree with that.

[22] **Q:** Expert people, those people on the panel

[1] same thing.

[2] **Q:** So your input was one of 11 or 10 or 12
[3] inputs into seismology issues within the expert
[4] panel?

[5] **A:** That is right.

[6] **Q:** What were the seismology issues that you
[7] were asked to provide opinions on within the expert
[8] panel?

[9] **A:** I don't know that it was an opinion so
[10] much as a data analysis project. We were provided
[11] lists of earthquakes and by interaction with
[12] Lawrence Livermore people we could have specific
[13] things computed. We defined seismic zones. They
[14] provided an analysis of those zones for
[15] earthquakes. We reviewed those zones, went back
[16] and forth with them. We could introduce our own
[17] hypothesis and feelings as to what the seismicity
[18] should be like. One expert had the whole east in
[19] one big zone — one of the expert panels. Others
[20] had micro zoned the area to death. Some of them,
[21] like myself, even had overlapping zones, and I
[22] think this was the basis of one of them.

[1] One of the outcomes was to say, in
[2] essence, what is the status or the current
[3] understanding by people working in the field of the
[4] seismicity of the Southeast and how should it be
[5] put into a hazard assessment program.

[6] Q: Was the Livermore study solely focused on
[7] the Southeast?

[8] A: No, it was national.

[9] Q: Where was it focused?

[10] A: National, continental U.S.

[11] Q: So as a participant in the expert panel
[12] you were asked to provide input on seismic zones
[13] for the whole United States?

[14] A: You know, I did not focus on outside the
[15] Southeast. I did do some in the Northeast and
[16] central U.S., but when you get past the Rockies, I
[17] did not make any attempt so I don't know if that
[18] was even part of the analysis.

[19] Q: Do you mean to tell me you did not
[20] provide any input for any seismic zones west of the
[21] Rockies?

[22] A: No, I did not.

[1] Q: You did not provide any input?

[2] A: No.

[3] Q: Do you recall what your input was for the
[4] Charleston seismic zone?

[5] A: My guess, it was a zone, a seismic zone
[6] surrounding the area of activity.

[7] Q: And that zone of activity would be
[8] defined as what — at the time?

[9] A: At the time — what was it? I would have
[10] to go back to documents to tell you exactly what it
[11] was. At that time the locations of a lot of the
[12] after shocks were not that well known. There was
[13] some question as to where the actual epi-center
[14] was. I probably included the Bowman zone as part
[15] of that because that was an area I was interested
[16] in.

[17] Q: Where is Bowman in relation to
[18] Charleston?

[19] A: Northwest, perhaps 30 to 60 kilometers.

[20] Q: Is it on the shore or further inland?

[21] A: Further inland. Northwest is inland.

[22] Q: In addition to giving input to seismic

[1] zones, what other input did you provide as an
[2] expert panelist for the Livermore study?

[3] A: We had rates — seismic zones implies you
[4] have a certain rate of activity associated with
[5] that. There were — it wasn't long after that we
[6] were also involved with an EPRI study and some of
[7] the times the studies get merged in.

[8] Q: If I can hold you to just to the
[9] Livermore — to the best of your recollection,
[10] other than rates of seismicity and —

[11] A: Little maps with squares and circles on
[12] them.

[13] Q: Showing the location of the seismic
[14] source zone —

[15] A: Right.

[16] Q: Were you asked to opine on the likely
[17] largest magnitude to be expected within that source
[18] zone?

[19] A: One had a maximum assigned to each
[20] seismic zones. In one area I had overlapping zones
[21] but they worked it out.

[22] Q: Why did you do that?

[1] A: Because I was differentiating between
[2] shallow mechanisms where the earthquakes were small
[3] and the potential for a larger earthquake, major
[4] earthquake.

[5] Q: Were you aware of what the other
[6] participants in the expert panel —

[7] A: No.

[8] Q: You did not know what their input was?

[9] A: We were not made aware entirely of their
[10] inputs, certainly not when we were in the early
[11] stages of developing it. When the reports came
[12] out, the experts were indicated anonymously as
[13] numbers.

[14] Q: Let me get to you focus just on
[15] Charleston. Do you recall what at the time your
[16] thinking was of the largest magnitude at
[17] Charleston, of the Livermore study?

[18] A: It was probably up in the sevens, seven
[19] something. I didn't put a big limit on it.

[20] Q: When you say seven something?

[21] A: When you get above 6.8, you start
[22] quibbling with magnitude scales.

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[1] Q: Why is that?

[2] A: Because certain scales don't go much
[3] beyond seven. Others go eight, eight and a half
[4] and how they are defined partly is as a result of
[5] the work during that period and other studies —
[6] most of the scales are resolving down to moment of
[7] magnitude. So moment of magnitude is becoming a
[8] default but at that time, that hadn't fully
[9] developed as the default magnitude.

[10] Q: Magnitude seven something at the time,
[11] what would that translate into a moment magnitude
[12] of what?

[13] A: Between seven and 7.8.

[14] Q: Between seven and 7.8?

[15] A: That would be liberal.

[16] Q: What is your understanding of the
[17] increase in energy from a seven to a 7.8?

[18] A: That is also not straightforward.
[19] Magnitude is generally the measure of the log or
[20] the amplitude so that when you go up one unit, the
[21] amplitude is increased by a factor of 10 so the
[22] amplitude of the waves increase. The energy is

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[1] probably going to — how does that work, the square
[2] root of that, something like that? A factor of
[3] three.

[4] Q: A factor of three. From 7.0 to eight?

[5] A: Seven to eight that is a factor of 10 in
[6] amplitude. In moment magnitude that translates
[7] back to the low DC end of the scale. So if you —
[8] if you look at a displacement from an earthquake
[9] and in terms of moment, that is — moment of
[10] magnitude goes up a factor of — for one unit of
[11] magnitude, it goes up a factor of 10 in
[12] displacement but that is at the DC end. When you
[13] compute the energy you integrate that spectra from
[14] zero or DC to five frequency and depending on what
[15] the stress drop, is you may get more or less energy
[16] for a given attitude and then you are back to
[17] seismic theory. So you may have different moments
[18] associated with it depending on how much energy
[19] there is contributing to the high frequencies.

[20] Q: What does DC stand for?

[21] A: That is where you don't have any — the
[22] differentiation I used there is DC means direct

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[1] current or a constant level. AC is alternating.

[2] By that I mean it is the zero frequency intercept.

[3] Q: Is that the same as saying peak ground
[4] acceleration?

[5] A: No.

[6] Q: You would have said at the time that you
[7] participated in the expert panel for Livermore that
[8] a Charleston earthquake would have the equivalent
[9] of a moment magnitude of 7.0 to 7.8; is that right?

[10] A: Yes, in that range.

[11] Q: What would you have said at that time
[12] would have been the rate of seismicity or the
[13] return period for a Charleston-type earthquake?

[14] A: I probably would have based that on the
[15] recursion relation although even at the time I was
[16] convinced that the recursion for Charleston was
[17] dominated by the extended after-shock sequence and
[18] I still believe that is the case. Whether we come
[19] up with a recursion relation for Charleston at that
[20] time, I don't know. I was probably thinking at the
[21] time that Charleston would be a singular event so I
[22] wasn't concerned about that and I would use the

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[1] after shock K rate to indicate potential for
[2] another major event. That is not to say I believe
[3] that today.

[4] Q: Of course. We are asking you what your
[5] opinion was at the time. I understand how you
[6] would have calculated it but do you recall whether
[7] it was shorter or longer than the rate of
[8] seismicity today?

[9] A: No, I don't recall. I don't really know.

[10] Looking at the recent data — and it is since all
[11] of that time that Talwani has done work on paleo
[12] seismicity and found evidence for events that
[13] occurred there but that has changed the picture
[14] perhaps some.

[15] Q: Would you have ever hypothesized — would
[16] the input to the expert panel on seismology on the
[17] rate of seismicity or return period for the
[18] Charleston ever have been a thousand years?

[19] A: I don't know. I would have to go back
[20] and look at those numbers and I don't know that
[21] they would be relevant.

[22] Q: Approximately what diameter circle would

(1) you have drawn around Charleston as input to the
(2) location of the Charleston seismic zone for your
(3) input to the expert panel for seismology for
(4) Livermore?

(5) A: You know, I don't remember what that was.
(6) My guess is it would have been around 40 or 50
(7) kilometer —

(8) Q: Radius?

(9) A: Radius. Whether that is relevant today,
(10) I don't know.

(11) Q: Of course. I am just trying to
(12) understand what your input might have been at the
(13) time.

(14) For New Madrid, what would you have input
(15) at the time for the magnitude for the Livermore
(16) expert panel on seismology?

(17) A: That would have been about the same,
(18) about seven to 7.8, in that average. I think there
(19) are some that are 7.5, 7.4. Again, the scale is
(20) crucial.

(21) Q: And the rate of seismicity at the time
(22) for the Livermore input for New Madrid?

(1) A: I have no idea.

(2) Q: And the location?

(3) A: For —

(4) Q: New Madrid source zone?

(5) A: That is fairly well defined by the
(6) after-shock zone. The location would have been
(7) drawn around the after zones.

(8) Q: At that time?

(9) A: At that time, yes. Most people drew that
(10) area as a fairly narrow strong zone around the
(11) active zones and a wider active area extending
(12) further out.

(13) Q: How do you know what the other people
(14) did?

(15) A: I have seen the maps later on that were
(16) eventually published. I haven't figured out which
(17) one is which.

(18) Q: Back to Charleston — not for Charleston.
(19) In general you mentioned you might have done an
(20) overlapping map for smaller and larger earthquakes.
(21) Was that done for Charleston?

(22) A: I think that was in Virginia. I am not

(1) sure.

(2) Q: Are there any other experts you are aware
(3) of having looked at the maps, that had overlapping
(4) maps?

(5) A: No.

(6) Q: So you think that of the experts that
(7) served on the Livermore panel, you were the only
(8) one that had overlapping?

(9) A: I believe so. Now, there is a question
(10) of how they defined results because they had what
(11) they refer to as background zone, which covered
(12) everything and then you placed on top of that the
(13) other zones that you worked with. So by default
(14) that was an overlapping of sorts, and I am not sure
(15) if they excluded — probably excluded the zones you
(16) put in from the background so everything you didn't
(17) put into a zone is lumped into a background zone
(18) and spread out all over the place.

(19) Q: Southeast Tennessee, was there any input
(20) given to a seismic source zone for Southeast
(21) Tennessee?

(22) A: I believe they put one in, yes.

(1) Q: Do you know, after the fact, looking at
(2) the maps for the Livermore study, whether any other
(3) participant in the expert panel placed a seismic
(4) source zone in Southeast Tennessee?

(5) A: I don't know the numbers exactly. Some,
(6) yes — probably most of them did put a seismic zone
(7) in. Some of the zones were very broad and
(8) inclusive. There were a couple that were done by
(9) outside experts that didn't understand. So there
(10) were some strange results but I would Gil
(11) Bolinger's would have been — if he were one of the
(12) experts would have been on the Tennessee side.

(13) Q: What magnitude would you have in the
(14) moment magnitude scale given to Southeast Tennessee
(15) at the time the Livermore study was done and you
(16) were an expert on the seismology panel?

(17) A: I would have given it as large a
(18) magnitude as New Madrid and Charleston.

(19) Q: And that would have been 7.0 to 7.8
(20) moment of magnitude?

(21) A: Yes. It was my opinion at the time and
(22) still is that Southeast Tennessee is as viable a

[1] seismic zone as New Madrid.

[2] **Q:** Do you know of any other people who
[3] participated in the expert panel who placed a
[4] similar or higher magnitude for the Southeast
[5] Tennessee area?

[6] **A:** I don't know.

[7] **Q:** Are you aware of any — scratch that.

[8] I will skip a few things. U.S. Corps of
[9] Engineers, waterways experiment station, evaluation
[10] of maximum earthquake.

[11] **A:** Yes.

[12] **Q:** When was that done?

[13] **A:** That was done in the '70s and it was a
[14] project that the Corps of Engineers had to
[15] reevaluate the seismic hazard associated with all
[16] their dams.

[17] **Q:** So the purpose was to identify the
[18] maximum earthquake for all of the dams for U.S.
[19] Corps of Engineers?

[20] **A:** Yes. They did them one by one, and there
[21] were some dams in which I was involved.

[22] **Q:** Do you recall which dams you were

[1] involved?

[2] **A:** There was Elvin Barkley dam, that is up
[3] in the Tennessee, Kentucky border. Richard B.
[4] Russell was the one I think referenced there.

[5] **Q:** What state is that?

[6] **A:** Georgia, South Carolina.

[7] **Q:** Pardon my ignorance.

[8] **A:** Might have done the Clark Hill one too.

[9] **Q:** What studies did you do to evaluate the
[10] maximum earthquake for any of the dams?

[11] **A:** There were pieces and they varied. For
[12] the Strom Thurmond, I developed the shallow seismic
[13] model, the model for shallow earthquakes and argued
[14] that the largest of that type of earthquake would
[15] be on the order of magnitude five and a half, I
[16] believe.

[17] **Q:** And was that determined to be the maximum
[18] earthquake for the Strom Thurmond dam?

[19] **A:** I don't know what they determined. I
[20] provided input into that.

[21] **Q:** So you provided input for the Strom
[22] Thurmond just on shallow seismic experience?

[1] **A:** I provided analysis on that.

[2] **Q:** Did you provide any different kind of
[3] analyses for any of the other dams you provided
[4] information to?

[5] **A:** On Strom Thurmond they asked me to run a
[6] magnetic line, which wasn't successful, to identify
[7] the fault. That was detailed field geophysical
[8] thing. For the Elvin Barkley dam, the total
[9] evaluation included looking at the dam site and
[10] then looking at results from some core samples
[11] where they were concerned about the low count for
[12] certain layers. My primary responsibility for that
[13] dam was attenuating the New Madrid seismicity down
[14] to the site. We did get involved in looking at
[15] stability and liquefaction but I did not contribute
[16] heavily to that.

[17] **Q:** Any work on deep earthquakes for U.S.
[18] Corps of Engineers regarding evaluation of
[19] earthquakes for their dams?

[20] **A:** Most of my work with the Corps of
[21] Engineers is focused on reservoir-induced so the
[22] focus on the shallow earthquake mechanism, I have

[1] probably saved them from damage from a number of
[2] earthquakes by doing monitoring. It seems when I
[3] monitor, we don't get earthquakes. I did a talk on
[4] that once. For the Corps of Engineers I did do a
[5] dam in North Carolina, which I monitored and I
[6] finally was convinced that I did get some
[7] earthquakes, five or 10 things and then there was
[8] the dam at Quarters Dam and that one I monitored —
[9] I did not record any significant earthquakes there,
[10] although I did regard some things I had interpreted
[11] as squirrels dropping nuts on the seismogram.

[12] **Q:** Most of the Law Engineering testing
[13] company —

[14] **A:** Which is now Maytech.

[15] **Q:** Technical evaluation in EPRI evaluation
[16] study?

[17] **A:** Yes.

[18] **Q:** You are member of a committee. Is that
[19] the same thing as being participant in an expert
[20] panel?

[21] **A:** The EPRI study was set up on the basis of
[22] X number, maybe five, six, or seven, regional

(1) evaluation committees, some more regional than
(2) others. The committee I was on was Southeastern
(3) U.S. and it included geologists, seismologists, and
(4) a number of — about four or five people.

(5) Q: So unlike the Livermore study, which had
(6) expert panels in specific fields such as
(7) seismology, the EPRI study was organized by
(8) committee with experts from all the various areas
(9) in separate committees?

(10) A: Yes.

(11) Q: And you participated in the Law
(12) Engineering Committee?

(13) A: Right.

(14) Q: How many other committees were there?

(15) A: There was a Northeast, Central U.S.,
(16) Northwest — somewhere between four and six. Those
(17) are — we are going back in history.

(18) Q: Are you saying the Law Engineering
(19) Committee was the only committee for the
(20) Southeastern United States?

(21) A: The responsibility of the Law Committee
(22) was the Southeastern United States. To the extent

(1) that in evaluating the Southeastern United States,
(2) we had to evaluate seismicity in other parts and we
(3) extended beyond the Southeastern United States. So
(4) there would be other committees that would likewise
(5) extend into the Southeastern United States and to a
(6) large extent — instead of dealing with seismicity
(7) catalogs and listings, this committee also dealt
(8) with geological mechanisms and hypotheses.

(9) Q: Do you know whether there were other
(10) committees that were specifically focused on
(11) Southeastern United States in the EPRI study?

(12) A: Not off the top of my head, no.

(13) Q: What was your role within the Law
(14) Engineering committee in the EPRI study?

(15) A: I was the principal seismologist.

(16) Q: Were there other seismologists on the
(17) committee?

(18) A: There were people knowledgeable about
(19) seismology, yes. I don't remember who exactly was
(20) on the committee at this point. The leader
(21) basically was Robert White of Law Engineering.

(22) Q: What was your role in providing input as

(1) a principal seismologist?

(2) A: Most of the EPRI work was done in
(3) committees and was done through Law Environmental
(4) Services company so my input was to work with them
(5) in pulling stuff together.

(6) Q: Would you have been providing your
(7) opinion on the exact same issues that you would
(8) have been providing opinion as a participant in the
(9) Livermore study?

(10) A: The EPRI study was much more open in
(11) terms of including opinions on hypothesis for
(12) earthquakes and speculating on whether earthquakes
(13) might occur at a given location because of the
(14) geological conditions not because there was the
(15) existence of seismicity there.

(16) Q: Would you have provided inputs for rates
(17) of return for various earthquakes in the U.S.?

(18) A: Yes.

(19) Q: Would you have done the same for size and
(20) location of seismic zones?

(21) A: Yes.

(22) Q: Would you have done the same for

(1) magnitude?

(2) A: We dealt with magnitude as well.

(3) Q: Any other things or sub issues that you
(4) would have provided input on?

(5) A: Geological hypothesis. And various
(6) mechanisms for earthquakes, and the major
(7) contribution — not the major, but in putting the
(8) EPRI results into the computer, they went through a
(9) listing of extensive probabilistic matrices in
(10) deciding how much weight to put to certain
(11) hypotheses.

(12) Q: The geologic hypotheses, what are those
(13) geologic hypotheses?

(14) A: There is one I can remember but I can't
(15) remember. I remember because we gave it a
(16) probability of .005. So let's say that everything
(17) got put in, including the kitchen sink. Any
(18) hypothesis that was out there that was anyway close
(19) to being viable was given a probability and
(20) assigned into this Law matrix. We probably wish we
(21) hadn't put so many in after we got done because not
(22) only did we have to put it in, we had to think of

[1] the probability that it was available and make an
[2] assessment as to the viability of the hypothesis.
[3] **Q:** Did you participate in any updates to the
[4] EPRI or the Livermore studies?
[5] **A:** I did participate in an evaluation of one
[6] of those but I don't know that I participated in an
[7] update or revision of it. I think not much has
[8] been done since '90 when the USGS initiated the
[9] hazard program. I believe the number of
[10] individuals have attempted updates or have tried to
[11] use the programs to compute hazard but I have not
[12] been involved.

[13] **Q:** There was an update to the Livermore
[14] study published in 1993. Were you asked to
[15] participate in that update that was published in
[16] 1993?

[17] **A:** I don't remember.

[18] **Q:** Were you asked —

[19] **A:** What I do remember is I had some contacts
[20] with them concerning the study, but whether they
[21] panned out as participant, I am not sure. I don't
[22] remember.

[1] **Q:** Do you recall approximately around the
[2] same time, ten years ago, EPRI doing some revision
[3] to its original study?

[4] **A:** No.

[5] **Q:** Were you consulting with Law Engineering
[6] at the time, in 1993?

[7] **A:** Yes.

[8] **Q:** I am sorry you weren't finished answering
[9] the previous question.

[10] **A:** In terms of additional studies, the test
[11] sites were done I believe after the two sites, and
[12] there was a comparison of the Lawrence Livermore
[13] and EPRI relevant to the two test sites but I was
[14] not involved in that. That was entirely
[15] computational.

[16] **Q:** What do you mean by test sites?

[17] **A:** They chose a number of sites around the
[18] country which were close to nuclear power plants
[19] and reran the computations.

[20] **Q:** Who is they?

[21] **A:** Lawrence Livermore and EPRI.

[22] **Q:** They both did this?

[1] **A:** Yes.

[2] **Q:** One more thing and then we will break
[3] for lunch.

[4] Georgia geological survey siting of
[5] nuclear waste depository in crystalline rock. What
[6] was your role in the siting of that facility or
[7] proposed facility, if it was never built?

[8] **A:** That was a study that was initiated and
[9] never followed through on. My role was to be a
[10] seismic consultant on it and basically I would
[11] bring in my experience. I did not produce any
[12] original work for that study. We had a couple of
[13] meetings, discussed processes and reports were put
[14] together but that is it.

[15] **MR. POLONSKY:** Why don't we break for
[16] lunch.

[17] (Whereupon, at 12:25 p.m., the deposition
[18] was recessed to reconvene at 1:25 p.m. that same
[19] day.)

[20]

[21]

[22]

[1] **AFTERNOON SESSION**

[2] (1:31 p.m.)

[3] Whereupon,

[4] **LELAND TIMOTHY LONG**

[5] having been previously duly sworn, was further
[6] examined and testified as follows:

[7] **EXAMINATION BY COUNSEL FOR THE DCS**

[8] **MR. POLONSKY:** Back on the record.

[9] **BY MR. POLONSKY:**

[10] **Q:** Do you know Dr. Carl Stepp?

[11] **A:** Yes.

[12] **Q:** Would you say Dr. Stepp is highly
[13] regarded as a seismic expert?

[14] **A:** Do we have to get into evaluations? I
[15] have always appreciated what he has done. He is
[16] one of the — one of the first things he did is a
[17] test for detection continuity which is a standard.

[18] **Q:** Would you say you regard him as a seismic
[19] expert?

[20] **A:** Well, he has been retired so he is not
[21] actively working. He is not in the research group
[22] of people that are actively worked on seismic

[1] problems. I would consider his opinion very
[2] highly.

[3] Q: Where do you know him from?

[4] A: That goes way back. He was with the NRC
[5] and then before that some of the work was — the
[6] coastal survey and then in the EPRI project.

[7] Q: Have you worked with him since then?

[8] A: No.

[9] Q: And that was late '80s?

[10] A: Yes.

[11] Q: Do you know Larry Salomone?

[12] A: No.

[13] Q: Do you have any reason to believe he
[14] can't give testimony in the proceeding?

[15] A: Since I don't know him I would have no
[16] reason.

[17] Q: Do you know Don McConaghy?

[18] A: No.

[19] Q: Do you have any reason to believe —

[20] A: If I don't know him I wouldn't have a
[21] reason.

[22] Q: Are you familiar with Richard Lee?

[1] A: Yes.

[2] Q: What is your opinion of Richard Lee?

[3] A: He is a young seismically-oriented
[4] investigator, not the stature of an academic person
[5] but he does good work.

[6] Q: Who does he work for?

[7] A: The Savannah River plant organization
[8] people, whoever is there. It has changed hands.

[9] Q: Would you say he is highly regarded as a
[10] seismic expert?

[11] A: I would say he is not in the top tier but
[12] he is someone knowledgeable about seismic issues.

[13] Q: Do you consider him to be an expert in
[14] any particular field of seismology?

[15] A: I think he is more an applied opinion.
[16] You do what you are told. Where an expert like
[17] myself, we pursue ideas, not necessarily what needs
[18] to be done to satisfy a job. So in terms of
[19] focusing — I think in his response to his work he
[20] is doing a fine job.

[21] Q: Are you familiar with Walt Silva?

[22] A: No.

[1] Q: When did you first learn about GANE?

[2] A: When was I first approached?

[3] Q: The question was when did you first learn
[4] about them?

[5] A: I did not know about them until I was
[6] approached.

[7] Q: When were you first approached?

[8] A: I think that was probably about a year
[9] ago.

[10] Q: And do you recall who approached you?

[11] A: It was — the person in — the lady in
[12] Georgia who is in charge of it there. She gave a
[13] call.

[14] Q: Would that be Glenn Carroll?

[15] A: Yes.

[16] Q: Do you recall what season it was that she
[17] called?

[18] A: No.

[19] Q: Do you recall what she said during that
[20] first communication?

[21] A: She wanted to find out who would be an
[22] expert.

[1] Q: An expert in what?

[2] A: In seismology.

[3] Q: Why did she come to contact you, do you
[4] know?

[5] A: Dr. Makajani had given her my name.

[6] Q: Was it your understanding that she had
[7] spoken to Dr. Makajani first?

[8] A: I don't know. I would assume that is the
[9] case.

[10] Q: What else did she ask you?

[11] A: She asked me if I would review the work.
[12] The way she expressed it is I believe they had a
[13] consultant who had put stuff together and he had
[14] expressed concerns about his capabilities of
[15] following up and they were looking for someone who
[16] could actually make a statement on the contention.

[17] Q: What else was discussed during that
[18] discussion?

[19] A: What else?

[20] Q: Yes.

[21] A: I have no idea.

[22] Q: When you finished that conversation, what

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[1] did you have in your mind was your role in — with
[2] GANE?
[3] **A:** They asked me whether I would consider
[4] working with them. I wrote them back and said that
[5] I would consider evaluating the contention that
[6] they have proposed for them. Their concern was
[7] whether or not they had any case at all and I said
[8] that the answer they get would be independent from
[9] whether I work for them or DCS or anything but I
[10] would work for them as a seismologist.
[11] **Q:** How many conversations did you have with
[12] Glenn Carroll?
[13] **A:** I would guess between five and 10, most
[14] of them short telephone conversations.
[15] **Q:** What were the subjects of those others,
[16] to the extent you can recall?
[17] **A:** Can I drop material off at your house.
[18] **Q:** Anything else?
[19] **A:** No. That is about it. I didn't consider
[20] her — I consider this my own opinion. I didn't
[21] delve into it in detail until I started working
[22] with Ms. Curran.

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[1] **Q:** Did Glenn Carroll ask you to — what your
[2] fees were?
[3] **A:** I don't remember.
[4] **Q:** Did you have an agreement at the time as
[5] to how much you would be paid?
[6] **A:** If and when I presented the fee
[7] structure, it would have been exactly the same as I
[8] have mentioned before. That was the fee structure
[9] I had with ongoing consulting and I just maintain
[10] the same.
[11] **Q:** Did you consider doing the work for GANE
[12] for free?
[13] **A:** No.
[14] **Q:** The material that was dropped off at your
[15] house, what materials were those?
[16] **A:** The preliminary CAR, I believe, and there
[17] were some other papers. It is a pile of stuff.
[18] **Q:** What other things have you since reviewed
[19] in your work for GANE on this contention besides
[20] preliminary CAR?
[21] **A:** I have a copy now of the final CAR and I
[22] also have received a disk with a lot of the

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[1] background publications on it, a CD. Some of those
[2] I have looked at, probably most I have not.
[3] **Q:** Have you actually reviewed the final CAR?
[4] **A:** I have read through the final CAR.
[5] **Q:** What other communications have you had
[6] with GANE other than communications with Glenn
[7] Carroll?
[8] **A:** My communications with GANE have been
[9] limited to Glenn Carroll and Diane.
[10] **Q:** Do you recall when you were officially
[11] retained?
[12] **A:** I could probably figure it out but I
[13] would have to go back to my records.
[14] **Q:** There is a formal retention in place?
[15] **A:** I suppose so.
[16] **Q:** How many hours have you worked for GANE
[17] so far?
[18] **A:** Probably about 50.
[19] **Q:** Five zero?
[20] **A:** Yes.
[21] **Q:** Have you invoiced GANE for that amount?
[22] **A:** Yes.

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[1] **Q:** And have they paid you?
[2] **A:** Yes.
[3] **Q:** That amount would be at \$100 an hour?
[4] **A:** Yes.
[5] **Q:** In addition to review the documents, have
[6] you done any other analysis for GANE?
[7] **A:** What was that question?
[8] **Q:** In addition to reviewing the documents
[9] you were provided, have you done any other — in
[10] reviewing those documents, have you done any other
[11] analysis for them?
[12] **A:** Not for GANE, no.
[13] (The witness consulted with counsel.)
[14] **Q:** Would you like to amend your response?
[15] **A:** The comments pertain to the fact that I
[16] have helped rewrite and amend the interrogatories.
[17] So I have not done — in terms of specific research
[18] requests, I have not done work, but I have provided
[19] data, information, to rewrite or modify the
[20] interrogatories.
[21] **MS. CURRAN:** Dr. Long is not a lawyer.
[22] When he says interrogatories, I think he means

(1) answers to interrogatories.

(2) MR. POLONSKY: I had interpreted that.

(3) THE WITNESS: It has taken some time to
(4) figure out which way I am going.

(5) BY MR. POLONSKY:

(6) Q: You are familiar with GANE contention
(7) three and its basis statement?

(8) A: Yes.

(9) Q: But you didn't write any part of it?

(10) A: The initial one I did not write at all.

(11) The modifications, I have provided suggestions and
(12) information for modifications.

(13) (The witness consulted with counsel.)

(14) THE WITNESS: Just the answers.

(15) BY MR. POLONSKY:

(16) Q: The contention and the basis statement,
(17) you had not yet been retained by GANE to provide
(18) any input on it.

(19) A: Okay.

(20) Q: But you did provide input to respond to
(21) DCS's interrogatories?

(22) A: Yes. I was brought in after the

(1) contention.

(2) (The witness consulted with counsel.)

(3) A: I could add when we recently cut back —
(4) when GANE was going to cut back on the contention,
(5) the answers, we approved on those.

(6) Q: Are you familiar with NRC regulations in
(7) 10 CFR, part 70, about designing facilities to a
(8) standard?

(9) A: I have not studied those in detail.

(10) Q: Have you read through them once?

(11) A: I have not read through them.

(12) Q: But you have had an opportunity to review
(13) the original and revised CAR?

(14) A: Yes.

(15) Q: And you provided input on GANE's
(16) responses to interrogatories?

(17) A: Yes.

(18) Q: Have you reviewed the NRC's staff's draft
(19) safety evaluation report dated April 2003?

(20) A: I looked at that early in the evaluation.
(21) If I am interpreting this as the one I looked at.
(22) NRC wrote a response.

(1) Q: There were two drafts. Initial draft
(2) safety evaluation report which was filed sometime
(3) in 2002. Did you have a chance to review the NRC's
(4) staff evaluation report written in April 2003,
(5) which is just a few months ago?

(6) A: I don't think so.

(7) Q: Have you reviewed the document which
(8) comes by various names, Lee, et al., 1997, or the
(9) 1997 PSHA for the Savannah River Site or WSRC-0085?

(10) A: I believe the '97 one is one I did read
(11) on the CD.

(12) Q: WSRC-TR-97-0085.

(13) MS. CURRAN: Would you just show that to
(14) Dr. Long so we can be sure you are talking about
(15) the same document?

(16) BY MR. POLONSKY:

(17) Q: This is a document that is part of the
(18) hearing file, hearing file 54 or 54 A.

(19) A: I believe I looked through this. I would
(20) have to say I probably looked through it with
(21) limited interest because a lot of it had to do with
(22) the soil and not the structure.

(1) Q: You stated that you assisted GANE in
(2) preparing GANE's interrogatories to DCS's —
(3) preparing GANE's responses to DCS's interrogatories
(4) on contention three. Do you have any basis today
(5) or reason to disagree with GANE's answers to any
(6) interrogatories?

(7) A: I don't believe so.

(8) Q: Do you agree with all of GANE's answers
(9) to interrogatories?

(10) A: On contention three?

(11) Q: Thank you.

(12) A: Yes.

(13) Q: Would you like to modify or augment those
(14) responses in any way?

(15) A: I think this article needs to be included
(16) in the references along with the Atkinson/Boore
(17) article.

(18) Q: When you are referring to this article —

(19) A: The Atkinson and Saunders article.

(20) (The witness consulted with counsel.)

(21) A: There are a few items that have been
(22) pointed out we considered. One concern was use of

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[1] a concentrated zones for seismicity of Georgia
[2] versus a more widespread zone, that in the
[3] statistical computations for intensity, a wider
[4] spread zone will increase the hazard —

[5] **Q:** What interrogatory are you referring to?

[6] **A:** December 20 —

[7] **Q:** There were two. Second supp and second
[8] set?

[9] **A:** Second supplemental.

[10] **Q:** What page?

[11] **A:** Three.

[12] **Q:** Okay. I am with you. There is a
[13] sentence in here that you would disagree with or
[14] would like to change?

[15] **A:** It says, "First, DCS unreasonably assumed
[16] that the Charleston type earthquake would only
[17] occur at Charleston or Bowman." I don't like the
[18] term unreasonable but it is a logical presentation,
[19] how it is presented in the analysis, and if a
[20] concentrated zone is used, the risk attenuates more
[21] rapidly with distance even though it is higher at
[22] the course than it does if a wider zone was used.

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[1] So a wider seismic zone would increase the hazard
[2] estimate at the site. I actually wrote a paper on
[3] that. It was in — I would have to look at my
[4] resume as to when it was .

[5] **Q:** I am not sure how that fits into what you
[6] said. Are you suggesting that the word
[7] unreasonably should be deleted?

[8] **A:** I am suggesting that I might not
[9] necessarily claim that it is unreasonable. It is a
[10] matter of how one presents the logic and the
[11] computation. I am saying that the assumption that
[12] Charleston is a point source would underestimate
[13] the hazard at the site relative to the assumption
[14] that the Charleston earthquake occurred in a larger
[15] seismic zone.

[16] **Q:** If you increase the Charleston seismic
[17] zone, would you not there be decreasing the hazard
[18] of an earthquake at Charleston itself?

[19] **A:** If you —

[20] **Q:** Increase —

[21] **A:** Increase the area of the seismic zone,
[22] you would decrease the hazard at Charleston but

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[1] increase the hazard outside of the zone.

[2] **Q:** You stated I might not necessarily claim
[3] that it is unreasonable. What factors would have
[4] been taken into account for you to assume that it
[5] was reasonable?

[6] **A:** I think the term unreasonable is what I
[7] might object to. I would prefer to say how does it
[8] relate to the logic of the computation.

[9] **Q:** So you don't have here today any
[10] amendment or change to the language here?

[11] **A:** The amendment is stated — or the change
[12] is that by assuming a point source rather than a
[13] larger area, that is, by assuming Charleston
[14] earthquakes only occur at Charleston and not some
[15] place else, would, in the statistical outfall of
[16] the computation like the Lawrence Livermore/ EPRI
[17] data, the seismic computation at the site, the
[18] point source would decrease the hazard at that
[19] site. It would decrease it relative to a larger
[20] seismic zone.

[21] **Q:** Do you have any words that you would
[22] change on page 3 of the second supplemental

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[1] response, and if so, what are those specific
[2] changes?

[3] **A:** The statement essentially stands as it
[4] is. The statement I made is actually an
[5] augmentation, addition to it, or an explanation.

[6] **Q:** I appreciate the explanation.

[7] **MS. CURRAN:** We just need to take a quick
[8] break.

[9] **MR. POLONSKY:** Off the record.

[10] (Discussion off the record.)

[11] **THE WITNESS:** The second part there,
[12] which states, DCS failed to make an evaluation of
[13] how long it would take for a new Charleston-like
[14] earthquake zone to develop in another location,
[15] while that maybe an interesting topic and could be
[16] factored in by statistical techniques, it is not
[17] one that GANE wants to pursue at this point.

[18] **BY MR. POLONSKY:**

[19] **Q:** Let me ask by clarification, and I don't
[20] know if you can answer this, but does that mean the
[21] whole line of questioning of the Kafka article and
[22] reliance on Kafka is not relevant or is Kafka still

(1) relevant to other parts of the contention or basis
(2) statement?

(3) A: I think Kafka may be relevant to the
(4) treatment of the statistic. The contention is that
(5) there is a 30 percent chance that the next major
(6) earthquake will be in a new area. I think that
(7) there is sufficient ambiguity in the process to not
(8) make it worth pursuing, for GANE not to pursue it.
(9) It is an intellectual exercise and it could
(10) impact — the statistics could impact, but I don't
(11) think there is enough certainty for that.

(12) I would like to note too that in terms of
(13) the underestimating of the mobile bounce, or post
(14) critical reflection, that the use of the Hermann
(15) velocity model is not appropriate.

(16) Q: The Hermann velocity model, is that the
(17) 1986 Hermann velocity model?

(18) A: I don't know the date. I thought it was
(19) earlier than that.

(20) Q: That is not appropriate; is that correct?

(21) A: Yes.

(22) Q: Do you believe that is a new position

(1) that you have taken, that the Hermann velocity
(2) model is not appropriate?

(3) A: Well, the position is that the test
(4) earthquake from Charleston propagated to the site,
(5) if propagated by a proper model, would very likely
(6) indicate a higher level of vibration. In looking
(7) at the Hermann model and figuring out why it has,
(8) the geometry and size it does, one can see that the
(9) interpretation that Hermann gave applies to a total
(10) path and not the short term path.

(11) Q: What do you mean by total path as opposed
(12) to short term path?

(13) A: His model was from Bowman to Atlanta or
(14) ATL which contains velocities which are
(15) significantly different than they are on the
(16) coastal plain. His technique was a surface wave
(17) technique which takes an average velocity. The
(18) average velocity between those two points doesn't
(19) necessarily represent the individual velocities for
(20) any part of that path.

(21) Q: You said that the position is that the
(22) test earthquake from Charleston propagated to the

(1) site, if propagated by a proper model, would very
(2) likely indicate a higher vibration. What is your
(3) basis for saying it would very likely indicate a
(4) higher level of vibration?

(5) A: Hermann's model includes a lower crustal
(6) layer of velocity, 6.6, which probably does not
(7) exist. That intermediate layer in the model would
(8) cause reflections and amplitudes at shorter ranges
(9) to be higher and would decrease the energy
(10) available for the post critical reflection. This
(11) is a case where a proper model should be used to
(12) see what the actual effect is.

(13) Q: Have you done any modeling or any
(14) calculations to see what the actual effect is?

(15) A: In this particular case, no. I have
(16) looked at amplitudes for my Ph.D. thesis but that
(17) is a long time ago and I based my conclusions on my
(18) experience. I do have a paper in BSSA which
(19) presents observed data for amplitude versus
(20) distance for smaller magnitude earthquakes, and
(21) that does show this effect.

(22) Q: What paper is that — is that listed on

(1) your biographical —

(2) A: Yes, Long, Jones and Macke — I am not
(3) sure how we did that.

(4) Q: You said the average velocity between
(5) these two points and I am assuming you are
(6) referring from Bowman to Atlanta, does not
(7) necessarily represent the individual velocities for
(8) any part of that path?

(9) A: That is right.

(10) Q: Does that in and of itself mean there
(11) definitely will be increased amplitude or some
(12) increase in the hazard at the Savannah River Site?

(13) A: That means that the model chosen for the
(14) shorter path is not the correct model and if one
(15) considers what the correct model should be, and
(16) just looks at what might happen, the conclusion I
(17) would have — the speculation I would have is that
(18) intermediate layer in the model would be reflecting
(19) more energy than we would want to be reflected and
(20) it would starve the energy going down to the most
(21) critical part of the model.

(22) Q: If what I will refer to as the historical

[1] check or seismic check of the 1886 Charleston
[2] earthquake was not part of the seismic design of
[3] the MOX Facility, would you have any other reason
[4] to be concerned with the Hermann velocity model?

[5] **A:** I don't think that Hermann was trying to
[6] compute a velocity model and to use it as a crustal
[7] model was probably not — was an extrapolation
[8] which might not be appropriate. Hermann's
[9] objective was to define the dispersion so he could
[10] define the focal mechanism and depth of the focus
[11] of the earthquakes and he did that for a number of
[12] earthquakes in that time period. To take that as
[13] an expression of a portion of the path would really
[14] not be appropriate. By analogy, what I do now for
[15] my major part of research is I look at surface
[16] waves, I look at dispersion and I look at the
[17] dispersion between a source, many sources and many
[18] receiving points. Along the path there is an
[19] average dispersion. It doesn't necessarily
[20] represent any single point, but I do a tomographic
[21] version to find the dispersion I can associate with
[22] a particular point in the area.

