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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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RELIABILITY & PRA SUBCOMMITTEE

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THURSDAY

OCTOBER 19, 2023

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The Subcommittee met via Video Teleconference, at 8:30 a.m. EDT, Vesna Dimitrijevic, Chairman, presiding.

COMMITTEE MEMBERS:

VESNA DIMITRIJEVIC, Member

RONALD G. BALLINGER, Chair

VICKI BIER, Member

JOSE MARCH-LEUBA, Member

ROBERT MARTIN, Member

DAVID PETTI, Member

JOY L. REMPE, Member

THOMAS ROBERTS, Member

MATTHEW SUNSERI, Member

ACRS CONSULTANT:

DENNIS BLEY

STEVE SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHSH

ALSO PRESENT:

VICTORIA ANDERSON, Public Participant

KEITH COMPTON, RES

SUSAN COOPER, RES

JONATHAN EVANS, RES

ALAN KURITZKY, RES

EDWIN LYMAN, Public Participant

SCOTT MOORE, ACRS

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

8:30 a.m.

CHAIR DIMITRIJEVIC: Good morning. It's 8:30, according to my time, so this meeting will now come to order. This is the Reliability and PRA Subcommittee Meeting in preparation for the Advisory Committee on Reactor Safeguards Review of the NSC Level 3 PRA project.

I'm Vesna Dimitrijevic, Chairman of today's Subcommittee meeting. Members in attendance are Bob Martin, Dave Petti, Joy Rempe, Matt Sunseri, Ron Ballinger. I saw the message from Vicki Bier that she was able to sign in. Vicki, are you there?

MEMBER BIER: Yes, I'm on, Vesna.

CHAIR DIMITRIJEVIC: Wonderful.

MEMBER BIER: Thank you.

CHAIR DIMITRIJEVIC: Wonderful. Okay. Did I miss anybody?

MEMBER MARCH-LEUBA: Yes, Jose. Jose is here too.

CHAIR DIMITRIJEVIC: Oh yes, Jose.

MEMBER ROBERTS: Yes, Tom Roberts is here too.

CHAIR DIMITRIJEVIC: Okay. All right, excellent. Tom Roberts and Jose March-Leuba are also

joining us. So some of our members are traveling so will not be able to join us.

We hold this open meeting to gather information to support our review of the NSC Level 3 PRA projects. The ACRS section of the U.S. NRC public website provides our charters, bylaws, agendas, reactor reports and full transcripts of all full and subcommittee meetings, including slides presented there. The meeting notice and agenda for this meeting were also posted there.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed position and action is appropriate for eliminating by the Full Committee. A transcript of the meeting is being kept and will be made available.

Today's meeting is being held virtual with remote Microsoft Teams capability. There is also a bridge line allowing participants over the phone.

When addressing the Subcommittee, participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard. When not speaking we require the participants mute their computers, microphone or phone.

Okay. So we will now proceed with the

meeting. And I call up on Jonathan Evans, PRA Branch Chief for NRC Office of Nuclear Regulatory Research to begin today's presentation. Jonathan?

MR. EVANS: Hi, good morning. Thank you, Vesna.

CHAIR DIMITRIJEVIC: Good morning.

MR. EVANS: So good morning to everybody. My name is Jonathan Evans. I am the Branch Chief for the Probabilistic Risk Assessment Branch in the Office of Nuclear Regulatory Research. I just want to thank the ACRS for the opportunity just to have us present and have this opportunity to discuss the Level 3 PRA project overview on the Volume 4 reports.

What I wanted to do is just a few moments just to thank the Staff in PRAB, and also in the rest of just the Agency who contributed to this project. This has been a very herculean effort and just wanted to say that we appreciate your efforts. And we look forward to answering your questions today from the ACRS. And with that, I'll turn it back over to Vesna or to Alan.

CHAIR DIMITRIJEVIC: Okay, thank you. Alan?

MR. KURITZKY: Thank you. Thank you very much, Vesna. Dr. Dimitrijevic and Jonathan. I just

want to echo, you know, Jonathan's sediments. We very much appreciate the opportunity to brief the Subcommittee. I recognize that you guys have your hands full with all kinds of exciting new and advance reactor work, and so we welcome, or appreciate the fact you're able to make time for us today.

We also had, oh. My name is Alan Kuritzky. I'm from the division of risk analysis in the office of research. I am the program lead for the Level 3 PRA project.

And we briefed the Subcommittee last year, I think in June, about Volume 3 of the Level 3 PRA project. Today we're back to review on, essentially an update on the project task, and also Volume 4 of the project.

And let me just get here. So what we hope to do today is to go over quickly the status of where the project stands near to the end of the project. Also, go over what public reports we have issued and what other ones will be coming forward.

I want to discuss, to some level of detail, but probably not excruciating detail, but the information that's in the overview report for Volume 4 which is the report that addresses the reactor at-power, PRA models for internal fires, seismic events

and high winds. And also addresses other hazards which we didn't model. And then the last thing we want to discuss today will be future interactions between the project and the Subcommittee and the Full Committee.

With that, I do want to acknowledge that a lot of work has gone into this project over the years. We've had some really excellent support from a number of organizations. Both within and without, outside the NRC.

So inside the NRC, NSIR, NRR, NMSS, the regions, TTC, everybody has had a hand in this and we greatly appreciate their work. Some of these organizations have had more input to the project than others, but everyone, all of these organizations have really done a great job in helping us out.

In terms of national labs, Idaho has been our main contractor. Our National Lab for this work. But also we've gotten a lot of support from Sandia National Laboratories, Pacific Northwest National Lab, and Brookhaven.

In terms of commercial contractors, NRG Research Incorporated has been our major contractor, but we also have gotten support from Applied Research Associates. And also IESS, Innovation -- Innovative

Engineering and Safety Solutions I think.

The PWR Owner's Group also support us later on supporting, organizing and running and funding some, a PRA standard based peer reviews for some of our early models. And Westinghouse and EPRI have both been supportive of the project. In fact, they have members on our technical advisory group for the project.

And of course the ACRS. We've gotten a lot of feedback. We've had, I've lost track now, this is probably close to 20 minutes that we've had with the ACRS since joining the project. Many of them were early on pre-pandemic when we were doing a lot of technical work. We had a lot of meetings to go over. And closed meetings because of the proprietary information. We had closed meetings to go into the technical details of every aspect of the project. And we greatly appreciate the time and the feedback we received from ACRS members.

CHAIR DIMITRIJEVIC: Alan, sorry for interrupting you --

MR. KURITZKY: Yes.

CHAIR DIMITRIJEVIC: -- but I noticed that you have the slides acknowledgments. Have we uploaded the slides because I don't see any slides?

MR. KURITZKY: Oh, these are not being -- oh, wait a minute. I'm not sharing this with you?

CHAIR DIMITRIJEVIC: No. I don't see them so --

MR. KURITZKY: Oh. No, you're right. You're right, I have them on my screen but I didn't share. Hold on one second. I apologize.

MR. BLEY: We are seeing you, Alan.

CHAIR DIMITRIJEVIC: We see you very nicely.

MR. KURITZKY: Okay, sorry.

CHAIR DIMITRIJEVIC: Okay. So I heard that Dennis is also here with us today.

MR. KURITZKY: Yes. Yes, I forgot to do the share. My apologies. I'm glad you mentioned it now and not ten slides into the presentation.

CHAIR DIMITRIJEVIC: Okay.

MR. KURITZKY: All right, thank you very much. Okay, does everybody see the slides now?

CHAIR DIMITRIJEVIC: Yes.

MR. KURITZKY: Okay. Okay, fantastic. Oh, also, that reminds me too. Because the slides are on my laptop right in front of my face, that's where the camera is so I'm facing that direction, so I do not see all the other stuff like the Teams Meeting

window and stuff, people raise their hands, et cetera. That's all to the side so I don't see that in my field of view.

So, Jonathan, if I could again impose upon you to let me know if anybody raises their hands or makes a comment, and if you could just interrupt me and pass it along. And everybody else, please feel free to interrupt me, I don't mind interruptions. So since I don't see the Teams screen, by all means feel free to verbally jump in with any questions or comments you may have.

MR. EVANS: All right, no problem.

CHAIR DIMITRIJEVIC: I think probably we will help you with this.

MR. KURITZKY: Okay, thank you. Okay, so now that we can see the slides, let me move on to, one caution I want to bring out up front is that the Level 3 PRA project study is basically a state of a practice study.

There were some areas where we had to push the state of the art just because there was no real state of practice. For instance post-core damage, human reliability analysis.

However, because of limitations, either in time, resources or the fact that we didn't have enough

information, we did have to make some simplifications or assumptions in some areas and so therefore it's important to recognize that even though we address something a certain way in the study, that does not mean that that's the way everybody else should do it. And it's particularly if you're talking about a regulatory application.

Just because we do something a certain way in this study does not necessarily mean that it's okay for regulatory purposes. So we just want to have that caveat. And this caveat of course shows up in every report of the project we have. A couple places in the report.

MR. BLEY: Alan?

CHAIR DIMITRIJEVIC: Alan.

MR. KURITZKY: Yes?

CHAIR DIMITRIJEVIC: Okay, Dennis, go. Go.

MR. BLEY: Yes, Dennis Bley. Two things. And we have talked about this in the past with you folks. With this published and on the street, essentially disavowing it for regulatory purposes seems a little strange. And I can't imagine that people won't look to it to see what NRC is considering as state of the practice approaches. I guess all

you're telling them is just look at the guidance, don't look at this.

The second thing along this line, we got to look at your slides a little ahead of time. I don't see any that really talks about your first bullet there. Summarizes what things you intended to do and we were expecting to see that are not going to be part of this study. And if you can address that one I'd appreciate it.

MR. KURITZKY: Okay. And thank you, Dr. Bley. And yes, you're right, this is something we've wrestled with throughout the project as, you recognize that this project will be looked at to people in the technical community as to ways to address a whole, a spectrum of PRA related issues. Particularly in those areas that have not been routinely practiced before.

Obviously Level 1 and LERF PRAs. Everybody and their brother have done them, and their sister, had done these things for years and so they're not necessarily looking to this project to tell them how to do those. There are standards out and everything else.

But some of the more novel areas that we've included, like spent fuel pool and multi and risk. Obviously people will be looking to that to see

what the NRC has done. And we do want them to look to this report to see what we've done.

It is a state of practice study but it does roll up all that state of practice in one big study that looks at all of different scope elements. And as I said, in some areas we have advanced the state of the practice which is good for people to be aware of.

But we do have to caveat the fact that, as I just said, there are some areas, hopefully not a lot, but some areas where we had to make assumptions or do something in a more simplified manner and so we don't want to have a blanket, we want to make sure that there is no blanket expectation that whatever it is in this study is okay for people who want to, you know, for instance, submit a risk-informed license amendment. You know, it's not necessarily that what we did in this approach is applicable or appropriate for that application.

In many cases it should be, and hopefully will be. But as you just mentioned, regulatory guidance supersedes. There is nothing in this study, this research study, is not intended to supplant regulatory guidance.

There may be a time when the NRC looks at

the results of the study and decides to amend the regulatory guidance, in which case then that will filter out to people wanting to use the approaches that are in this study, but unless and until that occurs, existing regulatory guidance is much to be followed.

So again, much of what's in this study, we want people to look to the study. Much of what's in the study should be useful and educational and beneficial to people doing PRA in many of these areas, but we just don't want there to be the expectation that just something is done a certain way in this study that it's necessarily appropriate for a regulatory purpose. That's the response --

MR. BLEY: Thank you.

MR. KURITZKY: -- to the one comment. The idea of what things that are covered and what are not.

This category is really more at a lower level to how we treated specific items. So there is no rule up to that, except in the fact that there are many areas, each of the detailed topical reports has sections on the areas where there is modeling uncertainties, which is really where these things would fall under. Or candidates for future research or additional investigation, which is the other place

where you would see these things and those two lists overlap significantly.

So that's where you'd see these things. But there is many of them, each aspect of the study. Not all of them are simply locations or limitations but they are areas that we've identified and have been either accepted as uncertain elements of PRA to date or new ones that we've ran into as we did this work.

CHAIR DIMITRIJEVIC: Alan --

(Simultaneously speaking.)

CHAIR DIMITRIJEVIC: -- has raised their hand. Joy?

MEMBER REMPE: Oh yes, thank you. When I was looking through the summary report in Section 4 I got the impression that you were going to get a lot of great insights that could be used to maybe simplify future PRAs when people looked at it and said, well, this wasn't found to be important. And I, maybe it's coming later in another report, but I didn't see any specific list of items that said, okay, you know, we spent a lot of time modeling something or other and it wasn't that important and it doesn't need to be model of that detail. Did I just get the wrong impression or is it going to be something that comes later?

MR. KURITZKY: So yes. Partly yes and

yes. It is something that's going to come later. The summary NUREG volume is where we're going to take a look at the various insights from the study.

Right now, any insights that we've gleaned are more, for lack of a better term, stovepipe to the specific models that we're looking at. And particularly for those areas where many PRAs, I just recently mentioned have been done already, like Level 1 internal event LERF, internal event type PRAs, there are not a lot of earth shattering insights that are coming from this work, as this work, this is well trod ground.

But there are going to be some novel areas where we hope to have learned things that we can share and would be insights that would be useful for the technical community at large. And that, and particularly we start to look at the medical level and, for instance, how things for reactor at power compare to reactor at shutdown or how things for the reactor compared to the spent fuel pool, the fuel pool to dry cask storage, et cetera.

And those types of items will not come until we do this more project-wide analysis at the end. And will be documented in that summary NUREG volume which I'll talk about in a minute. But Volume

1 will be the summary NUREG. And that will address more of these higher level items.

In terms of specifically insights that would lead us to, say hey, here is something that you did a lot of work on, it didn't really make much difference, it's not worth paying attention to in the future. I don't know if we call out things specifically in that way.

I think if people look through the list of results and insights they may see where we mentioned certain things did not tend to be important. It was something that we were uncertain about, we evaluated, it did not end up showing to be important, particularly we have sensitivity analyses to kind of demonstrate the impact --

(Off microphone comments.)

MR. EVANS: Hey, I'm sorry, it looks like not everyone is on mute. Can we make sure that we're all on mute for this? Thank you.

MR. KURITZKY: So, in any case, so if you look at some of the sensitivity studies or some of the discussion on areas of uncertainty, that's where you might be able to find something and say, hey, we don't really need to focus too much and this isn't really showing to be important. But it's not like we're

going through an existing, using existing PRA and saying, okay, here is Item 1, 2, 3, 4, 5, all these things, take it out of the PRA because they're just not important.

That really wasn't the goal though. That might fall out in just looking at some of the results. It might seem that certain things aren't as important. And it wouldn't be that you would necessarily rule them out of the PRA but you might not put much, you weren't worry about doing a lot of rigorous analysis to refine the numbers for some things just because they don't make that much difference.

