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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

March 8, 2006

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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EARLY SITE PERMIT SUBCOMMITTEE MEETING

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WEDNESDAY, MARCH 8, 2006

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The meeting was held in Room T2B3, Two White Flint North, Rockville, Maryland, at 8:30 a.m., Dana A. Powers, Chairman, presiding.

PRESENT:

DANA A. POWERS	CHAIRMAN
GRAHAM WALLIS	MEMBER
OTTTO C. MAYNARD	MEMBER
WILLIAM J. SHACK	MEMBER
MARIO V. BONACA	MEMBER
JOHN D. SIEBER	MEMBER
THOMAS S. KRESS	MEMBER
WILLIAM J. HINZE	ACNW
MICHAEL R. SNODDERLY	DESIGNATED FEDERAL OFFICIAL
DAVID FISCHER	STAFF ENGINEER

C O N T E N T S

P R O C E E D I N G S

(8:33 a.m.)

CHAIRMAN POWERS: The meeting will now come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Early Site Permits.

I'm Dana Powers, Chairman of the subcommittee. Members in attendance are Mario Bonaca, Otto Maynard, Tom Kress, Bill Shack, and Jack Sieber somewhere, and Graham Wallis, who thinks he's here, but the most important is we have the benefit of Bill Hinze from the Advisory Committee on Nuclear Waste attending and participating.

Welcome, Bill. Glad to have you here to keep us straight on all of this stuff.

The purpose of this meeting is to continue our review and discuss further the staff's final safety evaluation report regarding the Exelon Generation Company's application for an early site permit at the Clinton site. The meeting is going to focus on the applicant's performance based seismic hazard analysis methodology.

You will recall that this was new to us at our earlier meeting, and that at that earlier meeting

the staff had not approved that methodology, and today we're going to hear more about the details on that.

The subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full committee.

Mike Snodderly is our designed federal official for the meeting, but I'd like to introduce the subcommittee today. Fischer, he is going to be Ned's replacement and will be handling early site permits. Dave actually has a history with the ACRS, and so we look forward to working with you closely, Dave.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on February 23rd, 2006. The transcript of the meeting is being kept and will be made available as stated in the Federal Register notice. It is requested that speakers first identify themselves, speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's subcommittee meeting.

That doesn't mean that people can't make comments if they have things to contribute to our information gathering.

As I said, we're going to focus a lot on just the seismic issue. I think we'll probably get a status update on open items and things like that, but our real intent is to hone in on this performance based seismic methodology.

The contention, as you will recall, at our previous meeting was that this offers not only stability, but perhaps safety advantages. So it's really quite of interest.

Do any members of the subcommittee have opening comments they would care to make?

(No response.)

CHAIRMAN POWERS: Seeing none, I will turn to Laura Dudes, and you're going to give us an introductory comment?

MS. DUDES: Well, good morning. I think Marilyn Kray and Exelon will provide the early morning presentation, and then the staff will be up to provide their results on the safety evaluation report.

Marilyn.

CHAIRMAN POWERS: Not what it says on my agenda. You lead me astray all the time.

(Laughter.)

CHAIRMAN POWERS: Marilyn.

MS. KRAY: Yes. Well, we appreciate your --

CHAIRMAN POWERS: Cover for Laura.

MS. KRAY: We appreciate your flexibility and I know we're here at your ready. Thank you, Mr. Chairman.

And as you know, it was September of this past year that we were here in, I think, similar seats, and while it seems a short time ago, there has been a lot accomplished, and as you can imagine, this meeting is a significant milestone for Exelon, but it's also a significant milestone for the industry.

You are probably aware that the regulatory information conference is ongoing across the street, and while there are certainly some devoted sessions to new plants, the underlying theme throughout all of the sessions and probably more importantly on all of the discussions in the hallways during the network breaks is certainly new plants. And you're going to hear this morning, as you're expecting, detailed discussions on the seismic issues.

And while these are certainly critical to the Clinton early site permit project, they are

similarly critical to future ESP as well as COL applicants. So we are grateful to the efforts of both the staff and the industry through the NEI Seismic Issues Task Force to use this pilot application to set perhaps the precedence for some future licensing actions.

So, again, we thank the efforts of both the staff and the industry, and with that, I will turn it over to Eddie Grant.

MR. GRANT: Thank you, Maryland.

If I can get rid of this thing and learn how to use this machine, thank you for bearing with me.

My name is Eddie Grant. I'm the lead on the licensing for the safety side of the early site permit. I'd like to take you through the agenda real quickly this morning. What we have in mind, of course, is some quick introductions, just reminders of who we are, what we've been doing.

We'll look at significant changes since the draft safety evaluation report. We'll have a few minutes on the geotechnical approach because that was part of that supplemental draft safety evaluation report.

Certainly look at the seismic evaluation,

and that's where we'll get into the performance based and where we'll spend most of our time.

Then we have a few slides to quickly go through the supplemental draft SER issues' closure, and then summarize, and we'll move forward.

As I indicated quickly as introductions, you've already hear from Marilyn Kray, who is the project executive sponsor. Tom Mundy is also here with us. He has been the project manager, but he's moving on to the COL applications and going to be managing that project. So Kris Kerr is here with us in the audience. He is now the senior project manager on the early site permit, and like I said, I'm the safety and emergency planning lead, and Bill Maher was the environmental lead. He's back in the audience as well if anything comes up for him.

We had quite a support team. CH2M Hill was the prime contractor. They conducted the environmental reviews, did the site redress, did the geotechnical and drafted the emergency plan for us.

CH2M Hill then had a number of subcontractors. WorleyParsons did the safety evaluations. GeoMatrix, Mr. Bob Youngs and Kathryn Hanson over here in the audience with us did the seismic evaluations, the PSHA, and looked at the

paleoliquefaction. That's always an interesting topic.

And then we had a seismic Board of Review that helped us out with our reviews. As we went through we talked with them a little bit about what we were doing and had a few chats with them about where we should go that led to the change to going to the performance based methodology. As I indicated, they did an expert independent review of all of the information on the seismic side.

Carl Stepp was the Chairman of that Seismic Board of Review, and you'll hear from him as we get to the seismic piece. He'll be doing that presentation.

There were some others that did various pieces of the geotechnical borings and those types of things.

RPK Structural Mechanics Consulting, that's Mr. Kennedy, Bob Kennedy down on the far end. He is, I believe, the leading expert in the performance based methodology, and he'll be sharing some of that information with us today.

Sergeant Lundy did a quick draft application review when we thought we were pretty close to going, and of course, Morgan Lewis was our

legal counsel.

Just a quick reminder of where we're talking about, as you indicated, the Clinton Station, it's out in central Illinois. There is an existing plant, and it's AmerGen owned. Exelon Generation Company is the applicant, and it's a wholly owned subsidiary of Exelon Corporation.

Significant changes since the DSER. You may recall, I know this is focused on the seismic, but we've got a draft SER for everything but the seismic piece back in February of last year, and it had a number of open items and confirmatory items, and then, of course, the supplemental DSER addressing the geotechnical and seismic came out in August.

Then we met with you shortly after that in September, and we really had not had a chance at that point to look at or evaluate completely the supplemental draft SER open items.

Certainly since that time we have looked at those. We have responded to all of those, and the staff has just issued the FSER, which accepts those responses such that all of the open items are closed. So that's a significant change.

The staff had a few confirmatory items that they were looking at, and all of those have been

accomplished. So those are all complete.

DR. HINZE: Dr. Powers, could I interrupt here a moment and ask a question? I don't know who I should be asking this of, but obviously the technical work on this is a moving target that continues to expand and grow.

Is there a cutoff time specified ESP application in terms of the technical literature and the work that's being done? Is there a cutoff time that we can assume has been used by Exelon?

CHAIRMAN POWERS: Well, what Exelon uses, I'll leave them to answer, and I think it's a rule of reason applies here. I don't think you can expect them to have pulled down the latest copy of Geological Society of America or something like that, but they are required by regulation to look at the literature since in the interval of about 1984 and now, and what you're asking is what is now, I think it's the rule of reason here.

DR. HINZE: Well, one of the reasons I ask that is that the literature search seems to stop at 2004, and there are some interest articles that occur in 2005, and I am just curious as to whether those should be incorporated in or not.

CHAIRMAN POWERS: Well, I mean, again,

2004 seemed like a reasonable number for me in the application just because somebody has to sit down and write this thing. But if there are insights in the 2005 literature that would make qualitative changes to our perceptions, I mean, we can certainly bring those to our attention.

DR. HINZE: Good.

CHAIRMAN POWERS: All right.

MR. GRANT: All right. Again, one of the major changes or more significant changes is that, indeed, the staff has accepted the proposed SSE ground motion spectra for the Clinton Power Station early site permit. There were minor revisions to that ground motion spectra from what you saw in our earlier application as a result of the open items, and we'll address some of those when we're looking at the open items.

Again, the more significant changes since the draft SER is that the staff has documented their criteria for establishing what permit conditions are or should be, which items should be permit conditions and which items should be combined license action items.

You might remember we had quite a number of proposed permit conditions in the original draft

SER, and that has dropped significantly based on the new criteria, although the combined license action items have gone up, which is probably expected. There will be a lot of things that can't be addressed on an early site permit, and therefore, it's not unexpected that those would be expected to be addressed at the combined license stage.

And you'll see that response and closure of a couple of our open items depend on that.

What I'd like to turn to now is the geotechnical approach. I'd like to indicate primarily here what we did in relation to building on the existing Clinton Power Station information. Because this is an existing site, there is a lot of information that was readily available in the seismic and geotechnical areas, and we certainly didn't want to just throw that out.

And more importantly, we wanted to be as consistent as we could with the sister station. So we looked at the available information as far as regional geology, site geology, what exploration had been done back in the '70s, and the lab testing that had been done on the soils and properties in the area.

And then we did some work specifically for the early site permit to confirm those conditions,

that indeed, we got the same answers or close to the same answers that the folks had gotten back in the '70s, and we updated the information particularly in the areas of the geology and doing the literature search and what was available as far as any identified new seismic sources and/or seismic methodologies that were available to evaluate those sources.

This is just a quick plot here that shows the original Clinton Power Station site investigation locations. You can see that there are quite a number of areas where we did borings or other types of investigations across the site.

And what I'd like to do then is show you a slide that doesn't seen to want to --

CHAIRMAN POWERS: Didn't want to come up, huh?

MR. GRANT: -- come up. It was there this morning. Is it in your printed copies?

Okay. I apologize for this, but you can see not up here, but on your printed copies that, indeed, we overlaid the top dashed area there is where the existing Clinton Power Station is, and the bottom area is where we're proposing to place the early site permit structures.

You can see that, indeed, a large number

of the areas that were investigated during the '70s do overlay and encompass the new area, and then, of course, we did some specific investigations in the new area, and again, I just wanted to try to show you -- unfortunately I'm not succeeding real well -- on how those matched up.

CHAIRMAN POWERS: But we have been over this one before.

MR. GRANT: There it is. I've got two nines for some reason. Yes, there is the slide. The blue dots and plus signs or crosses are existing information from back in the '70s, again, from the early Clinton Power Station investigations.

The green and orange and red circles, squares and diagonals down in the red dashed area are the new investigations used to confirm that, indeed, the site is exactly in this area as we had thought it was based on the older information.

What we found, again, is that the site is relatively uniform across all that property. The soils are fairly stiff, but it is a soil site.

The field data shows that the sheer save velocities are, again, consistent with what we saw from the Clinton Power Station investigations, and the lab data showed a good match with the assumed EPRI

soil modulus and damping curves.

The red line there shows the information available from what we've done recently, and then a good number of the information, the darker line, I guess, that is dashed shows how it had been identified back at the Clinton Power Station. So, again, a close approximation.

And at this point we're going to move away from that and get over into the more important topic for the day, which is the seismic evaluations and how those were done. And I'm going to ask Dr. Carl Stepp to lead this discussion.

DR. STEPP: Thank you, Eddie.

The seismic valuation, particularly we're now focusing on the SSE ground motion determination, followed largely the guidance and methodologies that are laid out in Regulatory Guide 1.165. This viewgraph shows the areas where we followed the guide rather closely or completely, and the one area in which we departed from the guidance in 1.165.

We started as the regulatory guide allows with the EPRI work of the mid-1980s to late 1980s, and we updated that work with current knowledge base through the time of submittal of the licensing application two years ago.

Seismic sources were updated, using that information. Sensitivity studies were done. We did a SSHAC Level 2 evaluation to update the uncertainties in the input parameters for seismic hazard calculations and computed a new PSHA for the site with the updated information.

We departed from the regulatory guidance in actually computing the SSE ground motion spectra. Instead of using the reference hazard probability that is specified in the Reg. Guide 1.165, we used the performance based risk informed, I will call it, methodology that you will hear much more about today.

Next.

In deriving the ground motion from the probabilistic hazard, we followed, again, the regulatory guidance in de-aggregating the hazard across the spectra of interest, spectral frequencies of interest, and determining controlling earthquakes for low and high frequency part of the spectrum, then fitting the ground motion to those derived spectra.

We accounted for side effects and did site response analyses following the guidance that is provided in NUREG CR-6728.

Just a few examples of updating the information. This shows the seismicity prior to the

application. We used the EPRI work from a catalogue from 1777 through 1985, and that was updated using USGS regional network locations from the USGS catalogue and the council on national seismic systems to 2002, and you can see from these side-by-side comparisons that the pattern of seismicity had changed, and indeed, the rate of seismicity is generally unchanged except for the new add rate zone.

We also had new information on liquefaction that had appeared in the literature, and the next line followed up on that information by doing actual site investigations. The map you see here shows areas with new liquefaction information around the site.

The liquefication information has revealed that they are repeated large earthquakes in the New Medrid site and so on during the past 2,000 years that had to be taken in account in assessing the hazard from that zone.

It revealed that there are larger earthquakes in the historic/prehistoric past in the Wabash Valley zone.

CHAIRMAN WALLIS: I'd like to ask you about that.

DR. STEPP: Yes.

CHAIRMAN WALLIS: In the SER in your submittal there's a tremendous discussion, qualitative discussion, of all this stuff, but what matters eventually is the numbers you're going to use, and so I look for the numbers you used for this Wabash Valley, which is interesting because it happened 12,000 years ago and then 6,000 years ago. So it's going to -- no. Well, obviously that's not the case.

But if we look at the SER on page 21878, it says, "The applicant cited research that this Wabash Valley event 6,000 years ago was in the range 7 to 7.5 in magnitude."

And then on another page, 204, it says, "The applicant stated that the event 6,000 years ago was in the range of 7.2 to 7.8," which is a different set of numbers, and you know, this is logarithmic. So it's very important whether it's 7.5 or 8, presumably.

And then it says, "The EPRI SOG (phonetic) uses the range of 5 to 8," and then there's a qualitative statement on that, page 206, which says, "The applicant made adjustment to increase the maximum magnitude distribution for the Wabash Valley seismic zone."

It doesn't say to what, by how much, and why. It simply says that you increase the magnitude.

But I don't see any numbers associated with that increase. So I don't know what magnitude you used and why.

And then when I get -- I'm going to go on and give this speech and then you can answer, and it's probably all very easy to clarify -- on page 208 I find that the ten to the minus four high frequency hazard is actually dominated by this Wabash Valley zone, and then it becomes a 6.5 event.

Now, how do all of these numbers relate? And when you did increase the maximum magnitude, by who much did you and so on?

I mean, it's not clear to me what numbers were used and why.

DR. STEPP: Okay. We'll answer, I think, in two parts. First, to address how we increase the maximum magnitude and why and by how much, and then I think the second part is the deaggregation that you referred to, and that will be answered by, I think, Bob Youngs. Will you take the lead on this?

MR. YOUNGS: My name is Robert Youngs with GeoMatrix Consultants.

The maximum magnitudes that were used in the original EPRI study that was completed in 1985 arranged for the Wabash Valley up to the size of

events that had been reported in the literature from the paleoliquefaction information in terms of the size of earthquakes.

But the weights that were assigned to the larger magnitudes were relatively low compared to what we would interpret now based on this paleoliquefaction information.

So the revision that we did to that source was to change the weighting scheme to give a lot more weight to larger magnitude earthquakes, and on page 2-204 of the SER, down near the bottom in the paragraph under Wabash Valley source zone, at the end of that paragraph they list the distribution of magnitudes that we used.

CHAIRMAN WALLIS: Yeah, I guess it's .1, .4, .4, .1. Is that the --

MR. YOUNGS: Right. Those are the weights we assigned to those magnitudes.

CHAIRMAN WALLIS: I see those, yeah. But someone decided to use all of these numbers. How did you decide and where did you do this increase in the maximum magnitude? Is this increase in the maximum magnitude reflected in this .1, .4, .4, .1 distribution?

MR. YOUNGS: Yes.

CHAIRMAN WALLIS: But that seems to be 7 to 7.8, which you've already stated was what happened 7,000 years ago, 6,000 years. I don't see them increase.

MR. YOUNGS: No, they're increased from what the EPRI expert assessed back in the '80s. So it's an update to the seismic --

CHAIRMAN WALLIS: So increase over EPRI.

MR. YOUNGS: Yes. So it's a modification of the distribution of maximum magnitude.

CHAIRMAN WALLIS: How did you decide what to do? You could have increased it to eight since the EPRI gave a range of five to eight. Why do you sort of restrict -- I don't understand how you decide what numbers to use.

MR. YOUNGS: It's an evaluation looking at how various authors have interpreted what the size of those events and giving weight to various interpretations. It's basically a judgment call as to how we feel that the information that we see in the literature would indicate what the largest magnitude should be.

CHAIRMAN WALLIS: Well, that seems to me sort of the meat of the whole thing. I mean, I've got 200 pages of description, and I have a couple of

paragraphs that say you use these numbers. The justification for those numbers is the whole meat of the application, isn't it, really? The justification is more important than anything else.

MR. YOUNGS: Yes.

CHAIRMAN WALLIS: And I didn't see that. That's what puzzled me. It isn't my field. I just sort of picked that up as being rather strange.

DR. STEPP: The justification is a clarifying comment to the process. As I mentioned in my introduction, we applied SSHAC Level 2 assessment procedure, and it was through that procedure that we arrived at these weights on the numbers.

CHAIRMAN WALLIS: I have no idea what that is.

DR. STEPP: Well, I'm going to explain it. The SSHAC methodology, this procedure is for assessing subjective uncertainties that has been developed by a combination of NRC and industry support and DOE support, and one level of that, which we applied here, is the Level 2, which is a process by which new information is compiled, and it's assessed against the existing interpretation, which was the EPRI interpretation.

CHAIRMAN WALLIS: Is this a Baysian type

thing, is it?

DR. STEPP: The basic EPRI interpretations of the mid-1980s.

CHAIRMAN WALLIS: Is this a Baysian updating type thing?

DR. STEPP: It's a subjective updating, not a Baysian updating, just subjective updating based on the current state of knowledge of the scientific community. So the process that was done here is we updated the information, canvassed the scientific community, and the weights that you see assigned there represent the assessed weights that reflect the current state of the scientific community subjective interpretation.

CHAIRMAN WALLIS: And then you make this adjustment to increase the maximum magnitude?

DR. STEPP: Yes.

CHAIRMAN WALLIS: On top of that?

DR. STEPP: Well, that is the process by which we do that.

CHAIRMAN WALLIS: That's the result of that. So you weren't yourselves making an adjustment. These numbers come from analyzing the scientific community's --

DR. STEPP: The views reflect the

scientific community's views, yes. They're subjective interpretation.

CHAIRMAN POWERS: I think it's fair to state that they're completely prescriptive, analytic expression for the SSHAC approach is yet to be derived, that it is --

DR. STEPP: Well, it's not a Baysian approach.

CHAIRMAN POWERS: It is an exercise in engineering judgment, seismic engineering judgment.

DR. STEPP: It's a process by which scientific and engineering judgment is quantified and weighted.

DR. HINZE: As one of the members of the team back in those days, I can tell you that these numbers were just not pulled out of the air, but came as a result of a lot of literature search, a lot of discussion among various disciplines, and the information on which the so-called experts were making their decision were intended to be rather soft. So there had to be a lot of judgment.

And that's why it's necessary, I think, to include this probability range that we see this site safety report coming up with.

CHAIRMAN WALLIS: So your view is that

they did the right thing here?

DR. STEPP: Well, I think they did the right thing, probably the only thing --

CHAIRMAN POWERS: Yes.

DR. STEPP: -- to be very honest with you.

CHAIRMAN WALLIS: What I was missing is the rationale for the non-expert, which explained why what they did was reasonable.

MR. YOUNGS: Well, and I think there's an assumption here in preparing this report that everyone understands how all of this comes about, and as I read the report, if I didn't have the background of being involved in the EPRI study, I would have been lost, and so I really understand where your question is coming from Dr. Wallis.

CHAIRMAN POWERS: But, I mean, this whole thing speaks back to your original point. Where do you cut this stuff off? Because I mean in this report itself we see that they go to the Tutle paper, and then they go talk to Ms. Tutle, and she's changed her mind, and so this goes on and on and one.