[1] page 26, second sentence says, "The Charleston
[2] earthquake is the most severe seismic event that is
[3] related to the seismic design seen of the MOX
[4] Facility."

[5] Do you have any reason to disagree with
[6] this statement?

[7] **MS. CURRAN:** What page is it on? 26?

[8] **MR. POLONSKY:** 26.

[9] **MS. CURRAN:** Sorry.

[10] **MR. POLONSKY:** That is all right.

[11] **THE WITNESS:** I would agree, in terms of
[12] the known seismicity, it is at this point the most
[13] severe. To have measurements both at Savannah —
[14] at the site and the source.

[15] **BY MR. POLONSKY:**

[16] **Q:** Is your answer yes, the Charleston
[17] earthquake is the most severe seismic event that is
[18] related to the seismic design of the MOX Facility?

[19] **A:** No, I would restate that because the New
[20] Madrid seismicity was probably larger. How
[21] relevant are they, that is another question.

[22] **Q:** The statement is the most severe

[1] **Q:** My question was though that your dispute
[2] or your concerns with the use of the Hermann
[3] velocity model appears to be related solely to this
[4] historical check on the 1886 Charleston earthquake;
[5] is that correct?

[6] **A:** That is the only place I believe it was
[7] used.

[8] **Q:** So if the historical check was not part
[9] of the seismic design, would you have any reason to
[10] raise the issue of the Hermann crustal or Hermann
[11] velocity model?

[12] **A:** No. Unless you used it in some way to
[13] compute the probabilistic hazard.

[14] **Q:** Was Hermann crustal model around —

[15] **A:** It has been around a long time but it
[16] hasn't really been used in that context. I don't
[17] think it was ever considered as part of the EPRI or
[18] Lawrence Livermore studies.

[19] **Q:** Would you agree that the Charleston
[20] earthquake is the most severe documented seismic
[21] event for the Savannah River Site? Let me point
[22] you to GANE's first answer number 3.32, which is on

[1] documented historical seismic event that is
[2] relevant to the seismic design for the MOX
[3] Facility. Are you now saying the New Madrid event
[4] is more relevant to the seismic design than the
[5] Charleston earthquake?

[6] **A:** No, I didn't say that at all. The
[7] statement was is it relevant. To some extent. New
[8] Madrid events are larger and they do have some
[9] relevance because they were felt in that area. I
[10] think to simplify that you would say the Charleston
[11] earthquake is the largest post event to have
[12] occurred in historical times. So it would be, in
[13] terms of design, it would be the most — if you are
[14] going to limit it to earthquakes that have occurred
[15] in historical time, it would be the most severe.

[16] **Q:** What would you say is the magnitude —
[17] moment magnitude of the early 1800s New Madrid
[18] earthquake, the largest?

[19] **A:** I have tried to stay out of that
[20] argument. Some people think it is lower and some
[21] higher. Some recent studies say it is lower. Arch
[22] Johnson presents probably the most definitive study

[1] of that and I believe his numbers were in the 7.5
[2] range.

[3] Q: Then what is the moment magnitude of the
[4] Charleston earthquake in 1886?

[5] A: Probably around 7.0.

[6] Q: So because Charleston was a 7.0 and New
[7] Madrid is a 7.5, do you believe that the New Madrid
[8] is the most severe documented historical seismic
[9] event that is related to the seismic design of the
[10] MOX Facility?

[11] A: Not the most relevant but the largest
[12] that is relevant.

[13] Q: Although that is true, from what you said
[14] previously, you would agree that the Charleston,
[15] although a lower magnitude, contributes more to the
[16] seismic hazard of the Savannah River Site than the
[17] New Madrid?

[18] A: Yes. The USGS and LLNL and EPRI
[19] studies — or USGS studies, go through a process
[20] where they defragment the results and the
[21] defragmentation shows the relative contribution of
[22] various sources and when you do that for the

[1] Charleston area, for a site near Charleston,
[2] Charleston almost always comes out as the strongest
[3] contributor to the hazard.

[4] Q: When you say defragmentation, is that
[5] synonymous with disaggregation?

[6] A: That maybe the term, disaggregation,
[7] perhaps.

[8] Q: And Art somebody, that is at the USGS —

[9] A: Art Frankel.

[10] Q: At the USGS.

[11] If you could turn to page 17 to 18 of

[12] GANE's first set of interrogatory responses, the
[13] interrogatory has a question, does GANE agree that
[14] the reg guide, 1.60, 5 percent damming spectrum
[15] scaled up to 0.2 G peak ground acceleration, is
[16] more conservative than the PC-3 spectrum for SRS
[17] and the response was yes. Do you have any reason
[18] to disagree with this response? It goes from the
[19] bottom of page 17 and the answer given is at the
[20] top of page 18.

[21] A: The amplitudes are larger, yes.

[22] Q: Do you have any reason to disagree with

[1] this statement?

[2] A: No.

[3] Q: Do you agree with the statement?

[4] A: Yes.

[5] Q: Let me take you to the second
[6] supplemental response, page four, interrogatory
[7] 3.1. And the response — it should be part of the
[8] interrogatory. Does GANE agree that it is
[9] appropriate to use a regulatory guide parenthesis R
[10] G, 1.60, 5 percent spectrum scaled to a 0.2 G as
[11] the design earthquake for the MOX Facility and in
[12] the response, GANE says, no. GANE agrees that the
[13] regulatory guide 5 percent damming spectrum is
[14] appropriate to use as the design earthquake for the
[15] MOX Facility. You then say it should be scaled up
[16] to an appropriate value of acceleration at the
[17] surface. Do you have any reason to disagree with
[18] this response?

[19] A: I agree with that.

[20] Q: You agree with that? The question was do
[21] you disagree?

[22] A: I do not disagree.

[1] Q: It says that the spectra should be scaled
[2] up to an appropriate value of acceleration at the
[3] surface. Do you have a proposal what that
[4] appropriate value of acceleration should be?

[5] A: No, I don't.

[6] Q: Also on page four, in response to
[7] interrogatory number 3.2, does GANE agree that
[8] design earthquake with return interval of 10,000
[9] years is acceptable for the MOX Facility and the
[10] response is yes. On that limited issue, do you
[11] have any reason to disagree with GANE's response?

[12] A: I agree.

[13] Q: What is your understanding of the
[14] spectral response — what is your understanding
[15] of what the surface horizontal spectrum is for the
[16] MOX Facility?

[17] A: We are talking about the terms we talked
[18] about before, whether it is the hard rock or the
[19] natural surface.

[20] Q: Surface, that is why I used the word
[21] surface. Not a thousand feet or 800 feet below the
[22] surface. I am talking about what is at the

[1] surface. What is your understanding of the
[2] horizontal response spectra for the MOX Facility at
[3] the surface?

[4] A: That is the spectra that one gets when
[5] one puts into the base — or propagates an event to
[6] the site, either two — one or two dimensional
[7] analysis. The analysis provides output which gives
[8] the amplitude of each frequency at the surface or
[9] close to the free surface. So the surface response
[10] would be the response of the total soil column to
[11] inputted spectrum at the base.

[12] Q: Do you know what was chosen as the
[13] spectra — spectrum for the horizontal response
[14] spectra for the MOX Facility at surface?

[15] A: No, I don't know what exactly was chosen.
[16] I didn't look in detail at that.

[17] Q: Do you know what the peak ground
[18] acceleration of that surface spectrum is?

[19] A: The plots that you have vary from .3 to
[20] .6 or seven, depending on frequency, depending on
[21] the type of earthquake.

[22] Q: The specific question was what is the

[1] acceleration. That basically is an appropriate way
[2] to do it. Are there other ways, possibly, but that
[3] is generally the approach that most seismologists
[4] take. The contention though is that some of the
[5] input along the way has not — has been biased in
[6] one way or another.

[7] Q: Let me rephrase and correct me if I am
[8] wrong. Basically what DCS did in its methodology
[9] to generate a seismic hazard in your opinion was
[10] okay, was appropriate, but what they used as
[11] inputs, you have concerns with some of those
[12] inputs?

[13] A: Exactly.

[14] Q: Okay. That is very helpful.
[15] To these interrogatories, and I am
[16] referring to them all as a set, you stated that the
[17] only addition you would provide would be a single
[18] article that we have already identified. Are there
[19] any other documents upon which you plan to rely
[20] that we have not talked about?

[21] A: I don't believe so.

[22] Q: How much time did you spend preparing for

[1] peak ground acceleration, not depending on
[2] acceleration.

[3] A: I don't know what it is exactly. It is a
[4] function — it is an interpretation of a seismic
[5] data or in any case a number of runs of a
[6] seismic — number of runs of a program using
[7] different input to decide what that should be.

[8] Q: Let's move to the third supplemental
[9] interrogatory response, answer to interrogatory
[10] 3.30. Page five. The response to interrogatory
[11] number 3.30, GANE generally agrees that the
[12] approach taken by DCS in calculating the PSHA is
[13] appropriate and then with the inception of, et
[14] cetera, et cetera.

[15] Do you agree with this statement?

[16] A: You have taken — DCS has taken a
[17] standard procedure. They have obtained some
[18] information about seismicity, although they didn't
[19] input them into the base value. They tried to
[20] formulate a spectrum for the base, for the hard
[21] rock equivalent, and they have attempted to
[22] propagate that to the surface to get the surface

[1] your deposition?

[2] A: About four hours yesterday.

[3] Q: What did you do to prepare for your
[4] deposition?

[5] A: We went through the various documents and
[6] we discussed the logic of the basic problem.

[7] Q: Did you meet with anyone other than
[8] Diane?

[9] A: No.

[10] Q: Did you talk to anyone else?

[11] A: No.

[12] Q: Did any of the discussions you had with
[13] Diane prompt you to make a phone call to anyone
[14] else?

[15] A: No.

[16] Q: Did you bring any documents with you
[17] other than the Atkinson article?

[18] A: Not relevant to this.

[19] Q: What other documents did you bring?

[20] A: A paper I am reviewing — nothing
[21] relevant to the case.

[22] Q: What is the paper you are reviewing?

[1] A: A paper I am writing on the location of
[2] earthquakes.

[3] Q: What location or what area is the paper
[4] focusing on, if it has focus?

[5] A: Theory of technique.

[6] Q: Is there any particular geographic region
[7] that it is focused on?

[8] A: No. It is mostly theory. We have used
[9] examples from the Southeastern U.S.

[10] Q: Do you plan to have your name on that
[11] article when it is published?

[12] A: Yes.

[13] Q: Do you know when it will be published?

[14] A: No.

[15] Q: Is it likely to be published before
[16] February of 2004?

[17] A: I would give it a 30 percent probability.

[18] Q: Was anything read to you during your
[19] preparation for the deposition?

[20] A: Read to me?

[21] Q: Yes.

[22] A: No, just the stuff we had.

[1] Q: What stuff is that?

[2] A: The interrogatories and their answers.

[3] Q: Did you do anything to prepare for your
[4] deposition?

[5] A: For this deposition?

[6] Q: Yes.

[7] A: No. Turns out that I was pretty much on
[8] vacation and I didn't get the time I planned to so
[9] I didn't do it.

[10] Q: Have you ever testified before the
[11] Nuclear Regulatory Commission?

[12] A: No.

[13] Q: Do you consider yourself to be an expert
[14] with detailed specialized knowledge of NRC's
[15] regulations?

[16] A: No.

[17] Q: How about that same question with respect
[18] to NRC guidance?

[19] A: No.

[20] Q: Have you ever had any interactions with
[21] the NRC other than in relation to the Livermore
[22] study?

[1] A: For some time I maintained seismic
[2] networks in Georgia and Alabama and that was
[3] sponsored by NRC.

[4] Q: Anything else?

[5] A: There was an evaluation. I don't know
[6] whether that was the NRC or not.

[7] Q: What do you mean?

[8] A: Evaluation of one of these — evaluation
[9] of part of the Lawrence Livermore or EPRI studies.

[10] I am not sure which — if that was the NRC or not.

[11] Q: When you said sponsored by the NRC, did
[12] you mean funded by the NRC?

[13] A: Funded, yes.

[14] Q: Is that funding ongoing?

[15] A: No.

[16] Q: When did that end?

[17] A: 1990.

[18] Q: Where does your funding come from now?

[19] A: DOE.

[20] Q: Anywhere else?

[21] A: NSF by way of IRIS, I R I S, institute

[22] for Research in Seismology. And DARPA, D A R P A.

[1] Q: Anything else other than those three
[2] separate entities?

[3] A: At this time, no.

[4] Q: Do you have any grant requests
[5] outstanding to others?

[6] A: I have a grant request to NSF. I believe
[7] that is the only one.

[8] Q: What are you being funded for by the
[9] Department of Energy?

[10] A: Using seismic techniques to identify
[11] perturbations of velocity in the ground, shallow
[12] ground.

[13] Q: Do you know what the ultimate purpose of
[14] that research is?

[15] A: Yes.

[16] Q: Would you share it with us?

[17] A: The current — the original research —
[18] this is a continuation. The original research was
[19] to develop a surface wave technique to develop
[20] anomalies such as may be associated with waste
[21] disposal sites that may be lost or stuff that
[22] maybe — dense non-aqueous phase. I am not an

[1] expert in that. I am an expert in the seismic
[2] phase. In doing that research and developing the
[3] tomographic technique, I discovered that it might
[4] be possible to do a differential technique, this is
[5] a new technique which came out of that research,
[6] and I am in the process of testing that. The
[7] objective there is that if in the ground fluids
[8] change pressure or there is some change in the
[9] characteristics of the properties, the soils, then
[10] that would show up as a slight perturbation and I
[11] have developed a numerical technique to develop
[12] that. Its application would be for tracking
[13] groundwater, for identifying paths that water takes
[14] particularly during remediation processes.

[15] **Q:** When did your funding by the Department
[16] of Energy start?

[17] **A:** Last October, October 2002.

[18] **Q:** And how long is the term of that work?

[19] **A:** Two years.

[20] **Q:** Are there any applications of that work
[21] to nuclear facilities other than what you have
[22] identified which is a radioactive waste disposal?

[1] **Q:** What you are referring to about
[2] deterministic and the change to probabilistic, are
[3] you referring to that as applied to nuclear power
[4] plants or a broader range of facilities?

[5] **A:** Major concern in developing this was the
[6] concern with respect to nuclear power plants. That
[7] was the driving motivation. It is a general topic
[8] and it applies to such things as seismic hazard and
[9] like this Lawrence Livermore/EPRI studies pioneered
[10] the technique which Art Frankel developed with the
[11] USGS into the new hazard maps which applies to
[12] everything.

[13] **Q:** You have already told me that you haven't
[14] reviewed the NRC regulations in part 70 which apply
[15] to the MOX Facility but are you familiar with any
[16] NRC guidance documents?

[17] **A:** Not in detail, no.

[18] **Q:** Have you reviewed the standard review
[19] plan, which is an NRC guidance document new reg
[20] 1718, standard review plan for the MOX Facility?

[21] **A:** No.

[22] **Q:** Have you reviewed any other plans for any

[1] **A:** Waste disposal in general.

[2] **Q:** Any applications to nuclear facilities?

[3] **A:** I have not pursued all the potential
[4] applications. If I had known this technique and
[5] had the equipment when I was first asked to deal
[6] with it in Southwest Georgia to deal with sheer
[7] wave velocity, I would have used it then.

[8] **Q:** Do you have any experience with NRC
[9] regulations?

[10] **A:** No.

[11] **Q:** Are you aware that there are separate NRC
[12] regulations that deal with deterministic seismic
[13] analysis versus probabilistic seismic analysis?

[14] **A:** I am aware that the original regulations
[15] were closer to a deterministic approach which in
[16] many cases became unreasonable or very difficult to
[17] manage and that the Lawrence Livermore studies and
[18] EPRI studies were largely initiated to get away
[19] from deterministic and move toward a probabilistic
[20] approach. I am not aware of — have not read the
[21] regulations themselves. As to the history of why
[22] these were occurring, that is my understanding.

[1] other types of facilities?

[2] **A:** No.

[3] **Q:** Are you familiar with reg guide 1.60?

[4] **A:** No.

[5] **Q:** Have you ever looked at it?

[6] **A:** I don't know.

[7] **Q:** You don't know if you have ever looked at
[8] it?

[9] **A:** Right.

[10] **Q:** Do you have experience with the
[11] Department of Energy other than the work that you
[12] initiated in October of 2002?

[13] **A:** It was a five-year grant that led up to
[14] that study.

[15] **Q:** So I assume that five-year grant began
[16] sometime in 1997?

[17] **A:** Yes — yes.

[18] **Q:** And what was the purpose of that grant?

[19] **A:** That was the tomographic stuff.

[20] **Q:** The tomographic conversion —

[21] **A:** Of surface waves, yes.

[22] **Q:** Other than that, have you ever been

[1] funded by DOE?
[2] A: I don't think so.
[3] Q: Have you ever been funded by a DOE
[4] contractor?
[5] A: By someone who has contracted with DOE?
[6] Q: Yes.
[7] A: I don't know. Possibly.
[8] Q: Have you ever been funded by the
[9] Westinghouse Savannah River corporation or any of
[10] its prior entities that may have been referred
[11] to —
[12] A: Yes.
[13] Q: What work did you conduct for WSRC?
[14] A: We established and instrumented four
[15] seismic stations in Georgia.
[16] Q: When did that work begin?
[17] A: '90, 1990.
[18] Q: And when did that work end?
[19] A: '93, '92 or '93.
[20] Q: And why was it for such a short period?
[21] A: It was a single contract, set them up,
[22] and my guess — rocket continuation was a poor

[1] Q: 1021, performance categories?
[2] A: These are all DOE documents? I have not
[3] gone into to look at the DOE's documents. Whether
[4] I have seen them in some other context, I can't
[5] tell you. I don't remember.
[6] Q: Are you familiar with performance
[7] categories in general, PC 0 through PC 4?
[8] A: What I have learned in this review.
[9] Q: What is this?
[10] A: What I have learned in the review of this
[11] contention and your papers.
[12] Q: Have you reviewed any other documents
[13] generated by WSRC other than the 1997 WSRC — I
[14] gave you a copy already, 0085.
[15] A: I think this is the one I spent most of
[16] the time on, it seemed to be the most relevant.
[17] There were many other papers in there, some of
[18] which I glanced through. In terms of actually
[19] studying them for presentation, no. If you go into
[20] a historical context, I have on occasion received
[21] some of the documents that have been prepared
[22] concerning the Savannah River plant and looked at

[1] choice of instrumentation. We chose an instrument
[2] that relied on phone line for communication. This
[3] was pre-long term reporting capabilities of
[4] instrumentation, and we chose an instrument that we
[5] thought we could get into the field — we could
[6] order and have delivered and get into the field in
[7] a hurry. The contractor — the company didn't
[8] quite follow through on what they said they could
[9] in the way of delivery time so it was delayed.
[10] Q: Any experience with DOE regulations?
[11] A: No.
[12] Q: Any experience with DOE guidance
[13] documents?
[14] A: No.
[15] Q: Are you familiar with any of the DOE
[16] standards that were the basis of the 1997 PSHA?
[17] A: No, don't think so.
[18] Q: I am going to name DOE standard 1020.
[19] Does that ring a bell?
[20] A: Numbers won't ring a bell.
[21] Q: Entitled seismic design?
[22] A: No.

[1] those, not in relevance to this case.
[2] Q: What is your experience with emergency
[3] planning groups in the state of South Carolina?
[4] A: I have not dealt with those.
[5] Q: You haven't done any work with emergency
[6] planning groups in South Carolina the way you have
[7] done it in Georgia?
[8] A: No.
[9] Q: What is your experience with the United
[10] States Geological Service, which I will refer to as
[11] USGS?
[12] A: I have had some contracts with them.
[13] Q: Any in the past ten years?
[14] A: I don't think so.
[15] Q: Do you have any frequent interactions
[16] with anyone at the USGS?
[17] A: Normal interactions at society meetings
[18] and such. I do not work closely with USGS
[19] personnel.
[20] Q: Were you ever funded by USGS?
[21] A: I have been funded in the past.
[22] Q: And that would have been more than ten

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[1] years ago?

[2] **A:** Yes, I believe. There have been
[3] something like 50 or 60 grants. I can't remember
[4] which is which.

[5] **Q:** And you have never done any work on
[6] seismic design to support construction of a nuclear
[7] facility?

[8] **A:** By design, you mean shape of the building
[9] or construction, no. In terms of seismic criteria
[10] for design, that — we have already gone over with
[11] respect to the Law Environmental Services or Law
[12] Engineering company.

[13] **Q:** Outside of Law Engineering you haven't
[14] done any work on any specific facilities?

[15] **A:** No.

[16] **Q:** Have you ever yourself conducted a PSHA?

[17] **A:** I have computed an equivalent of that
[18] which is not the spectral components but the
[19] maximum velocity.

[20] **Q:** When did you do that?

[21] **A:** Late '80s or early '90s.

[22] **Q:** Why?

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[1] **A:** I did that because I, along with many
[2] other seismologists were not happen with the maps
[3] or the seismic hazards and we wanted something that
[4] was more representative of an awful lot of new data
[5] that had come out of various seismic monitoring
[6] programs. You stated it is not the spectral
[7] component but the maximum velocity.

[8] The particle velocity.

[9] **Q:** Why would you look at particle velocity
[10] or various components?

[11] **A:** Particle velocity there agrees most
[12] closely with intensity felt data and it could be —
[13] in that process I developed a relationship between
[14] intensity and particle velocity.

[15] **Q:** What is that relationship?

[16] **A:** I haven't published it yet.

[17] **Q:** When are you going to publish it?

[18] **A:** I may do it next year or two. I was
[19] looking at intensities from the Charleston
[20] earthquake and their decay with distance. I was
[21] looking at a number of smaller earthquakes, fitting
[22] that all together with the relationship that I had

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[1] published with Jones and Macke quite a bit earlier.
[2] I used that then in the hazard computation program
[3] which I wrote to compute probability that a certain
[4] particle velocity might be exceeded and came up
[5] with some maps for Georgia that showed the
[6] influence of various sources.

[7] **Q:** Did you come up with a map for South
[8] Carolina?

[9] **A:** I did not come up with a map for South
[10] Carolina. I believe at the same time Gil Bollinger
[11] put together some maps for South Carolina. I think
[12] that was contracted for by the Savannah plant. I
[13] used them to get to a map of Georgia.

[14] **Q:** So this work was done in the late '80s
[15] and '90s but you are hoping to publish it now?

[16] **A:** The particle velocity relationship might
[17] still be good enough to publish. The contouring
[18] and hazard was really — myself and a number of
[19] other people did this, presented talks on it, but
[20] in terms of publishing, it was limited, mainly
[21] because the USGS stepped in and did the full job.
[22] I was not funded to do that directly. It was more

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[1] something I felt needed to be done.

[2] **Q:** Does the work you did on the intensity
[3] felt area of the Charleston earthquake contradict
[4] any of the work Bollinger did in the late 1970s
[5] regarding the intensity meso seismal zones from the
[6] Charleston 1886 earthquake?

[7] **A:** I don't recall it contradicts his work,
[8] no. I may have looked at it a little more closer
[9] with some of the attenuation relationships. What I
[10] did in the attenuation relationship is developed
[11] something that accounted for the post critical
[12] amplitude of the seismic waves — most critical
[13] reflection, and incorporated that into equations I
[14] used. I used his intensity interpretation
[15] directly. I did not modify it in any way.

[16] **Q:** Have you ever developed a seismic
[17] response spectrum?

[18] **A:** No, I haven't. I haven't in the sense of
[19] a spectrum that you would consider for design
[20] purposes. With my Ph.D. thesis, I looked very
[21] carefully at the spectra of the wave form and the
[22] way the spectra is developed and attenuated.

[1] Q: You have told us that you have had
[2] intimate experience with the Livermore and EPRI
[3] work, that you were a participant on the expert
[4] panel for Livermore and on a committee for the EPRI
[5] work. Would you agree that due to the large
[6] uncertainty, and in all the geosciences data and in
[7] their modeling, that multiple model interpretations
[8] are often possible?

[9] A: Multiple interpretations are possible,
[10] yes, and in the timeframe of the Lawrence
[11] Livermore, publicity was considerably larger than
[12] it might be now.

[13] Q: Would you agree that when completing a
[14] PSHA particularly for a nuclear fuel fabrication
[15] facility specifically estimating annual frequencies
[16] of exceedence of earthquake-caused ground motions
[17] can be attained only with significant uncertainty?

[18] A: I would guess that today the uncertainty
[19] is more related to what is not known about
[20] earthquake rates and their variability over time
[21] than it is with the computations. I would think
[22] that given the premise or the constraints of the

[1] capture uncertainty?

[2] A: Yes. I think that the statement I liked
[3] at the time was that this was a cheap way to do a
[4] literature survey.

[5] Q: What was that in reference to?

[6] A: With respect to — if you pull together a
[7] whole lot of experts and you get their opinions and
[8] assessments, each expert looks at the literature
[9] and makes his assessment of that. So you are in
[10] effect pulling together the last five, 10, 15 years
[11] of the seismic literature into one big
[12] probabilistic ball which eventually boils down to a
[13] set of numbers with a scatter. If you were to take
[14] a seismologist who is fairly well qualified in
[15] understanding what is going on, a lot of the models
[16] and older hypothesis would be dropped and the
[17] scatter or range of that probability would be
[18] decreased. So I guess the bottom line is we should
[19] be able to do it better today. We should be able
[20] to get data that will define a lot of the
[21] parameters that were averaged or guessed at.

[22] Q: What do you do with the person that is

[1] studies, that they have improved so the uncertainty
[2] should be reduced today. Also, the number of wild
[3] theories have been cut down. So the uncertainty
[4] inherent in those studies should be reduced some.

[5] Q: Why do you think time has whittled down
[6] the number of theories?

[7] A: A lot of the theories were not based on
[8] strongly held data or observations and since that
[9] time we have more seismic data to look at, we have
[10] better definitions of earthquakes so the
[11] definitions, the locations of the earthquakes, have
[12] improved considerably or at least have until a few
[13] years ago.

[14] Q: Would you agree that in a PSHA the
[15] limited information that does can be and often is
[16] legitimately interpreted quite differently by
[17] different groups?

[18] A: I think different groups may come to
[19] different interpretations because they do not look
[20] at the fundamental assumptions that are made to
[21] pull the data together.

[22] Q: Isn't the whole purpose of a PSHA to

[1] participating in an expert panel assuming that a
[2] large effort was made — what do you do with that
[3] person who has some real outlier opinion about
[4] either source zone or magnitude or recurrence
[5] theory?

[6] A: That is a good question. That is
[7] entirely up to the person designing the survey as
[8] to how it is designed. If you are asking an
[9] opinion as to how I would handle it?

[10] Q: Yes.

[11] A: I am pretty happy with my own opinion and
[12] I wouldn't necessarily want to give a lot of weight
[13] to one I felt did not satisfy certain basic
[14] principles in seismology and some of them have,
[15] even some of my earlier ones today I understand
[16] with new data and understanding are not as viable
[17] as they were back some time ago. So how do you
[18] weight those? That is a time changing entity. I
[19] don't know that I can give you a discrete answer.
[20] There are people who are outliers and that is a
[21] real question, as to how do you handle those
[22] outliers. One of the experts I understand just

[1] drew a big circle around the whole eastern United
[2] States and said you have a seven anyplace and gave
[3] a rate for it. That is one outlier. Then there is
[4] some — to the extent that I have seen a number of
[5] papers — Ben Howell wrote a paper some time ago on
[6] the fact that almost all of the major eastern
[7] United States earthquakes, at least according to
[8] this data at the time had occurred in areas where
[9] there had not been previous seismicity and that
[10] scared him. However, we note from Charleston and
[11] New Madrid, those areas have exhibited seismicity
[12] and we know Seattle has had tremendous earthquakes
[13] and people thought it was pretty quiet up there.
[14] Just from historical data, a lot has been learned
[15] about seismicity but not enough to know where the
[16] next one is.

[17] Q: So wouldn't you agree that it is
[18] important to have outlier opinions in the PSHA?

[19] A: I agree you have to evaluate those
[20] opinions as to whether they are radical or outliers
[21] in terms of whether they disagree with the general
[22] opinion of seismologists. I have to admit that

[1] methodology used by the Livermore and EPRI PSHA
[2] study — if one were to be done today —

[3] A: Would we do it the same way —

[4] Q: Would you think it should be done the
[5] same way?

[6] A: It was very much an evolutionary process.

[7] We started out before then with the deterministic
[8] model which turned out to be unworkable in terms of
[9] licensing and realistically because emphasis was on
[10] the outliers and not the mean. So the point here
[11] was to incorporate the whole thing into some
[12] statistics. Lawrence Livermore took experts and
[13] had them develop the seismicity. EPRI took groups
[14] and said you have to include hypotheses and
[15] possibilities that earthquakes could occur, and
[16] then you have the USGS jumping in, finally
[17] admitting that the Elgin original hazard was way
[18] out of date and instead of using hypotheses, which
[19] is somewhat ambiguous, they said, let's boil it
[20] down to the facts we know, that is, a certain
[21] number of earthquakes have occurred in a certain
[22] number of areas and we will compute a hazard from

[1] myself, when I talk about eastern United States
[2] major earthquakes, I am probably a little bit of an
[3] outlier in the sense that they are not due to
[4] existing faults but due to weaknesses in crusts
[5] which evolve in both the earthquake and the fault.

[6] Q: Would you agree that a PSHA should
[7] incorporate the diversity of expert judgments into
[8] the analytical results by appropriately capturing
[9] the current state of knowledge of the expert
[10] community?

[11] A: That sounds quite reasonable, yes.

[12] Q: Are you familiar with the senior seismic
[13] hazard analysis committee which I will refer to as
[14] SHAC?

[15] A: No.

[16] Q: Are you familiar with any reports issued
[17] by SHAC?

[18] A: I don't think so.

[19] Q: So it is fair to say you have never used
[20] it as guidance?

[21] A: No.

[22] Q: What is your opinion of the underlying

[1] that.

[2] I am not really 100 percent happy with
[3] all of them. I think there are holes. One of the
[4] basic reasons I believe there are holes is my
[5] understanding of what triggers or what causes a
[6] major earthquake. I have explained already why I
[7] think stresses accumulate and intraplates — I
[8] think there is a weakness that accumulates but what
[9] actually triggers that may be something else and
[10] the process, whether you are dealing with a major
[11] earthquake or some of the shallow earthquakes, is
[12] one in which you are dealing with what may be
[13] called a chaotic process, and it is something a lot
[14] of seismologists will not admit, that the Gutenberg
[15] Richter recursion relationship is a log normal
[16] process. Log normal processes are by definition
[17] chaotic. That means that there is a certain level
[18] of unpredictability to earthquakes. That
[19] unpredictability comes as a result of processes
[20] that go on that are chaotic in the sense that one
[21] cannot predict now, or in two or three days, what
[22] is going to happen.

(1) So the process of triggering an
(2) earthquake, you can have — in the process of
(3) triggering an earthquake, you can have all the
(4) conditions ripe for triggering, but it may or may
(5) not happen depending on such small things. This is
(6) very analogous to weather prediction and modeling
(7) where the Lorenz effect says if you run a model and
(8) you get a sunny day in Ohio, if you change the
(9) model by having a butterfly flap its wing in Rio,
(10) you have a tornado. That is the unpredictability
(11) or inability. In other words, the processes —
(12) many of the processes associated with triggering an
(13) earthquake are of this type. That is my general
(14) opinion on that.

(15) Q: How does your theory, and I think it is a
(16) five step theory that you have identified in one of
(17) your processes, and the fifth step is a crustal
(18) healing process —

(19) A: That was in the Nutterly volume which is
(20) one of the earlier versions of that.

(21) Q: Do you still hold to that?

(22) A: Basically. There were modifications

(1) over time.

(2) Q: How does this chaos process play into
(3) crustal healing and trying to estimate the return
(4) period for an earthquake with crustal healing?

(5) A: It is difficult. It is difficult because
(6) the log normal relationship is not a statistical
(7) relationship. It is an exponential form. So you
(8) don't have a value with an error. You have a log
(9) normal. The distribution then is one of refractal,
(10) not a statistical distribution. So when you look
(11) at an area, you have to say you have epi centers
(12) around that area. You have a distribution, most
(13) often seismologists and for most of these studies,
(14) particularly Lawrence Livermore, they went to great
(15) pains to remove after-shocks but if you look at it
(16) from a fractal consideration, you would like to
(17) leave the after shocks in. So whether you leave
(18) the after shocks in or take them out makes a
(19) difference in what type of analysis you do. I
(20) don't know that anyone has really fully developed
(21) that for earthquake occurrences but that log normal
(22) relationship, the Gutenberg Richter recursion

(1) analysis says that is the analysis you should be
(2) using.

(3) Q: For the Charleston area, whether it is —
(4) how do you end up getting crustal healing in 550 to
(5) 650 years?

(6) A: How do you get a Mt. St. Helen's popping
(7) up in about 20 years? That is a short term rapid
(8) change in crustal properties in the period of a
(9) few, 10, 20, 30 years. You have hotter magma
(10) popping up there, heating it to a point where you
(11) can see a bulge 300 feet high and two weeks later
(12) it is blowing to smithereens. That is a fairly
(13) rapid process. If you just do that with fluids,
(14) you can have an episodic injection of fluids. That
(15) has been proposed by others or you can have fluids
(16) that have been captured and pushed down from the
(17) surface or you can have fluids that are released by
(18) a change in the mineral composition of the rocks.
(19) You can then change the physical properties because
(20) fluids have a tremendous effect on properties.

(21) Q: But the Mt. St. Helen's example is
(22) associated with a crustal boundary that subsides

(1) and your paper is an intraplate seismicity?

(2) A: Mt. St. Helen's was on the plate. The
(3) mechanics are the result of stuff that comes up
(4) with a plate and on to the surface. They are
(5) because they have been subducted, yes.

(6) Q: But we don't have that kind of
(7) subvergence on the East Coast?

(8) A: You have it in Yellowstone.

(9) Q: But on the East Coast?

(10) A: Some might argue there is off North
(11) Carolina. It doesn't have to be volcanic. It can
(12) be simply fluids or fluid content.

(13) Q: And it is your theory that is occurring
(14) in Charleston?

(15) A: I am trying to think of the guy's name,
(16) he graduated and worked for St. Louis for a while
(17) and he worked for Brian Mitchell there and is now
(18) working in another neighborhood university. He did
(19) an analysis, seismic — analysis of seismic
(20) velocities in New Madrid and he showed in the
(21) seismic zone there was a sufficient or significant
(22) decrease in the velocity which he explained as a

[1] possible explanation was an increase in fluid
[2] content or properties of that area.
[3] **Q:** Did those studies translate to
[4] Charleston? I understand they may be clear or
[5] somewhat clear in New Madrid?
[6] **A:** I don't know whether the velocity
[7] structure at Charleston has been studied in
[8] sufficient design to find out. I think that the
[9] five to 10 stations that are available in
[10] Charleston, considering the noise and the rate of
[11] activity, don't give enough data to do the type of
[12] conversion that one would need to do that. I would
[13] guess, yes, there is. I think in conversion of
[14] seismic data in Southeast Tennessee, I found a
[15] relationship between seismicity and lower
[16] velocities.
[17] **Q:** What tools are you aware of that you can
[18] determine what the most sensitive tool of a PSHA
[19] is?
[20] **A:** It is probably disaggregation.
[21] **MS. CURRAN:** Whenever you are ready to
[22] take a break.

[1] Lawrence Livermore and the NRC and wanted their own
[2] opinion and came up with an alternative way.
[3] Eventually the two results were compared.
[4] I think a lot of seismologists learned a
[5] lot about ideas and theories about seismicity,
[6] seismic zones, active levels of seismicity in the
[7] process. In terms of how one establishes a
[8] consensus view from the scientific community, this
[9] is probably an effective way of doing it. I do not
[10] know enough about some of the scientific procedures
[11] to know whether today it is considered the best
[12] way.
[13] There are questions concerning sampling
[14] of opinions, and obtaining opinions, asking
[15] questions in the proper form in order to solicit an
[16] unbiased opinion because even in an EPRI or
[17] Lawrence Livermore study one can present the data
[18] in a way that would influence the data or average
[19] out opinions that may not deserve to be averaged.
[20] One of the earliest problems is that the
[21] seismologists were coming up with budgets that
[22] exceeded the existing rate of earthquakes. Too

[1] **MR. POLONSKY:** Let's do it now.
[2] (Discussion off the record.)
[3] (Recess.)
[4] **BY MR. POLONSKY:**
[5] **Q:** I don't want to cut you off from a
[6] response you might have otherwise given. Is there
[7] anything that is pending on the table in your mind
[8] or should I move on?
[9] **A:** No, you can move on.
[10] **Q:** Would you agree that the Lawrence
[11] Livermore/EPRI PSHAs are the gold standard for
[12] capturing uncertainty in the parameters that
[13] comprise the PSHA?
[14] **A:** What is a gold standard?
[15] **Q:** The standard that someone would turn to
[16] if that they were designing a nuclear facility?
[17] **A:** I have to put this in historical
[18] perspective. Lawrence Livermore started up with
[19] their study contracted by the NRC. It was an
[20] expert's opinion pulled together at the time. The
[21] experts had a wide diversity of opinions. EPRI
[22] funded by the power plants probably didn't trust

[1] many hypotheses and too many earthquakes possible
[2] to occur and overestimated the total seismicity and
[3] that eventually had to be corrected. That led to a
[4] substantial uncertainty in the advice. Some
[5] sources of the uncertainties relate to the
[6] attenuation functions that were used and that is a
[7] part of the study I didn't get into but very often
[8] attenuation with distance can be anomalous and it
[9] can differentiate. With Eastern United States
[10] earthquakes, if we have a shallow earthquake, it
[11] can have a fairly anomalously high local intensity,
[12] whereas that would be totally unacceptable for a
[13] California earthquake. Those variations weren't
[14] recognized in attenuation relations.
[15] **Q:** If you were designing a nuclear facility
[16] today and you were told you needed to take a
[17] probabilistic approach, what PSHA would you use if
[18] you didn't have the funds to do a site-specific
[19] PSHA?
[20] **A:** I would probably go with USGS studies
[21] done recently and augment those with some — mainly
[22] because I think they put a little more in in terms

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[1] of what is understood with attenuation
[2] relationships. It is not terribly expensive to buy
[3] the program and run it and substitute a different
[4] attenuation relationship. You are not talking
[5] about big bucks.

[6] Q: Do you consider yourself an expert in
[7] ground motion attenuation?

[8] A: I believe I have done a number of studies
[9] related to the rate of decay of amplitudes with
[10] distance. Yes, I think probably as much as
[11] anybody.

[12] Q: Can you identify for me who you think are
[13] the leading experts in ground motion attenuation
[14] today?

[15] A: Most of that has been done in the
[16] engineering community and I am not that familiar
[17] with that community. I disagree with it, with some
[18] of their approaches. The engineering approach is
[19] to find an exponential or power law relationship to
[20] explain the data and I am not sure that works for
[21] these types of events.

[22] Q: Is Atkinson — are Atkinson/Boore in this

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[1] geotechnical side or are they —

[2] A: They are more seismological and for that
[3] reason I think they do have a relationship which
[4] reflects more accurately the possibility of a post
[5] critical application.

[6] Q: Are you familiar with Paul Somerville?

[7] A: I have met him.

[8] Q: How would you characterize him as an
[9] expert, what field?

[10] A: More toward the engineering side, as far
[11] as I know.

[12] Q: Norman Abramson?

[13] A: I don't know him. Sounds like an
[14] engineer.

[15] Q: Gabriel Torro?

[16] A: I have not worked with him. I don't know
[17] him.