But again, there is a difference between what is important for this PRA, which is based on a specific reference site and plant, and what might apply to other plants. So things that we discover in this study certainly apply to the reference plant.

They may in fact apply to many, the reference plant is a PWR Westinghouse four loop plant large dry containment. So other plants of that design might also think things may apply to them. Not necessarily but might.

Less likely, but still possible, it might apply to PWRs as a whole or all reactors as a whole. So again, you just have to be a little careful that

the insights that we get from this study, some of them we think will be applicable for the industry at large or other sub-populations of plants or sites. But they're not necessarily going to be universal, many of them might be site specific or plant specific.

MEMBER REMPE: So, Alan, I was just trying to cite an example, but I guess where I'm going with my comment is that yes, I realize there may be some caveats but there is such a large amount of material. I would encourage you to think, waiting to the final summary report might make it difficult and may miss some things.

If there had been some more summary highlights in this volume, that's the summary for the Section 4 of external events and things, I think it would have helped readers and others to say that, you know, some, to have an interim summary insight that, you know, with some caveats that it may not apply to everything, but it's very hard to get, to extract that is where I was trying to go with my comment, okay?

MR. KURITZKY: Yes. And I appreciate that, Dr. Rempe. And I agree. I mean, that's something, again, that we've wrestled with because we don't necessarily have anything just to wait till the very end, but the problem is that, as I said, many of

the insights are going to be more project-wide, which do have to wait till kind of the end. Even the ones that would apply to some of these areas.

The first reports that we had done, again, are areas that are well trod and there is not a lot of earthshattering new insights. Also, as I went to look at some of the material to try and extract some elements it really, you know, there is just so much, as you mentioned, there is so much material that is not going to be some like quick list of like five, here is the five. So here is the big five and boom, boom, and so everybody can see that.

There is just lists and lists and every, not just in every report but, and often times multiple sections of report because there is so many different areas covered. And every area could have a fairly extensive list of areas of either modeling uncertainty or key assumptions that in some cases we try to give relevant importance to them, high, medium, low. Other cases it's more of just a list.

And to try and extract those and compare it to each other, like this item for the Level 2 PRA, how important is that compared to this item we have here for the Level 1 intro fire PRA. You know, it's just an exercise that we just didn't have time for

right now. And we're hoping that when we get to the focus on the summary NUREG we can sit back and now look at a more holistic way and try and identify some of those things.

But again, we're almost handicapped by the sheer volume of information we have. As you mentioned it's difficult for the reader of course to try to suss out that information. It's honestly difficult for us too.

And to echo your concern about waiting till the end, not only does that make the stakeholders or the readers of the reports wait a longer time to get that information, but unfortunately many of the technical leads for this work, the ones who really know it, have since moved on. Either they've left the project, they've left the agency, so there is, yes, we're losing some of the information with the exit of those people too.

So I'm very sensitive to your concern. I just, we just haven't really had the ability, as we're trying to crank these things out, to step back and do that at this point because it would not be an easy exercise. But I am very sensitive, and I agree with your concern.

MR. BLEY: Alan?

MR. KURITZKY: Yes.

MR. BLEY: Dennis Bley. I've got three or four things, kind of high level. But I want to follow up Joy's questions.

And, you know, one thing is that after 50 years doing PRAs of one kind or another, we've seen that risk is very much plant specific, even with similar kind of facilities. I think being able to say X, Y and Z are not important, don't look at them, is probably not the answer.

But one thing you might have insight into, and might include in your summary report, are if you've actually done this. If you looked at some of these issues to decide if you would include them or not and came up with some approximate approaches that were helpful in eliminating some things or de-emphasizing some things from the scope, I think that could be very helpful to most practitioners.

The real question I wanted to get to, well the three, were, you mentioned the opportunities for future research that you point out. Are any of those active at the current time or are these things that will be a follow-on at some point in the future?

MR. KURITZKY: Well, the intention for us is just that these are things that would be done in

the future. So out of, in other words, they're really just out, we're specifying that they're out of the scope of this project. Now whether some of them are already being worked on, some are.

And there are different some areas that we've acknowledged. And this is an area that current research is ongoing and so it's acknowledged that there is current research in the area. Others are, here is something that would benefit from additional research. Most of those may not have started yet, though so many have. It depends.

If it was just purely associated with this project it's not like that it's been started already, but if it already was something that was being thought about in other areas of the Agency and they already may have started work on that, in that area, then it would be ongoing.

MR. BLEY: Okay.

MR. KURITZKY: But we, you know, we have not initiated follow-on projects based on the results of this project yet.

MR. BLEY: Okay.

MR. KURITZKY: That's something that would, the Agency as a whole, other decision makers would weigh in on probably after the project is

completed.

MR. BLEY: You mentioned something that many of the members might not be familiar with because they weren't here in the early says of this work. The reference plant. And we were involved in discussions with you about how you would select that plant.

I think some caveats for the Committee would be helpful. I know we can't identify the reference plant at this point any longer.

You and I had had quite a bit of discussion with them. I'm wondering if you and your reference plant PRA people ever came to a meeting of the minds. I know there were some areas where there was real dispute about things you were including that they didn't include. If you can talk about that a little bit I think that would be useful to all of us.

And the last thing is, one of your goals early on was training the Staff at NRC on performing PRAs so I'm a little, unhappiness is probably not the right word, when you say many of your key people are leaving or have left and the knowledge is gone, I sure hope they did enough training that maybe the knowledge isn't gone. You have others who can follow on with that. So if you can talk about those two I'll get out of your hair for a while.

MR. KURITZKY: Oh no. and I thank you, Dr. Bley. Please stay nearby and I always welcome your comments.

So I'll hit one and then the other and hopefully I'll remember the second one while I'm talking about the first one. So let me jump first to the knowledge transfer one. And that is a, that is a very good point.

One of the main focus of this work has been to bring up the state of practice. The capabilities of staff in PRA, particularly as we become a more risk informed regulator we want to have ample PRA capabilities on staff to process and evaluate risk-informed applications and other risk-informed issues. Or policies.

We have a new project that lasts a long time. I mean, people are constantly cycling. That's the nature of the beast. Whether they're getting at the end of their career and retiring, whether they find better opportunities in other agencies or outside the government or just move on in order to get, in reality, in order to get promotions in much of the agency or any other agency you have to move to a different organization within the agency in order to get a promotion so there is going to be constant flux

in turn. That's the reality of it.

But yes, we have tried to focus on making sure that when people go that there are other people to fill in. That's, in the macro, that was the whole idea. Was as more of the senior PRA people retired over the years that there would be this new crop of people to take over. And that's really happening in the climate with microcause and with people leaving the project over the last few years.

So we have had people that have come in. In some cases the change has been fairly abrupt and we've had, lucky to people that are still in the agency, in different organizations. We've been very fortunate that those organizations and those people have agreed to continue to support the project, that's helped us a lot.

And then therefore that knowledge does stay here in the agency. But there are other cases where we have had to bring in new people and bring them up to speed. Or at least get them as familiar as possible with this stuff.

My point was, the person who actually did the study, did the work, did the PRA model with all the thought thinking and documenting assumptions and everything else, they're going to know the stuff a lot

better than someone who comes along and is told about or taught about or plays around with it a little bit. So there is just natural leakage of knowledge when you go from someone who did the work to someone who now is familiar with the work or has been trained in that area.

Also, we've unfortunately, no secret, the agency has struggled to stay properly staff. We in PRA-B are very understaffed. And so because of that it's just a body count limitation in terms of people to be able to pick up and take over certain tasks. But that's certainly a priority.

We are trying to bring in people to fill in the rolls. We have brought in people just recently that are taking over more and more of the rolls and picking up information from more experienced people in the project and in the field of PRA.

And so, that's something we're always working at. And just because some of the people that did the actual initial studies, or models, have left, that doesn't leave us totally empty handed. We have, you know, success in many cases. We've had people that have just moved in seamlessly and taken over when one person has left.

And so I don't want to sound like

everybody has jumped ship and now we don't know anything that's happening on the project, I'm just saying for some of the details, even for people that are still here, I mean, they did the work five, six years ago, they're not going to remember every little detail, but there are some people that have left the agency and so it's just, it's a little more difficult to create every single thought process once people have moved on and new people have inherited the work.

But the other item? I knew I'd forget that.

MR. BLEY: Reference plants.

MR. KURITZKY: Oh yes. Thank you very much. So the reference plant. Yes, so, you know, I think I know what you're referring back to. We did have, early on, some disagreements and some modeling. This goes back to the Level 1 internal event PRA. It really was the only case where we ran into technical disagreements with how things are modeled in the reference plant PRA versus our own.

And those cases we just, we work with them to see if they could justify to our satisfaction what they did. We were never quit comfortable and so we relied on our own modeling and approach. And that's what the results show. So if the reference plant PRA

was compared to our PRA results you would see that our results differ, to some extent, because of the difference in how we treat those issues.

Primarily, I don't want to go into the technical details, but it primarily dealt with how we were modeling station blackout sequences. How we were modeling recovery of AC power. How we were modeling failures of certain emergency AC power components. As well as certain, quantification of certain human reliability actions. Not human, operator actions.

So that led to a difference in station blackout related core damage frequency, which is the main driver at this plant. Particularly in our model. And so you see some differences there.

But that was really, I think, the only area that we had any significant technical disagreement. Is that what you were referring to, Dr. Bley?

MR. BLEY: Yes, it was. And thanks for that answer. The other thing was, since many of the members weren't around at that time I guess the only thing is we cannot talk about who the reference plant is, so it's just a note to everybody.

MR. KURITZKY: Yes. And I appreciate that caution, yes, for those who don't realize that yes.

It's, we don't mention that now. Because in reality this model doesn't actually reflect an exact plant anymore anyway.

I'll get into this a little bit later, but this was based on the design operation of the reference plant in 2012, which is far different than in 2023. And in addition, we made other modeling decisions and other used various modeling technics from our SPAR models, et cetera, that would lead us to have different results that what the reference plant does.

So it doesn't really reflect any existing nuclear power plant, it's based heavily on a reference plant and site. But it doesn't really reflect any existing plant so it's legitimate to just refer to it as a reference plant.

Okay. Other questions?

CHAIR DIMITRIJEVIC: Now that I think of it, this has taken enough time now. I just want to mention that this is a Subcommittee meeting and all which we discuss here with you is our personal opinions and, you know, insights as we see them now. And our official suggestions will be provided in the latter, so, you know, all these discussion is based on our personal views of the things.

So, all right. I mean, you hear there a lot of comments. And, I mean, I had the, I mean, Dennis and Joy expressed a lot of what I wanted to say about these things, but in this moment we are not going to, at least in my opinion, we are not here to comment on the technical aspects of your work because this work is done and documented in so many volumes, so not any changes reasonable or should be discussed.

But we are sort of looking on how will all of these things be presented and documented. And, you know, and this is where most of our suggestions are.

And when I was reading all of these volumes I felt like, you know, I was in the, like a diamond mine. I would occasionally run into something which made me think, oh wow, this is really interesting, you know. But the thing is, there is so much material and those things are spread and sprinkle through the report, you know. So in the, what would you subtract to the summary report, which I guess you will now talk about structure, will be very important from the, you know, point of the project point of view. Okay, please continue.

MR. KURITZKY: Yes, I was thinking. Oh, okay. And thank you all for that. I appreciate that because that's exactly what we're looking for now.

You're right, the technical work has long since been done for the most part. We'll mention a few things shortly that are still being worked on. Much of this work has already been completed. So the work here on the Volume 4 models is done and so, yes, the messaging and the presentation information is really what we're looking for feedback on, so thank you.

Okay, so moving forward. I want to now just go over the project status. Oh, I'm sorry, one thing that is my mind, Doctor, because I got distracted when we were talking about the acknowledgments section.

So one thing that I did want to say and mention is, again, I am the program manager, I'm presenting this information today, but I'm not the one who did this work. As you just mentioned, there was a ton of work. And there's a ton of great technical work on the, work we're doing today as well as the project as a whole.

I've been very fortunate that we've had a tremendous number of really topnotch technical experts working on this, both within the NRC and also with National Labs and commercial contractors. And I've been very fortunate to be able to work with these

people and get their support.

And there are way too many names for me to individually list. I do suggest that if people get a chance, go look at those individual technical volumes, look at the title pages for the authors, look into the acknowledgment pages for other people that have supported the work and you can see all the people in there that have really just done some tremendous work.

And some of them have left the agency, but many of them are still here. And that gives me a lot of confidence that we will have a lot of PRA capability going forward.

So with that, let me just mention for a few minutes where we stand in terms of the project status. I want to focus, figure up, it's a figure that probably many of you have seen before. It's in most of my presentations. But I just want to, just to, I'm not going to go in detail here, but just to kind of refresh people's ideas in terms of the work being done.

All the models and internal reports are done in two phases. Phase 1 is where the bulk of the work is done. And that's the initial model and the initial report, internal report. And then Phase 2 is where we finalize the model and update the reports

based on some review feedback from external to the project reviews.

And so that's, there is Phase 1 and there is Phase 2. Phase 1 being the much bigger phase. And I just want you to have that in mind as we go to the next slide.

CHAIR DIMITRIJEVIC: So, Alan, before you leave --

MR. KURITZKY: Yes.

CHAIR DIMITRIJEVIC: -- there is a color code here, right? Is there some color code of what is green, what is orange and, or is that for artistic purposes?

MR. KURITZKY: Yes. The only color thing here is green, is actually the work on the models. And really models, well, documentation is kind of like a download, but that's models and documentation. And the orange is the reviews. So the green is really the work that the project team is doing, and the orange is the various reviews.

CHAIR DIMITRIJEVIC: So remind me again, where you are with this PWR peer review? Is that the finished --

MR. KURITZKY: The PWR Owner's Group led peer review?

CHAIR DIMITRIJEVIC: Yes.

MR. KURITZKY: Okay. So yes, that was something that early in the project we were very fortunate that PWR Owner's Group was willing to support us on doing some standard based peer reviews, just like they do for licensee PRAs.

So they did that for us for the Level 1 PRA for internal events, and the Level 1 PRA for internal floods. And then also for the Level 2 PRAs, Level 2 and Level 3 PRAs, provincial events and floods.

And they are, I think they also, they supported a, it wasn't a peer review, but they came up with criteria for us to evaluate the dry cask storage PRA because there was no standard for dry cask storage, they, we had kind of like an expert meeting that the PWR Owner's Group was in charge of where we came up with criteria for which to evaluate the dry cask storage PRA.

And I think we may also have had some support for them and some of the other hazards work. There was, or -- I can't remember. For some reason there was another, I think there was another thing they supported us on but I can't remember offhand.