But I mean, it's --

DR. STEPP: Well, it's science.

CHAIRMAN POWERS: And it's also the interpretation of single point measurements. I mean,

we've just got to get nature to give us more earthquakes.

(Laughter.)

DR. STEPP: Well, for example, the operation, the methodology for converting the paleoliquefication studies into magnitudes, there are a number of different techniques there. There are four different accepted techniques, and they will lead to different answers, and so depending upon the best possible way you can do it, and you need to really combine these, and you have to put some kind of weight of probability for justification on that.

CHAIRMAN POWERS: To my mind in looking at this, I think it's comforting to see that not only did they recognize major seismic zones here, but they were willing to adjust the assigned magnitudes to try to get them up to date, and they were willing to recognize even poorly understood seismic centers here, and asking them to get numbers that are justified down to the second decimal point is simply beyond the state of the art is my perception here.

DR. STEPP: It's beyond resolution, yeah.

CHAIRMAN POWERS: In fact, I had the benefit of consulting with a geoseismologist about this, and she was quite impressed that you got any

numbers at all.

CHAIRMAN WALLIS: Yeah, what I was missing was I didn't really expect great accuracy, but when I saw two sets of numbers that's different on different pages, and then I saw this mysterious adjustment to increase the magnitude without explaining what that was and what the numbers were that came out of that and why they were bigger by a certain amount and why you chose to increase them by .2 or .1 or .5 or something, there seemed to be no explanation for these things.

So I saw a story which to me was incomplete. That's all.

DR. STEPP: Well, I think it's sort of lost in the massive verbiage here, that the paleoliquefication studies were not available to the experts except in a very superficial way in the New Madrid area, were not available to the experts in the '85 time frame.

And so the report does an excellent job, I believe, of bringing that up to date, as you've said.

MR. GRANT: One thin that the report does is actually provide references to the EPRI report that was written. I think it was an EPRI report that was

written to document the SSHAC evaluation. So all of that is not, of course, repeated in the site safety analysis report, and again, it requires some familiarity with the SSHAC evaluations when you just get a quick reference to it in the SSAR without going back to look at all of the documentation that was done on how it was done.

CHAIRMAN POWERS: You know, when I cruise around in the literature in an undirected and undoubtedly superficial way, I see people attempting to take these data and fit them to explicit distributions, and Kagan distributions come to mind here, but I don't see this discussion of such attempts to fit the distributions here either in your application or in the SER.

I mean, this is more an item of curiosity. Why not?

DR. STEPP: Well, actually that's a very good question. In the early '80s when we initiated the EPRI SOG studies and NRC was going through similar studies with Lawrence Livermore Lab, we gave a lot of attention to more quantified approaches, and it turns out we concluded at that time that it turns out that those methods are not really very amenable to the very sparse data that we have, has extremely high

uncertainty in the data itself, and the process that we develop, which has later been adopted as the SSHAC methodology, seemed to work really well. It allowed earth scientists to weight data according to their judgments about its resolving power for a certain interpretation, and this has been a much more workable approach than purely quantified Baysian techniques which are normally --

CHAIRMAN WALLIS: Well, can I just round this off? I mean, if it had been eight instead of 7.8, would it have made any difference?

DR. STEPP: I'm sorry?

CHAIRMAN WALLIS: Suppose you had chosen eight instead of 7.8 for your maximum cutoff? This was already limiting at ten to the minus four high frequency hazard. Would it have made any difference to the answer that you got?

DR. STEPP: It would have made a difference.

CHAIRMAN WALLIS: Would it have been significant?

DR. STEPP: Some small difference, yes, depending on the weight given to an eighth, but we're constrained in making those assessments by the range of the data and by the professions, the --

CHAIRMAN WALLIS: So is it sensitive to these assumptions? That's what I'm trying to get at. I mean, is your answer, your bottom line about the site 0--

DR. STEPP: Yes.

CHAIRMAN WALLIS: -- the 6.5 event that you use and so on, is it critical whether or not the number 7.8 or 8?

DR. STEPP: Not critical.

CHAIRMAN WALLIS: Does it make a difference?

DR. STEPP: It's not critical, but it would make some small difference.

CHAIRMAN WALLIS: Some small difference.

DR. STEPP: Yeah. It would increase the --

CHAIRMAN WALLIS: It would increase the Gs, increase the Gs by five percent, 50 percent?

DR. STEPP: Five percent perhaps. I don't know.

CHAIRMAN POWERS: Well, I got the impression --

DR. HINZE: It depends upon the weight you put on it.

DR. STEPP: This process is --

CHAIRMAN WALLIS: Well, suppose we jack the whole distribution up by 22.

DR. STEPP: It's really hard to answer in a percentage, but I can give you an example and we will give you an example of the impact and the percentage that we -- of the updating of the New Madrid zone. That would, I think, answer your question more directly.

CHAIRMAN POWERS: Yeah, I think that gives a feel for -- I mean, I got the sense that when you adjusted New Madrid you got like about a ten percent change.

DR. STEPP: Yeah, nine or ten percent.

CHAIRMAN WALLIS: This goes a bit to the question of when you get new information what happens. I mean, this is a very uncertain field, and if there's an event in the Wabash Valley next year, it gives you new information. Is it going to change the answer significantly? That's the kind of thing I'm looking for.

DR. STEPP: It won't be large.

CHAIRMAN WALLIS: How careful do we have to be about getting sufficiently conservative numbers and things like that?

DR. STEPP: Okay. The amount of change in

the hazard is a complex tradeoff between the recurrent rate of the earthquakes and the sizes, and in New Madrid, that source zone, the great impact was the increased rate of large earthquakes based on new data. So it resulted in something like a ten percent or less change in the hazard.

CHAIRMAN WALLIS: There's a lot of stuff. There's probabilities; there's distribution, all this stuff.

DR. STEPP: Yes, exactly. Integrated, you know, for all of those parameters. It doesn't result in a large change in the hazard.

If we transfer in a hypothetical this kind of situation to the Wabash Valley, which is a little closer, and increase the magnitudes, say, we increase it to eight as you suggest; that doesn't change the rate. So the change in the hazard at the site would be proportionally very much less. The rate is very important.

CHAIRMAN WALLIS: And so it's once every 6,000 years?

DR. STEPP: Yeah. So it doesn't change it very much, and I would say -- I don't know. I won't hazard a guess of a percentage, but it's really quite insignificant compared to higher rates.

CHAIRMAN WALLIS: Thank you.

DR. STEPP: I think you had one other part to your original question which we have not answered, but --

CHAIRMAN WALLIS: Or maybe you've answered it.

DR. STEPP: -- if you'll allow us, we'll enter it later because we're coming to that very topic. Okay?

On this slide I think there's one more item that I had not discussed, and this is the moderate seismicity in the area of the site. In probabilistic hazard modeling, we define a background zone normally to account for earthquakes and seismicity that are not specifically associated with a specific defined source.

And in this case we have well defined within the uncertainty bounds that we work with, sources in the Wabash Valley and the New Madrid zone that contribute to the hazard at the site.

The other undefined area is the background zone, and in the background zone we simply define a region that has similar geologic tectonic characteristics and seismicity characteristics that contains the site and allows us to account for all of

the seismicity in the historic record.

In this case, our background zone is the Illinois basin region of the site, and that region in the EPRI studies, the maximum earthquakes were defined on the basis of the historic record. In the subsequent time since the mid-1980s, there has been information surfaced about larger potential earthquakes in that area, and the information leading to that is, again, the liquefaction information, and this resulted in our increasing the magnitude distribution for that background zone similarly to the increase that we implemented for the Wabash Valley zone.

DR. HINZE: Excuse me. May I ask a question? Are you going to come back to discuss the central Illinois seismic zone as you have defined it? Are you going to discuss that later?

DR. STEPP: I do not plan to discuss it later, no.

DR. HINZE: May I ask a couple of questions then?

DR. STEPP: Okay.

DR. HINZE: In talking with some of the experts on liquefaction and who have worked on the Springfield liquefaction sites, I sense that there is

more than one location for the Springfield earthquake, and I wanted to have a lat. and long. for that position so that I can put it on some of my maps to see how it works out.

And I'm wondering if there is consistency. I've tried to look at your map to see if there is consistency in where that site is, and I realize that it's dangerous to put a point on a map when we're dealing with a zone, but could you tell us: have you used a consistent location? And which location are you using? Are you using Obermeier's or are you musing McNulty and Obermeier? Which one are you using?

I think that would be very useful to have in the report.

DR. STEPP: I'll Ask Catherine Hanson to respond.

MS. HANSON: My name is Catherine Hanson, and I'm with GeoMatrix Consultants.

For the Springfield event, we initially started with the literature, McNulty and Obermeier's paper, summarized their current work at that time. So in our -- we have a complete discussion of the paleoliquefaction previous investigations and in an attachment to Appendix A of the SSAR.

So we used that. McNulty and Obermeier show the distribution of paleoliquefaction features they attribute to an event localized in the Springfield area. They provide what they call an energy center, which is basically a central point which they feel captures the sort of location of the energy that was released during that earthquake.

We, in our assessment, we've shown that energy center. We do not rely on that specific location as a specific earthquake, although we have analyzed it in subsequent analyses to look at the impact of an event of that size at that location at Clinton.

But we do rely on the general assessment of the magnitude and general location in the central Illinois, suggesting that there are sources of seismicity that could generate moderate size earthquakes in the central Illinois source based on that event, as well as the additional paleoliquefaction sites that we identified in our study.

DR. HINZE: So you put your energy source then as the center of the ellipse, if you will, that encompasses the so-called Springfield liquefication features?

MS. HANSON: That's correct. I mean, as far as figures go, we do acknowledge that there's uncertainty in the actual location of these events and that, in fact, some of these events may be or the liquefaction that you're looking at may be the result of a more distant earthquake source, and we've captured that in our alternative seismic source zonation models that account for possible larger events further to the south or elsewhere in the Illinois-Indiana region.

DR. HINZE: Thank you.

If I might ask another question, I can't find the figure right now, but you have a new diagram. I believe it's a new diagram showing the location of the central Illinois seismic zone, and this is a rectangle in which the site is located. Can you give me any information? There's nothing in the report that stated how you reach the limits in drawing that diagram.

I believe you referred to it as a simplified source zone.

MR. YOUNGS: Yes. This is, again, Robert Youngs from GeoMatrix.

The simplified source zone diagram was used for the purpose of calculating earthquake

recurrence rates based on the modern catalogue and comparing those to the rates based on the EPRI SOG catalogue. So it was just an area that represented the central portion of Illinois to use for the comparison of earthquake recurrence rates from the updated catalogue to the original catalogue. It was not used as an actual seismic source zone in the hazard calculation.

DR. HINZE: It probably would be worthwhile really emphasizing in the report because one has a sense that when one looks at the simplified models, you look at the New Madrid, the southern Illinois, the Wabash Valley, and they're very specific to those sites.

But the central Illinois which is, indeed, expected from the high frequency end, is very important to the site; that you come up with that rectangle, and it isn't clear to me why that rectangle does not go down and join the zones to the south. That seems to be separated away from it, and I assume that you used in that zone a background, just simply the mid-continent background.

MR. YOUNGS: We were using that simplified model to do sensitivity analysis, to compare the effects of changes in maximum magnitude and so forth

as a part of the evaluation of what information that we might need to update and what information that came from EPRI originally is still usable, but ultimately in the actual hazard analysis that was conducted for the site, we used all of the EPRI source zones, encompassed the entire region.

DR. HINZE: Why did you put it as a rectangle?

MR. YOUNGS: For ease in removing earthquakes for doing calculations for the sensitivity analysis.

DR. HINZE: And the actual location of the boundaries of this rectangle?

MR. YOUNGS: The rectangle was defined to encompass a region around the site that was large enough to capture local seismicity that would affect the hazard, but to keep the boundaries so that it would not impinge upon the other sources which we were going to do sensitivity on, which were the Wabash Valley and the Madrid.

So the actual size that was the bottom boundary of that goes down another 20 kilometers or is irregular, would not affect the comparisons on sensitivity, but it was only used for sensitivities, and it was just defined as a rectangle because that

was an easy thing to do.

DR. HINZE: Okay. Thank you.

Thanks.

DR. STEPP: The next slide is some additional comparison of the Reg. Guide 1.165, Appendix B approach to reference probability as compared to the performance based methods at Exelon followed.

The reference probability approach, which is described in Appendix B to 1.165, the reference probability is the annual probability level such that 50 percent of the set of modern design currently operating plants have an annual median probability of exceedance (phonetic) that is below one times ten to the minus five as determined at the average of five and ten hertz spectoral acceleration with five percent damping.

That's the guideline that is contained in the Reg. Guide 1.165 for reference probability. Instead of using that, Exelon elected to use the performance based approach that is described in ASCE 4305, and this approach, SSE's, that is, structure, systems and components, will have a target mean annual frequency of ten to the minus five for seismic induced onset of significant inelastic deformation. So it's

a component by component performance based approach.

CHAIRMAN POWERS: The issue of the meaning of "significant" in elastic deformation comes.

DR. STEPP: We're going to discuss that in the new viewgraph. We can go to that now if you'd like.

CHAIRMAN POWERS: I'm a patient person.

DR. STEPP: Okay.

CHAIRMAN WALLIS: It depends on what it is.

DR. BONACA: I have a question just for clarification. The seismic induced onset of significant inelastic deformation at least in the SER is referred to as intended to achieve the criteria of one in ten to the minus five, core damage frequency from seismic initiators.

DR. STEPP: Yes.

DR. BONACA: And so the question I have is why would that be significantly less than for existing plants when it is being characterized as being derived from a median out to nine existing plants.

DR. STEPP: Yes.

DR. BONACA: Why that statement at the bottom there.

DR. STEPP: This leads into the next

viewgraphs and perhaps the bottom --

DR. BONACA: Yes, I don't mind if you want to put it off as long as it gets addressed because I'm confused about that statement there and ten to the minus five.

And, actually, I had another question about ten to the minus five. I typically am uncomfortable on a seismic issue on a criterion that only focuses on core damage frequency because I'm concerned about containment, I mean, especially on a large dry you have an assumption of certain performance from containment, and so you would like to to see a criterion there.

Now, my concern is reduced by this statement in the first bullet: "seismic induced onset of significant" -- okay, but still, I would like to understand better how that translates into containment performance.

MR. KENNEDY: This is Bob Kennedy.

If I can keep that from falling down --

CHAIRMAN WALLIS: It's called significant inelastic deformation.

(Laughter.)

MR. KENNEDY: Basically, and there are some follow-on slides that go into this, but I think

since the question came up here, let's go through it right now. ASCE 4305 was originally written to replace DOE standard 1020, and it was to cover a wide variety of facilities that had different risks and, therefore, different levels of potential safety goals.

So the standard basically assigns five different what I'll call quantitative performance goals in terms of annual frequency of unacceptable performance, and then it defines four different levels of unacceptable performance. So you have 20 different categories actually.

The unacceptable performance, the most severe one, is that the structures, systems, and components must remain essentially elastic. That's actually the one we're using because we have to talk in terms of what is unacceptable performance. We use the words "onset of significant inelastic deformation." What that simply means, we've gone beyond essentially the elastic limit.

Now, why the word "essentially" rather than just "elastic" is that even when you're at code allowable stresses, there can be some local inelasticities and strike concentration points, but the overall structural system and component behavior remains elastic, and so going beyond remaining

elastic, we use the word "onset of significant inelastic deformation."

CHAIRMAN WALLIS: Well, this assumes that the components are all elastic. I mean, they're not brittle. Some materials don't have any elastic deformation, to speak of. The buildings at Stanford University didn't have much elastic deformation when there was an earthquake.

MR. KENNEDY: It basically is that you stay within code allowables and behave as essentially a linear elastic system, and not behaving that way is unacceptable performance.

Now, for brittle failures, behaving as an essential elastic system in code allowables may put you right on the verge of failure. For a ductile system, that could be a lot of margin beyond that point.

The ASCE code has, as I said, four limit states. The most severe is to remain essentially elastic. The next level and the level that is primarily used on DOE facilities is to continue to serve as a confinement barrier. That allows some inelastic failure as long as the failure mode is ductile. If the failure mode is brittle, you don't get any benefit going to that state. The most is what

is called large inelastic deformation, and it's a collapse prevention state.

So you can have several different. The ones that are being used here is the most severe of the ASCE categories remaining essentially elastic.

DR. SHACK: But again, to address Mario's question, although you talk about CDF, the same criteria would apply to the containment.

MR. KENNEDY: Yes. The NRC, for instance, on advanced lightwater reactors -- and we'll get into this in a later viewgraph, too, but rather than holding off -- the NRC requires that all advanced lightwater reactor submittals demonstrate what's called a HCLPF seismic margin, which basically corresponds to on a mean or composite fragility curve the one percent probability of unacceptable performance. They require this HCLPF seismic margin against seismic core damage to be at least 1.67 in SECY 093.

So when you're worried about seismic core damage for an advanced lightwater reactor as opposed to for an existing plants, they are required to demonstrate a HCLPF seismic margin of 1.67. The ASCE 4305 code aims at a HCLPF seismic margin of 1.0.

So this onset of significant inelastic

deformation is defined in terms of a HCLPF seismic margin of 1.0. You would also have to demonstrate for an advanced lightwater reactor that you have a margin of 1.67 against seismic core damage.

CHAIRMAN WALLIS: What is significant inelastic deformation of something like a vacuum breaker which is designed to open under a small pressure? If it rattles, it might damage. How do you define something like that in the passive system which has vacuum breakers that have to work between, say, the dry well and the wet well and then modern BWR?

MR. KENNEDY: Basically the vacuum breakers that I'm familiar with are typically qualified by testing, testing on a shape table test, and there's no real distinction between. I mean --

CHAIRMAN WALLIS: So there's a separate criterion.

MR. KENNEDY: -- it's not really a structural failure mode that you're worried about. You want to at least set properly.

CHAIRMAN WALLIS: Right, right.

MR. KENNEDY: And the word "significant inelastic deformation" or the word "essentially elastic behavior" wouldn't really apply to those items. they would be, in my judgments, automatically

applied into this most severe damage state category, Category D. You would have to test and you would have to demonstrate that you --

CHAIRMAN WALLIS: Except to a performance on --

MR. KENNEDY: -- performed under the test.

CHAIRMAN WALLIS: Okay. Thank you.

DR. BONACA: But this I understand and I agree with what you're saying, and I can see consistency between the first bullet you have and the third bullet.

And then that raises the question of why have you introduced this number one to the minus five core damage frequency that is typical of existing plants. I mean, is it like a fragility study they should do beyond the design value to show the margin that you have?

It seems to me that continuing to set ten to the minus five seems to be low and seems to be characteristic of the co-generational plants.

MR. KENNEDY: Basically here, again, ASCE 43-5 was originally written primarily for use on DOE facilities. It was adopted here because the standard was close to coming out, adopted here for nuclear power plant design. The idea was that if you hold

essentially elastic behavior to mean one times ten to the minus five where seismic core damage frequencies for existing plants average about mean one times ten to the minus five, that we knew there was margin beyond this essentially elastic behavior and that we would be achieving seismic core damage frequency substantially less than one times ten to the minus five.

Studies have been done on 28 of the 29 sites that were included in coming up with Reg. Guide 1.165, of finding out what seismic core damage frequencies -- if you were designing to a design response factor developed by ASCE 43-5 by the most severe criteria therein, the one we're using, seismic design 5(d); if you design to those and you had a HCLPF seismic margin against seismic core damage of 1.67 because you're required to have at least that, what seismic core damage frequency would this lead to?

For the 28 sites studied using their hazard curves, the seismic core damage frequency numbers came out between about one times ten to the minus six and five times ten to the minus six. There was a range.

I'll show you where Clinton comes out within that range. It's on one of the subsequent

slides, but the idea was that if you held this one times ten to the minus five for essentially elastic behavior, that you would be well below that for seismic core damage frequency and you would be able to adopt a professional consensus committee standard.

DR. BONACA: I think this is an important discussion that I'm not sure is documented as well in the SER. That's why -- anyway, because everything provides an insight on this margin. In part, I mean, my question was coming. I was trying to figure out how this is going to be done within the PRA, what, in fact, for the plant they're going to do and what kind of target they were going to achieve.

DR. STEPP: So perhaps I could just complete the logic on this viewgraph.

DR. SHACK: Let me ask. You're very careful on this 1.67 for components to prevent core damage, but do you maintain that also for the containment?

MR. KENNEDY: Yes. The SECY 093 maintains that same margin. I'm not a systems engineer, but it's what do you call it, LE?

PARTICIPANTS: LERF.

MR. BAGCHI: LERF, early release frequency.

My name is Goutam Bagchi, and I really like to address the question that Dr. Shack had asked. Containments are designed for combined internal pressure and SSE load to meet the code allowable minimums. Therefore, if it is only seismic, the containment has a very substantial margin against just the seismic. All containments do, and I have seen most of the new lightwater reactors that have very substantial margin.

DR. SHACK: Do we require a margin or it just comes out that way because the design against the pressure, you get the margin?