[18] Q: And you said you don't know Walt Silva?

[19] A: No.

[20] Q: Have you done any ground motion
[21] attenuation work since the two studies you
[22] identified which I think were in the late 1970s?

[1] A: There was the late '80s and '90s particle
[2] velocity versus distance attenuation. All the work
[3] I did was ground noise and how rapidly this ground
[4] noise decayed with distance and the frequency.

[5] Q: But the ground noise was shallow?

[6] A: Yes.

[7] Q: Have you done any work ever in ground
[8] motion attenuation for deep earthquakes?

[9] A: For earthquakes. I did it with respect
[10] to the Norris Lake — they weren't deep
[11] earthquakes. They were shallow.

[12] Q: The question was have you ever done
[13] ground motion attenuation work for deep
[14] earthquakes?

[15] A: Not really deep earthquakes but deep
[16] earthquakes is 80 to 100 kilometers.

[17] Q: The definition you gave me before about
[18] shallow and deep — what is your definition of a
[19] shallow earthquake?

[20] A: My definition of — the — let me first
[21] give a seismological definition. It has basically
[22] shallow earthquakes as anything above 30 or 40

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[1] kilometers. The deep are ones that occur at 100
[2] kilometers down to 600. When I talk about
[3] seismicity in the eastern United States I talk
[4] about crustal earthquakes and very shallow
[5] seismological events which are within a few
[6] kilometers of the surface and seismological —
[7] sometimes I say deep but they are the major
[8] earthquakes in the crust. Seismologists would call
[9] them shallow.

[10] Q: Under your definition, before you defined
[11] shallow as 0.25 to 2 kilometers, what is your
[12] definition of a deep earthquake?

[13] A: Anything from two to 15 to 30 kilometers.

[14] Q: Have you ever done any ground motion
[15] attenuation work in the 15 to 30 kilometer deep
[16] range?

[17] A: We did simulation of amplitudes for
[18] earthquakes in Southeastern Tennessee seismic zone.
[19] We had a couple of earthquakes there where we
[20] looked at velocity in particular and the way it was
[21] attenuated out.

[22] Q: Who is we?

[1] A: My students and myself.

[2] Q: When was that work done?

[3] A: That work was in the late '80s.

[4] Q: And other than Southeast Tennessee, have
[5] you done any attenuation work in the area of 15 to
[6] 30 kilometers?

[7] A: Not directly. It is a problem we have
[8] addressed.

[9] Q: Do you know Ken Campbell?

[10] A: I know the name, yes. I haven't worked
[11] with him.

[12] Q: Do you know what field he is in?

[13] A: I don't know the details of what he has
[14] done.

[15] Q: How do you know the name?

[16] A: He was associated with a lot of the early
[17] Lawrence Livermore studies and EPRI studies.

[18] Q: Before you referred to the term seismic
[19] budget, either in reference to Livermore or EPRI.
[20] What is that?

[21] A: Total catalog for eastern United States.

[22] Q: You also said that regarding the either

[1] Livermore were regional and meant to be used in a
[2] wide area.

[3] Q: What is your basis for that statement,
[4] just your understanding —

[5] A: That is my understanding. I remember
[6] asking someone about that and I don't remember who
[7] and when. It was someone involved in the studies.
[8] Basically, I had concern way back then, how can you
[9] use these generalized relationships for specific
[10] sites and I remember asking someone and he said
[11] they were not intended for a final answer but that
[12] any new site would have to be evaluated based on
[13] recent information.

[14] Q: Give me your definition of what a major
[15] earthquake is in your opinion. Can you define what
[16] small and large are for me in your opinion, and if
[17] we could give it the moment magnitude but just for
[18] the purposes of currency?

[19] A: There is a term called micro earthquake
[20] which is generally believed to be anything that is
[21] not felt but may be recorded and that is about
[22] magnitude one or less in the western U.S.. They

[1] EPRI or Livermore work, that some sources of the
[2] uncertainties relate to the attenuation functions
[3] that were used and that is a part of the study I
[4] didn't get into. What do you mean?

[5] A: I did not reproduce the attenuation. The
[6] Lawrence Livermore and EPRI, I was a seismology
[7] expert. They had a separate panel for attenuation.
[8] They accepted relationships from the seismology
[9] group and attenuation from the attenuation group.
[10] I was not a part of the attenuation group.

[11] Q: GANE has stated that EPRI and Livermore
[12] were intended for first-guess work only. Do you
[13] agree with that statement?

[14] A: I agree with the statement that the
[15] Lawrence Livermore and EPRI studies were intended
[16] to give a regional assessment of the hazard. That
[17] their application to a particular site was to be a
[18] first guess in the sense that any individual site
[19] should be reevaluated given the details of
[20] seismicity and details of attenuation relationships
[21] for that particular site. Seismicity and
[22] attenuation relationships used in EPRI and Lawrence

[1] might be magnitude two or less because people are
[2] less sensitive out there. I could say the ground
[3] motion is not as strong on the surface because they
[4] are deeper. A small earthquake is larger than a
[5] micro earthquake and we are talking about
[6] earthquakes that don't cause significant or
[7] extensive damage.

[8] Q: So magnitude one or two to what?

[9] A: On the order of three, three and a half.

[10] Q: And a large earthquake?

[11] A: Large earthquake is going to be three and
[12] a half to five or six.

[13] Q: And then major was five and a half to
[14] anything above that?

[15] A: Yes.

[16] That is just sort of off the cuff.

[17] Occasionally we get e-mails saying we have to
[18] define these terms and here it is and they seem to
[19] differ. After you have gone through about six of
[20] these you don't remember which definition to work
[21] with.

[22] Q: Is there a category above major?

(1) A: I don't know if it would be relevant or
(2) not.

(3) Q: What is a typical rate of error in
(4) determining earthquake magnitude?

(5) A: Earthquake magnitudes vary quite a bit
(6) depending on how they are done. By quite a bit —
(7) if you have an earthquake, the typical range for
(8) the magnitude is plus or minus .3 units.

(9) Q: Is that in today's instrumentation
(10) standards?

(11) A: Pretty much that is what you would get
(12) today. For many of the smaller earthquakes. But
(13) it depends on how you are computing the — there
(14) are different magnitude scales.

(15) Q: That is why I was hoping to stay with
(16) moment magnitude.

(17) A: You can't measure moment directly. You
(18) have to infer it from other measurements. The way
(19) I do it is to wait until the USGS says what it is
(20) and I use that number. They get the most stations
(21) in most rapidly and they come up with an average
(22) and if you look at that, it is going to be plus or

(1) minus three. In the studies I have done, in terms
(2) of measuring the amplitudes, that is what Otto
(3) Nutterly did in the '70s. I was able to reduce
(4) that to magnitude plus or minus point one five but
(5) that is more perhaps an artifact of the data than
(6) it is a real improvement in the magnitude.

(7) Q: What about pre-recording or
(8) pre-instrumentation, what is the rate of error
(9) there?

(10) A: There is both the rate of error and the
(11) rate of detection. Most of that pre-recording has
(12) to be based upon intensity data, and I think that
(13) intensity data historically and today is probably
(14) interpreted a little bit differently. How to
(15) quantify that, I don't know. The uncertainty is
(16) probably point five units of magnitude.

(17) Q: Have you ever calculated the ground
(18) motion at Savannah River Site from a repeat of the
(19) 1888 Charleston earthquake?

(20) A: I have not done that.

(21) Q: Have you done that calculation from any
(22) Charleston earthquake?

(1) A: I have put together the attenuation
(2) relationship I discussed earlier with respect to
(3) relating intensity to particle velocity and I used
(4) that in my estimate of hazard and so that would
(5) count as computation of distance versus amplitude.

(6) Q: When you said you used it, did you
(7) mean —

(8) A: I used the relationship which I derived
(9) which was based on the Charleston and many other
(10) earthquakes — not many. We don't have many. I
(11) guess we have a few.

(12) Q: Are you familiar with the term
(13) frequencies of structural interest?

(14) A: Those would be the frequencies most
(15) likely to cause damage to the structure. Now, what
(16) they are would depend on the structure, to a large
(17) extent.

(18) Q: Do you agree that the frequencies of
(19) structural interest for a typical nuclear facility
(20) are between 2.5 and 9 Hz?

(21) A: I don't have a basis for judging the
(22) response of a nuclear plant. I have not done those

(1) studies.

(2) Q: Would you have any opinions for a MOX
(3) facility?

(4) A: I haven't gone into the construction
(5) aspects of those facilities.

(6) Q: Are you familiar with the term peak
(7) ground acceleration?

(8) A: Peak ground acceleration, yes.

(9) Q: What does it mean to you?

(10) A: That means the peak acceleration of the
(11) ground in a time trace of an earthquake.

(12) Q: If I understand you correctly, peak
(13) ground acceleration is an actual recorded peak on a
(14) seismograph?

(15) A: It should be. Lots of times it is
(16) synthesized.

(17) Q: Do you know what the peak ground
(18) acceleration is for the spectrum of the MOX
(19) Facility?

(20) A: No, I don't know.

(21) Q: Is peak ground acceleration a term that
(22) could be used at both surface and bedrock?

[1] A: I would think so, if it is simply the
[2] response of the site to a wave — if you look at a
[3] seismogram you come up with a peak ground
[4] acceleration.

[5] Q: Do you know if the peak acceleration that
[6] was used for the horizontal surface spectrum for
[7] the MOX Facility was synthesized or is based on an
[8] actual recorded?

[9] A: It would have to be synthesized.

[10] Q: Are you aware that the Vogel nuclear
[11] power plant uses the same peak ground acceleration
[12] as the proposed MOX Facility?

[13] A: No. I thought they might be lower.

[14] Q: Why would you think that?

[15] A: Because they were done earlier. Number
[16] of plants have used lower. I think Marconi is .18.

[17] Q: Do you think a MOX facilities should have
[18] a higher peak ground acceleration than a nuclear
[19] facility?

[20] A: I think the MOX Facility should be
[21] designed for what is known as the best acceleration
[22] today, not relying on other comparative analyses.

[1] Q: And you don't have an opinion on what
[2] exactly that peak ground acceleration should be for
[3] the horizontal spectrum for the MOX Facility?

[4] A: No, but if you give me a good contract, I
[5] will compute it for you.

[6] Q: Do you have an opinion of where the epi
[7] center tier of the 1886 Charleston earthquake was?

[8] A: I have an opinion, yes.

[9] Q: What is that opinion?

[10] A: I have had recent conversations with
[11] Pradeep Talwani and I have seen his recalculated
[12] epi centers and I can therefore calculate where the
[13] main shock must have occurred — must have
[14] occurred.

[15] Q: Getting back to the question or its
[16] answer, but if you give me a good contract, I will
[17] compute it for you. Approximately how many hours
[18] do you think it would take you to compute it?

[19] A: We are talking about hard rock or —

[20] Q: Surface. Only talking about surface.

[21] A: That would depend on some of the data,
[22] whether it was available or not. If there was a

[1] USGS refraction survey — I am not sure if results
[2] from that were incorporated into this or not. I
[3] haven't had time to look for that particular
[4] detail. Most of the work would be based on
[5] modeling, crystal modeling and propagation. I
[6] could probably do that in a couple of months. That
[7] is based on programs I have.

[8] Q: Would that be full-time or part-time?

[9] A: That would have to be part-time.

[10] Q: What data would you need to do that and
[11] what programs would you need to do that?

[12] A: I would use data based — I would have to
[13] do a review of the crystal structure path between
[14] Charleston and the site and I would have to review
[15] the surface layering as well. With the crystal
[16] path I would use a finite difference program which
[17] I have developed for surface wave analysis.
[18] Scaling it up is no problem. It would be either
[19] full elastic or sheer wave, either way. I could do
[20] a more detailed higher frequency modeling with
[21] sheer wave. I would then have to look at the near
[22] surface, although I would probably look to a large

[1] extent on what has already been done to propagate
[2] the base up to the top.

[3] Q: And what programs would you use?

[4] A: I would probably use my own, although
[5] SHAKE is such a standard I might go ahead and use
[6] that.

[7] Q: Any other programs other than SHAKE to
[8] bring it up from bedrock to surface?

[9] A: Not really.

[10] Q: You said you had an opinion on where the
[11] epi center of the 1886 Charleston earthquake was
[12] located based on conversations with Pradeep
[13] Talwani. Do you have any idea without looking at a
[14] map how far or how many kilometers outside of
[15] Charleston that epi center is?

[16] A: Without looking at a map. It is in
[17] Summerville/Middleton area. That is the general
[18] vicinity. How far is that from Charleston? Maybe
[19] 30 kilometers from the city, 15, 20 miles, I guess.

[20] Q: But the 1886 Charleston earthquake you
[21] believe was epi-centered within the
[22] Charleston/Middleton place seismic zone?

(1) A: Summerville/Middleton is the official
(2) name the USGS decided to use.
(3) Q: That is where it was based in 1886. Why
(4) do you believe that it could occur elsewhere?
(5) A: The 1886 earthquake occurred in that
(6) site. That site, because it has anomalous crustal
(7) features, could in the future develop new
(8) earthquakes. Other areas would depend on the
(9) development of the weakness or as may be evident by
(10) existing seismicity. There is the zone to the
(11) southwest for which there is a scattering of
(12) earthquakes, in the Charleston area. There is the
(13) Bowman area. There is the Bluffton seismicity.
(14) All evidence of something happening in the crust.
(15) So those areas really can't be entirely ruled out
(16) as a potential site of a major earthquake on a
(17) long-term assessment.
(18) Q: Other than paleo seismic evidence of an
(19) earthquake at Bluffton, what other evidence is
(20) there to suggest seismicity in that area or that an
(21) earthquake had occurred in that area or could occur
(22) in that area?

(1) Q: Have you conducted any studies?
(2) A: On that area, no. That was a historical
(3) event for which there weren't a lot of reports.
(4) Those that there were, may have been studied by —
(5) prepared by people at that but I did not put a lot
(6) of stock into that at Lamont.
(7) Q: When you say Lamont, you are referring to
(8) the Lamont Observatory at Columbia University?
(9) A: Yes.
(10) Q: When you refer to Talwani as an
(11) individual that has placed an event at Bluffton,
(12) are you talking about the paper that is appended as
(13) an exhibit to the original GANE contentions or some
(14) other paper?
(15) A: No. I think this is a paper he put in
(16) Seismological Research Letters that referred only
(17) to a recent earthquake at Bluffton.
(18) Q: When was that article published?
(19) A: I would have to look. It is at least
(20) four years old.
(21) Q: Do you plan on relying on it?
(22) A: I had not planned to. I would refer to

(1) A: Two or three earthquakes.
(2) Q: What are those?
(3) A: One was soon after the Charleston
(4) earthquake. Some people thought that was a
(5) mis-located one from Charleston or as an
(6) after-shock, but I think now people will accept it
(7) as an earthquake in that area. And Talwani wrote a
(8) paper on the other one.
(9) Q: Let me focus on the mis-located
(10) after-shock of 1886. What is your basis for
(11) stating that it was mis-located and it actually
(12) occurred in Bluffton?
(13) A: No. I said other people thought it was a
(14) mis-located Charleston earthquake. Other people
(15) wanted to take it away from Bluffton or Savannah
(16) and put it in Charleston. I always felt it was
(17) where it was mapped originally.
(18) Q: And other than your personal feelings
(19) about it, do you have any evidence to support that
(20) actually occurred at Bluffton?
(21) A: I have not gone into details on that
(22) intensity study.

(1) that paper for details on that earthquake. It is
(2) not something I studied. It is something Pradeep
(3) studied.
(4) Q: What was the magnitude of that
(5) earthquake?
(6) A: Somewhere between 2.5 and 3.5.
(7) Q: Is that a magnitude which is relevant to
(8) the seismic design of the MOX Facility?
(9) A: That is a magnitude which suggests that
(10) there is seismicity at that point and that the
(11) potential for additional or other effects should be
(12) considered. That makes it relevant.
(13) Q: For the historical check, is that
(14) earthquake at Bluffton relevant?
(15) A: For the same reason, that it suggests
(16) that perhaps an earthquake of larger magnitude may
(17) have or may in the future occur.
(18) Q: But for the historical check?
(19) A: You want to check the largest earthquake
(20) that has affected the site and, no, that would not
(21) be.
(22) Q: Do you believe there are any inadequacies

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[1] in the location where the CAR assumed a repeat of
[2] the 1886 Charleston earthquake for purposes of a
[3] historical check, that being 120 kilometers south
[4] southeast of the Savannah River Site?

[5] **A:** Mostly east. No, that would be
[6] realistic.

[7] **Q:** Do you think that is conservative?

[8] **A:** Do I think you erred on the positive
[9] side?

[10] **Q:** We can get some things right.

[11] **A:** I think it should be done correctly. I
[12] don't think you should throw in errors to make it
[13] look like a more severe case. I think it is
[14] probably realistic.

[15] **Q:** Do you agree that it was appropriate to
[16] use the magnitude that was used for that historical
[17] check?

[18] **A:** In terms of identifying it as the
[19] Charleston earthquake, that particular one, that
[20] would be adequate. It may or may not be adequate
[21] if one were looking at a comparison — a direct
[22] comparison between Charleston seismicity and its

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[1] rate of occurrence and what might have occurred at
[2] Charleston and its effect on the site. So it
[3] really doesn't verify anything with respect to the
[4] event because it is not comparing it. It is just
[5] saying if you had an earthquake in Charleston the
[6] same size as in 1886, what would its effect. It is
[7] not saying if you look at Charleston seismicity and
[8] you had a repeat occurring at the rate of every
[9] 2500 years, that might be of a different magnitude.

[10] **Q:** Your concern is if this was the sole use
[11] of a probabilistic seismic hazard, that would
[12] concern you but for a historical check —

[13] **A:** This is the maximum that has occurred in
[14] historical times.

[15] **Q:** What is your opinion about the depth of
[16] the focus of the 1886 Charleston earthquake?

[17] **A:** I think it probably mirrors the
[18] after-shock of the focus which varied from three or
[19] four down to around eight or nine, perhaps 12.

[20] **Q:** Can you narrow that range any?

[21] **A:** An earthquake of magnitude seven has a
[22] fault plain that is going to be five, 10, 15

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[1] kilometers in diameter. You can't narrow that down
[2] in terms of where is the whole Charleston
[3] earthquake. That whole area generates energy. If
[4] you are looking at epi centers today, you are
[5] looking at small locations that may be meters in
[6] diameter. So you can pick a location. You can
[7] actually pick a location for the Charleston earth
[8] quake but one of the things we learn in seismology
[9] is that the location is where the earthquake
[10] ruptures first, not necessarily where the energy is
[11] created or transmitted. So that energy that may
[12] cover an area which differs significantly from the
[13] different earthquake and because of the size of the
[14] Charleston earthquake, I would say you are looking
[15] at a range of depths from 12 or so up to the near
[16] surface.

[17] **Q:** Where is near surface in the
[18] Charleston/Summerville/Middleton seismic zone?

[19] **A:** Summerville/Middleton. The surface
[20] sediments, the coastal plain sediments, are about
[21] 4,000 feet. They are low velocity. They are soft.
[22] They don't hold stress very well. So they really

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[1] don't play a role in this earthquake. The
[2] significant earthquake is going to be below that,
[3] below that contact, and you are looking at anywhere
[4] from a kilometer and a half or four or 5,000 feet,
[5] maybe two kilometers down to around 12 to 14
[6] kilometers as the fault plain associated with that
[7] earthquake. There may be in fact more than one
[8] fault plain or it may be curved but that is the
[9] general dimension.

[10] **Q:** Would it surprise you if there were four
[11] kilometers of sediments on the coastal plain?

[12] **A:** Most of the depths I have seen have been
[13] around 4,000 to 5,000 feet, which is around two
[14] kilometers of sediments, down to what is referred
[15] to as J horizon, and that is a big smooth salt flow
[16] that covers a good part of the area. Below that
[17] there have been hypothesized a number of structures
[18] which could be termed in some sense sedimentary
[19] structures. They are Triassic basin. There are
[20] indications of volcanic plugs. You have a source
[21] for the volcanoes and you get flows from some of
[22] the volcanoes. The crust then is the remnants of a

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(1) temporary extensional crust that when the Atlantic
(2) first started to open. You have a lot of these
(3) features.

(4) Q: Can that support an earthquake, those
(5) sediments, even though they may not be traditional?

(6) A: Most of the sediments are volcanic. They
(7) have been in place long enough and hard enough to
(8) support an earthquake but an earthquake will
(9) probably be below that.

(10) Q: How far below?

(11) A: You are getting picky.

(12) Q: Give me a range?

(13) A: In the range of — the fault plain is in
(14) the range of two to four kilometers and that is
(15) based on the dimension.

(16) Q: Where is the majority of the energy
(17) released from a fault plain that long?

(18) A: You are getting into basics. Also, you
(19) are getting into fundamental aspects of seismology
(20) which I alluded to before. The California paradigm
(21) of faults causing earthquakes. What you really
(22) have in Charleston is not necessarily an existing

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(1) fault that is being reactivated. You have a
(2) volume — a volume of crustal rock that is
(3) experiencing stress and that at some point, either
(4) through fluid intrusion, fluids, or from some
(5) mechanism or weakening, that portion of the crust
(6) fails, and it fails along a fault plain. When we
(7) look at after-shocks today, we are probably seeing
(8) evidence of where the major earthquake occurred. A
(9) lot of those earthquakes will be on adjacent
(10) faults.

(11) Q: Where would the energy predominantly come
(12) from along this band of two kilometers?

(13) A: The energy radiates from the volume. The
(14) energy is stored in the volume, not on the surface.
(15) It radiates from the volume.

(16) Q: Let me ask if you are doing a ground
(17) motion attenuation model, how do you take into
(18) account propagation of seismic waves from a fault
(19) that is 13 kilometers long at the Savannah River
(20) Site?

(21) A: I would define the input to the model
(22) along the fault plain. I would define the input in

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(1) terms of a time series which would be based on a
(2) simple drilling model although it could also be a
(3) double corner model as well because some of the
(4) recent stuff — from Atkinson, has indicated a
(5) couple or eastern U.S. I am not sure I agree
(6) entirely, but that is what they observed for a
(7) rather deep anomalous event. I think I would put
(8) that ground motion in along the surface in such a
(9) manner that it would be representative of
(10) displacement of a fault.

(11) Q: How would you model post critical
(12) reflection from a break 13 kilometers long?

(13) A: The program does that for me. What you
(14) put in is a velocity model. You put this into the
(15) final difference code. The velocity model I would
(16) put in would be one that would be a gradient. It
(17) would be a gradient above and below the level. It
(18) could accommodate scattering that occurs naturally
(19) with the variations in velocity that occur with
(20) Triassic basins. They would include a slight
(21) decrease in the depth of mobile because that is
(22) what you see when you are going from Charleston to

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(1) the site. I would include a surface layer of the
(2) sediments because they sometimes enhance or
(3) increase the reflections. I would include a
(4) thinning of that layer as you go toward the
(5) Savannah River Site, and I would probably see
(6) whether or not I can see evidence of other
(7) structures that might be included in that model
(8) along that path.

(9) Q: Does the USGS take into account all the
(10) things you described?

(11) A: No. They are looking for an average for
(12) the U.S.

(13) Q: So for a MOX Facility, if they are not
(14) going to do their own brand-new PSHA, and they are
(15) going to take a PSHA, and you stated the USGS would
(16) be the PSHA you would use —

(17) A: I said, of the group that is probably the
(18) best at this point because they include the
(19) Atkinson/Boore model as part of their analysis, at
(20) least one-third contribution.

(21) Q: What PSHA should an applicant for a MOX
(22) Facility use?

[1] A: I think they should redo it.
[2] Q: I understand you think they should do it
[3] but of the PSHAs out there, what would they choose?
[4] A: If they were forced to choose one and
[5] didn't want to take into consideration facts that
[6] may affect that one way or the other, I think I
[7] would go with the USGS at this point.
[8] Q: Do you know whether NRC regulations
[9] require an applicant for a MOX Facility to redo a
[10] PSHA for a MOX Facility site?
[11] A: No. It is just the understanding I had
[12] before from conversations that individual sites
[13] should be recomputed to take into account local
[14] conditions and variations.
[15] Q: What does take "into account local
[16] conditions and variations" — are those
[17] site-specific or do they go 200 kilometers?
[18] A: They are probably site-specific and 200
[19] kilometers is site-specific.
[20] Q: Then what is the purpose of using a
[21] Livermore or EPRI PSHA if you have to look at
[22] everything that is 200 kilometers around the site?

[1] you should look at changes for that particular
[2] site.
[3] Q: Isn't it true when you take the Livermore
[4] and EPRI studies for a specific site, you actually
[5] take a specific latitude and longitude for that
[6] particular site for which you are proposing the
[7] facility be built, so therefore you are taking into
[8] account some site-specific information as outputs
[9] from EPRI and Livermore?
[10] A: Some, but not all. You mentioned Torro.
[11] I realize now he is one of the attenuation guys.
[12] It is an exponential relationship and he has
[13] one-third input. His relations, the Atkinson and
[14] the Boore, and I think Boore is the third one,
[15] those three are averaged to get the acceleration at
[16] the site based on a given magnitude distribution
[17] for various source zones. If you know for a fact
[18] that the attenuation relationship is not correct,
[19] and is under-estimated by all three of those
[20] models, you should know for a fact that the
[21] acceleration at the site is going to be
[22] underestimated in that study.

[1] A: To avoid doing it, I guess. They are
[2] done in a general sense, and if you can show or
[3] demonstrate that the site conditions or the
[4] regional conditions are consistent with and
[5] identical to those that were used in the EPRI and
[6] Lawrence Livermore studies, then those results
[7] should be adequate. The attenuation relationship
[8] and some of the relationships used are not
[9] consistent with what was used in the EPRI and
[10] Lawrence Livermore studies.
[11] Q: But the purpose was to capture the
[12] uncertainty in the scientific community, wasn't it?
[13] A: It was initially to get away from the
[14] deterministic model and to use a — move toward a
[15] probabilistic technique. It was at the time — the
[16] programs were designed to use a technique which was
[17] in vogue at the time which is one of expert opinion
[18] to pull those opinions together and say this is a
[19] consensus. So in essence it is doesn't necessarily
[20] have the objective of getting a correct vocal
[21] answer. It tells you what about the answer should
[22] you look at. If you want to do a specific site,

[1] Q: Have you done any work or any
[2] back-of-the-envelope calculations, to determine
[3] whether those three attenuation relationships
[4] actually would underestimate the ground motion at
[5] the MOX Facility?
[6] A: I think the back-of-the-envelope
[7] calculations are those in this article by Atkinson
[8] and Sonley, I think that is the one — excuse me,
[9] it was the Atkinson/Boore article in '95. There
[10] was a statement in there that there is an anomalous
[11] zone at 100 kilometers. When you look at their
[12] data, you see at around 100 kilometers, for some of
[13] their observed data, it exceeds the theoretical
[14] computation by a factor that is as high as two to
[15] four. It is point six on the log scale.
[16] Q: Isn't it true that Atkinson/Boore itself
[17] is not a regionally specific attenuation model?
[18] A: Atkinson has concentrated on the eastern
[19] United States, particularly eastern Canada and the
[20] data she is using is more related to eastern United
[21] States than a number of the other attenuation
[22] relations.

[1] Q: But it is not specific to the path from
[2] Charleston to the site?
[3] A: No. It is more representative of what I
[4] think should be there and even their data suggests
[5] that the post critical path should model as a
[6] higher level than what is seen.
[7] Q: Do you have any understanding of whether
[8] or the not the Livermore or EPRI studies took into
[9] effect the Moho bounce or post critical evaluation?

[10] A: Again, I was not involved in the
[11] attenuation studies so I don't know the details of
[12] their development or the arguments that go into
[13] them. It is my understanding though from looking
[14] at the curves that they are largely exponential or
[15] power log decay relationships.

[16] Q: When you say that, do you mean uniform
[17] decay, is that what power log decay means?

[18] A: Power log decay means various terms,
[19] sometimes a long-distance, sometimes a distance to
[20] some power relationship, and they were inserted
[21] into the computational program by using
[22] coefficients for those terms. Those types of

[1] relationships don't lend themselves to seeing or
[2] reflect upon the potential for things like the post
[3] critical force.

[4] Q: If this anomalous zone at 100 kilometers,
[5] as you describe it in Atkinson and Boore, fell
[6] within the zone of — fell within the range of
[7] expert opinions and, therefore, was already
[8] captured within the uncertainty of the EPRI or
[9] Livermore studies, would you be of the opinion that
[10] the use of the EPRI or Livermore data would be
[11] appropriate?

[12] A: Well, the condition is if there is a
[13] critical point. I don't think it does.

[14] Q: I understand. I am asking you if —

[15] A: If there was no evidence in
[16] Atkinson/Boore that the anomalous features at 100
[17] kilometers existed, that there is a post critical
[18] bounce, if there was no evidence for it, then, yes,
[19] I would go with it. It is just not the case. But
[20] you would have to deny all the evidence I have seen
[21] in my own data and these publications.

[22] Q: I am probably miscommunicating to you.

[1] A: I thought so.

[2] Q: Atkinson and Boore as you have explained
[3] it to me identifies this Moho bounce at about 100
[4] kilometers?

[5] A: They comment on it.

[6] Q: If their model or the output of their
[7] model was already — if the level of ground motion
[8] for the anomalous zone that you see in Atkinson and
[9] Boore at 100 kilometers falls within the range of
[10] uncertainties already taken into account in
[11] Livermore or EPRI, would you find it acceptable to
[12] you as Livermore or EPRI, assuming that was the
[13] only issue you had with Livermore or EPRI?

[14] A: Probably not, and the reason is when you
[15] have a systematic variation in the attenuation
[16] relationship, that is an error. Even though it
[17] falls within a plus or minus, if it is systematic
[18] in one direction, it will systematically bias the
[19] result you get, and the systematic bias is that, in
[20] this case, because Charleston, Bluffton and Bowman
[21] are the most active seismic areas and they are all
[22] within that distance range, they will have some

[1] impact on the computation and that is my concern.
[2] These are all at that distance. At that distance
[3] there is a bias in the data even though it may fall
[4] within the range. That bias suggests when you run
[5] the final computations, you will be biased by about
[6] that same amount.

[7] Q: And that bias would not be erased by
[8] inserting the latitude and longitude of this
[9] specific site from the Livermore and EPRI studies?

[10] A: No. That would have no effect on it.

[11] Q: Has the opinion of seismic experts
[12] changed over the years regarding the size of the
[13] Charleston seismic zone?

[14] A: I think Pradeep Talwani has probably done
[15] the most work in relocating the earthquakes in that
[16] area and in attempting to find evidence of faults
[17] that may have existed or may have shown rupture.
[18] One of the basic problems initially with the
[19] Charleston seismic zone was to explain how such a
[20] large event emanated from such a small spot and
[21] since the early studies in the '70s, it has been
[22] increasingly recognized that the stress drop for

{1} eastern United States earthquakes can be quite
{2} large, and what that means is that you get the same
{3} energy out of a smaller fault plain. So I would
{4} say in general the opinion of the size of the
{5} existing Charleston earthquake has condensed or
{6} gotten smaller so you can get the same energy out
{7} of a smaller period.

{8} **Q:** Do you know whether the USGS in their
{9} 2002 maps adopted this narrower interpretation of
{10} Pradeep Talwani?

{11} **A:** I do not know the answer to that, no.

{12} **Q:** Would it surprise you if they did?

{13} **A:** Yes. I don't think they are fully aware
{14} of all of his results. I think that they would be
{15} reluctant to assign as high a stress drop as you
{16} might want to although the Saguenay earthquake had
{17} a high stress drop.

{18} **Q:** When you say high stress drop, ballpark
{19} figure?

{20} **A:** It used to be that 100 bars was high.
{21} For western United States 20 to 40 is typical.
{22} Some of the earthquakes in the east have gone above

{1} aspect it is a seismic zone which is as extensive
{2} and has geometries that look a lot like New Madrid.
{3} On the other hand, when you look at individual
{4} earthquakes they don't seem to agree with the model
{5} you have with New Madrid so it is a big question
{6} mark in my mind.

{7} **Q:** Have you ever done any modeling to
{8} determine stress drop at any of those three
{9} locations we just discussed?

{10} **A:** I have attempted it in some of the — for
{11} some of the events in the Southeastern Tennessee
{12} area. I couldn't tell you what the results were
{13} offhand.

{14} **Q:** Is there conclusive evidence of large
{15} pre-historic earthquakes originating out of the
{16} Charleston seismic zone?

{17} **A:** Is there conclusive evidence?

{18} **Q:** Yes.

{19} **A:** You are asking me about the liquefaction
{20} studies.

{21} **Q:** I am just asking in general if you think
{22} there is conclusive evidence?

{1} that. Saguenay was 500 bars. That is a number
{2} that at one time was thought to be unreachable,
{3} but is now observed.

{4} **Q:** What about for Charleston?

{5} **A:** I think probably they are using a value
{6} of around 100 bars. Could be larger.

{7} **Q:** What about for New Madrid?

{8} **A:** I don't know what they are using for
{9} that.

{10} **Q:** Eastern Tennessee?

{11} **A:** I doubt that they even considered that.
{12} That has been grossly overlooked potential seismic
{13} area.

{14} **Q:** What is your opinion about what the
{15} stress drop should be at New Madrid?

{16} **A:** I would say 100 bars is probably
{17} realistic.

{18} **Q:** Charleston?

{19} **A:** I would go higher than that, 200 maybe.

{20} **Q:** Eastern Tennessee?

{21} **A:** I wish I knew. I really don't know. The
{22} seismicity in that area is an enigma because in one

{1} **A:** That is probably the only way in which
{2} one is going to get evidence unless one finds an
{3} actual fault zone. I don't believe faulting has
{4} occurred, observable faulting has occurred for
{5} major earthquakes that are within fairly recent
{6} time. Probably the most famous evidence of an
{7} aseismic fault is the Mirrors fault in the west but
{8} we are talking about Charleston —

{9} **Q:** Yes, please.

{10} **A:** There have been a number of people who
{11} have suggested that there are features that show
{12} faulting in the Charleston area. I don't think any
{13} of them have convinced me that there is that type
{14} of evidence for earthquake. At the same time that
{15} evidence is not available for Charleston itself.

{16} **Q:** If there is no other evidence of
{17} pre-historic earthquakes other than paleo seismic
{18} liquefaction, does the paleo seismic liquefaction
{19} provide conclusive evidence of earthquakes
{20} occurring outside of the Charleston area?

{21} **A:** I think I am fairly confident that there
{22} is one or two — I don't know that paleo seismic

[1] data are terribly conclusive because it depends on
[2] so many factors. You have to have a certain level
[3] of shaking and you have to be able to identify it
[4] and you have to be able to date it and those are
[5] all difficult. It is not obvious — it is not
[6] necessary that you have enough areas where you have
[7] near surface conditions that are conducive to
[8] liquefaction to preserve any evidence.

[9] Q: Can I get a yes-or-no as to whether you
[10] believe there is pre-historic evidence of
[11] earthquakes outside of the Charleston area?

[12] A: I would say no.

[13] Q: Is there pre-historic evidence of
[14] earthquakes occurring outside of coastal South
[15] Carolina?

[16] A: In the coastal plain, I assume that is
[17] what you are asking. I think most of the
[18] liquefaction is in the coastal plain of South
[19] Carolina, possibly some to the north. Outside that
[20] area, I am not really that familiar with the
[21] details of the study. Liquefaction I know went up
[22] the coast quite a ways. I would say I don't know

[1] is, the whole area, the Piedmont, the area
[2] underneath the coastal plain sediments unless you
[3] get into the plastics — and even some of the stuff
[4] under the coastal plain, where you have potential
[5] for earthquakes. Certainly in the Piedmont you
[6] have the potential for the small earthquakes
[7] occurring just about anyplace. Are they a factor
[8] in the MOX site? That might be debatable. One
[9] would have to run the computations through and see
[10] whether or not the structure would be affected by a
[11] very local high frequency earthquake.

[12] Q: Besides Piedmont, Charleston and
[13] Southeastern Tennessee, are there any earthquake
[14] threats to the MOX Facility?

[15] A: There is one in Greenville, Georgia,
[16] single event but I wasn't able to get enough data
[17] to say what the cause was but there is evidence of
[18] an earthquake there.

[19] Q: What was the magnitude of that event?

[20] A: Three and a half.

[21] Q: Why would that be relevant to the seismic
[22] design of the MOX Facility?

[1] whether or not there is conclusive evidence.

[2] Q: You do not know whether there is
[3] conclusive evidence of large pre-historic
[4] earthquakes originating outside of coastal South
[5] Carolina?

[6] A: Yes. If you want to extend it outside of
[7] the coastal plain, there are many large earthquakes
[8] that have occurred in coastal plain environments or
[9] near shelf-edge type environments, and there is
[10] also an epi-center offshore that has a couple of
[11] earthquakes associated with it.

[12] Q: What epi-center offshore are you
[13] referring to — this is offshore South Carolina?

[14] A: Yes.

[15] Q: How far offshore — is it in a distance
[16] that would be relevant to the seismic design of the
[17] MOX Facility?

[18] A: Not with Charleston sitting there, no.

[19] Q: Besides Charleston and Southeast
[20] Tennessee what do you believe are the earthquake
[21] threats affecting the MOX Facility?

[22] A: There is a general regional effect, that

[1] A: Because, again, it suggests that there is
[2] a site where earthquakes may be occurring. If you
[3] are asking what is the existing most relevant
[4] event, like the Charleston event, that has been
[5] stated, like Charleston but there is events like
[6] Bluffton, Reedville, Bowman, and these should be
[7] considered in any way in any analysis.

[8] Q: Would the input of those earthquakes
[9] materially affect the seismic design of the MOX
[10] Facility?

[11] Let me rephrase that.

[12] Are there earthquake threats materially
[13] affecting the MOX Facility site other than
[14] Piedmont, Southeast Tennessee, or Charleston?

[15] A: That is probably pretty much it.

[16] Q: Has a Charleston-type earthquake occurred
[17] elsewhere on the coastal plain?

[18] A: Possibly offshore New England, 17
[19] something.

[20] Q: Would that event be materially relevant
[21] to the seismic design of the MOX Facility?

[22] A: Only to the extent that it says there are

[1] other earthquakes that occur in those types
[2] environments, that Charleston is not necessarily
[3] unique.

[4] **Q:** Where else on the South Carolina coastal
[5] plain could a Charleston-type earthquake occur
[6] other than Bluffton, any other place?

[7] **A:** Bowman.

[8] **Q:** It is not on the coast but it is in the
[9] coastal plain?

[10] **A:** Yes.

[11] **Q:** Any others?

[12] **A:** There is the — I think he refers to it
[13] as the Adams Run, southwest of
[14] Summerville/Middleton place there.

[15] **Q:** Who is "he"?

[16] **A:** Talwani. Excuse me.

[17] **Q:** Any others?

[18] **A:** Not that I am aware of offhand. There
[19] are some small events that have been identified
[20] near the Savannah River Site.

[21] **Q:** But that is not a Charleston type event?

[22] **A:** No, not necessarily.

[1] **MR. POLONSKY:** Let's take a break.

[2] (Discussion off the record.)

[3] (Recess.)

[4] **BY MR. POLONSKY:**

[5] **Q:** Looking solely at the historical check of
[6] the 1886 Charleston earthquake, do you have an
[7] opinion as to whether or not the horizontal surface
[8] spectrum being used for the MOX Facility envelopes
[9] the ground motions associated with that historical
[10] check?

[11] **A:** I believe that was a conclusion in the
[12] CAR, or some document I have seen. The check of
[13] the historical Charleston earthquake came up with a
[14] spectra that was less than — or was enveloped by
[15] the MOX spectrum.

[16] **Q:** So you agree that the horizontal surface
[17] spectra for the MOX Facility envelopes the ground
[18] motions associated with the deterministic check as
[19] calculated?

[20] **A:** As calculated.

[21] **Q:** I understand you may disagree with the
[22] inputs to that historical check?