But anyway, it was primarily the initial

PRAs that they did. Unfortunately budget constraints and other issues led to that, eventually stopping that work. But the initial models we were very fortunate to have. Those owners who led peer reviews.

Both because we got a lot of good feedback from them on those reviews. Also, they allowed NRC Staff to both be on the peer review panel as well as observe, which normally people don't do.

But they allowed us to observe some of the peer review proceedings and so we both got a very good understanding of what that process is, which is beneficial. As well getting the input on our specific PRA models, which sort of helped us in two different ways.

CHAIR DIMITRIJEVIC: And --

MR. KURITZKY: And it was also beneficial for them because some of those were trial used standards and so they got a lot of use from us as we allowed them to pile up those standards. Like for Level 2 and Level 3. Sorry, go ahead.

CHAIR DIMITRIJEVIC: Are you planning to document some of those results because you didn't in Volumes 2 and the, you know, the 4th. I mean 3 and 4. You didn't document, I didn't see any, the commutation on results of those peer reviews.

MR. KURITZKY: Yes, that's all internal information. All those, the studies they were reviewing were official use only. They had a lot of proprietary information. And the reviews themselves from the PWR Owner's Group are identified as, what do they call it, confident, I'm drawing a blank on the word. Not, you know, proprietary. They were proprietary.

CHAIR DIMITRIJEVIC: Oh, proprietary. Okay.

MR. KURITZKY: So we have them internally but we don't, they have not been --

CHAIR DIMITRIJEVIC: You can't share the results. Okay.

MR. KURITZKY: Right.

CHAIR DIMITRIJEVIC: Okay.

MR. KURITZKY: Right. Okay. So that's Phase 1 and Phase 2, just to keep in mind as we go to the project status dashboard. This is how I kind of keep track of where things stand.

On this dashboard, which you guys have probably see at some point before, but along the top you see the various PRA levels, one, two and three, as well as the last column, 2020, as we work to support the overview reports. Which because the base model,

the model is based on the plant, the reference plant as designed and operated back at the project cutoff date, which was in August of 2012.

So there's a lot of features that are currently in the plant that were not reflected so we went and did an updated. Essentially a sensitivity study where we incorporate some of these more recent features.

And those are documented in the overview report, and so therefore there was a lot of internal calculation notes, Level 1, 2 and 3 PRA calc files to support that. So that was something that was added to the scope of the project afterwards, and that's in that last column. And we'll discuss more about that in a few slides.

So those are the four columns on top. The rows going down are the different rheological sources on the site, as well as different plant operational states and the different hazard groups.

So if you kind of step back and look at the whole picture, we pretty much completed most of the technical work. The only areas that really have technical work left, you know, the phase one work is just in, there is yellow boxes.

So for the low power shutdown there is the

2020 FLEX sensitivity case which we've completed for the Level 1 shutdown PRA, but we still have to complete for the Level 2 and Level 3 shutdown PRAs. Also, for the spent fuel pool, the Level 3 work for the spent fuel pool still has to be completed. And we were doing active work on the integrated site risk task.

So outside of those three there is not that much more that has to be done. You'll see a few of these boxes in blue. Those, for the shutdown PRA. Spent fuel and dry cask storage. There is some additional tie-up documentation items and reviews that have to be completed, but the technical work is essentially done.

MR. BLEY: Alan?

MR. KURITZKY: Yes.

MR. BLEY: It's Dennis again. So as I understand you, and you'll talk about this more at the end I think, the three that are Phase 1 will eventually become Phase 2 when they complete?

MR. KURITZKY: Yes.

MR. BLEY: Okay.

MR. KURITZKY: God willing, yes.

(Laughter.)

MR. BLEY: And you'll talk about the

schedule for that before you're done today?

MR. KURITZKY: Yes. I'm going to talk about the schedule because, so just to be clear, this is all, the technical work and internal reports have to be done.

And then, the one thing that remains, and thank you for reminding me, the only thing that remains after all this is converting them into public reports which really is just scrubbing out proprietary information. That's really the bulk of it. And formatting for, editing and formatting for NUREG publication. So that's the piece that will come out.

And that's what happens before they come out to the public and before we come back to brief the ACRS on those. And so I'll go over the schedule for those being released publicly.

MR. BLEY: Well I'm pleased to hear that. I heard rumblings that you kind of given up on anybody that cited risk, and we were very interested in that. So we look forward to when you wrap that up.

MR. KURITZKY: Yes. And just to be clear, because I'm not discussing integrated at-risk at this meeting, but just for your information, I don't know where the grumblings came from, but we have recognized that we are not going to a full quantification

integrated site risk for this study. What we'll end up doing is, more of a proof of concept.

We have some Level 1 multi-unit core damage frequency results for this referenced site. But for Level 2 and 3 multi-unit core results as well as integrated site risk. We bring in the spent fuel and dry cask storage. Those will mostly be just some pilot applications or some discussions because we recognize that the level of effort required to do that work completely unfortunately we just don't have the time or resources left to do it.

Just to kind of give you the concept, when you go look at multi-unit core damage frequency in the Level 1 space, if core damage results for one unit, you can have core damage results for the second unit and you can combine them together for a core damage result that involve both units. But again, you have one metric, it's core damage.

When you go to the Level 2 space, and we have 16 release categories. So when you have a release category, and it's not even the fact that if you have at least Category 1 for Unit 1 that you'll have released Category 1 for Unit 2, and so you have 16 now instead of one metric, you actually could have cross combinations. So you could have really 16 times

16, minus some duplications, but you end up having, I can't remember, but a hundred plus different combinations. So it really wasn't practical for us to do all that here. But we do it for --

The good thing is having the Level 3 results for the single unit we know which are the more important release categories, and so we are doing a, kind of a pilot application, looking at some of the more important release category combinations. Which should actually give us a fair idea of what type of Level 2, and then possibly Level 3 risk, multi-risk is involved. But we will not be doing the complete soup to nuts.

So that may be what they're grumbling. We're not doing a full qualification but we are going to have a lot to say about integrated service.

MR. BLEY: Okay. And we look forward to seeing that. I think it's going to be important for other plants in the future. And anything that we've learned that can be passed on will be very helpful.

MR. KURITZKY: Yes, thank you. Okay, I think that's it's for project status. Let me now move on, as I was mentioning, the public reports because that's, the public facing information.

And so, what we intend to do is produce

the work in eight different volumes, including, or consisting of, probably more than 20 individual reports, as you can see on this diagram. This summary report. Let me see if my mouse will work. Summary report here Volume 1.

And that's the one I was mentioning before, is going to capture the overall results and the insights. It's going to look into things like perspectives, comparisons, maybe other studies. Recommendations for future work. Identifying what are the areas that, you know, drive the risk or areas that we're uncertain about. So that all will show up in the summary volume, which is I believe the final volume that we produce.

Volume 2 is the background volume that --

CHAIR DIMITRIJEVIC: Alan, sorry to interrupt you.

MR. KURITZKY: Yes.

CHAIR DIMITRIJEVIC: You know, you always talk about the four main goals on this project, you know. And the last one there is to, you know, to the realistic cost of developing levels to be PRA. Will that also be part of the summary Volume 1?

You know, because, you know, this is your Number 4 goal. First is, you know, develop these new

methods, get new insights, train the staff, you know. And then the fourth one is sort of summarize the extent of this effort. So, are you planning to include that in the Volume 1?

MR. KURITZKY: Yes. Volume 1 will address all the four main objectives of the project. But just to be clear, that last objective will be the one that probably gets the least amount of space in the report because it was something that initially, I think there was some thinking amongst the Commission at the about whether or not we have Level 3 PRAs performed by other plants and so they wanted to understand what the level of effort and cost would be.

I don't think there is really that much of a, you know, with the current Commission I don't think there is that much of interest in that. Pursuing that.

And also, the one thing that we realize too is that the cost of doing this is very project specific because it depends on a lot of key factors. It depends on how many of the, what's the extent of the PRA models that the plant already has? Do they already have a very well developed Level 1 PRA, do they have a Level 2 PRA? Have they looked at, you know, what type of hazards are we currently, are we

looking just at internal events and internal floods, are we also looking at fire and seismic wind? Are we looking at shutdown, are we looking at just plant, you know, at full power? And so there are a lot of factors involved.

Are the people that did those earlier models, are they available to the organization doing the study or do they have to have other people try and understand what's done before them and come up to speed and further that work? How much access do they have to the plant and to get plant information? There is just a lot of factors.

Is the team that's going to be working on it, are they dedicated to just getting that done? Are they experienced people? There is a lot of factors that go into it.

And the way we approached it here with NRC is very different than the way, versus a private organization would go about it. One of the things that many of you have heard me discuss it over the years is the fact that we don't have a dedicated team for this project and so we get people's time when it's available. There is other higher priority work we'd have to work on and so they are constantly cycled in and out of this project.

Because the project is one that a lot of interconnected steps where things build on each other so that if someone, at some point, is pulled off and doesn't get their stuff done then the person who needed their input can no longer do their work. And that person comes back, they may finish their work after some runup speed again, but now the other person is no longer available to do it.

And so, we also, again, as you mentioned before, one of the things we wanted to bring up and train lots of people, we used a lot of junior and mid-career staff. We didn't have a team of just experts working on this.

And whereas a private organization might higher a consulting company or higher their own staff that are just focused, better experienced PRA people. So there are so many variables that our experience, particularly with this project, wouldn't really extrapolate to other organizations.

So we'll probably talk quantitatively about some of the experiences we had with this project, but there is not going to be a lot of our number type information that we can say, hey, this is what it takes to do this type of work and if you want to do it expect this is what you would have to put

forward to doing it. So yes, it's something that will get addressed but probably not in --

CHAIR DIMITRIJEVIC: Not for the --

(Simultaneously speaking.)

MR. KURITZKY: -- detail.

CHAIR DIMITRIJEVIC: All right, thanks.

MR. KURITZKY: Yes. Okay, so again, Volume 2. The background volume. So that kind of just describes the background of the project. It also describes the reference plant insight. And includes at a high level the technical approach for the various aspects of the study. The overall study.

And volume, then the rest of the volumes hit more of the detailed technical information. Volume 3 is the reactor at power for internal events and internal floods. And we have separate Level 1 reports for internal events and internal floods for Level 2 and 3, they're combined together. And then we have also the overview report that came later.

Same idea for internal fires and external events for Volume 4. We have separate Level 1 reports for fire, seismic and a combined high wind and other hazards report.

And then for Level 2 and 3 it's all combined into a single report. And again, an overview

report, low power shutdown, separate Level 1, 2 and 3 reports, we just look at internal events.

By the way, that goes back to a question that I, I can't remember if it was Dr. Bley, but, you know, what stuff did we, what do we no longer look at. And individual items, too difficult for me to say offhand, there is a million things that we did or didn't do. We either didn't look at or did a separate occasion for all the different parts of the study.

But one thing that was major on a scope level is we decided not to, the reason we're going to do shutdown for all hazards also. And we realize, Don, that we just didn't have the time or resource to do everything in the original scope so we had to decide what to cut back on.

And it was decided that we would not pursue the low power shutdown for the other hazard just because that was one that we didn't really, that was one of the areas that we really didn't have a lot of experience with. There was a lot of open issues that would have to be addressed in order to move forward with that work, so if we did it, it wouldn't have been that complete of a job and so it was felt that the ACRS, actually the Subcommittee I think agreed with us that if we couldn't really do it, a

really good job, I thought that was probably something we best to leave off.

So now the low power shutdown just looks at internal events. So that's what will be in Volume 5.

Volume 6 is the spent fuel pool. We have a combined Level 1, Level 2 PRA, which will be in one report. And then the Level 3 in another report.

We may in fact not actually have an overview report for spent fuel pool because we're probably not going to have a FLEX sensitivity case for that. But our dry cask storage will be in Volume 7. Everything together. Level 1, 2 and 3 PRA and all hazards, and then integrates that risk that's in Volume 8. So that's all the reports we'll be producing publicly.

So far, the Level 3 reports, they went out for public comment back in April of '22. We've since gotten the public comments back, updated those reports. And they have been submitted to the Office of Administration for final publication as NUREGs.

Volume 2 was also something that we set out for public comment in April of '22, but we have not submitted that one back for final publication because we realize that it references all the other

reports and so we can't really put the bow on that one until we know the reference information from the other reports. So those are actually going to get published at the end of the project when all the other reports are going out too.

And then Volume 4, which is the subject of today's presentation, those reports went out for public comment back on August 18th. I think the public comment period ends tomorrow, so I'm interested to see what comments we receive on those reports.

And then the remainder of the reports I have on this list right here. You can see if you look down, for the third bullet and further down, these are the ones that have yet to be completed. And they have various dates in calendar date year 2024. So they'll be released at various times in 2024.

Those dates are in gray to indicate that there is great uncertainty with the dates for anything that's more than a few months away, particularly because, as I mentioned before, we don't have a dedicated team so it really depends on how much time the various technical leads can spend on this work will determine how fast those reports can get out. But again, we're targeting to have them all done, for our calendar year, 2024.

Okay, so that's the overview of where we stand on the technical work and the public reports. I now want to spend the bulk of the remainder of the presentation, let me just do a time check, 9:30. So we're going to discuss Volume 4. So particularly the overview report for Volume 4, which is the reactor at-power results for fire, seismic and wind.

MR. EVANS: Yes, Alan?

MR. KURITZKY: Yes.

MR. EVANS: Before you get started it looks like we have a question from --

MR. KURITZKY: Okay, sure.

MR. EVANS: -- Dr. Rempe.

MEMBER REMPE: It's Joy.

MR. KURITZKY: Yes.

MEMBER REMPE: And I'm a little late in raising my hand, I apologize. But could you talk a little bit about the public comments you did receive on Volume 3, just at a high level?

Were they in the weeds about you, you didn't have a component accurately modeled or were they high level concerns?

MR. KURITZKY: So thank you, Dr. Rempe, that was something I was thinking of mentioning and I appreciate you bringing that up.

So yes, the comments that we received on Volume 3 were more high level, they really weren't, we had a few technical questions from the PWR Owner's Group, but mostly they were higher level. They were essentially like, well, first let me mention that we got comments only from three stakeholders.

Which would be an individual stakeholder that was more concerned about the consequences and the focus, our focus on just radiological consequences when Fukushima and other accidents show that the biggest health concerns are associated with the evacuation, more than the radiological exposure. And so we were able to respond to that one because our Level 3 reports, not only do we calculate risk measures or consequence measures for health effects, but we also look at things like affected population. Which is kind of a surrogate for the impact on people having to evacuate. And we also lack contamination and economic costs, et cetera. So that was one comment.

But the other two organizations that submitted comments were NEI and the PWR Owner's Group. NEI comments were more of the line of, hey, we agree with the results you came out with, your Level 3 results for the internal event and floods.