MR. BAGCHI: You get the margin primarily because you design against the pressure and the concrete provides a little bit of shielding. The structure is there. So the inherent --

DR. SHACK: Would the 1.67 apply to that component?

MR. BAGCHI: Absolutely it would apply. Aside from that, SECY 93-087 requires the continuing performance to be shown that for severe accident loading it has integrity at ASME Service Level C for pressure that builds up 24 hours after the severe accident initiation. It is in the SECY tape. Containment is protected against a much tougher

criterion.

MR. KENNEDY: This is Bob Kennedy.

Having done a large number of fragility estimates on a large number of plants, I can second what Gouptam just said. First of all, the SECY document does require the 1.67 margin for seismic core damage and for LERF. In actual fact though for LERF it would be higher.

Containments have always had substantially higher HCLPF seismic margin capacities than those items that were critical to core damage. So there will be a substantial additional. I don't know what that is. The minimum requirement is that they have at least 1.67, but the fact that they're designed for pressure and seismic leads to higher.

DR. STEPP: Okay. To complete the last two points on this viewgraph, the criterion, onset of significant inelastic deformation, we will show in subsequent discussion, and Bob has already explained, I think, to a large degree has a significant margin against SSE failures that might lead to core damage, and we will demonstrate using the subset of existing sites with modern designs that it leads to seismically induced core damage frequency that is significantly less than that population of existing plants.

With that, I think Bob Kennedy will take up the next several viewgraphs and go into a lot more detail about some of the questions that you have raised here.

MR. KENNEDY: The idea of a performance based development of a performance based seismic design criteria really started heavy emphasis in around 1985, and it basically came about. We were starting to see that there was a lot of seismic probabilistic hazard curves being developed. It gave us ideas of what was the ground motion in terms of spectoral acceleration, in terms of heat ground acceleration. What was the ground motion levels that corresponded to certain annual frequencies of exceedance?

Given these seismic hazard curves that define ground motion levels as a function of annual frequency of exceedance, the obvious question is, well, what annual frequency of exceedance should we be aiming at? We have a whole series. Which one of these ground motion levels should we use in design?

In addressing that, it became clear that what we really ought to aim at is some kind of performance goal, a target performance goal, and if we knew what target performance goal we wanted to aim at,

we could back figure what ground motion level, what annual frequency of exceedance ground motion level we should design for, given our target performance goal and the level of conservatism in our design criterion.

The first document that really documented this approach, there were earlier drafts that came out earlier than what is shown here, but the first one that really documented was Lawrence Livermore National Lab, UCRL 15-910, which was adopted by the DOE in 1990 and required for their plants. It basically had four performance levels in it as a function of how much risk individual facilities had. They would be assigned to one of four performance levels.

That was replaced in 1994 by DOE Standard 1020. Basically it's the same thing, but now it has been upgraded to a DOE standard. that standard was more recently updated in 2002.

During this same period of time, the NRC was also looking at updating regulatory guidance, and there is a NUREG CR Report 6728 that recommends in their going to a risk consistent ground motion design spectra as opposed to a hazard consistent.

The problem is a uniform hazard response spectrum does not lead to uniform risk because different sites have different slopes to their hazard

curve, and if a steep slope on the hazard curve, you would want to design for an earthquake with a higher uniform hazard annual frequency of exceedance than if it was a very shallow slope.

So that was addressed in 6728. It had been previously addressed in UCRL 15910 and DOE Standard 1020.

After 2002, DOE from the Defense Nuclear Facilities, DNFSB, Safety Board wanted a professional consensus, a professional committee consensus code as opposed to DOE having their own standard. That led to the development of ASCE 4305, primarily to address DOE facilities, but it expanded upon DOE 1020 where DOE 1020 had four categories, it was felt that to be a broader use, the number of categories needed to be expanded. They've been expanded to five different quantitative performance goals that ranged from annual frequencies of exceedance of unacceptable performance of one times ten to the minus three to one times ten to the minus five.

We have chosen here the highest of those, the one times ten to the minus five, and then they have four different limit states. So any structure or system component, you would assign it to a quantitative performance goal and a qualitative limit

state. I think I briefly talked limit state.

The most severe of these limit states remaining essentially elastic. Now, for use on a nuclear power plant and for use in the Exelon ESP submittal, we have followed the criteria associated with the most severe of those ASCE categories, seismic design category 5D.

In any kind of performance based approach, first you need to establish what is going to be your risk goal. That is established by two things, and one is the quantitative annual frequency of unacceptable performance and the other is what constitutes acceptable performance, constituted here by following ASCE 43-05 is acceptable performance is to remain essentially elastic. Therefore, unacceptable is the onset of illastic (phonetic) deformation, and the quantitative goal is set by ASCE 43-5 at mean, one times ten to the minus five.

ASCE also then goes on to establish seismic design criteria. The seismic design criteria is a function of the limit state that you are permitted to go to. We have used the most severe of these limit states that are in ASCE 43-5, the limit state remaining essentially elastic.

The ASCE criteria associated with

remaining essentially elastic is very similar to the seismic design criteria of the NRC and NUREG 0800. Obviously for a nuclear power plant the design criteria would adopt the seismic design criteria of NUREG 0800, but this most severe ASCE criteria is very similar.

Now, once you've established your quantitative performance goal, you also need to decide on a reference seismic hazard curve to define a uniform hazard response spectra all at that same annual frequency of exceedance.

That hazard curve of values are then adjusted by a factor called a design factor, DF, to hit your risk goals or our performance goal. The uniform hazard response spectra won't directly hit this performance goal. It has to have an adjustment factor.

That adjustment factor is based on a couple of assumptions. The first assumption is that your design criteria will meet certain upper limits on the probabilities of unacceptable performance if the design earthquake were to occur. For both ASCE standard and for NUREG 0800, basically for the onset of significant inelastic deformation or coming out of this essentially elastic behavior there's less than a

one percent probability of that occurring at the design earthquake level. There's less than a ten percent change of that occurring at one and a half times the design earthquake level.

With these two criteria here, you can then go and create appropriate seismic fragility curves that can then be convolved with the hazard curves.

Next slide, please.

Now, the specific criteria that's been selected at its highest category, seismic design Category 5D, is the target performance goal is to be less than or equal mean ten to the minus five, and why mean ten to the minus five? That was selected in both DOE 1020 and then subsequently in ASCE 43-05 because the average bias of seismic core damage frequency reported in for plants that have done seismic PRAs has been reported to be about mean one times ten to the minus five. In fact, they range from down around one times ten to the minus seven to around one times ten to the minus four.

But the median of that range of means -- each one of these is a mean annual frequency of exceedance seismic core damage -- the median of all those means is around one time ten to the minus five.

CHAIRMAN POWERS: This always bothers one.

If I had been you, I would have fought like crazy never to cite that.

MR. KENNEDY: Okay.

CHAIRMAN POWERS: Because suppose I do ten more seismic PRAs.

MR. KENNEDY: The value would maybe change and maybe not, depending on what --

CHAIRMAN POWERS: Maybe change and maybe not.

MR. KENNEDY: Yes.

CHAIRMAN POWERS: Suppose I'm very crafty and I do ten more on South Texas. I can knock your number down to ten to the minus six if I do enough of these things.

MR. KENNEDY: You'd probably have to do more than ten.

CHAIRMAN POWERS: May be more than ten.

MR. KENNEDY: Because I've got 25 already.

CHAIRMAN POWERS: I may have to work a little bit.

I mean, it seems to me the entire thrust here is to get stability, and this just invites instability, and the fact is it seems to me the much more plausible reason was ten to the minus fifth, a pretty small number. It's small relative to ten to

the minus four. Why not? I mean, since a totally arbitrary number is going to get selected no matter what here.

MR. KENNEDY: I agree with your statement. This is both how DOE 1020 got this number and how the ASCE Committee continued with this number, but I agree. It is an arbitrary number. It's something that I like to say is a policy maker decision.

CHAIRMAN POWERS: That's exactly right, and you guys picked ten to the minus fifth in your role of policy making, and you ask, well, is this good enough, and it looks good to me. I mean, when you think about it, the reciprocal is 100,000 years. That's a bunch.

MR. KENNEDY: Particularly when I'm going to show that the seismic core damage numbers are less than that.

CHAIRMAN POWERS: Yeah. I mean, that part is plausible, and that's part of your philosophy. Well, it doesn't matter, but I mean, stability has to be one of our objectives here.

MR. KENNEDY: Well, I think once the criteria is developed, the criteria is the number --

CHAIRMAN POWERS: Yes.

MR. KENNEDY: -- not --

CHAIRMAN POWERS: Not how we got to it.

MR. KENNEDY: Not how we got to it because the actual fact is if these 25 were done today, they would produce higher numbers because the EPRI 03 hazard curve is significantly higher than the hazard curve that was used when those numbers were computed. If they were all redone today using the same fragility curves, the core damage risks would be higher than what was recorded.

CHAIRMAN POWERS: But I guarantee you that if we insisted that they do them, they would come in lower.

MR. KENNEDY: They would sharpen their pencil and eventually get them lower.

DR. KRESS: I'm not sure how you translate this into core damage frequency. Is the implied assumption that only SSCs lead the core damage if they fail?

MR. KENNEDY: If you're talking about seismic induced core damage frequencies --

DR. KRESS: Yeah.

MR. KENNEDY: -- it's seismic failure of various structure systems and components coupled with random failures or operator errors that lead to seismic induced core damage. Random failures or

operator errors that do not occur concurrent with seismic don't lead to seismic core damage failures. They lead to other core damage things. When you talk seismic core damage failures, they have to -- the initiator is seismic.

DR. KRESS: How do you define what's an SSC in this context? You don't have a plant yet, right?

MR. KENNEDY: For a new plant? How it's defined in this context for a new plant is the NRC SECY document does require for advanced lightwater reactors that they must demonstrate that they have a HCLPF seismic margin against core damage of 1.67. In other words, they will have to demonstrate for core damage purposes that the one percent probability of failure point is at least five-thirds of the design basis earthquake letter. That's how it's done here, is every one of these advanced light water reactor plants will have to demonstrate they have that seismic margin against Florida Image and against LERF.

Now, if we didn't have that, then we'd have no basis of saying, you know, what will be the seismic core damage frequency HCLPF level of a future plant that isn't fully designed.

DR. KRESS: Generally the piping design is

left to the COL. So does this have to be demonstrated at the COL?

MR. KENNEDY: Oh, yes.

MR. MAYNARD: Basically what you're defining is the seismic response spectrum that then the future plant has to be designed to meet and to meet the margins and various things they have to do.

MR. KENNEDY: Yes. The purpose here is to define the design response spectra, the SSC design response spectra. Once that's defined, the plant has to be designed in accordance with NUREG 0800 and in accordance with SECY 093 that it has this margin's requirement in it.

In the ASCE 43-5 approach, the uniform hazard response spectra is defined at mean ten to the minus four. The methodology works very well when you define the uniform hazard response spectra at a factor of ten higher than the performance goal probability that you're trying to achieve and you design to conservative design criteria. So the performance goal is mean ten to the minus five. The uniform hazard response spectra is defined at mean ten to the minus four, and that uniform hazard response spectrum is multiplied by a design factor. That design factor is a function of several things. The factor that the

uniform hazard response spectra exceeds the performance goal in this case is a factor of ten. It's a function of the seismic margin conservatism factor. In this case that margin conservatism factor is 1.0, and it's a function of the slope of the hazard curve.

Steeper slope hazard curves, its design factor is lower. More shallow slope hazard curves, it's flatter. Typically it ranges from one to two. It cannot be less than one, and for the excellent ESP site because it's a soil site and the ground motion is fairly high, we're in a portion where as you go from ten to the minus four ground motion to ten to the minus five ground motion, the increase in ground motion associated with that is about a factor of two, and that's a fairly steep hazard curve.

For this case the design factor ranges from about 1.04 to 1.3. We did perform a probabilistic convolution of hazard and fragility curves. For the fragility curve we did use this minimum HCLPF seismic margin factor of 1.67, and demonstrate that for the ESP site the seismic core damage frequency is less than or about equal to two times ten to the minus six per year, which is significantly less than the median of the existing

plants.

A lot of details on this were submitted in a detailed primer type document which is under this storage number. I don't know whether that was received by ACRS from the NRC or not.

Let's go on then.

DR. KRESS: Do you choose an ESBWR for this site? Then seismic CDF becomes the dominant CDF?

MR. KENNEDY: If all of the others are very, very low, seismic could easily be the dominant CDF, yes. The problem with seismic is these hazard curves just keep going on out. It's a real struggle to go from five to -- I mean, going from five times ten to the minus five, for instance, to one times ten to the minus -- I'm sorry -- five times ten to the minus six to one times ten to the minus six for seismic core damage frequency increases the ground motion a factor of 1.6 to two and gets to very high ground motions relative to what we have previously designed plants for.

But seismic, yes. I mean, it's very difficult to keep pushing the seismic number down, and it could easily be the dominant.

Shall we go to the next? Ah, there it is.

Basically what we did, and this has been

done for all 28 sites, but I just simply put up the excellent ESP site. If you design to the ACSE method defined design response spectra and you're interested in seismic core damage frequency and you have this HCLPF seismic margin against seismic core damage, then this defines the one percent probability of failure point on the fragility curve. The other thing that defines these fragility curves is the logarithmic standard deviation.

For seismic core damage frequency, most appropriately these logarithmic standard deviations in the .3 to .4 range are more appropriate than the higher numbers.

We have hazard curves at one hertz, two and a half hertz, five hertz, ten hertz, and we did it for each of these hazard curves and obviously you get a different answer because these hazard curves all have different slopes. They've all had their design value. Design spectra acceleration has been selected by this method, which gives a fairly constant frequency of onset of significant inelastic deformation, but because their slopes are different, it does not give a constant core damage frequency.

In reality, most of the equipment from past seismic PRAs, actually seismic core damage

frequency typically depends on the hazard curves in the five to ten hertz range. So probably the most appropriate estimate is this estimate based on the average of the five and ten hertz. But it basically says for the Exelon ESP site, seismic core damage frequency is expected to be in the range of one times ten to the minus six to two times ten to the minus six.

For all 28 sites the ASCE method would lead to numbers in the range of one times ten to the minus six to about five times ten to the minus six.

I believe that completes what I was to cover.

CHAIRMAN POWERS: Question. Maybe this is the right time to ask it. Maybe it is not. In looking at these ground motions, there were a lot of discussions about randomizing things in the presentation, and I guess I came away with two questions.

One, do we have a list of all those things that were randomly sampled in this? I mean, is there one list of all those things or do I have to find them in each paragraph of the text where it was done?

Second of all, how do you know they're all independent?

MR. KENNEDY: You're talking about in arriving at the ground motion at the ground surface?

CHAIRMAN POWERS: Yes.

MR. KENNEDY: Bob, would you be the right person to answer that? I can attempt to, but I think Bob Youngs would be a better person to answer what you randomized.

MR. YOUNGS: I'm not sure exactly what you're referring to in randomization. There were two analyses done. One is the probabilistic seismic hazard analysis in which we use probability models for the location and size of earthquakes and for the ground motions that they may produce to generate the hazard curve.

And the second analysis was the site response analysis in which we calculate the amplification of the motions from rock up to the soil surface, and in that application, we randomized the soil properties. Principally we randomized the velocities in the soil layer.

So are you referring to --

CHAIRMAN POWERS: Yes.

MR. YOUNGS: Okay. In terms of the randomization for the second part, the soil layer, we do assume there is correlation in the velocity

structures. So there are models that have been built up looking at a large number of sites and looking at a large number of velocity profiles that indicate the general level of correlation between the velocity and one layer in the velocity and the next layer below it, and we use that correlation model as a part of the randomization. We generate correlated velocity profiles for the site.

So there is correlation that we account for in that randomization process.

In terms of the seismicity or the PSHA part of the analysis, we don't actually perform a randomization. We actually calculate the frequency of earthquakes at all possible locations on a one kilometer -- basically consider as an approximation of a one kilometer grid across the region.

So there is not actually a randomization process in that sampling. We calculated a rate of earthquakes based on the past pattern of earthquake occurrences in the region and used that to define a future rate at each location in the region.

CHAIRMAN POWERS: Well, I don't have my sheet of randomizations here, but I got the impression there were more randomizations than that.

MR. KENNEDY: Dr. Powers, a number of

years ago for a site on soil people developed the ground motion hazard curves using attenuation relationships that were developed from soil site ground motion, develop the surface motion directly using those soils attenuation relationships.

The more recent approach basically advocated in NUREG CR-6728 was, no, it is better to define the ground motion probabilistic seismic hazard curve in terms of a reference rock, and the reference rock in EPRI-03 is 9,200 feet per second sheer weight velocity rock, and so the probabilistic seismic hazard curve is first defined down here at this 9,200 feet per second rock and then has to be convolved up through the soil layers to get the motion at the ground surface.

This convolution process you don't want to work with a single soil profile because you've got a lot of uncertainty on the soil information, and so they do do this process of selecting a best estimate soil profile and variability about that best estimate, and then they do a number of randomized samples to get a mean amplification function.

And these randomized samples, as Bob Youngs was mentioning, they do include correlation. You don't assume that this layer in a sample could be

particularly soft and this layer right below it particularly stiff because there is correlation between their stiffnesses.

But you come up with this best estimate soil profile and then you randomize the properties about the best estimate profile, but with correlation included in that randomization. This leads to a broader frequency and more realistic response spectra at the ground surface.

That's the only place that I'm aware of where there is randomization used in the process.

CHAIRMAN POWERS: Okay. Let's go on.

DR. HINZE: Can I ask a related question?

CHAIRMAN POWERS: Sure, yes.

DR. HINZE: You justify the randomization in order to account for the uncertainty and variability. What is the difference -- what's your meaning of the term "uncertainty" and "variability"? You use both of those terms.

MR. KENNEDY: Well, when I'm trying to be careful they have a very different meaning.

DR. HINZE: Yes.

MR. KENNEDY: There is inherent variability from if I had a bore hole here and another bore hole here, there will be differences in the

properties of the soil in these two bore holes. To me that is almost what I would call random variability.

I also have uncertainty as to what the real properties are because, for instance, I may know of low strength properties from the soil, but I'm interested in the properties at seismic strengths. So I have to take into account effects at higher strengths. My effective sheer modulus is lower than at low strengths. My effective material damping is higher.

DR. HINZE: So measurements.

MR. KENNEDY: So there are both uncertainties in my knowledge of the data, and there's random variability of the data. They're not really separated in this case. The randomization process considers both.

DR. HINZE: Right.

DR. STEPP: Okay. We're ready to go on then. And this slide that is on the screen now we show the site specific performance based ground motion spectra for the vertical and horizontal ground motions. I believe vertical is in the dash. The horizontal is in the solid line.

And we compare that with the Reg. Guide 1.60, general site independent response spectrum

anchored at .3 G, which is kind of a target for seismic design basis for many of the advanced reactors.

There is a step in the derivation of this ground motion which goes to the question that you asked very early on, Dr. Wallis, and if you'd like, we could stop here and respond to that in more detail.

Bob Youngs offered a response to that. It involves the deaggregation of the motion and properly accounting for distribution of that in that distribution of the deaggregated motion for the controlling magnitudes that contribute to the hazard at the site.

MR. YOUNGS: This is Robert Youngs again.

You asked earlier where the magnitude of 6.5 came from after we were talking about larger magnitudes. In the process for defining, once we have defined the hazard curve and we now are to do evaluation of the response of the site to the earthquakes that produced that hazard curve, through the process we typically define what is called a controlling earthquake which represents on an average basis all the earthquakes that have contributed to the hazard.

The probabilistic analysis considers

earthquakes from magnitude five up to the largest, and there are frequencies, and they all contribute to the hazard curve, and they contributed different amounts depending on their frequency and on their size.

Typically, earthquakes nearby, you can get small magnitude earthquakes contributing to the hazard, and as you move further and further away from the site, the earthquakes have to be bigger and larger and larger to contribute significant motion to the site.

That is also combined with the fact that small earthquakes occur more frequently than large earthquakes so that we have the combination of large events from a distance and smaller, more frequent events in close contributing to the hazard.

And I don't have a slide, but if you have the SER here, the slide figure on page 2-212, the figure here, that shows the history. So the amplitude of those peaks represents basically the relative contribution of earthquakes and different magnitude intervals and different distance intervals to the hazard number at ten to the minus four, and the controlling earthquake is basically the weighted average of that histogram, magnitudes and distances weighted by their relative contribution.

So we come up from that histogram with the number of 6.5 as a weighted average magnitude, and it represents a combination of earthquakes locally in the Wabash Valley and in New Madrid, and it just so happens that it come s out with an average distance that's close to the Wabash Valley distance, but the magnitude is lower than the maximum magnitude in Wabash Valley because the hazard is controlled by earthquakes that are occurring more frequently than the maximum earthquake.

And then we use earthquakes of that average magnitude, we use time histories of earthquakes of that size to run the site response analysis to develop the amplification of the rock motions to the soil surface.

DR. STEPP: Thank you.

