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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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DESIGN-CENTERED REVIEW: TERRAPOWER SUBCOMMITTEE

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THURSDAY

SEPTEMBER 19, 2024

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The Subcommittee met via Teleconference, at 1:04 p.m. EDT, Thomas E. Roberts, Chair, presiding.

COMMITTEE MEMBERS:

THOMAS E. ROBERTS, Chair

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VICKI M. BIER, Member

VESNA B. DIMITRIJEVIC, Member

CRAIG A. HARRINGTON, Member

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DAVID A. PETTI, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANTS:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

KENT HOWARD

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P-R-O-C-E-E-D-I-N-G-S

1:04 p.m.

CHAIR ROBERTS: This meeting will now come to order.

This is a meeting of the TerraPower Natrium Design Centered Subcommittee of the Advisory Committee on Reactor Safeguards.

I am Tom Roberts, Chair of today's Subcommittee meeting.

ACRS members in attendance virtually via Teams are Ron Ballinger, Vicki Bier, Greg Harrington, Bob Martin, Dave Petti, Vesna Dimitrijevic, and myself. If I missed anybody, please speak up.

MEMBER KIRCHNER: Tom?

CHAIR ROBERTS: Go ahead.

MEMBER KIRCHNER: Tom, this is Walt. I'm here.

CHAIR ROBERTS: Oh, I'm sorry. And then, Walt Kirchner.

We have our consultants participating via Teams, Steve Schultz and Dennis Bley.

Kent Howard of the ACRS staff is the Designated Federal Officer for today's meeting.

No member conflicts of interest were identified for today's meeting.

And we have a quorum for the Subcommittee meeting.

During today's meeting, the Subcommittee will receive a briefing on the Topical Report and staff Draft Safety Evaluation for TerraPower, LLC, Natrium Topical Report entitled, "Plume Exposure Pathway Emergency Planning Zone Sizing Methodology," which they've numbered NAT-3056.

The Emergency Planning Zone, or EPZ, is the area for which emergency planning is needed to assure prompt and effective actions can be taken to protect the public in event of a radiological incident. Judgment is required to determine what accident scenarios should dictate the size of the EPZ. The bases for this judgment date back to the 1970s and have evolved over the years, culminating in a new Regulatory Guide 1.242 that was issued late last year.

The Topical Report is the first use of that Regulatory Guide. So, this review will allow us to understand the choices made by the Applicant; why the staff accepted them with Limitations and Conditions, and determine whether this application of the new Regulatory Guide is suitable or whether revisions to either the Topical Report or the Regulatory Guide should be considered.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, or FACA. The NRC has issued regulations that implement FACA. Per these regulations and the Committee's Bylaws, the ACRS speaks only through its published Letter Reports. So, all member comments should be regarded as only the individual opinion of that member, not a Committee position.

All relevant information related to ACRS activities, such as letters, rules for meeting participation, and transcripts, are located on the NRC public website and can be easily found by typing "About Us ACRS" in the search field on the NRC's home page.

The ACRS, consistent with the agency's value of public transparency in regulation of nuclear facilities, provides opportunity for public input and comment during our proceedings. We have received no written statements or request to make an oral statement from the public. We have set aside time at the end of this meeting for public comments that may arise from the meeting discussions.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed conclusions and recommendations, as

appropriate, for deliberation by the full Committee in a subsequent Committee meeting.

A transcript of this meeting is being kept and will be posted on our website. So, when addressing the Subcommittee, the participants should first identify themselves and speak with sufficient clarity and volume, so that they can be readily heard. If you're not speaking, please mute your computer on Teams or by pressing *6 if you are on a phone.

Also, please do not use the Teams chat feature to conduct sidebar discussions related to the presentations. Rather, limit use of the meeting chat function to report IT problems.

And finally, if you have any feedback on the ACRS about today's meeting, we encourage you to fill out the public meeting feedback form on the NRC's website.

And with that, I would like to turn over the presentation to the NRC staff; typically, Ms. Candace de Messieres, who is the Branch Chief of Technical Branch 2 in DANU at Nuclear Reactor Regulation.

Candace?

MS. DE MESSIERES: Great. Thank you, Member Roberts and TerraPower Subcommittee Members,

for the opportunity to present today.

So, as was mentioned, I'm Candace de Messieres, Chief of Advanced Reactor Technical Branch 2 in the Division of Advanced Reactors and Nonpower Production and Utilization Facilities, or DANU, in the Office of Nuclear Reactor Regulations.

As Member Roberts summarized, during this meeting, TerraPower representatives will provide a summary and NRC staff will discuss its review of the TerraPower Topical Report titled, "NAT-3056, Plume Exposure Pathway Emergency Planning Zone Sizing Methodology, Revision 1." This Topical Report describes TerraPower's risk-informed approach for determining plume exposure pathway Emergency Planning Zone size, or EPZ.

I'll take a moment to highlight a few items related to this review.

First, this review is interdisciplinary in nature, bringing together expertise from across the agency in areas of emergency preparedness, consequence analysis, and probabilistic risk assessment. I would particularly like to thank staff and senior technical leaders in the Office of Nuclear Security and Incident Response for their support.

Second, similar to several other Topical

Reports this Subcommittee has considered in support of Natrium, this Topical Report review is focused on the acceptability of the methodology. Reviews to ensure appropriate implementation will be performed as part of separate licensing actions.

Finally, I would like to mention that this Topical Report incorporates approaches described in the alternative emergency preparedness requirements that were effective in December of 2023, colloquially described as "the EP for SMR and ONT rule."

Though this Topical Report was originally submitted prior to final rule promulgation, as Mallecia and Michelle will mention, it was later revised to incorporate reference to the final.

Thank you again for the opportunity to present today and we will look forward to your observations and feedback. Thank you.

CHAIR ROBERTS: Okay. At this time, we'll turn it over to TerraPower.

MR. GUILFORD: Good afternoon.

My name is Ian Guilford. I'm a senior manager on the licensing team at TerraPower. We appreciate the opportunity today to engage with the ACRS Subcommittee and look forward to the discussion.

To lead the discussion on our side, we

have John Biersdorf, who is a principal engineer on the Natrium project.

Thank you to the NRC staff and the ACRS members for the time reviewing the Topical Report.

And now, I'll turn it over to John.

MR. BIERSDORF: Good afternoon, everybody.

Can you guys see me quick?

I just thought I would introduce myself. Like Ian said, I'm John Biersdorf, principal engineer in the PRA group at TerraPower.

I'm going to shut off my camera, if that's okay, just for the presentation.

Okay. So, I'm here to give you a summary of the EPZ Topical Report that we've submitted. So, the summary is just going to include the guidance that we used; a brief description of the methodology that's outlined within the Topical Report, and then, the conclusions that we can generate from the use of the Topical Report.

Next slide.

So, there are a few specific pieces of guidance that we utilized for this, but, primarily, the plume exposure pathway EPZ Topical Report was developed with the use of Reg Guide 1.242. And this Reg Guide provided the framework and basis to help

establish the methodology outlined within our Topical Report. And then, additionally, as identified within Reg Guide 1.242, NUREG-0396 was also used in support for establishment of our criterion, which we'll discuss in later slides, for the evaluation of the events.

Next slide.

So, in this slide, on the righthand side, there's a flow chart that kind of goes through the process within our plume exposure pathway EPZ methodology. This is identified within the Topical Report itself, however, high level.

The EPZ methodology, it was designated with the intent of evaluating all modes of operation and all hazards that could affect the facility. This is accomplished by assessing all the events identified from the PRA, in addition to other events that may be identified as necessary to evaluate.

These events are developed; they contain the initiator, a plant response, timing of evolution, and source terms generated from the event. That methodology is broken up into the events where we identify either seismic or non-seismic events. A screening process then takes place to identify the specific events that are considered for further

evaluation, and that specific screening process is discussed at these slides.

Once we have the specific list of events that we are going to utilize for our evaluation, we collect site-specific meteorological data and we use that to quantify the radiological consequences of the events, and then, those consequences of the events are evaluated against the EPZ criteria to identify any consequences that exceed our limits for an identified boundary.

If not, we begin an iterative process that takes advantage of the risk-informed nature of our methodology. So, we can, first, look at the events to see if those criteria are not met. We then assess them to see if prompt protective measures are necessary. If prompt protective measures are not necessary, those events are cleared from further analysis.

If prompt protective measures are necessary, we reevaluate the events in question. To do this, we utilize different avenues to reassess. We can identify conservatisms within the analysis that may be refined. We can also look -- well, during the design phase, we can look to identify if there's a possibility to redesign specific SSCs to reduce the

consequences or we can extend the EPZ boundaries, so that we meet the dose consequences set in our methodologies criteria.

And then, finally, once the events that we've identified meet the criteria that have been identified within the Topical Report, we can establish that EPZ boundary at the final size used within our quantification.

Next slide.

So, this is a more detailed aspect of our event selection. So, this discusses, on the righthand side again, there's a flow chart that illustrates kind of the process for selecting non-seismic events. So, for non-seismic event, we include all DBAs; we include events with a 95th percentile release frequency greater than 1E to the minus 7, and additionally, events with a mean release frequency greater than 1E to the minus 8 are considered for cliff edge effects.

Next slide.

For seismic events, again, we have kind of a flow chart that kind of discusses our process for selecting events. For seismic events, there's a different approach that we utilize and there's two stages of the approach.

The first stage --

CHAIR ROBERTS: Hey, John?

MR. BIERSDORF: Sorry. Yes?

CHAIR ROBERTS: Yes, this is Tom Roberts. It took me a couple of minutes here to unmute my mic.

If you go back to the previous slide --

MR. BIERSDORF: Yes.

CHAIR ROBERTS: Or if you could talk a little bit more about the reasons why you chose 10 to the minus 7 and 10 to the minus 8?

MR. BIERSDORF: Yes. It might be easier -- do you mind if we table that and discuss it with the criterion? It's kind of attached to how we utilize that. Well, I guess, how do you want me to answer? Do you want me to jump to a couple slides? Or do you want me to focus on that when we get to the slide --

CHAIR ROBERTS: Oh, no, if you're going to get back to it, I'm willing to wait a couple more slides. Thank you.

MR. BIERSDORF: Okay. Yes.

So, yes, if you want to jump back to slide 4?

So, as I was saying with this one, with regards to the two stages, we have a construction permit stage and an operating license stage. So, in

the first stage -- well, for both, the first step is we develop a limiting PGA. That is utilizing a scoping seismic PRA. The limiting PGA, we choose to achieve at least two times the ground motion response spectra for the site or apply an upper bound of 1.0.

Once we get that limiting PGA established, in the CPA portion we develop a bounding seismic event that kind of demonstrates an adequate response or for the facility to show the adequate of the facility and represent a seismic event.

And then, with our operating license, we will generate a list of seismic LBEs and utilize that limiting PGA as the threshold, similar to the threshold mentioned for the non-seismic events.

So, those are the two specific selection criteria.

And then, if you go to the next slide, hopefully, this will address your question.

So, when we selected these thresholds, the intent was to capture the language within Reg Guide 1.242 where we're talking about, you know, identifying things from worst-case radiological release sequences, and most radiological release sequences, we felt that those thresholds captured those events that meet those criterion. So, by having a threshold set there, we

can incorporate enough events that we feel we're meeting these criteria.

Is that kind of clear for that in terms of the specific thresholds?

CHAIR ROBERTS: Yes, I'm wondering if that's based on precedent or that's based on some, basically, judgments that you made based on some early analysis. Or I'm trying to understand. Because there's a 10 to the minus 6 that you didn't have in the previous slide that goes with criteria A and B, as I understand it, and then, criterion C is the one that uses the 10 to the minus 7 and 10 to minus 8 from the previous slide. I was trying to understand all three thresholds, how you picked them.

MR. BIERSDORF: Yes, I mean, it was a little bit engineering judgment in terms of selection of things with relation to the NEI 18-04 framework in capturing, you know, our BDBE space. So, we go below that a little bit, 5E to the minus 7. So, it was kind of we wanted to make sure that we were capturing the most radiological release sequences with that 1E to the minus 6, which is what you're identifying for that criterion B.

And then, for the worst-case scenarios, we decided to extend it below that 5E to the minus 7

threshold to make sure that we were incorporating events that even exceeded beyond that case, just to make sure that we were fully capturing the level of risk. And then, with the cliff edge that goes down to 1E to the minus 8, we just wanted to ensure that everything was kind of incorporated into the analysis, so that nothing was missed.

CHAIR ROBERTS: Okay. So, if I take that as an order of the -- the criteria A and B, as I've understood NUREG-0396, in the late 1970s the frequency was around 10 to the minus 5th, according to that report. So, it would appear you've gone an order of magnitude below that. Is that a fair characterization?

MR. BIERSDORF: Yes. And I believe we kind of utilized some precedence in the NuScale paper, and then, there was a NUREG-1855 that helped kind of frame our reference, but the idea was just to capture all of that and, yes, we went an order of magnitude below and felt that this was adequate.

CHAIR ROBERTS: Because one of the questions would be the effect of uncertainties. And one thing at least I've noted is -- and maybe you all or the staff can come up and comment -- I found the Reg Guide a little bit vague on whether you apply

uncertainties when you assess to criterion B or whether the uncertainties only apply when you assess the criterion C.

And, yes, I might argue that what you've done by going an order of magnitude below what the 0396 would have you go is that's some assessment of uncertainties for criterion B. Or maybe it would need to be, you know, a different approach, but I'll leave that as a question, again, for you and staff to take on as a role, the uncertainties in assessing criterion B.

MR. BIERSDORF: Sorry, was there a direct question there? I apologize.

CHAIR ROBERTS: Yes, I was wondering if you had any comments on that. Is there work that's required in your view to assess the criterion B, you know, assessing uncertainties? Or did you think you did that by using 10 to the minus 6? Or do you not think that requires an assessment of the uncertainties because that's all covered in criterion C? You know, I could get any of those interpretations from what I read out of the Reg Guide. I was wondering what your view on that is.

MR. BIERSDORF: Yes, and hopefully, let me try to answer that.

So, we do incorporate uncertainties across our spectra of our analysis. So, we do incorporate it within when we're quantifying it for source term PRA and RADCON, radiological consequences. So, that level of uncertainty is kind of already captured there, and then, like you stated, the bounds of our analyses is another portion to capture uncertainty.

CHAIR ROBERTS: Okay. That makes sense. And for criterion C -- and, Dave Petti, I see your hand is up, but I'll finish this question, and then, give you your shot here -- criterion C, the 10 to the minus 7 is a 95 percent frequency; 10 to the minus 8th is a mean frequency, and the 10 to the minus 8 is intended to address cliff edge effects.

If I look at the Reg Guide, there's really no discussion of a threshold of frequency for cliff edge effects assessments. And the implication -- again, it's hard to say from what the Reg Guide doesn't say -- but the implication is it's independent of frequency that is more of a deterministic look at cliff edge effects, not just down to 10 to the minus 8th. I was wondering if you could comment on that.