And basically they felt that, hey, you've done enough, there is no real need to keep doing work, we don't agree, we're completing the project. I think that was more of, in a nutshell, in a higher level.

The PWR Owner's Group also had some higher level comments and some, as I mentioned, some more technical comments. But their basic thing was, hey, we see the margins that you're showing in the Level 3 space to the QHOs, has there been some thought about, you know, how that would roll back into regulatory guidance? And that's something that is not something we're addressing as part of this project.

So when we, when the reports finally do get published, when Volume 3 gets published as final NUREGs, like I said, they're with our publications department in the Office of the Administration right now, when they come out there is also going to be a file in the package that has a table with all the comments and our proposed responses to them. So you'll see some of our responses there.

But basically, any impact that the results of this study has on regulatory applications, it will be done, not by the project team, but will be done by the cognizant organizations and the agency, so that's basically what, in a nutshell, what the comments were.

MEMBER REMPE: Great, thank you.

MR. KURITZKY: Sure. Okay. So in terms of the Volume 4 results, I do want to mention up-front that, well, as I mentioned earlier, the base case model for the study, which we refer to as the Circa-2012 case, is based on the design and operation of the reference plant back in, at the cutoff PRA study cutoff date of August 2012. And so there is a lot of more recent changes to the plant and other aspects that have not included in this study.

So we decided to do a, essentially a glorified sensitivity case. We call it the 2020 FLEX case, in where we incorporate certain things that have changed since that time.

And specific are the items you see right here on this slide. We now incorporate the passive shutdown seals for the reactor coolant pumps. These are Westinghouse reactor coolant pumps. And we also include the FLEX strategies. Particularly for dealing with an extended loss of AC power or relap.

And then if FLEX were to not be successful, we also credit the continued operation of the turbine-drive aux feed for secondary side cooling given that you lose all installed AC and DC power essentially referred to as blind feeding of the steam

generators. So those are the things that we include in this 2020 FLEX case.

CHAIR DIMITRIJEVIC: Alan --

MR. EVANS: Hey, Alan, before you move on it looks like we have a, yes.

CHAIR DIMITRIJEVIC: Yes. From Tom Roberts. Go ahead please.

MEMBER ROBERTS: Yes. Alan, if you go back to the slide you just had up? The last bullet gives me the chance to ask the question I wanted to ask about operator actions. The credit for a continued turbine-drive aux feed pump operation seems to credit the ability of the operators to continue operating that system after the releases are modeled in Level 2 and Level 3, is that right?

MR. KURITZKY: So thank you for that question. You for me to go into a little bit of technical detail here. And also expose some laundry, dirty laundry. I don't know.

So here mentioned, in the Level 1 PRA we did not, in the base case Level 1 PRA we did not create continued turbine-drive aux feed in the absence of installed AC and DC power. And that was for several reasons. We felt that it was just too uncertain about success.

When you have those conditions there is a possibility to over or under feed the steam generators. You can end up tripping off the turbine generator from getting water in the steam lines. And given the conditions we felt that it was not appropriate to give credit for that and so we didn't in the Level 1 base case model.

However, in the Level 2 base case model we did credit that. The Level 2 team did create that for its effect on acts and timing. They did give a very high failure probability. I think the failure probability was something around .6, so it wouldn't have made that much difference on the results whether they credited you or not, but they do have that in there.

So in fact, when we go in and credit here for this 2020 FLEX case, we had to strip out its use in the original Level 2 model and replace it with this new FLEX model, which actually credits it for Level 1 and then therefore propagates the Level 2 and Level 3.

So I don't know that I directly addressed your question. Do you want to just repeat this to make sure I --

MEMBER ROBERTS: Yes, right. I have a more general question that this just offers a chance

to ask which is the role of operator action in the Level 2 and 3 progression after the release becomes significant to the environment.

And we had a meeting yesterday on the high burn-up fuel rulemaking where there was some discussion on control room dose. And there was a footnote in that report, I'm not sure if you're familiar with the footnote that says that, basically risk analyses don't care about the operator dose, that they don't model the change in errors of a commission or omission caused by, you know, whatever the dose rate environment might be.

Yes, I was wondering, a, if that's accurate, and then b, just your general thoughts on the role of operator action in the control room and in the old site technical support center during the release phases of a Level 2 and Level 3 PRA because it would see like the presence of operators in the facilities could be helpful in terms of accident management. And if it's not modeled in the PRA I'm just wondering how you account for that?

MR. KURITZKY: Okay. Thank you for that question. So I'll probably give you a partial response and maybe I can phone a friend for more details.

So this treatment was done pre-core damage. It's a Level 1 treatment so it has impacts for Level 2 and 3 but the actions occur pre-core damage. So they're not impacted by any radiological effects in the control room.

We do have, as I mentioned before, the areas we kind of pushed to the state of the art was we do have a post-core damages HRA that we performed and we do credit certain mitigation actions in the Level 2 space. You know, in post-core damage. Up to a certain point.

But the, and I don't know specific, I think we considered all aspects, including habitability concerns which would directly include not just temperature and steam but also possibly radiological concerns. And for Level 3 I don't think we considered specific operator actions in the Level 3 space, we considered things more broadly about just assuming certain evacuation things.

So most of the stuff with the TSC or other things could be in the Level 2 space as part of that post-core damage HRA. I think we consider things like that, but I don't specifics.

I don't know if Susan Cooper is on the line and is able to answer any more on that. I don't

like to put people on the spot because, again, Susan was just one of three people that worked on that and they did it many, many years ago so I don't know --

MEMBER PETTI: She put it in the chat, Alan. So you can --

MR. KURITZKY: Oh, okay.

MS. COOPER: Yes, I can --

MEMBER PETTI: That doesn't help, say it on the record, Susan.

MS. COOPER: Okay. Susan Cooper, Office of Research. Yes, the Level 2 HRA approach addressed many aspects with respect to environmental hazards, and habitability was one of those. So that was addressed.

We had a lot of information from the larger Level 2 PRA about different areas of the plant that would impact operators and equipment and its availability to perform. So that was definitely part of it.

I will say that we found out somewhat late that there were some areas of the plant that we didn't have radiation information. We did chase that a bit at a site, plant site visit. And worst case we decided that probably maybe they would do a survey first so it would slow things down.

But one of the things that we did in the Level 2 HRA was say, hey, don't give us some made up time we'll estimate how long it's going to take these actions to be performed and then figure out where that levels you so far as containment end states. So it might have stretched the time some, but the general answer is yes, we considered habitability, including radiation, among other things.

MEMBER ROBERTS: Thank you very much, Susan. I assume that's a report that was issued that we could probably get access to?

MR. KURITZKY: Susan, I'll jump in for that one. So there are two reports that document our work on the post-core damage HRA. There was one that addresses the approach and there is one that addresses the implementation.

The approach report I think will be made publicly available, but I can't remember where that stands. But the implementation one will not. So possibly we're re-discuss the specifics and what we consider for this study will probably not be publicly available because there is a lot of proprietary plant specific information in it.

MEMBER ROBERTS: You'll get that one.

(Simultaneously speaking.)

CHAIR DIMITRIJEVIC: That one may include action discussion. You say that those, you know, actions you use the simplified method so that was the one, it was one of the products you're not endorsing, right, when we were discussing introduction.

One of the things you mentioned analyzing this accident management action was something that you didn't have too much guidance and the simplified approach was developed. Is that a true statement?

You said that in the introduction when we were discussing what approach, you know, what approaches you don't want to endorse.

MR. KURITZKY: Yes. Actually, I apologize because I don't think I was very clear about discussing that. That was, at the beginning of that bullet when I was talking that was an example of an area we advanced the state of the art. And so that is an area where we would like people to look.

We don't expect that our approach for post-core damage HRA is going to be the official final approach that all post-core HRAs have done for the rest of PRA eternity, but we think we put a pretty good beachhead down for how to do this. And hopefully people as they, like other areas in PRA and everything else, people will work with it, build on, improve it,

you know, whatever and hopefully it will find, you know, widespread acceptance.

But it something that we do want people to look at and work with. So that was -- and that's the example of something we did push to the state of the art and we do want people to use as opposed to the simplifications that we don't necessarily want people to use. So no, that wasn't an example of the simplification, that was an example of an area that we did push the state of the art and we're very happy to work with and critic it and improve it.

CHAIR DIMITRIJEVIC: Okay. Because in this Volume 4, the actions which were discussed, you know, connected in preventing corrosion events or controlling containment pressure or flooding cavities, they all come with the number one or a 01. And also there is mention that those HRA analyses didn't include equipment. And Susan just said that that actually, the state of the severability of equipment was also analyzed.

So I guess we will have to wait for your report on this HRA, right?

MR. KURITZKY: Well, so again, I apologize because maybe that wasn't as clear as it should be. So the zero and the one for, like for instance,

containment venting and preventing base mat melt through, and there was another one, I think controlling hydrogen, et cetera, that was probably a sensitivity study that I did.

I'm going to get to that when we talk about the Level 2 results, but just since you bring it up now, so we credit, in the post-core damage HRA we credit actions in the short time frame. We credit actions up around the time or shortly after vessel breach. Okay? And generally at most two actions per sequence.

But we carry on this severe accident analysis generally for up to seven days. And so what happens, we don't credit other mitigation action in that longer time frame. So what we wanted to do is just see if we did credit additional actions how much impact could that have on the result.

So that table you're referring to that has the ones and the zeros, I think that just shows up in Volume 3 on internal event, internal flood --

CHAIR DIMITRIJEVIC: Right. Right.

MR. KURITZKY: -- report. So that is just, it's just a sensitivity case to see what potential impact it would have.

And we show that there was some of those

things could actually be very beneficial. I think particularly the one where we control containment pressure. It was very influential. And then as it was combined with the control of hydrogen combustion even more so. So that was just a sensitivity study.

In the actual evaluation for the base case model we do HRA analysis and consider the specifics of the SAMGs and the severe accident management guidelines and the extensive damage mitigation guidelines at the reference plant to come up with fairer probabilities. So that was more of a --

CHAIR DIMITRIJEVIC: We have a bunch of questions. I think Joy was first, then Dave, then Dennis, all right?

MR. KURITZKY: Okay.

MEMBER REMPE: Oh, sure. Thank you. Back when the industry decided to implement FLEX there was always an interesting characteristic that the building, as I recall, the building or house that the equipment is housed in, is not required to withstand a higher seismic load or wind loads, flooding.

I'm not sure about what the situation was at the reference plant, but how did you address this in the study and did you consider, as you've talked about, that you've tried to broaden it beyond to the

reference plant. Did you do sensitivities to say, okay, yes, there is the FLEX equipment but the building may not be able to withstand the wind loads or the seismic loads and did you look at that issue?

MR. KURITZKY: Thank you, Dr. Rempe. Yes. So as I'll discuss, we're going to get in just a few minutes here to the FLEX case, and we did not do a rigorous detailed analysis of the FLEX fire probability we did a parametric study. But in doing so we considered the impacts of, for instance the hazards, and also considered whether or not if the bio was higher or lower what would be the impact on the results. So we did address that topic. And I'll go into more specifics in a couple slides.

MEMBER REMPE: Great, thanks.

MR. KURITZKY: Yes.

MR. EVANS: Next?

CHAIR DIMITRIJEVIC: Dave?

MEMBER PETTI: I think you're going to get there. I was just interested in some of the FLEX results and the human reliability aspect of it and whether or not you accounted for if they failed the first time that they try again and again, because that's what operators will do, if you just assumed they failed and that, you know, you only get one

chance to, you know, to implement it. So when you get there, I'd like to sort of understand that.

Because I think what struck me, again, not being an expert, is the letter on its face, FLEX doesn't seem effective. That's what I took away from reading the summary report. Now I'm sure that's not what we want to say, but again, I could have misread it, but that's the impression I have, so.

MR. KURITZKY: Yes, I think we are going to get to the results in the next slides and so --

MEMBER PETTI: Right.

MR. KURITZKY: -- you'll see that, no, FLEX does have, the reference plant does have significant impacts.

But just not to jump the gun, but again, we did not do a detail analysis for FLEX there probably so we don't have extensive detailed HRA on the actions it's more of a, like I said, a parametric study. But I'll go into that --

MEMBER PETTI: Okay.

MR. KURITZKY: -- probably in the next slide or two.

MR. BLEY: Alan, it's Dennis.

MR. KURITZKY: Yes.

MR. BLEY: Your discussion with Susan

irked my interest. You went through the eight volumes of your study earlier, but you didn't mention side technical reports. And it sounds like there is at least one for HRA, or at least level 2 HRA. And I'm wondering if there are others? Maybe things you did with success criteria or is that all included in the main eight reports?

MR. KURITZKY: So success criteria is included in the reports themselves. Particularly, for instance, for the Level 1 for intro management. There is a Chapter 4 which goes into detail about all the MELCOR runs and work that we did. And the reference plants max, not max, map runs --

MR. BLEY: Yes.

MR. KURITZKY: -- and stuff. So that's all integral to the reports.

But the, just making a note about, so the other reports, and particularly the one is the HRA reports. You know, that is one that we had, we had these two reports. They were internal reports.

The one is, doesn't really have information that would preclude it from being publicly released, so we had someone work to pull together some of the HRA from all the different parts of the study including that, into, well that was a Level 2 report,

but even the Level 1 HRA stuff into some kind of document which, unfortunately that person has since left the agency, but we have it in some kind of form. And it just hasn't, like folks on the other reports we haven't done much with it.

But that's one of the decisions we have to make when we get near the end of the project is, which of these other reports, besides the exact volumes you saw, what, if any other reports, should we put out? Mostly we would like to attach these things as appendices to the existing report so that it's --

MR. BLEY: Sure.

MR. KURITZKY: -- easier for people to find them and then they don't have to, like hey, how do I find this, I'll just get a report, you know, it's in ADAMS dockets, how do I know that. But the, so we have to figure out exactly what we're going to do there.

I'm trying to think now. Yes, the Level 2 report, we added a number of appendices to it from other supporting reports that we had internally, but we did not have the HRA report as one of them. So that's a good point. We may have to, that's one that we might just have to put out as a separate report, but that's a decision we're going to make a little bit

further down the road.

MR. EVANS: We've got a comment --

(Simultaneously speaking.)

CHAIR DIMITRIJEVIC: Susan has --

MR. EVANS: -- by Susan.

CHAIR DIMITRIJEVIC: Susan? Susan, we see your hand up.

MS. COOPER: Okay, thank you. Thank you, Vesna.

So, not for FLEX because was a different case. And Alan is going to talk about that in a minute. But since we're talking about the Level 2 HRA, yes, I think there is an awful lot about the Level 2 HRA that would be good to get out and a lot, unfortunately the specifics are always going to be proprietary, but there is some good information in there.