The NRC's review of this found the motions acceptable for the ESP site, Clinton ESP site, and the condition is that the motion will be compared with the actual design response spectra at COL stage. Here we've compared them with the .3 sale standard Reg. Guide 160.

There were a number of open issues following the August issue of the DSER, and these have all been closed subsequently and resolved. Issue

2.5.1-1 had to do with the sizes of the New Madrid earthquakes. We alluded to earlier in this discussion all seismic information is undergoing continuous evaluation at all times, and there are new estimates of magnitudes that are being proffered for these large earthquakes that occurred now almost 200 years ago.

And with this issue had to do with incorporating the latest estimates of those magnitudes.

Two, point, five, point, two, dash, one had to do with a distance conversion methodology for EPRI ground motion Model 03. In that model there are a number of different proponent attenuation models are used and weighted, and those proponent models have different measures or metrics for distance from the earthquake source, and this had to do with explaining in detail how those were converted to a single metric.

Two, point, five, point, two, dash, two had to do with the use of the site velocity model. You've heard some discussion of that already. The issue of properly representing the variability in the properties in the shallow part of the soil or underlying geologic section at the site.

Two, point, five, point, two, dash, three had to do with the proper representation of the site

dynamic properties, and the question there was a comparison of the actual site properties with the dynamic modulus reduction in damping curves that were used at the site.

Two, point, five, point, two, dash, four addressed the adequacy of the ground motion estimate at the site, that is, the SSE ground motion derived for the site as compared to local prehistoric earthquakes which we discussed earlier.

CHAIRMAN POWERS: Is this where we get into the discussion of what actually moves at the New Madrid site?

I mean, New Madrid site seems to have three, as I understand it, three major seismic faults.

DR. STEPP: Yes.

CHAIRMAN POWERS: And it says an open question of do they all three occur --

DR. STEPP: Yes.

CHAIRMAN POWERS: -- at roughly the same periods of time or some of them aftershocks or some of them just don't occur.

DR. STEPP: Yes.

CHAIRMAN POWERS: And just talk to me a little qualitatively of how you came up with this kind of one-third, one-third, one-third when there, in

fact, seem to be about nine possibilities.

DR. STEPP: Yes, okay. We responded to that in an earlier request for information, but it can be addressed now, as 2.5.1-1 is part of that response, and again, Dr. Youngs is the person who will address that.

MR. YOUNGS: The original assessment in our original submittal was based on an interpretation of a figure that was presented in Tutle, et al., which from that figure implied that looking at the estimated sizes of the two previous earthquake sequences, the one that occurred in approximately 1450 and the one that occurred in approximately 900 A.D., that one of the three events would have been appreciably smaller than the other two. I can't remember the actual order, but I think in one sequence the northern event seemed to be much smaller and in one sequence the southern event seemed much smaller.

So we had interpreted that to imply that in several sequences -- in not all sequences do we get three events of similar size, and in subsequent discussions with her, she indicated that that was, say, an overly favorably interpretation of what she was trying to say in that figure, and that she felt that in all cases the data suggested that all of the

events had been at least as large as magnitude seven.

So our revision was to say that in every sequence the ruptures are at least magnitude seven on all three parts of the system, and we just interpreted the one-third, one-third, one-third as that they were smaller than the largest that we saw in 1811. I think on the northern one two out of three times they were roughly the same size, and one time they were smaller, but they were still magnitude seven.

CHAIRMAN POWERS: This all raises an interesting question in my mind. When we think about these plants suffering a seismic event, we think about them suffering one seismic event in time, but here with the New Madrid, you kind of get three. I mean, they're spread over a few years. I mean, how do we respond to that?

Suppose I have a seismic event of substantial magnitude. Let's say four or, a better number, 7.4 at this new plant that you constructed, and it will cruise right through it, right? No trouble. I mean, we'll shut the plant down. We'll probably have a lot of inspectors come look at it. But in hopefully a short period of time you're back up and operating.

Do you?

DR. STEPP: Well, this is an interesting and challenging issue in hazard modeling, which we have given a lot of thought to. This New Madrid strain release behaves as a clustered release, in the most recent sequence, in the 1811 and 12, the three earthquakes that occurred over approximately a three-month period, a little less than three months.

One would have to presume that the past sequences may have followed the same pattern. Now, this is a clustered, in a tectonic sense, a clustered set of earthquakes that is for my awareness not normally seen, but it is seen here. So one has the option, you know. The challenge here is whether one models this cluster as a single event with a magnitude representative of the total energy release or models as multiple events the three events with slightly different locations and with energy releases that represent each of the individual sectors of the source that broke in that particular earthquake.

It has become the preferred method to model these as separate events, separate earthquakes because they have somewhat distinctive characteristics of sources. There's difference in geographic locations. Mechanisms of the central zone is different than the north and south parts of the zone.

So they have been as a matter of professional preference modeled as separate events in recent hazard studies.

Perhaps, Bob Youngs, you would like to amplify on this.

CHAIRMAN POWERS: I just through there was a question, and I can be clearly wrong about this, strictly a question on my part, that seismic types were discovering more and more of these clusters. I mean, there's a fairly famous sequence of earthquakes that occur along the Black Sea in Turkey that seem to get one and then six months later get another one and they progressively head toward -- like the Persian Army or something like that.

DR. STEPP: But this is a very different mechanism. The Anatolian fault, which you were referring to along the Black Sea is similar to the San Andreas fault, and it connects Baja, California with Cape Mendocino.

These earthquakes along the Anatolian fault -- let me back up and say it seems that the strain released along the Anatolian fault zone occurs in spatially sequenced earthquakes. That is true. It turns out that over a period of 100 years or more, you tend to have a kind of clustered strain release along

that entire zone, but it's actually occurring in different sectors of the zone, each earthquake, and that's fairly typical of tectonic strain released worldwide.

There is a certain clustering, and you people have referred to it as the strain cycle for particular large plate boundaries, for example.

In time of the release of strain and then perhaps a hiatus when that cycle is completed before it's completely started again.

CHAIRMAN POWERS: But you see what I'm asking is or I'm curious what does the seismic fragility analysis say. Okay. I've got this plant. It's all in good shape. Nothing ever happened to it. Then something happens and the plant does just fine.

Is that fragility analysis now applicable when three months later I get another earthquake?

MR. KENNEDY: This is Bob Kennedy.

Yeah, I mean, that's a significant issue because after almost every very large ground motion, we gave after shocks and quite a long series of after shocks, typically somewhat less ground motion, sometimes not less, but what we have found both in earth quake experience data and shake table testing data, we have found that if the structure, system or

component remains essentially elastic during the shaking, there's been no degradation.

So another one comes along. It will behave basically the same.

If the structure, system or component goes inelastic, at the next shaking it will be somewhat more flexible. It will not have the same elastic frequency as it had before the previous shaking, and it will gradually become more flexible, but we have not seen a rapid degradation increase in damage until we reach a stage where under that earlier shaking, let's say we know what its capability would be if it had been just shaken once.

Under that early shaking if we've exceeded about 80 percent of its capacity that it would have been able to take if it had only been shaken once, the next shaking it will not have that same capacity as it had for the previous, and so that if we've gone up over 80 percent, about like that, the next one we may -- and let's say we get the same size the next one. We reached 85 percent capacity on the first one. The second one we reached 85 percent of the original capacity. We may suffer very serious damage on the second one.

We tried to take that into account with

our variabilities on these fragility curves. I mean as we start to approach -- I mean, our fragility curves cover a significant amount of uncertainty as to what these capacities are. I don't see if we've exceeded the HCLPF capacity we're so far below what we think our realistic capacity is. I don't think we will have changed the HCLPF capacity any.

If we start approaching anything approaching our median or best estimate of the capacity is, I think the next time if we knew that had occurred, the fragility curve for the next event would be steeper because we would lower that median.

DR. HINZE: If I might, this is even more complicated than you suggest, Dr. Powers, because as I recall at our September discussion we brought up the topic of far field triggering, that is, where earthquakes are triggered far afield, and there was some consensus that perhaps this didn't occur in interplate regimes, such as we have in the mid-continent.

And then subsequent to the meeting I recalled Sue Huff's paper in the Seismological Society of America in 2003 in which she and Sieber and Ambruster looked at the possibility of far field triggering from the 1811-1812 New Madrid events and

also the 1886 Charleston event. And they found at distances comparable to the Clinton site triggering.

And I'm wondering if this has been taken into account. I mean, this is not only pretty repetitive events, but also there's also the possibility of considering the probability of considering the probability of an event being triggered near the Clinton site as a result of this.

And I'm wondering if this was taken into account in the hazard evaluation.

DR. STEPP: My answer is not specifically, but I would answer that in the discussion of whether to treat New Madrid as a single composite event with energy release comparable to the co-energy of the three earthquakes vis-a-vis there's three different energy releases closely spaced in time. The concept of triggering enters in. Just people have considered this, for example, with the Anatolian fault and the San Andreas fault. So it would be reasonable to consider that you have one large earthquake occurring in the Mississippi with two earthquakes of comparable size being triggered by that first one.

But triggering more distant earthquakes, to my awareness there's no observational evidence of that in the world, in the stable continental region.

DR. HINZE: Hough's paper seems to indicate that. You know, they could be wrong, of course, but they've looked at the historical record on this from the Charleston, Connecticut, from New Madrid down to the Birmingham, Alabama area, Montgomery, Alabama area, and so forth.

DR. STEPP: It's really pretty difficult to make that tie very confidently. I mean, it's entirely possible that small earthquakes will occur in time, closely following any large earthquake and not be triggered by that earthquake.

So I think there has to be more of a demonstration of proof of that than simply an inferred association.

DR. HINZE: Colonel, I understand where you're coming from, but you know, if one reads Hough's paper, there are some pretty good evidence there. For example, the Charleston earthquake producing earthquakes in Southern Indiana that were from newspaper accounts fell -- I don't recall the exact distance -- but 50 kilometers distance between these.

So this would indicate that it's not just a very minor earthquake, but it has some felt area. I think it's still an open topic. I think it's one that we need to learn more about because we don't

really understand the triggering events in the western United States.

DR. STEPP: It would be an interpretation that is not currently incorporated into the hazard modeling.

MS. HANSON: This is Catherine Hanson from GeoMatrix.

I'd like to just make one comment on some of the observations that were cited in the Hough, et al., paper as well as the Mueller, et al., paper which also looked at evidence for locating one of the large magnitude events in the sequence farther to the north than had been previously acknowledged by previous investigators.

I think there's a lot of controversy about whether there is really evidence for paleoliquefaction of the magnitude that they cite in southern Illinois. I think talking with Dr. Obermeier and various other people there's a question that what they interpret as large sand blows that would have occurred during that event are, in fact, not demonstrated to be such.

DR. HINZE: I quite agree with you. Southern Illinois, you know, there seems to be little question but that they were out of line.

DR. STEPP: I just would add one other

thing to my comment, that it's not specifically modeled in seismic hazard modeling. Notwithstanding we do account for any earthquakes that are in the history directly in the seismic hazard model, and they're accounted for as being associated with a particular source where they occurred.

Now, if they were triggered by a more distant source, we would not have that temporal relationship in the model

CHAIRMAN POWERS: Let me ask where we stand on the presentation. Do you have significant points you want to make on these opening items?

MR. GRANT: We have two or three slides that are short slides.

MS. KRAY: From the cover one, yeah.

MR. GRANT: We've covered most of these points already.

CHAIRMAN WALLIS: You're talking about performance based method, and my impression is that this is a good way to go about things. It makes sense whether I understand the details or not. The approach seems to make sense to me.

DR. STEPP: The open issue, 2.5.2-5 had to do with further clarifying the assumptions for implementation of the performance based methodology,

and you have heard discussion of we responded with specific clarifications that the staff requested, and I think you heard discussions of each of those in Dr. Kennedy's earlier presentation.

MR. GRANT: There was one geotechnical issue that had to do with whether or not we were going to do additional borings, and we said certainly we're going to.

In summary, again, all of the open items are closed. All of the confirmatory items are completed, and the SSE ground motion spectra that we proposed has been accepted.

CHAIRMAN POWERS: Any additional questions you'd like to pose to the speaker?

MR. MAYNARD: One quick question. I realize the existing station which is tied to its own licensing base. I'm just asking for insights. Going through this for the early site permit, did you gain any insights or did it raise any potential safety questions for the existing site?

MR. GRANT: The only insight that we got was that the two methodologies are distinctly different and that you really cannot do a comparison of the two.

CHAIRMAN POWERS: Why don't we take a

break until five of?

I thank the speakers. It's a very useful introduction to an arcane subject. Well, it's an interesting subject in the sense that one would like to know a lot more than one does, but we still have to act upon what we do know, and sometimes you just have to do the best you can.

Let's take a break for 15 minutes and reassemble at five of.

(Whereupon, the foregoing matter went off the record at 10:41 a.m. and went back on the record at 10:58 a.m.)

CHAIRMAN POWERS: Laura, it strikes me that you get to work with all of the precise sciences, weather, seismic.

MS. DUDES: Oranges. Well, I think -- are we going to start?

CHAIRMAN POWERS: We are in session.

MS. DUDES: I would be happy to provide opening remarks at this time.

CHAIRMAN POWERS: If you would be so kind as to provide opening remarks. Guide us through this thicket of complexity.

MS. DUDES: Okay. Well, first and foremost I want to introduce the staff members

presenting to you today. I'm sure these gentlemen are all familiar to you:

John Segala, the senior project manager for the Clinton early site permit, as well as the senior project manager for early site permits in general, and John should be back before the Committee not only tomorrow for the full committee, but also in the near future for some early site permit lessons learned and this topic probably being one of them.

Dr. Cliff Munson and Goutam Bagchi, who will also provide the staff's technical discussion on this.

I appreciate the discussion this morning, a very long, detailed discussion on this issue. I think as Marilyn Kray had indicated, this is the first time the staff had seen this method. It's not our preferable approach to review a new technical approach during an application, but the staff did so. The original schedule for this early sites permit completion was changed by approximately seven months so that we could develop an agency-wide, not just a singular Office of Nuclear Reactor Regulation, but an agency of wide consensus on some of the conclusions in the safety evaluation report presented to you.

I think the work that was done on Clinton

in this performance based approach will inform generic work that the staff is developing now as we look forward, and that is essential work. I think Marilyn Kray alluded to the NEI Task Force on this issue, and it's essential as we look forward, and I'm sure you know about our 11-plus COLs that we expect to arrive on our doorstep in 2008, many of them on sites that will be using similar methods, and we will be continuing to expand our knowledge in the area of seismic.

But even before 2008, we can expect and we do expect our next early site permit to arrive in August 2006, and I have every indication that a similar type of method for this site will be used, and so the education that we have gotten through this first early site permit is beneficial, and we will look forward to expanding on that in the future.

So with that, I'm going to turn it over to John Segala.

CHAIRMAN POWERS: John, I would appreciate it if you would recognize that we have had substantial discussions here, and that the committee is particularly interested in not so much the historical chain of events, but more in the way you went about reviewing this, where you found the rough spots and

how you resolved those rough spots

MR. SEGALA: Okay. I do think that a lot of our earlier work might have been repeated by the applicant. So I'll try to go through very quickly, and then I'll turn it over to Dr. Munson.

So we're going to provide an overview of our seismic review and answer any questions you have. I'll briefly touch the milestones for the schedule. We'll discuss how we resolve the open items and have any questions or comments that you might have.

Highlights, the application came in on September 25th of 2003 and we've issued our final safety evaluation report on February 17th of 2006. The ACRS full committee meeting is schedule for tomorrow, and we hope to get a letter from the ACRS by the end of March and then incorporate that into our SER and issue that as a NUREG the beginning of May of 2006.

There are a total of seven seismology and seismology open items in the supplemental draft safe evaluation report. Two of those were related to the performance based approach for determining safe shutdown earthquake. Two of them were other seismic related items, and three of them were geotechnical items.

I'm going to very briefly hit on the two seismic and two geotechnical, and Dr. Munson will discuss the two performance based questions.

The first item, 251-1, incorporating the most New Madrid seismic source, the applicant did that. We reviewed that and found that acceptable.

Two, five, two, dash, one, clarify the EPRI ground motion. The applicant provided the detailed description of their distance conversion method, and the staff reviewed that and found that acceptable.

The next slide on geotechnical open items, 252-2, site response model does not accurately represent the variability of the soil. This became clear to us after discussions with the applicant, that they were removing the top 60 feet of the soil. We made that a permanent condition in the final safety evaluation report and closed the open item.

Two, five, two, dash, three, site response analysis should use appropriate sheer modules in damping curves. The applicant provided data demonstrating the soil has low plasticity and incorporated 15 percent damping cutoff, and the staff reviewed that and found it acceptable.

Two, five, four, dash, one, further soil

exploration needed for COL. That was more of a clarification item. The applicant revised their application to make it clear that they were going to perform further drilling and sampling during the COL stage in accordance with Reg. Guide 1.132, and the staff made this a COL action item in the final safety evaluation report.

Just to give you an overview of our experience with this performance based methodology, back in April of 2002 we were first introduced to this method through NUREG CR-6728. The staff participated in the committee that developed ASCE 43-05.

We first learned of an applicant doing this performance based approach in Exelon's application, September of 2003. As a result, we informed Exelon that it was going to take us additional time to do the review.

We formed a seismic technical advisory group made up of seismic and civil engineering experts from NRR, NMSS, and Research. They served in an advisory role to NRR for the review of this performance based approach for Exelon, and Dr. Andrew Murphy, who is here in the back, is from the Office of Research, and he's the chairman of the seismic TAG.

Okay. I'm going to turn it over to Dr.

Munson to go through the performance based review.

MR. MUNSON: Before I start on the slides, I'd like to mention that we also had some outside consultation from Brookhaven National Lab, and also the USGS to form our final conclusions regard the performance based approach.

As Laura stated in the beginning, it was a challenging review. It did take us extra time, and I hope that we can demonstrate the thoroughness of our review over the next half hour or so.

I'd like to start off with what we concluded and then develop each conclusion in more detail, and in the process cover each of the open items that we had on the performance based approach.

Our first conclusion was that the performance based approach is based on a sound technical approach.

Our second conclusion was that the seismic design using the performance based SSE achieves the safety level generally higher than operating plants.

And the third conclusion we reached, that the SSE adequately reflects the local hazard from a Springfield type earthquake.

CHAIRMAN POWERS: When you say it adequately reflects Springfield, you mean you just

don't see how they could do much better.

MR. MUNSON: I'll cover that when I get to conclusion three, but basically --

CHAIRMAN POWERS: Well, am I correct in my assumption that this is a fairly mysterious source of seismic activity?

MR. MUNSON: Right. There's no remnant seismicity in the Springfield area that would indicate a source. So it's not a very certain earthquake, in other words. We just wanted to do a sanity check to make sure that ground motion from a Springfield earthquake, given that magnitude and distance, would be enveloped by the performance based SSE.

CHAIRMAN POWERS: This surely cannot be the only seismic event that occurs that is not associated with a seismic structure of some sort.

MR. MUNSON: Right, and that's why they define this central Illinois as a background source zone, because there is no structure that can be directly correlated to a Springfield earthquake.

CHAIRMAN POWERS: What I'm floundering around a little bit on is saying, okay, well, presumably earthquakes can produce a distribution of events, magnitude of events. When you've got a one point source, it's hard to think of a distribution.

So you have to think of analogue sources to arrive at that distribution.

Does one do that sort of thing?

MR. MUNSON: They used a uniform distribution for the central Illinois source zone so that they didn't limit the Springfield earthquake to that particular location.

CHAIRMAN POWERS: Okay.

MR. MUNSON: Okay. Back to conclusion one, the overriding goal of the performance based approach is to achieve both high and consistent level of seismic safety in the design of future nuclear power plants. The performance based approach is risk based in that it includes both seismic hazard and fragility information. So both capacity and demand information, and the performance based approach requires structures to be designed to a target performance goal.

The performance based SSE can be determined by two approaches. The one that Dr. Kennedy described this morning is the design factor approach, which is an ASCE 43-05. You can also directly integrate the risk equation which is the basis of the performance based approach, and the staff used this approach as a check, a verification on the

assumptions, the modeling assumptions, that the applicant made or that are made in ASCE 43-05.

A little bit of description of the design factor method. The performance based SSE is determined by multiplying this design factor times the ten to the minus four uniform hazard response spectra, and this design factor is given by the only variable that appears in this is the amplitude ratio between the ten to the minus five and ten to the minus four uniform hazard response factor.

Would you go to the next slide, please?

This is a graphical illustration of the approach. At five and ten hertz, the dotted line is the ten to the minus four uniform hazard and the dashed line is the ten to the minus five. So the ratio of these two points are close to two and then the design factor is given by this formula right here, and then you arrive at your safe shutdown earthquake using this formula.

CHAIRMAN WALLIS: There's something empirical about this presumably.

MR. MUNSON: This is totally --

CHAIRMAN WALLIS: Whereas the other method makes some sense. I mean the direct integration of risk equation is something that's logically

explicable. I'm not so sure how much you want engineers integrating.