MR. BIERSDORF: Yes. We kind of left it at 10 to the minus 8th just to make sure that we've had a framework to apply for the specific events to

include for consideration, and then, those events were assessed with their direct impacts to our consequences, if you will.

So, we chose an order of magnitude below because we felt that was a level that would fully encapsulate the events that had a potential to cause those cliff edge effects, and then, apply that cliff edge analysis to those events.

CHAIR ROBERTS: So, if you had something in the 10 to the minus 9 that was a lot worse, you know, would that not be a concern because it's a lower frequency or is there something else in your process that would have already ferreted that out? That's what I'm trying to understand.

MR. BIERSDORF: In terms of a lot worse, are you saying in just direct-dose consequences or in terms of cliff edge effects?

CHAIR ROBERTS: Direct-dose consequences, which would be a manifestation of a cliff edge effect, I suppose.

MR. BIERSDORF: Yes, and for our analysis, we felt that that was, you know, beyond the scope for what we deemed part of the analysis, just as it was so unlikely that it wouldn't, I guess, be of concern.

CHAIR ROBERTS: Yes. Okay. I think I

understand.

Dave?

MEMBER PETTI: Yes, just a question. I understand this is a methodology and I'd like to jump to the answers. I don't want to get into some details because it might be proprietary.

Let me just say I know you guys have design features to mitigate seismic. In that event, in such a case, in your design, do you expect the seismic to dominate here or the non-seismic events in terms of the EPZ sizing?

MR. BIERSDORF: Give me a second. I'm not sure if, yes, I'm not sure if our -- so, our bounding analysis gives us enough of an assessment. I don't know if I can state publicly at the moment for what the specific results are.

MEMBER PETTI: Okay. I just note that you can get different answers here, right, on some of these considerations? And since you're one of the first ones coming in, it could look quite different than another applicant in terms of how they decide to deal with seismic, in particular.

MR. BIERSDORF: Yes. Yes, that's correct. So, we have been following the methodology that we've outlined. We've quantified it to the extent that our

methodology has, and then, our results are consistent with what we were expecting, I guess is what I'd come up with saying in a public space.

MEMBER PETTI: Okay. Okay.

MR. BIERSDORF: Sorry.

MEMBER PETTI: Okay. I mean, I'm kind of thinking ahead, too. So, that sort of agrees with what mentally my picture is. Okay. Thanks.

MR. BIERSDORF: Uh-hum.

Yes, and I apologize. So, we just started discussing this, so I can kind of walk through the specific criterion.

But, primarily, again, as stated, the intent of the selection criteria was to encompass the specific criterion that was outlined within Reg Guide 1.242. So, for our criterion A, we have projected doses from our DBAs and they would not exceed 1 rem for our mean four-day TEDE; 5 rem for the 95th percentile TEDE, four-day TEDE.

For criterion B, projected doses from most radiological release sequences, which in our methodology we define that as events with a mean release frequency greater than 1E to the minus 6. They would not exceed 1 rem mean for a four-day TEDE and 5 rem for the 95th percentile four-day TEDE.

And then, finally, for the criterion C, immediate life-threatening doses from the worst-case radiological release sequences, which again we've defined as events below 1E to the minus 6 and greater than 1E to the minus 7, they would not exceed a 24-hour, 200-rem red marrow acute effective dose.

And final slide.

CHAIR ROBERTS: Yes, I had a quick question on the red marrow --

MR. BIERSDORF: Okay. Sorry.

CHAIR ROBERTS: -- the red marrow dose versus the whole body dose or some other criterion. The section of 0396 that your Topical Report references, as justification, has a statement that you also have to look at lung dose as part of the assessment. And I was wondering why that didn't carry forward into your method.

MR. BIERSDORF: So, specifically, when we were assessing this, we just identified that the whole body was identified specifically in 0396 and pointed to the red bone marrow. We identified it as a limiting parameter, and then, we did tests to confirm that. And that was just the organ that was chosen to represent it.

CHAIR ROBERTS: So, you're not concerned

that you might miss a more limiting situation by not looking at the lung dose? Because 0396 does talk about that as something that needs to be checked. I believe the 0396, through the leverages of WASH-1400 analysis, those did show that the red bone marrow were limiting. But the bottom line was that you would need to look at both.

And when we get to the staff presentation, they put out a white paper about three years ago and they also had a footnote in the white paper that the lung dose in certain circumstances may be limiting. So, I don't think it will change your answers by much, but it's just something I was just looking at for completeness, to continue to make sure that the red bone marrow really does tell the whole story.

MR. BIERSDORF: Okay. Noted.

CHAIR ROBERTS: Okay. Thank you.

MR. BIERSDORF: And then, next slide.

So, in conclusion, the basis for the Topical Report was to utilize an iterative process to establish the EPZ sizing. We just take advantage of the risk-informed process outlined in 1.242. It allows for design changes during the design process or expansion of the EPZ boundary to ensure that events meet the established dose consequences that we

outlined. And then, essentially, the final EPZ size is based off the smallest distance at which our criteria is met.

So, that's the summary of our Topical Report in a nutshell.

CHAIR ROBERTS: One remaining question might be somewhat editorial. But the Topical Report had a discussion of the use of the 10 to the minus 8th threshold for cliff edge effects. One place it said that you were going to look for frequencies below 10 to the minus 8th to determine cliff edge effects, and the rest of the report, including your recitation today, said you meant above 10 to the minus 8th. So, I just wanted to make sure that that was a typographical error in the Topical Report and it was not your intent to go below 10 to the minus 8th to look at cliff edge effects.

MR. BIERSDORF: That's correct, we don't intend to do that. Do you happen to know where that editorial was located?

CHAIR ROBERTS: That was on page 25 of the report. I can get it up here quickly and just read what it says. I've just written down it's page 25. So, I've got to get to page 25 now.

Yes, it says, "In the context of the EPZ

seismic method, these steps take the following form: one, if the mean value of the sequence frequency is an order of magnitude or more below the screening criteria, i.e., less than or equal to 10 to the minus 8th per year, then the sequence is screened out after consideration of cliff edge effects."

MR. BIERSDORF: Okay. Yes, that appears to be a typo. So, I appreciate you pointing that out.

CHAIR ROBERTS: Yes. Okay. I just wanted to make sure I read it right. Thank you.

Any other questions from members or consultants for TerraPower?

MEMBER KIRCHNER: Tom, this is Walt, if I may?

CHAIR ROBERTS: Sure. Go ahead, Walt.

MEMBER KIRCHNER: Yes. John, how are you approaching cliff edge effects? Typically, is it dominated in your case -- I know we're getting into design, not methodology. But just how do you consider cliff edge effects? Are you looking at mainly seismic events? Or are you looking at other design aspects when you address cliff edge effects?

MR. BIERSDORF: Yes, we do look at all events within that range. So, it's not just seismic for it. And then, we're looking for, basically,

single deviations that may either directly impact the plant response or severely change the plant response or impact the consequences in a significant manner. So, it's not just seismic.

MEMBER KIRCHNER: Are you at liberty -- I know this is a methodology topical that we're reviewing, not the design. But in the course of your iterations on your design, did you identify anything that was in that category?

MR. BIERSDORF: In terms of did we capture any --

MEMBER KIRCHNER: And then, redesign for it? Yes. Did you, in your PRA exploration of your design, did you identify anything that stood out, as you mentioned, and then, redesigned to take it out of consideration?

MR. BIERSDORF: I believe I can state it. We did identify things in the cliff edge region, but nothing that required a specific design change from our analysis.

MEMBER KIRCHNER: Okay. Thank you.

MR. BIERSDORF: I think that's okay for me to say.

MEMBER KIRCHNER: Yes. All right. Thank you.

MR. BIERSDORF: Yes.

CHAIR ROBERTS: Any other questions from members or consultants?

MEMBER PETTI: Yes, this is Dave. Just a quick one, Tom.

So, give us a sense, of all these events you looked at, you know, how many end up, sort of rough number, as part of the evaluation of EPZ? Is it 10 sequences or is it more like two dozen sequences?

MR. BIERSDORF: I believe it's more of the latter. I can't recall off the top of my head.

MEMBER PETTI: Okay. So, it's a large number, though?

MR. BIERSDORF: It's more than a few, yes.

MEMBER PETTI: Yes, yes. Okay. Thank you.

CHAIR ROBERTS: Okay. Seeing no more hands up or any more questions, I'd like to thank TerraPower for the presentation. John, that was very good.

Now, we'll go ahead and transition over to staff. I guess Mallecia and Michelle Hart have lead with it, but I'll let you figure that out.

MS. SUTTON: Yes, I'm going to go ahead and present. Give me a second, please, okay --

CHAIR ROBERTS: Okay.

MS. SUTTON: -- to get the presentation up.

(Pause.)

Can everyone see my shared screen?

CHAIR ROBERTS: It looks good, Mallecia.

MS. SUTTON: Okay. Wonderful.

So, hello, everyone.

Again, my name is Mallecia Sutton, a senior licensing project manager at the NRC and the lead project manager for the TerraPower Natrium project, and for the plume exposure pathway Emergency Planning Zone sizing methodology. So, going forward, I'm going to say, "EPZ sizing methodology" for this Topical Report.

This slide describes the agenda of the NRC's staff presentation today. We will review the chronology of the staff's review; the purpose of the staff's review, and the staff's review strategy for the Topical Report. We will provide an overview of the contents of the staff's Safety Evaluation Report, and then, summarize the NRC staff's conclusion regarding TerraPower's EPZ Sizing Methodology Topical Report.

With me today for this presentation is

Michelle Hart, who is an NRC nuclear engineer and a lead NRC technical reviewer for the TerraPower EPZ Sizing Methodology Technical Report.

And Hanh Phan is Senior Reliability and Risk Analyst, one of the principal authors on the SE, the Safety Evaluation.

Other technical reviewers that supported and authored the Safety Evaluation are Edward Robinson, the Senior Emergency Preparedness Specialist, and Kenneth Mott, an Emergency Preparedness Specialist, from the Office of Nuclear Security and Incident Response.

Regarding the timeline of the review, at the pre-submittal meeting on October 2022, TerraPower submitted Revision 0 of the Topical Report in March of 2023.

The NRC staff accepted the Topical Report for review and began the staff's review in June of 2023. The NRC staff conducted an audit of the Topical Report from August through October of 2023.

And then, at the completion of the NRC staff's review, TerraPower submitted Revision 1 of the Topical Report in November 2023.

The NRC staff's Draft Safety Evaluation report was issued in September of this year.

For content, March 2024, TerraPower submitted, on behalf of US SFR Owner, a construction permit application for the Kemmerer Power Station Unit 1 that included a preliminary Emergency Planning Zone determination technical report.

I would like to note that the presentation today corrects a typo on slide 15 and staff bolded some of the text in the Limitations and Conditions slide for emphasis. Otherwise, the text remains the same.

Now, I'll turn over the presentation to Michelle.

MS. HART: Good afternoon.

My name is Michelle Hart. I'm a senior reactor engineer in NRR, as Mallecia had said, and I was the lead technical reviewer, and I will go over certain portions of the review. And I will go off-camera now.

The purpose and review strategy that the staff took are presented on this slide. The purpose of the Topical Report was to provide a methodology and criteria to be used to establish the site-specific plume exposure pathway Emergency Planning Zone size for the Natrium reactor. And it's a risk-informed approach to meet the EPZ criteria in

10 CFR 50.33(g)(2), which was part of the EP for SMRs and ONTs rule that Candace referred to earlier.

The staff's review strategy was to review the consistency with the technical basis for the alternative EP framework in that rule, 10 CFR 50.160, and conformance with the guidance in Reg. Guide 1.242 on plume exposure pathway EPZ sizing.

We also assessed the acceptability of the risk-informed approach and interaction with the overall Natrium licensing approach using the Licensing Modernization Project methodology, or LMP.

As was noted, in November 2023, the EP for SMRs and ONTs rule was issued. Revision 1 of the Topical Report made changes to address the proposed final rule and guidance.

Next slide, please.

Next, we'll go over the Safety Evaluation contents and this is an overview of the contents. We'll talk about regulations; the guidance that we used to review; the EPZ sizing methodology steps in the Topical Report, and we'll break that down further into the accident screening methodology; the radiological consequence analysis; the determination of the plume exposure pathway EPZ size, and then, some Limitations and Conditions on use of the Topical

Report that the staff is proposing, and then, our conclusions.

Next slide, please.

To go over the regulations, as we had said, 10 CFR 50.160 is the alternative emergency preparedness requirements for small modular reactors and other new technologies. And during that rule, there was a change made to 50.33(g) to add 50.33(g)(2)(i), which defines the plume exposure pathway Emergency Planning Zone as the area within which public dose exceeds 1 rem total effective dose equivalent over 96 hours from the release of radioactive materials from the facility, considering accident likelihood and source term; timing of the accident sequence, and meteorology, and is also the area within which predeterminated prompt protective measures are necessary.

Next slide, please.

So, for our guidance of the review of the EPZ sizing methodology consequence analysis, we did look at Reg Guide 1.242, which was issued last year along with the rule, and we also considered the technical basis for Emergency Planning Zone sizes in NUREG-0396.

Next slide, please.

For guidance to review the risk-informed approach, we did use Reg Guide 1.233, which is guidance on the Licensing Modernization Project process; Reg Guide 1.247, which is about acceptability of probabilistic risk assessment results for non-light water reactor risk-informed activities, which includes some endorsement and guidance on use of PRAs developed with the non-light water reactor PRA standard; and also, Reg Guide 1.253, which is guidance on the content of applications for a license application which uses the Licensing Modernization Project process.

Next slide, please.

Now, I'll go over the overview of the methodology steps in total. The first portion of the methodology goes through the accident screening to identify a spectrum of events to use for the Emergency Planning Zone size analysis. I won't read through each of these steps. We'll go over them a little bit further in later slides.

Next, we'll go through the radiological consequence analysis, taking information from the spectrum events. And that includes, as TerraPower had described, using site-specific meteorological data, performing consequence analysis, and evaluating the

radiological consequences against the dose-related criteria that they've developed.

And then, the final step is to determine the plume exposure pathway EPZ distance, based on the EPZ sizing criteria, which includes both the consequence analysis and the determination that predetermined prompt protective measures are necessary.

Next slide, please.

So, our assessment of the steps as a general thing, you know, like the overview of it, is that the staff finds TerraPower's considerations were consistent with the considerations in the basis for scalable plume exposure pathway EPZ in the rule and supports the objective of emergency response plans to provide dose savings for a spectrum of accidents that could produce offsite doses in excess of the U.S. Environmental Protection Agency Protective Action Guides, or PAGs.

The staff finds that the steps of the Topical Report methodology are consistent with the size analysis methodology guidance in Appendix A to Reg Guide 1.242.

Next slide, please.

Next, we'll be talking about the accident

screening methodology. This is event selection and spectrum events determined through a risk-informed process using site- and design-specific PRA.

The staff finds the use of risk-informed methods and event selection to determine a spectrum of events for this analysis is acceptable because it is consistent with the guidance in Reg Guide 1.242.