And we did address things, Dave said a moment ago about operators trying multiple times to get equipment going. I mean, that was in fact the rationale, the reason behind us saying, we're going to estimate how long the operators might need to get the equipment, you know, transported from the warehouse to near the water tanks and connect up the hoses and pull the hoses where they need to go and get pumps started

and all that kind of stuff.

We recognize that that was not going to be just like pushing a button in the control room because we walked it down. We talked with the operators and so forth. So that is part of the underlying HRA, Level 2 HRA method for the Level 2 PRA. But that's not what was done for FLEX, as Alan is going to explain.

I did do a paper with my coauthors for one of the PSA conferences way, way back when. I don't know if it was, I don't know what year it was, but, I mean, it does explain something about the method and something about what we learned from the plant site visits that shaped how we developed the method. But until then I think that's the only thing that's out there. Thanks.

MR. KURITZKY: And thank you for that comment too because, yes, I've highlighted that needs to arise further on my radar. The idea of how we're going to get that post-core damage HRA report into the public domain. So thank you for that feedback.

MR. EVANS: Alan, we have another hand up. Dr. Roberts.

MR. KURITZKY: Okay.

MEMBER ROBERTS: Yes. Just to close out

my question. That was very helpful, Susan, in terms of explaining the Level 2 HRA. I wonder if there is any thought on Level 3? Whether there is some influence in the ability to make better decisions on protective actions based on having people available in the control room with the technical support center or whether that's stuff we didn't factor in at all?

MR. KURITZKY: Well, my, the quick answer is, I don't think that is something that we specifically focused on. But if Keith Compton is here he's our Level 3 expert and so he can speak to it more intelligently. But I don't think we got to that level of detail. Keith, are you on the line?

MR. COMPTON: Yes, I'm on the line. This is Keith Compton from the Office of Research. Can you hear me?

MR. KURITZKY: Yes, we can hear you.

MR. COMPTON: Okay. I just wanted to make sure. Yes. No, that's an interesting question. I have to be honest, I hadn't really thought that much about it. So that implies that the answer is no, we didn't include it. But I'm intrigued by the thought so I'll take that thought back.

MEMBER ROBERTS: Okay. Yes, thank you, Keith. And this relates a little bit to a discussion

we had yesterday on the high burn-up fuel rulemaking. Again, they're looking at changing the allowable control room dose for the design basis cases.

And a question I had asked, whether that has any implication on some of the work in the Level 2, 3 space because that's not a direct requirement anywhere that, at least that I'm aware of. So again, it probably is worth some thinking about so thank you.

MR. COMPTON: Sure.

MR. KURITZKY: Okay, thank you for the question. And, again, Keith and Susan, thank you very much for your responses. Okay, so are we clear to move forward? I'm assuming no more hands up. Okay.

So just one thing I do want to mention about the FLEX case. For those who are as familiar with FLEX so, it involves a three-phrase approach. Phase 1 is where the plant will initially cope to, with ELAP by relying on installed plant equipment and resources.

There may be some different strategies. For instance, shedding, load shedding for the safety batteries, but you're using the existing normal equipment. And Phase 2 you start to rely on the FLEX equipment. Which would be your backup pumps and diesel generators, et cetera. And batteries.

And then Phase 3 is when you start to, in the longer term, you need to bring in additional resources and equipment from offsite. For instance, one of the SAFER Centers that have been established in the country.

This analysis, our 2020 FLEX case, only considers those first two phases. We don't go into the long-term phase in bringing stuff in from offsite.

CHAIR DIMITRIJEVIC: Alan?

MR. KURITZKY: Yes.

CHAIR DIMITRIJEVIC: I just want to do some clarification. Since you have this separate slide on the FLEX.

You're 2020 FLEX case is only partially connected with FLEX. To other important parts of the, you know, the design change on RCP seals, and also crediting these auxiliary feedwater extended operation.

So, the changes which we see in the tables when you consider the FLEX case, you know, 2012 case, are combination of these three, and we don't really know how much of that change can be contributed to FLEX and how many do the very important change in RCP seals or crediting the extended, to the auxiliary feedwater operation?

MR. KURITZKY: That's correct. And we don't have specific sensitivity studies to break that out, that was, because we had it limited to exactly what we were going to evaluate. We thought that one wasn't as essential to breakout, but you're right, it includes all those three things.

The FLEX and the extended turbine-drive aux feed are really two sides of the same coin in the sense that they're doing the same function. You just need one or the other. And so that's why, as I'm about to describe on the next, maybe the next slide, or sometime in the next couple of slides, this whole idea of this Parameter P that combines the two together.

And the actual, the other item, which was the new passive shutdown seals, that one we did evaluate as a sensitivity in the original study for the Level 1 internal events. And we showed that it reduced core damage frequency by around ten percent.

And what it really addressed was the scenarios involving loss of nuclear service coolant water. Because those, you lose all the cooling for the seals. As well as the makeup systems that you would need in the case of an RCP seal LOCAL.

So those loss of service water scenarios

contributed around more or less 14 percent to core damage frequency for the internal events. Level 1 internal events.

And so, the use of the new RCP seals reduce core damage frequency around ten percent or so. Maybe a little more. So that's kind of like ballparking it back then, if you want to kind of carry that ten percent thing along.

And you'll see when we show some of the results, as we go forward, you can see that the, in general the reductions are more than that in the 2020 FLEX case because of the FLEX pieces to this. The FLEX in the extended turbine-drive aux feed as opposed to the seals, but they both contribute.

And when we get into, it's hard to partially get to Level 2 and 3 results because now you know and see the nuclear service clean water versus the other scenarios. But much of the reduction is occurring because of station blackout scenarios which more is attributable to the FLEX and extended turbine-drive aux feed. But again, even in those scenarios you do result in RCP seal LOCAs many times but in those cases --

CHAIR DIMITRIJEVIC: Right.

MR. KURITZKY: -- even if you didn't have

an RCP seal LOCA, if you have, essentially an recoverable station blackout, you're going to end up having core damage anyway. You may have a slightly different flavor of core damage and different timing of core damage but you're getting there anyway.

So I think the bulk of the reduction in the Level 2 and 3 arena really comes from the combination of the FLEX strategies and extended turbine-drive aux feed. Though there is contribution from the new shutdown seals too.

CHAIR DIMITRIJEVIC: Okay. I just want to point out that it's not really clear, you know, to say, okay, with introduction of the FLEX strategies that's what happened to model because it's a little more complex mix of the changes.

MR. KURITZKY: Yes. Yes, thank you. And just going back to the previous slide, so that's why I tried to, I tried to refer to it as the 2020 FLEX case in the discussion just because of human nature to shortcut things sometimes I might talk about FLEX.

Usually if I'm talking about FLEX I mean the 2020 FLEX case so it's more than FLEX, it's these other items too. But I'll try and say the 2020 FLEX case to be clear. But yes, even the fact that we call it the 2020 FLEX case is a little bit misleading but

we need some shorthand way of referring to it and so that's just what we came up with.

Okay. So moving on to the result for the 2020 FLEX case. First, looking at Level 1 PRA. So if you look at the table here, down at the bottom the total for all hazards. For the Circa-2012, the base case, the total hazard CDF is around one and a half ten to the minus four. In the 2020 FLEX case it drops almost 40 percent down to a little over nine ten to the minus five.

And so again, the bulk of that reduction is because of the FLEX and turbine-driven aux feed. Changes go, part of it is also due to the new RCP shutdown seals.

If you look at the different hazards individually you can see that the internal events and floods and the high winds have reductions of around 60, in the ballpark of 60 percent, while the fires, internal fires and seismic events, is much lower. And the reason for that is that the internal events and the high winds have a large contribution from a station blackout sequences. And those are the sequences, the types of scenarios that FLEX has been designed for so they're fairly effective there.

For the fire and seismic you also, there

are a lot of station blackout type sequences for those hazards too, but we gave less credit for the FLEX strategies and the turbine-drive aux feed, et cetera, in those cases because of the direct impact of those hazards on both the equipment itself, as well as the operators who have to take, whether it's accidents in the main control room or local FLEX actions.

So, and that goes back to, I think it was Dr. Rempe's question, do you consider the fact that, hey, in this case the reference plant, EDMG pump, there is two, but the one that's most readily available is in a warehouse which is not seismically qualified. So we intentionally gave less credit for the FLEX in those cases because of the more significance of the hazard itself. And I'll talk a little bit more about that in a couple of slides.

Looking at these pie charts, just to kind of get a breakdown of what hazards are contributing, the base case, Circa-2012 on the left, FLEX on the right. So you can see, if you squint, you can see that internal events and internal fires are the dominate contributors for the base case. Which one contributes around 40 percent.

And if you go over to the FLEX case and you see that now internal fires has really jumped

ahead, and that's because, as we just mentioned, we gave more credit to FLEX for the internal events so you see a bigger reduction there. You don't see as much of a reduction on, for the fire, so now the fire has become essentially twice as important as the internal events.

You also see something similar with the high winds and seismic events. In the base case on the left you can see the high winds is around nine percent of total CDF and seismic is seven, but when you go to the FLEX case it flips and you have seismic at nine and wind around five. And again, it's because the FLEX was much effective. In our assumptions it was much more effective for the high wind than it was for seismic.

One thing you don't see on these charts, again, you see these four hazard categories, you don't see all the other hazards. So again, we did, and I think someone asked about this earlier on, we did go through and evaluate and screen out either through qualitative or semi-qualitative analysis all the other hazards based on the criteria in the PRA standard.

However, there were some external hazards or other hazards that we did not, we did not screen per say by those criteria, but we just were not able

to, we did not include qualification for it either because there was ongoing active research in those areas, going back to a question, a comment someone had before about whether there was active research in some of these, active research in some areas so we were not, we did not address those items because the information was changing.

And also, things that were just beyond the state of the art. For instant, space weather. So things like solar flares. It was something that definitely could be of concern, and no question. In fact, that's actually one of the public comments we just got today on these reports. But it's just something that's beyond the standard. We don't have any way of evaluating that right now.

So most the other hazards were all screened out by the criteria in the standard, but there were a few things that we just had to leave off the table because they are beyond our capability right now. Or they were subject to ongoing research.

Okay, moving on to --

MEMBER REMPE: This is Joy.

MR. EVANS: Alan, we have a question.

MR. KURITZKY: Sure.

MR. EVANS: Go ahead, Joy.

MEMBER REMPE: I just want to make sure I understand you. I did see something in the report saying what you've said here about that they did realize in higher seismic events that the building wasn't qualified.

What about wind, was the building qualified for high winds at the reference plant?

MR. KURITZKY: I don't remember. You know, honestly we ended up having a very top notch, five research associates, a very top notch wind curate outfit come in and do walk-downs and evaluations for us.

I don't know if they actually walked down that building because it wasn't part of the, in this case PRA, so I don't think we ever got an actual evaluation of that building.

But, again, as I am going to mention, and we can go back to, or on the next slide, we don't go into a very detailed analysis of FLEX, and so this P value that we pick for the different hazards -- Well, actually, let me just, because I was going to this anyway, so if you look at this slide, again, we did not do a detailed analysis.

We did a parametric study using engineering judgement. We used P as the parameter of

merit and we defined P down below here as the probability of the FLEX failing and the probability of the extended turbine-driven aux feed failing, because you just need one or the other.

And so you see that, you know, for P for internal events we had a value of 0.09, but for these other hazards the values are higher, 0.50 for fire and seismic and 0.25 for wind.

So, again, the fire and the seismic have fairly high values because of what we were just mentioning, that the impact, the potential impact of these hazards that they'll be able to implement FLEX or the turbine-driven aux feed leads us to think that they, you know, would be much higher than just a sunny day internal event type situation.

The high winds was not as extreme of conditions that you would get for some seismic so we picked a value that's kind of in between internal event and seismic event.

So to go to your question, Dr. Rempe, we didn't do a detailed analysis and we I don't think we did an evaluation of the fragility of that maintenance building to wind, but we have picked a value that says, hey, there is a much better chance that you are going to have problems under a wind condition than you

would just for an internal event but maybe not as much as if you had a seismic event.

As you are going to see in the next slide, let me just go to the next slide, because of the fact it was just a parametric uncertainty and we did not do a rigorous analysis, so we wanted to see what would be the impact of using other values.

Now in the internal event case in Volume 3 we actually had a more detailed look at different values for P for internal events.

Here we looked at just a few cases, but in this graph right here you can see that the three points that are on it are if we give no credit at all to FLEX and the turbine-driven aux feed, and then you have the base case, which is really the 2020 FLEX case, that means the base case of the FLEX case, of the 2020 FLEX case, and then the last one is if FLEX, well either FLEX or turbine-driven aux feed were perfectly reliable, and so you could 100 percent rely on them.

What you see here is that the slope of the lines from the base case to the perfect case are fairly flat, and so this shows you that doing a more detailed rigorous analysis wouldn't really buy you a lot more in terms of CDF reduction.

By the same token, for the purposes of our study, for our study, this really supports our decision not to do a lot more work to get a more refined number because it really wouldn't, it wouldn't really change things for us.

Now that's not to say that for some other applications, for our regulatory application, for instance an event assessment type of application, that you wouldn't want to have a much more detailed and rigorous analysis.

In that case you might want to do something like a detailed HRA and also incorporate operational experience, you know, operational equipment failure data for the FLEX equipment, to get a much more accurate number.

So that's something that you probably would want to do, but for the purposes of our study it wouldn't make much difference in the insights. Again, this is just a sensitivity case. This is not part of our base study, so as a sensitivity analysis there was no need for us to put that much more effort into it.

MEMBER REMPE: Okay.

MR. KURITZKY: But if you do -- I guess more to your question, Dr. Rempe, it's the other side, it's going from no credit to base case, so, yes, you

do see if we did not -- If we assume that the failure of probability for high wind was, you know, even higher than that 0.25, you can see from that lower gray line at the bottom that you do see an increase.

Again, this is -- No. Actually, no, this is an arithmetic scale, it's not logarithmic, so, yes, you see some increase but it's not substantial and you wouldn't expect it to go to one in either case, so -- Because, again, this is a, another simplification is in reality you would have a value of P, you know, a failure of probability for FLEX and a failure of probability for the extended turbine-driven aux feed that was contingent on the exact magnitude of the event.

You know, with seismic in our study we had eight seismic bins and in wind we have multiple bins for straight line winds and tornados, et cetera. So you would expect for the lower bins the probability would be close to what you have for internal events and for the higher bins it would be getting closer to, you know, the no credit line or failure of probability of one.

But what we have done is actually picked values as kind of like in the middle that is kind of a hedge and then this parametric study to look at what

happens when you move it up or down.

If you are looking at seismic, the very high seismic bins like seven and eight, which have widespread destruction, we don't credit the FLEX at all anyway so we wouldn't have to worry about being non-conservative for those.