[1] **A:** Yes.

[2] **Q:** Why do you think it is important to take
[3] into account the specific pathway in a
[4] probabilistic seismic hazard assessment for
[5] Savannah River Site from Charleston to SRS — is it
[6] your opinion that Charleston is the predominant
[7] seismic hazard for the MOX Facility?

[8] **A:** Sounded like two questions. Was it?

[9] **Q:** You are absolutely right. I will
[10] rephrase. Is it your opinion that the Charleston
[11] is the predominant seismic hazard for the MOX
[12] Facility?

[13] **A:** Charleston epi-central zone as computed
[14] would be the predominate seismic hazard, yes.

[15] **Q:** Have you done any work to independently
[16] determine that?

[17] **A:** Not directly, no.

[18] **Q:** Other than your opinion, what is the
[19] basis for that?

[20] **A:** The basis is seismicity, observed
[21] earthquakes. When EPRI did a study that included
[22] hypotheses and there were things like metric

[1] intrusions that got plugged into the equation and
[2] wherever they occurred there was a probability of
[3] an earthquake occurring, that was based on
[4] seismicity.

[5] **Q:** For the Savannah River Site, would it
[6] surprise you if, for example, a Piedmont, one of
[7] the five or six Piedmont earthquakes you identified
[8] was the predominant seismic hazard?

[9] **A:** In a probabilistic study, one would put a
[10] maximum magnitude on that earthquake and that
[11] if — because the site would be within — the zone
[12] would be — if the maximum earthquake occurred
[13] underneath the plant, then there is some chance it
[14] could be more severe than the Charleston
[15] earthquake. The frequency, content and duration
[16] would be all be different and would have to be
[17] evaluated for its effect.

[18] **Q:** Have you done any evaluation to determine
[19] its effect?

[20] **A:** You are asking if I have done structural
[21] evaluations? No, I don't do those.

[22] **Q:** Have you done any kind of evaluation to

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(1) determine whether a Piedmont would be the
(2) predominant seismic hazard for the SRS — or the
(3) MOX facility at SRS?

(4) A: Not for that site, no.

(5) Q: Would it change your opinion if it were?

(6) A: If the Piedmont event were the dominant
(7) hazard —

(8) Q: For the MOX Facility?

(9) A: Such an event up close would be
(10) predominantly higher frequency, and depending on
(11) how the system building was designed and
(12) response — how it responds to those high
(13) frequencies would really be the critical factor
(14) there. The acceleration for events as small as two
(15) and a half or three at close range, that could be
(16) .2, .3 G. So if you get a major earthquake at that
(17) close range, it could be very, very high, but
(18) predominantly the energy would be at higher
(19) frequencies so you would have to evaluate—
(20) evaluate the structural response and that is not an
(21) area where I am comfortable.

(22) Q: But the peak ground acceleration then

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(1) would be governed by a local earthquake as opposed
(2) to a more distant earthquake under the scenario you
(3) presented?

(4) A: Yes.

(5) Q: If the peak ground acceleration were
(6) determined by a local earthquake and not a far
(7) distant earthquake, would there be any, in your
(8) opinion — what would be the importance then of
(9) taking into account an Atkinson/Boore study which
(10) had Moho bounce in it?

(11) A: You would have to have that study — you
(12) would have to take that into consideration and
(13) verify that it wasn't. You are assuming an answer
(14) and then — you are saying if this Piedmont
(15) earthquake was the pre-dominant effect, why would
(16) you study the other. Well, you wouldn't know it
(17) was a dominant effect unless you studied the other
(18) and determined that it was less than the effect.

(19) Q: But in a PSHA you wouldn't be doing that
(20) kind of calculation, would you?

(21) A: A PS — in a check?

(22) Q: In a PSHA.

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(1) A: PSHA is an integration of all of the
(2) effects. If you wanted to do disaggregation, then
(3) you would find which effects would be the
(4) strongest.

(5) Q: In a PSHA, you would be looking at the
(6) effects from all different locations; is that
(7) right?

(8) A: That is correct.

(9) Q: And in looking at the effects from all
(10) different locations, Moho bounce would only be
(11) relevant for those locations within about 100
(12) kilometers from the site?

(13) A: That is where it would have its maximum
(14) effect, yes.

(15) Q: Then why, if you need to take into
(16) account all of these earthquakes in a radius around
(17) the site, would you place emphasis on a single
(18) model or only use one model that had Moho bounce at
(19) 100 kilometers?

(20) A: When you do a PSHA you consider the rate
(21) of activity at a site, for example, Charleston or
(22) some place in the Piedmont. You take the

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(1) probability that that earthquake will occur,
(2) various magnitudes. Then you take the ground
(3) motion from each of those magnitudes and you
(4) propagate it to the site and you develop a
(5) cumulative probability function. That cumulative
(6) probability tells you what the probability is that
(7) particular acceleration will be exceeding. Not
(8) just from Charleston but from an accumulation of
(9) all of them. When you do that as a function of
(10) frequency, it gives you a spectral distribution for
(11) the peak velocity.

(12) Q: But that is if you have lots of money and
(13) generate your own PSHA from scratch for your site?

(14) A: Lawrence Livermore and EPRI had lots of
(15) money and they did that. The codes exist. They
(16) are not terribly difficult to modify. I haven't
(17) worked with them myself. I have actually written
(18) some similar codes. So if you take the pertinent
(19) data and apply it, and come up with an answer, then
(20) you can accommodate the local structure.

(21) Q: Are you aware of any applicant for any
(22) facility, nuclear or otherwise, that has taken EPRI

[1] or Livermore and changed the code just for its
[2] site, other than punching in the latitude and
[3] longitude and using EPRI and Livermore just as they
[4] are?

[5] A: I really haven't followed that either in
[6] the literature — this would be the gray
[7] literature.

[8] Q: So you are not aware of any facilities?

[9] A: I am not aware of that. It has been
[10] apparent to me that the codes that have been
[11] developed are evolutionary, that they have modified
[12] them with time and redone the studies.

[13] Q: To meet NRC regulations why do you think
[14] that the MOX Facility or DCS in proposing to build
[15] a MOX Facility should be generating its own PSHA
[16] from scratch and not using a PSHA based on
[17] Livermore or EPRI?

[18] A: They should do it by — from scratch,
[19] which to me means inputting attenuation
[20] relationships that are appropriate and
[21] re-examination of the seismicity based on more
[22] recent earthquakes so that the probability that you

[1] get at the site will be representative of crustal
[2] propagation as it is best known today and as the
[3] seismicity rates are best known today.

[4] (The witness consulted with counsel.)

[5] A: To some extent whether you redo or not is
[6] also in essence dependent on whether you think
[7] there might be a significant change in the results.
[8] And when I do the — when I look at the
[9] Atkinson/Boore data, and when I see that they have
[10] a factor of two to four which is greater and
[11] recognize that that is — that that anomalous zone
[12] is at the critical distance from Charleston, Bowman
[13] and Bluffton, that tells me that the amplitudes
[14] that are computed for the probabilities computed
[15] for the Savannah River Site should be on the order
[16] of two to four higher. Exactly how much higher, I
[17] don't know but in terms of their relative model,
[18] they should be higher.

[19] Q: Are you aware that DCS as an applicant to
[20] the Nuclear Regulatory Commission has to meet
[21] certain requirements and seismic design
[22] requirements?

[1] A: You are talking about the legal aspect of
[2] that and I don't go into that.

[3] Q: Do you know whether or not NRC expects
[4] each facility that is proposed to be built, each
[5] nuclear facility, to generate a new PSHA?

[6] A: If I were the NRC, I would. I think
[7] there is sufficient variability and
[8] misunderstanding — sufficient variability in the
[9] responses and local characteristics to warrant that
[10] computation.

[11] Q: In your opinion how much would it cost to
[12] do a new PSHA for a facility assuming nothing had
[13] been done there before?

[14] A: I am not that familiar with the cost
[15] structures. I do know if you were to hire a
[16] company like I did the consulting with —

[17] Q: That is Law Engineering?

[18] A: Yes. Their overhead is horrendous. I
[19] think we are looking at a few hundred thousand
[20] bucks, in an extreme case, depending on what it
[21] went into in terms of details and how much they
[22] wanted to milk you, might grow to a million.

[1] Q: Are you aware of how much — I guess you
[2] are not aware of how much a facility — any
[3] facility has to spend to generate its own PSHA?

[4] A: No. I am not familiar with finances on
[5] that.

[6] (The witness consulted with counsel.)

[7] A: Your question stipulated if one were to
[8] start from scratch in a new area. If you were to
[9] do it here, it wouldn't cost near as much because
[10] you already have a lot of the data laid out.

[11] Q: And my question is how much do you think
[12] it cost WSRC to do its PSHA in 1997?

[13] A: I don't know. I have no idea.

[14] Q: What was done in 1997 by WSRC for
[15] Savannah River Site, do you think that incorporated
[16] EPRI and Livermore?

[17] A: Did their study incorporate the EPRI and
[18] Livermore studies? They accepted the average
[19] values for input.

[20] Q: Why would they need — wouldn't they need
[21] to just start from scratch then?

[22] A: Well, when you start from scratch you are

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(1) saying develop the program and pull the data
(2) together and analyze it. They already have done a
(3) lot of that. What you are talking about here is
(4) you have got the EPRI and Livermore studies. They
(5) exist. Programs exist. They have, as an input, an
(6) attenuation relationship. They have the
(7) capabilities of modifying those to fit local
(8) situations. So the existing program could be run
(9) with a more appropriate attenuation relationship
(10) and the results looked at in comparison to what
(11) they were prior to that.

(12) Q: So you think that EPRI should reconvene
(13) at least the ground motion attenuation panel and
(14) redo all the work and recompute it back into the
(15) code so that it can be used today?

(16) A: No. I think EPRI should make a code
(17) available for individuals, consultants and
(18) companies to utilize for that type of study.

(19) Q: Then you wouldn't have an EPRI standard.
(20) You would have lots of people tinkering with the
(21) EPRI code?

(22) A: That is right. You would have lots of

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(1) people putting their own input in and seeing what
(2) the output is. But as — with this study what I
(3) didn't see was a good careful consideration of what
(4) the input was, and relating it to the output in
(5) terms of the EPRI study.

(6) Q: Are you required to do that for a site,
(7) is that how EPRI and Livermore work?

(8) A: Again, EPRI and Livermore studies were
(9) general. They came up with relationships that fit
(10) regions or the eastern U.S. and weighted them in
(11) different ways.

(12) Q: What do you think the purpose of WSRC
(13) 0085 was then — what does all that paper do, that
(14) is the Lee, et al., 1997 PSHA?

(15) A: To propagate the hard rock motion to the
(16) surface.

(17) Q: That is all that WSRC did?

(18) A: He presented the data from EPRI. They
(19) talked about aspects of seismicity. I don't
(20) believe it was ever incorporated in the analysis.

(21) Q: Are you familiar with the term paleo
(22) liquefaction?

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(1) A: Yes.

(2) Q: What does it mean to you?

(3) A: Paleo means it is preserved in rocks and
(4) liquefaction is — usually a conversion of a fine
(5) sand to a fluid state in which it flows out on the
(6) surface. When it stops flowing it settles back and
(7) then you can look at that. They look at —
(8) interpret where various organic matter has moved
(9) and use that for dating purposes.

(10) Q: What size magnitude earthquake do you
(11) need on a moment magnitude scale to cause
(12) liquefaction?

(13) A: That depends on who you talk to.

(14) Q: What is your opinion —

(15) A: What is my opinion, yes. I am not sure I
(16) have a strong opinion on that. From what I have
(17) seen some engineers will push it down to as low as
(18) 5.5. Most seismologists push it a little higher.

(19) Q: So liquefaction —

(20) A: I would go with the seismologists on
(21) that.

(22) Q: How high is what the seismologists say?

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(1) A: Six to six and a half.

(2) Q: Moment magnitude to cause liquefaction?

(3) A: The problem is it is a function of
(4) duration and it is a function of amplitude and it
(5) is a function of the position of the sediments and
(6) condition of the sediments at the time. There are
(7) an awful lot of variables in it.

(8) Q: Do you consider yourself an expert in
(9) evaluating liquefaction data?

(10) A: No.

(11) Q: Have you published any studies on it?

(12) A: No.

(13) Q: Do you think every liquefaction feature
(14) is evidence of a major earthquake?

(15) A: No.

(16) Q: Do you think that each of the paleo
(17) liquefaction features identified in the Talwani and
(18) Schaeffer paper is evidence of a major earthquake?

(19) MS. CURRAN: Which paper, the one
(20) attached our paper?

(21) MR. POLONSKY: There is only one Talwani
(22) and Schaeffer paper I know of.

BY MR. POLONSKY:

[1] Q: Do you think that each of the paleo
[2] liquefaction features identify in the Talwani and
[3] Schaeffer paper is evidence of a major earthquake.
[4]

[5] A: I would guess yes but I don't know that I
[6] have looked at all of those in sufficient detail to
[7] come to an opinion.

[8] Q: So you don't have an opinion?

[9] A: Probably best to say I don't have an
[10] opinion as to the validity it although I understand
[11] he has worked very hard on that problem.

[12] Q: Off the record.

[13] (Discussion off the record.)

[14] (Long Exhibit No. 1 was

[15] marked for identification.)

BY MR. POLONSKY:

[17] Q: Page one, and I am in the first paragraph
[18] below the section heading, Likelihood of
[19] Significant Seismic Event. This cites various
[20] sections of the CAR, the original CAR, obviously,
[21] and it says at the end, these assertions do not
[22] consider recent paleo seismic work on the South

[1] I looked at the literature and I found the articles
[2] that are in the Seismological Research Letters.

[3] Q: The statement we just read from one of
[4] the revised contention, is it your opinion that it
[5] deals only with Talwani and Schaeffer?

[6] A: When I was asked to review it and look at
[7] it, I had these other articles. So from my point
[8] of view, no. From the previous point of view,
[9] perhaps yes.

[10] Q: The two additional articles that you are
[11] discussing, are they the discussing Hu, Gassman and
[12] Talwani papers?

[13] A: Yes.

[14] Q: And what do you believe is the relevance
[15] of those Hu, et al., papers to the seismic design
[16] of the MOX Facility?

[17] A: They established a rate of activity for
[18] the Charleston seismic zone.

[19] Q: How did they do that?

[20] A: By looking at paleo seismic data.

[21] Q: How did they look at paleo seismic data?

[22] A: They looked for evidence of liquefaction

[1] Carolina coastal plain showing more activity in the
[2] last 6,000 years and over a wider area than
[3] previously known."

[4] Do you agree with this item?

[5] A: Basically, yes.

[6] Q: What recent paleo seismic work is this
[7] referring to?

[8] A: The Talwani/Schaeffer work and recent
[9] studies.

[10] Q: And what recent studies were those?

[11] A: I don't know the specific articles but
[12] there was two articles — Seismological Research
[13] Letters that I believe I listed.

[14] Q: Those were published in 2002; is that
[15] correct?

[16] A: Yes.

[17] Q: So they couldn't have been referred to
[18] here because this was dated August of 2001, this
[19] contention. Is it just talking about Talwani and
[20] Schaeffer?

[21] A: This was put together not by me but the
[22] other previous consultant. When I came in later on

[1] and used the organic matter in those to date that
[2] material, to date the liquefaction event.

[3] Q: And what did they find — do you know
[4] without reading the articles, Dr. Long, what they
[5] found?

[6] A: Offhand, recalling it offhand, not in
[7] detail, no. A lot of these papers kind of merge
[8] together.

[9] Q: These are the only two papers that you
[10] have cited as a basis for this portion of the
[11] contention and you are telling me you don't even
[12] recall what they are?

[13] A: I am saying my impression of these papers
[14] was that the seismicity that they projected based
[15] on their analysis was more widespread and more
[16] accurate than was used in the original CAR.

[17] Q: How is it more accurate?

[18] A: That would be determined by comparing the
[19] Talwani/Schaeffer paper with these.

[20] Q: How is it more widespread?

[21] A: This paper notes both north and south
[22] potential areas.

(1) Q: That is not true at all. What paper are
(2) you referring to?
(3) A: Hu, Gassman and Pratti.
(4) Q: They are both that. Which one — what
(5) page number?
(6) A: Magnitudes of pre-historic earthquakes
(7) paper.
(8) Q: Page 979 of Eastern Section Seismological
(9) Research Letters. Isn't it true what you are
(10) looking at is table one which is cut and pasted
(11) from the Talwani and Schaeffer paper?
(12) A: Could be.
(13) Q: Isn't it true that the Talwani and
(14) Schaeffer paper look at three areas, south, north
(15) and Charleston?
(16) A: Yes.
(17) Q: And Hu, Gassman and Talwani only looked
(18) at Charleston and to the north?
(19) A: I don't know the answer to that.
(20) MS. CURRIAN: May be we should take a
(21) break.
(22) MR. POLONSKY: I am surprised he doesn't

(1) did not do independent research on paleo
(2) liquefaction?
(3) A: Talwani and Schaeffer have done
(4) research —
(5) Q: In this particular paper —
(6) A: This paper summarizes a good share of
(7) their results.
(8) Q: What does re-analysis mean?
(9) A: It means they go back and look at it
(10) again.
(11) Q: So they presented a re-analysis of
(12) results of 15 years of paleo liquefaction research.
(13) Which means no new work was done to support the
(14) Talwani and Schaeffer paper?
(15) A: Not necessarily. I am sure they put
(16) considerable amount of thought into the paper and
(17) considerable amount of thought into whether or not
(18) the earlier analysis was correct and consistent
(19) with contemporary interpretation.
(20) Q: Does this paper support an epi center at
(21) Bluffton?
(22) A: I don't know the conclusion to that

(1) know what this is based on. It is not appropriate
(2) to take a break. This is what the whole contention
(3) is based on.
(4) THE WITNESS: The issue you are bringing
(5) up is whether a Charleston size earthquake could
(6) occur elsewhere and I believe that is one that
(7) could be argued about extensively. We are looking
(8) here at whether or not they have physical evidence
(9) of earthquakes occurring of substantial size
(10) elsewhere and they do present it as some evidence,
(11) both south and north and central part.
(12) BY MR. POLONSKY:
(13) Q: Let me walk you through the Talwani and
(14) Schaeffer paper. You have it as Exhibit five to
(15) the contentions. Let me know when you are there.
(16) A: Okay.
(17) Q: What is the first sentence of the
(18) abstract?
(19) A: "We present a re-analysis of results of
(20) 15 years of paleo liquefaction investigations in
(21) the South Carolina coastal plain."
(22) Q: Isn't it true that Talwani and Schaeffer

(1) specific example.
(2) Q: Have you ever reviewed this paper before
(3) today?
(4) A: I have read this paper in the past.
(5) Q: And isn't an epi center at Bluffton one
(6) of the major points of GANE's contention three?
(7) A: The potential existence of other epi
(8) centers is a contention, yes.
(9) Q: Doesn't it state on page two of the
(10) revised contention that the other scenarios near
(11) Bluffton, South Carolina, in other words, contrary
(12) to what the CAR says, major events may have
(13) occurred much closer to the SRS than the Charleston
(14) seismic zone?
(15) A: I don't know about the distances.
(16) Q: Have you reviewed this contention to see
(17) whether you support the contention itself?
(18) A: I support the contention that earthquakes
(19) could occur elsewhere in the coastal plain.
(20) Q: Let's go through the contention now and
(21) see what statements we can cross out because you
(22) don't support them.

[1] Let's start with the top. In section
[2] 1.3.-1.3.7 of the CAR, DCS specifies the design
[3] criteria for the MOX Facility to withstand any
[4] geological hazard. Is there any article of dispute
[5] with this sentence?

[6] **A:** I cannot quote those sections. I don't
[7] know whether they are disputed or not. I would
[8] assume if I looked at it they would have specified
[9] the design criteria.

[10] **Q:** So you would agree that there is nothing
[11] in dispute in this first sentence?

[12] **A:** No. I would agree, yes.

[13] **Q:** You would agree there is no dispute?

[14] **A:** Yes.

[15] **Q:** DCS claims that conservative design
[16] criteria have been established. Would you agree
[17] that DCS claims that conservative design criteria
[18] have been established?

[19] **A:** They certainly do claim conservative
[20] design criteria, yes.

[21] **Q:** No problem with that?

[22] **A:** No.

[1] **Q:** "Understanding site response is a rapidly
[2] evolving field and much is being learned as strong
[3] motion accelerographs are deployed in areas that
[4] experience earthquakes"?

[5] **A:** That is not a sentence. Site response is
[6] a rapidly evolving field. I would agree with that.

[7] **Q:** "It is essential, therefore, that any
[8] seismic design of the MFFF be complete, accurate
[9] and up-to-date."

[10] **A:** I would agree with that.

[11] **MS. CURRAN:** Can we stipulate that the
[12] quotations from the CAR are correct because I don't
[13] think Dr. Long can verify that the quotations —
[14] unless you give him a copy of the CAR, you are not
[15] being fair.

[16] **MR. POLONSKY:** I can't stipulate to them
[17] because I think some of the quotations are not on
[18] the pages quoted but we will move beyond the
[19] quotes.

[20] **BY MR. POLONSKY:**

[21] **Q:** Skip to page two, top of the first full
[22] paragraph. "Most regional paleo seismic work has

[1] **Q:** This assertion is not supported because
[2] DCS has not performed a seismic analysis that is
[3] either adequate in scope or adequately calculated?

[4] **A:** I would agree with that.

[5] **Q:** "Basis, the seismic hazard of a site
[6] depends on two factors: One the likelihood of a
[7] seismic event, and, two, the expected site response
[8] for such an event."

[9] **A:** Yes, I agree with that.

[10] **Q:** "Precisely predicting the likelihood a
[11] future seismic event is not currently possible."

[12] **A:** I would agree with that.

[13] **Q:** "The best one can do is extrapolate from
[14] past seismicity, compare regional tectonics to
[15] those of similar regions and seek reasons for
[16] recent tectonic activity"?

[17] **A:** I agree with that.

[18] **Q:** "The site response depends on how the
[19] local geology, soils and sediments and bedrock
[20] would respond to an expected seismic event, the
[21] design basis earthquake"?

[22] **A:** I would agree with that.

[1] only dealt with events in the Charleston because
[2] liquefaction features were originally located
[3] there."

[4] **A:** I will agree with that.

[5] **Q:** Are you aware of any discussion of paleo
[6] liquefaction features in the CAR?

[7] **A:** Am I aware of —

[8] **Q:** Any discussion of the paleo liquefaction
[9] features in the CAR?

[10] **A:** Without reviewing it, I will assume they
[11] were discussed.

[12] **Q:** And what do you assume would have been
[13] discussed in the CAR?

[14] **A:** I would assume that the Schaeffer work
[15] was largely discussed.

[16] **Q:** And what would that work have been?

[17] **A:** The work that was reviewed by Talwani and
[18] Schaeffer.

[19] **Q:** The pre-existing work?

[20] **A:** Yes.

[21] **Q:** So the underlying work in the Talwani and
[22] Schaeffer paper was not new information?

[1] A: I really don't know the answer to that
[2] because I know that Talwani has had a long and
[3] continuing interest in paleo seismic studies.
[4] Whether or not he input some of that information
[5] into this article, I couldn't tell you.

[6] Q: Since you are relying on Hu, et al.,
[7] papers, is the Talwani and Schaeffer paper relevant
[8] at all, may be we can just dismiss discussing
[9] Talwani and Schaeffer?

[10] A: It is relevant certainly from a
[11] historical standpoint.

[12] Q: Is it relevant from the purpose of
[13] discussing whether the seismic design of the MOX
[14] Facility is adequate?

[15] A: I would guess that the Hu, et al., is an
[16] update or upgrade to some of the conclusions.
[17] Whether all of the areas that are studied in the
[18] Talwani Schaeffer paper are considered in the Hu,
[19] et al., paper, I couldn't tell you that.

[20] Q: You are unwilling to remove Talwani and
[21] Schaeffer paper from the table at this point?

[22] A: Yes.

[1] Q: Do you know Talwani or Schaeffer?

[2] A: Yes. I know both of them.

[3] Q: How do you know them?

[4] A: I met Pradeep soon after he arrived in
[5] South Carolina. We have interacted at meetings and
[6] have done work over the years extensively.

[7] Q: And Schaeffer?

[8] A: I knew him as a student and as working
[9] with Pradeep.

[10] Q: Do you consider Talwani to be a seismic
[11] expert?

[12] A: Yes.

[13] Q: Do you think he is highly regarded in
[14] this field?

[15] A: I think he is regarded in the paleo
[16] liquefaction area, yes.

[17] Q: What about Schaeffer, is he a seismic
[18] expert?

[19] A: I have listened to Schaeffer's talks and
[20] I would consider the work he did was quite good.

[21] Q: Are they experts in geosciences?

[22] A: Are they experts in the geosciences?

[1] Q: Yes.

[2] A: I would consider that Schaeffer has been
[3] working in the engineering geology area and he is
[4] an expert in that area. I would say Pradeep is a
[5] general scientist as well as a seismologist and an
[6] expert, yes.

[7] Q: Would you agree that the findings of the
[8] Talwani/Schaeffer paper are not relevant to the
[9] historical check for the MOX Facility?

[10] A: The historical check was for the largest
[11] historical earthquake which is quite irrelevant to
[12] whether pre-historical earthquakes have occurred.

[13] Q: So would your answer be yes?

[14] A: Yes.

[15] Q: Would you agree that the Talwani and
[16] Schaeffer paper is not relevant for considering the
[17] most severe documented earthquake for the MOX
[18] Facility?

[19] A: Yes.

[20] Q: Do you concur with the findings in the
[21] Talwani and Schaeffer paper regarding return period
[22] for a Charleston paper earthquake?

[1] A: What is that return period?

[2] Q: Let me rephrase the question. Do you
[3] know what the return period is without looking at
[4] the paper?

[5] A: I do not know what it is without looking
[6] at the paper. That is a number that has floated up
[7] and down over the years. It is probably close to
[8] 600 years today.

[9] Q: In your opinion what should the return
[10] period be for a Charleston type?

[11] A: On the order of 600, plus or minus, plus
[12] four or 500 and minus two. On the order of 600
[13] plus 400 minus two.

[14] Q: Minus 200?

[15] A: Yes.

[16] Q: Does the Talwani and Schaeffer paper
[17] state that there is more seismic activities in the
[18] last 600 years and over a wider area than
[19] previously known?

[20] A: My impression was that the Talwani and
[21] Schaeffer paper pulled together a number of studies
[22] which essentially established a rate of activity.

[1] I don't know whether it was more or less than what
[2] other people had assigned. Most of the assignments
[3] would have been based not on paleo seismicity but
[4] just seismic activity.

[5] Q: You will agree with me that the paper is
[6] based on paleo liquefaction data?

[7] A: Yes.

[8] Q: And solely based on paleo liquefaction
[9] data for earthquakes?

[10] A: I think so, yes.

[11] Q: So if they didn't collect any new paleo
[12] liquefaction data for this thing, they just
[13] re-analyzed the existing data, then they wouldn't
[14] have found more seismic activity in the last 6,000
[15] years, would they have?

[16] A: Re-interpretation may imply dividing or
[17] subdividing events in different events so the
[18] numbers could change.

[19] Q: And did they find that these events or
[20] earthquakes could have happened over a wider area
[21] than previously known?

[22] A: I don't know the answer to that.

[1] MS. CURRAN: Would you like Dr. Long to
[2] come back in the morning?

[3] MR. POLONSKY: I think that would be the
[4] best use of everyone's time.

[5] (Whereupon, at 5:30 p.m., the taking of
[6] the deposition was concluded.)

[7] (Signature not waived.)

[8]

[9]

[10]

[11]

[12]

[13]

[14]

[15]

[16]

[17]

[18]

[19]

[20]

[21]

[22]

[1] CERTIFICATE OF DEPONENT
[2] I have read the foregoing 247 pages,
[3] which contain the correct transcript of the answers
[4] made by me to the questions therein recorded.

[5]

[6]

DR. LELAND TIMOTHY LONG

[7]

[8]

[9]

[10]

[11]

[12] Subscribed and sworn to before me this
[13] _____ day of _____, 2003.

[14]

[15]

[16]

Notary Public in and for

[17]

[18] My commission expires: _____

[19]

[20]

[21]

[22]

In the Matter of:

Duke Cogema Stone & Webster

Deposition of Leland Timothy Long, M.D.

Vol. 2, June 26, 2003

Miller Reporting Company, Inc.

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:
DUKE COGEMA STONE & WEBSTER : Docket No.:
: 0-70-03098-ML
(Savannah River Mixed Oxide : ASLBP No.:
Fabrication Facility) : 01-790-ML

----- x VOL. II

Washington, D.C.

Thursday, June 26, 2003

The continued deposition of DR. LELAND
TIMOTHY LONG, called for examination by counsel for
DCS in the above-entitled matter, pursuant to
Notice, in the offices of Morgan, Lewis & Bockius,
1111 Pennsylvania Avenue, N.W., Washington, D.C.,
convened at 9:08 a.m., before Cathy Jardim, a
notary public in and for the District of Columbia,
when were present on behalf of the parties:

APPEARANCES:

On behalf of Georgians Against
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Also Present: JOHN M. MCCONAGHY, JR.

LAWRENCE A. SALOMONE
CARL STEPP
JEFF KIMBALL
JOHN STAMATAKOS

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EXHIBITS

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PROCEEDINGS

[1]

[2] Whereupon,

[3] LELAND TIMOTHY LONG,

[4] having been previously duly sworn, was further

[5] examined and testified as follows:

[6]

EXAMINATION BY COUNSEL FOR DCSW

[7]

BY MR. POLONSKY:

[8]

Q: Dr. Long, there were a number of

[9]

questions which I posed to you yesterday in the

[10]

morning first thing, about not interrupting each

[11]

other, me asking you questions and you trying to

[12]

answer them to the best of your ability and

[13]

accurately and truthfully. You are aware that you

[14]

are still under oath?

[15]

A: Yes.

[16]

Q: Again, any of the other instructions

[17]

about taking a break, consulting with counsel,

[18]

those are still in effect, and please let me know

[19]

if you would like to take a break or if any of the

[20]

questions I ask you are not clear and you need them

[21]

clarified. Otherwise, I will assume you have

[22]

understood the question.

[1]

Exhibit No. 5 to GANE's original

[2]

contentions is an article by Talwani and Schaeffer

[3]

dated 2001. Can you please state for me what your

[4]

opinion is as to why this article is relevant to

[5]

the seismic design of the MOX Facility?

[6]

A: This article pulls together a number of

[7]

documents and studies relating to identifying,

[8]

locating — and locating sites of liquefaction in

[9]

the coastal plain. They also reconsidered and

[10]

recalibrated the dates of the liquefaction based on

[11]

carbon 14. The significance to the Savannah River

[12]

Site is that it suggests that there may be sites

[13]

other than Charleston which have experienced major

[14]

earthquakes and that those sites should be included

[15]

in any PSHA that is performed.

[16]

Q: Yesterday we had a discussion about the

[17]

various opinions that were provided by the

[18]

participants on the expert panel to, for example,

[19]

the Livermore study, and you stated there were a

[20]

range of opinions regarding various seismic source

[21]

zones including the Charleston Seismic Source Zone;

[22]

is that correct?

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[1] A: That is correct.

[2] Q: Does this paper by Talwani and Schaeffer
[3] provide any new opinion about the location of
[4] earthquakes on the Carolina coastal plain that was
[5] not already considered and proposed by an expert —
[6] by a participant in the expert panel in the
[7] Livermore study?

[8] A: What they have done is to pull together a
[9] considerable amount of information pertaining to
[10] potential sites for a major earthquake. A lot of
[11] that information was not available to the
[12] participants in the Lawrence Livermore study. Some
[13] of those participants called for huge origin
[14] encompassing zones, and technically one would have
[15] to see that those large encompassing zones would
[16] have to include all these events. Because of those
[17] zones, that would not be appropriate for a specific
[18] site in this area.

[19] Q: The question was, though, specifically
[20] does this paper by Talwani and Schaeffer provide
[21] any new opinion about the location of earthquakes
[22] on the Carolina coastal plain that was not already

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[1] considered or proposed by a participant on the
[2] expert panel in the Livermore study?

[3] A: The answer is basically yes, it does
[4] refine the data, it does provide constraints on the
[5] data that were available to the experts at the time
[6] of the qualification on that that I gave was that
[7] some experts were so broad and inclusive that you
[8] might say that their response included anything
[9] that might possibly be discovered.

[10] Q: So, for example, one expert may have
[11] placed a 7.5 earthquake anywhere on the Carolina
[12] coastal plain, not just limited to the three places
[13] Talwani and Schaeffer did?

[14] A: That is right.

[15] Q: So, for Livermore and probably EPRI,
[16] there are opinions that encompass the locations
[17] identified in the Talwani and Schaeffer paper?

[18] A: That would be true. The impact on the
[19] study would be different though. The impact of a
[20] broad area which encompasses all these sites would
[21] be different than the distribution of sites that
[22] would be implicated by the Talwani and Schaeffer

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[1] paper.

[2] Q: What is your basis for stating that
[3] people today — let me rephrase that — that
[4] experts today, if they were empaneled today — let
[5] me rephrase it.

[6] Would you believe that there would be
[7] today in a new PSHA study similar to Livermore or
[8] EPRI, at least one person who had the opinion that
[9] a 7.5 could occur anywhere on the South Carolina
[10] coastal plain?

[11] A: I think that if it were formulated in an
[12] EPRI study where that was given a probability, a
[13] number of scientists would say that is a
[14] possibility.

[15] Q: So the opinion here is not necessarily a
[16] new opinion about location of earthquakes since the
[17] opinion that an earthquake could occur anywhere on
[18] the coastal plain has been out there for 20 years?

[19] A: That is true, yes. That idea has been
[20] around for a long time.

[21] Q: So you are pointing to this one paper and
[22] GANE is stating that this paper shows that there is

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[1] seismic activity over a wider area than previously
[2] known?

[3] A: I don't think it says that. It says the
[4] DCS didn't consider that distribution.

[5] Q: Point 1 on the revised contention, under
[6] the paragraph "Likelihood of significant seismic
[7] event," the last sentence: "These assertions do
[8] not consider recent paleoseismic events on the
[9] South Carolina Coastal Plain showing activity in
[10] the last 6000 years, and over a wider area." The
[11] only paper cited is Talwani and Schaeffer?

[12] A: The term previously known might be
[13] interpreted various ways. I think when you look at
[14] the studies that Duke performed, I believe they
[15] were concentrating on a Charleston epicenter. When
[16] you look at a panel of experts with very wide
[17] variations in opinions, those opinions will
[18] encompass any hypothesis or distribution you want
[19] to put in there.

[20] Q: Does the Talwani and Schaeffer paper show
[21] more activity over a wider area than previously
[22] known, yes or no?

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[1] A: I would say yes, in the fact that the
[2] definitive — the definition and depth of the
[3] Bluffton and northern sites was not previously
[4] known. In other words, they provided concrete data
[5] establishing liquefaction in areas where other
[6] experts had not been told there was concrete data
[7] indicating liquefaction.

[8] Q: But if a PSHA includes an opinion that an
[9] earthquake could have occurred in that location,
[10] what new does this add to the PSHA, keeping in mind
[11] that you said this paper is inapplicable to the
[12] historical check?

[13] A: What is new is that they have defined
[14] areas where there is activity. What that does is
[15] constrain the activity to some extent, not
[16] entirely, but it does provide some constraints and
[17] when one computes a PSHA, one integrates over an
[18] entire area, and the effect over constrained sites
[19] is going to give a different answer than an
[20] integration over a broad area or a variety of
[21] zones.

[22] Q: Why don't you walk through the paper and

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[1] you can show me where they identified new areas of
[2] activity.

[3] A: I think it is in the abstract.

[4] Q: Why don't you show me that place in the
[5] abstract?

[6] A: In the first scenario, three seismic
[7] zones exist within the coastal plain of South
[8] Carolina, Charleston, A B E and G, with magnitude
[9] seven plus; Georgetown, CNE, and Bluffton, D, with
[10] magnitude six. That looks like three to me, three
[11] sites, not just one at Charleston.

[12] Q: Would you agree that there is a second
[13] scenario that they hypothesize in the same paper?

[14] A: I would agree they hypothesize a couple
[15] of scenarios.

[16] Q: Would you agree that the second scenario
[17] does not include Bluffton as a location where a
[18] historic or paleoearthquake occurred?

[19] A: The second scenario is a simplistic
[20] approach which says a much greater earthquake
[21] occurred at Charleston to explain the liquefaction
[22] at the outlying sites.

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[1] Q: Would you agree that the second scenario
[2] does not include Bluffton as a location where a
[3] paleoearthquake occurred?

[4] A: The second scenario says that it is
[5] possible that all the earthquakes were at
[6] Charleston. I don't want to say that they don't
[7] believe Bluffton was the site because that is not
[8] stated.

[9] Q: The question was would you agree that the
[10] second scenario does not include Bluffton as a
[11] location where a paleoearthquake occurred, yes or
[12] no?

[13] A: The second scenario doesn't say that.
[14] The second scenario says that earthquakes occurred
[15] at Charleston. It doesn't eliminate the
[16] possibility they occurred somewhere else.

[17] Q: If they occurred at Charleston, how could
[18] they have occurred somewhere else?

[19] A: They are not saying there were not other
[20] earthquakes in the area of Bluffton. They are
[21] saying the earthquakes they examined possibly
[22] occurred all at Charleston.

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[1] Q: So there is at least two authors who have
[2] proposed a hypothesis that all of the earthquakes
[3] could have occurred at Charleston?

[4] A: They have proposed two hypothesis, one
[5] that they all occurred at Charleston and one that
[6] they were distributed.

[7] Q: But there are two authors that
[8] hypothesized that they all occurred at Charleston?

[9] A: There are two authors that proposed two
[10] hypothesis, one, they are distributed, and two,
[11] they all are at Charleston.

[12] Q: And that is the paper, Taiwani and
[13] Schaeffer?

[14] A: Yes.

[15] Q: Do the liquefaction features identified
[16] in the South Carolina Coastal Plain as identified
[17] by Taiwani and Schaeffer indicate multiple
[18] seven-plus earthquakes?

[19] A: Yes, they do.

[20] Q: In your opinion, not discussing Taiwani
[21] and Schaeffer — I assume you are not relying on
[22] Taiwani and Schaeffer — do you believe the

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[1] liquefaction features on the South Carolina coastal
[2] plain indicate multiple seven-plus earthquakes?
[3] **A:** I have not gone into that analysis, but I
[4] believe that Talwani's hypothesis is basically
[5] correct.

[6] **Q:** Do you agree that the CAR discusses
[7] paleoliquefaction events on the Carolina Coastal
[8] Plane leading to the Charleston events?

[9] **A:** The CAR discusses a number of features,
[10] including that.

[11] **Q:** Do you think the discussion of
[12] paleoliquefaction in the CAR is adequate?

[13] **A:** It was more than adequate for what it was
[14] used for.

[15] **Q:** Do you believe the CAR should have
[16] discussed anything additionally with regard to
[17] paleoliquefaction?

[18] **A:** The essence of a paleoliquefaction is
[19] that there are multiple seven plus centers
[20] occurring in the coastal plain that provides a
[21] basis for seismicity or A value in the recursion
[22] relationship which is an input parameter for the

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[1] PSHA. That is the real significance of the
[2] liquefaction studies.

[3] **Q:** Whose liquefaction studies?

[4] **A:** A variety of people — the summary of the
[5] liquefaction studies as given by Talwani and
[6] Schaeffer. There are a number of participants in
[7] these studies, a number of Talwani students, USGS,
[8] private consultants.

[9] **Q:** How would you evaluate the liquefaction
[10] data identified in the Talwani and Schaeffer paper?