Next slide, please.

Now, I'll turn the presentation over to Hanh.

MR. PHAN: Thank you, Michelle.

Good afternoon, ladies and gentlemen.

My name is Hanh Phan. I am the Senior PRA Analyst in NRR, Division of Advanced Reactors.

In the next four slides, I will focus on the PRA and the event sequences that support the EPZ sizing calculation.

First and foremost, to identify release sequences, the design- and site-specific PRA will be used. The PRA will address all internal and external hazards, all modes of operation -- that includes at-power and during low power and shutdown mode -- and all sources of radioactive materials.

The PRA will be developed in accordance with the guidance provided in the ASME/ANS NLWR PRA

standard. Note that Reg Guide 1.247, which endorsed the NLWR PRA standard, provides the criteria for PRA acceptability.

The PRA will undergo a peer review, and the key assumptions and sources of uncertainty in the PRA will be assessed to determine their impacts on the calculation.

There are five Limitations and Conditions that the staff has established that's relevant to the PRA. I will return to those L&Cs at the end of the presentation.

But for now, please move to slide 14.

Regarding the hazards and initiating events considered in the EPZ's calculation, the hazards from the NLWR PRA standard, including those listed in the PRA standards, Table HS.2, lists the paragraphs for consideration, and as with the site-specific hazards, will be assessed for potential inclusion.

The screened hazards will be documented with justification provided. In addition, the methodology will also incorporate security events, which means that a qualitative or quantitative assessment of security events will be conducted and documented in the size calculation.

The staff finds the approach for identifying PEP EPZ events to be consistent with the guidance in Reg Guides 1.242 and Reg Guide 1.247, and therefore, acceptable.

Next slide, please.

First, we apologize that there's a type in the top bullet on this slide. The frequencies of 1E minus 8 per reactor year should be 1E minus 7 per reactor year.

Regarding the selection of non-seismic release sequences, the non-seismic release sequences to be retained for EPZ evaluation will include those with the frequencies greater than or equal to 1E minus 7 per reactor year, and also, those with the frequencies that contribute 1 percent or more to the total release frequency.

Other criteria have also been considered, such as, if the sequence mean frequency is an order of magnitude or more below the screening criteria, which means less or equal to 1E minus 8 per reactor year, then the sequence is screened out after consideration of cliff edge effects.

If the 95th percentile is greater than or equal to 1E minus 7, not E minus 8 -- this is the typo -- then the sequence is screened into the process and

included in the dose analysis.

Individual events and groups with total frequencies greater than 1E minus 8 per reactor year will be assessed for the cliff edge effects.

These sequences will be included if the 95th percentile frequencies exceeds 1E minus 7 per reactor year.

The staff finds the approach for screening, both screening in and screening out, non-seismic release sequences to be consistent with Reg Guide 1.242, and therefore, acceptable.

Next, please.

CHAIR ROBERTS: Hanh, before you go on, that second major bullet that you say there's a typo, that the minus 8 be minus 7, in that second line of the second bullet, is that what you said? That's what I thought I heard you say.

MR. PHAN: But that's the third bullet.

CHAIR ROBERTS: Yes, the second major bullet. "If the sequence mean frequency is an order of magnitude or more below the screening criteria...." -- that one. Because what I heard the Applicant say is that it's not an order of magnitude or more below 10 to the minus 7; it's an order of magnitude; that they're not looking below, you know, more than an

order of magnitude below the 10 to the minus 7.

So, I was trying to understand what this second major bullet was intending to say.

MR. PHAN: Give me one second, please.

Okay. Oh, okay. So, I did not look at the very latest set of slides. Someone already corrected this bullet. So, the error is no longer there. The third bullet before, showing 1E minus 8, now is showing 1E minus 7. So, the typo was corrected.

CHAIR ROBERTS: Okay. Well, what this bullet says doesn't seem consistent with what the Applicant said they intended. They intended, the 10 to the minus 8, that's a cutoff and they weren't going to look below 10 to the minus 8.

This bullet says that at least your understanding is that they will look below the 10 to the minus 8 because of the order of magnitude or more below the screening criteria. And so again, it just doesn't seem like it's consistent with what the Applicant intends to do.

So, was it your understanding they would look below 10 to the minus 8 for cliff edge effects?

MR. PHAN: So, for any frequency, I mean, the mean frequency sequence, frequency higher than 1E

to minus 8, they will retain those for an evaluation, and if the 95th percentile associates with those sequences higher than 1E minus 7, they will include those in the dose analysis.

So, that's my understanding, but US Owner, would you be, are you there to confirm my position there?

DR. BLEY: Hey, Tom, this is Dennis. Could I sneak something in?

CHAIR ROBERTS: Go ahead. Go ahead, Dennis.

DR. BLEY: You're looking at the second major bullet, right? And there's a missing parenthesis after "i.e., less than or equal to 10 to the minus 8th per reactor year." It should be close parenthesis. Then, it's screened out, which I think is what the Applicant said, too.

CHAIR ROBERTS: Yes, the question, Dennis, is whether cliff edge effects are considered for sequences below 10 to the minus 8th. That's what my question is.

What this one paragraph in the Topical Report seems to say is they will look almost without bound, you know, because it just says "less than 10 to the minus 8th," and then, it's screened out after

consideration of cliff edge effects, which would seem impractical to me because, if there's no lower bound, then that's -- I don't even know what that means.

But the Applicant I believe said is that 10 to the minus 8th or less, they don't look. So, the 10 to the minus 8th --

DR. BLEY: I thought that's what this bullet said, too, if you put the right parentheses in. Now, in the report, maybe it's stated wrong.

CHAIR ROBERTS: Yes, it says, "after consideration of cliff edge effects." So, the way "after consideration of cliff edge effects" is written in this bullet would seem to say that the screening is after, for any frequency, after they consider cliff edge effects. So, maybe I need to read this more carefully with the close parens put in there.

"If the sequence mean frequency is an order of magnitude or more below the screening criteria..., then the sequence is screened out after consideration of cliff edge effects."

So, that seems to me to say that you consider cliff edge effects, regardless of the frequency of the sequence.

MS. DE MESSIERES: Yes, this is Candace de Messieres of the staff.

I think there was a missed bracket. I also think that was, you know, we could have phrased that a little clearer, but I do think the intent is consistent with the discussion earlier today. But I'll defer to Hanh to confirm that.

MR. PHAN: Thank you, Candace.

So, based on the information that we have from the Topical Report, any sequences lower than 1E minus 8 will not be analyzed for cliff edge effects.

But US Owner, please confirm my statement.

(No response.)

Shall I repeat my statements once more?

All sequences which mean frequencies less than 1E minus 8 would not be analyzed for cliff edge effects. Is that correct?

MR. BIERSDORF: Sorry, I was double muted.

CHAIR ROBERTS: Go ahead, John.

MR. BIERSDORF: Sorry, I was double muted.

Yes, the way Hanh is phrasing it there is consistent with ours and it's slightly confusing from that bullet. So, I would agree that it's not consistent with our approach.

CHAIR ROBERTS: Okay. Thank you.

So, if you just took out the phrase "after consideration of cliff edge effects," it sounds like

that would be accurate.

MR. PHAN: Thank you. Yes.

CHAIR ROBERTS: Okay. Thank you.

MR. PHAN: Thank you.

So, as said, the staff finds the approach acceptable.

So now, we go to the selections of the seismic release sequences, slide 16.

For the selection of the seismic release frequencies, during the CP stage, the limiting peak ground acceleration ratio will be used to establish the bounding seismic events.

For the OL or CL application stage, the limiting PGA will be used as the event screening threshold for the selection of seismic events.

The site-specific scoping level seismic PRA will be performed to provide insights for establishing the limiting PGA.

The limiting PGA will be chosen to achieve at least two times the ground motion response spectrum.

And in addition to that, an upper-bound PGA of 1.0 g for intentional ground acceleration will be applied in the selection of seismic events.

Uncertainty and cliff edge effects will

also be evaluated and incorporated into the seismic event selection process.

With adding seismic events, one Limitation and Condition has been established to ensure that the seismic PRA is of sufficient technical acceptability to support the EPZ calculation. As I mentioned earlier, I will return to these L&Cs at the end of the presentation.

So, with that, I will --

CHAIR ROBERTS: Okay, go ahead. Yes, Walt has a question.

MR. PHAN: Yes. Thanks.

MEMBER KIRCHNER: Yes. Hanh, are these somewhat, the lower bullets on this graph, I was trying to sort this through in my own head. Are these contradictory? I mean, it's saying in the fourth bullet that the limiting PGA will be at least two times the GMRS. But, then, you go on to say the upper-bound PGA will be 1 g.

Now, I know site-specific considerations will come into play in establishing the GMRS, but I don't get the logic for the fourth and fifth bullets. Could you elaborate, please?

MR. PHAN: Bullet four, bullet four and fifth? Those went to --

MEMBER KIRCHNER: It's like you're overspecifying the result. What if the PGA -- what if the GMRS tells you it's .6 or .7 g, why would you then cap at an upper-bound PGA of 1.0, when you're saying you're going to double it in the fourth bullet?

MR. PHAN: Yes, I see your points right there. That's unclear. With the term "upper bounds," that may be confusing, yes.

So, both criterias should be met. So, in the selection of the limiting PGA, most of these will be met. That has to be two times the GMRS and, if not, then the upper bound of the PGA of 1.0 will be used.

MEMBER KIRCHNER: Okay. So, maybe it's just because of the way it's presented in the viewgraph in shorthand. But if you have a site, like I said, that had a .6 g out of the GMRS, you would then use the two times that rather than the 1.0. I guess it's the word "upper bound."

MR. PHAN: Yes.

MEMBER KIRCHNER: It seems to me it's an "either/or," but the most limiting of the fourth and fifth bullets would then be applied.

MR. PHAN: Yes, exactly what you just said.

MEMBER KIRCHNER: Okay. Thank you.

MR. PHAN: This is not clear. Thank you.

MEMBER KIRCHNER: Yes.

MR. PHAN: Any other questions? Other questions --

CHAIR ROBERTS: Walt, that might be worth clarifying from TerraPower, too. Because the word "upper bound" is in the Topical Report. And just re-reading the paragraph, most of the paragraph reads exactly like Hanh described. So, I'm not sure why they use the term "upper bound," but it does seem like their intent is to -- you have a g or double the GMRS, whichever one is higher. So, "upper bound" is kind of an odd term to use there. I'm wondering maybe if TerraPower could give some insights as to why that term was used in the Topical Report.

MR. BIERSDORF: Yes, the interpretation is actually the other way around. So, if it was .6 and it was 2X, with the 2X being 1.2 g, we would use an upper bound of 1 g; where if the GMRS was, let's say, .4 g, the 2X is .8 g. So, then, that would be the limiting PGA that's selected.

MEMBER KIRCHNER: So, if I get that logic, then, at the most, the PGA at 1 g would be used?

MR. BIERSDORF: Correct.

MEMBER BALLINGER: Yes, this is Ron Ballinger.

The 1 g is a cap then, right?

MR. BIERSDORF: Correct. That's why we tried to state it as upper bound.

MEMBER KIRCHNER: So, you're kind of saying that's the safe shutdown earthquake, and then, you apply that as you go through your seismic evaluation?

MR. BIERSDORF: Yes. We just established that as our limiting PGA that we will use as our threshold moving forward, if that's identified as the limiting. So, it's "either/or."

MEMBER BALLINGER: So, rewording it, so to speak, as at least two times the ground motion spectrum with an upper bound PGA of 1 g?

MR. BIERSDORF: That would be accurate. I don't have in front of me what the specific wording is.

MEMBER BALLINGER: Oh, oh. I'm sorry.

MR. BIERSDORF: I apologize.

But your interpretation is accurate.

CHAIR ROBERTS: Okay. Yes, I'll certainly defer to other seismic effects on the Committee -- or seismic experts rather on the Committee. That's

certainly not me.

But reading the Topical Report, it sure seemed like that Hanh's interpretation was more what you intended. And I guess I'm kind of left with not really understanding what the intent.

Just reading the paragraph, it says, "The limiting PGA value determined for the EPZ analysis would be aligned to achieve at least twice the ground motion response spectrum to limit the seismic hazard under consideration to credible ground motions. However, an upper bound of 1 will be used to acknowledge the limitations of the PRA and uncertainties associated with availability of local and state emergency response infrastructure in large ground motions."

So, I guess I read that as that you would never let it be less than 1, and I just, obviously, misread that. But does that make sense? Because there's something about 1 g, that if they go above 1 g, it's just not a physically possible earthquake? Or I'm not quite sure what the logic is to have an upper bound like that.

MS. DE MESSIERES: Okay. So this is Candace de Messieres.

So, the staff, we certainly appreciate

this discussion. I think this is an important distinction. So, we'll certainly note this and consider that in our continued evaluation, but appreciate this discussion. Thank you.

DR. BLEY: Hey, Tom, it's Dennis.

I think there is no such upper bound as a real physical thing. And depending on where one wants to site one of these, that assumption either applies or it doesn't, I think is the case. So, if this comes up later, a particular site might well have an acceleration greater than 1 g.

CHAIR ROBERTS: So, the methodology then would lower it to 1, at least as we're discussing it now. So, yes, like Candace said, maybe this is a subject for further discussion.

DR. BLEY: I'd say it would mean this doesn't apply; the whole guidance document doesn't apply, because the assumptions aren't met. And they would have to do, you know, a from-scratch analysis to look at the things higher than 1 g. I mean, there's nothing physical that limits it. There are sites that have higher accelerations than that.

CHAIR ROBERTS: Right. So, you're suggesting that the upper-bound PGA of 1 g doesn't really make sense because you would either double what

you have or -- you would double what you have. If it exceeded 1, you would use the higher number.

Yes, it sounds like, as Candace suggests, this would be a subject for a different discussion.

MS. DE MESSIERES: Yes, we'll take this back. We'll take this one back. Thanks.

MR. PHAN: This is Hanh again.

So generally, for the 1 g peak ground acceleration, for the mean curve, that is equivalent to about 1E to minus 6 annual frequencies. That's why, when I reviewed the documents and I saw 1 g there at the CP stage, I concluded that ratio would, and now, the criteria above that, that twice or two times the GMRS is also in the consideration. And that's the basis for my acceptance of using 1 g at the CP stage because the frequency is just above 1E minus 6.

CHAIR ROBERTS: Okay. Walt?

MEMBER KIRCHNER: I'm not certain that you want to change the criterion when you get to the OL stage. That would be a concern. There have been numerous -- and this is an observation, not a question.

I am familiar with changes in the seismic design criteria for major DOE projects that incurred huge costs. So, I don't know why you would have

different criteria CP versus OL. So, assuming you already have a site selected.

MR. PHAN: Yes. So, at the OL stage, we expect that the applicant is going to develop the seismic PRA, which will use the full set of hazards curve without any upper bound to quantify the seismic risk.