But, again, to the extent that we were doing a sensitivity study just to see the general impact, we were comfortable with what we have done here.

So, again, 0.09 for internal events, 0.50 for fire and seismic, and 0.25 in the middle for high winds. While we recognize that for everything except probably the internal events these are probably pessimistic values in reality.

We do that to be, okay, just because, as I mentioned, there is a lot of uncertainty associated with these types of hazards and both of their impacts on equipment and the OP interactions both in the controlment and locally, so we felt justified using, you know, higher values for P for those hazards.

MEMBER PETTI: So, Alan, this is Dave.

MR. KURITZKY: Mm-hmm.

MEMBER PETTI: Again, this is where I got really confused because if you would incorporate the

uncertainties as you note and put some error bars on these is there really that big of difference in FLEX?

I mean I look at the seismic case, which, you know, you think about FLEX being born out of Fukushima, this says it won't, it may not help in a seismic event, a severe seismic event at least.

So that's where I am -- I just -- Yes, I mean I look at these numbers and, again, I'm not a risk person, but, you know, 30 percent doesn't sound to me in light of the uncertainties as being significant.

Am I wrong there? Is that really from a risk perspective an important reduction? I can see when you get, you know, 50, 60, 70 percent, but help sort of calibrate me on what's the, you know, when is something significant versus insignificant in light of uncertainty.

MR. KURITZKY: That's a very good question. We have -- So specifically for the uncertainty analysis I think in the actual reports, I don't know, it may not have made it to the, I don't think we had it in the overview reports, they are in the supporting internal calculation files we did, you know, we propagate uncertainties.

We assigned uncertainty bound to these

values and propagated them through the model just like we do for all the other basic events in the PRA model to come up with a parametric uncertainty balance.

But, more specific to your question, yes, when you're talking about 10, 20 percent, given the uncertainties it is not significant, you are correct, and it goes back again to what Dr. Rempe had mentioned, that because the design specs or whatever, requirements for the FLEX equipment, was that not that it had to be in a, you know, seismically robust structure.

So when you look at seismic events you have to accept the fact that there's a good chance it's not going to work. Yes, it was born out of Fukushima, but as Dr. Rempe pointed out, they are not required to being seismically qualified structures.

So, you know, there is only so much credit you can give for not -- I don't know whether, if a licensee were to come in with a detailed analysis, again, remember, we're doing a very crude parametric study, but if a licensee were to come in with a more detailed analysis for some type of regulatory application or some type of event assessment or whatever, it would be interesting to see what kind of credit they gave to it for seismic events.

And it may be that, you know, some plants might have it, even though it's not required they might have it in a seismically qualified structure, others may not, so, you know, it's going to be somewhat case by case.

But in terms of just a general idea of uncertainty and results, you are correct, a 10 to 20 percent difference is -- We report them because we do the study, but are they significant in terms of the overall uncertainties, no, probably not substantial, I agree. A 60 percent change --

MR. BLEY: Alan, this is Dennis.

MR. KURITZKY: Okay. Yes?

MR. BLEY: You know, the assumption that it sounds like is in there because the shed they keep this stuff in isn't seismic that it gets wiped out and you can't use the stuff, I don't know if you did it but the Committee went out to visit the SAFER site out in Phoenix some years ago and what we learned out there was SAFER can deliver all of that equipment to any site in the country in less than 72 hours, substantially less in many cases, and that there are agreements among the people who belong to SAFER and FLEX that nearby or reasonably nearby plants would share their equipment if a particular plant was

affected.

So I think that's a grossly simplified assumption I think that if the shed fails you don't have any of this FLEX equipment.

MR. KURITZKY: Okay. So, Dr. Bley, thank you very much for that because, again, I want to -- It got lost through all the discussion, so I want to reiterate that our 2020 FLEX case only focuses on Phase 1 and 2 of the FLEX response.

We specifically do not consider the offsite resources, so, yes, the fact that we have minimum credit for FLEX in a seismic event in this study for Phase 1 and 2, for the onsite FLEX equipment, is not to say that FLEX as a whole is not more effective.

Yes, with the SAFER Centers and also figuring that, you know, whatever hazard is impacting the site is very unlikely to impact the SAFER Center, you know, except for maybe if there happens to be a plant in the near vicinity of it, but I think there is only a couple of sites in the country.

MR. BLEY: Well and they are widely separated.

MR. KURITZKY: Yes, and they are widely separated, so there is always going to be something

available, except for the solar flare, but, anyway, I am not going there.

So in any case, yes, thank you very much for pointing that. We are talking just about the impact of FLEX Phase 1 and 2 using onsite equipment, not the overall benefit of FLEX when you consider offsite resources also.

MR. BLEY: And I think you were clear about that, but the discussion implies -- The reader is not always aware of the significance of those assumptions and limitations.

MR. KURITZKY: Right. Let me just make a note on that to see if we can iterate that in other points in the report.

MEMBER PETTI: Yes, thanks, Dennis. That was my concern as sort of misinterpreting what you are really trying to say.

CHAIR DIMITRIJEVIC: Okay. This could be -- Because we are going to switch from Level 1 to Level 2 in the next slide, this could be a good time for us to take a break.

We are back on the schedule, so let's take the 15 plus minutes break and let's get back together at 10:35 and resume our meeting, all right. Thank you.

MR. BLEY: Bless you, Vesna.

CHAIR DIMITRIJEVIC: Mm-hmm.

(Whereupon, the above-entitled matter went off the record at 10:18 a.m. and resumed at 10:35 a.m.)

CHAIR DIMITRIJEVIC: Okay. It's now 10:35 so we will resume back our meeting. Scott Moore expressed the desire to make some remarks. Scott, are you there?

MR. MOORE: Yes, I am. Thank you, Chairman Dimitrijevic. Just a brief comment to everybody that's online, please do not use the chat feature in Teams.

The chat does not get recorded in the transcript and we're trying to keep, you know, a running transcript for the meeting.

The one thing you can use chat for is if you are having audio or visual or computer problems, but if it's related to the content of what is being presented or discussed please don't use chat. Thanks. That's it, Chairman.

CHAIR DIMITRIJEVIC: Okay. Thank you, Scott. All right, Alan, so now we can see you again. We hope to see slides soon, too.

MR. KURITZKY: Oh, okay, I forgot. Thank

you for reminding me. Let's see.

CHAIR DIMITRIJEVIC: Excellent. We see them now.

MR. KURITZKY: Okay, good. Thank you. I don't know why they disappeared, but, anyway. Okay, so I hope everybody had a good break. Thank you for coming back. Now we will move on to the Level 2 and Level 3 results.

First, for the Level 2 PRA you can see here on this table there is a comparison between the circa 2012 case and the 2020 FLEX case for three different surrogate risk metrics.

LERF, L-E-R-F, which is Large Early Release Frequency, which has been defined for this study as the frequency of a large release that occurs early enough that there is the expectation of the possibility of early fatalities.

Then we have LRF, or Large Release Frequency, which has been defined as the frequency of any large release that occurs prior to the termination of the severe accident analysis for the study.

Then, lastly, CCFP, Conditional Containment Failure Probability, which is just the conditional probability if the containment fails given core damage.

So looking at those three results, for LERF, first off, you can see that in the base case, circa 2012, it's 1.9 e minus 6 per reactor critical year for all hazards combined and if you recall the core damage frequency for all hazards combined was 1.5 10 to the minus 4, so it's a little over 1 percent that's LERF.

The reason why LERF is so low in this case is the fact that the accidents that do not involve, the severe accidents that do not involve containment bypass occur slowly enough that evacuation would be effective. So that leaves with you containment bypass events which are primarily three types.

There is interfacing system LOCAs, loss of coolant accidents, and then there is also pressure induced steam generator tube ruptures which occur primarily after an ATWS event and you end up having a pressure induced steam generator tube rupture prior to core damage and that rupture occurs at a level above any water, so there is no scrubbing of the release.

Also, that scenario involves at least one secondary side relief value, either intensity being opened or it being in the stuck open position.

The third primary contributor to LERF is temperature induced steam generator tube ruptures and

these are post-core damage steam generator tube ruptures.

All three of those cases, all three of those scenarios, have very low frequencies and so that's why you don't see a very large LERF contribution.

If you look at the 2020 FLEX case you see that it drops down to 1.3 minus 6, around a 30 percent reduction, but the same types of scenarios are contributing with the primary reduction being in the category of those post-core damage thermally induced steam generator tube ruptures which often result from station blackout scenarios.

The other two categories, the FLEX and turbine-driven aux feed, et cetera, had very little impact on it.

Moving to the second, well actually the second and third, the late release frequency and the CCFP, both of those you see a fairly high value, particularly in comparison to core damage frequency.

The reason there is because most, a large contributor to those are station blackout sequences and station blackout sequences you tend to not have containment heat removal, so eventually those sequences would tend to lead to over-pressurization of

the containment.

So you have a fairly high conditional probability of containment failure and, therefore, large release for those sequences.

Again, looking at the FLEX case you see that FLEX is effective in reducing them by nearly 40 percent. If we recall that's kind of the same reduction you saw for CDF for all hazards and that's because, again, it's the similar profile, risk profile, it's primarily driven by station blackout sequences.

CHAIR DIMITRIJEVIC: Alan?

MR. KURITZKY: Yes?

CHAIR DIMITRIJEVIC: Okay, so here is where I was really, my first really big surprises came looking in the results. This is an awfully high large release frequency, right?

MR. KURITZKY: Mm-hmm.

CHAIR DIMITRIJEVIC: That technically is different than it was reported for the new reactors, right, because new reactors reported large release frequencies, not the large early release frequencies, and also CCFP and the requirement there was, you know, to meet the safety goal the same as the LERF.

So here there is a lot of question

actually how we define large release frequency. I notice that there is a lot of -- you have some consideration, you know, for that the radiological release is either seven days or two days timeframe.

So can you discuss that and what does that actually mean? Is this actually new mission time for Level 2? Actually, can you actually discuss really why is this LERF so big, how does it differ from the one which was reported for advanced reactors, what are those different timeframes considered in this?

They make actually a pretty big difference but still LERF is very large. All right.

MR. KURITZKY: Okay. So let me just go on to the next slide because that's where I am going to really get into that and the timeframe.

So as you mentioned the LRF is relatively large here. It's, I don't know, 70 percent of core damage frequency. Well, inconsistent with the CCFP. So because of that -- So with -- In order to get a better, a more complete understanding of long term severe accident progression and radiological release considerations, we took the severe accident analysis out to a stable state with a 7-day backstop.

But as I mentioned earlier, we credit post core damage and mitigative actions up to, around, or

slightly after vessel breach, but we don't consider additional actions in the longer timeframe after that.

So because of that and because there is no consensus mission time for severe accident analysis for core damage frequency, there is a generally understood mission time of 24 hours.

You might take a little bit longer for certain sequences, you know, especially if they are coming up to a cliff edge effect, but, you know, there is kind of a consensus around 24 hours.

Well there is no such thing for Level 2 space for severe accident, so given that we wanted to look into what would be the impact on the results if we used a shorter time, if we terminated the severe accident analysis earlier.

So we looked at two different cases, both of them peg to when you enter the Severe Accident Management Guidelines, SAMG entry, which essentially is when core damage occurs.

So we looked at one case where we stopped the analysis 36 hours after SAMG entry and in another case it was 60 hours after SAMG entry. As you mentioned in terms of the timeframe from event initiation, so the base case was seven days after event initiation, the time of core damage will change

depending on the sequence but it's generally going to be somewhere between a few hours after event initiation up to maybe around 12 hours after event initiation.

So if you just want to kind of get a ballpark idea for comparison, SAMG plus 36 hours is more or less two days after event initiation and SAMG entry plus 60 hours is roughly three days after event initiation, so you are looking at two, three, and seven days after event initiation here.

If you look -- First let me just mention just to get it off the table, large early release frequency you see no change in the numbers, either for the base case or the 2020 FLEX case, and that's because by definition those releases are occurring early on and are occurring before you even get to 36 hours after SAMG entry, so the shorter timeframes make no difference on the results.

But that's certainly not the case for the large release frequency. If you look at an LRF in the top table for the circa 2012 case you can see that in the SAMG plus 60 hours case, well, you know, essentially both of the shorter timeframes, you have a significantly reduced large release frequency.

The reason for that is the large release

frequency of course is composed of all the different release categories in the study, but one of the major drivers of large release frequency is a release category that we call LCF, or Late Containment Failure, and what it really involves is a containment failure tens of hours after vessel breach. It's a quantity static over-pressurization failure of the containment.

The representative sequence for that release category in MELCOR shows that the release is occurring by SAMG, by 60 hours after entering the SAMGs, but it hasn't, the cumulative release hasn't risen to the threshold that we call large, which I think is, I don't remember, it was something like 4 percent of cesium or -- It was some fraction of I think it was cesium source term, but it hasn't gotten to that level yet that we would call large.

In fact, it doesn't get to that level until almost right before the seven days, in fact. So that's why you see a substantial reduction in LRF for those shorter timeframes.

But if you look down at the conditional containment failure probability you see actually that drop off doesn't occur, it only occurs for the 36 hours after SAMG entry and that's because that same

representative sequence for the late containment failure release category has, at 36 hours after entering the SAMGs it hasn't even failed containment yet.

The containment fails sometime between 36 and 60 hours after SAMG entry and so that's why you then have the jump up in conditional containment failure probability and then the actual release becomes what we call large near the end of the 7-day period and that's why you see the bump up in LRF only for the 7-day after event initiation.

So, again, it's tied to the fact that we had that 7-day severe accident analysis termination time that leads to such a large contribution.

Now, again, other plants might have it different, and this is based on the profile, this is based on the dominance of station blackout type scenarios, which without containment heat removal it will slowly build pressure to your failed containment and then the release starts off small and slowly builds up over time, so, of course, other plants might have different results, but this is what we see with this study.

But what this also leads us to is the fact that because we don't credit any additional mitigative

actions after that shortly after vessel breach, so it does tell you that if someone were to credit actions or able to implement some type of actions to prevent containment failure in say two days, within the two days after the event initiation, by for instance recovering containment heat removal or containment venting, then they can prevent a large release because they will prevent the containment from failing and prevent the eventual large release.

Well, on the other hand, the flip-side of that, the other big takeaway is that if a licensee or some other applicant were to come in with a Level 2 analysis and they generally only carry out their severe accident analysis for let's say 48 hours after event initiation or 72 hours after event initiation, they may very underestimate what the plant risk is because they would not capture some of these longer term issues or longer term failures. So that's the two sides of it.

The fact that the shorter timeframes means that you do have an opportunity to take additional action to prevent the large release, on the other hand if you can't prevent it and you don't model it you are going to underestimate what the actual event risk is. Did that address your --

CHAIR DIMITRIJEVIC: Oh, yes. Well, this is extremely, I mean, in my opinion, extremely important. Because it may have a really regulatory impact, you know, because the -- okay, so here you consider 72 hours Level 1 mission time. And most of the new advanced plants consider 72 hours mission time for both Level 1 and Level 2.