[11] **A:** Talwani and Schaeffer were intimately
[12] familiar with the processing of the data,
[13] developing it and putting it into a final form. I
[14] really haven't been intimately familiar with the
[15] processing or development or obtaining of that
[16] data. It would be difficult to say exactly how I
[17] would proceed. The standard procedure which they
[18] used, USGS used and other people used, was to
[19] excavate or to trench areas where there was
[20] liquefaction, take samples, do the dating, provide
[21] samples to the dating.

[22] This is a somewhat — it is an

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[1] interpretation problem. It is a geological or
[2] spatial interpretation problem because you have to
[3] define where organic matter in fact has been moved
[4] during this episode of liquefaction, pulling that
[5] data together and analyzing it. I think I would
[6] have done it the same way.

[7] **Q:** From what you said, would it be correct
[8] to say that it is entirely possible that errors can
[9] be made in the carbon dating since you are
[10] collecting material that contains carbon and
[11] assuming that that material was placed at the time
[12] of the liquefaction?

[13] **A:** That is right.

[14] **Q:** So there is some uncertainty in the data?

[15] **A:** Yes, and I think Talwani well pointed
[16] them out and made their arguments.

[17] **Q:** Understanding that it is useful for
[18] Talwani and Schaeffer to try to date the material,
[19] what in your opinion is the rate of error in the
[20] carbon dating of those materials?

[21] **A:** One of the purposes of the review they
[22] did was to correct carbon dating. It has been

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[1] discovered that carbon dating was in error because
[2] of variations in the atmospheric content of O18.
[3] So variations there with time has varied the date.
[4] They did a systematic correction for the errors
[5] made. They come up with plus or minus variations.

[6] **Q:** Do you know what those plus or minus
[7] values are?

[8] **A:** They vary depending on the sample and the
[9] technique. I believe they are listed in the text.

[10] **Q:** In the text of the Talwani and Schaeffer
[11] paper?

[12] **A:** Yes.

[13] **Q:** Could you show me where in the Talwani
[14] and Schaeffer text those errors are?

[15] **A:** Where should we begin? Figures 5A, 5B,
[16] 5C, 5D, 5E, 5F, 5G, Figures 7, paragraph 5. Table
[17] 3.

[18] **Q:** What page are you on for Table 3?

[19] **A:** This copy is not that good. I can't read
[20] the numbers. 17, I believe.

[21] **Q:** I found Table 3. What are the error bars
[22] for carbon dating range from?

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[1] A: You want me to read the table?
[2] Q: Sure.
[3] A: Plus or minus 17; plus or minus 30; plus
[4] or minus something I can't read; plus or minus 70;
[5] plus or minus 212; plus or minus 66; plus and minor
[6] 165; plus or minus 500.
[7] Q: Which of these scenarios — let me
[8] rephrase that. Which liquefaction episode
[9] identified by Talwani and Schaeffer discusses
[10] Bluffton?
[11] A: D.
[12] Q: And what is the error rate in years for
[13] Bluffton?
[14] A: 212 on this table.
[15] Q: Do you have an opinion as to why in the
[16] second scenario presented by Talwani and Schaeffer,
[17] they did not discuss Bluffton, and was part of that
[18] potentially — was part of that due to the large
[19] error in dates for liquefaction episode D?
[20] A: I don't know their logic or thinking.
[21] That would be something I would have to try and
[22] pull out of the text in detail. The essence of the

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[1] paper is not the plus or minus, it is the thinking
[2] and the establishment of a multiple sequence of
[3] earthquakes.
[4] Q: What is the magnitude for liquefaction
[5] episode D, which is the Bluffton site?
[6] A: They based it on area, and it would have
[7] been about magnitude of six and a half, six
[8] something.
[9] Q: What does Table 3 say under scenario 1 is
[10] the magnitude for liquefaction episode D?
[11] A: About six.
[12] Q: That has a little squiggle line?
[13] A: Right, approximately.
[14] Q: Can I ask you to turn to page 6636, or it
[15] is the page which has Figure 5G on it. Are you
[16] familiar with am brace ceases formula?
[17] A: No.
[18] Q: Would you know how to apply Ambraseys'
[19] formula?
[20] A: I would assume as a scientist I could
[21] read the definition and apply it.
[22] Q: Would you question Talwani and

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[1] Schaeffer's application of Ambraseys' formula?
[2] A: I would not comment until I know what
[3] that is. I would assume he as a scientist would
[4] know how to apply it.
[5] Q: On the page there is a section 5.4,
[6] episode D. The last sentence of the first
[7] paragraph which discusses assessment of magnitude
[8] says, application of Ambraseys' formula and
[9] assuming an epicentral distance of 10 kilometers
[10] yields a magnitude 5.7.
[11] A: That is what it says. Talwani puts it in
[12] the table at about six. I think he is suggesting
[13] in the interpretation that there is significant
[14] uncertainty in the actual magnitude.
[15] Q: Do you believe that 5.7 magnitude would
[16] be an appropriate magnitude for an event at
[17] Bluffton assuming one actually occurred at Bluffton
[18] as described in episode D by Talwani and Schaeffer?
[19] A: I think 5.7 is on the low side. I think
[20] it is on the low side because I think liquefaction
[21] over an area requires a larger-size earthquake
[22] myself, but that is a personal opinion. I think

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[1] the essence is not that it was a magnitude five,
[2] seven or six, but that there was an earthquake
[3] epicentral zone there that was capable of providing
[4] a major earthquake, and that one should consider
[5] this a potential site for a magnitude of six or
[6] seven.
[7] Q: Do you think that any time a paper comes
[8] out, that a PSHA for a site has to be redone?
[9] A: It depends on what the paper says.
[10] Q: At what point do you stop taking into
[11] account every paper that comes out and accept the
[12] PSHA as it is done?
[13] A: I don't think you should ever accept the
[14] PSHA as done. I think you have to reevaluate it
[15] all the time.
[16] Q: What happens if it is clear that the PSHA
[17] is overly conservative taking into account whatever
[18] new paper might come along?
[19] A: I think that then it would do the job of
[20] being conservative.
[21] Q: But you don't think the PSHA would be
[22] appropriate for use?

(1) **A:** PSHA is a determination of a probalistic
(2) term. When new knowledge comes about, probability
(3) is likely to change, it may go up, it may go down.
(4) You are trying to bridge a gap between what is the
(5) scientific numbers or crunching part of this deal
(6) and what is the moral responsibility of the people
(7) who are building the construction.

(8) If a building is built with a bridge and
(9) the engineers discover that columns on the bridge
(10) were off by a factor of two and they are too small,
(11) they have the responsibility to reexamine it. If
(12) they build a bridge and it is twice as big, they
(13) know they are safe. They may have spent more
(14) money, but at the time they did the original PSHA,
(15) that was the best knowledge they had.

(16) **Q:** In reality, trying to build a facility
(17) like the MOX Facility, at what point can you submit
(18) an application to the NRC and say what we have done
(19) is sufficiently robust, when a party can come
(20) forward and just identify a new paper and say, hey,
(21) you haven't considered this, you haven't considered
(22) this, this just came out this year, you should

(1) results.

(2) **Q:** And your position is that because it
(3) presents in your mind some new information, that it
(4) has to be looked at from a purely scientific
(5) perspective, you don't have an opinion as to
(6) whether it may or may not change?

(7) **A:** If the changes that are presented suggest
(8) that there may be a problem in terms of the
(9) determination — and by a problem, I mean maybe
(10) underestimated in some way — then it should be
(11) looked at.

(12) (The witness consulted with counsel.)

(13) **BY MR. POLONSKY:**

(14) **Q:** Dr. Long, if the Talwani and Schaeffer
(15) scenarios narrow the areas of earthquakes — let
(16) rephrase that. If one of the scenarios by Talwani
(17) and Schaeffer narrows the area to three areas,
(18) Charleston, Bluffton and some northern part,
(19) wouldn't this produce a lower ground motion than
(20) the SRS in the PSHA than if the PSHA includes a
(21) broader seismic zone that can contribute to the
(22) damage?

(1) consider this, at what point do you stop?

(2) **A:** I don't think you ever stop. I think at
(3) the last minute, you think you are all done, you
(4) have gotten approval, a new paper comes out and
(5) says there is an active fault underneath this
(6) building. I am not saying there is, but if someone
(7) says that, and we have new evidence that something
(8) is happening, it changes a lot.

(9) **Q:** I agree with that statement, but that is
(10) identifying a known feature, a known fault. No one
(11) has identified any new feature in any of the papers
(12) you have identified. All that they have identified
(13) are new interpretations of the data or additional
(14) theories, and when people are identifying new
(15) theories and hypotheses, those are interesting to
(16) think about and they should be considered seriously
(17) by the expert community, but they are just another
(18) opinion in the range of opinions.

(19) **A:** This article presents data which strongly
(20) suggests that there are other areas of activity. I
(21) think that is significant enough to consider some
(22) review. Now, it may or may not change any of the

(1) **A:** Repeat that?

(2) **Q:** If one of the Talwani and Schaeffer
(3) scenarios narrow the area of earthquakes to three
(4) areas, Bluffton, Charleston and a northern part,
(5) wouldn't this produce a lower ground motion in SRS
(6) than the PSHA than if the PSHA included a broader
(7) seismic zone that can contribute to the ground
(8) damage?

(9) **A:** Possibly.

(10) **Q:** Have you done any studies to determine
(11) whether it would?

(12) **A:** Not specific to this area, but with
(13) respect to another area, I have a paper published
(14) that explains that if you use a broad area, the
(15) hazard in the central area — I went the other way.
(16) If you take a broad area, then the hazard just
(17) outside the broad area is going to be less at a
(18) greater distance. It might be a slight bit more,
(19) but — whereas the hazard at the earthquake would
(20) be decreased by a broader area.

(21) Our spectral hazard assessments are based
(22) on a combination — the addition of contributions

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[1] from many source zones. If you have events
[2] concentrated at Charleston, it seems that the
[3] return period is going to be shorter. If you have
[4] a distributed number of events, the return period
[5] in the distributed areas would be less.

[6] The net effect at the site would be a
[7] function of distance or attenuation more than from
[8] the sites. So it would have been something — it
[9] would be a function of distance from the site, so
[10] it would have to be something that would have to be
[11] computed to see if it was a significant strength or
[12] not.

[13] (The witness consulted with counsel.)

[14] BY MR. POLONSKY:

[15] Q: Dr. Long, are there other possible
[16] interpretations of the data presented in the
[17] Talwani and Schaeffer paper?

[18] A: I would think that any scientist could
[19] come up with a number of interpretations, but the
[20] scientist would have to evaluate those. I think
[21] Talwani and Schaeffer have done the best job they
[22] can to come up with what they felt were the best

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[1] explanations.

[2] Q: You cited to two other papers by Ke Hu,
[3] Sarah Gassman and Pradeep Talwani. Do you know Ke
[4] Hu?

[5] A: No.

[6] Q: Do you know Sarah Gassman?

[7] A: No.

[8] Q: Do you have any knowledge as to what
[9] fields they are experts in?

[10] A: Talwani is an author on those papers as
[11] well.

[12] Q: But I asked you about Ke Hu and Sarah
[13] Gassman?

[14] A: Right.

[15] Q: Do you have any knowledge as to what
[16] fields those two people are experts in?

[17] A: Those two papers dwell in the area of
[18] determining the acceleration and the soil
[19] properties that the acceleration with given soil
[20] properties would be required to cause liquefaction.
[21] That work was then based in the civil engineering
[22] range or domain.

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[1] Q: It is okay to say you don't have an
[2] opinion if you don't have one.

[3] A: I don't know those people.

[4] Q: So you don't have any knowledge of what
[5] fields those two people are experts in?

[6] A: I can infer the knowledge from the
[7] papers, but I do not know what area of expertise
[8] they are. I do not know whether they are students
[9] or professionals.

[10] Q: Have you seen their names before looking
[11] at these two papers that you cite?

[12] A: No.

[13] Q: How did you learn about those two papers
[14] by Hu, Gassman and Talwani?

[15] A: I read the literature.

[16] Q: Does that mean when it arrived on your
[17] stoop, in the mail, you read it?

[18] A: Within a month or two, yes.

[19] Q: What is your opinion regarding the
[20] difference between the Talwani and Schaeffer paper
[21] and the two Hu, et al., articles?

[22] A: The two Hu, et al., articles are

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[1] companion articles. One goes into the technical
[2] aspects of how one determines soil properties and
[3] how they are going to liquefy. The other is
[4] associating liquefaction at various sites to ground
[5] motion, acceleration and G. That G is then
[6] converted to an estimate of magnitude.

[7] Q: Do you agree with the methodology — let
[8] me back up. For ease of use, can we refer to them
[9] as Hu, et al., 1, and Hu, et al., 2?

[10] A: Okay.

[11] Q: And for the record, I guess I have to
[12] clarify that Hu, et al., 1 is — starts on page 964
[13] of the eastern section seismological research
[14] letters, Volume 73, No. 6, November 2002, and runs
[15] to page 978. And Hu, et al., 2 begins on page 979
[16] of the same volume and number and continues to page
[17] 991.

[18] Do you agree with the methodology used in
[19] Hu, et al., 1, or do you have an opinion as to the
[20] methodology used in Hu, et al., 1?

[21] A: That is really not my field. I would
[22] accept their work based on what I do know.

[1] Q: You do not have an independent opinion —

[2] A: I would not review that paper as an
[3] expert.

[4] Q: What about Hu, et al., 2?

[5] A: That is magnitudes —

[6] Q: Magnitudes of earthquakes in the coastal
[7] plain from geotechnical data?

[8] A: I would say I was familiar with that
[9] material to some extent.

[10] Q: Do you agree with the methodology used in
[11] Hu, et al., 2?

[12] A: I agree that it is an appropriate
[13] approach.

[14] MR. POLONSKY: Off the record.

[15] (Discussion off the record.)

[16] (Long Exhibit No. 1 was
[17] marked for identification.)

[18] (Long Exhibit No. 2 was
[19] marked for identification.)

[20] BY MR. POLONSKY:

[21] Q: We have marked Hu et al. 1 as Long
[22] Exhibit 2 and Hu et al. 2 as Long Exhibit 3. How

[1] is that there were major earthquakes, and I think
[2] they have an estimate or way of estimating the
[3] magnitudes of these.

[4] As for the details, the technical details
[5] is what they are asking about. There are a number
[6] of ways in which engineers can determine the
[7] strength of liquefaction. Most common is a low
[8] count analysis, number of times it takes to pound a
[9] pointed object through sand one foot, or something
[10] like that.

[11] These all are measures of the sheer
[12] strength and they have been refined to relate them
[13] to soil constraint properties. That is an
[14] engineering domain. I would assume that certainly
[15] Talwani has looked into this for the article, and I
[16] assume that the two co-authors have perhaps more
[17] expertise in this area than he does.

[18] Q: Would you say basically that Hu et al. 1
[19] then is a geotechnical paper?

[20] A: For the most part, yes. It provides the
[21] background geotechnical information needed to
[22] compute the magnitude to show there were major

[1] do you believe Hu et al. 1 is relevant to the
[2] seismic design for the MOX Facility?

[3] A: It provides further estimates of
[4] magnitudes that are indicative of major
[5] earthquakes.

[6] Q: Does Hu et al. 1 do that?

[7] A: Hu et al. 2 provides —

[8] Q: My question was regarding Hu et al. 1.

[9] A: Hu, et al., 1 provides techniques,
[10] background techniques, as background type article.

[11] Q: Do you know what they actually did as the
[12] basis for Hu et al. 1?

[13] A: My understanding is that they ran a
[14] number of tests and looked at the properties of the
[15] soils.

[16] Q: Do you have any opinion as to how soil
[17] properties can affect a later assessment of
[18] magnitude?

[19] A: I have some idea. I have not gone in
[20] detail because I don't feel that is an area where I
[21] am an expert, nor do I need to know that material
[22] for assessment of seismicity. The basic conclusion

[1] earthquakes.

[2] Q: And that was the input used for Hu et al.
[3] 2?

[4] A: Yes.

[5] Q: Let's go to Hu et al. 2. What is your
[6] understanding of how Hu et al. 2 is relevant to the
[7] seismic design of the MOX Facility?

[8] A: Hu et al. 2 is relevant because it
[9] demonstrates that there were magnitude six and
[10] seven earthquakes possibly in three locations. If
[11] those earthquakes existed, that means there are
[12] sites where major earthquakes could exist.

[13] Q: Anything else?

[14] A: If this has not been included in a PSHA,
[15] which if it hasn't, the PSHA has not been
[16] recomputed, it might affect the results.

[17] Q: If I understand you correctly then, it
[18] almost doesn't matter what magnitude they actually
[19] came up with in Hu et al. 2 for the various
[20] episodes they looked at, as long as they were
[21] magnitude six or seven earthquakes in three
[22] locations, that is all that you are relying on?

[1] A: The power spectral hazard computation or
[2] assessment requires that one determine a seismicity
[3] rate and the zone in which that seismicity rate
[4] occurs. In essence you are not looking at single
[5] events with single magnitudes. You are looking at
[6] return periods or the area or volume in which these
[7] return periods are valid.

[8] Q: But Hu et al. 2 is not looking at return
[9] periods, it is just looking at magnitudes.

[10] A: The primary focus is on determining the
[11] magnitudes. I do not recall if it was they or
[12] Talwani and Schaeffer that had come up with return
[13] periods.

[14] Q: If you look on the first page, Table 1 is
[15] listed from the Talwani and Schaeffer paper.

[16] A: Right.

[17] Q: So Talwani and Schaeffer, 2001, as it is
[18] entitled, looked at recurrence rates, reanalyzing
[19] 15 years of paleoliquefaction in the South Carolina
[20] Plain?

[21] A: Yes.

[22] Q: And Hu et al. 1 looks at liquefaction at

[1] the paleo sites?

[2] A: Yes.

[3] Q: And two looked at the magnitudes of
[4] prehistoric earthquakes?

[5] A: Looked at the properties to look at
[6] magnitudes.

[7] Q: If the thrust of your argument is that
[8] six or seven magnitude earthquakes could occur in
[9] three locations, and all of that is discussed in
[10] the Talwani paper, why do we need to look at Hu, et
[11] al., 1, and Hu, et al., 2?

[12] A: Perhaps you don't.

[13] Q: Could we remove Hu, et al., 1, and Hu, et
[14] al., 2, from discussion for this contention if the
[15] basis for your argument is there are six or seven
[16] magnitude events in three locations historically
[17] and that that should be included in a PSHA?

[18] A: The Hu, et al., 1, and 2 provide
[19] additional strength to the argument that there are
[20] sites of major earthquakes on the coastal plain.

[21] Q: What strength is that?

[22] A: They have been able to narrow down by

[1] using geotechnical techniques the ranges of
[2] acceleration that might have occurred to cause the
[3] liquefaction.

[4] Q: What does that give us that is applicable
[5] to the design of the MOX Facility? That is not an
[6] input used to the design of the MOX Facility?

[7] A: You should be computing a PSHA. As far
[8] as I understand it, you have assumed Lawrence
[9] Livermore and EPRI PSHA value. I believe the
[10] Lawrence Livermore and EPRI values don't
[11] necessarily include some of the information with
[12] respect to recurrence rates and locations that are
[13] now available based on Talwani and Schaeffer and as
[14] refined by this paper.

[15] Q: And I am just asking you how was it
[16] refined by Hu, et al., 1, and Hu, et al., 2?

[17] A: How was it refined?

[18] Q: Yes.

[19] A: In what way?

[20] Q: That is relevant to a PSHA — the PSHA
[21] input would be seismic source zones should include
[22] Charleston, Bluffton and Georgetown; is that

[1] correct?

[2] A: Yes. These articles provide more
[3] constraints on the magnitudes of the events.

[4] Q: What constraints are those regarding the
[5] magnitude?

[6] A: Reduction in the plus or minus value on
[7] the estimate of the magnitudes.

[8] Q: And what is that reduction?

[9] A: Exactly?

[10] Q: Yes.

[11] A: I don't know. That would be a matter of
[12] analysis.

[13] Q: You don't have an opinion as to what the
[14] reduction — you have stated that. Okay,

[15] Do you agree that Hu, et al., 2, does not
[16] discuss Bluffton, nor does it provide magnitudes or
[17] any refinement of earthquakes at Bluffton? Simple
[18] yes or no.

[19] A: I am not sure that they discuss Bluffton
[20] as an epicentral area in detail. I pause because I
[21] believe I saw the statement they were looking at
[22] three areas. I was trying to check that.

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[1] Q: I agree it is somewhat misleading because
[2] if you look on the first page, which is copied from
[3] Talwani and Schaeffer, they have episode D. They
[4] don't say Bluffton, but they still have it, and
[5] when you look at the second page of Hu et al. 2,
[6] they have a figure and that figure seems to have a
[7] circle drawn around the area of Bluffton, but in
[8] the result section and anywhere else they do not
[9] discuss Bluffton.

[10] In fact, the final estimation of
[11] magnitude and peak ground acceleration for
[12] prehistoric earthquakes in the South Carolina
[13] Coastal Plain on Table 7, which is on page 990,
[14] does not include Bluffton. If you look in episode
[15] by age, scenario D is gone. It is not there. And
[16] episode D is the only place where Bluffton was
[17] included; is that right?

[18] A: That would be right. There are question
[19] marks —

[20] Q: The question marks have a source of
[21] Charleston, not Bluffton?

[22] A: Yes.

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[1] Q: So this paper — I am just trying to
[2] define the issue — this paper, Hu et al. 2, does
[3] not refine in any way the magnitude of an
[4] earthquake at Bluffton?

[5] A: It may not.

[6] Q: Well, it doesn't, does it?

[7] A: It discusses — to the extent that it
[8] discusses the episode D, it has the question marks.

[9] Q: Please show me where it discusses episode
[10] D.

[11] A: It seems to me you are trying to negate
[12] the possibility of an earthquake occurring at
[13] Bluffton —

[14] Q: I am not. I am trying to limit
[15] discussion of Bluffton and magnitude in Talwani and
[16] Schaeffer.

[17] A: That would be fine. A magnitude of
[18] significance did occur at a given time and that
[19] contributes in a way, whether it is at Bluffton or
[20] whether it is at Charleston, it will contribute the
[21] same amount to the PSHA if it were recomputed.

[22] Q: I agree. But for purposes of us

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[1] discussing Bluffton and any enhancement of
[2] magnitudes to Bluffton, do you agree we can limit
[3] our discussions to Talwani and Schaeffer 2001?

[4] A: We can do that.

[5] Q: And that Hu, et al., 2, does not provide
[6] any enhancements on the magnitude to Bluffton?

[7] A: Specific to Bluffton, no. To other
[8] areas, it provides enhancements and should be
[9] included and considered in any reevaluation.

[10] Q: Let's go to now the discussion in Hu, et
[11] al., 2, of the other area because if you look on
[12] Table 7, there is just a discussion of Charleston
[13] as a source or Northeast as a source, and Northeast
[14] is listed as a possibility for scenarios C and F;
[15] is that correct?

[16] A: Yes.

[17] Q: Is Northeast listed for any other episode
[18] scenarios?

[19] A: No.

[20] Q: What do you believe is the refinement to
[21] magnitudes provided in Hu, et al., 2, to the
[22] Northeast source?

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[1] A: That would be a matter of comparing the
[2] two estimates, and that is purely number crunching.
[3] If you want to do that, I suppose we can.

[4] Q: Yes, I would like to walk through that.
[5] Let's look back at Talwani and Schaeffer. I think
[6] the table is the first table.

[7] A: The magnitude columns has numbers like 7,
[8] 7.3, 7 plus, 6.0, 7 plus, a 6 plus and a 7 plus.

[9] Q: Let's go by liquefaction episodes.

[10] A: Table 7, you see 7.4, 7.6. Those numbers
[11] are significantly narrower than an integer type
[12] representation in scenario 1 or 2 where you have
[13] simple one-digit numbers. That is a refinement of
[14] the magnitude.

[15] Q: So instead of saying seven plus in
[16] Talwani and Schaeffer, Hu, et al., has some up with
[17] 7.4 to 7.6. Is that significant in any way for the
[18] seismic design of the MOX Facility?

[19] A: Will that affect the PSHA if it were
[20] computed?

[21] Q: Will it affect the ground motion at the
[22] MOX Facility such that it will affect the design of

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[1] the MOX Facility?

[2] **A:** The difference in those two, I don't
[3] believe that either Schaeffer or this were actually
[4] input into a PSHA. So if we are going to say it
[5] will affect the design — if you were to use
[6] Schaeffer and then to use this, would the effect be
[7] different? The two results would be very close.

[8] **Q:** Again, I am just asking because I would
[9] like to make our life simple, does this paper add
[10] anything or can we just rely on Talwani and
[11] Schaeffer?

[12] **A:** In terms of the PSHA computation, it does
[13] not add a significant amount. It does give
[14] credence and definition to the magnitudes.

[15] **Q:** Would you agree — and I will use a
[16] three-legged stool as an analogy — that Hu et al.
[17] 1 is providing most of the legs for that stool and
[18] the stool is Hu, et al., 2, which is determining
[19] the magnitude, and that if there were an error
[20] somewhere here that caused a reevaluation of the
[21] soil properties and you pulled one of those legs
[22] out of the stool, that the refinement in magnitudes

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[1] here wouldn't be valid?

[2] **MS. CURRAN:** Objection. Long and
[3] compound.

[4] **MR. POLONSKY:** It was.

[5] **BY MR. POLONSKY:**

[6] **Q:** If you were to learn that there was an
[7] error in the underlying data, which is Hu et al. 1,
[8] would that affect in your opinion the magnitudes
[9] determined in Hu, et al., 2,?

[10] **A:** It would depend on the error. If there
[11] were systematic and gross errors in summary
[12] assumptions, that would certainly affect the
[13] results.

[14] **Q:** But you are not a geotechnical expert?

[15] **A:** I am not. I can't go into details.

[16] **Q:** Have you spoken to Talwani about these
[17] papers?

[18] **A:** No.

[19] **Q:** But you speak to Talwani?

[20] **A:** Yes.

[21] **Q:** Do you have any intention of speaking to
[22] Talwani about these papers?

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[1] **A:** No.

[2] **Q:** If there were an error in the estimation
[3] of the soil strengths identified in Hu, et al., 1,
[4] would that change the findings in Hu, et al., 2,
[5] regarding magnitude of earthquakes?

[6] **A:** Again, you are asking for a geotechnical
[7] interpretation —

[8] **Q:** You can say you don't have an opinion if
[9] you are not an expert in geotechnical issues.

[10] **A:** I have looked at some of that data and
[11] there is a great deal of uncertainty and
[12] variability in how one interprets it and how one
[13] gets results. The properties depend strongly on
[14] number parameters which can vary in time. So that
[15] when you have a quantity like a dirty sand or soil
[16] or even a clean, washed sand or soil, the
[17] properties of that can be temporarily variable.
[18] They can depend on the water table. They can
[19] depend on age. They can depend on how much
[20] shaking, the frequency of the shaking.

[21] I notice that the articles did not
[22] include a frequency analysis of the vibration, and

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[1] that can be significant, but in general, what they
[2] have done is to come up with an analysis which they
[3] believe is relevant. I think time and further
[4] analysis will determine whether there are
[5] significant errors in this or not.

[6] **Q:** Are you suggesting that each paper as it
[7] comes out should be analyzed for its impact on an
[8] ongoing PSHA — I thought you stated earlier that
[9] new data, new publications should be considered on
[10] an ongoing basis.

[11] **A:** I think it is should be considered on an
[12] ongoing basis.

[13] **Q:** How much time do you think is appropriate
[14] to wait after those publications come out before,
[15] as you just stated, errors are identified — it
[16] wouldn't make sense to rely on a paper as soon as
[17] it comes out before a paper is corrected?

[18] **A:** I think the essence here is that the
[19] power spectral hazard assessment hasn't included a
[20] lot of the more recent stuff and that that really
[21] needs to be redone with a number of considerations.

[22] As to how long you wait before you make a

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[1] correction, if you have made a mistake, how long —
[2] whether or not you consider an article depends on
[3] what is actually stated in the article and what the
[4] implications are. Time can be of an essence or it
[5] may not be relevant. It depends on what is there.
[6] It is in a sense a very hypothetical type of
[7] situation.

[8] **Q:** Knowing that people sometimes make errors
[9] and that sometimes papers are pulled, doesn't it
[10] make sense to wait a certain amount of time before
[11] automatically diving in and taking into account a
[12] paper that has just been published for a \$1.5-
[13] billion facility like the MOX Facility?

[14] **A:** You would need to provide an expert on
[15] the paper to see whether or not it was a
[16] significant paper. Yes, you need to consider it,
[17] but how soon and how fast, you would have to
[18] consult experts on the particular topic.

[19] **Q:** Would you consider Hu, et al., 1, in
[20] conjunction with Hu, et al., 2, significant papers?

[21] **A:** I am not familiar with the literature
[22] entirely, in terms of assessing accelerations from

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[1] liquefaction. I think that what they did is a
[2] significant contribution, certainly to South
[3] Carolina seismicity, because they have pulled
[4] together, first of all, the basis for what the
[5] properties of soils are and what acceleration is
[6] required to cause liquefaction, and then they have
[7] applied that to a situation where they have
[8] determined accelerations and extrapolated estimated
[9] magnitudes on that basis. So I think that is a
[10] significant contribution.

[11] **Q:** On page 977 of Hu, et al., 1, the last
[12] sentence of the conclusions, that sentence says,
[13] "The effect of aging of the source sands on the
[14] liquefaction potential of the SCCP requires further
[15] study." Do you know what that means or what they
[16] are hinting at?

[17] **A:** Geologists learn early in their career
[18] that the strength or hardness of the rock is a
[19] function of age, that rocks change with age, that
[20] they condense, they compress, and they get
[21] sometimes stiffer and harder. The rate that that
[22] occurs varies, and I think they are saying when

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[1] that material has sat in place for X number of
[2] years, it may become more stable. I think they are
[3] saying that that aspect, that potential area of
[4] uncertainty leads to more investigation. They may
[5] also have been hedging some of their uncertainties.

[6] **Q:** If there were an error in the estimation
[7] of the age of the soils such that the Hu, et al.,
[8] 1, authors assumed newer soils as opposed to older
[9] soils, what is your opinion on how that would
[10] impact what the results of Hu, et al., 1, and Hu,
[11] et al., 2, is?

[12] **A:** I don't know what their opinion is. My
[13] opinion is that an older soil would be a more
[14] stable soil and that with time it would take a
[15] higher acceleration to cause liquefaction, so if
[16] they assumed it was younger, then it would perhaps
[17] take a lesser acceleration to cause liquefaction.
[18] They do mention too the possibility that water
[19] levels vary. Water content is a critical factor in
[20] terms of liquefaction.

[21] **Q:** Would you agree if less acceleration was
[22] required, that the magnitude assumptions in Hu, et

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[1] al., 2, would have to be lowered?

[2] **A:** Given the hypothetical case that they
[3] were wrong in the age, possibly could be lower,
[4] yes.

[5] **Q:** What do you mean possibly could be lower?

[6] **A:** There are other factors like water
[7] content, water saturation.

[8] **Q:** But for purposes of these papers, do you
[9] know whether they assumed a specific water content?

[10] **A:** I don't recall that.

[11] **MS. CURRAN:** It has been about an hour.

[12] **MR. POLONSKY:** Let's take a break.

[13] (Discussion off the record.)

[14] (Recess.)

[15] **BY MR. POLONSKY:**

[16] **Q:** Dr. Long, are you familiar with any
[17] studies by Obermeier regarding the location of
[18] Charleston-type earthquakes on the South Carolina
[19] Coastal Plain?

[20] **A:** I have heard that name and I believe I
[21] have read the paper, but I believe it is at least
[22] ten years ago, and I have not seen it recently.

[1] Q: Are you familiar with any studies by
[2] Amick regarding the location of a Charleston-type
[3] earthquake on the South Carolina coast?
[4] A: They did a bunch of liquefaction work,
[5] partly in association with Talwani.
[6] Q: Was the Amick work before 2001?
[7] A: Yes.
[8] Q: Do you recall whether the Amick work
[9] included discussion of Charleston-type earthquakes
[10] both north and south along the coast of South
[11] Carolina?
[12] A: I haven't reviewed that article in a long
[13] time, so I don't know the details.
[14] Q: If the Amick and/or Obermeier papers
[15] included a discussion of earthquakes north and
[16] south of Charleston, would you still be of the
[17] opinion that the Talwani and Schaeffer papers are
[18] providing new interpretations about the location of
[19] earthquakes on the South Carolina Coastal Plain?
[20] A: The Talwani and Schaeffer paper
[21] summarizes existing work, which includes
[22] Obermeier's as well as Amick's work. The new

[1] contribution is interpretation and correction to
[2] the age dates.
[3] Q: That will take us back to the revised
[4] contention, page 1, same sentence as last time.
[5] Both these assertions do not consider recent
[6] paleoseismic work on the South Carolina Coastal
[7] Plain showing more activity in the last 6,000 years
[8] and over a wider area than previously known.
[9] My question is does the Talwani and
[10] Schaeffer paper actually identify any earthquake
[11] over a wider area than previously known?
[12] A: I believe the answer to that was it
[13] defines the northern and southern or Bluffton zones
[14] as additional sites of liquefaction which might be
[15] associated with major earthquakes.
[16] Q: But if those sites were already
[17] identified by Obermeier and Amick —
[18] A: I don't know that Obermeier identified
[19] those sites.
[20] Q: If Obermeier and Amick identified those
[21] sites, would you agree that Talwani and Schaeffer
[22] did not identify earthquake activity on the coastal

[1] plain on a wider area than previously known?
[2] A: The sequence of when certain people
[3] identified certain areas is one that might be
[4] debated even among the participants. Sometimes one
[5] identifies things just to obtain credit for it even
[6] if it is studied in detail or not.
[7] I think the essence of any of those
[8] articles on the total suite of these articles or
[9] studies of liquefaction in the Charleston plain —
[10] South Carolina Coastal Plain, the essence is that
[11] major earthquakes have occurred and that they have
[12] occurred repeatedly.
[13] The computation then of the PSHA should
[14] include that information, and as I understand it,
[15] you have simply accepted the Lawrence Livermore and
[16] EPRI PSHAs without refinement of the expert
[17] opinions and definitions nor the attenuation
[18] relationships when computing it.
[19] Q: All I am talking about is location of the
[20] Charleston earthquake or Charleston-type
[21] earthquakes along the coastal plains. If there
[22] were previously out there opinions that earthquakes

[1] could have occurred north and south, in the areas
[2] of Bluffton or Georgetown, and those were included
[3] in the PSHA, as people suggested that there were
[4] large areas where Charleston-type earthquakes
[5] occurred on the coastal plain?
[6] A: It is not whether they were included. I
[7] already said the range of opinions in that area
[8] were very diverse, very wide, and a lot of that had
[9] to do with the fact that a lot of the experts
[10] didn't know what was going to happen in the next 20
[11] years in terms of scientific studies including
[12] liquefaction.
[13] Q: If the NRC said it was acceptable to use
[14] EPRI or Livermore or a combination, would you agree
[15] that by using the EPRI or Livermore studies, that
[16] DCS would have satisfied the requirement by the
[17] NRC?
[18] A: In a legal sense it would have required
[19] it, but perhaps not in a moral sense. I will give
[20] an example.
[21] I was told that it was acceptable to
[22] visit Mount Saint Helens in April, two weeks before

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[1] it blew. In retrospect, I wouldn't have done that.
[2] There has been a lot learned in volcanics to say
[3] that would have been an obvious mistake and not one
[4] being made today.

[5] I think we are dealing here with an
[6] acceptance of a study done — Livermore and EPRI,
[7] they were done in the '70s. They included a wide,
[8] diverse group of opinions. They didn't include a
[9] lot of the opinions we know today. They included
[10] hypotheses and ideas that can be discounted today.
[11] I think that we have new data, new information that
[12] today we can insert into a PSHA that would refine
[13] and give a better or more confident result.

[14] Q: Would you agree that if the Livermore and
[15] EPRI studies are wrong in your view, but are wrong
[16] on the conservative side, would they be acceptable
[17] to use?

[18] A: I think you should establish that they
[19] are not in error. I think you should establish
[20] what is a correct value and determine whether or
[21] not your error or conservative values are above or
[22] below the correct value.

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[1] Q: Your assumption is that it should be
[2] correct, not more conservative, not less
[3] conservative?

[4] A: Yes.

[5] Q: We have had conversations about people
[6] choosing large areas for the location of the
[7] Charleston seismic zone in the Livermore and EPRI
[8] studies, and you stated — what I am getting at
[9] today is that in some way today you drop an expert,
[10] you just wouldn't consider that opinion any more
[11] because the scientific community has refined its
[12] understanding about the location of the Charleston
[13] seismic zones since then, and if you got a panel of
[14] experts today and did the same thing, you would get
[15] a different result?

[16] A: I think that is true.

[17] Q: If you have that outlier person, and who
[18] is considered an expert, is part of the panel, how
[19] do you decide to drop an expert?

[20] A: I think in many cases, perhaps most of
[21] the cases, the experts themselves would say, oops,
[22] I know more now, this is a better answer.

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[1] Q: Do you recall what you should have chosen
[2] for the Charleston seismic zone in the Livermore or
[3] EPRI studies?

[4] A: I would have chosen a zone around
[5] Charleston of 15 or 20 kilometers.

[6] Q: That is your recollection?

[7] A: Yes.

[8] Q: What would you do today if you were
[9] empaneled and the whole thing was done again?

[10] A: I would include that same Charleston
[11] zone. I would include Bowman and two other areas
[12] north and south that are separate, known likely
[13] areas. I would have a background area where it
[14] might occur anyplace.

[15] Q: I am sorry.

[16] A: I would have a background area in which
[17] major events could possibly occur just about
[18] anyplace.

[19] Q: Let me understand what that means. I
[20] thought the input you give as an expert is where do
[21] you think the zone is. But you are telling me —

[22] A: You have a definition of zones and you

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[1] have a background area. Background area is every
[2] place that is in the zone, and it is generally used
[3] to assign events that were not included in the
[4] specific seismic zone; so the total rate is lower.

[5] Q: And yesterday you said you would on a
[6] moment magnitude scale assign 7.0 to 7.8 for
[7] Charleston-size earthquake?

[8] A: Yes.

[9] Q: And what would you assign for the
[10] background zone?

[11] A: Same magnitude regarding maximum
[12] magnitude. You have to distinguish that seismicity
[13] that goes into the probabilistic spectral —
[14] seismic hazard assessment consists of a rate of
[15] activity and a B value which tells you how much —
[16] how many big events you have for low events, and
[17] that is the Gutenberg-Richter's recursion analysis.

[18] We don't put magnitude in per se except
[19] to define where the maximum magnitude is that you
[20] would consider for some zones, and you don't put
[21] minimum magnitudes in except at a certain level
[22] they have no contribution. So we are not — if you

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[1] say you put a magnitude such in a certain zone,
[2] that is not true. What you do is you put a
[3] magnitude seven every 600 years in the Charleston
[4] zone and that defines a curve or a relationship.
[5] One also has to say that the B value is on the
[6] order of .8.

[7] Q: And why would you put an equal maximum
[8] magnitude on the background zone? Let me
[9] understand that.

[10] A: Why would I not? I am not hypothesizing
[11] that a different type of earthquake would occur in
[12] the background zone.

[13] Q: What you are saying is the same
[14] Charleston-type earthquake could happen in the
[15] background zone; is that another way of saying what
[16] you have just said?

[17] A: Yes, but there is a probability
[18] associated with that as well.

[19] Q: And what is that probability?

[20] A: That would come out of computations,
[21] however you decide to do it.

[22] Q: The recurrence interval that you assign

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[1] for the Charleston zone, whatever it is, 600 plus
[2] or minus, do you have to assign a recurrence
[3] interval for the background zone?

[4] A: You would.

[5] Q: What would you assign for the background
[6] zone?

[7] A: Recurrence interval?

[8] Q: Yes.