MEMBER KIRCHNER: Yes, but if you go into construction -- and usually, early in, you know, the first thing you do is footings. If you don't get the footings right for the reactor building and structures, you're into some serious problems at the OL stage.

MR. PHAN: Yes, sir, I agree with you. If they do not plan correctly, there will be a serious issue when they apply for the OLs.

CHAIR ROBERTS: Okay. Any more questions or discussions on this slide?

MEMBER KIRCHNER: One more, Tom. If I may, just one more.

When you go through the seismic release sequences for this, do you also look at seismic-induced fire problems that may impact the release sequence?

MR. PHAN: It's not specifically spelled

out in the Topical Report. But there's no position or any discussion in the Topical Report, but it's not clear whether the Applicant will address that or not at this stage. But there's not any requirement to evaluate that at this stage, but, surely, at the OL stage, when they develop their seismic PRA, seismic-induced fires or any others, like seismic-induced flooding, should be included in their seismic PRA model.

MEMBER KIRCHNER: Well, just again, I'll observe that doing it at the OL stage is not without risk. Pardon the poor choice of words.

MEMBER DIMITRIJEVIC: Tom? Tom?

CHAIR ROBERTS: Vesna, yes, go ahead.

MEMBER DIMITRIJEVIC: Yes. Okay. I would like, actually, to go back to slide 15 because now I got utterly confused after we made these changes. I mean, there was a typo, but, then, we decided that we're going to remove the cliff edge effects from the second paragraph.

So, let's just make sure I understand this selection. So, every frequency greater than 10 to minus 7 would be in. Any sequence, I mean frequency greater than 10 to minus 7 would be considered in approximately 5 percent that the total release.

Now, if the mean frequency is 10 to minus 8 or less, in our previous discussion we said that that will be screened out, but that's not a true statement because it would not be screened out if the 95 percentile of that sequence is greater than 10 to minus 6. So, actually, there is no screening base -- or there is no screening out based on mean frequency. The screening out for the sequences is based on the 95th percentile, which applies then to 10 to minus 6.

See, Tom, because when you said we need to remove this, that's not a true statement. And then, this other magnitude, it's now totally confused, you know, with this 10 to minus 6.

CHAIR ROBERTS: Vesna, my understanding is, if you look at the fourth major bullet on this chart --

MEMBER DIMITRIJEVIC: Right.

CHAIR ROBERTS: -- that's the one that says that between 10 to the minus 8th and 10 to the minus 7th will be assessed for either cliff edge effects, or if the 95th percentile were to exceed 10 to the minus 7. So, there's two criteria for this --

MEMBER DIMITRIJEVIC: Yes, but they start mixing apples and oranges. Now, it's says total frequency, total mean frequency, and what is the total

mean frequency or is the 95th percentile? You know, the uncertainties and things are starting mixing. So, it's not really -- it needs to be much more precisely defined.

CHAIR ROBERTS: Sure. I will defer to Hanh --

MEMBER DIMITRIJEVIC: Yes. Right.

CHAIR ROBERTS: -- and to TerraPower. But I think they meant mean frequencies in that fourth bullet.

MR. PHAN: Thank you.

MEMBER DIMITRIJEVIC: And maybe the second paragraph, I don't see any value of that.

But, Hanh, let me ask you this: when we talk release frequencies, what release? Are those sequences from the Level 2 PRA?

MR. PHAN: The answer is no, but I will get back to that.

MEMBER DIMITRIJEVIC: Sure.

MR. PHAN: Thank you for pointing this out.

MEMBER DIMITRIJEVIC: All right.

MR. PHAN: The correct statement should be any sequences with the 95th percentile less than 1E to minus 8 will be screened out. And that's consistent

with your point. Are you okay with that statement?

MEMBER DIMITRIJEVIC: Yes, I will be okay with that statement. But, then, when I was looking and I saw the numbers, I got really curious.

MR. PHAN: Thank you. Thank you. You point it out clearly and we're going to correct that - -

MEMBER DIMITRIJEVIC: Okay.

MR. PHAN: -- and make that clear.

MEMBER BIER: A quick question. This is Vicki Bier.

On that issue of percentile versus mean frequency, can somebody confirm if that is stated correctly in the document and only unclear on the slides? Or is it also unclear in the original document?

MR. PHAN: I will take the first cut. That is unclear in the Topical Report. That's unclear in the Staff Evaluation and it's unclear clear. So, we will take that action; go back and make sure everything is considered.

MEMBER BIER: Okay. Thank you.

MR. PHAN: Thank you.

So, your second question regarding the frequencies, the outcome of the Level 3, that is the

dose release frequencies, not the Level 2 frequency.

MEMBER DIMITRIJEVIC: Well, you know, now when we talk about uncertainty analysis, that's far from just simple Monte Carlo. And we will need the Level 2. I mean, this is why I sort of like -- I have never done this. So, I don't really know exactly. I mean, I need to have my hands dirty of doing this type of analysis.

But in the release, in the Level 3, we are looking in consequences now.

MR. PHAN: Yes, so much. Yes, because we recognize the issue with the uncertainty for the Level 3. That's why we have the working groups with support from PNNLs to look into the options to evaluate the uncertainties. We have been in discussion. We have a draft report with that no finalized and that not going through the administrative reviews, but soon we would like to send that to the ACRS and asking for your feedback on what we missed studying on the consequence uncertainty and the frequency uncertainty.

Please, Candace.

MS. DE MESSIERES: Yes. Sure. This is Candace de Messieres again from the staff.

I just wanted to make sure we're making progress here, and I'm going to summarize some of the

take-homes here.

So, on this slide related to ensuring clarity, again, to summarize, I think that the staff, the Topical Report, and the ACRS comments seem to all convalesce in a common understanding of what was actually done. So, we will go back and ensure clarity in the text and in the bullets here and in the text in the SE and in the Topical Report. So, we'll take an action to ensure clarity, that what we understand is the approach is clearly documented.

On the next slide, there was a discussion of a difference in understanding and we're going to be taking that one back. But, in the interest of time and scope -- and we do have some additional slides to get through -- I would just offer that we have noted those for action.

And I would offer that we could continue with the presentation if all are in agreement with that summary.

CHAIR ROBERTS: Well, Candace, that sounds good to me.

One question that I'd like to ask -- and you can figure out when the appropriate time is -- is the same question I asked the Applicant about the 10 to minus 6, 10 to minus 7, 10 to minus 8 thresholds

and how you concluded those were appropriate thresholds to use. So, whether that's now or whether that comes later in this presentation, I'll leave up to you.

MS. DE MESSIERES: Yes. Thank you very much. And, yes, we can revisit that at the end. I think we will address some of the continued questions throughout the presentation.

Thank you.

CHAIR ROBERTS: Okay. And just looking at the slides, we're at 16 of 41 and we've been at this for an hour and 25 minutes. So, we're not all in the same room; I can't really look at body language. But is there kind of a consensus of now is a good time for a break?

DR. BLEY: Yes.

MEMBER PETTI: Sure, Tom.

CHAIR ROBERTS: Okay. Sure. I got one vote.

So, it's now 2:23 Eastern Time. So, if we take a 12-minute break and come back at 2:35 Eastern Time, that should give people a chance to get up and stretch a little bit. Sound good?

Okay. With that, we're in recess until 2:35 p.m. Eastern.

(Whereupon, at 2:24 p.m., the foregoing matter went off the record and went back on the record at 2:35 p.m.)

CHAIR ROBERTS: Okay. It's now 2:35 p.m. and the meeting is back in session.

Back to, I guess, Hanh of the NRC staff.

MR. PHAN: Everyone, this is Hanh.

So, we're done with slide 16. If there's no other questions, Michelle, please go over the section on radiological consequence analysis.

MEMBER BIER: Excuse me.

MS. SUTTON: This is Mallecia. Can you see the slide?

MEMBER PETTI: I still have trouble seeing the slides, but I'm following along with the slides sent us.

MEMBER BIER: Excuse me. This is Vicki Bier.

I just wanted to make one comment on the previous discussion before we move on, which is my personal view. I don't know whether Vesna and others on the Committee would agree. I would be comfortable with a strategy that said that the main determination was based on mean frequencies and 95th percentile was only used kind of as a conservatism. But, you know,

I will wait to see how this is resolved in the document.

Sorry for the interruption.

MR. PHAN: Thank you. We will take that into further consideration and update our Safety Evaluation according to your feedback. Thanks.

MS. HART: Okay. This is Michelle Hart again from the NRC staff. And now, I'll be talking about the radiological consequence analysis to support the Emergency Planning Zone sizing methodology.

The sizing analysis for the EPZ does use output of methodologies and related Topical Reports which are currently under review, those being the Radiological Source Term Methodology and the Radiological Release Consequences Methodology.

I have a note at the bottom of the page that has a link to the information on the public website that gives information on those Topical Report applications.

Source terms are developed as part of the Safety Analysis and the PRA and are used as input to the EPZ sizing analysis. So, source terms will not be developed specifically for Emergency Planning Zone size differently than they would be in developing the PRA in general. And we will review the development of

those source terms as part of its review of a related license application safety analysis report, including implementation of the related Source Term Topical Report.

Next slide, please.

That being said, there are a few pieces of information that are specific to Emergency Planning Zone sizing that they emphasize in this Topical Report; that the radiological consequence analysis methodology would include specific meteorological data requirements for the initial analysis and for the final analysis. It would require more data for the final analysis.

Dose information time periods, in other words, they use the 96-hour time period for the DBAs and most release sequences and 24-hour exposure period for the criterion C, for the very severe accidents.

There's no modeling of protective actions to the public in these analyses and the exposure pathways are cloud shine, inhalation, resuspension, and ground shine.

We find the Topical Report methodology acceptable because the consequence analysis inputs and assumptions are consistent with the guidance in Reg Guide 1.242.

Next slide, please.

So, when it comes to the estimation of dose, the Topical Report methodology identifies that doses are first estimated at a proposed plume exposure pathway EPZ distance and compared to the three dose-based criteria, which I will discuss later. The plume exposure pathway EPZ is established as the furthest distance at which all three criteria are met.

The iterative process to determine a plume exposure pathway as TerraPower had described is if they do not meet the results of all three criteria, their proposed distance, they would either change the plume exposure pathway EPZ size; make some changes to their analysis to accomplish within reason, or make design changes if it's during the design phase. Once they have sent in or gotten a license for the facility, it's not expected that they would be making design changes.

Next slide, please.

So, the next step in the methodology is, then, to use the analysis output from the consequence analysis, the probabilistic dose aggregation in comparison to the dose-related criteria, and also, a comparison to the criteria for necessity of predetermined prompt protective measures to compare to

the regulatory criteria in the 10 CFR 50.33(g)(2).

Next slide, please.

So, for dose-related criteria A and B, the projected doses from the design basis accidents for criterion A and for most radiological release sequences -- and that would be Criterion B -- would not exceed the EPA PAG levels outside the plume exposure pathway EPZ.

The design basis accidents for criterion A are derived from the design basis events, and that's determined through the use of the LMP. So, it would be the same DBAs that they are using in their Safety Analysis Report.

Criterion B events are taken from the PRA, the site-specific and design-specific PRA, and those are the events with mean release frequency greater than 1 times 10 to the minus 6 per reactor year.

We did find that the basis of these criteria in the EPA PAGs is acceptable and the specific groupings are acceptable because they are consistent with the goals for emergency planning as described in NUREG-0396, the guidance in Reg Guide 1.242, and the dose criterion for determination of Emergency Planning Zone size in the regulation.

Next slide, please.

MEMBER KIRCHNER: Michelle, this is Walt.

MS. HART: Yes? Yes?

MEMBER KIRCHNER: So, in effect, what you're saying under that second sub-bullet is that's the definition of most release frequencies, quote-unquote, "most release events" -- "sequences"? Sorry, I misspoke.

MS. HART: Yes, most radiological release sequences would be --

MEMBER KIRCHNER: It is defined de facto as greater than 1 times 10 to the minus 6?

MS. HART: Correct, in this methodology for this purpose.

MEMBER KIRCHNER: Yes. Okay. Thank you.

CHAIR ROBERTS: And, Michelle, that's based on precedent or based on some other criteria? I was curious why 10 to the minus 6 is the right number. And the related question is, does that consider the effect of uncertainty? Because it's based on a mean release frequency. And so, if you had something that was slightly lower with a much larger consequence, you may or may not include it?

MS. HART: Correct. So, it's more of a reasonableness criterion. I think, you know, there's not a specific criterion in NUREG-0396. There's not

a specific criterion in the regulations, either, that would say what events should be compared to the Emergency Planning Zone sizing criterion of 1 rem over 96 hours.

I think we'll talk a little bit more in two slides from now about the comparison to this criterion. They're not just comparing the mean dose to 1 rem. They're comparing the 95th percentile to the upper end of the PAG range as well, to kind of try to evaluate some of that uncertainty in the consequence assessment. And those analyses, the radiological consequence analysis methodology and the source term methodology, include consideration of uncertainty. And I won't say that it's completely a quantified uncertainty. We are still reviewing those analyses. But there is some room for deterministic-ish kind conservative assumptions.

And I don't know if that answered your --

CHAIR ROBERTS: Yes, that makes sense.

MS. HART: Yes.

CHAIR ROBERTS: I think that makes sense, Michelle. I'm thinking just a hypothetical. There's something at 9.5 to 10 to the minus 7 that gives you 100 rem.

MS. HART: Right.

CHAIR ROBERTS: So, that would be, you know, something that would probably, I would hope, bubble up somehow as, boy, that's very close and I'm sure it's a whole lot worse than the target consequence. So, let's go look at that. And that's really what I'm wondering about, the uncertainty.

If you look at the words in the Reg Guide -- Appendix B I think it was -- talked about you need to consider uncertainties for cliff edge effects and adequacy of defense-in-depth. And it wasn't clear to me whether that applied to criteria A and B or just to criterion C. I was wondering if you had any thought on that. Is that something that is clear or needs to be clarified?

MS. HART: So, yes, I take your point on the language in the Reg Guide. And, of course, you had pointed out earlier this is one of the first uses of the guidance in the Reg Guide.

I think we, generally, intend that it's an overall consideration; like the whole analysis would take those kind of considerations into account. In Appendix A to Reg Guide 1.242, we pointed back to, basically, Appendix I or Appendix 1 of NUREG-0396, which did some of that dose-at-distance evaluation and trying to look at how the consequences would be

increasing, or decreasing -- excuse me -- outside of the Emergency Planning Zone that they had chosen for large light water reactors.

So, I think there's a general intent that we think that an analysis like this should include this larger kind of integrated kind of evaluation, looking at them, all of these events, as a whole. Does it give you the right area? Would it change your determination on where you may need to have preplanned prompt protective measures ready to go, if there were an event? You know, for those likely type of releases that could occur from the facility.

CHAIR ROBERTS: Right. I assume that's the kind of thing you'll be looking at when you get to the first actual analysis that uses this methodology to see if there is some -- I won't use the term "cliff edge" again -- but some sort of, something that's really close to an edge of a frequency threshold that has significantly different consequence, whether or not that would have bubbled up by some other part of LMP or some other part of the evaluation.