But what you are telling us, that this severely underestimates large release frequency. And also, you know, the silent CCFP of 0.1, which is one of the safety goals, if you extended this timeframe to the, you know, seven days after that event, you may not satisfy the surrogate measures for advanced reactors. So in your opinion is this how you see implication of this result?

MR. KURITZKY: Well, I'm not in a position to say, because I don't know the -- obviously this very design-specific, the new reactor designs. This is an artifact of the large drive containment design, and the station blackout sequences, and their impact. And some should be going what mitigated activities did you take.

But yes, for these types of plants, if you don't mitigate the station blackout, and it just keeps on going, you get containment over pressure, you will

eventually fail the containment and get a large release.

But I don't know the design of the new reactors or the advanced reactors, whether the same types of sequences occur, whether the design features of their containments, et cetera. You know, I can't really extrapolate or speculate what the impact would be for them.

(Simultaneous speaking.)

MR. KURITZKY: But the overall insight is that, yes, make sure that they are looking at a sufficiently long timeframe that they're not clipping higher potential failure probabilities, containment failure probabilities because they just arbitrarily terminated their analysis at some point in time.

Sorry, go head --

(Simultaneous speaking.)

MEMBER PETTI: This is Dave. Just, you know, many of the advanced reactors do not require power from safety functions. And so the whole station blackout picture looks very, very different, I think, when we actually get, you know, an application.

But at least the stuff that I've seen, that's when I was reading it, that's how I was kind of trying to think about it, put it in that context. In

kind of many of these cases, there are, quote, "cliff edge" effects in some of the designs. Here you're just seeing all the cliff edge effects coming to the fore, right. So, yes.

CHAIR DIMITRIJEVIC: All right. Well, I think that this is, I mean, a lot of those plants have a passive feature. I happen to work with one which is very similar to this which is APR. It's very off-site power dependent, in fact there are very similar issues, like the four-loop with Westinghouse.

So there this is very applicable stuff. But also the most important point is that maybe those mission times cannot be prescribed in advance. You know, they should be sort of related to what's happening in the severe accidents in the plant afterwards. So you cannot just say, okay, we're going to use either 24 hours or 72 hours, because that's how it is done.

So from my point of view, it's very interesting that this brings up also how long you're going to look in the containment response after the initiation of the event. So I think that will definitely -- I hope you will definitely, you know, have a prominent place in your summary report on the, you know, compare it with the coolant practice.

Well, okay. So all right, well thanks for the discussion.

MR. KURITZKY: Okay. And again, thank you for the question. And let me also just mention just two quick follow-up things. One is in this case it's station blackout that's driving that result. But the overall concept that you've got to be careful about how long you run the analysis out is important.

It would take me too long to find the actual MELCOR output graph. I'm not even sure it's publicly available. But you see, in the graph you can see, after the containment fails, you see measuring the source term, and I think, again, I think it was the cesium pressure, cesium release. And you see it slowly going up.

And so it actually is right before, really something like 6.9 days that you get to what we happen to call, though again that's an arbitrary number too, right, I mean whether you're a few, you know, periods below, or above, or whatever, that's not important. But nonetheless, it's a slow progression.

And so if we only did the analysis for two or three days, we would see it never getting near the threshold for large. But as we did do it to seven days, you do see it, you could get that far.

So any type of analysis, and recognizing that I know the NRC is not going to see these detailed analyses from applicants, but I think they have the right to go look at them, you want to see what kind of -- if they do have such analyses, and I guess there's might be with MAP or something.

But if the source terms are trending upward, and they just happen to cut the analysis at that point, you know, a fair question is well, hey, what it you extend this thing out? That would just keep going up. Eventually you're going to get to a problem.

So the concept about when to terminate the severe accident analysis I think is important because of what the design of the plant is.

MR. BLEY: Alan, this is Dennis.

MR. KURITZKY: Yes.

MR. BLEY: I'm going to emphasize that even more. There ought to be a physical reason for where you stop the analysis, something you can tie back to what's happening in the plant and what might be happening externally that you could use.

Just in an aside, 24 hours came about back during WASH-1400 times. People sat around the room and said, well, after about a day you could probably

get help from other places that bring you stuff, so you probably don't need to go beyond that. There's no reason for that to hang on as long as it has. There ought to be a basis in physics and physical attributes that determines when you stop that analysis.

MR. KURITZKY: And thank you, Dr. Bley.

(Simultaneous speaking.)

MR. KURITZKY: You're probably one of the only people that were around back then to be able to tell us that.

CHAIR DIMITRIJEVIC: And that is also, I don't really -- I was going to go back to the standards, PRA standards. I don't remember what do they say about the mission time, and especially for the Level 2.

MR. BLEY: I don't remember exactly, but I know it had some element of, you know, it's not a fixed number. You want to base it on what the analysis is telling you.

CHAIR DIMITRIJEVIC: Okay. That would be good then.

MR. KURITZKY: Yes, actually I could -- two points here. So yes, Dr. Bley, this is an example of the 24 hours. It's one of those things where if you say something and repeat it enough it just becomes

fact of type of thing, right, even if there's no basis for it. But I think the standard says you need to reach a safe and stable state.

And so you'll see in our Level 1 PRA provincial events, Line 3A, we have a whole discussion on safe and stable. We went back to our event trees and we added some additional nodes for -- and this particularly became important with RCPC LOCAs, because we had cases where we were not getting core damage at 24 hours.

But you were not in a stable state. The leak was increasing, and you were eventually, if you couldn't take action to ameliorate it, you were going to get to core damage. And so for those cases we added these extra nodes to, you know, make up, consider alternative ways to rod cooling or make up charging to the primary system.

And so we added several nodes for that on the basis of getting to a safe and stable state. So I think really, the standard I think leads you to go to a safer, stable state. But there's no definition of what safe and stable means.

MR. BLEY: It's certainly not a case where things are continuing to get worse.

MR. KURITZKY: Right, exactly.

MR. BLEY: The pressure is still going up, temperature is still going up, that sort of thing.

So I'm going to have to go back and look at the Level 1, because I don't remember that when I reviewed it. And I don't think I've gone back to take a look to see what you added in. So that might be something worth pointing out in your final summary report, when it's reasonable to stop the timeframe of an analysis.

MEMBER REMPE: But, Dennis, along the same point, when you stopped it back at 24 hours, not including the offsite equipment, you're going for seven days, is that not a bit misleading?

(Simultaneous speaking.)

MR. KURITZKY: I'm sorry, is that question to me or Dr. Bley?

MEMBER REMPE: I'll give it to both of you. But to me that seems a bit misleading.

MR. BLEY: Can you sat it again? I didn't parse it --

MEMBER REMPE: Well, it didn't include the offsite FLEX equipment, and why go for seven days if you're not including something that could perhaps mitigate what was going on, or at least say it's there and say a 50 percent chance to get flown in, and get

it installed, and it does something. It sounds like it was totally neglected. But you went for seven days, right?

MR. BLEY: No. I agree with you. I mean, they told us what they did. And what they did says under this condition here's what the results are. My worry, that I stated earlier, is because of those assumptions it can be misinterpreted. And it's hard to put warnings about results that are coming because of assumptions. It's hard to put enough warnings there that people really pay attention to them. So, yes, it's a little misleading.

MR. KURITZKY: So here's my crack at it, Dr. Rempe. So we recognize that the whole reason for this thing you're seeing on the slide right now is because we recognize that in doing it for seven days we haven't credited other actions beyond essentially the time of the vessel breach or shortly thereafter.

So we recognize that there are other actions that could be taken. That was the thing that Dr. Dimitrijevic was mentioning from the Volume 3 Report where we had the sensitivity of looking at other potential mitigative actions in the longer timeframe and see what the impact of those were. And that's why we look at these shorter timeframes here.

So we recognize that we're not considering all the things you could do in that longer timeframe. But as it specifically refers to FLEX, and the fact that we only consider those first two phases, and we don't consider the long term phase, is the fact that FLEX is primarily focused on preventing core damage.

So the strategies from FLEX aren't really intended to deal with a post-core damage environment and mitigate releases. They're really set up to prevent core damage.

(Simultaneous speaking.)

MR. BLEY: I've got to jump in, if you don't mind?

MR. KURITZKY: Sure.

MR. BLEY: Originally that was true. And when representatives of industry came to the ACRS and described these, they were very adamant about that. And as more and more individual plants began to look, they began to see that this would be very useful in other ways.

And eventually people backed off of that only consider it pre-core melt. And we've got some -- well, I'll leave it there. That's just based on what people brought to ACRS and talked about.

I agree with you that that's the way it

started. I think owners of these plants saw that they could get a lot more out of FLEX than not. And, you know, some of the things that were walked through in meetings with the ACRS and with the industry, and we'd only done that for BWRs, really showed that value. In any case, I think that's not a good argument anymore.

MR. KURITZKY: Okay. Also appreciate that, but again, if they want credit for that in the PRA, and certainly we were going to credit it in the PRA, something would have to be showing up in their FLEX implementation plan or procedures to take credit for that, not just that, hey, we would do something.

And the second thing is we do, and I think it's in the older report, I know it's in the supporting calculus, but I think it's in the older report too for where they talk about with the Level 2 and Level 3 cases.

We mentioned that the FLEX, as we're applying it into this sensitivity case, really only impacts the core damage frequency. And so we're not really -- it could be potential things that they could do in the later timeframe in Level 2 or 3 space, but we're not actually crediting them in this particular sensitivity study.

And I don't know -- in the internal report

I know we identify some of the potential things that could be done in Level 2 space. I don't know if that's in the overview report or not, but it would be in the chapter on Level 2 modeling for the sensitivity case.

But anyway, the points are all valid. There are definitely things that can be done beyond what we've credited here up until the point, especially you talk about these things that don't become large until seven days.

But really, your best shot of avoiding something is preventing the core damage, excuse me, preventing the containment failure. Once the containment has failed, if you're just marking time until the release gets big enough, there's not a heck of a lot you could do.

I mean, you can spray on the outside of the wall, right, if you know where the leak is, et cetera. But the bulk of what you can do, the most stuff you can do is before core damage. The next most things you can do is before the containment fails. After that, your tool box is getting thin. And if you wanted to create something at that point, you would have to have procedures for it.

MR. BLEY: I'd almost say the most

satisfying things you could do, rather than the most things you can do. Okay, ha, ha.

MR. KURITZKY: All right. I'll go with that. Okay, let's see, I think we've finished this slide, right? Yes, exactly, we were --

CHAIR DIMITRIJEVIC: I think we did, yes.

MR. KURITZKY: Yes, I think we --

CHAIR DIMITRIJEVIC: I mean, you point to this interesting thing there like the CCFP was always, you know, measures the core damage frequency over the, you know, lot of, or a lot of, because nobody was ever sure about the things. But here you have a very good point, and that's a separate measurement.

MR. KURITZKY: Right.

CHAIR DIMITRIJEVIC: You know, so you point that in the regs. So I think we are done with the slide.

MR. KURITZKY: Okay, good, thank you.

Moving on to Level 3, it's a Level 3 period study, we've got to have Level 3 results. So in this presentation, in the overview report we focused on two specific risk metrics, the two that are associated with the quantitative health objectives, the Commission's safety goal policy statement. And so that's individual early fatality

risk and individual latent cancer fatality risk.

That's not to say that we haven't perused a lot of other measures. Actually in the Level 3 report which is Volume 4(e), I think, in the current set, it was 3(d) for internal events, we report results for over, I think, I dozen different risk metrics. And so there's a lot more information there than I'm going to talk about here. But we only did the FLEX evaluations for these two risk metrics.

So looking for individual early fatality risk, if you look at this chart you can see that the quantitative health objective is up at the top, the dashed line, 5(e) minus 7.

And then down at the bottom you have all the contributors for the different hazards. The blue bars are for the base case, circa 2012. The green bars are for the 2020 FLEX case, and each pair of bars is associated with a different hazard. You have internal events and floods in the beginning and then fire, seismic, wind, and then all hazards combined.

And so if you look at these bars, you can see that the biggest contributors to individual early fatality risk come from the internal events and the seismic events. And that's because internal events you have --

CHAIR DIMITRIJEVIC: Alan?

MR. KURITZKY: Yes?

CHAIR DIMITRIJEVIC: I always said incredible, this is totally personal, but I have an incredible problem with presenting such low numbers. You know, we are talking here in something that is three trillion years, you know, one event in three trillion years. And the age of universe or big bang is, like, three billion years.

So I mean, you know, introducing such small numbers in many period study, I'd really, you know, couldn't we just say negligible or something. Do we really gain anything? And then we compared those ten to minus 30 numbers to each other.

That's really something I have a really -- it's totally, you know, it's totally, it doesn't make sense, in my opinion. So I don't know how to avoid that. I can see you are showing that you did the calculation, and there is a difference.

All right, Tom has raised his hand. Tom?

MEMBER ROBERTS: If I could, just for a minute --

MR. KURITZKY: Yes.

MEMBER ROBERTS: Yes, I'd like to add to that question, right, before you answer it.

MR. KURITZKY: Okay.

MEMBER ROBERTS: It wasn't clear in my reading the report how those numbers came about. Usually there's about a six order of magnitude plus reduction between the larger release frequency and these early fatality risks.

So in pouring through the reports, the only thing I found was very deep in the Volume 4 (e) was a discussion about meteorology and wind. And it's kind of hard to imagine that you get six orders of magnitude reduction from meteorology and wind.

So I just wondered if you'd, not to get beyond Vesna's point about showing such low numbers, how do you calculate them, and how have you concluded they're reasonable?

MR. KURITZKY: Okay. So a good question, and that's one where I'm going phone a friend and. And I'm sure the friend knows who is going to get tapped in a second. But before I go there, you know, I do echo your concern, Dr. Dimitrijevic, about the low numbers. But as you said, you know, what's the alternative?

I do know that in the actual overview report, in the summary table we have up in the key messages, you know, the Section 2 both for the

internal event and the fire, seismic, wind one, we put in the table. We put in approximately zero as opposed to Action Number 4 in that exact reason because, you know, such low numbers look odd.

Then we have a footnote that I think actually provides the actual numbers down in the fine print. But in the table itself, we just put approximately zero, because the numbers are so low. But nonetheless, I mean, that's what the calculation shows.

If you want to know exactly, going to the question about why they're so low, Dr. Compton, are you ready to jump in? There's more factors than just wind that are involved. But, Dr. Compton, are you online?

MR. COMPTON: Sure. I will jump in. I don't know if I can fully answer the question, because I can speak about this for hours when I want to. But I will highlight a few things that maybe will hit some things.