[9] A: The equation you assign is an A value,
[10] seismicity value, and it is a value of number of
[11] earthquakes of magnitude zero and greater in a
[12] given area. So if one is going to assign a value
[13] to that, one would have to take the area in which
[14] you consider the background zone, locate the rate
[15] of seismicity for the total background zone, and
[16] break that down to the contribution from individual
[17] areas. That probability will be significantly less
[18] than a probability of an event occurring in
[19] Charleston because there is a known history and
[20] repeat of earthquakes at Charleston.

[21] Q: Could you today provide a return interval
[22] for the background zone?

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[1] A: I probably could compute it.

[2] Q: Could you today just sitting here —

[3] A: Not sitting here. No, I wouldn't want to
[4] guess on it.

[5] Q: What weight would you place on the
[6] Charleston zone?

[7] A: I would take the seismicity of the
[8] Charleston zone, the return periods, to define the
[9] recursion relationship which essentially says a
[10] magnitude seven every 600 years, something like
[11] that, and I would assign that as the seismicity for
[12] that area, and I would say that would be it, that
[13] would be a probability of one.

[14] Q: And what weight would you place on the
[15] background zone?

[16] A: Unless you have overlapping zones, you
[17] have a probability of one. Now, you have a weight
[18] of one. If you have multiple zones, then you have
[19] to decide between which of those — if you have
[20] multiple zones in one area, you have to decide what
[21] weight you are going to assign each, and the EPRI
[22] project went into that in detail.

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[1] Q: Help me understand. I thought the
[2] probability of one meant it happens and that that
[3] type of language is used in deterministic analysis,
[4] but that for probabilistic analysis, everything is
[5] fed in so that there is never a probability of one

[6]
[7] A: You asked for weights. I used the term
[8] probability by mistake. You asked for a weight.
[9] If you are assigning a weight to a seismicity zone,
[10] if you only have one zone there representing the
[11] area, that has to have a weight of one. It has to
[12] add up to one. If you have two zones, you can
[13] assign a weight of .5 and .5. That adds up to one,
[14] total contribution. If you don't conserve your
[15] weights you end up overestimating or
[16] underestimating the total seismicity budget.

[17] Q: In the second GANE supplemental
[18] interrogatory response, 3.11. The second full
[19] paragraph of the answer says the seven-event
[20] sequence with four magnitude seven and three
[21] magnitude six is perhaps the least seismically
[22] active. Hence, full consideration of all the other

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[1] likely sequences would increase the estimated
[2] acceleration when factored into the PSHA or
[3] earthquakes propagated to the MOX Facility. And my
[4] question to you is do you agree with this
[5] statement?

[6] A: Yes.

[7] Q: Why do you think that full consideration
[8] of all the other likely sequences would increase?
[9] That seems like pretty strong language. Should it
[10] be may increase, could increase?

[11] A: The other scenario gives all the
[12] earthquakes a magnitude seven, rather than three of
[13] them a magnitude of six. When you increase the
[14] magnitudes of the earthquakes, presuming they are
[15] at about the same distance from the site, the
[16] computed PSHA would increase under other scenarios.

[17] Q: Help me understand that in the context of
[18] this interrogatory response, hence, full
[19] consideration of all the other likely sequences
[20] would increase. It doesn't say, hence, full
[21] consideration of this sequence would increase when
[22] compared to others.

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[1] A: If you have a sequence which is — has
[2] lesser-magnitude earthquakes occurring than others,
[3] by having the same number of earthquakes but with
[4] larger magnitudes, you increase the seismicity.
[5] When you increase the seismicity, that is what is
[6] propagated to the size in the PSHA and would
[7] increase the value.

[8] Q: I agree with what you are saying, but is
[9] that what this says in the interrogatory response?

[10] A: It says that the sequence with
[11] magnitude — four magnitude seven and three
[12] magnitude six is less seismically active. Thus,
[13] full consideration of other sequences would
[14] increase the estimate by a factor —

[15] Q: For all the other —

[16] A: Whether you consider them as weighted
[17] contributions or whether you consider them
[18] independently, if they have a higher magnitude
[19] sequence and the locations don't change
[20] significantly, then the acceleration or PSHA at the
[21] site should increase.

[22] Q: Should?

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[1] A: That's right.

[2] Q: Not would increase?

[3] A: All other computations remaining the
[4] same, the value would increase. If you add other
[5] corrections or uncertainties, they might increase.

[6] Q: Is the assumption for this statement that
[7] the Charleston earthquake or Charleston-type
[8] earthquake is the primary contributor of the
[9] seismic hazard at the MOX Facility?

[10] A: I don't know that that is an assumption
[11] for the statement.

[12] Q: If the Charleston seismic zones was not
[13] the primary seismic hazard for the MOX Facility —

[14] A: It still is true.

[15] Q: It still is true?

[16] A: Yes. If the Charleston seismic zone were
[17] almost inconsequential, located 500 kilometers
[18] away, and you change the seismicity rate slightly,
[19] it would have an increased effect, although almost
[20] inconsequential.

[21] Q: How much of a contribution would you say,
[22] in your opinion, would be required from a

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[1] Charleston-type earthquake on the South Carolina
[2] Coastal Plain to have a material effect on the
[3] seismic design of the MOX Facility?

[4] A: Probabilistic seismic hazard analysis
[5] includes a number of factors. Primary one is the
[6] rate of seismicity. If you increase the rate of
[7] seismicity at Charleston and your de-aggregation
[8] results show that Charleston is the primary
[9] contributor to the hazard risk, then it will have a
[10] very significant contribution to the hazard risk.

[11] In addition, the propagation path, other
[12] factors can contribute to the hazard or risk, and
[13] remember, the Lawrence Livermore and EPRI studies
[14] did not use locally verified propagation paths or
[15] attenuation relationships. So if you are going to
[16] redo it, if you want to redo it, then you should
[17] consider all the factors and not just the change in
[18] seismicity.

[19] Q: Do you think there is a role that a PSHA
[20] based on a national grid — let me rephrase that.

[21] What role do you think there is for a
[22] national-based PSHA like EPRI, Livermore or USGS?

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[1] A: Those two studies were landmark studies.
[2] Lawrence Livermore was initiated by NRC in order to
[3] put some order to the computation of hazards at a
[4] site. It was a matter of getting away from the
[5] deterministic method which was unrealistic. EPRI
[6] was done to give a little different approach to it
[7] and as a check. Those two studies established and
[8] developed a technology for doing the computation.
[9] They took the data as it existed, the knowledge of
[10] experts as they were available at the time, and put
[11] them into the program and came up with a national
[12] map on a grid.

[13] The USGS in the third study took a
[14] different approach. They said some of the stuff
[15] that EPRI got into and some of the work that was
[16] inherent in the Lawrence Livermore studies were not
[17] concrete enough and that we need to do this based
[18] on something definitive such as the existing
[19] seismicity.

[20] So the USGS studies made a philosophical
[21] change in the sense that they used existing
[22] seismicity as primary contributor for determining

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[1] risk. Whether that is 100 — I don't believe that
[2] is 100 percent correct, and I believe that Kafka,
[3] for example, has demonstrated that existing
[4] seismicity is not 100 percent reliable in terms of
[5] predicting new sites of earthquakes, at least the
[6] statistics he gave it was around 30 percent.

[7] So we have new information. We have very
[8] definitive information now on the Charleston
[9] seismic zone and we have information on zones like
[10] Bowman and Bluffton and Georgetown that were also
[11] seismically active. If one were to revise then the
[12] probabilistic seismic hazard assessment and utilize
[13] this new information, then the results may change.

[14] I don't think you can overlook the real
[15] contribution that those three studies have made.
[16] They did establish a technology. They showed how
[17] it should be done, and in essence they said if you
[18] want to now apply this to a specific local area, be
[19] sure the relationships are appropriate for that
[20] area. In other words, those studies couldn't be
[21] done for another country unless they put in all the
[22] parameters for that other country or continent.

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[1] Q: But they were specifically done for the
[2] United States?

[3] A: They were done for the United States.

[4] Q: Do you believe the EPRI and Livermore
[5] studies as they are right now without any changes
[6] can be used to site a nuclear facility?

[7] A: I think that if you took those two
[8] studies and in each case where you wanted a nuclear
[9] facility you did a supplemental evaluation of the
[10] parameters that went in, you could determine
[11] whether or not the EPRI and Lawrence Livermore
[12] values were appropriate.

[13] Q: Is Bluffton closer to SRS than
[14] Charleston?

[15] A: I think they are about the same distance.
[16] Considering the dimensions of SRS, it would be plus
[17] or minus.

[18] Q: Do you know why in the contention they
[19] state that Bluffton is closer?

[20] A: No.

[21] Q: Do you agree?

[22] A: I think that was in there before I came

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[1] on.

[2] Q: Do you agree that — page 2 of the
[3] revised contention, second full paragraph, third
[4] sentence says the other scenario would put one
[5] magnitude six event near South Carolina only 100
[6] miles from the SRS, and the others near Charleston
[7] and Georgetown. In other words, contrary to what
[8] the CAR says, major events may have occurred closer
[9] than thought to the Charleston seismic zone. Do
[10] you agree with this statement?

[11] A: Not necessarily.

[12] Q: What do you disagree with?

[13] A: The term much closer. In the sense —
[14] there are two aspects of the statement. One is
[15] perhaps a misinterpretation of the distance from
[16] Bluffton to the Savannah River Site —

[17] Q: Can we focus on that, just distance,
[18] Bluffton's distance?

[19] A: If you want to focus on Bluffton's
[20] distance, why don't we pull out a map and measure
[21] it? Do I believe it is a certain distance? Why
[22] not measure it?

[1] Q: We could dispose of this issue by pulling
[2] out a map and measuring the distance from Bluffton
[3] to SRS?

[4] A: Yes.

[5] Q: Do you have an opinion whether Bluffton
[6] is closer to the Charleston seismic zone?

[7] A: I believe they are about the same
[8] distance. Again, why guess at a distance when you
[9] would go to a map and measure it?

[10] Q: All right. The same sentences we were
[11] just referring to in the revised contention on page
[12] 2, are there other issues there that you disagree
[13] with?

[14] A: The potential existence for seismic
[15] activity closer to the site still exists as a
[16] possible input into a PSHA.

[17] Q: And what would be the basis for that
[18] statement of yours?

[19] A: Background — the background zones
[20] discussed earlier.

[21] Q: And what is the basis for the background
[22] zones, is that your personal theory of how

[1] consider a — GANE's first interrogatory response,
[2] 316 states that it is reasonable to consider a
[3] magnitude seven event at Bluffton. Do you agree?

[4] A: I would agree.

[5] Q: What is your basis for that statement?

[6] A: That there is an indication of magnitude
[7] six that occurred there.

[8] Q: Anything else?

[9] A: Magnitude six indicates a sufficiently
[10] large earthquake to suggest that a crust is
[11] involved, the total thickness of the crust is
[12] involved in the seismicity. That implies to me
[13] that you have a mechanism which could or may have
[14] been similar to that at Charleston.

[15] Q: Do you know if there is any requirement
[16] by the NRC or the DOE to consider larger events
[17] than have happened?

[18] A: I don't know the requirements.

[19] Q: Did Talwani and Schaeffer include a seven
[20] magnitude occurred at Bluffton?

[21] A: They concluded a magnitude of about six.

[22] Q: Can you identify a study which concludes

[1] earthquakes occur, that we discussed yesterday
[2] morning?

[3] A: Yes.

[4] Q: Any other reasons for that belief?

[5] A: Basically the earthquakes occur, I
[6] believe, according to my theory, as a result of the
[7] weakness in the crust, already developing weakness,
[8] and accumulation of stress about those weaknesses.
[9] We do not have a full enough understanding of the
[10] crust and the location of where those might
[11] possibly occur.

[12] Q: Is the issue of Bluffton being closer to
[13] SRS that is raised in the contention, does that
[14] have any bearing on the historical check or is that
[15] limited to the probabilistic analysis?

[16] A: That would not bear on the historical
[17] check since the historical check is to take the
[18] largest known earthquake, and that would be the
[19] Charleston, and that would include some of the
[20] historical Charleston earthquakes which are seen in
[21] the paleoliquefaction, which could be larger.

[22] Q: Why do you think it is reasonable to

[1] a seven occurred at Bluffton?

[2] A: No.

[3] Q: So this is — magnitude seven event at
[4] Bluffton is forward looking?

[5] A: A magnitude seven at Bluffton is using
[6] the types of relationships which are incorporated
[7] in the PSHA. In other words, the relationship that
[8] goes into the computation of the PSHA is where you
[9] look at the rate at which earthquakes occur, and
[10] you assign both a rate and a slope to the curve.
[11] Specifying a single magnitude doesn't do anything
[12] but pinpoint one point on a line. You have to
[13] associate that with a return period.

[14] Now, here we are talking about the
[15] deterministic check. The deterministic check as I
[16] understand it is what events are historically
[17] recorded and known to exist, and that would be the
[18] Charleston. When we talk about calculating the
[19] PSHA, which is a different beast, we are looking at
[20] probabilities.

[21] So, based on the evidence near Bluffton,
[22] one would apply a lower seismicity rate, but the

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[1] maximum magnitude one would accept would be on the
[2] same order as the maximum magnitude you would
[3] accept for Charleston.

[4] Q: So in a PSHA, if you were empaneled on a
[5] seismicity panel, would you assign a seven plus at
[6] Bluffton?

[7] A: I would assign an A and B value at
[8] Bluffton for the different areas. That is what the
[9] seismicity panel people did. They did not assign
[10] specific earthquakes to sites.

[11] Q: Would those A and B numbers in your mind
[12] have been placing a seven earthquake —

[13] A: Whatever magnitude you place is an upper
[14] level.

[15] Q: And the upper limit you would have placed
[16] at Bluffton would have been?

[17] A: About seven and a half.

[18] Q: Would there be any other experts that
[19] would place a seven plus at Bluffton as the maximum
[20] magnitude?

[21] A: I believe almost all the experts would
[22] say if there was a Charleston-type earthquake

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[1] occurring anywhere, the upper limit would be on a
[2] seven and a half.

[3] Q: Do you know any other experts that would
[4] say that a seven-plus magnitude should be
[5] considered in a PSHA at Bluffton?

[6] A: The analogy here is that we are assuming
[7] that Bluffton — the indications I have is that
[8] Bluffton is very analogous to Charleston. The data
[9] would suggest it is. I would believe any expert
[10] would say that.

[11] Q: I understand any expert, but would all
[12] the experts say that?

[13] A: You want to define expert again? We can
[14] go far enough —

[15] Q: How many people would think that a seven
[16] plus is the magnitude at Bluffton?

[17] MS. CURRAN: Calls for speculation.

[18] BY MR. POLONSKY:

[19] Q: How many people do you think would agree
[20] with you?

[21] A: Go through the roster of the SSA, I
[22] suppose.

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[1] Q: How many members?

[2] A: About 1600.

[3] Q: How many experts in southeastern
[4] earthquake work would place a seven plus at
[5] Bluffton?

[6] A: There are only a few people that have
[7] worked on that in detail. Talwani is one of them.
[8] I think he would.

[9] Q: He would place a seven plus?

[10] A: He has it in the literature, seven plus,
[11] seven plus.

[12] Q: Not at Bluffton, he doesn't?

[13] A: You are confusing an issue here. Your
[14] confusion as to do with what has been the evidence
[15] for an earthquake of an existing size, and you are
[16] confusing that with what would be the maximum
[17] earthquake that would occur if the seismic zone
[18] were active and could be observed for a long period
[19] of time.

[20] Q: I am trying to understand if we were to
[21] empanel a PSHA —

[22] A: You would be asking two questions of that

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[1] panel. You would be asking them what is the
[2] seismicity, what earthquakes are observed, and then
[3] at a second point you would ask them what are the
[4] implications of that seismicity in terms of maximum
[5] probable magnitude. You can go back to Lawrence,
[6] Livermore and EPRI studies and see what were put
[7] down in terms of maximum magnitudes and you will
[8] find maximum magnitudes in an area where the
[9] earthquake was two.

[10] Q: Do you think there were maximum
[11] magnitudes of seven plus in the Livermore PSHA?

[12] A: Yes, definitely.

[13] Q: Why do we need to do a new PSHA if it was
[14] done before?

[15] A: Let me explain once again what a PSHA
[16] does. That is a computation where you take
[17] individual estimates of seismicity and you find out
[18] by extrapolations what that contribution is to a
[19] particular site. You then add all the
[20] contributions from many sites.

[21] In these studies they provided a weighted
[22] average of all the experts' opinions. So that one

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[1] expert — hypothetically there may have been one or
[2] two experts that put a magnitude seven at Bluffton
[3] at the time this was done. That would have given
[4] maybe one-tenth the probability or weight to that
[5] contribution. Today, 90 percent of the experts or
[6] 100 percent might have considered a magnitude seven
[7] as a possibility at Bluffton. That would put a
[8] much greater weight on that estimate.

[9] **Q:** So absent a redo —

[10] **A:** With local considerations —

[11] **Q:** Of an EPRI or Livermore, the only way you
[12] would be satisfied with a seismic design of, for
[13] example, the MOX Facility would be to do a
[14] full-blown, site-specific PSHA?

[15] **A:** I could figure out shortcuts. I think if
[16] you went back into the Lawrence Livermore and EPRI
[17] studies and evaluated the contributions and you
[18] looked at the changes in the contribution based on
[19] what was put in then and put in now, you could
[20] evaluate what it should be changed to.

[21] **Q:** Do you know if the NRC requires an
[22] applicant to do that?

[1] **A:** No. The paper Lee et al. says you
[2] utilize a PSHA which has been done in the last ten
[3] years, which would mean that the PSHA for Lawrence
[4] Livermore and EPRI would have to have been done
[5] after '93.

[6] **Q:** Can you show me where Lee, et al., '97
[7] says that?

[8] **A:** I believe I can.

[9] **Q:** Please.

[10] **A:** Page 21. "A probabilistic seismic hazard
[11] assessment, PSHA, must be conducted for the site or
[12] used in the existing PSHA that is less than ten
[13] years old."

[14] **Q:** Is this referring to an NRC requirement?

[15] **A:** "The fundamental elements of the criteria
[16] for higher hazard nuclear facilities, PC-3 and PC-4
[17] are: 1."

[18] **Q:** Is this for an NRC facility?

[19] **A:** Higher hazard nuclear facilities, I would
[20] assume that NRC has jurisdiction over that.

[21] **Q:** Let me bring you to the top of the page,
[22] page 21, where it says DOE — design basis, DOE

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[1] **A:** Lee et al. says that there is a
[2] requirement that the PSHA must be done within the
[3] last ten years. I don't know if there is an or on
[4] that.

[5] **Q:** What PSHA is it referring to?

[6] **A:** For the site. In other words — if the
[7] PSHA was done specifically for the site in the last
[8] ten years, it would not have to be redone.

[9] **Q:** When was the PSHA done for the Savannah
[10] River Site?

[11] **A:** I don't know that you have ever done one.
[12] You have taken the Lawrence Livermore and EPRI
[13] study results.

[14] **Q:** So taking the Lawrence Livermore and EPRI
[15] results from 1997 and applying that to the Savannah
[16] River site, does not in your mind —

[17] **A:** Those results were much earlier than '97.

[18] **Q:** The Lee, et al., paper discussing the
[19] application of the EPRI and Livermore PSHAs to the
[20] Savannah River Site —

[21] **A:** That was in '97.

[22] **Q:** Is that within the past ten years?

[1] standard 1023. Would you agree this is a DOE
[2] standard?

[3] **A:** Not having read the standards, no. I
[4] have read this and I interpret that.

[5] **Q:** Can you identify any place where NRC
[6] requires that?

[7] **A:** No, I do not have familiarity with NRC
[8] rules.

[9] **Q:** In GANE's second supplemental
[10] interrogatory response, 3.11.

[11] **MR. POLONSKY:** Do you want to take a
[12] short break?

[13] (Discussion off the record.)

[14] (Recess.)

[15] (Long Exhibit No. 3 was
[16] marked for identification.)

[17] **BY MR. POLONSKY:**

[18] **Q:** Dr. Long, at the bottom — on page 9 in
[19] response to interrogatory number 3.11, GANE states,
[20] based on Kafka 2002 and Hu 2002, one should
[21] consider a rate of activity consistent with seven
[22] magnitude seven events in the last 6,000 years.

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[1] Sixty to 70 percent of these events should be at
[2] Charleston or other established epicentral zones
[3] and 30 plus would float in the coastal plain.

[4] Do you agree with the statement?

[5] A: Yes.

[6] Q: What is your basis for this statement?

[7] A: The conclusion of Kafka that
[8] approximately 30 percent of the significantly
[9] larger events occur in areas where previous
[10] seismicity had not been known.

[11] Q: Any other basis besides Kafka?

[12] A: The statement is based on Kafka, should
[13] one consider this division? Are there other
[14] arguments? There are other seismologists who
[15] perhaps, including myself, would say there is a
[16] probability of earthquakes occurring in new areas.
[17] The exact ratio I might not agree with, and that
[18] function may be a function of area of study or
[19] region. That is something that one would have to
[20] evaluate critically for this area.

[21] Q: Is this a generally accepted principle in
[22] the scientific community?

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[1] A: It is a new idea — no, I can't say it is
[2] new. It is a periodically brought back idea.
[3] Perhaps the main difference between Kafka and all
[4] the other previous proponents of this idea is that
[5] Kafka has put some concrete statistics to it.

[6] Q: Has anyone put concrete statistics to it
[7] besides Kafka?

[8] A: I don't know the answer to that.

[9] Q: Can this particular —

[10] A: My familiarity with this is that I am
[11] familiar with the eastern U.S., and his focus was
[12] initially on the eastern U.S.

[13] Q: Do you think this theory can be tested?

[14] A: I think Kafka tested the theory and came
[15] up with some statistically derived numbers. The
[16] hypothesis he had was that conventional seismology
[17] doesn't necessarily always indicate all the areas
[18] in which earthquakes were going to occur, and he
[19] tested that by looking at catalogs of earthquakes.

[20] Q: Is the testimony that you plan to provide
[21] on behalf of GANE for the hearing on this
[22] contention going to rely on any papers other than

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[1] Kafka and Hu for this proposition?

[2] A: I don't think so.

[3] Q: Do you intend to interject into that
[4] testimony your own earthquake model?

[5] A: I have some ideas with respect to Kafka's
[6] work which has not been expressed yet here, namely,
[7] with the nature of the statistical analysis. I
[8] probably will not interject that. I don't know.
[9] It has to do with the uncertainty where earthquakes
[10] might occur.

[11] Q: Could you explain to me what you mean by
[12] you have opinions on Kafka's statistical analysis?

[13] A: Kafka did conventional statistics. He
[14] did not establish that the distributions were
[15] purely plouisson in character. I believe they are
[16] more likely to be found to be scale invariant, or
[17] what is often referred to as fractal.

[18] (Long Exhibit No. 4 was
[19] marked for identification.)

[20] BY MR. POLONSKY:

[21] Q: Do you have any other criticisms of
[22] Kafka's paper which we have now marked as Long 4?

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[1] A: No. I don't consider that a criticism.
[2] I consider it something he has overlooked or hasn't
[3] gone that far into.

[4] Q: To your knowledge, was this paper
[5] peer-reviewed?

[6] A: Seismological Research Letters are
[7] reviewed, yes.

[8] Q: Do you know what the peer-review process
[9] was?

[10] A: I was editor and I instigated it. One
[11] chooses or selects three or more people they feel
[12] are knowledgeable in the field. They send the
[13] article to the people. They review it and send
[14] their opinion back to the editor and then the
[15] editor decides to publish, to publish with
[16] revisions or to request major revisions or not to
[17] publish.

[18] Q: Did you have any role in Long No. 4?

[19] A: No.

[20] Q: Did you have a role in the review of any
[21] of the other articles, Talwani and Schaeffer, 2001?

[22] A: No.

[1] Q: Hu, et al., 1 or 2?

[2] A: No.

[3] Q: When you say other established epicentral
[4] zones or when GANE in its response says other
[5] established epicentral zones, what are you
[6] referring to there?

[7] A: I am not sure. I think it is Charleston
[8] and other areas. That is a simple way of saying
[9] you have identified Charleston as a seismic zone.
[10] If you decide to define other areas as distinct
[11] seismic zones, they would not be included in the
[12] background, but — because they would be known.
[13] The 30 percent would be applied to areas that are
[14] not known or not considered active.

[15] Q: Does other established epicentral zones
[16] refer to Bluffton or Georgetown or Bowman?

[17] A: It could.

[18] Q: Does it?

[19] A: One would have to come to an opinion
[20] statement as to whether the seismicity at Bluffton,
[21] or Readesville, Georgia, or Bowman, are sufficient
[22] to justify an independent seismic zone. If that

[1] Charleston, I would include Bowman. I would also
[2] include Readesville, Georgia.

[3] You didn't ask what weight I would put on
[4] it, and I would be hesitant to do that at this
[5] point. The significant fact is it is the
[6] distribution of the seismic zones relative to the
[7] site and whether they contribute independently or
[8] together to a potential increase to the hazard. As
[9] I look at these zones, they all are about the same
[10] distance away, and if the attenuation relationships
[11] I was talking about before are in error — in the
[12] area of 100-kilometer range, then that could
[13] conceivably increase the hazard.

[14] In a sense, I am more concerned that you
[15] have accepted the Lawrence Livermore and EPRI
[16] studies without evaluating what the impact of a lot
[17] of this new information is. In terms of
[18] attenuation relationships, I think you made some
[19] mistakes. That is really my concern.

[20] Q: The attenuation relationships, and I want
[21] to touch on it for a second, applies to both the
[22] probalistic and the historical check?

[1] conclusion was made, yes, it would. Otherwise they
[2] would be lumped.

[3] Q: DCS has a real world job to apply
[4] potentially these statements in its analysis. So,
[5] GANE is stating that one should consider a rate of
[6] activity, et cetera, et cetera, and that these
[7] events would be at Charleston or other established
[8] epicentral zones. Unless you can establish what
[9] they are, not can be, then DCS doesn't know what to
[10] apply. I need to know we can satisfy GANE's
[11] concerns.

[12] A: Perhaps I should ask for a contract.

[13] Q: Other established epicentral zones is a
[14] bit ambiguous.

[15] A: I am not saying that — what I would say
[16] is an established zone is what I would end up with
[17] as an established zone, if I were to give it the
[18] attention and detail that I would in a
[19] contractual-type arrangement where I was asked to
[20] divide it. Based on the evidence I have seen
[21] presented here, I would include Bluffton, I would
[22] include northern part, Georgetown, I would include

[1] A: Yes.

[2] Q: Is it your opinion that a seven-plus
[3] earthquake could occur anywhere on the Carolina
[4] Coastal Plain, yes or no?

[5] A: I don't think we have the data to say it
[6] could not. I think if I were to have information
[7] that were sufficiently detailed, I could place some
[8] fairly low probabilities on certain areas.

[9] Q: Is the Savannah River Site underlain by
[10] the Carolina Coastal Plain?

[11] A: Yes, the coastal plain goes up underneath
[12] the Savannah River Site. The coastal plain
[13] sediments are about a thousand feet underneath the
[14] Savannah River Site. The definition of the coastal
[15] plain though — once you get to an area where they
[16] call a fault line off of the Piedmont province into
[17] coastal plain sediments, they continue to some
[18] distance underneath the coastal plain sediments,
[19] and the Piedmont crystalline hard rocks then
[20] terminate in what are essentially — what is
[21] essentially a failed rift and early separation of
[22] the Atlantic Ocean. That failed rift then left

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[1] behind volcanics or Jurassic basins, and numerous
[2] other structures of that type. Finally the rifting
[3] shifted further off coast and the Atlantic Ocean
[4] opened. So the coastal properties on the north
[5] reach of the Savannah River Site moved more toward
[6] the Piedmont type. You have Dunbarton Jurassic
[7] basin that are extensional in character within the
[8] site.

[9] Q: You are saying Dunbarton is part of the
[10] coastal plain?

[11] A: It is underneath the coastal plain.

[12] Q: For definitional purposes, when you say
[13] South Carolina Coastal Plain, that area extends on
[14] to the Savannah River Site?

[15] A: Yes.

[16] Q: In your opinion, does Talwani and
[17] Schaeffer undermine the position that a magnitude
[18] seven or larger earthquake could occur anywhere on
[19] the coastal plain?

[20] A: Talwani and Schaeffer present strong
[21] arguments for continued activity at Charleston and
[22] possibly a couple of other sites. They provide

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[1] data that would imply that the probability of an
[2] earthquake in another area could be significantly
[3] less. I don't know that it undermines the
[4] hypothesis. It provides new information that could
[5] be interpreted to limit seismicity, at least in
[6] part, to those areas.

[7] Q: Has any paper been published by someone
[8] other than yourself which states that a seven-plus
[9] magnitude earthquake could occur anywhere on the
[10] Carolina Coastal Plain?

[11] A: I don't believe I can answer that. I
[12] don't have the details on publications.

[13] Q: Are you aware of any papers that have
[14] been published which state that a seven-plus
[15] magnitude earthquake could occur anywhere on the
[16] Carolina Coastal Plain?

[17] A: Most of your published papers deal with
[18] specific topics, seismic zones and such. A few of
[19] them, most occurring in more engineering-type
[20] literature, have dealt with seismic zones and
[21] definitions. My concentration has been with the
[22] scientific literature, not the engineering aspects.

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[1] I have seen some of the articles, but without
[2] reviewing the articles there is no way I can tell
[3] you if they said seven anyplace.

[4] Q: So sitting here today, you can't identify
[5] for me any papers which state that a seven-plus
[6] magnitude earthquake could occur anywhere on the
[7] Carolina Coastal Plain?

[8] A: I do not recall one, not because I have
[9] looked for it, but because I simply have not looked
[10] for that information. By way of clarification,
[11] with the EPRI and Livermore studies, that topic was
[12] extensively discussed, whether or not it was a
[13] maximum magnitude, how widely it was disbursed, and
[14] there were a number of experts, some of the experts
[15] that published their results later, but I could not
[16] tell you who or where.

[17] Q: What is your opinion of Alan L. Kafka,
[18] the author of the article marked as long Exhibit 4?

[19] A: I think he has done some good work. I
[20] talked with him when he was doing surface wave
[21] measurements, and he was using techniques very much
[22] like I have been using and I talked to him about

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[1] this particular article and his ideas and I think
[2] he is doing some very good work. He has other
[3] responsibilities, academic responsibilities which
[4] don't leave him full-time to do research, but he is
[5] doing excellent work.

[6] Q: You stated you talked with him regarding
[7] this article. What were —

[8] A: I talked to him regarding the topic of
[9] this article. I am not sure when I talked to him
[10] that this article had been published.

[11] Q: What conversations did you have with him
[12] regarding this article?

[13] A: We discussed his techniques, and we
[14] discussed the results. This was prior to
[15] publication.

[16] Q: Did he have any concerns about the work
[17] that he was doing?

[18] A: No. He was very enthusiastic.

[19] Q: Did you provide any input to him on the
[20] work or the conclusions?

[21] A: This was before the paper, so whether
[22] there was input to his conclusions, I don't know.

[1] We discussed the general topics and causes and
[2] perhaps effects and explanations.
[3] **Q:** Do you consider Kafka to be a seismic
[4] expert?
[5] **A:** I consider him to be an expert in this
[6] area, yes.
[7] **Q:** What area is that?
[8] **A:** Statistics of the distribution of these
[9] earthquakes.
[10] **Q:** Is Kafka an expert statistician?
[11] **A:** He is a seismologist.
[12] **Q:** Is he an expert seismologist?
[13] **A:** I would call him an expert seismologist.
[14] **Q:** Is he an expert statistician?
[15] **A:** There are a lot of seismologists who
[16] learn to use statistics that are quite
[17] sophisticated. I don't know that we would call
[18] ourselves statisticians. I think we call ourselves
[19] seismologists. Now, whether he has had the
[20] experience and background and training that would
[21] qualify him to be an expert in statistics, I have
[22] no idea. I have examined the statistics he used in

[1] this paper, and with the caveat that they I already
[2] mentioned — that I mentioned, I would agree with
[3] him.
[4] **Q:** And what was the caveat?
[5] **A:** That the statistics would better be
[6] described by a fractal type distribution.
[7] **Q:** When did you first learn about Kafka's
[8] 2002 paper?
[9] **A:** He presented the preliminary work as a
[10] talk and I don't remember the date.
[11] **Q:** And when did you first get a copy of the
[12] paper?
[13] **A:** Probably when it came in the mail.
[14] **Q:** Do you recall getting a copy of it before
[15] it came in the mail?
[16] **A:** No, I did not get a copy before it came
[17] in the mail.
[18] **Q:** Just to confirm from yesterday, GANE has
[19] dropped the issue that Charleston-like earthquake
[20] zones develop in new locations?
[21] **A:** What page was that on?
[22] **MR. POLONSKY:** Interrogatory response.

[1] It is in general interrogatory 3 on the second GANE
[2] supplemental.
[3] **THE WITNESS:** Yes, we did.
[4] **MS. CURRAN:** Just want to clarify. We
[5] are referring to a sentence in the answer to
[6] general interrogatory number 3 that says, second,
[7] DCS failed to make any evaluation of how long it
[8] would take for a new Charleston-like earthquake
[9] zone to develop in another location.
[10] **MR. POLONSKY:** That has been dropped for
[11] now?
[12] **MS. CURRAN:** Yes.
[13] **THE WITNESS:** Yes.
[14] **BY MR. POLONSKY:**
[15] **Q:** Where in Kafka's paper does he say new
[16] earthquakes will be in new areas or that there is a
[17] 30 percent chance there will be a new earthquake in
[18] a new area? And I will direct you to the second
[19] supplement, page 11, in response to 3.20, which
[20] states Kafka's observation that 30 plus of new
[21] earthquakes will be in new areas. Show me where
[22] Kafka observes that.

[1] (Pause.)
[2] **THE WITNESS:** Based on this — this is
[3] page 1001, right column, based on this test of
[4] statistics, we can raise the value of C as high as
[5] 71 percent and reject the null hypothesis at 95
[6] percent level of statistical significance. This
[7] means that at the 95 percent level of the
[8] statistical significance, we can expect that on
[9] average more than 71 percent of the large
[10] earthquakes in the region will tend to occur near
[11] previous small earthquakes.
[12] **BY MR. POLONSKY:**
[13] **Q:** Is that the same as saying that 30
[14] percent will occur in other areas?
[15] **A:** Twenty-nine.
[16] **Q:** Is that what Kafka —
[17] **A:** Either they occur in the same areas or
[18] they occur in other areas. If 71 percent occur in
[19] the same area, 29 percent occur in other areas.
[20] Are there other areas? I don't think so.
[21] **Q:** What you read to me, is that a
[22] statistical certainty, that Kafka observes 30

[1] percent events are occurring in new areas?
[2] **A:** Twenty-nine percent, to be exact, if you
[3] really want to get picky.
[4] **Q:** The statement you used was that 29 or 30
[5] percent of large earthquakes could occur in new
[6] areas?
[7] **A:** Then the Kafka statement was that 71
[8] percent of the large earthquakes in the region will
[9] tend to occur near previous small earthquakes.
[10] **Q:** How does Kafka define large earthquakes?
[11] **A:** I think we will have to read the article
[12] to find out.
[13] **Q:** Let's do it.
[14] **A:** It is a question of definition. It is a
[15] relative-type thing, so I would have to go through
[16] the article and find out.
[17] **Q:** We can do that now.
[18] **A:** In my opinion, it is irrelevant.
[19] **Q:** And why is it irrelevant?
[20] **A:** Because I believe the seismicity is scale
[21] variant or refractal. To provide explanation,
[22] scale or variant, it doesn't matter whether you are

[1] looking at a small sample in the lab or the whole
[2] United States, the results should be approximately
[3] the same.
[4] **Q:** Let's go to Table 1, next to the word
[5] region there is a little asterisk, and that has an
[6] explanation — page 998. It says, "Numbers in
[7] parentheses are small- and large-magnitude cutoffs,
[8] respectively."
[9] **A:** Okay.
[10] **Q:** Do you see where SEUS is for southeastern
[11] United States in Table 1?
[12] **A:** Two and 3.5.
[13] **Q:** Two is the cutoff for small earthquakes?
[14] **A:** That is pretty close to the detection
[15] threshold.
[16] **Q:** And 3.5 is the cutoff for large
[17] earthquakes?
[18] **A:** He considered large earthquakes 3.5 or
[19] larger.
[20] **Q:** This says cutoff.
[21] **A:** That would imply that his events were
[22] larger than 3.5, and he did not consider seismicity

[1] of events less than 2.0.
[2] **Q:** That is your opinion?
[3] **A:** Yes.
[4] **Q:** Does he state that?
[5] **A:** No. That is obvious.
[6] **Q:** What were the highest magnitude
[7] earthquakes that Kafka considered for the Southeast
[8] United States?
[9] **A:** He probably used the series catalog. The
[10] dates of the catalog would determine what the
[11] largest earthquake was.
[12] **Q:** Let me refer you to Table 2 which is on
[13] page 1002, and again for the SEUS, what is the
[14] magnitude large for the largest earthquakes?
[15] **A:** 4.3 to 4.8.
[16] **Q:** Back to the interrogatory response to
[17] 3.20. GANE's previous response to this
[18] interrogatory is supported by Kafka's 2002
[19] observation that 30 percent of major events in the
[20] United States are in new areas. Where is the
[21] support in Kafka's 2002 paper for that statement?
[22] **A:** In that statement I read to you that said

[1] of the large earthquakes, 29 percent occur in new
[2] areas, areas not defined by previous seismicity.
[3] **Q:** But the definition of large is 4.3 to 4.8
[4] since those are the largest earthquakes he looked
[5] at?
[6] **A:** Kafka looked at statistics. If you look
[7] at the Gutenberg-Richter recursion analysis, it is
[8] a straight line. That defines a refractal type
[9] phenomenon. If you look at statistical
[10] distribution of earthquakes, they occur on a
[11] fractal type distribution. Statistically that is
[12] essentially the same thing in terms of analysis and
[13] from the analysis, it doesn't matter whether you
[14] are dealing with a catalog that varies from 25 to
[15] 50 magnitude or one .1 to .5. The results are
[16] going to be the same.
[17] **Q:** Your definition of major earthquakes is
[18] 5.5 moment magnitude or greater?
[19] **A:** My definition of major earthquake is 5.5
[20] or greater.
[21] **Q:** Major event, which is stated in response
[22] to interrogatory 3.20, is that definition in this

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[1] interrogatory response consistent with your
[2] definition of major event? That is a yes-or-no
[3] question. We have to get the definition straight.
[4] The word major appears here.

[5] A: Where is this?

[6] Q: Interrogatory response 3.20 says Kafka's
[7] observation of 30 plus major events — it is on
[8] page 11. We have been very careful to define the
[9] terms. I want to be sure we are being consistent.
[10] The word is major.

[11] A: Major events.

[12] Q: You can change your definition for
[13] purposes of this, but I want to be able to note
[14] that your definition here is different than your
[15] opinion.

[16] A: My definition of a major event refers to
[17] the type of mechanism that would occur — that is,
[18] it is an earthquake of sufficient dimension to
[19] rupture the solid part of the earth's crust. That
[20] starts at about five and a half to six. The
[21] definition that Kafka used is what — in a catalog
[22] the data he had available, he divided it as events

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[1] into the largest group and the smaller group. He
[2] called the largest group the major ones and the
[3] other ones. His major events varied depending on
[4] which catalog he had access to.

[5] In terms of this interrogatory here, this
[6] says that the contention that — GANE's previous
[7] responses were supported by Kafka's observation
[8] that 30 percent of major events in the eastern
[9] United States are in new areas.

[10] Kafka's contention is that when you
[11] consider a catalog of southeastern United States or
[12] Turkey or California, and you divide that catalog
[13] into sections, you end up finding out that about 30
[14] percent in the case of the southeastern — in this
[15] case, you find out that around 30 percent of the
[16] major events in that catalog occur in new areas.