MS. HART: Correct. And you're right to point out the LMP does do some of these uncertainty and cliff edge effects analysis are also included in that process. So, there's this general analysis, you

know, rigor that they're going through to try to quantify these events, so that we can use them in this risk-informed kind of process to determine the Emergency Planning Zone size as well.

And so, I think there's a general thought that, should you have additional information here over what you're already doing for the safety analysis, I mean, that kind of, as you're pointing out, remains to be seen when we look at the actual implementation. And I think that's one of the things that's difficult with methodologies. It's because there could always be some strange outlier, and does that really affect the decision we would make? It's hard to tell until you actually see that example.

CHAIR ROBERTS: Right. Okay. Yes, thanks, Michelle.

MS. HART: Okay. Next slide, please..

So, for criterion C, this is what we're saying is the immediately life-threatening doses from the worst-case radiological release sequences would generally not occur outside the plume exposure pathway EPZ.

And to give a marker for what an immediately life-threatening dose would be, they chose to use the 24-hour exposure, 200-rem red bone marrow

effective acute dose. And that this is for these events with mean release frequency between 10 to the minus 7 and 10 to the minus 6 per reactor year.

The staff finds criterion C is acceptable because the dose metric and events are comparable to the dose metric of 200-rem whole body acute dose and consideration of event frequency and low probability of dose exeedance used in NUREG-0936 of very severe accidents, although in that case it was for worst-case core melt sequences with containment failure or bypass for large light water reactors.

MEMBER BIER: Michelle?

MS. HART: Yes?

MEMBER BIER: This is Vicki Bier again.

MS. HART: Hi.

MEMBER BIER: I'm a little troubled by that word "generally" in the second line. Can you talk about how I should interpret that?

MS. HART: So, we can't say definitively that they would not occur outside of the plume exposure pathway, but for most cases, you know, probabilistically, it should be less than -- you know, you should not exceed that. But there may be a few sequences with low frequency, but there should be a low dose exceedance frequency, was the way that they

talked about it in NUREG-0396.

So, in that case -- and this is not the criterion that the Topical Report methodology is using -- but in NUREG-0396, it was the conditional probability of exceeding that dose would be 10 to the minus 3 or lower, and it was conditioned on core melt, which in that case was 1E minus 5 per reactor year.

In this case, they're using the release frequency, not the event frequency, and they do not have a specific dose exceedance criterion or probability of dose exceedance criterion. They're just saying, you know, for these events, it would not exceed that dose.

We'll talk a little bit more in two more slides from now about the comparison to this criteria. There is an evaluation similar, as in NUREG-0396, where they do a dose-at-distance curve and look at how that turns out.

CHAIR ROBERTS: Yes, Vicki, we're just getting to your question. If you look at the actual words in the Reg Guide, there's a couple of words missing on this slide. The Reg Guide says, "For the worst core melt sequences, immediately life-threatening doses would generally not occur outside the EPZ."

Because I think "for the worst-case melt sequences" is actually important there because the worst core melt sequences does not imply some sort of probabilistic frequency threshold. It's the worst thing you could possibly dream up, is the way I would interpret those words.

So, I think, in the context of those words, the word "generally" makes a little more sense. I'd be curious if that makes sense to you or to Michelle.

MS. HART: I mean, I agree with it.

MEMBER BIER: I would probably need to think about it more, but I appreciate the explanation. Thanks.

CHAIR ROBERTS: Yes.

MS. HART: And I see, Steve, you have your hand up.

DR. SCHULTZ: Yes, Michelle. Thank you.

I'm just going back to the question that Tom asked of John earlier, when TerraPower was making the presentation. Looking at NUREG-0396, both Tom and I looked at what was in there associated with the life-threatening doses. And they do mention there the lung dose as well as the whole body or the red bone marrow dose.

I'm just wondering whether you had an opinion as to why it's not important to look at all sequences and determine whether a lung dose might be more limiting than the whole body dose.

MS. HART: Yes, I think that's a good question. I think, in the context of the decision that we're making, like, is this a reasonable area to set up, you know, predetermined prompt protective measures such as evacuation or sheltering, that the red bone marrow dose from the external exposure instead of inhalation dose to the lungs is a reasonable marker to use for that acute radiation syndrome.

DR. SCHULTZ: Yes, I think that 0396 says there might be sequences where the lung dose might be so high that it could cause immediate consequences. But just looking through the literature, I wasn't able to find any that really fit that, those conditions.

MS. HART: Right.

DR. SCHULTZ: I understand that they weren't looking at long-term consequences, and so forth. That's where a lung dose might have an impact.

MS. HART: Right. And I think that's one of the -- this is not a comparison to the QHOs or anything like that. This is a marker for, do you

think you would have to take prompt protective measures? And if you were not able to take or it took you a little bit longer to take those measures, or if you didn't have preplanned measures -- that's actually the way to say it -- you know, would you expect to have life-threatening doses outside of the Emergency Planning Zone where you have those preplanned actions?

And there's always the capability of, you know, taking actions, regardless of whether you have the preplanned measures inside the Emergency Planning Zone. We're not crediting that, but that's the decision we're making, is: where is it reasonable to have them have an Emergency Planning Zone prepared for the likely events that would occur?

DR. SCHULTZ: That makes sense. Thank you.

MEMBER BIER: This is Vicki Bier again.

If I can make one other comment on that, it seems like, if we're talking about just barely outside the EPZ, anybody needing a response would be very close to a prepared responder. And, you know, if you're talking about large EPZs, you know, a 10-mile radius and possibly consequences well outside that, people could be far away from the resources they need. But if the EPZ itself is small and we're talking

about, hopefully, only small departures from that, that may not be as big of a concern. Am I misinterpreting something there?

MS. HART: I think that's a reasonable interpretation. You know, certainly, in this analysis, we cannot say for sure what actions may or may not be able to be taken. We're trying to determine where is an area that you would have to preplan for actions and what is a reasonable area to do that.

And we shouldn't be -- you know, there's some consideration that you should be relying too heavily on one specific sequence. So, yes, looking at the whole thing, looking at the overall evaluation, if there's one or two outliers, would that change your decision? It's something that could be taken into account.

And like I had said earlier, it's a little hard to -- I mean, you can speculate that there could be things like that, but without the actual implementation, it's hard to tell if that's a real big problem that should be, you know, try to be addressed by the methodology in a more specific way.

I don't know; did that answer your question or help?

MEMBER KIRCHNER: I would just make another observation, Michelle. This is Walt.

MS. HART: Okay.

MEMBER KIRCHNER: Underlying 0396 is the presumption of prudent measures and that's hard to quantify. So they, I believe, erred on the conservative side.

So, yes, there's no just, to Vicki's point, I don't think there's any fine defining line. In analytical space, yes, we can define a place where that dose threshold is crossed, but, you know, as Vicki said, if another hundred yards or meters out you're at 50 rem, then prudent measures would suggest that the EPZ maybe needs to be enlarged.

And certainly, 0396 has a very qualitative aspect to it when it's interpreted for actual sizing. So, there is, for the agency, when it reviews a specific application for a specific site, not just the exact -- what I want to say, just that the agency doesn't rely just on a precise calculation, but, also, what is a prudent interpretation of the situation.

MS. HART: I agree with that and I believe, through discussions with TerraPower, that that's the intent of their methodology as well.

DR. BLEY: This is Dennis Bley.

Michelle, this probably isn't fair to ask you this, but I'm going to. 0396 was pretty cleverly done. Brian and some other smart people sat down with the very first two PRAs that were ever done in WASH-1400 and dreamed beyond them some and came up with a pretty nice layout and plan. The designs for those plants and operating conditions are more than 60 years ago.

Staff's never talked about trying to revise 0396 into some kind of updated basis document. Do you have any concerns about its right now antiquity and use of it today?

MS. HART: So, I hear what you're saying. I think, in general, when we developed Reg Guide 1.242 and when we wrote the EP for SMRs and other new technologies rule, we took the general tenets of 0396. We did not intend to say you should do something exactly as in 0396. So, the idea that you would determine an area where it's likely that you may have to take predetermined prompt protective measures is still the goal of the Emergency Planning Zone, and that it is a tool in the emergency preparedness to be able to provide dose savings in the event of a release from a facility.

So, we're trying to take those same

thoughts that they used when they developed the information in 0396 and developed the original EP rules into account when we're looking at these new analyses that are sized more to the risk of the facility that we have in SMRs and other new technologies, such as light water reactors.

DR. BLEY: That's probably as good an answer as exists. And I'm wondering if it might be better in future applications to refer more to how that's been adapted and used when you're referring to you know, something that's held up very well, I agree with that, and they did a good job.

MS. HART: Yes.

DR. BLEY: But making it clear that it's the tenets from there that have been in a sense revised to apply to current designs and operating regimes.

Okay. Thanks, Michelle.

MS. HART: Thank you.

I see Todd has his hand up. Did you want to say something?

MR. SMITH: Well, hi. This is Todd Smith. I'm the COL advisor for emergency preparedness responses.

It's a great question and Michelle's

answer was spot-on. And I just wanted to add to that, in fact, as we were developing the guidance for the rule, we went back and actually interviewed Brian Grimes because we wanted to understand more of the essence, their philosophical approach, rather than the specifics of the information they had to work with at the time. And we are also working to capture the essence of that philosophy for future generations.

MS. HART: Okay.

CHAIR ROBERTS: I just wanted to add just a little thing, that NEI, I think just last week, rolled out this new NEI 24-05 standard that is kind of the next step in clarifying the intent of how 0396 applies in the guise of the new EP rule and Reg Guide 1.242.

And I assume the staff will be reviewing that over the next year or so, and it would probably be a good subject for us to give briefed on when the appropriate time comes, as to how the agency and the industry have converged on what these criteria mean today.

DR. BLEY: This is Dennis.

That's really good. I hadn't seen that come out.

MS. HART: Okay. The next slide, please.

So, as I had said, when they compare the dose results -- sorry -- when they compare the dose results to the dose-related criteria, for most events -- is the terminology I'm using -- for criterion A, the design basis accidents, as a reminder, and criterion B, those events with mean release frequency greater than 1E minus 6 per reactor year, you compare the mean of the 96-hour dose for the event to the lower end of the EPA PAG range. That would be 1 rem total effective dose equivalent. And you would compare the 95th percentile, 96-hour dose for the event to the upper end of the EPA PAG range, and that's 5 rem TEDE.

As we had said before, the groupings of events and the associated dose-related criteria are acceptable since they are similar to those evaluated in NUREG-0396 and discussed in Reg Guide 1.242.

Go to the next slide, please.

For the worst-case radiological release sequences, you would compare the dose against the dose metric of 200 rem red marrow acute effective dose for a 24-hour exposure period. You would also generate a dose distance chart mapping the dose reduction as one moves away from the Emergency Planning Zone size that they have chosen.

And that analysis helps to ensure that the dose, or it looks to ensure that the dose drops rapidly beyond the plume exposure pathway EPZ size boundary. And I think it's kind of a little bit qualitative, but the intent is there, similar to the intent that was in the analysis in Appendix I or Appendix 1 to NUREG-0396.

And the staff does find this methodology for the worst-case radiological release sequences and the associated dose-related criteria acceptable because the evaluation is similar to the evaluation of the worst core melt accidents in NUREG-0396, which is referred to in Reg Guide 1.242, Appendix A, "Guidance on Probabilistic Dose Aggregation."

Next slide, please.

I'm going to talk a little bit more about the probabilistic dose aggregation and the treatment of uncertainty steps.

Criterion C, which is that's the worst-case release consequences, considers a scenario with lower frequency than are used to determine licensing basis events with the LMP. In other words, there's another half order of magnitude of event frequency that they would be looking at as compared to or included in the licensing basis events for their

Safety Analysis Report.

Section 6.3 of the Topical Report describes the uncertainty and sensitivity analysis methodology. They do say that they're going to use Monte Carlo sampling on the PRA event frequencies. Source term and consequence analysis uncertainty results are included, as determined in the related methodology Topical Reports, as I had stated earlier.

And there are also cliff edge effect evaluations, and that's for events with frequencies down to 10E minus 8 per reactor year. The primary focus of these cliff edge effect evaluations, as TerraPower had described, is the focus on single failures that would dramatically change either the risk metrics or the effects of the accident sequences, such as timing, plant response, source terms, or end states.

And through this, the methodology will ensure very low probability events with potentially high consequences will not be inappropriately scoped out of the plume exposure pathway EPZ sizing analysis.

Next slide, please.

And finally, to help, in the regulation there is a second criterion for the Emergency Planning Zone size, and that is that the radiological release

timing will be used in the methodology to identify the necessity of prompt protective measures. Each event will be assessed individually to determine if the timing supports the necessity of prompt protective measures. Any identified protective measures through this process will inform the emergency plan and procedures that they will be developing for their application. And it is not part of this methodology.

Staff finds the use of radiological release timing to determine the necessity of prompt protective measures is acceptable because it's consistent with the guidance in Reg Guide 1.242.

Next slide, please.

And now, I will turn it over to Hanh to discuss the proposed Limitations and Conditions.

MR. PHAN: Thank you, Michelle.

So, as I mentioned earlier, the staff has established five Limitations and Conditions related to the PRA which will be utilized to support the EPZ calculation.

As highlighted in the last statement on this slide, the first L&C is intended to ensure that, prior to the initial fuel loading, any exceptions to meeting the capability categories referred to in the Reg Guide 1.247 should be justified and documented.

Next, please.

As highlighted in the last statement of Limitation and Condition 2, prior to the initial fuel loading, PRAs supporting this methodology must include all applicable hazards and operating modes not covered in the non-LWR PRA standard.

The third L&C pertains to the PRA key assumptions and key sources of uncertainty, which states that "An applicant that references this Topical Report must provide discussions of (1) how PRA key assumptions and key sources of uncertainty for each analyzed hazard, mode, and radioactive source were identified; (2) how the key assumptions and key sources of uncertainty identified have been characterized in a manner consistent with the current state of knowledge; and (3) how the impacts of each identified key assumption and source of uncertainty was assessed and dispositioned."

Next, please.

MEMBER KIRCHNER: Hanh?

MR. PHAN: Yes, sir?

MEMBER KIRCHNER: This is Walt.

On your previous slide, I'm a little confused by the terminology. Maybe I'm not reading it correctly. Your highlight under bullet No. 2,

Limitation and Condition No. 2, all applicable hazards and modes not covered by the non-LWR -- what do you mean by that?

MR. PHAN: So, in the PRA standard, there are accident hazards listed for consideration.

MEMBER KIRCHNER: Uh-hum.

MR. PHAN: And also, there's the requirements regarding identification of initiating events, which there is no specific list; that's up to the design and additional site-specific hazards may be out there for further considerations.

So, this L&C to ensure that not totally relies on the PRA, but the applicant should take their own approach, like, you know, the ones and other techniques, you know, like human events, to identify any specific initiators and any local or site-specific hazard.