CHAIRMAN WALLIS: You wanted to use the handbook rather than doing it.

MR. MUNSON: Yes.

CHAIRMAN WALLIS: Do you think they find integration difficult?

MR. MUNSON: You need to carry out the integration. You need to carry it out to several places. So you need to have an accurately defined hazard curve. There's several things you need to consider.

CHAIRMAN WALLIS: With computers you might be able to do it a little bit quicker than in the past.

MR. MUNSON: I mean, we take this approach and we're going to use this approach in the future as a check on any performance based approaches that we receive from industry, but the ASCE 43-05 approach is using design factors and amplitude ratios.

MR. BAGCHI: He's using a line and approach that is adopted in a consensus standard. That's an easy thing to do and there is no way to make mistakes. It has been gone through several checks for many sites and it has turned out to be quite

conservative.

DR. SHACK: I mean, I think it's unfairly maligns it. I mean they did the risk integral obviously, and they just fit it with a simple function. That's all. I mean, it's a question of we do the integration now or do it later.

MR. MUNSON: And to derive the design factor, I mean, they did the integration. They assumed model parameters, and they assume a log normal distribution. I'm going to go through all of this. So why don't you go through?

The performance based approach is based on this integral of the hazard curve and the fragility curve, and the purpose is to achieve this target performance frequency that we discussed.

Go ahead to the next.

This is an example of a hazard curve and a fragility curve. So these two curves are multiplied together and then integrated to determine the SSE that meets the target.

The first step is determining the target. So our first open item dealt with your performance target. As we discussed this morning or Bob Kennedy described this morning, the performance target frequency is one times ten to the minus five per year,

and that implies that the probability of onset of inelastic behavior shall be less than ten to the minus five per year.

And as Bob also described, the performance target is based on comparison between the IPEEE seismic PRAs and equating the two values, even though the performance target corresponds to a minimum damage state and seismic core damage would correspond to a higher damage state. So the staff felt that that was a conservative comparison, although as was pointed out, it is an arbitrary choice.

Our initial concern was does that mean the target will change if the hazard information changes. In other words, -- go ahead to the next -- these 25 IPEEE seismic PRA core damage frequencies are dependent on seismic hazard information. As the seismic hazard goes up, these values, the frequency, would go down.

So our concern is that -- our initial concern was that this target would be a moving target, but the applicant responded by informing us that this was going to be fixed at the one times ten to the minus five.

CHAIRMAN POWERS: I mean, it seems to me we've discussed this before, but earlier today, that

it is a policy decision that says, okay, ten to the minus a fifth is kind of what we want as a target.

MR. MUNSON: Right, and we needed to come to the conclusion that that was a reasonable value.

CHAIRMAN POWERS: That's right. That's right. You earned your salary when you came up with that decision. Well, it's not an easy decision to come to.

DR. BONACA: I think the only point I was talking about, my confusion before is that he equated the PFT to one and ten to the minus five per year as the probability of the onset of inelastic behavior and then the acceptable CDF, one in ten to the minus five period, they're not the same thing.

MR. MUNSON: They're not. It's a much more conservative -- it's a very conservative assumption that core damage is equated with onset of significant inelastic --

DR. BONACA: That's right. So that's really what leads to that confusion, I think.

MR. MUNSON: One of the basic premises of the risk performance based approach is that the hazard curves are linear between ten to the minus four and ten to the minus five.

Could you show a hazard curve really

quick?

What we're talking about is between these two points the performance based approach assumes a linear on a log-log sale, a linear model on a log-log scale.

So we checked that by doing a direct integration not assuming a linear fit versus solving the risk equation and doing a linear fit, and as you can see, if you go back to the picture again, there's a slight -- it's hard to see, but there's a slight downward curvature of these curves.

So by assuming a linear fit, it's slightly conservative. If you go back to the table, the values we get by not assuming that linear fit are slightly lower than you get by assuming the linear fit. So we felt that that was an acceptable assumption, that there was a linear fit between --

CHAIRMAN WALLIS: It's surprising the effect is go big. It's a ten percent effect or something, or more. In other words, they look pretty linear.

MR. MUNSON: Right. So by assuming that linear fit, it's conservative.

CHAIRMAN WALLIS: but it's surprisingly effective so bad, considering how really it is pretty

close to linear unless this is --

CHAIRMAN POWERS: You don't have to deviate very much in a log-log formation.

(Laughter.)

CHAIRMAN WALLIS: Maybe it depends on how you draw your line. It depends on how you draw your line.

MR. MUNSON: Did you have a -- I had a hand up.

CHAIRMAN WALLIS: That's okay. I'm not worried about it.

MR. KENNEDY: This is Bob Kennedy. I think I can answer that.

When you do the rigorous integration, could you put back up the curve? It's not just between ten to the minus four and ten to the minus five that control the final risk number. That's the central region that controls, but on this plot if you're aiming at ten to the minus five, it's from about five times ten to the minus four to about five times ten to the minus six that controls.

And so this linearization is known to introduce some conservative bias depending on how much curvature there is on these plots.

MR. MUNSON: right. So for the direct

integration approach we integrate over the whole hazard curve and the whole fragility curve, and this is what the hazard curve looks like on a linear plot instead of a log-log plot.

Go ahead.

CHAIRMAN WALLIS: The plot is piece-wise linear anyway.

MR. MUNSON: The next assumption that they made is that the seismic fragility assumes a model seismic systems structure component, seismic fragility using log normal distribution, and the log normal distribution is the same as the normal distribution with the exception of this term here.

CHAIRMAN POWERS: I have to admit that I kept coming back in your SER, kept coming back to that. It's totally stated, the log normal distribution. I think why. Why is this distribution appropriate?

MR. MUNSON: The log normal distribution has been used to model fragility forever.

Do you have any insight?

MR. BAGCHI: You can give that to Bob, but I do know that Professor Linwood had done some study. It was published in Nuclear News, I think, not Nuclear News. I forget the name of the magazine, but anyway,

he looked at all of the distributions, and his conclusion was log normal fits very well.

CHAIRMAN POWERS: Well, log normal is an amazingly flexible distribution, and you can get a plausible looking fit with just about any set of data to a log normal distribution.

MR. KENNEDY: This is Bob Kennedy.

We have in the past done a lot of study on distributions. What I can say is when you go through and you vary damping of structures, you vary natural frequency of structures, you take your response spectra and you do multiple time history analyses, we can show that the demand in the structures fits wonderfully to a log normal distribution at least within the central region, the central region being from the one percent to the 99 percent.

I'm not so sure that the tails -- I mean, certainly the log normal distribution having had tailed down to zero and a tail up to infinity, those are not reasonable, but the central region, the demand fits wonderfully. We did nominee analyses on the Diablo Canyon long-term seismic program. We did 300 nonlinear time history analyses for a nonlinear response. The data fit very well to a log normal distribution. Capacity data fits also well.

CHAIRMAN POWERS: You sit it fits very well except where it doesn't, and unfortunately where it doesn't is exactly where we're going to do the integration.

MR. KENNEDY: No. That's the nice thing about seismic. The hazard curves are so flat that the convolution of hazard and fragility, that probability of failure number you get up there is absolutely totally dominated from about the one percent point on the fragility curve to about the 70 percent point. We've done where we have truncated the log normal at the one percent versus using the log normal, and it makes very little difference in the computed probabilities of failure.

In internal events, it's those low frequencies that are important, but when you convolved hazard and fragility curves, it's the part from about the one percent point to the 70 percent point that are important.

MR. MUNSON: So with the fragility curve it's approaching zero down here. That's also where your hazard curve is approaching.

CHAIRMAN WALLIS: Well, the important part is the curve where you actually convolute the two, and that's what you're going to show us.

MR. MUNSON: Right, right.

CHAIRMAN WALLIS: The next slide.

MR. MUNSON: First I have to get through this.

CHAIRMAN WALLIS: Okay.

MR. MUNSON: The two parameters that control the log normal probability density function are the mean and the standard deviation, and we can express the mean in terms of the one percent capacity or HCLPF value, and that point corresponds to the one percent capacity level on a mean fragility curve.

So the mean in terms of -- this is the means in terms of the one percent capacity.

CHAIRMAN POWERS: Is your log normal distribution correctly written up there?

MR. MUNSON: I believe so.

CHAIRMAN POWERS: Your equation has units. I would think a probability --

CHAIRMAN WALLIS: What's the A doing down there?

MR. MUNSON: The A is the ground motion. It's defined in terms of ground motion, the fragility.

CHAIRMAN POWERS: It will have units.

CHAIRMAN WALLIS: It will have units.

CHAIRMAN POWERS: And the probability

density function really shouldn't have, should it?

MR. MUNSON: I'm sure this is right with the probability.

CHAIRMAN WALLIS: Well, you must be dimensionless if you're going to take its log.

CHAIRMAN POWERS: Well, I think you may be correct. It's just that we don't have the differential that you're going to use here. If you're going to integrate this over A as opposed to log A, then you need the A down there.

MR. MUNSON: Right. The important step is to quantify the one percent capacity in terms of the SSE times the margin. So this is how the SSE shows up in the log normal PDF.

These are the different quartile values for the log normal PDF.

And this is how we usually see fragility curves in terms of the cumulative distribution function. This is the one percent HCLPF point.

So once we had the SSE written in the fragility PDF, we can determine the SSE that meets the target performance goal. I've already discussed the target and the linear hazard curve. The other two parameter assumptions are the standard deviation is 0.4 and that the seismic margin is one.

Again, to test the validity of this assumption we looked at these SSE values for different frequencies and back-calculated what target we achieve by using these SSE values. For betas of .4, .5 and .6, we achieve this target or better. So they're slightly lower frequencies than the target, which is better.

For a beta of .3 we're slightly higher than the target, but it's not significant.

On the seismic margin, as we discussed this morning, the SECY 93-087 requires a seismic margin of 1.67. Earlier versions of this performance based approach actually took credit for this margin. In the ASCE 43-05 they don't take credit for the margin. They assume only a margin of one.

If you solve for the SSE after you solve the integral, the margin appears in the denominator. So if you assume a higher margin, you're going to have a lower SSE.

So in summary, just conclusion one. The staff came to the conclusion that the performance based approach achieves both high and consistent level of seismic safety. They don't take credit for a seismic margin. They equate the performance target to seismic core damage frequency, and we were able to

determine that it's based on conservative parameter in modeling assumptions.

Conclusion two was that the performance based SSE achieved safety levels generally higher than operating nuclear power plants for the Clinton site. The Commission policy on advanced reactors was that advanced reactors have the same degree of protection as operating nuclear power plants, and that advanced reactors provide enhanced margins of safety.

Using the Clinton performance based SSE values and the HCLPF seismic margin of 1.67, what are seismic core damage frequency values and how do these seismic core damage frequency values compare to current nuclear power plants?

So we looked at five and ten hertz. These are the two performance based values, and as a check, we looked at what would we get if we had used the old Reg. Guide 1.165. I'm calling it "old." It's not that old, but these are two points that would actually have been on the reg. guide SSE spectrum if we had done the reference probability approach.

CHAIRMAN WALLIS: Can you tell me? I'm getting puzzled here. What does SSE mean?

MR. MUNSON: Safe shutdown --

MR. SIEBER: Safe shutdown.

CHAIRMAN WALLIS: This is the ground motion, right?

MR. MUNSON: Ground motion.

CHAIRMAN WALLIS: And so when you have a higher MS you get a lower ground motion? I don't understand what you mean by that.

MR. MUNSON: Do you want to go back to that slide, please?

CHAIRMAN WALLIS: You mean that a given structure can withstand a lower ground motion? Is that what you infer?

MR. MUNSON: If you assume a higher margin, you design for a lower SSE.

CHAIRMAN WALLIS: But the ground motion I don't understand. They ought to design for a higher ground motion.

MR. MUNSON: No, if you take credit for a higher margin, then you can design for a lower SSE. If you take credit for no margin, then you have to have a higher SSE.

CHAIRMAN WALLIS: I don't understand. SSE is the ground motion which nature gives you, right?

MR. MUNSON: No, SSE is --

CHAIRMAN WALLIS: If you want a structure which has a greater margin of safety, it has got to be

stronger.

DR. SHACK: No, an SSE is selected.

MR. MUNSON: This is the selected performance based SSE.

DR. SHACK: You choose.

CHAIRMAN WALLIS: Well, I assume you know what you're doing. I'm baffled anyway. I thought a margin of safety was you made the thing stronger than you had to make it for a given SSE.

MR. BAGCHI: Perhaps one way to look at that is that this safe shutdown earthquake ground motion is going to be used in the design. This is the early site program. The site has the characteristic nature, has defined based on the probabilistic --

CHAIRMAN WALLIS: That's what's in the dots or is it in the left-hand side?

MR. MUNSON: That's the SSE.

CHAIRMAN WALLIS: What's what nature defined, the dots or the other side?

CHAIRMAN POWERS: Nature doesn't design the SSE.

MR. MUNSON: The hazard curve is in the dots. So that's what comes from the PSHA.

CHAIRMAN WALLIS: And SSE is what you design for?

MR. MUNSON: Yes.

CHAIRMAN WALLIS: So if you have a bigger margin, you design it to be a weaker structure?

MR. BAGCHI: If you later on assure that we are going to verify something for a margin beyond what the SSE calls for, then it would be stronger.

MR. MUNSON: So in other words, if we take credit for a higher margin --

CHAIRMAN WALLIS: What do you mean by taking credit for a higher margin? If nature gives you one, and you have the safe margin, then you get an SSE of .6 or something. It means you're now designing for .6 instead of for one? It doesn't make any sense, but maybe I'm just stupid.

MR. KENNEDY: Could I make an attempt? I'm not sure I can do any better, but let me make an attempt.

If you have a goal, let's say we have a goal, seismic core damage frequency, five times ten to the minus six. So that's our goal. The next thing we need to say is how much margin above our design SSE do we have.

If we assume we have a margin at one percent chance of failure, the margin for a one percent chance of failure versus the design is only

1.0, we would have to design for a higher SSE to achieve our performance goal of five times ten to the minus six. Then we would have to do if we said the one percent chance of failure point on the fragility curve is 1.67 times the design SSE.

CHAIRMAN WALLIS: This is because your CDF is realistic? Is that what it is in the seismic --

MR. KENNEDY: You're trying to aim at a realistic seismic core damage frequency.

CHAIRMAN WALLIS: Okay. Now I understand.

MR. KENNEDY: And where you set your earthquake could be lower if you have a higher HCLPF margin that you're taking credit for. I think that's all that Cliff is trying to get at there.

DR. SHACK: Another way of looking at it is it's the excitation that causes the structure to fail, and if you take a full account of the strength of the structure, obviously you can have a higher expectation. If you take a lower -- if you don't take account of the strength of the structure, you have a lower excitation, and that's what they've done.

CHAIRMAN WALLIS: So your CDF is realistic. That's what you mean.

DR. SHACK: No.

CHAIRMAN WALLIS: That's why it comes up.

DR. SHACK: It's conservative when you do it this way.

MR. MUNSON: If you are targeting onset of significant inelastic deformation, which is a lower damage state, then you assume no margin. If you're targeting seismic core damage, then you assume a margin of 1.67.

CHAIRMAN WALLIS: Okay.

MR. MUNSON: So go ahead to the next slide.

If we look at -- Bob showed this in a table this morning. For five and ten hertz, the seismic core damage frequency turns out to be compared to the other 25 sites, has a recurrence interval that's higher than the other sites. If we had used Reg. Guide 1.165, the average of five and ten hertz would be close to ten to the minus seven. So it shows that the Reg. Guide 1.165 that would have given a very, very conservative result.

CHAIRMAN WALLIS: An interesting plot. Usually it's frequency which goes the other way.

MR. MUNSON: I had decided to do it in terms of recurrence.

For conclusion three, we wanted to make sure that the SSE reflected the local hazard, and so

we took a closer look at the Springfield earthquake. We know that it was about 6,000 years ago nearly Springfield, which is about 60 kilometers southwest.

Original magnitude estimates were in this range, 6.2 to 6.8. The applicant in response to our open item cited a new study which put the magnitude estimate a little bit lower, down toward 6.3.

MR. SIEBER: And that's all based on liquefication?

MR. MUNSON: Liquefaction, the spread of the liquefaction features.

CHAIRMAN WALLIS: This is 6.3 plus or minus one uncertainty.

MR. MUNSON: Yes.

CHAIRMAN WALLIS: Is it an uncertainty of two or something or what is it?

MR. MUNSON: I have to look at the recent paper that they're citing. I can't remember off the top of my head what the uncertainty is.

CHAIRMAN WALLIS: Well, it's probably pretty big, isn't it, for this kind of earthquake?

MR. MUNSON: I would say at least .5.

CHAIRMAN WALLIS: And if it changes between estimates by .5, that's probably an indication of uncertainty.

MR. MUNSON: So here's the location of the site. Springfield is right here. These are some of the Wabash Valley. This is the figure from the original paper by Obermeier and McNulty.

The applicant did several of their own paleoliquefaction surveys on streams near the site to look for evidence of more of these earthquakes, and what they found was that there's no evidence of repeated moderate to large earthquakes comparable to Springfield. So, in other words, they didn't see paleoliquefaction evidence on the streams closer to their site that showed evidence of this type of large earthquake.

We asked Exelon to model the ground motion estimates from Springfield to compare them to the ten to the minus four in performance based SSE. That's the next slide.

This is the median ground motion expected from a Springfield earthquake given this magnitude range, and it is the 84th percentile compared to the ten to the minus four UHS.

The performance based SSE is slightly higher than this red curve.

Go back.

For the numeral estimate, as you can see,

it's a little bit lower for a magnitude of 6.3. The median and the 84 percent.

Okay. So in summary --

CHAIRMAN POWERS: But that presumes that if we had a repeat of the Springfield earthquake, it would be no larger than 6.3, right?

MR. MUNSON: Well, the first graph showed from 6.2 to 6.8. So they weighted those, again, like we did for the Wabash Valley.

CHAIRMAN POWERS: What I'm saying is you have one sample in the distribution. Okay? And you're uncertain about that, but there's no reason to think your uncertainty caps the terminus of that distribution.

MR. MUNSON: Right. So I mean, this is just a deterministic check basically. The probabilistic seismic hazard approach, this is like an old Part 100 check on --

CHAIRMAN POWERS: I understand what you're doing, but in the back of your mind you've clearly got -- in fact, on all of these earthquake sources you've got some idea that there is a maximum earthquake that one of these sources can produce, and you have historical evidence of samples from that distribution, but there is a cap on it.

MR. MUNSON: Right.

CHAIRMAN POWERS: And what I'm struggling, more out of curiosity than pertinence here, I'll admit, but is how do we know what that cap is. It's clearly not the biggest earthquake that has ever been observed at the site, though I could be close, and especially my understanding of the New Madrid earthquake is, indeed, maybe the maximum is going down as a function of time, but --

MR. MUNSON: But the recurrence is going up.

CHAIRMAN POWERS: And the recurrence is going up, and that, too, would make a lot of sense, but I mean, what --

MR. MUNSON: Would you go to the back-up slides?

MR. SIEBER: Don't you have to know something about the geological feature that caused the earthquake to be able to predict?

MR. MUNSON: In this case we don't. You rely on that.

CHAIRMAN POWERS: There is none.

MR. SIEBER: There is none. Well, that's a clue as to how soon it will recur and how big it will be.

CHAIRMAN POWERS: Well, it's not a clue to me of any kind.

MR. SIEBER: Well, there's one instance, and there is no source identified.

MR. MUNSON: What they look at is the occurrence of these liquefaction features. Over what area can they correlate them? And if it's a large area and the features themselves show a certain thickness, they're able to back calculate a magnitude for that.

MR. SIEBER: Right.

MR. MUNSON: So it's not the most certain exercise, but I guess this is at Springfield, and then this is some of the liquefaction features they found that were associated with that earthquake.

So for going in the probabilistic seismic hazard, they went up to magnitude 6.8 for the Springfield.

CHAIRMAN WALLIS: So how do they know it's Springfield? They look around at these streams and they see all of these features and they sort of draw a circle and find its middle or something? There must be a very qualitative sign. There could have been two separate earthquakes in two different places that gave rise to the same features.

MR. MUNSON: They have to do carbon dating.

CHAIRMAN WALLIS: But then you have to sort of figure out where it came from, don't you?

MR. MUNSON: They have to do carbon dating of material that they find.

CHAIRMAN WALLIS: Springfield is just sort of at the center of these symptoms presumably. It's a rash, and Springfield is somewhere near the middle.

DR. HINZE: Well, you don't find any other dates from any other of the surrounding areas. So that suggests that it's local.

CHAIRMAN WALLIS: So it's in this general area.

DR. HINZE: Right.

CHAIRMAN WALLIS: In Springfield, because Springfield happens to be near the middle.

DR. HINZE: The problem as I see it is that there has been no geological information provided that we can assess whether there's a structure or not. I mean a 6.2 to a 6.8, that's a very reasonable structure, and yet we don't know what the drilling is in that area.