[17] The statistics are such that it doesn't
[18] matter whether we are talking about a seven or a
[19] three or a 1.0. The support is in the
[20] characteristics of the earthquake occurrence and in
[21] the statistics, not in the definition of the
[22] specific magnitude or range of magnitudes to which

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[1] the data were referring.

[2] Q: We need to go back to answer my question
[3] because I don't think you have answered it. Major
[4] event, what magnitude in moment are referring to in
[5] interrogatory response 3.20. Is it 5.5. and above?

[6] A: In this interrogatory, it would be 5.5
[7] and above. Kafka supports that by showing the
[8] statistical relationship is 30 percent of events in
[9] the catalog occur — major events in the catalog
[10] occur in new areas.

[11] Q: But the largest earthquakes that he looks
[12] at in the southeastern United States appears to be
[13] 4.3 to 4.8, which is not a major event; is that
[14] correct?

[15] A: What he calls a major event are the
[16] larger events in the catalog.

[17] Q: Does he call anything a major — I don't
[18] see him call anything major. He says small and
[19] large. I don't see major. Can you point to me
[20] where he —

[21] A: I call major an event that ruptures the
[22] crust mainly because that is a way of defining a

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[1] mechanism which can create a large earthquake which
[2] can cause significant damage. The statistical
[3] studies that Kafka does refer to a set of data.
[4] Perhaps this is a little abstract in terms of
[5] statistics, but it is a set of data and when you
[6] examine that data set, you find out that the new
[7] events 30 percent of the time or 29 percent of the
[8] time occur in areas that have not been defined by
[9] seismicity in the past.

[10] What he is saying is when he looks at
[11] many catalogs around the world, with magnitude
[12] ranges that vary from — probably the lowest was
[13] southeastern U.S., to like 7.4 in SEA, wherever
[14] that is, he gets this relationship. He sees that
[15] the new events appear in areas where they haven't
[16] appeared before on a statistical basis. His
[17] support is then that major events, according to the
[18] statistics — if one looks at the current catalog
[19] of events, which Kafka used, this catalog had
[20] events ranging up to four and a half. Those events
[21] are those that occurred in documented recent times,
[22] good locations, good magnitude. If you were to

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[1] instead substitute a catalog that presumably could
[2] be generated for the last 200 years, this largest
[3] magnitude would be including the Charleston
[4] earthquake.

[5] Q: I am going to read back the response you
[6] said and if you were incorrect at the time, just
[7] correct it. The definition that Kafka used is what
[8] is in the catalog, the data that he had available.
[9] He defined it as events into the largest group —

[10] A: Divided.

[11] Q: He called the largest group the major
[12] ones. I would like you to point out where he uses
[13] the term major in his paper.

[14] A: Perhaps I misread that. Let me see if I
[15] can find that sentence again. He used the term
[16] large earthquakes in a region. I think in terms of
[17] definition, the larger earthquakes are the major
[18] earthquakes, in a general sense. My definition of
[19] major earthquake was more specific with respect to
[20] crustal size.

[21] Q: I understand. I see a disconnect between
[22] the interrogatory response and the paper. The

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[1] interrogatory response tells me go look at Kafka.
[2] Kafka's observation that 30 percent of major events
[3] in the eastern United States were in new areas. I
[4] go to Kafka's paper, I don't see that.

[5] A: He says 30 percent of the larger events
[6] were in new areas.

[7] Q: But large, small and major have very
[8] different definitions in moment to magnitude as we
[9] discussed yesterday?

[10] A: No. Kafka's definition is relative,
[11] relative to the statistical distribution. His
[12] conclusions are independent of scale.

[13] Q: How can that be? How can you say a seven
[14] magnitude earthquake can be independent of prior
[15] seismicity? How can you say the probability —

[16] A: How can I say that major earthquakes have
[17] occurred with no fore shocks? I have heard that
[18] many times. I think we can point to the Saguenay
[19] earthquake. Almost no fore shock activity. There
[20] are places where earthquakes have occurred where
[21] there was no fore shock activity, no prior seismic
[22] activity.

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[1] Q: What were the magnitude of those
[2] earthquakes?

[3] A: Saguenay, six to seven.

[4] Q: That is a big range?

[5] A: That is a guess. It is in the six-to-
[6] seven range.

[7] Q: Is there any other example that you would
[8] give, except we will have to check on that
[9] magnitude, without any prior seismicity for any
[10] major event?

[11] A: New Madrid, Charleston —

[12] Q: Why is Charleston an example?

[13] A: From a statistical basis of this catalog
[14] which deals with the time period —

[15] Q: That is 1924 on, isn't it?

[16] A: Yes.

[17] Q: Of course, if you only look at 1924 on,
[18] then you will not even see the 1886 Charleston.
[19] Isn't this paper limited to the data set that it
[20] looked at?

[21] A: Is it limited to the data set it looked
[22] at? It looked at around 10 data sets.

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[1] Q: The years were only 1924 to the present,
[2] so it is making a generalized statistical
[3] statement. It is not saying an applicant for a MOX
[4] facility should take into account this paper and
[5] absolutely should incorporate this into their PSHA.

[6] Would you agree that this paper is a
[7] first stab by Kafka at assessing whether there is a
[8] statistical relationship between prior seismicity
[9] and future seismicity?

[10] A: Definitely. It is a pioneer paper in
[11] that respect although I could not tell you that
[12] other people have not attempted this. There has
[13] been a lot of work in California to try to use
[14] statistics to predict earthquakes. We are looking
[15] at gaps and missing areas.

[16] Q: I can tell you with my background, this
[17] was very interesting to read. I found it
[18] fascinating, but at the same time I was putting my
[19] head in the position of DCS and trying to think
[20] what do I do with this paper as it applies to
[21] designing a MOX Facility, and I couldn't see
[22] applying it because it is so out there in the

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[1] forefront of a new idea.

[2] **A:** LLNL had a number of experts, they had a
[3] number of ideas. A lot of those ideas were out on
[4] the forefront and they were attempting to come to
[5] some conclusion, their best opinion as to what
[6] happened — what the seismicity is. This paper
[7] comes up with some statistical — using a
[8] statistical analysis, demonstrates that if you rely
[9] solely on existing seismicity as a guide for future
[10] seismicity that is going to occur, and if you have
[11] a ^ finite-length catalog, you could be mistaken.
[12] There are going to be events that are going to be
[13] surprises.

[14] This event in northeast Alabama that
[15] occurred earlier this year, I don't know that one
[16] event has occurred there in the past. I know one
[17] has occurred nearby, but not necessarily in that
[18] spot. I have been surprised myself. I looked at
[19] an event that occurred in Green County, Georgia. I
[20] had no idea we had earthquakes there and I have
[21] been looking at earthquakes for 30 years.

[22] If I go back and look at where

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[1] earthquakes have occurred in Georgia, on a small
[2] scale, and admittedly you have trouble translating
[3] between scales on earthquakes, but if I go back and
[4] look at it, I would see every so often there is a
[5] surprise, and it may be that statistics might be 30
[6] percent of new areas.

[7] **Q:** Do you think the opinion of Kafka was
[8] taken into account by one of the opinions in the
[9] Livermore or EPRI studies?

[10] **A:** In a very general sense it might have
[11] been included. I think, yes, there was at least
[12] one expert who said we have no idea where the major
[13] earthquakes will occur next. Does that have an
[14] effect? Yes. That expert would have one extreme
[15] view. Other experts had other views and they were
[16] averaged out.

[17] I think Kafka has put some fairly
[18] definitive statistics on this problem and he said,
[19] look, whether you look in California, Turkey or the
[20] southeastern U.S., you have catalogs which when
[21] statistically analyzed suggest something like 30
[22] percent of the largest events in the catalog occur

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[1] in areas, areas not defined by seismicity, and I
[2] think the USGS will have to seriously consider
[3] their analysis based on this because it is
[4] currently based entirely on where earthquakes have
[5] occurred.

[6] **Q:** Do you think that the concept that you
[7] raised earlier about background zone adequately
[8] captures the uncertainty raised in Kafka's paper?

[9] **A:** Kafka's paper provides statistics which
[10] would allow one to assign a weight to a background
[11] zone.

[12] **Q:** But doesn't it assign some weight now?

[13] **A:** If it has been included, yes.

[14] **Q:** So if some weight were or had been
[15] assigned to the uncertainty of a new earthquake
[16] happening somewhere else, it would have captured
[17] Kafka's paper?

[18] **A:** It would have captured the concepts
[19] presented. Whether the magnitude of the
[20] contribution would be appropriate, that is
[21] something else.

[22] **Q:** Does Kafka refer to the California

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[1] coastal plain at all in his paper?

[2] **A:** I do not know.

[3] **Q:** Does Kafka refer to Charleston type of
[4] events in the southeastern United States?

[5] **A:** Kafka's paper concentrates on the
[6] statistics and he does it with worldwide analysis.
[7] If he were to have commented on individual events
[8] like Charleston, it would have been a very long
[9] paper.

[10] **Q:** Are Kafka's conclusions inconsistent with
[11] a position that the South Carolina Coastal Plain is
[12] aseismic?

[13] **A:** Yes.

[14] **Q:** Can we go to the first GANE interrogatory
[15] responses, page 22? Interrogatory 3.20. The
[16] response says, "We think DCS should consider an
[17] event of the magnitude of the 1883 Charleston event
[18] for Bluffton because the Carolina Coastal Plain is
[19] largely aseismic except for major events. It is
[20] hard to immediately localize where strong magnitude
[21] events would take place. Thus, conservatism is
[22] necessary." I would like to direct your attention

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[1] to the second sentence.

[2] A: Because recent networks have not
[3] identified smaller earthquakes in a few areas.
[4] That is what is meant by aseismic.

[5] Q: That is inconsistent with Kafka's paper?

[6] A: No, I don't believe so. Kafka's paper
[7] says that new events 30 percent of the time will
[8] occur in areas where there are no earthquakes. The
[9] fact that South Carolina Coastal Plain doesn't have
[10] earthquakes observed in some areas according to
[11] Kafka's paper suggests that maybe earthquakes would
[12] occur.

[13] Q: Can I have an answer on the record to
[14] this question: Are Kafka's conclusions inconsistent
[15] with the position that the South Carolina Coastal
[16] Plain is aseismic and you said, yes.

[17] A: Kafka says it might be seismic, that
[18] earthquakes might occur there. I am wondering if
[19] you are misinterpreting the question.

[20] Q: Wouldn't doubt it.

[21] A: The implications of Kafka's paper are
[22] simply that on a statistical analysis, earthquakes

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[1] could occur anyplace and that 30 percent of the
[2] time they do occur just about anyplace except where
[3] they have occurred before. To take the observation
[4] that the South Carolina Coastal Plain is, according
[5] to the current seismic monitoring, in part aseismic
[6] is not inconsistent. That is consistent with
[7] Kafka's hypothesis.

[8] Q: As an academic exercise, would you agree
[9] that Kafka specifically ignored geology and any
[10] known geologic features?

[11] A: Yes.

[12] Q: And the purpose of his paper was to
[13] isolate statistically without any consideration to
[14] geology?

[15] A: Yes.

[16] Q: If you have already addressed it, forgive
[17] me, but could you tell me how Kafka's paper
[18] addresses truly — I won't say truly large —
[19] addresses magnitude seven-or-greater earthquakes?

[20] A: Kafka's paper treats catalogs from many
[21] areas of the world. Some of those catalogs cover a
[22] range of very large earthquakes.

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[1] Q: Do you know why Kafka chose the radii he
[2] chose around known seismicity in order to try and
[3] create those earthquakes that fell within areas of
[4] prior seismicity or were outside that area and
[5] therefore were new areas of seismicity?

[6] A: I don't know the details of why he chose
[7] a particular radii. When one computes a fractal
[8] dimension for distribution of points in an area,
[9] one looks at that radius and how many other events
[10] are contained within that radius and evaluates that
[11] for the statistical analysis and the fact that he
[12] has chosen a radii which he has defined in some
[13] way — I think he probably detailed it and has come
[14] to a conclusion based on that.

[15] Q: Would it be appropriate to have different
[16] radii for different areas of the United States and
[17] other areas of the world if that is what Kafka
[18] looked at?

[19] A: Very possible. I don't know if he looked
[20] at that or not. In fractal analysis one uses
[21] different radii.

[22] Q: Let's say he used 30 kilometers, and any

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[1] earthquake that occurred outside the 30 kilometer
[2] area would be then considered a new earthquake, or
[3] an earthquake that occurred in a new area; is that
[4] right?

[5] A: Yes.

[6] Q: If you were to change that 30 kilometers
[7] to 40 kilometers, wouldn't he be potentially
[8] changing the results of his analysis, since some of
[9] those that were normally outside the area are now
[10] in the area since he changed the diameter of the
[11] circle?

[12] A: You are getting into the details of the
[13] statistics. You are asking questions concerning
[14] the details of the statistical treatment of the
[15] data. I am sure he has thought of that and
[16] analyzed it. I cannot recall without looking at
[17] the paper in detail exactly how that was taken
[18] account of.

[19] Q: How would you, if you were looking at the
[20] southeastern United States from a statistical
[21] perspective, how would you decide what the radius
[22] should be to determine whether one should be inside

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[1] or outside an area of seismicity?

[2] **A:** That is a function of precision and
[3] location. If you have a catalog that is located
[4] plus or minus 10 kilometers, then you cannot
[5] distinguish whether an event 10 kilometers from
[6] another is independent or within the area. That is
[7] a limitation on the data. I have an area where I
[8] have a one-kilometer precision and I can
[9] distinguish areas that are four or five kilometers
[10] apart.

[11] The first criteria is what is your
[12] location precision for the events in the catalog.
[13] The second criteria is the dimension of the fault
[14] plane with respect to the magnitude. If you have a
[15] fault — a magnitude four earthquake, you may have
[16] a fault plane that is a kilometer or so in
[17] dimension. So you would certainly not want to have
[18] an earthquake which is within a kilometer or so of
[19] a previous earthquake considered a new area. That
[20] is within the dimension of the fault.

[21] The primary concern is is this a seismic
[22] zone. You might say if you have an earthquake of

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[1] one magnitude four, then anything within that
[2] kilometer which might be a radius of influence of
[3] that particular magnitude would be considered the
[4] same zone. Those are the considerations one would
[5] apply to that problem.

[6] **Q:** And that might vary from one area of the
[7] United States to another area of the United States?

[8] **A:** Yes, it would — it could.

[9] **Q:** And it would vary probably based on the
[10] year of the earthquake since earthquakes that
[11] occurred prior to instrumentation would have less
[12] accuracy than those that were post instrumentation?

[13] **A:** That is right.

[14] **Q:** Does Kafka treat what you would consider
[15] shallow earthquakes differently than what you would
[16] consider deep earthquakes? Tie that to the
[17] discussion we had yesterday about your separate
[18] theories of shallow and deep earthquakes.

[19] **A:** I don't think he attempted to
[20] distinguish. I think he looked at catalogs.

[21] **Q:** Would it have made a difference if he had
[22] looked at the difference between shallow and deep

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[1] earthquakes?

[2] **A:** I don't believe so, no. I think his
[3] conclusions would be the same.

[4] **MR. POLONSKY:** Why don't we break for
[5] lunch?

[6] (Whereupon, at 12:35 p.m., the deposition
[7] was recessed to reconvene at 1:30 p.m. that same
[8] day.)

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[1] **AFTERNOON SESSION**

[2] (1:44 p.m.)

[3] Whereupon,

[4] LELAND TIMOTHY LONG,

[5] having been previously duly sworn, was further
[6] examined and testified as follows:

[7] **EXAMINATION BY COUNSEL FOR THE NRC**

[8] **BY MR. HULL:**

[9] **Q:** For the record, my name is John Hull. I
[10] represent the NRC staff in this proceeding. I
[11] wanted to first just make sure I understood
[12] correctly some of the testimony you gave early
[13] yesterday.

[14] You — and correct me if I am wrong
[15] because I am summarizing and paraphrasing here, but
[16] I think you said that it was your opinion that
[17] there was — talking about the South Carolina
[18] Coastal Plain in general, that you thought there
[19] was a zone of weakness or local weakening in the
[20] earth's crust which has deformed the crust. Did I
[21] understand you correctly?

[22] **A:** Near Charleston, yes.

[1] Q: And I think you acknowledged that your
[2] theory of this zone of weakness, if I could
[3] summarize it in that fashion, has not been entirely
[4] accepted by the scientific community.

[5] A: Well, I don't know that I can measure the
[6] level of acceptance. I believe that a lot of
[7] people still hold on to the California mentality of
[8] earthquakes occurring on existing faults.

[9] Q: Now, if I wanted to try to learn more
[10] about your model, one of the papers that you had
[11] authored from December of 1988, titled "A model for
[12] major intraplate continental earthquakes" — are
[13] there any subsequent papers that you have published
[14] that are peer-reviewed which further discuss the
[15] model that you postulate here?

[16] A: There is a paper by Zelt and Long, or
[17] Long and Zelt.

[18] Q: And what is the title of that one?

[19] A: I would have to look at my resume.

[20] Q: To speed things up, I do have your — for
[21] the record, I am looking at the biographical sketch
[22] that was submitted by GANE on your behalf. Under

[1] refereed publications on page 2, one of the
[2] articles listed here is "A local weakening of the
[3] BRDL ductile transition can explain some intraplate
[4] seismic zones." Is that the paper you were
[5] referring to, by Long and Zelt?

[6] A: Yes, that would be it.

[7] Q: And I also see a paper authored by — I
[8] won't read the names, but the title is "Intraplate
[9] seismicity and stress in the southeastern United
[10] States." That was published in TectonoPhysics in
[11] 1989. Would that also be related to this 1988
[12] paper?

[13] A: Who were those authors?

[14] Q: Kuang, K-U-A-N-G, Long and Marechal?

[15] A: That work is more of John Claude
[16] Marechal's work than mine. John Kuang was a
[17] student I helped on his thesis. That work related
[18] to topographic anomalies and density anomalies to
[19] densities in the crust and hypothesized to where
[20] the stresses might be.

[21] Q: Now, the topics discussed in that 1989
[22] paper, in your opinion, do they have any relevance

[1] to the proposed MOX Facility and the seismic issues
[2] we are dealing with?

[3] A: Very marginal.

[4] Q: Would the topics discussed in the 1988
[5] paper that I referenced earlier, would those have
[6] relevance to the seismic issues that we have in
[7] this case?

[8] A: The paper by Long and the paper by Zelt
[9] are relevant.

[10] Q: Moving forward from this 1991 paper, the
[11] one by Long and Zelt, are there any subsequent
[12] papers which have been published which further
[13] describe your model? I will put it that way.

[14] A: I would have to go through the list. If
[15] you want to let me look at that, I will go down it.

[16] Q: I am handing Dr. Long a list of the
[17] publications.

[18] A: There is a paper by Long in '98 which
[19] says, "Shallow earthquakes in the eastern United
[20] States," proceedings with Sixth U.S. National
[21] Conference on Earthquake Engineering. That has to
[22] do with the implications of computing seismic

[1] hazards for earthquakes that are shallow versus
[2] those that are deep.

[3] Q: Now, is it fair to say that the
[4] earthquakes of concern regarding the proposed MOX
[5] Facility would not be shallow earthquakes?

[6] A: Would you repeat that.

[7] Q: Would it be fair to say that the
[8] earthquakes that would be of concern with respect
[9] to the proposed MOX facility would be deep
[10] earthquakes as opposed to shallow earthquakes?

[11] A: I would be concerned with all
[12] earthquakes. It is a matter of relevance as to how
[13] much concern you apply to the shallow earthquakes.

[14] Q: Could you explain what relevance you
[15] believe shallow earthquakes in the South Carolina
[16] Coastal Plain would have to seismic issues at the
[17] proposed MOX Facility?

[18] A: The shallow earthquakes I have discussed
[19] pertain to a mechanism which is fairly limited to
[20] the top few kilometers, maximum depth of four or
[21] five kilometers. Those earthquakes could obtain a
[22] magnitude of four and a half to five — perhaps

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[1] five and a half. The rate of recurrence is small,
[2] but they could occur many places in the Piedmont or
[3] in the coastal plain where the perturbation for the
[4] earthquake would be below the coastal plain
[5] sediments.

[6] What impact they would have on a facility
[7] would be dependent upon the response of that
[8] facility to various amplitudes and frequencies of
[9] vibration, and that would be for an engineer to
[10] answer.

[11] Q: I think you previously testified that you
[12] are not an expert on those structural issues.

[13] A: No. I don't evaluate structures for
[14] their vibrational response.

[15] Q: Would a cluster —

[16] A: Another paper here?

[17] Q: I am sorry.

[18] A: This is by Kaufman and long, "Velocity
[19] and structure of seismicity of southeastern
[20] Tennessee."

[21] Q: And does it indicate when that was
[22] published?

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[1] A: 1996.

[2] Q: And in what — what relevance do you
[3] believe that article would have to the issues we
[4] are dealing with here?

[5] A: That article presented a velocity
[6] structure, velocity inversion for seismic data
[7] which showed that the earthquakes tended to occur
[8] in areas of lower velocity.

[9] Q: How would you say or how would you relate
[10] either of those two papers that you have just
[11] referenced, how would you relate those to your
[12] model as described in the 1988 paper?

[13] A: The last one I referenced, Kaufman 1,
[14] showed data, velocity data that correlated — the
[15] anomalies in the velocity data correlated with the
[16] seismicity, implicating a different type of crustal
[17] material because the correlation was for lower
[18] velocity. The implication was it was weaker
[19] crustal material, supporting the hypothesis that
[20] weaker crustal formations do form and allow
[21] accumulation of stress.

[22] Q: Any other materials which postdate the

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[1] 1991 article that you believe are related to it?

[2] A: That is probably about it.

[3] Q: You mentioned earlier today, and correct
[4] me if I am wrong, about if you have a broad
[5] earthquake area, that would decrease the hazard at
[6] the center of that area. Did I understand that
[7] correctly?

[8] A: That is correct, the computed hazard at
[9] the center of that area.

[10] Q: And you mentioned a paper of yours which
[11] stated that, but I don't think you were asked which
[12] paper it was that you were talking about there.

[13] A: That was one in that sixth annual
[14] conference of earthquake engineering.

[15] Q: If you could look at your list and
[16] identify which paper it is that talks about that?

[17] A: Long 1998, "Shallow Earthquakes in
[18] Eastern United States: Implications for Hazard
[19] Evaluation."

[20] Q: Referring back to again to this 1988
[21] paper, "Model for major intraplate earthquakes,"
[22] has your opinion of this general model changed or

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[1] evolved at all since 1988 or is it basically still
[2] the same as expressed in this paper?

[3] A: The paper represented a presentation of
[4] an idea. The idea certainly has undergone some
[5] development and some expansion. Even though that
[6] is not a major emphasis in my research, funded
[7] research at this time, I still keep it on the back
[8] burner to publish some work that will further
[9] explain how this mechanism operates.

[10] Q: You anticipated my next question. Do you
[11] have any firm idea at this point in time as to when
[12] you would publish the paper you just mentioned?

[13] A: No.

[14] Q: And would you be able to state today
[15] whether there would be any other authors of such a
[16] paper or would you accept it would just be
[17] yourself?

[18] A: Some of the ideas that have developed
[19] either have been in collaboration with other
[20] people — but that has not been a formalized
[21] relationship.

[22] Q: Would you be able to identify any of

[1] these other people there is a possibility you would
[2] publish this paper with?

[3] A: I did write a proposal with a Leonin
[4] Germonivch.

[5] Q: Better spell that.

[6] A: I am not sure I can.

[7] G-E-R-M-O-N-I-V-C-H, I believe.

[8] Q: What is his affiliation?

[9] A: He is presently a professor of civil
[10] engineering at Georgia Tech.

[11] Q: Any other individuals that you would
[12] possibly collaborate with on a future paper?

[13] A: A future student.

[14] Q: I take it from that that would be
[15] unidentifiable.

[16] A: An unidentified student. That would be
[17] what I could say at this time.

[18] Q: Would you be able to state what journal
[19] you would try to get such a paper published in, or
[20] would it be any one of a number of journals?

[21] A: It would be any one of a number,
[22] principally JGR or BSSA.

[1] Q: And what are those?

[2] A: Journal of Geophysical Research and
[3] Bulletin of Seismological Society of America.

[4] Q: For the seismological issues that we have
[5] been talking about, do you view those two journals
[6] as being the most authoritative in the U.S.
[7] literature?

[8] A: Yes, Seismological Research Letters is a
[9] subsidiary of the Bulletin of Seismological
[10] Society.

[11] Q: My notes indicate that at one point
[12] yesterday you were talking about the area
[13] surrounding Charleston and you mentioned that there
[14] were certain anomalous crustal features, and I
[15] think you said something to the effect that there
[16] is evidence of something happening in the crust
[17] there. Did I understand you correctly yesterday —
[18] did I summarize what you stated yesterday
[19] correctly?

[20] A: Yes. Reasonably correctly.

[21] Q: What exactly do you think is happening in
[22] the crust? You made a reference to something

[1] happening, but I don't think you got into the
[2] specifics of what you thought it was that was
[3] happening.

[4] A: My background in the structure of the
[5] crust comes from, first of all, I had a student who
[6] did a gravity survey of the area and graduated with
[7] that as a thesis. I had another student look at
[8] combination of gravity and magnetic data and I have
[9] had other experience of looking at the structures
[10] of the crust in that area.

[11] The concept or idea that I have for a
[12] major earthquake implies that there must be some
[13] deformation going on to create or generate the
[14] stresses, some weak zone in a field of uniform
[15] plate stress. I think as for specific evidence for
[16] that, there is some evidence in the topography, I
[17] am not 100 percent convinced that that evidence is
[18] entirely convincing itself, but I have looked at
[19] the topography for that type of evidence and at
[20] least two other people have looked at that type of
[21] information for evidence of deformation in the
[22] crust.

[1] Q: Now, earlier today counsel for DCS
[2] confirmed with you that GANE is not pursuing what
[3] was listed here as one of three areas, and I am
[4] referring now to response to general
[5] interrogatories number 3 in the December 20, 2002,
[6] Georgians Against Nuclear Energy response to
[7] applicant's first set of interrogatories, and page
[8] 3, there were three items that had been listed and
[9] the second of those three items you had confirmed
[10] today were not — it was not being pursued by GANE.

[11] A: That is correct.

[12] Q: What we were just talking a moment ago
[13] about evidence of something happening in the crust,
[14] does that relate to the second point that GANE and
[15] yourself are no longer pursuing in this case?

[16] A: With my model, the time it takes for a
[17] weakness to develop is not — has not really been
[18] ascertained or determined. That means it hasn't
[19] been determined how long it takes a crustal feature
[20] to develop the properties that are conducive to a
[21] major earthquake. We are not pursuing that because
[22] it is rather speculative.

[1] Q: If you do end up publishing a further
[2] paper in the future, and this was the same paper we
[3] were referring to earlier, is it your intent to try
[4] to explore that idea further, or is that not a line
[5] of inquiry you plan to pursue in your academic
[6] pursuits?

[7] A: I don't really plan to pursue that. I
[8] think it is a much more complicated issue than one
[9] in which the results could be about anything you
[10] want to make it. It is that complicated. I would
[11] pursue aspects of the problem which relate to the
[12] nature of the deformation that results from a weak
[13] spot.

[14] Q: I am referring now to the responses that
[15] start on page 4 of the December 20, 2002, second
[16] supplemental response, response to interrogatory
[17] number 3.1. You state there in part that the
[18] spectra should be scaled up to an appropriate value
[19] of acceleration at the surface. Do you have a
[20] specific value in mind when you make that
[21] statement?

[22] A: When I look at that, I think that the

[1] spectra was scaled for hard rock, not at the
[2] surface. We went through definitions there of
[3] surface and hard rock. My opinion is that the
[4] computation — or the development of the PSHA was
[5] deficient in some aspects, and so, that needs to be
[6] evaluated to determine what it should be scaled to.
[7] I do not — or I have not performed calculations
[8] which would allow me to specify exactly what that
[9] should be.

[10] Q: Do you have any intention with respect to
[11] your involvement in this case to make those sorts
[12] of calculations to be able to come up with a
[13] specific value?

[14] A: That depends on the requests from the
[15] people who might sponsor that. A detailed would be
[16] simpler. Some calculations could be done that
[17] would show order-of-magnitude changes. I don't
[18] know whether I will do that or not. I am concerned
[19] that the Lawrence Livermore and EPRI evaluations
[20] for that were accepted without checking variations
[21] in things such as a distribution of seismicity that
[22] is now better known and propagation path effects

[1] which have now been defined better.

[2] Q: Similar sort of question with respect to
[3] response 3.7, which is at the bottom of page 7 of
[4] the document you are looking at. You state there,
[5] in part, that DCS may have underestimated the
[6] acceleration factor in a distance range from the
[7] coastal plain that includes the SRP. Do you have
[8] any opinion as to by how much DCS underestimated
[9] that factor?

[10] A: What do you mean by acceleration factor?
[11] Is that the acceleration itself?

[12] Q: I am just referring to the interrogatory
[13] response. My understanding is you had a lot of
[14] input to these responses; is that correct?

[15] A: I had input, yes.

[16] Q: I would have to bounce that one back to
[17] you. I don't know what you were referring to
[18] exactly.

[19] A: This refers to the reflections from the
[20] Moho or the post-critical reflections. If those
[21] were properly inserted in the attenuation
[22] relationships which were used for the PSHA, because

[1] of the distance from the site of the Charleston
[2] earthquake, I believe it would increase.

[3] You asked me how much. I haven't done a
[4] calculation, but the anomalous numbers that come
[5] out of Atkinson and Boore show trends that range
[6] from a factor of two to a factor of four and higher
[7] for some of that data. That doesn't mean that the
[8] data from South Carolina would be that much higher.
[9] I think that is something that has to be looked at.

[10] Those computations were not done. The attenuation
[11] relations and seismicities were accepted as
[12] presented — as used in the Lawrence Livermore and
[13] EPRI studies and not, in my opinion, updated.

[14] Q: Similar then to my previous question, do
[15] you have any present plans to do those calculations
[16] yourself to come up with a specific acceleration
[17] factor?

[18] A: I do not have any personal plans to do
[19] that. That doesn't mean I won't change my mind.

[20] Q: Have you discussed any such plans with
[21] GANE?

[22] A: No — by discuss, I haven't sat down and

[1] said this is what it will take and this is what I
[2] would do. We have discussed what might be done.

[3] Q: Has GANE requested you to do such
[4] calculations?

[5] A: My requests from GANE are on a
[6] case-by-case or point-by-point issues. So at this
[7] point, I have no formal requests beyond this
[8] interview here.

[9] Q: Can you give us an estimate as to how
[10] much time it would take you to perform such
[11] calculations if you were requested to do so?

[12] A: Are you making an offer?

[13] Q: I am referring to requests from GANE.

[14] A: I would have to evaluate what was needed
[15] in terms of the total package. I think if you
[16] wanted to do a very short analysis to determine
[17] what the influence would be, that could be probably
[18] cranked out in a couple of months simply because I
[19] know I have programs that could crank out that
[20] problem. If you wanted me to do the entire
[21] project, that is not something I could handle. In
[22] other words, to redo an entire PSHA, I would not be

[1] able to handle that.

[2] Q: If you would refer to response number
[3] 3.12 on page 9. You talk about difficulty of
[4] assigning locations to earthquakes on the coastal
[5] plain. Based on the article by Hu, et al., which
[6] was marked as Deposition Exhibit No. 3, what
[7] uncertainty would you assign based on that — the
[8] contents of that article?

[9] A: Again, I would refer to the article and
[10] use their values of uncertainty.

[11] Q: You would accept those values of
[12] uncertainty?

[13] A: I would certainly accept them at face
[14] value. If I were to put them into equations, I
[15] might further evaluate their techniques to
[16] determine whether or not I was entirely convinced
[17] that their uncertainty is as good as they claim.

[18] Q: Now, in the PSHA for the Charleston
[19] earthquake that was performed by Livermore and
[20] EPRI, do you know what uncertainty ranges those
[21] studies used for the Charleston earthquake?

[22] A: You mean the PSHA for the Savannah site

[1] area?

[2] Q: Yes.

[3] A: Do I know what uncertainties were used
[4] for Charleston? You are looking at 10 or so
[5] experts who put in values and uncertainties. I
[6] don't recall offhand what the range of the
[7] uncertainty is that the computations gave as a
[8] result of combining the inputs from all the
[9] different experts.

[10] Q: Off the record for a minute.

[11] (Discussion off the record.)

[12] BY MR. HULL:

[13] Q: Refer, if you will, to interrogatory
[14] response 3.15 on page 10. You state in part there
[15] that, "We think it would be reasonable to believe
[16] that such an earthquake would call for a design
[17] earthquake with higher peak acceleration and a
[18] shorter return interval." Do you have any opinion
[19] as to — focusing on the first part of that — how
[20] much higher the peak acceleration would be?

[21] A: Placing an epicenter at Bluffton would
[22] increase the probability of a given acceleration at

[1] the site. Exactly how much that would be would be
[2] dependent upon how the information concerning the
[3] Bluffton factored in the PSHA.

[4] Talwani and Schaeffer have a couple of
[5] scenarios. One has lower-magnitude earthquakes in
[6] the north and southern part with earthquakes —
[7] with fewer earthquakes in Charleston. The other
[8] one puts all of the earthquakes in with a larger
[9] magnitude. How those integrate in to determine the
[10] hazard at the site would be dependent on a number
[11] of factors, and in particular, if one accounts for
[12] the seismicity at Bluffton by including it in the
[13] Charleston seismicity, it is possible it would have
[14] zero effect. If you have not accounted for that
[15] seismicity in the model, it might have
[16] increased effect.

[17] Q: Again, similar to questions asked
[18] previously, has GANE asked you to try to come up
[19] with a specific figure for what you think the
[20] higher peak acceleration should be?

[21] A: They asked me the same question you have,
[22] did I think I could do it.

[1] Q: And your answer was?

[2] A: I think I could give a preliminary
[3] answer.

[4] Q: Do you plan to do further research in
[5] order to come up with an answer that would be more
[6] than just a preliminary one?

[7] A: I don't have definitive plans to do that
[8] research, no. That will depend on requests. It
[9] will also depend on my available time.

[10] Q: If you were called upon to do such
[11] research, what would be your estimate as to how
[12] long it would take you to do that?

[13] A: Before I give an estimate of how long, I
[14] think I would have to know what the outcome would
[15] be — not the outcome of the research, but what
[16] level of report, how much analysis would be
[17] required in order to sit down and say what is going
[18] to pull it all together.

[19] This is really the type of job I would
[20] like to assign to a student for three to six
[21] months, something like that, and have them do a lot
[22] of the leg work and preliminary stuff and run

[1] preliminary models and be able to examine it more
[2] thoroughly. In a very short case, I could run a
[3] model in a couple of weeks which would give me an
[4] idea as to exactly what the increase might be, but
[5] it wouldn't give me the answer, the exact answer.
[6] But that was — that might not be a model I could
[7] defend strongly.

[8] Q: Now, in your opinion, is there existing
[9] data which would enable one to do such a model, or
[10] would it first require collection of additional
[11] data?

[12] A: My experience — with my experience in
[13] analyzing and looking at the crustal structure in
[14] the coastal plain and northern Georgia — all the
[15] way across Georgia and the Southeast, I could draw
[16] something that would probably be within 10 percent
[17] off the cuff. That wouldn't be publishable. I
[18] would need to spend some time to go back to the
[19] literature and find out exactly where these models
[20] would be justified.

[21] I think there are some coastal study work
[22] out of theses in South Carolina. My students have

[1] done so many, although that is in northern Georgia.
[2] We would have to pull that literature together to
[3] be sure that we have the information that is
[4] important in terms of crustal structure.

[5] Obtaining good crustal structure is the
[6] objective of the new U.S. array project which won't
[7] be here for another five or six years, but this is
[8] something that could be done on a preliminary
[9] basis. I might point out that when DCS used a
[10] crustal model, they used a model that was obviously
[11] inappropriate for the section of the path that was
[12] involved.

[13] Q: Does that get into the attenuation
[14] factors you have talked about?

[15] A: Yes.

[16] Q: Now, in interrogatory response 3.15, you
[17] also used the term shorter return interval, and do
[18] you have an opinion today as to how much shorter
[19] the interval should be for the studies applicable
[20] to the MOX Facility?

[21] A: I think I said I thought the return was
[22] on the order of 600 years plus four minus two,

[1] something like that. I don't know that a PSHA
[2] would turn into all those other established for —
[3] it simply accepted the posit of the turn intervals
[4] from the Lawrence Livermore and EPRI studies.

[5] Q: Turn to interrogatory response 3.27 on
[6] page 13. You state in part there, by accepting the
[7] LLNL and EPRI results, many attenuation results and
[8] seismic source zones were included that would not
[9] be accepted today in light of recent studies on
[10] crustal structure and historical seismicity.

[11] Can you specify what those recent studies
[12] are that you reference there?

[13] A: I don't know whether it is that recent,
[14] but the attenuation relations used in the Lawrence
[15] Livermore and EPRI studies were really based on
[16] major earthquakes, based on regional studies, and
[17] as such they were fairly sparse, in terms of data.
[18] There is much more — Atkinson and Boore and others
[19] have pulled together more recent data to evaluate
[20] the attenuation relations, and the Atkinson-Boore
[21] study does point out that there is a significant
[22] post-critical reflection effect in the data they

[1] have observed, and I have observed that as well.
[2] I believe there is an article by Jones,
[3] Long and Macke — Long, Jones and Macke, I guess it
[4] is — or I have forgotten when it went out, and we
[5] found evidence of a post-critical bounce.

[6] Q: Do you recall offhand what the date would
[7] be of that Jones, Long and Macke article?

[8] A: I believe that was in the '70s. It was
[9] in BSSA.

[10] Q: But if one wanted to find recent studies
[11] on crustal structure, one would need to go to the
[12] Atkinson-Boore studies and whatever studies that
[13] were referenced there you were referencing here?

[14] A: I think Atkinson-Boore is a good example
[15] of a study that takes observed data in the eastern
[16] continental U.S., and they fit relationships to it
[17] and they demonstrate that there is a Moho bounce.
[18] There are a lot of people studying crustal
[19] structure. I could find much evidence for it,
[20] although it may have been applied in different
[21] applications.

[22] For example, I know that Rob Halmond at

[1] the University of Georgia has done studies of
[2] crustal structures using quarry blends. His
[3] interpretation — I don't know if he goes into the
[4] coastal plain or not, but his interpretations could
[5] be utilized to refine the crustal structure. As
[6] well as for the inner Piedmont, we have had a
[7] publication by Keene and Long in which we have a
[8] velocity model for the inner Piedmont that has
[9] worked very well for seismic data.

[10] Q: Turn, if you would, to a response to
[11] interrogatory 3.29 there at the bottom of page 13.
[12] It states there or makes reference to the fact that
[13] you had not completed your review of a certain
[14] response to a request for additional information
[15] that DCS had submitted and that a supplemental
[16] response would be provided by GANE once you had
[17] completed your review. Have you now completed the
[18] review that is referenced there?

[19] A: This is my response? The response is in
[20] this March 5 document.

[21] Q: Could you show me what you are referring
[22] to there, please.

[1] MR. HULL: Off the record.

[2] (Discussion off the record.)

[3] BY MR. HULL:

[4] Q: Dr. Long, earlier today you made
[5] reference to the — I may be mispronouncing this,
[6] but the Gutenberg-Richter model?

[7] A: Charles Richter. Famous guy.

[8] Q: In your crustal weakness theory, do you
[9] rely on that model or some different model?

[10] A: The Gutenberg-Richter is not really a
[11] model. It is what is referred to as a recursion
[12] relationship. It describes in general the
[13] statistical property that earthquakes have that for
[14] every magnitude six, you are going to get 10
[15] magnitude fives and 100 magnitude fours or some
[16] slight variation on that depending on what the
[17] quote B unquote value turns out to be. So that is
[18] a statistical relationship.