In summary, this L&C just ensures that: do not rely on the PRA standard, but do additional assessments to ensure that all internal and external hazards will be identified and considered.

DR. BLEY: This is Dennis Bley.

I'm going to speak on behalf of the non-PRA standard people. We criticized an earlier draft of that standard and they revised it to discuss how

one needs to begin with no prior assumptions and look at all possible events.

And I think if you came up with something using what you just suggested, it would definitely within the scope of what the standard tells people to do. So, I'm a little, I won't say uncomfortable. I think that statement is overkill.

MR. PHAN: Thank you. I understand your position there, but we want to ensure that at least one deductive and one, you know, one technique to ensure that the list is comprehensive and complete.

MEMBER KIRCHNER: Is this something -- Hanh, this is Walt again -- that you would negotiate with the applicant somewhere early in the process? I mean, if you're hanging your hat on the PRA to develop everything that follows, whether it's event selection or consequence analysis, or so on, it seems to me that there needs to be some agreement early in the process between the applicant and the regulator.

That's why I was perplexed, like Dennis, by not covered by non-LWR PRA standard. Because earlier we say you need to do the PRA to the non-LWR PRA ASME/ANS standard, and then, peer review it. So, I'm confused a little bit about what contingency is this providing for.

MEMBER DIMITRIJEVIC: So, Hanh, is what you're telling us you wanted to say, prior to -- that the PRAs supporting PRAs supporting this methodology must also consider applicable hazards and modes which are not covered in that? You mean, in addition, you know, you want to say the hazards and the modes, which I don't know about modes not covered, but not covered, and the PRA standard should also be considered? Is that the point of this?

MR. PHAN: Thank you.

So, my position is that the PRA to be used for this methodology will cover all initiators almost and all sorts of materials. So, it's not clear to us what those facilities are at this stage. And I don't know exactly what operating modes for those facilities. It means non-reactor facilities. And I don't know exactly yet what to be considered as initiators for those non-reactor facilities. So, I put that statement there to ensure that any radiological materials outside that building also are considered appropriately.

MS. DE MESSIERES: This is Candace de Messieres again.

I think the feedback is received and I think the staff can take a look at that one and

confirm if it is or is not covered. I think it's a good point. The non-LWR PRA standard was intended to be inclusive. And so, if there's an opportunity to ensure and check, you know, we certainly will do that. So, I think we can take that one as well.

CHAIR ROBERTS: Yes, Candace, this is probably a good time to reiterate that all of the comments from ACRS members are their personal opinions, and there's certainly no requirement for you to take those opinions and make changes to the document based on them.

If your assessment, after hearing the opinion, is that there's additional work that's warranted, you know, that's certainly what you ought to be doing. But I just want to be clear that any discussion during this meeting is just to exchange information and, yes, you might hear opinions that may or may not be something that you consider warrants action.

MS. DE MESSIERES: Sure, sure. No, thank you for that.

CHAIR ROBERTS: I make that public safety announcement.

(Laughter.)

MS. DE MESSIERES: Thank you.

I wanted to ensure that we heard the comment and that we're considering the comment. So, that's the extent of that.

So, thank you for that.

MR. PHAN: Thank you.

So, next, please.

CHAIR ROBERTS: I think I have a related question on No. 3 to the discussion we just had on No. 2. I read No. 3 and it seems like this should apply to anything that a PRA does; that if you've got a PRA and you're using it for anything, it seems like you would want every one of these three bullet points to be achieved. Is your intent to put this L&C in, basically, every Safety Evaluation that documents PRA work in support of LMP?

MR. PHAN: On those in the Topical Report, the Applicant mentioned LMPs, but it's not specifically identified in the methodology. It's not certain, at least to me, that the Applicant referenced this Topical Report will implement LMP on that.

CHAIR ROBERTS: Okay. I'll defer it to Dennis and Vesna. But it seems like if you're going to use the PRA to inform design or to justify design, you would want to meet all three of these metrics.

And I certainly would agree with you that

these are things that you would expect. I'm just not sure if your intent is or the need is to say these in every Safety Evaluation or whether this is just what comes with the cost of doing business when you're using a PRA to justify design.

MR. PHAN: I apologize. Is that question to me or to the ACRS members?

CHAIR ROBERTS: Yes, I'm just wondering, well, certainly for you, but I'm wondering if Dennis or Vesna, or somebody else, has a view on that. Just there's no harm I can see in saying this, but it seems like it should almost go without saying that, if you're going to use a PRA for justifying design, you would want to have all these things documented and justified.

DR. BLEY: Yes, Tom, this is Dennis.

I certainly agree with you a good PRA would do this. A PRA that meets the non-LWR PRA standard would do this.

And there was a time back with NGNP, when the staff reviewed those white papers and came to us, they threw the same thing kind of in, where, in addition to the initiating events, you come up here separate from the PRA, one ought to think broadly and qualitatively about what else may happen.

I think that non-PRA standard has you do that now, No. 1. No. 2, even back then, we said that's a good idea, and if whatever you come up with isn't separate from the PRA, you'll need to incorporate it into the PRA if you came up with something you hadn't found by your other search techniques.

And I think what I just said there is consistent with the history of ACRS letters and positions in this area.

CHAIR ROBERTS: Yes. Okay. I'm not seeing any harm with certainly reiterating the importance of these points. I'm just wondering if the intent is to keep saying them in every SE or whether at some point this becomes ingrained in what the expectation is. But I guess I'll leave it at that.

MEMBER DIMITRIJEVIC: Well, Tom, this is Vesna.

You know, I mean, maybe here it makes -- it's most significant because they are actually using results of uncertainty in the license, you know, in some actions.

So, I mean, the other thing is that it suggests the road. There's not really, there are not really methods that you can, you know, that

incorporate the essentials and sensitivity things in that. So, I mean, but it doesn't do any harm. So, I mean, you are right, I mean that goes with every PRA. And so, the thing is only when you're using this result, selection then becomes much more challenging.

CHAIR ROBERTS: All right. Okay. Thanks, Vesna.

Yes, Hanh, let's move on.

MR. PHAN: Thank you.

So, on this slide, Limitation and Condition 4 is associated with the seismic PRA. As highlighted in the last statement, this specifies that, prior to the initial fuel loading, an applicant that references this Topical Report must reassess the EPZ size using a seismic PRA that meets the requirements of non-LWR PRA standard, as endorsed in Reg Guide 1.247.

Next, please.

And the last L&C states that periodic evaluation of the plume exposure pathway EPZ sizing analysis must be performed following an update or upgrade to the user's PRAs, based on those changes to the plant's SSCs, operational practices, and applicable plant and industry operational experience.

With that, Michelle, please take the

microphone to close the presentation.

MS. HART: Thank you, Hanh.

This is Michelle Hart again from the staff.

So, the conclusions of our safety analysis is that the staff finds the Topical Report, subject to the Limitations and Conditions, provides an approach acceptable to develop analyses to aid in the determination of a site- and design-specific plume exposure pathway EPZ for the Natrium reactor.

And accordingly, we conclude that the Topical Report can be used in establishment of a plume exposure pathway EPZ size to support emergency planning and preparedness in compliance with the regulatory requirements.

And that concludes our presentation. Do you have any additional questions?

CHAIR ROBERTS: Okay. I'm not seeing any hands or any other questions.

MEMBER BIER: Yes, Tom, this is Vicki again.

I don't want to harp on the obvious, but coming back to the whole idea of mean versus percentiles, the justification of using the mean is that it inherently incorporates the entire

distribution, including 95th percentile and above. And there's nothing magical about 95th compared to 99th or 80th or any other percentile.

So, from kind of a mathematical basis, mean value should be good enough. And I appreciate that, yes, the idea of looking at 95th percentile kind of covers us in case we missed something, in case we got something wrong in the analysis, et cetera, in case things are worse than we thought. So, it makes sense to do that, but that perspective may help simplify the whole discussion; that, you know, the main checks maybe should be based on mean value, and then, the others as double-checks or conservatisms, or whatever.

Anyway, I'll wait to see what everybody comes up with on this, but that's my two cents.

And I see that there are no more hands raised also.

MEMBER KIRCHNER: Yes, Vicki, this is Walt. I was waiting for you to point this out.

I will ask my colleagues to tell me why the mean isn't sufficient, especially when you have another criterion that the Applicant proposes, and the staff accepts, of looking at the 10 to the minus 8th category and searching for cliff edge effects.

So, what does this 95th percentile gain in this other than complicating things? I'm missing something because I would observe that the errors of omission probably are much bigger with a new technology than chasing down the 95th percentile.

The danger of the PRA not including something is probably much more of concern than getting to the 95th, when you already have a mean value that you're using down to 10 to the minus 7th, and then, searching down to 10 to the minus 8th for cliff edge effects.

So, I concur with your observation, Vicki, even though, mathematically, I'm not on solid ground.

DR. BLEY: Hey, it's Dennis.

I second what Vicki said and go one step further. If you have broad distributions, and if you've played with these at all, the mean can be higher than the 95th. It's not necessarily conservative to pick the 95th. So, I think Vicki had it stated well.

CHAIR ROBERTS: From what my understanding -- and I know what Candace said is they're going to look at the need to clarify this -- the intent was to look only at the 95th percentile for the sequences below 10 to the minus 7 as kind of an adjunct to their

cliff edge effects assessment; that, basically, if they could promote a sequence to be above 10 to the minus 7th using the 95th percentile, then rather than think about cliff edge effects, we'll say we'll just throw it in. And so, they will go down to 10 to the minus 8th regardless for the cliff edge effects.

So, yes, I'm not sure they gain a whole lot out of that, either. Just it seemed like it was more having less deterministic kind of judgments as opposed to just using a quantitative criterion to throw them in.

But I'd also observe that we have a Subcommittee coming up in less than two weeks, so on October 1st, where we'll get into more detail on cliff edge effects. And I think the question I'd ask the Applicant -- I haven't really asked the staff yet -- is why 10 to the minus 8th is the right number, or mean or 95th percentile, or whatever, for cliff edge. And I think that will probably be a better place to discuss it on October 1st, rather than spend more time in this discussion.

But when do you conclude that your PRA is good enough and you're smart enough that you don't have to do an additional assessment for cliff edge determination? -- is what I hope we'll talk about in

two weeks.

MEMBER PETTI: I just though the 95th percentile was also not consistent with some of aspects of LMP where they ask you to consider the uncertainties both in frequency, but also in consequence space, to make sure that something isn't just over the edge there that needs to be considered.

I see it more as a completeness thing. I also say there are many, many, many places where the NRC uses 95 percent confidence in all sorts of areas in the agency in making evaluations.

MEMBER KIRCHNER: But that's a bit different, Dave. This is Walt.

You know, let's take up something like experiments to measure critical heat flux. That's something you're working within a known space and you can repeat the experiments over and over again.

Here, we're in design space. We don't even have the reactor plant built. So, that's why I think, you know, 95/95 for CHF correlation that's based on experiments that can be reproduced over and over again under controlled conditions in a laboratory is different than a nuclear power plant where you haven't even built it yet.

And it just strikes me as, I guess, in

your description, yes, it probably helps the completeness of the exercise, but I thought Vicki's comments about the mean for this particular application of doing an EPZ size made more sense to me.

MEMBER DIMITRIJEVIC: This is Vesna.

I think that this is, as you know, it's from my perspective, this is much more complicated than we have yet. We don't have to address in the regulation, you know, uncertainties and how it reflects and what type. So, I think it's best to leave this for this Subcommittee where we can discuss it further.

And this is what I just say about it: there are so many different aspects. It's not just the distributions that we have for components. And most of the current uncertainty analysis comes to that, this Monte Carlo running through the distribution. But when it comes to missing things, model uncertainties, once when you exit the Level 1 PRA, this agreement on uncertainties, there are a lot that we talked in development. There are small uncertainties.

Much bigger uncertainties that are in phenomena, the things we did not look in, you know,

the things which we don't know; the things which we make assumptions. And all these things on which we make assumptions, we can look in each one of them and through them in the sensitivity, but we don't really have a way to put that sensitivity back in uncertainty distribution.

This is such a complicated subject, and this is why I said the last time when we discussed, wherever we have a project Level 3 PRA, I think this is one of the things which maybe they should really pull out of that, is these uncertainties as processed through the Level 3 PRA, and how to reflect on this.

And so, it is really my expectations should be maybe higher, and that's why I don't know should we address that through this unless we research, and development should be addressed through our PRA additional things.

But, anyway, my main point, that this is so complicated that I sort of really, you know, I don't even know how we can conclude. Because if this 95 includes all of this other stuff, then it makes sense. If it only includes the random distribution, then Vicki is right, that's just why the distribution will increase the mean value.

So, I think the time is right for us to

discuss and think more about how to discuss it for our ACRS meetings.

CHAIR ROBERTS: Okay. Any more questions for the staff?

(No response.)

Okay. Hearing none, I would like to thank Michelle and Hanh and Mallecia for the presentation. It was very comprehensive and certainly elicited a lot of questions, things that maybe I didn't notice when I read the Topical Report that helped to guide the discussion.

So, the next step is to see if there's any member of the public who are online who would like to make a comment.

So, if anybody out there wishes to make a comment, either raise your hand or just go ahead and unmute yourself, state your name and affiliation, if appropriate, and then, state your comment.

(No response.)

Okay. I am not seeing any or hearing anything.

So, with that, just looking through the attendees just for the court reporter, it appears that Matt Sunseri joined us. It's not like I mentioned Matt's name at the outset. So, just for completeness

of the record.

And with that, the next step would be to discuss next actions and I think we don't need the court reporter for that anymore. So, unless I'm wrong about that, I guess, okay, Mr. Cordes, you're free for the rest of today.

Okay. Thank you.