CHAIRMAN POWERS: Didn't they give us a map of some sort?

DR. HINZE: No.

PARTICIPANT: They did a structural map.

DR. HINZE: but the structural map doesn't tell you anything if you don't know the data distribution, and the data distribution that you need is the pre-Pennsylvanian drill holes or you need to have some seismic work done in that area to discern whether there is a structural feature or not.

And if you were going to do this really right what you would do is you would do some three dimensional seismic work in that area and look not only at the final result, the sedimentary rugs, but you'd look at the basement rugs as well.

MR. MUNSON: And what would help is if we had a lot more earthquakes. I mean, no.

(Laughter.)

CHAIRMAN POWERS: I keep telling you we've got to have more earthquakes.

MR. MUNSON: But as a geophysicist, we would like to see more earthquakes. We could define it. We could locate them along a possible source and get a better idea what's going on, but there are just no earthquakes in that area. So I mean, the people of Springfield don't want more earthquakes.

PARTICIPANT: The thing is we want data.

DR. HINZE: The fact that we say that there is no structure just means that we have not looked. We don't have the data in which to look for that. But there's a difference here which we know the correlation and not the information to determine that.

CHAIRMAN POWERS: Yeah, I think the staff has been careful about saying there's no known structure in their documents.

DR. HINZE: But it also has to be stated why there is no known.

CHAIRMAN POWERS: It's not known because we didn't look.

DR. HINZE: Right.

MR. MUNSON: We would need more earthquakes actually occurring there unless we did do active exploration like you're suggesting.

I think that's all the slides I have.

DR. HINZE: Let me ask you a related question. One of the open items or one of the requests for further information by the staff was that you would like to have a better definition of the central Illinois seismic zone. Did you get that?

MR. MUNSON: I don't believe we asked. I'm trying to remember exactly, but I don't think we characterized the question in that. We wanted to get

an idea of the type of ground motion -- the most severe type of ground motion we would expect from a Springfield type earthquake.

I think we were aware of what Bob was talking about this morning, that it's almost there's no -- a rectangular source doesn't make, you know, sense in a geologic fashion, but they use that to envelope the site and encompass all of the local seismicity.

So the hazard is determined on the one kilometer grid interval when they do the PSHA. So the boundaries of the source zone are not critical.

DR. HINZE: You'd like to have it make some geological sense though, wouldn't you? A lot more comfortable.

MR. MUNSON: At least for when you put it up on a map and you see a rectangle you'll know what it is.

MR. SIEBER: Assuming the county is related.

MR. MUNSON: Yeah, the county line.

So hopefully we've demonstrated that we did a very thorough review of this performance based approach. We wanted to make sure that the parameter assumptions, the modeling assumptions that they made

for this approach were conservative and that we were coming up with a safe shutdown earthquake ground motion that we felt comfortable with and that compared favorably with current nuclear power plants.

And we found that the performance based SSE generally gives a higher level of seismic safety than existing nuclear power plants.

We're continuing to look at performance based. We're continuing to interact with industry looking at this approach, how to refine it further for future applications.

CHAIRMAN POWERS: Do you anticipate staff coming out with a reg. guide that endorses this?

MR. MUNSON: Perhaps I could have Andy. He's our site tech. chairman, and he's in our research -- address that question.

MR. MURPHY: Would you repeat your question, please?

CHAIRMAN POWERS: Well, I mean it's not uncommon for the staff to come out with a regulatory guide that says one of these standards is acceptable to the staff for this, and I'm just wondering do you anticipate doing this.

MR. MURPHY: Yes, we are anticipating very definitely revising Reg. Guide 1.165, and one of the

items very prominent on our table for consideration at this stage is the ASCE 43-05 standard. Basically we are looking at it, having some contractors look at it for us as well with the determination to make use of it.

It would not be at this stage a direct endorsement, but more like speaking at important parts of it because there is an awful lot of material in 43-05 that is not exactly pertinent to our problem.

CHAIRMAN POWERS: Okay. That is a little different way of portraying it, but the same net effect.

MR. MURPHY: Yes, sir.

MR. MAYNARD: Question. You said that this performance based method will result in -- I forget how you put it -- safer plants or plants that have higher margin than the existing plant. I tried to understand.

Does that mean that the newer plants will have -- using this methodology, will they have to build the newer plants to a higher design criteria or does it mean that the seismic response spectra comes out less?

MR. MUNSON: Well, what will happen is the sites that do COLs or ESPs will come up with the safe

shutdown of earthquake, and then they'll have to pick an advanced reactor design that envelopes the site SSE.

MR. BAGCHI: Can I address your question directly?

I think that the response spectra will come out higher. The hazard has gone up. The performance based method gives us some kind of a stability with respect to how the designs are incorporated, how the SSE is determined, but clearly, you know, you can compare the existing response spectrum against the new one, and you will see that it's much bigger.

MR. MAYNARD: That answers my question.

CHAIRMAN POWERS: I mean, that's a phenomenological fact that the earthquakes are now more frequent, and in some cases have higher magnitudes.

MR. BAGCHI: Well, that aside, we are targeting a performance. That's the best part of this method.

DR. BONACA: But doesn't Figure 29 -- the Figure 29 shows that the performance based approach is still conservative with respect to the current plants, but not as conservative as the one on Reg. Guide

1.165.

MR. BAGCHI: That's the crux of the problem with targeting a reference probability. The reference probability will change if only the earthquake hazard at a few specific plants changes, and how much do you chase around this? Then you cast aspersions against the existing plants, like the ones that we are facing today.

DR. BONACA: Now I understand about stability. Okay? I understand the issue.

DR. SHACK: That sort of implies though that the performance you thought you were getting would be developed in 1.165 is similar to the performance you're getting now out of the performance based thing. Is that true? Was that your intent?

MR. MUNSON: The Reg. Guide 1.165 approach is using 1990s hazards.

DR. SHACK: No, when they picked the frequency that they presumably looked at, they presumably picked that frequency so they would get some performance.

MR. MUNSON: They picked it as the median of all these 25 sites. That's what the reference probability is based on.

MR. BAGCHI: Reg. Guide 1.165 really

focused only on hazard. If you go back and read that, you'll see that it is based on the hazard, the assurance was, that the existing 28 sites or 25 sites have SSEs that in the median, the average have the same kind of reference probability.

That's why one of the ways would have been to go back and establish a new reference probability, but what would that do? In another five years some change in geoscientists and we're going to have yet another reference probability.

So that's a very unstable way to do this. That's why this performance based approach is a target of the performance of the plant.

CHAIRMAN WALLIS: Well, it makes sense, but I'm just trying to clarify what you've been saying here. What I think I heard is that if you used this performance based approach, this plant is going to be safer against seismic than the average of existing plants, but it's going to be less safe than if you had used the 1.167 methodology.

MR. BAGCHI: That's right.

CHAIRMAN WALLIS: So you are relaxing something.

DR. BONACA: And the issue is -- the reason why I was pursuing that is, you know, you seem

to imply that you're comfortable with that, and I want to hear it.

PARTICIPANT: Well, if we can go back and look at what we had accomplished with Reg. Guide 1.165 with a reference probability with only emphasis on hazard, we in hindsight are now finding out that that is a very unstable way to determine how to design the plant for earthquakes.

DR. BONACA: I understand the issue of stability. I repeat that.

PARTICIPANT: Let me try to address that.

DR. BONACA: I still say, you know, we went from one they gave you for a new plant. They set them out to a certain value, 2.1, that gives you stability, but is not as conservative, and so I want to hear from you that you're comfortable with the conservatism that this matter still includes.

MR. MUNSON: Well, if you look at Reg. Guide 1.165, the basis of the reference probability is it was the median of all of these SSE sites. So we were picking the middle value of all these 29 sites and setting our reference probability level.

Now what we're doing, we're looking at this in terms of seismic core damage frequency in terms of this, and we're seeing a much higher in terms

of recurrence, a much higher value. This is unreasonable. That's 12 million years of recurrence right there.

I mean, how can we expect them to design to 12 million years of recurrence?

CHAIRMAN POWERS: We do that for Yucca Mountain.

MR. MUNSON: I don't want to talk about that.

(Laughter.)

DR. BONACA: I know that. Now that makes more sense to me, what it is conveying, okay?

MR. BAGCHI: As a structural engineer, I'll give you my other sense, which is I've designed a lot of plants. Before I came to the United States 31 years ago, I designed plants for seismic resistance, and I know how the response factor evolved, and if you look at the response factor at North Anna ESP site versus the whole site, you'll find that the response factor is much higher. The design would be I mean just in fewer seismic there, it's going to be higher.

So we are comfortable with that.

CHAIRMAN POWERS: Any other questions for the speakers?

DR. SHACK: Well, it's the question we came to earlier today now. What implications does this higher hazard mean for the existing plants?

MR. BAGCHI: We have the Generic Issue 199 identified for that, and Office of Research is --

MR. MUNSON: Engaged.

CHAIRMAN POWERS: Any other questions?

(No response.)

CHAIRMAN POWERS: Well, than you very much.

Do you have any closing comments, Laura?

MS. DUDES: No. Just thank you. I think again, you know, this is just the beginning. I know you're going to hear about the issue generically through the reg. guide development and through the generic issue resolution, and we will be approaching this again shortly with our next early site permit.

CHAIRMAN POWERS: That brings up the issue. You're presenting at the full Committee.

MS. DUDES: Tomorrow.

CHAIRMAN POWERS: And what do you think ought to be presented at the full Committee? You catch me a little bit flat footed. Your presentation was an excellent presentation, but I think it might be just a little terse for the full Committee.

Is the applicant intending to present to the full Committee?

MR. GRANT: Yes, I believe we have a presentation prepared.

CHAIRMAN POWERS: I think your introductory presentation and synopsis would be just excellent for the full Committee. You probably don't need to plunge into the details, but where you've been and where we're going and that you've closed all of the issues probably is the level of detail they need.

And then, Laura, you need to figure out -- I mean "you" collectively, John -- need to figure out how to communicate fairly succinctly to the committee that you've looked at this in some depth and for the agency as a whole, and I think it's very important for that to come across to the full committee.

And I will have to say that you have definitely persuaded me that you've looked very thoroughly. So I would hope that you would persuade the rest of the Committee.

Do other members have suggestions on how they present this material?

How much time do we have on the Committee schedule? It's fairly short.

MR. SNODDERLY: About two hours.

CHAIRMAN POWERS: Oh, well, we have a world of time.

(Laughter.)

CHAIRMAN POWERS: Lots of time.

I don't expect you to get -- okay. We have lots of time, and I don't expect you to get a very close interrogation because most of the people who would interrogate you have already been sitting here. So this is likely to go very quickly I would suspect.

DR. BONACA: But there's George.

MR. MUNSON: Would you like a more qualitative description of our approach to it rather than these probability density function and --

CHAIRMAN POWERS: I think you've hit upon it. With some discussion of this agency-wide will get it across to the full members.

MR. MUNSON: Okay.

CHAIRMAN POWERS: I mean, don't get me wrong. I liked your presentation a lot, and you succeeded in your mission, which was to persuade me you've done a good job reviewing this material, and I very much got that impression.

CHAIRMAN WALLIS: Well, I wouldn't take out all of the quantities of stuff. I think the

business of the two curves that you multiply together to get something with an X on showing that you don't need to worry about the tails and so on is important. I think some of the equations you could do without.

A graph like that that really is the core of what you did I think is important to show.

MR. MUNSON: Okay.

MR. BAGCHI: Dr. Powers, just one point of caution. We did look at this method for this particular site, and it detailed a thorough submittal in the future along the lines of Exelon, would probably receive a lot fewer requests for additional information, but let's keep in mind that our generic guidance is yet to come.

CHAIRMAN POWERS: Right, and you should make that point as well.

Any other comments to guide them on presenting to the full committee?

MR. SEGALA: In terms of the whole review, do you just want me to briefly --

CHAIRMAN POWERS: Quick status report because I think we in our interim letter, we gave you a pretty blanket endorsement of what you were doing there save for the fact that we really don't like the way you handle weather.

But other than that, I mean, I think our interim letter essentially closed out all of the issues save the seismic, but a quick status report never hurts.

MR. SEGALA: Okay.

CHAIRMAN POWERS: Okay. At this point I'm going to go off the record and I want to poll members on comments and developing our draft position. People are certainly welcome to stay and clarify our thinking.

(Whereupon, at 12:04 p.m., the meeting was adjourned.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Early Site Permit Subcommittee

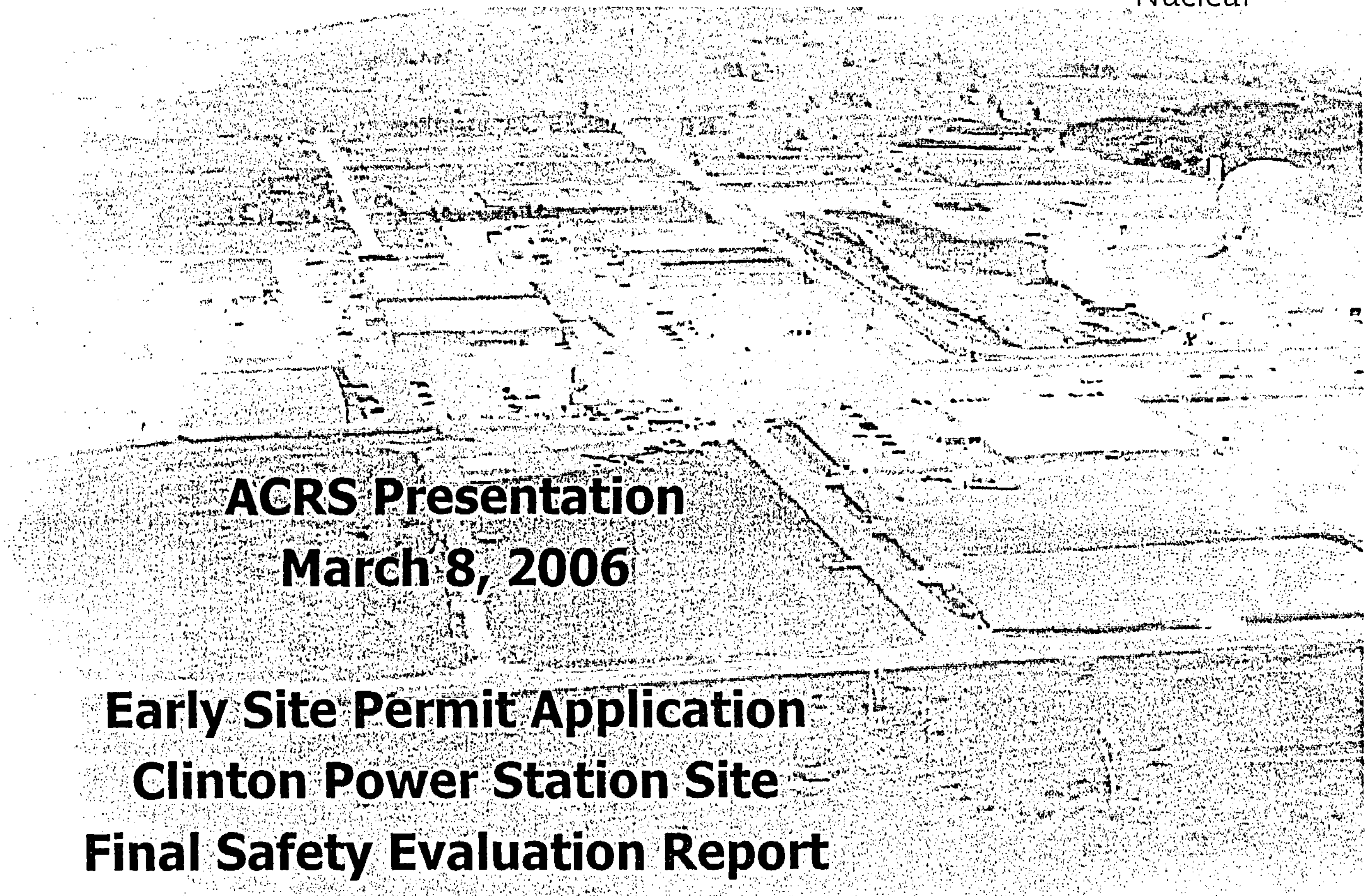
Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Eric Hendrixson
Official Reporter
Neal R. Gross & Co., Inc.

Exelon Nuclear



ACRS Presentation
March 8, 2006

Early Site Permit Application
Clinton Power Station Site
Final Safety Evaluation Report

Exelon Nuclear

Agenda

- Introductions
- Significant Changes Since Draft Safety Evaluation Report (DSER)
- Geotechnical Approach
- Seismic Evaluation
- Supplemental DSER Issue Closure
- Summary

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Introductions - ESP Project Team

- Marilyn Kray – Project Executive Sponsor
- Christopher Kerr – Sr. Project Manager
- Eddie Grant – Safety / EP Lead
- William Maher – Environmental Lead

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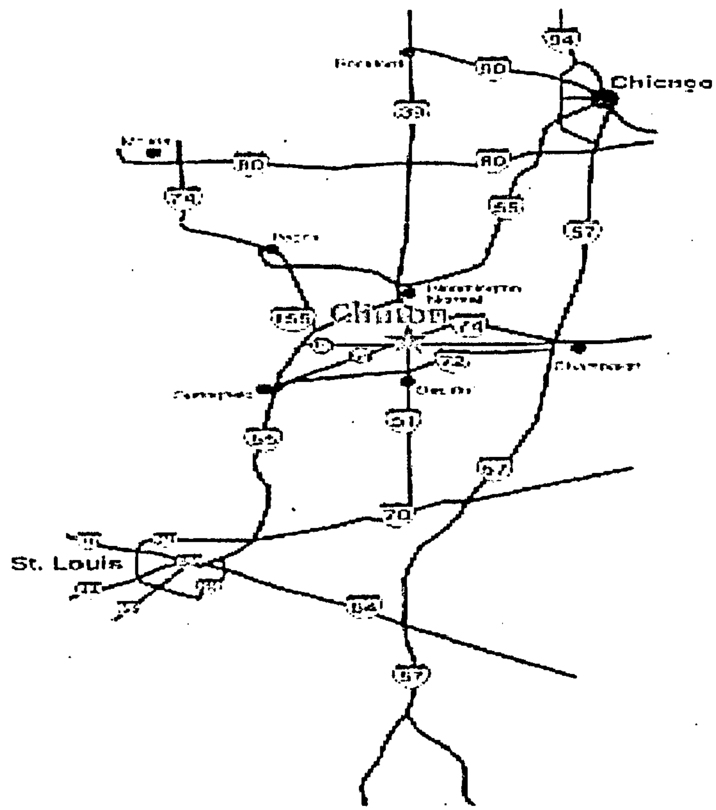
Introductions – Support Team

- CH2M Hill (Prime Contractor)
  - Environmental / Redress
  - Geotechnical
  - EP
- CH2M Hill Subcontractors
  - WorleyParsons
    - Safety
  - Geomatrix
    - Seismic
  - Seismic Board of Review
    - Expert, independent review
  - Others
- RPK Structural Mechanics Consulting
  - Seismic
- Sargent and Lundy
  - Draft Application Review
- Morgan Lewis
  - Legal counsel

Introductions – Site Location

- ESP Site Location
  - Central Illinois
  - Clinton Power Station Property
  - AmerGen Owned (EGC Subsidiary)
- Applicant
  - Exelon Generation Company, LLC (EGC)
    - o Wholly owned subsidiary of Exelon Corporation



Significant Changes Since DSER

- ➢ Closure of all Open Items
- ➢ Completion of all Confirmatory Items
- ➢ Acceptance of SSE ground motion spectra
  - Minor revisions in response to open items
- ➢ Documented Criteria for:
  - Permit Conditions
  - Combined License Action Items

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Geotechnical Approach

- ➢ Builds on existing CPS information
  - Regional geology
  - Site geology
  - Exploration
  - Laboratory testing
- ➢ EGC ESP work
  - Confirm conditions
  - Updated information