[19] Q: And is it fair to say that in your
[20] crustal weakness theory, you rely on that
[21] statistical relationship, or not?

[22] A: No. That has very little to do — that

[1] statistical relationship exists. It exists within
[2] aftershock sequences, and it exists within
[3] earthquakes in general.

[4] Q: There is another statistical model that I
[5] will refer to as the characteristic model. Are you
[6] familiar with that?

[7] A: Yes.

[8] Q: Is the characteristic model one you rely
[9] on in your crustal weakness theory?

[10] A: No.

[11] Q: What, if any, statistical model do you
[12] rely on in your crustal weakness theory?

[13] A: I am not sure I rely on any statistical
[14] model. It is a mechanical model, a physical model,
[15] of the way in which the earth's crust may be
[16] deformed and in so deforming create the stresses
[17] and weaknesses or the combination of stresses and
[18] weaknesses needed to generate a large or major
[19] earthquake.

[20] Q: This mechanical/physical model you are
[21] referencing now, is this one you would need to do
[22] further work on before you would be in a position

[1] to publish your next paper on, or is this one that
[2] you feel comfortable with that has been fully
[3] developed?

[4] A: Let me say I have confidence in its
[5] correctness. I have not worked off the details,
[6] putting it actually on paper. I did present the
[7] basics of it in an oral talk, but since then I
[8] haven't written it up.

[9] Q: When did you give this oral talk?

[10] A: A long time ago. Eight, ten years ago.

[11] Q: Do you recall where you gave the talk?

[12] A: No. That is something I would have to
[13] look up.

[14] Q: Will your mechanical physical model
[15] produce Gutenberg-Richter or characteristic type
[16] distribution of earthquakes?

[17] A: The difference between a Gutenberg-
[18] Richter recursion relationship and the
[19] characteristic earthquake relationship is that the
[20] characteristic earthquake relationship takes the
[21] tail or the — all the large earthquakes above a
[22] certain level and concentrates the level of

[1] occurrence at some characteristic or maximum
[2] earthquake.

[3] The logic behind that has to do with the
[4] concept that was commonly thought in California
[5] concerning existing asperities along faults. The
[6] sections between asperities or rigid spots on a
[7] fault would rupture and they would rupture
[8] repeatedly for the same size earthquake, the
[9] so-called characteristic earthquake.

[10] The seismicity — the earthquakes at
[11] Parkfield were believed to be one example of a
[12] characteristic earthquake where about every 25
[13] years they had a magnitude five and a half
[14] occurring, except for the last 25 years where it
[15] hasn't occurred yet.

[16] Q: I am not sure if you answered the
[17] question.

[18] A: I was trying to do a little education on
[19] the difference between characteristic and
[20] Gutenberg-Richter relationship. Gutenberg is part
[21] of the characteristic earthquake relationship, but
[22] the characteristic relationship lumps all

[1] earthquakes into one maximum size which is
[2] hypothetically determined by the size of the
[3] rupture zone.

[4] How would that apply to my model or
[5] anybody else's model, that has to do with a finite
[6] length weakness in the crust of the characteristic
[7] earthquake would then be the largest earthquake
[8] that would fit in that zone of weakness. If it is
[9] repeated, it would be repeated as a characteristic
[10] size earthquake, presuming that you would not get a
[11] physical model to support a much larger earthquake.

[12] Q: Let me try to understand what you are
[13] saying. If your crustal weakness theory is
[14] correct, would you expect to be able to predict
[15] future earthquakes in the South Carolina Coastal
[16] Plain based on the GR model or the characteristic
[17] model or any other model?

[18] A: No statistical model will predict
[19] earthquakes.

[20] MR. HULL: Thank you. That is all I
[21] have.

[22] MR. POLONSKY: Why don't we take a short

[1] break.

[2] (Discussion off the record.)

[3] (Recess.)

[4] FURTHER EXAMINATION BY COUNSEL FOR DCSW

[5] BY MR. POLONSKY:

[6] Q: If you could look at revised contention,
[7] page 4, the only full paragraph remaining. It
[8] might be logical to start with the first sentence,
[9] but I would like to start with the last two
[10] sentences because they are a discrete issue.

[11] In the CAR the applicant asserts that
[12] "MFFF-designed earthquake is the existing SRS PC-3
[13] spectrum." Then there is a citation. "This
[14] spectrum is not site-specific but was computed for
[15] the whole Savannah River Site in 1977." Is this
[16] still a valid part of the contention, Dr. Long, in
[17] your opinion?

[18] A: I really don't know. I am trying to
[19] figure out the basis here. My guess is that you
[20] have considered DCS computed the spectrum for the
[21] site.

[22] I think the issue stated there is that

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[1] the spectrum was not site-specific but was computed
[2] for the whole Savannah River Site, and I was under
[3] the impression that we were not pursuing the
[4] difference between the site response from nearby
[5] areas.

[6] Q: That was my understanding too.

[7] Off the record.

[8] (Discussion off the record.)

[9] MS. CURRAN: We will stipulate that GANE
[10] will withdraw the sentence on page 4 of the revised
[11] contention which states this spectrum is not
[12] site-specific but was computed for the whole of the
[13] Savannah River Site in 1997.

[14] BY MR. POLONSKY:

[15] Q: Dr. Long, the previous sentence is a
[16] quote of the CAR, of the original CAR, which says:
[17] "MFFF-designed earthquake is the existing SRS PCS-3
[18] spectrum." Do you know whether the MOX Facility
[19] designed earthquake is the PC-3 spectrum?

[20] A: I am not sure that that is here.

[21] Q: Could you look at that page of the CAR?

[22] This is a revision date of 2001 and the page is

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[1] 1.3.6-23, and it is the second-to-last paragraph.
[2] It starts, the sentence starts, "The technical
[3] basis for the MFFF-design earthquake is the
[4] existing SRS PC-3 spectrum." Then it goes on to
[5] state, "The design of the MFFF SRS PC-3 is based on
[6] the regulatory guide, 1.60, horizontal spectrum
[7] shaped scaled to 0.22 PGA which envelopes the PC-3
[8] surface spectrum."

[9] So would you agree —

[10] A: Surface spectrum or hard rock spectrum?

[11] Q: It says surface spectrum.

[12] A: Does it mean that?

[13] Q: PC-3 is a surface spectrum, not a hard
[14] rock spectrum.

[15] A: Because that is a fairly low value for
[16] surface spectrum. I would expect that with hard
[17] rock.

[18] Q: What is low?

[19] A: Point 2.

[20] Q: PGA seems like a low value?

[21] A: Yes.

[22] Q: But let me get back to the question of

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[1] the contention states that the applicant asserts
[2] that the MFFF-design earthquake is the existing SRS
[3] PC-3 spectrum. Do you agree we didn't assert that,
[4] but the CAR states the technical basis for it is
[5] the existing PC-3 spectrum, but in fact the MOX
[6] Facility horizontal surface spectrum is a reg guide
[7] 1.6 spectrum scaled to 0.2 Gs?

[8] A: I will agree to that.

[9] MR. POLONSKY: Off the record.

[10] (Discussion off the record.)

[11] MS. CURRAN: We have stipulated that GANE
[12] will withdraw a sentence on page 4 of the revised
[13] contention which states that in the CAR, the
[14] applicant asserts that the MFFF design earthquake
[15] is the existing SRS PC-3 spectrum.

[16] BY MR. POLONSKY:

[17] Q: Dr. Long, the beginning of this
[18] paragraph, in the contention, on page 4, discusses
[19] the new reg 0800 standard review plan for nuclear
[20] power plants, cite section 2.5.6 from a revision
[21] dated 1997, and the contention then states this —
[22] "GANE cites it for the proposition that licensed

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[1] applicants should develop a site-specific design
[2] spectrum. This means that the probability for
[3] seismic hazard, that is, the risk of a major event,
[4] should be expressed as a spectrum of the intensity
[5] of shaking and frequencies of structural interest.

[6] Has DCS satisfied this language?

[7] A: I don't believe they have, because they
[8] have not evaluated such things as propagation path
[9] effects and revised evaluations of seismicity to
[10] see what effect it would have on a PSHA.

[11] Q: Do you have an opinion as to whether new
[12] reg 0800 applies to the MOX Facility?

[13] A: That sounds like a legal opinion. I
[14] would not.

[15] Q: The reason I am stating it is the
[16] proposition is this new regulation and this new
[17] regulation is for nuclear power plants?

[18] A: Whether it legally applies or not, the
[19] implication of this is that the probability for
[20] seismic hazard with risk of a major event or risk
[21] of an acceleration being exceeded should be
[22] reevaluated, and it would be done for frequencies

[1] of interest to the structure.

[2] Q: Yesterday we had a discussion about the
[3] USGS national hazard maps, and if I recall
[4] correctly, you stated that the reason that USGS
[5] generates hazard maps is to support building codes,
[6] something along those lines; is that a fair
[7] characterization?

[8] A: Well, the congressional mandate for the
[9] USGS has to do with hazards, hazard mitigation and
[10] developing a hazard map as part of that mandate and
[11] they do — the maps that they have generated are or
[12] have been submitted for various building codes and
[13] applications of building codes. They do not
[14] dictate that to be applied.

[15] Q: Do you think that the USGS PSHA was
[16] generated in a manner that was as rigorous as EPRI
[17] and Livermore?

[18] A: It is hard to compare three different
[19] philosophical approaches and to say one is more
[20] rigorous than the other. I would say all three
[21] were done with a considerable amount of rigor and
[22] check. While their results represent opinions at

[1] the time they were done, and they represent the way
[2] in which the input data were treated, the results
[3] were different somewhat because of the way in which
[4] the data had been treated.

[5] The USGS approach was — it was decided
[6] with that approach to be very straightforward and
[7] to use only observed seismicity, treating that
[8] carefully for completeness and such.

[9] Q: Do you believe that looking at observed
[10] seismicity only is in some way a fault in the USGS?

[11] A: Yes. I think some consideration should
[12] have been given to the statistical analysis that
[13] Kafka has done. All of that has been done later,
[14] that that type of approach will eventually enter
[15] in. There are continually occurring earthquakes
[16] that are surprises.

[17] Q: Did you participate in any way in the
[18] generation of the 1996 USGS hazard maps?

[19] A: I was not a direct participant in that.

[20] Q: Were you a direct participant in the
[21] generation of the 2002 —

[22] A: No.

[1] Q: USGS hazard maps.

[2] A: Both of those efforts were largely
[3] in-house. They did have hearings and they did
[4] solicit comments.

[5] Q: Are the USGS hazard maps useful for
[6] earthquakes with annual probability exceedence of
[7] 10 to the minus 3?

[8] A: Three to the 10 minus three —

[9] Q: 10 to the minus 3?

[10] A: In other words, earthquakes occur every
[11] thousand years. I remember reading a study which
[12] in essence said that there was about a factor of 10
[13] reliability in estimating seismic rates and values
[14] in terms of duration. So if you had a catalog of
[15] 100 years, you could assume that that would be
[16] fairly verifiable out to about a factor of a
[17] thousand years, a factor of 10.

[18] On that basis, then I would evaluate your
[19] question by saying that that thousand years is
[20] probably at the margin of reliability in terms of
[21] long-term seismic estimates, and the reason for
[22] that obviously is places like New Madrid and

[1] Charleston have major earthquakes and the next
[2] earthquakes maybe 600 years ago, so the current
[3] seismicity in the area which is represented in the
[4] maps might not represent the long-term seismicity.

[5] Q: So in your opinion then, it would be
[6] inappropriate to use the USGS hazard maps for an
[7] annual probability of exceedence of 10 to the minus
[8] 4?

[9] A: It would be no more inappropriate to use
[10] them than it would be to use any other, Lawrence
[11] Livermore, EPRI, whatever. They are all based on
[12] the last 100 or so years available. You are
[13] extrapolating from that database.

[14] Every attempt to input factors that would
[15] extend that back in time so that perhaps it was a
[16] little longer — for example, the Miers fault,
[17] which is entirely seismic today, was factored in as
[18] a potential hazard, potential risk factor. That
[19] wouldn't be in the new — in the USGS analysis.
[20] Whether it is appropriate or not, it is hard to
[21] say.

[22] We can't fault it — you have to say what

[1] else is there, and I would say, well, you can use
[2] the USGS, it is going to give you a good answer.
[3] You could use Lawrence Livermore. You could use
[4] EPRI. But then you would have to go back and look
[5] at what were the basic assumptions for the
[6] computations in those methods, do they apply to a
[7] particular site of interest, and if you have a site
[8] that has some potential anomalous feature one way
[9] or the other, you should appropriately factor that
[10] in.

[11] When you look at Kafka's result, where 30
[12] percent or so of the new larger earthquakes occur
[13] in areas where there have not been previous
[14] earthquakes, you have to say, does the USGS
[15] statistical technique which relies solely on
[16] placing earthquakes where they have been, is that
[17] appropriate, or should the USGS have taken a
[18] seismicity rate in which in the future 30 percent
[19] would occur anyplace.

[20] Q: Would you use the USGS 2002 hazard maps
[21] as a basis for constructing a facility where you
[22] were concerned about annual probabilities of

[1] exceedence of 10 to the minus 4?

[2] A: That would be my first stop.

[3] Q: That is where you would go?

[4] A: That is where I would stop.

[5] Q: What happens for — same question, but
[6] for an annual probability of exceedence of 10 to
[7] the minus 5.

[8] A: I think that you have to accept these
[9] maps at face value. They represent a database
[10] which is 200 years, maybe 100 years in some places,
[11] that is what the database is. If you are in Turkey
[12] or China, you can go back a couple thousand years,
[13] but in the Southeast U.S., you have 100 or 200
[14] years of good continuous data. That is what your
[15] database is.

[16] You are attempting to extrapolate that to
[17] very large time periods. That to me has a problem.
[18] I don't know an alternative except that Kafka has
[19] offered a solution, a statistical solution which
[20] could be factored into the U.S. computation, and I
[21] think that might even reduce the effect of
[22] Charleston.

[1] Q: Would it be fair to say that USGS creates
[2] general site condition numbers?

[3] A: I really only look at them with respect
[4] to hard rock. They do have general condition
[5] numbers, but I look solely at what I would expect
[6] to see.

[7] Q: You mentioned hard rock, but would you
[8] agree that USGS maps are for soft rock conditions?

[9] A: They do have soft rock condition maps.

[10] Q: Does the 2002 USGS hazard maps have hard
[11] rock maps?

[12] A: My understanding is they have a typical
[13] or a hard rock base rock response. I would have to
[14] check. The thing to do would be to go on the Web
[15] and see what it says.

[16] Q: In the second supplement, interrogatory
[17] 2.2, page 4. The interrogatory question is does
[18] GANE agree that a design earthquake with a return
[19] interval of 10,000 years where the freer see S of
[20] practical structure interest is acceptable to the
[21] MOX Facility?

[22] The response is yes, and the response

[1] continues, the June 2002 USGS hazard map gives an
[2] acceleration greater than 0.2G with a 2 percent
[3] probability of exceedence in 50 years at the
[4] Savannah River Site. This is equivalent to a
[5] return period of 2500 years. This suggests that
[6] the 10,000-year return period should require a
[7] acceleration greater than 0.2Gs.

[8] Is that your response?

[9] A: I believe it is.

[10] Q: How did you calculate that it was a
[11] 2500-year return period?

[12] A: Two percent — a 2 percent probability of
[13] exceedence in 50 years. You write the
[14] approximation that is the product —

[15] Q: I am sorry. I am not asking you how you
[16] calculated 2 percent of 50 to get to 2500 years.
[17] How did you identify on the USGS map that 0.2 G at
[18] the Savannah River Site has a 2 percent probability
[19] of exceedence in 50 years?

[20] A: It is on the map. You can read it off
[21] the map. The contour lines are labeled.

[22] Q: Where did you get the map?

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[1] A: Off the Web.

[2] Q: Do you recall when you did that?

[3] A: I have done that a number of times.

[4] Q: Do you know what the assumptions are
[5] regarding the volume of soil above bedrock in the
[6] USGS hazard maps?

[7] A: No.

[8] Q: Go back to the revised contention, bottom
[9] of page 4. "In addition, the approach to the PSHA
[10] has been insufficiently conservative. In Table
[11] 1.3.6-7, the applicant estimates the return period
[12] for SAG equals 0.375 G at 5 Hz is 2700 years." And
[13] then you cite the WSRC reports that these are
[14] derived from.

[15] "In contrast, the national seismic hazard
[16] mapping project," and you provide a Web site
[17] address, "estimates a return period of 1200 years
[18] for the same event at the SRS." I know you didn't
[19] write this, but looking at it now, is there any
[20] part of this that we don't need to discuss and that
[21] we can withdraw?

[22] A: I would like to think about that.

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[1] Basically, the value that one pulls off the map
[2] from the URL is larger than the hazard value that
[3] was used from Savannah River plant.

[4] MR. POLONSKY: Off the record.

[5] (Discussion off the record.)

[6] MS. CURRAN: We are stipulating that GANE
[7] will withdraw a sentence at the bottom of page 4 of
[8] the revised contention which states in Table
[9] 1.3.6-7 at page 1.3.6-39, the applicant estimates
[10] the return period for SAG (equals 0.375 G at 5 Hz)
[11] is 2700 years.

[12] MR. POLONSKY: Off the record.

[13] (Discussion off the record.)

[14] MS. CURRAN: We have another stipulation
[15] that GANE is going to withdraw two sentences at the
[16] bottom of page 4 of the revised contention. These
[17] estimates are derived from Westinghouse Savannah
[18] River company reports, WSRC-TR-97-0085, and
[19] WSRC-TR-98-00263. In contrast, the national
[20] seismic hazard mapping project, URL — there is a
[21] Web site here — estimates a return period of 1200
[22] years for the same event at the SRS.

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[1] MR. POLONSKY: And that spills onto page
[2] 5, so the only sentence remaining in the last
[3] paragraph is the first sentence of that paragraph.

[4] MS. CURRAN: Right.

[5] MR. POLONSKY: Off the record.

[6] (Discussion off the record.)

[7] BY MR. POLONSKY:

[8] Q: Dr. Long, you stated that one of your
[9] concerns is that DCS relied on attenuation data
[10] inherent in the Livermore studies and we didn't
[11] take into account one of the more recent studies,
[12] one of which you cited to be the Atkinson and Boore
[13] study?

[14] A: The Livermore and EPRI studies didn't
[15] take that into account, right.

[16] Q: One of the statements you made in
[17] relation to the Atkinson-Boore paper was that it
[18] would increase something by a factor of two to
[19] four. Now, could you elaborate on what that factor
[20] is and what it increases?

[21] A: One of the last figures of the
[22] Atkinson-Boore papers is a comparison of their

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[1] computed average attenuation relationship —

[2] Q: Before you go on, do we have a copy we
[3] can mark.

[4] (Long Exhibit No. 5 was
[5] marked for identification.)

[6] BY MR. POLONSKY:

[7] Q: This is dated February 1995, which we
[8] have marked as Long 5, Ground-Motion Relations for
[9] Eastern North America," and starts on page 17 and
[10] goes to page 30. I interrupted you rudely, but you
[11] were pointing to a page or a table?

[12] A: I was referring to Figure 8. Figure 8
[13] shows the differences between individual
[14] observations and their predictions as a function of
[15] distance, and according to them the only apparent
[16] trend is a region of positive residuals at about
[17] 100 kilometers.

[18] If I look at the 10 Hz version of that,
[19] you see a cluster of points that are, in terms of
[20] logged values, .3 to .6 or .8 above the mean. That
[21] means a factor of 2 to 4 or even more.

[22] Q: And what you just identified was the 10

[1] portion of Figure 8?

[2] A: Yes, the 1 Hz portion also shows more
[3] anomalous values at that range.

[4] Q: And that is a 2-to-4 —

[5] A: A factor of 2-to-4 higher. It is a log
[6] scale, 3 is a factor of 2.

[7] Q: It is a 2-to-4 factor of what, higher
[8] than what?

[9] A: Amplitude. It is comparison of the
[10] amplitudes, of the predicted values of amplitudes
[11] versus observed values of amplitudes. These are
[12] the values that would be used in a PSHA in order to
[13] compute the hazard.

[14] Q: On page 1 of the Atkinson and Boore
[15] paper, earlier you said that the Saguenay
[16] earthquake was between a magnitude of six and
[17] seven. Doesn't this say it is magnitude 5.8?

[18] A: Yes, it does, 5.8.

[19] Q: Do you think that is a correct magnitude
[20] for Saguenay?

[21] A: I would not doubt it. There is a Nahaney
[22] earthquake at 6.8.

[1] Q: On the second page, page 18, left-hand
[2] column, there is a sentence that says, "Wave-
[3] propagation studies suggest that ground-motion
[4] relations should show little regional variation
[5] over most of ENA," and ENA is Eastern North
[6] America; is that correct?

[7] A: Yes.

[8] Q: "With the exception of the Gulf Coast
[9] region," and there is an EPRI cite. "Therefore
[10] ground-motion relations derived from data in
[11] southeastern Canada and the northeastern United
[12] States should be applicable over most of NA."

[13] A: That is their argument.

[14] Q: Do you disagree with the argument?

[15] A: They say most of ENA, and I would agree
[16] most of ENA is correct. Now whether that applies
[17] to coastal plain of Charleston, which is more like
[18] Gulf Coast than eastern North America, that is
[19] something we would have to investigate.

[20] Q: How is the Carolina Coastal Plain similar
[21] to the Gulf Coast region?

[22] A: The extensional range. There are

[1] differences in many ways. The Gulf Coast has

[2] thicker sediment and deposition.

[3] Q: Does Atkinson-Boore say with regions that
[4] are similar to the Gulf Coast region or do they say
[5] with the exception of the Gulf Coast region?

[6] A: They say with the exception of the Gulf
[7] Coast region.

[8] Q: Page 22, right-hand column, the paragraph
[9] begins, "We conclude that the simple quadratic
[10] equations will work just fine in seismic hazard
[11] analyses in the cases where it matters most."

[12] What is your opinion on that?

[13] A: I think it is a generalization.

[14] Q: Why don't we go to the Atkinson and
[15] Sonley paper.

[16] (Long Exhibit No. 6 was
[17] marked for identification.)

[18] BY MR. POLONSKY:

[19] Q: We have marked the Atkinson and Sonley
[20] paper entitled "Ground Motions from the 2002 Au-
[21] Sable Forks, New York M 5.0 Earthquake" as Long
[22] Exhibit No. 6.

[1] Also, during the break, we deleted
[2] language in the revised contention which is Long
[3] Exhibit No. 1 to reflect those sentences that GANE
[4] stipulated are no longer part of the contention
[5] statement.

[6] Dr. Long, at the bottom of the second
[7] column on the first page of Long No. 6, there is a
[8] sentence which says, "We compare actual ground-
[9] motion levels to those predicted by the relations
[10] of Atkinson and Boore (1995), Toro et al. (1997),
[11] Campbell (2002), and Somerville et al. (2002)."

[12] I asked you yesterday whether you were
[13] familiar with these people and you said no. On
[14] Figure 6, which is on page 346 of long Exhibit 6,
[15] are graphical illustrations of those comparisons.
[16] Have you reviewed this figure before?

[17] A: Yes.

[18] Q: Figure 6 shows four separate graphs, one
[19] for 1 Hz, one for 0.5 Hz, one for 5 Hz, one for 10
[20] Hz, and in all of those graphs, can you describe
[21] for me the shape of the Toro et al. 1997 curve?

[22] A: Toro '97 is a dotted curve.

[1] Q: Does it look like it has a break or a
[2] relaxation in attenuation which is present in
[3] Atkinson and Boore?

[4] A: It is generally exponential. It does
[5] have a slight indentation at the lower magnitudes.

[6] Q: And the curve for Somerville 2002, can
[7] you describe what that curve — the shape of that
[8] curve?

[9] A: That looks like a purely exponential
[10] form. It is hard to see at the higher magnitudes.

[11] Q: Would you agree that both the Toro et al.
[12] and Somerville, et al., curves go through the
[13] center of the data?

[14] A: That is a function of frequency. The
[15] Somerville is underneath the data for the lower
[16] frequencies. The Toro is about high at the low
[17] frequencies and through the data — excuse me, the
[18] low frequencies, and within the data at greater
[19] distances for the high frequencies.

[20] Q: Do you believe that Somerville captures
[21] the data?

[22] A: We have exhibited here four curves and we

[1] at 100 to a thousand kilometers, greater distances,
[2] so there is a certain amount of ambiguity in the
[3] close-in range. Whether or not these curves fit
[4] the data in that range could be questionable. Your
[5] question was whether it was appropriate. I think
[6] one has to look at the situation.

[7] Q: In the third GANE supplemental
[8] interrogatory response, 3.6, which is on page 3,
[9] toward the bottom of the response, it says the
[10] dominate component of the earthquake hazard at the
[11] MOX Facility comes from a repeat of the Charleston
[12] event at approximately the same distance of 80 to
[13] 150 kilometers. Therefore, attenuation curves
[14] should be corrected to reflect increased amplitude
[15] at the MOX facility site. This would
[16] correspondingly increase the hazard and reduce the
[17] return period."

[18] Focusing just on the historical check of
[19] the 1886 earthquake, and I want to avoid the
[20] discussion of probalistic or PSHA for now, you
[21] stated yesterday that the Hermann crustal model,
[22] which I think is 1986, is inappropriate because it

[1] have data obtained on both rock and soil. The
[2] curves are fairly consistent at 5 Hz. The curve
[3] that exhibits the greatest amount of perturbation at
[4] 100 kilometer range is Atkinson-Boore. The others
[5] are much more closely related to attenuation. The
[6] data again showed there is a wide spread of values
[7] at 100, 150-kilometer region.

[8] Do the single curves capture the data? I
[9] think that would be best answered by doing a
[10] statistical fit of some type and finding a
[11] statistical parameter that shows how well the lines
[12] go through the data, the scattering of data and the
[13] fact that there are two kinds of data, hard rock
[14] and soil, might make that a little bit difficult.

[15] Q: Would it be your opinion that it would be
[16] improper to use Somerville, et al., or Toro, et
[17] al., ground attenuation models for the design of a
[18] facility?

[19] A: It is my opinion that when you do the
[20] actual attenuation values — unfortunately these
[21] curves don't have a lot of data in the 10, 20 or
[22] 100 to 80 kilometer range. They are looking mostly

[1] does not take into account the Moho bounce
[2] phenomenon; is that a fair characterization?

[3] A: Hermann's crustal model is inappropriate
[4] because of the way it was derived. It doesn't
[5] apply to the path of Charleston to the site. I can
[6] explain how I derived the model and why it is
[7] inappropriate.

[8] Q: You mentioned yesterday that it was a
[9] path from Bowman to Atlanta?

[10] A: That is correct.

[11] Q: Is the path appreciably different from
[12] Bowman to Atlanta than Charleston to SRS?

[13] A: Yes.

[14] Q: How is it appreciably different?

[15] A: The crustal thickness near ATL, the
[16] seismic station that was used, is close to 40
[17] kilometers deep. The crustal thickness in the
[18] coastal plain is closer to 30 kilometers deep. In
[19] creating a dispersion curve, which is a combination
[20] of the two crustal models, Hermann obtained a
[21] dispersion relation which is valid for the entire
[22] path, which means he averaged the dispersion over

[1] the entire length. So for the upper part of the
[2] crust, he was getting crustal velocity. For the
[3] lower part, he was averaging not only the crustal
[4] velocity under ADL but the mantle velocity under
[5] the coastal plain. He came up with a two-layer
[6] plain, two-something and 6.6, and that is a result
[7] of averaging two different thicknesses, not
[8] averaging — not observing velocity of that factor.

[9] Q: What effect, in your opinion, would that
[10] have on the ground motions at SRS for the
[11] historical check?

[12] A: The theoretical seismogram was generated
[13] using a two-layer model using lower velocity
[14] crustal layer, but there was a higher velocity
[15] intermediate layer given for the crust. In the
[16] theoretical modelling for that, that layer would
[17] have reflected energy and increased the amplitudes
[18] of shorter distances and starved or decreased the
[19] amplitudes or energy going to the greater distances
[20] or the Moho bounce.

[21] Q: What effect in your opinion would that
[22] have had on the ground motions at SRS for the

[1] historical check?

[2] A: The predicted ground motion for the
[3] historical check would be less than it would be
[4] normally for a more correct crustal velocity.

[5] Q: Do you know how much lower?

[6] A: No.

[7] Q: Could you gather a guess in percentage,
[8] 10 percent, 2 percent, 5 percent?

[9] A: In the range of 10 to 50 percent.

[10] Q: Ten to 50?

[11] A: Yes.

[12] Q: How would you go about determining
[13] exactly what that percent error was?

[14] A: Well, the first one I would do is a
[15] straight — take that intermediate layer off. The
[16] next one I would do is put an appropriate radiant
[17] in. And third, I would introduce structures that
[18] are appropriate for that path. I would introduce
[19] the coastal plain sediments in a wedge. I would
[20] introduce velocity anomalies that are consistent
[21] with the Triassic basins and I would put in a
[22] gradient in the lower part of the crust that would

[1] be consistent with a transition from the crust to
[2] the mobile.

[3] Q: Are you aware that the Hermann crustal
[4] model as published in 1986 was modified for the
[5] Savannah River Site?

[6] A: It was modified by shallowing it. The
[7] two-layer version of it was maintained, and that
[8] was perhaps the most incorrect part.

[9] Q: What do you mean by it was modified by
[10] shallowing it?

[11] A: The depth of the Moho was made to equate
[12] to 29 to 30 kilometers.

[13] Q: Do you know what else was done to modify
[14] the Hermann crustal model for SRS?

[15] A: In detail — we would have to go back and
[16] look at it and make a detailed comparison.

[17] Conceptually, the difference is Hermann's model had
[18] the two-layer crust, a two-layer crust was — that
[19] two-layer crust with a thickness of close to 40
[20] kilometers was modified for a 30-kilometer crust
[21] for that path from Charleston to the Savannah River
[22] plant.

[1] Q: That shallowing from about 40 to about 30
[2] kilometers, you had said — let me scratch that.

[3] A: Hermann's model is a fabrication to begin
[4] with.

[5] Q: You had stated that 10 to 50 percent
[6] increase in amplitude existed —

[7] A: I guessed 10 to 50 percent.

[8] Q: Ten to 50 percent increase in amplitude
[9] would exist for using the Hermann 1986 model with
[10] the revision of bringing it from 40 kilometers to a
[11] shallower depth of 30 kilometers. What would the
[12] error be there or increase in amplitude?

[13] A: My assumption is that I was dealing with
[14] a model that had been thinned to 30 kilometers.

[15] Q: I asked you a question about the Hermann
[16] model that existed in 1986.

[17] A: I misunderstood that. The difference
[18] there would be that the effect would essentially be
[19] the same as that for the shallower except it would
[20] be scaled in distance and proportion to the
[21] differences in the depths.

[22] Q: Why don't we walk through part of the Lee

[1] et al. 1997 document which is WSRC-PR-970085. You
[2] should be familiar with these pages. They were
[3] sent specifically to you.

[4] MS. CURRAN: Has this been marked as an
[5] exhibit?

[6] MR. POLONSKY: Doesn't need to be. It is
[7] in the hearing file.

[8] BY MR. POLONSKY:

[9] Q: On the bottom of page 24, it states that
[10] the band-limited white-noise random vibration
[11] theory ground-motion model are used to estimate
[12] ground motion. Do you think that was appropriate?

[13] A: No. I have not reviewed that technique.

[14] Q: Do you think it is appropriate to use a
[15] band limited white noise random vibration theory
[16] ground-motion model?

[17] A: Band-limited means you restrict the
[18] frequency. White noise means the spectrum is a
[19] constant value or close to it and random vibration
[20] theory says that you put random noise into the
[21] system. Engineers have dealt with various
[22] perturbations of these concepts for years to try to

[1] of an approximation, Hermann 1990, to account for
[2] direct, reflected and some multiplied reflected
[3] seismic arrivals including the post-critical
[4] reflection.

[5] Are you familiar with Owens/Hermann or
[6] the Owens/Hermann approximation?

[7] A: Probably not.

[8] Q: Have you ever heard of Owens/Hermann?

[9] A: I know of Hermann. I do not know Owens.
[10] I have heard of him.

[11] Q: If you don't know what the approximation
[12] is or what it did to the calculations, do you have
[13] any way of assessing whether this corrected for any
[14] of the features that you were concerned about?

[15] A: I would find it hard to believe that it
[16] would correct for the errors that are in the
[17] Hermann model. When one makes — when one
[18] publishes an article like Owens/Hermann where you
[19] have beta approximations, the goal is usually to
[20] obtain results that are representative of what
[21] theoretically the results should be if a complete
[22] or exact analysis were made.

[1] simulate or compensate for the lack of real
[2] earthquake time series. They do a fairly good job.
[3] I would assume this has done a reasonable job.

[4] Q: Further down in the same paragraph it
[5] says, "Recent comparisons of the RBT predictions
[6] with measured data show that the methodology yields
[7] conservative results for eastern U.S. site
[8] conditions."

[9] Do you disagree with that?

[10] A: I don't like the use of the term
[11] conservative. That implies it makes erroneous
[12] results.

[13] Q: I understand, but you understand in
[14] regulatory space, and this was generated by
[15] Savannah River Site, they have to build in some
[16] conservatism. Do you any reason to disagree with
[17] this —

[18] A: I have no reason to agree or disagree. I
[19] don't know if it is giving errors that are positive
[20] or negative.

[21] Q: On the next page, page 25, the RVT
[22] calculations performed for this evaluation make use

[1] Q: Let's go to page 39 where there is more
[2] discussion about Owens/Hermann. There is a
[3] two-paragraph section entitled "Source distance and
[4] parameters." And I think this discusses the issue
[5] you are concerned about, of Moho bounce. Ground-
[6] motion prediction for the Charleston site is
[7] somewhat sensitive to the distance used by the SRS
[8] because of the effects of Mantel bounce. Do you
[9] think that Mantel bounce is the same as Moho
[10] bounce?

[11] A: Yes.

[12] Q: For geometrical attenuation, the 1990
[13] approximation is used to account for the Mantel
[14] post-critical reflection. Mantel post-critical
[15] reflection is the same as saying Mantel bounce?

[16] A: Yes.

[17] Q: The crustal model used in this design
[18] basis selection is the modified Hermann 1986 model
[19] discussed in section 3-B. The effect of the
[20] Owens/Hermann approximation is to decrease the
[21] attenuating loss between distances of 80 to 120
[22] kilometers. Using a point source for the

[1] Charleston event the RVT ground motions are
[2] sensitive to source, depth and distance.
[3] Would you agree then that the path that
[4] was — or the model that was used was modified to
[5] take into account the Moho bounce?

[6] A: The Owens/Hermann model apparently does
[7] take into account, according to this, the Moho
[8] bounce. It was applied to a Hermann model and that
[9] contains an intermediate layer, and physically an
[10] intermediate layer is going to reflect the waves
[11] and starve the energy that is available for the
[12] Moho bounce. Unless you are fudging and making
[13] mistakes, you are not going to get rid of the
[14] physical problem of the Hermann model not giving
[15] you a proper attenuation and distance relation.

[16] Q: But since you haven't done any studies,
[17] you don't know if the Owens/Hermann approximation
[18] as applied to the modified Hermann crustal model
[19] makes any significant difference than a path that
[20] you would choose specifically from Charleston to
[21] SRS?

[22] A: I have done a number of studies starting

[1] with my Ph.D. thesis on the attenuation of
[2] propagation of waves in the crust. Those studies
[3] included determination of amplitude as a function
[4] of distance using a number of techniques, and I
[5] know that certain models are physical models, in
[6] particular the layering model as presented by
[7] Hermann is going to give a different distance
[8] response than a layer model that does not contain
[9] an intermediate layer.

[10] If these people are using correct
[11] formulations of elastic theory and making
[12] appropriate approximations, they are going to
[13] respond to the model in the same way any other
[14] propagation theory will.

[15] Q: But the distance response might be off by
[16] one or two percent with all of the changes they
[17] made — you wouldn't know because you haven't done
[18] any calculations; is that right?

[19] A: I haven't done the calculations for this
[20] particular model.

[21] Q: Let me go down further. Figure 10.1
[22] shows the SRS site relative to the — 1886

[1] Charleston MMIX is a seismic contour. The closest
[2] distance to the site is approximately 120
[3] kilometers. The 120 kilometers is what was used as
[4] the distance from SRS for the historical check for
[5] the 1886 earthquake. Do you agree that there would
[6] be a Moho bounce phenomenon between that distance
[7] and SRS?

[8] A: Yes, there would be.

[9] Q: Do you agree that Lee, et al., 1997,
[10] acknowledged that and modified the Hermann crustal
[11] model would take into account the Moho bounce by
[12] taking into account the Owens/Hermann model?

[13] A: No. They used an inappropriate Hermann
[14] model which starves the energy out. It doesn't
[15] matter which theory you use, if have you a
[16] reasonably correct response, even if it is off by a
[17] few percent, you will get the appropriate answer.

[18] I think the case here is one where in the
[19] crustal model they used, the Hermann model, is a
[20] fabrication and it doesn't represent what actually
[21] exists, and that particular model they chose to
[22] use, if you apply attenuation relations to it, is

[1] going to give you a lower value of the Moho bounce
[2] than a more correct one.

[3] Q: You stated you have a couple of issues
[4] with the way the historical check was done. One of
[5] those issues was you thought that they had not
[6] taken into account Moho bounce. Is it still an
[7] issue that you think SRS doesn't take into account
[8] the Moho bounce?

[9] A: They did not properly take it into
[10] account because they did not use the proper model.
[11] They may have attempted to take it into account,
[12] but if you use the wrong model, it doesn't work.

[13] MR. POLONSKY: Off the record.

[14] (Discussion off the record.)

[15] (Recess.)

[16] BY MR. POLONSKY:

[17] Q: In the Lee, et al. 1997 paper, we had
[18] looked at page 25 before, and if you could turn it
[19] to now again. You appear to have some concerns
[20] which I can't fully articulate about the various
[21] layers in the Hermann 1986 crustal model and that
[22] no matter how it was modified by SRS or at least

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[1] your understanding of how it was modified by SRS,
[2] that underlying issue about the layer wouldn't be
[3] resolved; is that —

[4] A: That is correct.

[5] Q: In the middle of the page on page 25 is
[6] this — what appears to be layer thicknesses in
[7] kilometers and there are four layers. Can you tell
[8] me what your concern is with respect to this little
[9] mini-table which is in the middle of page 25?

[10] A: He has a layer at 14.5 kilometers. That
[11] is five plus nine plus five, going from 3.76 to a
[12] 4.01. That implies to me it is a more metric or
[13] higher crustal velocity or lower crustal layer. He
[14] gives that layer a thickness of 14 kilometers.

[15] In any kind of modeling structure, when
[16] you put a substantial velocity discontinuity at
[17] that depth, it is going to reflect a significant
[18] amount of energy, and if we starve the energy going
[19] down to the Moho, that reflected energy will be
[20] causing amplitudes somewhat higher at closer ranges
[21] but not necessarily at the distances of the Moho
[22] post-critical reflection.

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[1] I guess my main objection to the model is
[2] it doesn't have information relative to the coastal
[3] plain. It is a model taken basically out of
[4] context because when Hermann designed the model, he
[5] designed it as a model that would fit dispersion
[6] data, but the dispersion data are an average along
[7] the entire path and how you get the layering and
[8] how you define the averaging determines what type
[9] of modeling you should have.

[10] MR. POLONSKY: We are done.

[11] (Whereupon, at 4:32 p.m., the taking of
[12] the deposition was concluded.)

[13] (Signature not waived.)

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CERTIFICATE OF DEPONENT

I have read the foregoing 191 pages,
which contain the correct transcript of the answers
made by me to the questions therein recorded.

LELAND TIMOTHY LONG

Subscribed and sworn to before me this

_____ day of _____, 2003.

Notary Public in and for

My commission expires: _____