(Whereupon, at 3:35 p.m., the open session was adjourned.)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Staff Review of TerraPower Topical Report: "Plume Exposure Pathway Emergency Planning Zone Sizing Methodology"

Office of Nuclear Reactor Regulation (NRR)
Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)

Office of Nuclear Security and Incident Response (NSIR)
Division of Preparedness and Response (DPR)

ACRS Subcommittee Meeting
September 19, 2024

Agenda

- Review staff
- Review chronology
- Topical report (TR) purpose and review strategy
- Safety evaluation (SE) overview
- Conclusions

Review Staff

- Michelle Hart, Lead Technical Reviewer - Senior Reactor Engineer, NRR/DANU/UTB2
- Hanh Phan - Senior Reliability and Risk Analyst, NRR/DANU/UTB2
- Edward Robinson - Senior Emergency Preparedness Specialist, NSIR/DPR/RLB
- Kenneth Mott - Emergency Preparedness Specialist, NSIR/DPR/RLB
- Mallecia Sutton - Senior Project Manager, NRR/DANU/UAL1

Review Chronology

- October 31, 2022: Pre-application public meeting (ML23030B894)
- March 20, 2023: Submittal of TR, NAT-3056 “Plume Exposure Pathway Emergency Planning Zone Methodology,” Revision 0 (ML23080A045)
- June 12, 2023: TR accepted for review by NRC staff (ML23158A203)
- August through October 2023: Audit conducted (ML24008A057)
- November 16, 2023: Revision 1 of TR submitted (ML23321A036)
- September 16, 2024: NRC staff SE issued (ML24242A101)

Related submittal -

- March 28, 2024: TerraPower submitted, on behalf of US SFR Owner, LLC (USO), a construction permit (CP) application for the Kemmerer Power Station Unit 1 (ML24088A059)
  - Includes preliminary emergency planning zone (EPZ) determination technical report

TR Purpose and Review Strategy

- Purpose of TR
  - Provide methodology and criteria that will be used to establish the site-specific plume exposure pathway (PEP) EPZ size for the Natrium reactor
  - Risk-informed approach to meet EPZ criteria in 10 CFR 50.33(g)(2)
- Review strategy
  - Review consistency with the technical basis for the alternative EP framework in 10 CFR 50.160 and conformance with guidance on PEP EPZ sizing
  - Assess acceptability of the risk-informed approach and interaction with overall Natrium licensing approach using the Licensing Modernization Project (LMP) methodology

Note - 10 CFR 50.160 was issued November 16, 2023. TR Revision 1 made changes to address the proposed final rule and guidance.

Safety Evaluation Overview

- Regulations
- Guidance
- EPZ sizing methodology steps
- Accident screening methodology
- Radiological consequence analysis
- PEP EPZ size determination
- Limitations and Conditions
- Conclusions

Regulations

- 10 CFR 50.160
  - Alternative emergency preparedness (EP) requirements for small modular reactors and other new technologies

- 10 CFR 50.33(g)(2)(i)

  The PEP EPZ is the area within which:

  (A) Public dose, as defined in § 20.1003 ["Definitions"] of this chapter [Chapter I to Title 10] is projected to exceed 10 mSv (1 rem) total effective dose equivalent [TEDE] over 96 hours from the release of radioactive materials from the facility considering accident likelihood and source term, timing of the accident sequence, and meteorology; and

  (B) Pre-determined, prompt protective measures are necessary.

Guidance - EPZ

- **RG 1.242,** "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities" (ML23226A036)

- Consideration of technical basis for EPZ in **NUREG-0396**, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," (ML051390356)

Guidance – Risk-informed Approach

- **RG 1.233**, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors" (ML20091L698)
- **RG 1.247** (For Trial Use), "Acceptability of Probabilistic Risk Assessment [PRA] Results for Non-Light-Water Reactor Risk-Informed Activities" (ML21235A008)
- **RG 1.253**, "Guidance for a Technology-Inclusive Content of Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," (ML23269A222)

EPZ Sizing Methodology Steps Overview

- Accident screening to identify spectrum of accidents
  - Compile release sequences from the PRA for all internal and external initiators
  - Perform screening of non-seismic release sequences based on frequency, including uncertainty
  - Perform screening of seismic release sequences with a unique set of selection criteria, including uncertainty

- Radiological consequence analysis
  - Collect meteorological data and incorporate into the radiological consequence analysis
  - Perform source term and radiological consequence analysis
  - Evaluate the radiological consequences against the PEP EPZ dose-related criteria to determine if changes are needed

- Determine PEP EPZ distance based on EPZ sizing criteria

Staff Assessment of TR Methodology Steps

The staff finds TerraPower's considerations in determining the EPZ sizing methodology are consistent with the considerations in the basis for the scalable PEP EPZ in 10 CFR 50.160

- Supports the objective of emergency response plans to provide dose savings for a spectrum of accidents that could produce offsite doses in excess of the US Environmental Protection Agency (EPA) Protective Action Guides (PAGs)

The staff finds the steps of the TR methodology are consistent with the PEP EPZ size analysis methodology guidance in Appendix A to RG 1.242

Accident Screening Methodology

- Event selection and spectrum of accidents is risk-informed using a site- and design-specific PRA

The staff finds the use of risk-informed methods in event selection to determine a spectrum of accidents is acceptable because it is consistent with the guidance in RG 1.242

Development and Uses of PRA

- The design and site-specific PRA will be used to identify release sequences
- The PRA will address all hazards (internal and external), all modes of operation, and all sources of radioactive material
- The PRA will be developed in accordance with the guidance provided in the ASME/ANS NLWR PRA standard
- RG 1.247 provides criteria for PRA acceptability
- The PRA will undergo a peer review
- Key assumptions and sources of uncertainty in the PRA will be assessed to determine their impacts on the calculation
- Five Limitations and Conditions (L&Cs) have been established as relevant to the PRA

Hazards and Initiating Events

- Hazards from the NLWR PRA standard, along with the site-specific hazards, will be assessed for potential inclusion
- Screened hazards will be documented with justifications provided
- The methodology will incorporate security events
  - A qualitative or quantitative assessment of security events will be conducted and documented in the size calculation

The staff finds the approach for identifying PEP EPZ events to be consistent with the guidance in RG 1.242 and RG 1.247, and therefore acceptable.

Selection of Non-Seismic Release Sequences

- The non-seismic release sequences to be retained for PEP EPZ evaluation will include those with:
  - frequencies greater than or equal to 1×10^{-7} per reactor year (/ry)
  - frequencies that contribute 1% or more to the total release frequency
- If the sequence mean frequency is an order of magnitude or more below the screening criteria (i.e., less than or equal to 1×10^{-8}/ry), then the sequence is screened out
- If the 95th percentile value is greater than or equal to 1×10^{-7} /ry, then the sequence is screened into the process and included in the dose analysis
- Individual events and groups with total frequencies greater than 1×10^{-8}/ry will be assessed for cliff-edge effects
  - These will be included if the 95th percentile frequencies exceed 1×10^{-7}/ry

The staff finds the approach for screening in and screening out non-seismic release sequences to be consistent with RG 1.242, and therefore acceptable.

Selection of Seismic Release Sequences

- During the CP stage, the limiting peak ground acceleration (PGA) will be used to establish the bounding seismic events
- For the operating license or combined license application stage, the limiting PGA will be used as the event screening threshold for the selection of seismic events
- The site-specific scoping level seismic PRA (SPRA) will be performed to provide insights for establishing the limiting PGA
- The limiting PGA will be chosen to achieve at least two times the ground motion response spectrum (GMRS)
- An upper-bound PGA of 1.0 g will be applied in the selection of seismic events
- Uncertainty and cliff-edge effects will be evaluated and incorporated into the seismic event selection process
- An L&C has been established to ensure that the SPRA is of sufficient technical acceptability

Radiological Consequence Analysis to Support EPZ Sizing

- EPZ sizing analysis uses output of methodologies in related TRs under review*
  - Radiological Source Term Methodology
  - Radiological Release Consequences Methodology
- Source terms are developed as part of safety analysis and PRA - used as input to EPZ sizing analysis
  - NRC staff will review the development of source terms as part of its review of a related license application safety analysis report, including the implementation of the related source term TR

* Information on Natrium topical report reviews available at https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/licensing-activities/pre-application-activities/natrium.html

Radiological Consequence Analysis to Support EPZ Sizing (cont.)

- Radiological consequence analysis methodology assumptions and inputs specific to EPZ sizing analysis methodology TR
  - Meteorological data requirements for initial and final analysis
  - Dose estimation time periods
  - No modeling of protective actions for public
  - Cloud shine, inhalation, resuspension, and ground shine exposure pathways

The staff finds the TR methodology acceptable because the consequence analysis assumptions and inputs are consistent with the guidance in RG 1.242

Dose Estimation

- TR methodology identifies that doses are first estimated at a proposed PEP EPZ distance and compared to the three dose-based criteria
  - The PEP EPZ will be established at the furthest distance at which all three criteria are met
- Iterative process to determine PEP EPZ
  - If the result at the proposed distance is unacceptable, change the PEP EPZ size or make design changes (during design phase)

PEP EPZ Size Determination

- Analysis to address regulatory PEP EPZ criteria
  - Probabilistic dose aggregation and comparison to dose-related criteria
  - Necessity of predetermined prompt protective measures

Dose-related Criteria A and B and Event Selection

- Projected doses from the design basis accidents (DBAs) and most radiological release sequences would not exceed EPA PAG levels* outside the PEP EPZ, respectively
  - Criterion A DBAs are derived from design basis events, determined through use of LMP
  - Criterion B events with mean release frequency greater than 1×10^{-6} /ry

The staff finds Criteria A and B, and their basis in the EPA PAGs, are acceptable because they are consistent with the goals for emergency planning as described in NUREG-0396, the guidance in RG 1.242, and the dose criterion for determination of EPZ size in 10 CFR 50.33(g)(2)(i)

*The EPA PAG levels to recommend evacuation or sheltering of the public during the early phase of a radiological incident are 1 to 5 rem (10 to 50 mSv) projected dose over four days (2017 EPA PAG Manual)

Dose-related Criterion C and Event Selection

- Criterion C: Immediately life-threatening doses from the worst-case radiological release sequences would generally not occur outside the PEP EPZ
  - 24-hour exposure 200 rem red bone marrow effective acute dose
  - Events with mean release frequency 1×10^{-7} /ry to 1×10^{-6} /ry

The staff finds Criterion C is acceptable because the dose metric and events are comparable to the dose metric of 200 rem whole body acute dose and consideration of event frequency and low probability of dose exceedance used in the NUREG-0396 analysis of very severe accidents (i.e., the worst-case core melt sequences for large LWRs)

Comparison to Dose-related Criteria for Most Events

- Criteria A (DBAs) and B (mean release frequency > 1×10^{-6} /ry)
  - Compare mean 96-hour dose for event to lower end of EPA PAG range (1 rem TEDE)
  - Compare 95th percentile 96-hour dose for event to upper end of EPA PAG range (5 rem TEDE)

The staff finds the groupings of events and the associated dose-related criteria are acceptable since they are similar to those evaluated in NUREG-0396 and discussed in RG 1.242

Comparison to Dose-related Criterion for Worst-case Radiological Release Sequences

Criterion C

- Compare against dose metric of 200 rem red marrow acute effective dose for a 24-hr exposure period
- Generate dose-distance chart mapping the dose reduction as one moves away from the EPZ
  - Analysis to ensure that the dose drops rapidly beyond the PEP EPZ boundary

The staff finds the methodology for worst-case radiological release sequences and the associated dose-related criteria is acceptable because the evaluation is similar to the evaluation of the worst core melt accidents in NUREG-0396, which is referred to in RG 1.242, Appendix A, guidance on probabilistic dose aggregation

Probabilistic Dose Aggregation and Treatment of Uncertainty

- Criterion C considers scenarios with lower frequency than used to determine licensing basis events with LMP
- TR Section 6.3 describes the uncertainty and sensitivity analysis methodology
  - Monte Carlo sampling on PRA event frequencies
  - Source term and consequence analysis uncertainty results are included, as determined in the related methodology TRs
  - Cliff-edge effect evaluations
    - Events with frequencies down to 1×10^{-8} /ry
    - Primary focus on single failures that would dramatically change either risk metrics or the effects of the accident sequences (timing, plant response, source terms, or end states)

The TR methodology will ensure that very low probability events with potentially high consequences will not be inappropriately scoped out of the PEP EPZ sizing analysis

Necessity of Predetermined Prompt Protective Measures Criterion

- Radiological release timing used to identify necessity of prompt protective measures
  - Each event assessed individually to determine if timing supports necessity of prompt protective measures
  - Identified protective measures will inform emergency plan and procedures

The staff finds the use of radiological release timing to determine the necessity of prompt protective measures is acceptable because it is consistent with the guidance in RG 1.242, Appendix A

Proposed Limitations and Conditions

1. The PRAs used to implement the TR methodology will be design- and site-specific and developed for all applicable hazards, all modes, and all sources of radioactive material, using the guidance in RG 1.247 “Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities” and appendix A to RG 1.253 “Guidance for a Technology-Inclusive Content-of-Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors” (ML23269A222). **Prior to the initial fuel loading, any exceptions to meeting capability categories referred to in RG 1.247 should be justified and documented.**

Proposed Limitations and Conditions (cont.)

2. An applicant that references this TR must justify the technical acceptability of the PRAs performed for the selected hazards and modes (e.g., site-specific scoping level PRA). **Prior to the initial fuel loading, PRAs supporting this methodology must include all applicable hazards and modes not covered by the non-LWR PRA standard.**

3. An applicant that references this TR must provide discussions of (1) how **PRA key assumptions and key sources of uncertainty** for each analyzed hazard, mode, and radioactive source were identified; (2) how the key assumptions and key sources of uncertainty identified as having the potential to significantly impact the PRA results have been characterized in a manner consistent with the current state of knowledge; and 3) how the impact of each identified key assumption and source of uncertainty was assessed and dispositioned.

Proposed Limitations and Conditions (cont.)

4. An applicant that references this TR must justify that the scoping level seismic PRA is of sufficient technical acceptability. This means that the model will be design- and site-specific and developed based on acceptable methods and data. The engineering analyses, assumptions, and approximations used in developing the scoping level seismic PRA should be appropriate and should demonstrate the robustness of the conclusions with respect to the uncertainties in the assessment. **Prior to the initial fuel loading, an applicant that references this TR must reassess the EPZ size using a seismic PRA that meets the requirements of non-LWR PRA Standard, as endorsed in RG 1.247,** to the extent necessary to support plume exposure pathway EPZ sizing calculation.

Proposed Limitations and Conditions (cont.)

5. **A periodic evaluation of the plume exposure pathway EPZ sizing analysis must be performed following an update or upgrade to the user's PRAs** based on a review of changes to the plant structures, systems, and components, operational practices, and applicable plant and industry operational experience. The periodicity of the evaluation will be consistent with the requirements of 10 CFR 50.71(h)(2). Prior NRC approval, under 10 CFR 50.90, is required for any changes to the EPZ size resulting from an PRA update or upgrade.

Conclusions

The NRC staff finds that TR, subject to the limitations and conditions, provides an approach acceptable to develop analyses to aid in the determination of a site- and design-specific PEP EPZ for the Natrium reactor.

Accordingly, the NRC staff concludes that the TR can be used in establishment of the PEP EPZ size to support emergency planning and preparedness in compliance with the regulatory requirements in 10 CFR 50.33(g) and 10 CFR 50.47(c)(2), as applicable, for prospective TerraPower Natrium reactor CP or operating license applications under 10 CFR Part 50 and combined license or early site permit applications under 10 CFR Part 52.