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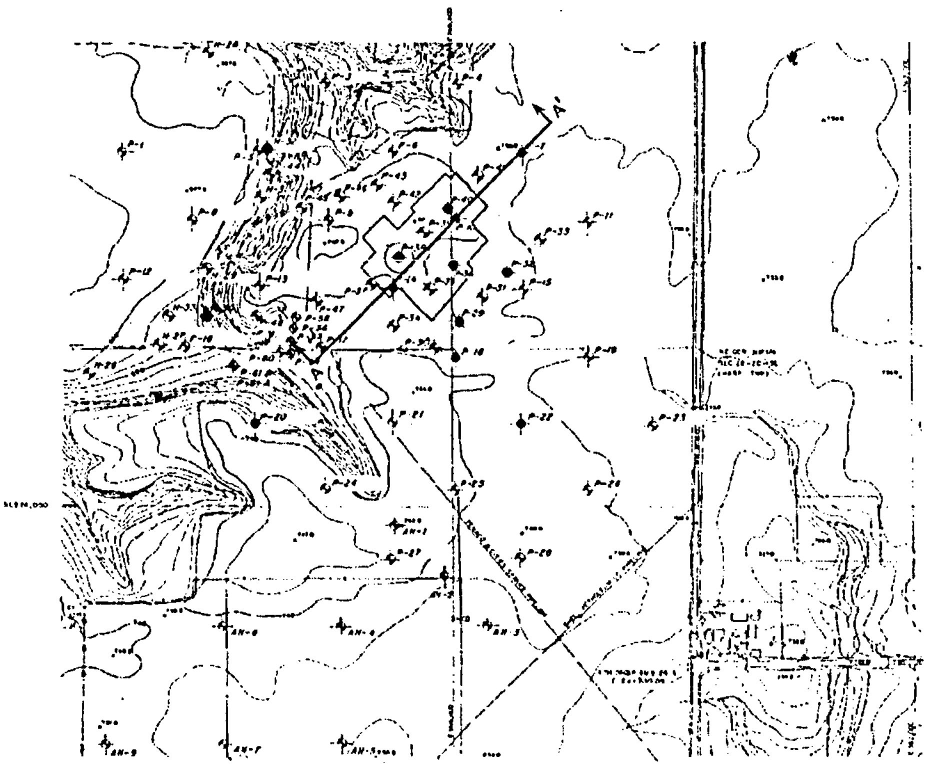
Geotechnical Approach (cont'd)

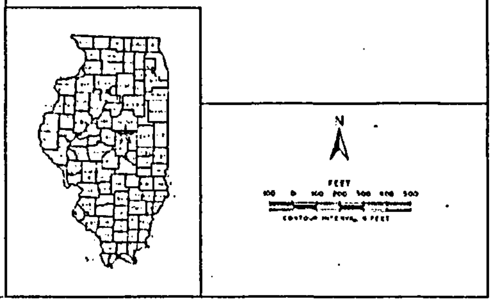
Geotechnical Report for the EGC Early Site Permit

Figure 2-5
Original CPS Site
Investigation Locations



Legend
Topographic Contours
Borehole Location
Location of Borehole that Extended to Bedrock
Section A A' (See Figure 2 6)

Notes:
1. Modified from: CPS, 2002



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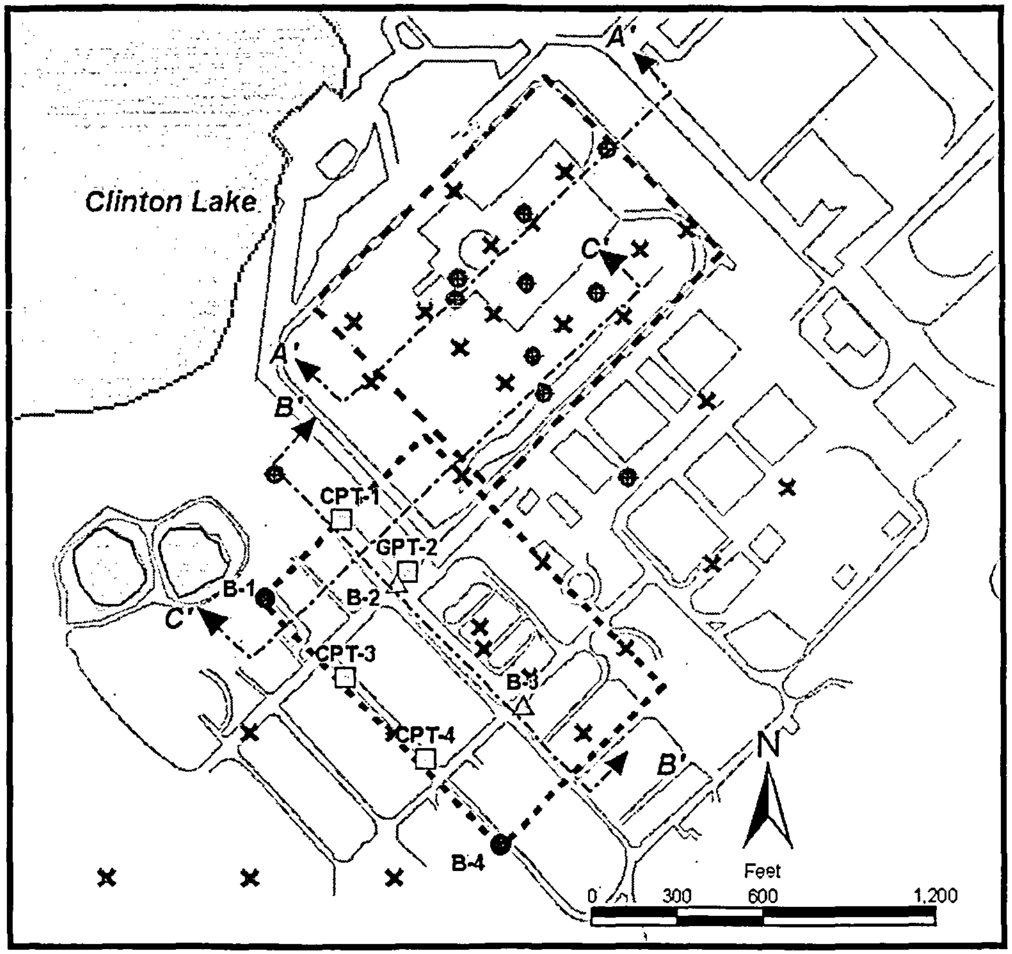
Geotechnical Approach (cont'd)



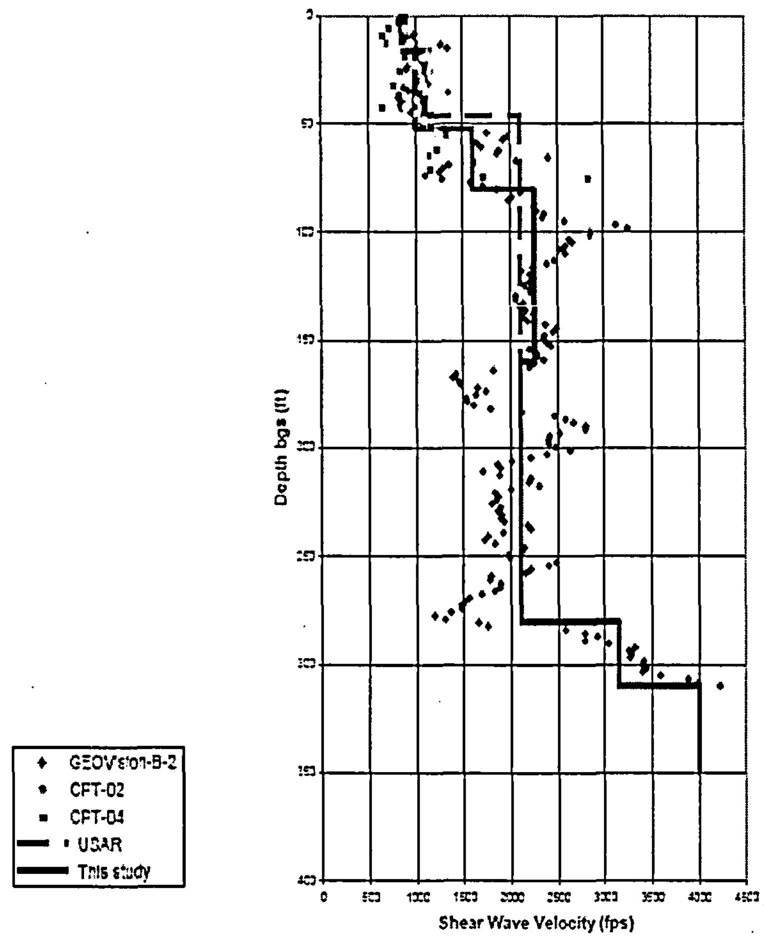
Modified from ESP SSAR, Appendix A, Figure 3-1

Geotechnical Approach (cont'd)

Site is:
- ➢ Relatively uniform
- ➢ Stiff soils

Field data shows:
- ➢ Shear wave velocities consistent with CPS characterizations

Lab data shows:
- ➢ Good match to EPRI soil modulus and damping curves



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Seismic Evaluation
SSE Ground Motion Determination

RG 1.165 Methodology

- Investigations
- Seismic sources update
- SSHAC assessment
- PSHA
- Determine SSE ground motion spectra
  - **Relative based -- Reference Hazard Probability Criterion**

EGC ESP Application

- Same
- Same
- Same
- Same
- Determine SSE ground motion spectra
  - **Performance-based – Risk-informed Criterion**

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Seismic Evaluation (cont'd)

SSE Ground Motion Determination (cont'd)

RG 1.165 Methodology	*EGC ESP Application*
➢ De-aggregate to identify controlling earthquakes	➢ Same
➢ Account for site effects	➢ Same [NUREG/CR-6728]

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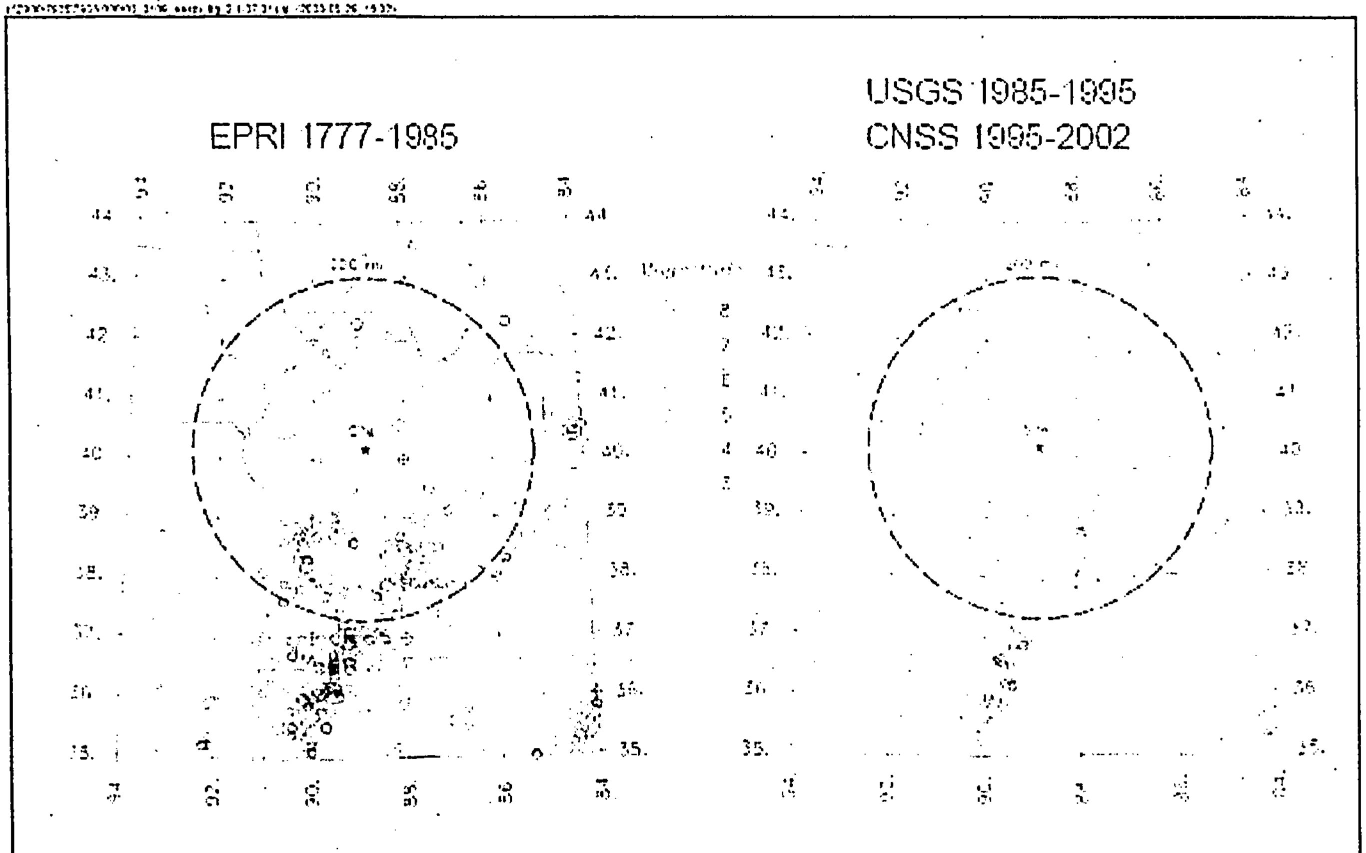
Seismic Evaluation (cont'd)

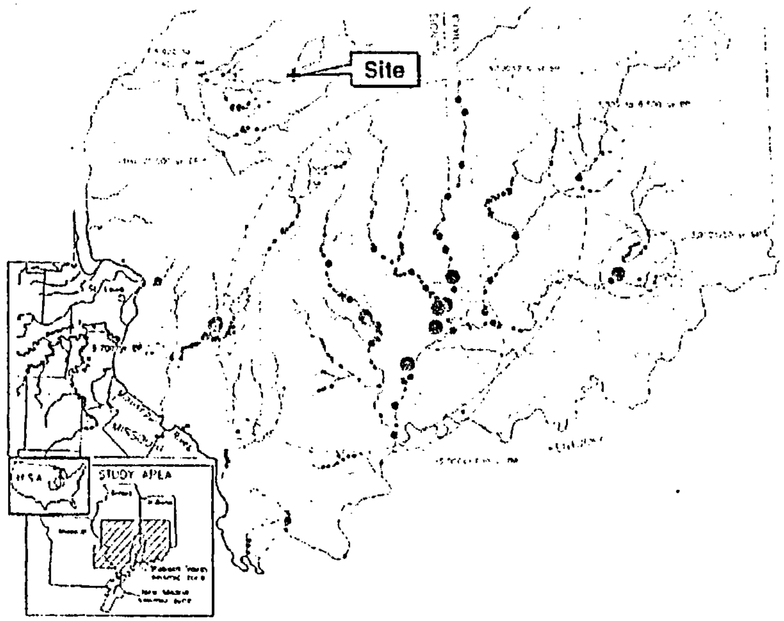


Seismic Hazards Report for the EGC ESP Site
Updates to Seismicity Catalog

Figure 2.1-11

Seismic Evaluation (cont'd)

- Major new information
  - Repeated large events in New Madrid seismic zone in past 2,000 years
  - Large events in Wabash Valley/ Southern Illinois in past 12,000 years
  - One moderate event with energy center ~30 miles SW of site at Springfield ~6,000 years ago



Seismic Evaluation (cont'd)

Reference Hazard
RG 1.165, App. B

- Reference Probability
  - The annual probability level such that 50% of the set of most modern design currently operating plants have an annual median probability of exceeding the SSE that is below this level (1E-5) determined at an average of the 5 and 10 Hz SSE spectra with 5% damping.

Performance-Based
ASCE 43-05

- Performance-Based
  - SSCs will have a target mean annual frequency of 1E-5 for seismic induced onset of significant inelastic deformation.
  - Significant margin against SSC failures that might lead to core damage.
  - Leads to seismically induced CDF significantly less than for existing plants

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Seismic Evaluation (cont'd)

Performance-Based Approach History

- LLNL UCRL-15910, Design and Evaluation Guidelines for U.S. Department of Energy Facilities Subjected to Natural Phenomena Hazards, 1990
- DOE-Std-1020, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, 1994 & 2002
- USNRC NUREG/CR-6728, Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines, 2001
- ASCE/SEI 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities, 2005

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Seismic Evaluation (cont'd)

Performance-Based Approach Basis

- Establish Target Seismic Risk Goal, P_{FT}, Against OSID
- Establish Design Criteria Conservatism
  - ASCE Most Stringent Seismic Design Category, SDC-5D
  - Similar to Seismic Design Criteria, NUREG-0800
- Establish UHRS
  - Reference Seismic Hazard Exceedance Frequency, H
- Increase UHRS by "Design (Scale) Factor," DF

  (Based on Minimum Seismic Margin Factors for OSID)
  - 1% Probability of Unacceptable Performance for SSE
  - Also 10% Probability of Unacceptable Performance for 1.5xSSE

Seismic Evaluation (cont'd)

Performance-Based Approach Application

- Target Seismic OSID Risk Goal, $P_{FT} \leq$ mean 10^{-5}/yr
  - Based on Reported Seismic CDF of 25 licensed plants
- Design Criteria, NUREG-0800 ~ ASCE SDC-5D
- UHRS established at mean 10^{-4}/yr
- "Design (Scale) Factor," DF = 1.04 to 1.30 for EGC ESP
- Perform Probabilistic Analysis
  - Seismic CDF $\leq$ mean 2×10^{-6}/yr for EGC ESP

[[Detailed Derivation (ADAMS ML050250137)]]

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Seismic Evaluation (cont'd)

Seismic CDF for EGC ESP Hazard Curves

β	ASCE Method - SCDF $F_{1\%} = 1.67$ $*1x10^{-5}/yr$				
	1 Hz	2.5 Hz	5 Hz	10 Hz	Average 5 & 10 Hz
0.3	0.39	0.26	0.22	0.16	0.19
0.4	0.27	0.17	0.14	0.11	0.12
0.5	0.20	0.12	0.11	0.086	0.096
0.6	0.15	0.10	0.087	0.078	0.082

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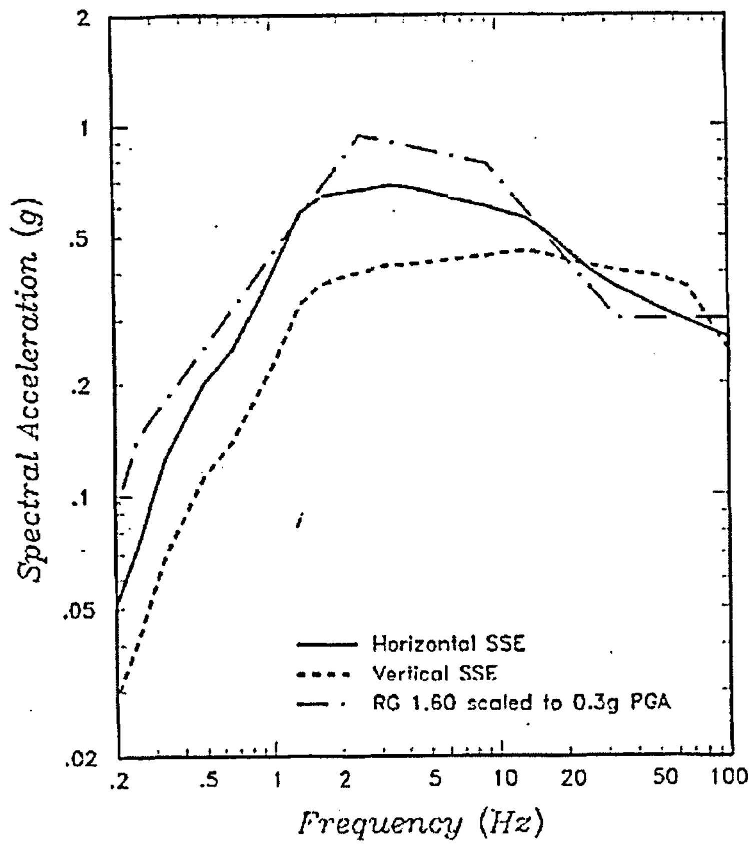
Seismic Evaluation (cont'd)

- Performance-Based EGC ESP SSE Ground Motion Spectra
  - Horizontal DRS
  - Vertical DRS
  - RG 1.60 0.3g PGA (for reference only)
  - Acceptable to NRC Staff
  - Compared to Design Spectra at COL stage



Supp. DSER Issue Closure

- Open Items (7) - resolved
  - 2.5.1-1, New Madrid magnitude estimates
  - 2.5.2-1, Distance-conversion in EPRI '03 Ground Motion Model
  - 2.5.2-2, Site velocity model for response analysis
  - 2.5.2-3, Site dynamic response analysis
  - 2.5.2-4, SSE ground motion adequately represents local prehistoric earthquakes
  - 2.5.2-5, Performance-based method clarification
  - 2.5.4-1, Additional borings

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Supp. DSER Issue Closure

- New Madrid magnitude estimates
  - 2.5.1-1, NRC Issue – Incorporate hazard due to recent new estimates of magnitudes of the New Madrid earthquakes

Applicant actions:

- Hazard revised to include the small impact
  - o Site response spectra revision < 10%

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Supp. DSER Issue Closure (Cont'd)

➢ Distance-conversion in EPRI 03 Ground Motion Model

- 2.5.2-1, NRC Issue – Provide further clarification of EPRI 03 Ground Motion Model distance-conversion methodology

Applicant actions:

- Provided detailed description of the EPRI '03 distance-conversion implementation process

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Supp. DSER Issue Closure (Cont'd)

- Site velocity model for response analysis
  - 2.5.2-2, NRC Issue – Further justify using a single velocity model for variability in strength and stiffness of site soils

Applicant actions:

- Variability of concern is in top 60 ft of soil profile
  - This soil will be removed/replaced to address the potential settlement and liquefaction issues
  - Identified by NRC as proposed Permit Requirement

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Supp. DSER Issue Closure (Cont'd)