Abbreviations

ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CP	construction permit
DBA	design basis accident
EP	emergency preparedness
EPA	Environmental Protection Agency
EPZ	emergency planning zone
g	gravitational acceleration
GMRS	ground motion response spectrum
L&C	limitation and condition
LMP	Licensing Modernization Project
mSv	millisievert
NLWR	non-light water reactor
PAG	protective action guide
PEP	plume exposure pathway
PGA	peak ground acceleration
PRA	probabilistic risk assessment
RG	regulatory guide
ry	reactor year
SE	safety evaluation
SPRA	seismic probabilistic risk assessment
TEDE	total effective dose equivalent
TR	topical report

Backup Slides

RG 1.242, Appendix A

- Describes an acceptable approach to meet the EPZ sizing requirements for 10 CFR 50.160 and the criteria in 10 CFR 50.33(g)(2)
- Generalized from the consequence assessment that informed NUREG-0396

RG 1.242, A-3
Generalized Methodology

- General steps for consequence analysis to support the determination of the plume exposure pathway EPZ:
  - Identify events and radiological release scenarios for the facility
  - Develop meteorological data
  - Develop atmospheric transport, dispersion, and deposition model
  - Model potential exposures to offsite populations
  - Model potential doses to offsite populations
  - Aggregate dose distance information

RG 1.242, A-3.1
Event Selection

- Applicant should consider licensing basis events from the facility safety analysis report as candidates
- For an application using LMP to develop safety analysis
  - Design basis accidents – derived from licensing basis events
  - Beyond design basis events
- If using accident or release frequency values from a PRA
  - Ensure PRA is acceptable for use in the risk-informed application
  - Uncertainty of the frequency estimate should be quantified

RG 1.242, A-3.1
Event Selection (cont.)

- Event likelihood may be used to determine whether the accident should be included in the range of accidents used in the PEP EPZ sizing consequence analysis
- Ensure that radiological releases with large potential consequences that may affect the size of the EPZ are not inappropriately scoped out of the consequence assessment based on low likelihood by considering the uncertainty of the accident likelihood

RG 1.242, A-3.1
Event Selection (cont.)

- Consider internal and external initiating events, multi-module and multiunit accidents and interactions, and all sources of radioactive material whose release may result in the need to take prompt protective actions
- Timing of the radiological release to the environment, as justified, may be used to determine whether an accident scenario should be included
  - In relation to reasonable amount of time for offsite response organizations to take appropriate response actions

RG 1.242, A-3.7
Probabilistic Dose Aggregation

- Aggregate doses from different source terms, given consideration of their frequencies
- The likelihood of exceeding a TEDE of 10 mSv (1 rem) due to the combined effect of accident frequency and variability in meteorological conditions should be discussed
- The likelihood of exceeding a TEDE of 10 mSv (1 rem) at the proposed EPZ boundary should be consistent with the evaluation in Appendix I to NUREG-0396, which provides relative probabilities of exceeding certain critical doses as a function of distance from the facility for a spectrum of severe accidents

RG 1.242, A-3.7
Probabilistic Dose Aggregation (cont.)

- The probabilistic dose aggregation in NUREG-0396 demonstrated that the PEP EPZ of about 10 miles in radius for large LWRs was of sufficient size such that all of the following conditions were met:
  - Projected doses from the traditional design-basis accidents would not exceed EPA PAG levels outside the EPZ
  - Projected doses from most core melt sequences would not exceed EPA PAG levels outside the EPZ
  - For the worst core melt sequences, immediate life-threatening doses would generally not occur outside the EPZ

RG 1.242, A-3.7
Probabilistic Dose Aggregation (cont.)

- The methodologies used for event selection, identification of source terms, modeling of releases, and aggregation of potential offsite doses should provide similar confidence as in NUREG-0396 that appropriate offsite planning will be identified

Plume Exposure Pathway Emergency Planning Zone Sizing Methodology

Natrium™

a TerraPower & GE Hitachi technology

ACRS Subcommittee Meeting

September 2024

TerraPower

Natrium™

TP-LIC-PRSNT-0029

Table of Contents

- Overview of NAT-3056, Revision 1, TerraPower, LLC (TerraPower) Natrium Topical Report: Plume Exposure Pathway Emergency Planning Zone Sizing Methodology
  - Guidance used
  - Methodology
  - Conclusion

NAT-3056 Revision 1

Guidance Used

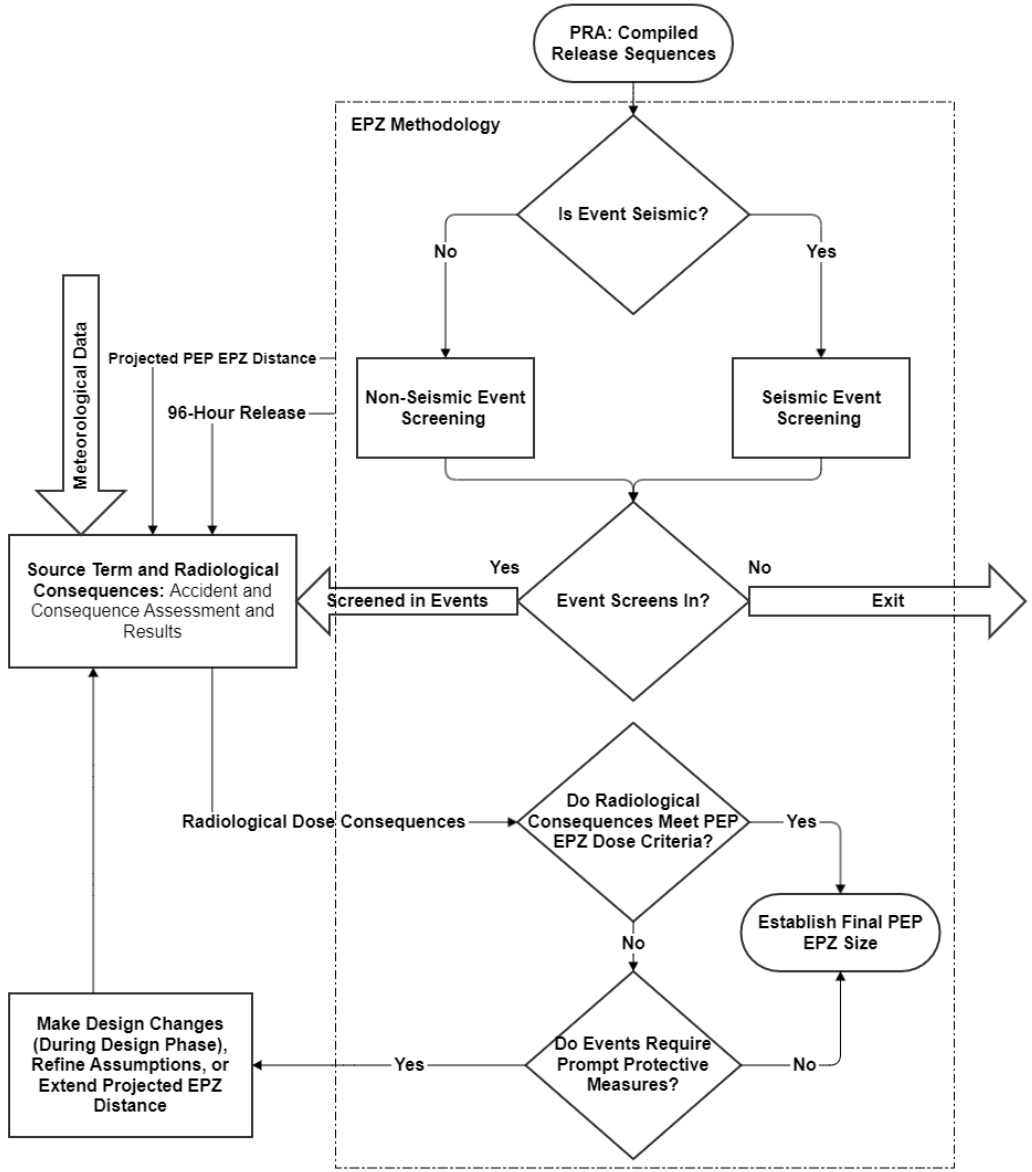
- Regulatory Guide 1.242, “*Performance-Based Emergency Preparedness for Small Modular Reactors, Non Light-Water Reactors, and Non-Power Production or Utilization Facilities*” was utilized in developing the overall methodology.
- Supporting information from NUREG-0396, "*Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants*“ was used to assist in the development of the evaluation criteria.

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

NAT-3056 Revision 1

Overall EPZ methodology

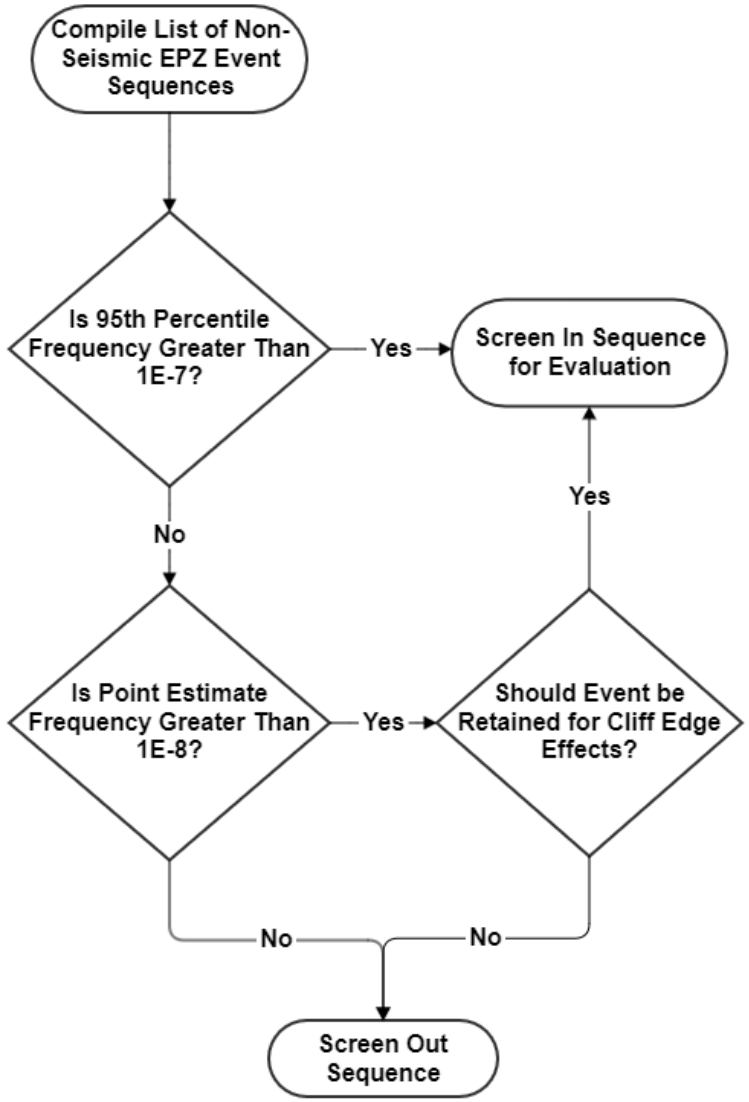
- Assesses all modes and all hazards
- Incorporates site specific meteorological data
- Assesses radiological consequences
- Identifies prompt protective measures
- Establishes final PEP EPZ Size



NAT-3056 Revision 1

Non-seismic Event Selection

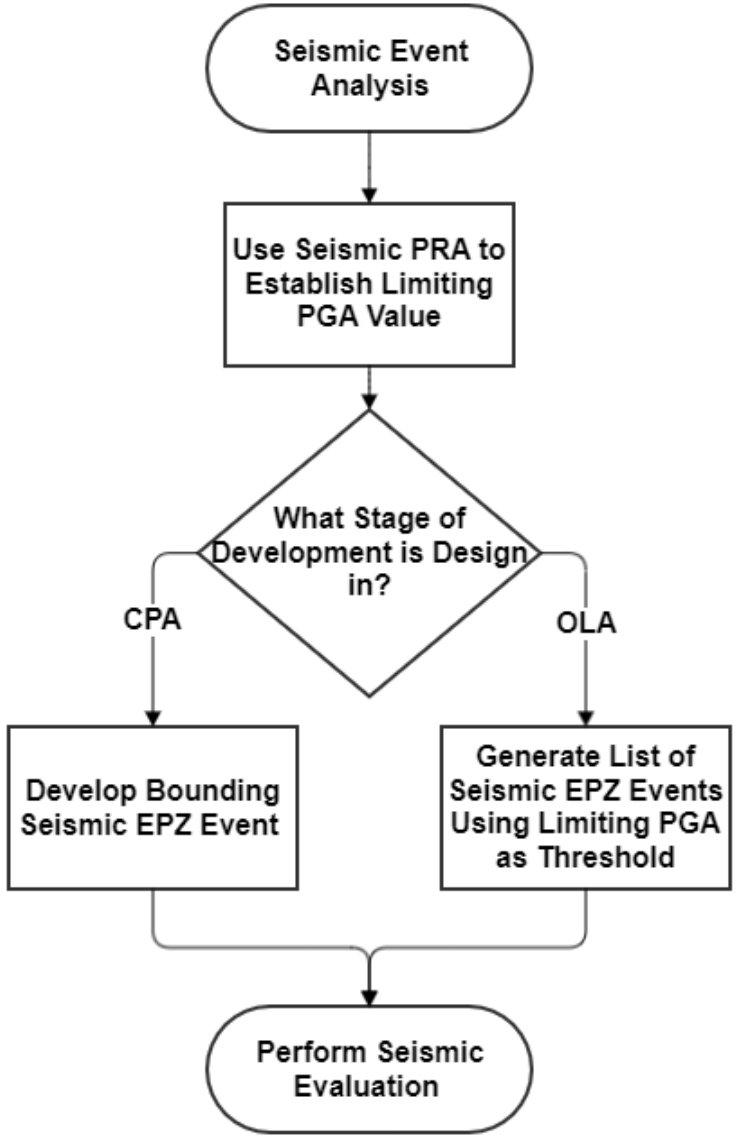
- Includes DBAs
- Includes events with a 95th percentile release frequency greater than 1E-7
- Includes events for cliff-edge consideration if they have a release frequency greater than 1E-8.



NAT-3056 Revision 1

Seismic Event Selection

- Bounding seismic event for the CPA
- List of seismic EPZ events using a limiting PGA as threshold to support OLA



NAT-3056 Revision 1

Criteria for PEP EPZ Sizing

- Criterion A: Projected doses from the DBAs would not exceed 1 rem mean 4-day TEDE and 5 rem 95th percentile 4-day TEDE.
- Criterion B: Projected doses from most radiological release sequences would not exceed 1 rem mean 4-day TEDE and 5 rem 95th percentile 4-day TEDE.
- Criterion C: Immediate life-threatening doses from the worst-case radiological release sequences would not exceed 24-hour 200 rem red bone marrow acute effective dose.

NAT-3056 Revision 1

Conclusion

- EPZ size is set based on smallest distance criteria are met.
- If the criteria are NOT met at a desired EPZ size, determination is made if design changes or refinements can be made to reduce EPZ size. Otherwise EPZ is expanded to meet the criteria.

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

Acronym List

CPA – Construction Permit Application
DBA – Design Basis Accident
EPZ – Emergency Planning Zone
OLA – Operating License Application
PEP – Plume Exposure Pathway
PGA – Peak Ground Acceleration
PRA – Probabilistic Risk Assessment
TEDE – Total Effective Dose Equivalent