➢ Site dynamic response analysis

- 2.5.2-3, NRC Issue – Demonstrate appropriateness of site dynamic properties model and implement 15% damping cutoff on free-field site response

Applicant actions:

- Provided additional information on soil plasticity and revised analysis using 15% damping cutoff
  - o Site response spectra revision < 2%

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Supp. DSER Issue Closure (Cont'd)

- SSE ground motion adequacy
  - 2.5.2-4, NRC Issue – Justify SSE adequacy as bounding local prehistoric earthquakes

Applicant actions:

- Clarifying information provided addressing:
  - o Use of prehistoric earthquake data in PSHA
  - o Determination of controlling earthquake per RG 1.165
  - o Relation of SSE ground motion to controlling earthquake
  - o Comparison of SSE ground motion to estimated local prehistoric earthquake

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Supp. DSER Issue Closure (Cont'd)

➢ Performance-Based Method Clarifications

- 2.5.2-5, NRC Issue – Provide additional information regarding assumptions for implementation of the performance-based methodology

Applicant actions:

- Clarifying information provided addressing:
  - o Appropriate mean annual hazard for implementing method
  - o Determination of design factors and assumption of HCPLF margin and SSC capacity
  - o Onset of significant inelastic deformation
  - o Target performance goal value, its stability, and applicability for advanced reactor designs
  - o Similarity of design criteria in SRP and ASCE

Supp. DSER Issue Closure (Cont'd)

➢ Additional borings

- 2.5.4-1, NRC Issue – Additional borings will be needed at COL stage

Applicant actions:

- COL applicant will address additional borings per RG 1.132 guidance

Summary

- All Open Items Closed
- All Confirmatory Items Completed
- SSE Ground Motion Spectra Accepted

Exelon Early Site Permit
Seismic Review Status

March 8, 2006

Advisory Committee on Reactor Safeguards
Early Site Permit Subcommittee Meeting

John Segala, Senior Project Manager
Office of Nuclear Reactor Regulation

Purpose

- To provide the ACRS an overview of the Exelon early site permit (ESP) application seismic review
- Answer the Subcommittee's questions

Meeting Agenda

- Schedule Milestones
- Seismic Open Items
- Presentation Conclusions
- Discussion / Subcommittee questions

Completed Milestones

- Received Exelon ESP application - September 25, 2003
- FRN published announcing acceptance – October 31, 2003
- FRN published for mandatory hearing – December 12, 2003
- RAIs issued to the Applicant – July, 27, 2004
- Draft SER issued – February 10, 2005
- Applicant responds to Draft SER open items – April 26, 2005
- Supplemental Draft SER issued – August 26, 2005
- ACRS Full Committee Meeting - September 8, 2005
- ACRS interim letter – September 22, 2005
- Staff provided Final SER to ACRS – February 9, 2006
- **Staff issued Final SER – February 17, 2006**

Remaining Milestones

- ACRS Full Committee Meeting – March 9, 2006
- ACRS letter assumed -- March 30, 2006
- Final SER issued as NUREG – May 1, 2006
- Mandatory hearings begin Fall 2006
- Commission decision assumed mid 2007

Seismic Open Items

- 7 Seismology and Geology Open Items
  - 2 - Performance-based (PB) approach for determining safe shutdown earthquake (SSE)
  - 2 – Seismic
  - 3 - Geotechnical

Seismic Open Items

- 2.5.1-1, Incorporate most recent New Madrid seismic source model into the PSHA and SSE
- 2.5.2-1, Clarify the EPRI ground motion attenuation study distance-conversion method

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Geotechnical Open Items

- 2.5.2-2, Site response model does not adequately represent variability of soil properties
- 2.5.2-3, Site response analysis should use appropriate shear modulus and damping curves
- 2.5.4-1, Further soil exploration needed for COL

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NRC Experience with the Performance-Based Methodology

- NUREG/CR-6728 (April 2002) first introduced the staff to the performance-based approach
- NRC staff participated on the Committee that developed ASCE 43-05
- Use of a performance-based approach for determining the SSE first identified in Exelon's application in September 2003
- NRC formed a Seismic Technical Advisory Group
  - Seismic & Civil Engineers from NRR, NMSS, and RES
  - Served in an advisory role to NRR for review of performance-based approach

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Exelon's Performance-Based (PB) Safe Shutdown Earthquake (SSE)

NRC staff concluded:

1. PB method based on sound technical approach
2. Seismic design using PB SSE achieves safety level generally higher than operating plants
3. PB SSE adequately reflects local ground motion hazard from Springfield earthquake

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Conclusion 1

PB method based on sound technical approach

- Overriding Goal: Achieve both high and consistent level of seismic safety in the design of future NPPs
- PB approach is risk-based
  - Incorporates both site specific seismic hazard and structural fragility model
- PB approach requires structures be designed to achieve target performance goal

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Conclusion 1 (Cont.)

- PB SSE determined by two approaches:
  - Design Factor Method (ASCE 43-05)
  - Direct Integration of Risk Equation
- Design Factor Method
  - PB SSE determined by multiplying 10^{-4} UHRS by design factor to achieve target performance goal

$$PB\ SSE = DF \times UHRS_{10^{-4}}$$

$$DF = \text{Max}\ (0.6A_R^{\ 0.8}, 1.0)$$

$$A_R = \frac{UHRS_{10^{-5}}}{UHRS_{10^{-4}}}$$

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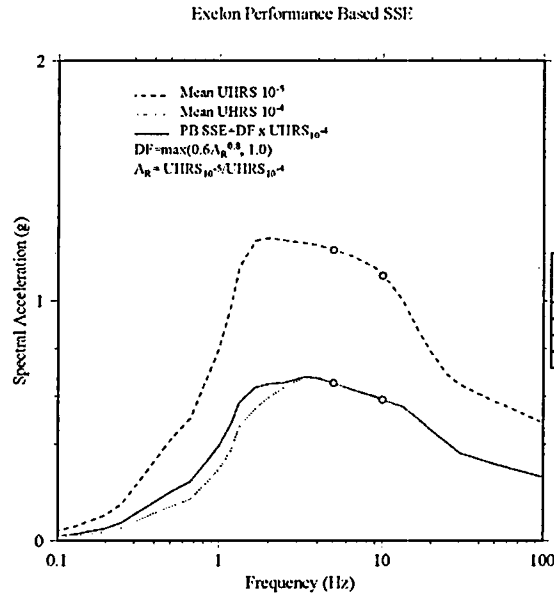
Conclusion 1 (Cont.)



Spectral Frequency (Hz)	10-4 Mean UHRS (g)	10-5 Mean UHRS (g)	AR	DF	Horiz. SSE (g)
1	0.297	0 802	2.700	1.328	0.395
2.5	0 638	1.256	1 968	1.031	0.658
5	0 657	1.215	1 849	1.000	0 657
10	0.586	1.107	1 887	1.000	0.586

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Conclusion 1 (Cont.)

- Direct Integration

$$P_{fT} = \int H(a) f_c(a) da$$

P_{fT} = Target Performance Frequency

$H(a)$ = Seismic Hazard Curve

$f_c(a)$ = Probability Density Function for SSC Seismic Fragility

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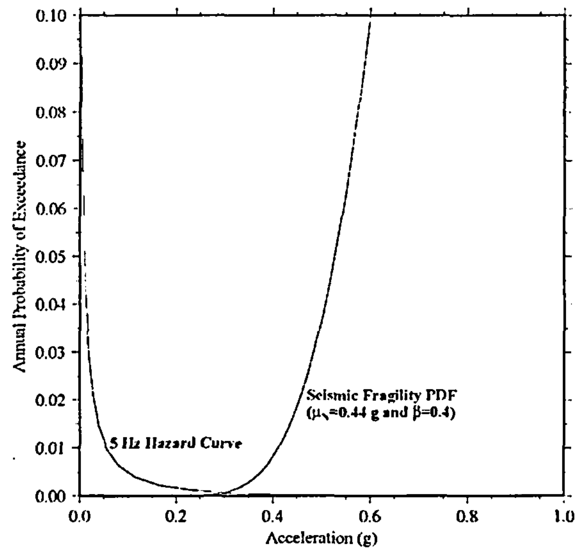
Conclusion 1 (Cont.)



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Conclusion 1 (Cont.)

- Performance Target (P_{FT}) is $1\text{x}10^{-5}$ per year
  - Implies probability of onset of inelastic behavior shall be less than 10^{-5}/yr
- Basis for P_{FT} 10^{-5}/yr:
  - IPEEE Seismic PRAs conducted for 25 NPPs during mid/late 1990s determined annual seismic CDF values
  - Median SCDF is 1.2x10-5/yr
- P_{FT} corresponds to minimum damage state
- SCDF implies a higher damage state

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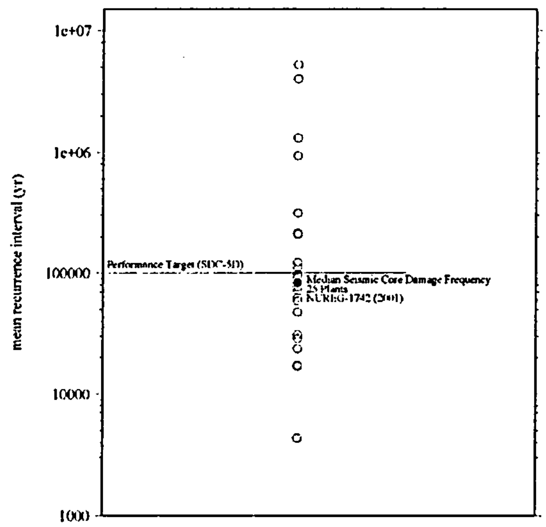
Conclusion 1 (Cont.)

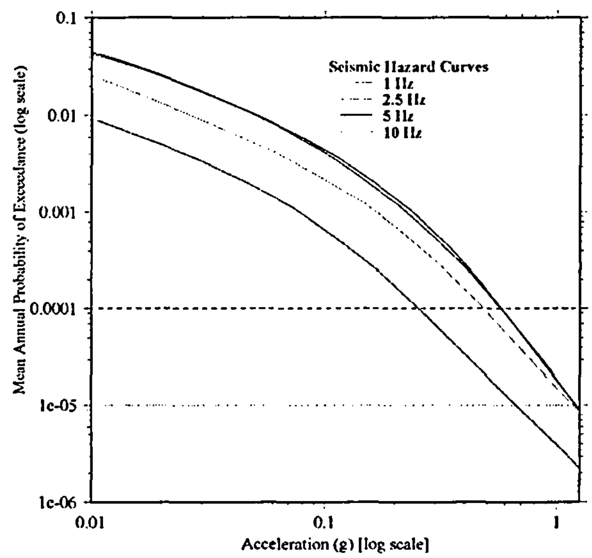


Conclusion 1 (Cont.)

- Seismic Hazard Curve
  - ASCE 43-05 assumes a linear hazard curve between 10^{-4} and 10^{-5}
  - Slight downward curvature of hazard curve

	SSE	
Frequency (Hz)	Risk Integral (g)	Risk Equation (g)
1	0.337	0.395
2.5	0.574	0.658
5	0.604	0.657
10	0.559	0.586

Conclusion 1 (Cont.)



Conclusion 1 (Cont.)

- Seismic Fragility
  - PB approach models SSC seismic fragility using lognormal distribution

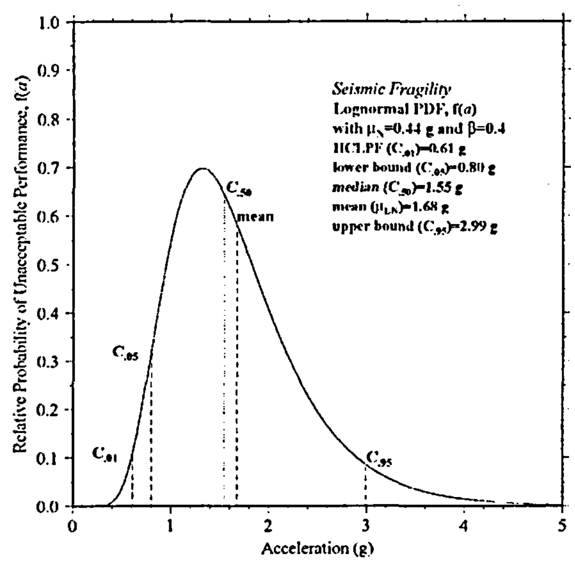
$$f_c(a) = \frac{1}{\sqrt{2\pi}\beta a} \exp\left[-\frac{1}{2}\left(\frac{\ln a - \mu}{\beta}\right)^2\right], a > 0$$

  - Fragility Parameters: Mean (μ), SD (β)
    - Mean expressed in terms of $C_{1\%}$ or HCLPF
    - HCLPF corresponds to 1% capacity level on mean fragility curve

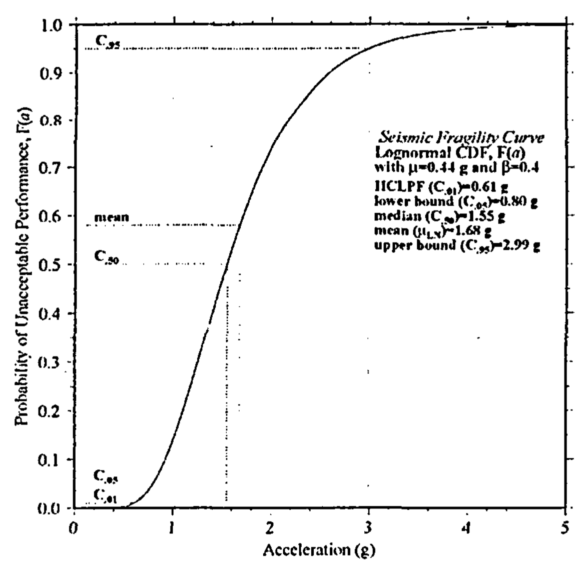
$$\mu = \ln HCLPF + 2.32\beta$$

$$HCLPF = SSE \times M_s$$

Conclusion 1 (Cont.)



Conclusion 1 (Cont.)



Conclusion 1 (Cont.)

- Parameter Assumptions
  - SSE is back-calculated by assuming:
    - Target $P_{FT} = 1x10^{-5}/yr$
    - Linear Hazard Curve
    - $\beta = 0.4$
    - Seismic Margin = 1

Conclusion 1 (Cont.)

Target Performance Frequency for $\beta = 0.4$

		PFT*10-5/yr			
Freq (Hz)	SSE (g)	β=0.3	β=0.4	β=0.5	β=0.6
1	0.395	1.08	0.95	0.7	0.55
2.5	0.658	1.05	0.97	0.73	0.59
5	0.657	1.03	0.96	0.71	0.58
10	0.586	1.02	0.91	0.65	0.52

Conclusion 1 (Cont.)

- Seismic Margin (M_S)
  - SECY 93-087 requires an overall HCLPF Seismic Margin of 1.67
  - ASCE 43-05 does not take credit for Seismic Margin ($M_S = 1$)
    - Higher M_S results in lower SSE

$$SSE = \frac{1}{M_s}(\ldots)$$

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Conclusion 1 (Cont.)

<u>Summary of Conclusion 1</u>:

- PB Approach
  - Achieves both high and consistent level of seismic safety
  - No credit for seismic margin
  - Equates performance target to SCDF for existing NPPs
  - Based on conservative parameter and modeling assumptions

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Conclusion 2 PB SSE achieves safety level generally higher than operating NPPs

- Commission Policy on Advanced RXs
  - Advanced RXs same degree of protection as operating NPPs
  - Advanced RXs provide enhanced margins of safety
- Using Clinton PB SSE values and HCLPF seismic margin of 1.67 (SECY 93-087)
  - What are SCDF values?
  - How do Clinton PB SCDF values compare to current NPPs?

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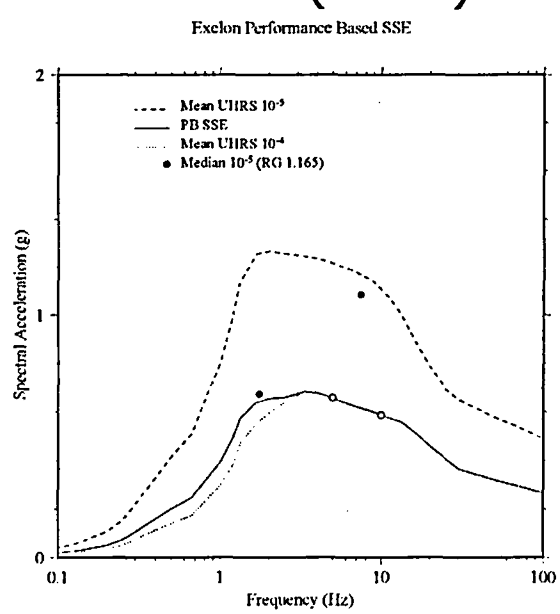
Conclusion 2 (Cont.)



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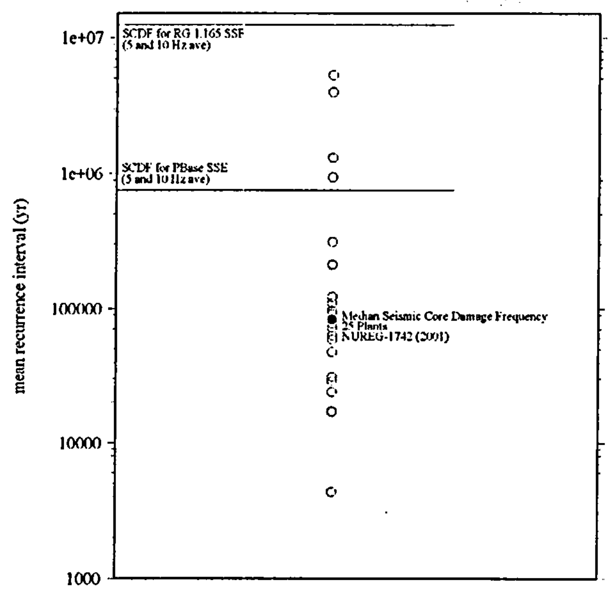
Conclusion 2 (Cont.)



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Conclusion 3

PB SSE adequately reflects local ground motion hazard

- Staff reviewed SSE to ensure it reflects local seismic hazards
- Greatest seismic hazard for central Illinois from Springfield earthquake
  - Prehistoric earthquake (5900 to 7400 years ago)
  - Near Springfield (60 km SW of ESP site)
  - Magnitude estimates (6.2 to 6.8)
    - Recent Study (M6.3)

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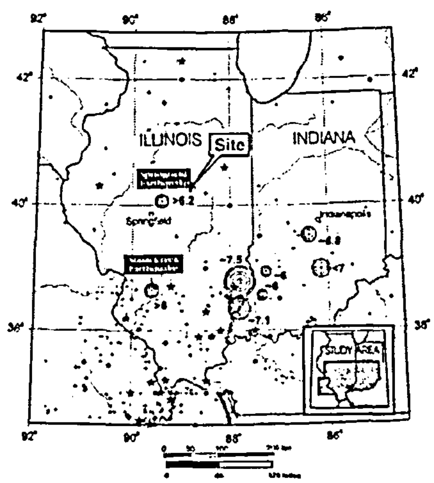
Conclusion 3 (Cont.)



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Conclusion 3 (Cont.)

- Exelon conducted Paleoliquefaction surveys on streams near ESP site
  - Found no evidence of repeated moderate to large earthquakes comparable to Springfield earthquake
- Exelon determined ground motion estimates from Springfield earthquake enveloped by $UHRS_{10^{-4}}$ and PB SSE

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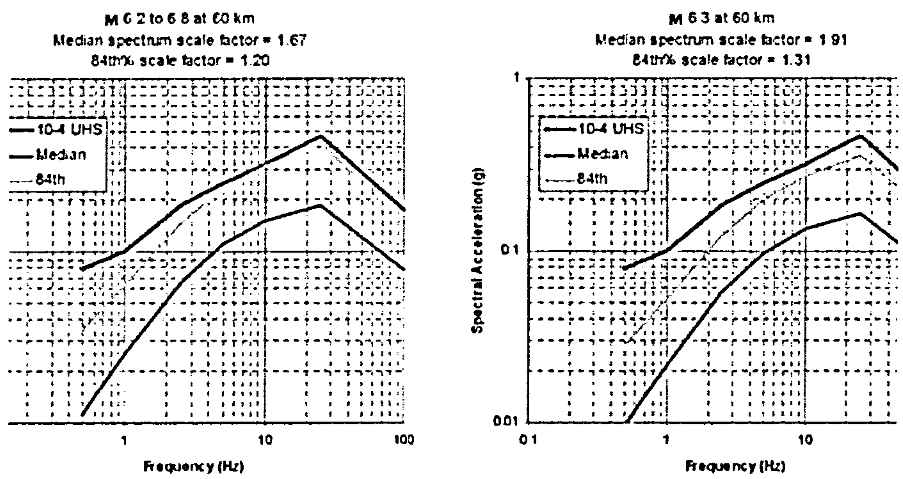
Conclusion 3 (Cont.)



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Summary

- All seismic open items resolved
- SSE is appropriate for the ESP site
- Questions or comments?

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