And one of the things, I do understand these are really low numbers, and interpreting them in kind of, I don't know, a realistic or actual point of view, it's hard to understand what they mean.

They're useful, the actual numbers are

useful to me as an analyst, because it helps me to discern, hopefully a reader who spends a lot of time, to discern why the numbers are that low. And it's hard to do that when you're giving kind of inequalities, you know, less than.

So anyway, so there's -- and I'm glad you found it, it was buried in the, as you mentioned, in the Level 3 report. There's basically four reasons why the early fatality risk is so low. Actually, it's not really just the early fatality risk, it's these are the reasons why high doses, whether they lead to early fatalities or not, these are the reasons why high doses are low.

So the first reason is just that, as Alan said, they only arise under bypass scenarios. You only get those high doses under bypass scenarios which are, you know, very large and very fast releases. And there are some tables and figures in the report, I won't go through them right now unless you ask, but they can kind of illustrate that.

The second is the fact that there is a pretty low, a very low frequency of what I call adverse meteorology, even for those cases that lead to early health effects. Only about one percent of the weather, you know, trials, the actual weather

conditions, led to early fatalities in those, I think, three or four cases.

So another factor is the fact that the range at which you can get those early fatalities is very short. And at least at this site the population is very sparse. There is only, I think within one mile of the site boundary, there is only kind of one out of the 64 directions has a populated sector, one or two. I don't remember the exact number. But the point is that you have to be downwind. And if there's not a lot of people downwind, that will drive the risk lower.

And then the final factor is there's a very low likelihood of delayed or slow evacuation of the populations close to the site. We looked at, in this study, we looked at a pretty fine grain detail about, you know, the early evacuees, kind of the medium evacuees, the late evacuees, the non-evacuees.

And so again, it doesn't, even if you met the other conditions, you had a bypass, and you had the right weather condition, even only the very late evacuees, or those who don't evacuate, show any non-zero or early fatality risk.

So I think if you start adding all those pieces together, and you look at the actual numbers,

and you can see that they kind of hang together when you slow the evacuation down, those low numbers get a little bit larger.

And then if you start, you know, kind of adding in things, you can see what's going to make those numbers go up. And to me that's what's important, is not just the low number but kind of understanding that the story hangs together and what could defeat that story.

That's all I have. Hopefully that is helpful in some way.

MR. KURITZKY: It looks like we have a question. Dr. Bley?

MR. BLEY: Yes. Not so much a question as a comment. This same issue, of course, came up with WASH-1400. And the primary authors of that report testified before Congress, and they did something similar to what Keith did. They wrote it out as a product and showed these various things.

I think if you're going to keep something like this in the report, even if it's in a subtle place, having that litany of three things that all have to occur to get fatalities makes it a lot easier to see why there's, you know, another ten to the minus six added onto the numbers we saw earlier.

And Keith did it really well. And I think it's just a sentence or a note to do that. But I think it really helps a lot.

MEMBER ROBERTS: Yes, Dennis, I agree with that. I think it's important to understand the plant-specific nature of a very large part of that delta. You know, one concern I'd have is somebody interpreting this report as refuting the NUREG 1860 discussion of why LERF is a reasonable surrogate metric for the early fatality risk. Because you can interpret this plot that that number should be a lot higher and it maybe not even be a concern.

Because for any reasonable value of LRF you're still going to meet the QHO for early fatality. So I think it's important to have that perspective, that there's a site-specific nature to this. And if you have a slightly more adverse situation at the site, or a different meteorology, these numbers change by orders of magnitude. So again, just to, you know, just a thought.

CHAIR DIMITRIJEVIC: Okay. If you just point out exactly what I was, and I'm actually questioning how the surrogate things makes -- because it was based on the old study data. And you cannot really avoid to question this, because we are not

talking one order of magnitude. You know, we are taking about like five orders of magnitude.

So I don't know what kind of the wind, the population will change that. But basically, based on this, maybe some evacuation probability. So this is why -- I talked directly with Dennis. You should really present -- you know, you claim a small probability, which I can also question why is the LOCA, you know, re-sequenced as such a small probability?

But he said that we're not going to go in technical details. And that could be part of uncertainty analysis. But this has all started with probably something, you know, the one E to the minus six. And then we are adding now ten to the minus five factors based on evacuation, wind and population.

I would like to see how those factors add up. Or otherwise I definitely will plan to question, and I already do this, connection of QHOs to the surrogate measures.

MR. KURITZKY: Okay. Well, thank you all for those comments.

MR. EVANS: It looks like Keith has his hand up. I'm sorry, Alan.

MR. KURITZKY: Oh, sure.

MR. COMPTON: Sure. I would just, I appreciate all the comments. And I have struggled for a long time to try to really understand why we get such different results in this study than we get in NUREG 1150. I think is very much related to these three things.

I have looked at the, you know, looked at the specific source terms in NUREG 1150. And I've been trying, and I'm still working on it, I haven't come to really a clear exposition but, you know, to try -- it's hard to compare them and do this percentage of the reduction comes from this factor.

But the modeling was very different, you know, the number of population sectors were different. The meteorology was different, the approach to modeling evacuation was different. And all that is simply saying is that it is an important thing. It may take some time to do that comparison and that evaluation properly. But I do think it's important to do.

CHAIR DIMITRIJEVIC: Well, and therefore you still, if this plant was going to submit under the, you know, the QHO requirement, it could make a case that don't really -- that can have a, you know, as Jon point out in some of his comments we exchanged,

we can have a little fun. This is for this specific plan, because all of those submittals will be based on the plant, you know, specific locations and cases.

All right. Okay. I mean, I think this is very interesting and really different for what was in the original NUREG. So definitely it deserves a lot of discussions.

MR. KURITZKY: I think it also, just to mention too, I don't think he -- I think he's still out of the country, but Sunil Weerakkody, he has been also looking into, you know, as I'll get to in the final slide in this part of the presentation, we'll talk about the difference in margin to the QHOs versus the surrogate risk metrics.

And he is fond of pointing out that the safety goal policy statement doesn't just talk about the quantitative health objectives. You know, it talks about qualitative objectives too.

And it talks specifically about the need, you know, for the nuclear industry to -- if any type of severe accident, so it says that the staff, I guess, the administrator, I don't remember the exact word, should be striving to have no severe accidents. So it's not just a question of meeting one QHO number or another QHO number. The striving should be to have

as low a CDF as possible, to have no core damage.

So, you know, it's one of these cases where I think the QHOs have kind of taken on -- I mean, they're certainly important. There's no question about it. But they're not the end all and be all and the single thing by which all things should be measured. So we just have to, you know, keep that in mind too.

But again, as Keith said, we will try to dig up some more information that we can describe how you get from, for instance, a lower frequency or a core damage frequency to the individual early fatality risk numbers and kind of show all the multipliers that bring the value down, to the extent that we can.

CHAIR DIMITRIJEVIC: Well, you know, I have this discussion with my colleagues in ACRS about the safety goals ongoing. And I have not been really, I have to say, I have not been very successful in explaining well my concerns. So to be honest with you, I was counting with your staff showing them you know, and also when comes to uncertainties associated with these quantifications. So I am sort of, like, very interested in this results.

MR. KURITZKY: Okay. Well, thank you very much. Hopefully this will provide some information

for you.

Going back now, if I could just wrap up this slide, so as I was mentioning, the drivers here are internal events and seismic provincial events, as we were discussing before, the interfacing system LOCAs, particularly those where you have the auxiliary building failed, so you don't have any retention really of the source, the radionuclides.

And then for seismic, it's primarily two types of steam generator tube rupture. I think we may have already mentioned them. It was the pressure induced steam generator tube ruptures that occur prior to core damage that generally come about because of an ATWS event. And then there are the -- and in this case the seismic leads to a higher frequency of ATWS, that you get for internal events.

And then there's also the post core damage, thermally induced steam generator tube ruptures, which also come about for a number of the sequences under the seismic initiator. So that's why the internal event and the seismic are the drivers here.

You certainly can't tell by the logarithmic curve, you know, plaque, but if you look at the numbers you see there's not very much

reduction. The FLEX case doesn't really reduce individual early fatality risk much. And that's, again, because these types of sequences that I just mentioned, they're not the ones that the FLEX guides used in the turbine driven aux feeder are targeted towards.

The one area where you do see that reduction is for the wind. If you look at the wind you see that it drops from roughly 90 minus 14 to 40, minus 14. And the reason the wind drops so much is because the early fatality risk for wind is almost entirely made up of station blackout sequences where the wind causes a loss of offsite power.

And then you have a combination of wind induced or random failures of emergency AC components leading to station blackout sequences that eventually propagate to these post core damage thermally induced steam generator tube ruptures.

And so those are things that the FLEX and turbine driven aux feed, extended turbine driven aux feed, can ameliorate. And so you see that reduction for the wind. Overall, you just see a 12 percent reduction for all hazards combined. But again, as we were just mentioning, there's a huge margin to the -- for the reasons that Keith specified a few minutes

ago.

Okay. If we've beaten the early fatality risk horse enough, we'll move on to latent cancer fatality risk, the other QHO. And here we see that the QHO is up at the top at 210 to the minus 6. You see that you don't really have the same type of margins you did for early fatality risk, but they're not insignificant.

The drivers here, again a little difficult to see because of the logarithmic scale, but the drivers here are internal events and internal fires. And they actually combine. You can't really tell from here, but I know the numbers. And they combine to about 80 percent of individual latent fatality risk.

And if you recall, that's essentially what they were in terms of a contribution to core damage frequency. And then that's for the base, the circa 2012 case. And the reason that you have that time is because both of these, the latent fatality risk from these two types of initiators are based on two primary release categories.

And those are the ones that are driven by station blackout sequences, so you get that same type of profile in there for the same type of impact from FLEX and the turbine driven aux feed as you do for

core damage. And so that's why they're very analogous in terms of the impact of FLEX.

If you look at the overall drop, you see it goes from 6.5(e) minus 8 to 4(e) minus 8, a drop of just under 40 percent, again, very similar to the total CDF reduction for all hazards for FLEX.

And again, Keith mentioned too that the reasons we still have a fairly good margin to the QHO here is some of the same reasons that we have a lot of margin from the early fatality risk. And that's the fact that we really don't have many sequences that provide dose -- the frequency of sequences that provide dose in the early phase are very low, okay, it's those bypass sequences that are very low frequencies.

And effective protective actions are taken that minimize how much exposure you receive at a later phase too, essentially to the habitability criterion. So it's not until people move back later that they get really that exposure.

They're not getting exposed right after the accident from the radioactive cloud, let's say. It's more exposure when they move back later in time. So that's why you still have a fairly good margin to latent cancer fatality QHO.

Okay. But for latent fatality risk, there's also a number of key assumptions that were made or boundary conditions that we wanted to look to see what the impact of those would be. So looking at this chart, the first two columns you see base case and the 2020 FLEX case that was -- the circa 2012 case has a margin of around 30 to the QHO. The 2020 FLEX case, that increases to around 50.

So we also wanted to look at the accident termination timing. Remember, that was the thing we were discussing back in Level 2 space where we run the accident analysis out to seven days, but we also looked at a couple of shorter timeframes.

So we wanted to see what was the impact on latent fatality risk if we terminated the severe accident analysis, therefore the releases, at 36 hours after SAMG entry. And so that's this third bar that you see. And in doing so, latent fatality risk, now you have a margin of about 150 to the QHO. So it definitely makes an impact.

It doesn't look as big on here, because it's a logarithmic scale, but it's a significant impact if you terminate those accidents at 36 hours after SAMG entry.

And then the other thing we really wanted

to look at was the low dose model. In the base case, what we used is the linear no-threshold, LNT model for low dose exposure. And that is something that is consistent with how the NRC, you know, that we generally use the LNT in regulatory applications involving dose modeling.

But there's also a lot of -- there isn't really consensus in, let's say, the health physics community or the technical community about how you should be treating low doses. And is there some threshold below which it's not meaningful to expedite a number of statistical cancers that may increase and statistical cancers that may occur?

And so we did an example where we found a threshold, we actually picked one from a 2010 Health Physics Society paper. And it had some thresholds for low dose to low dose modeling, and we applied those. And here you see a very substantial reduction in individual latent fatality risk.

And the reason, it's not surprising because, as I was just mentioning, the risk really comes, the latent cancer fatality risk really comes when people move back. And they spend the rest of their lives with a very minimal increase in background radiation.

So it doesn't take much of a threshold to eliminate those increases in statistical cancer deaths. So if you do have some kind of threshold, even if it's a fairly low one, you can have a very big impact on the calculations.

CHAIR DIMITRIJEVIC: Yes, I find this also very interesting, Alan. And I appreciate that you guys say, no, we got material from Scott and to show the Commissioners, they're not ready to consider this. You know, they're staying with a non-threshold models.

But you pointed in those volumes that those, you know, this alternative, those truncation have a scientific merit and should be considered. And this is very interesting since utility study is showing the, you know, two order of magnitude is reducing latent risk. So I appreciate that you considered that. That was very interesting from my point of view too.

I see that Keith has his hand raised.

MR. COMPTON: Yes, thank you. This is Keith Compton from the Office of Research. And I did want to emphasize one of the things. I think this particular sensitivity analysis can be very insightful.

It can be a bit challenging to interpret,

because it is mathematically a threshold model, but it's not a model that's -- it's not implying that there is a biological threshold. It's simply a model where we don't quantify the risk below the threshold, if that makes sense.

In other words it's not -- and that's kind of the challenge, is that what it's really telling you is how much of the risk is coming from, you know, doses that are significantly higher than background. How much of it is coming from moderate or high doses. So I just wanted to --

CHAIR DIMITRIJEVIC: Right, yes. And that's, as Alan pointed out, they're just really important, because this is where you are allowed to return. You know, background radiation is acceptable for people to return to the zone. And also, so it's basically low. The big influence comes from those long term long doses.

MR. COMPTON: That's exactly right.

CHAIR DIMITRIJEVIC: Yes. And also I notice that you also for this, the late fatalities, you considered this release category which is basically intact containment, you know, so basically just based on the tech specs leakage. It also has contribution to this latent fatality risk. You know,

obviously this is very interesting question to discuss.

Ron, you have your hand raised and --

MEMBER BALLINGER: Yes. It's likely to be way, way too early, but is there any data that's coming out with respect so Fukushima and Chernobyl where people have moved back into the area? Is there any data that suggests that there'll be a big reduction?

(Simultaneous speaking.)

MR. KURITZKY: Keith, I don't have any information on that.

MR. COMPTON: Is the question is there information from Chernobyl or Fukushima suggesting that there would be a big reduction in kind of cancer risk?

MEMBER BALLINGER: Right.

MR. COMPTON: So yes, so I guess the question would be, or a way to put that is, you know, tracking what the cancer fatality risk coefficients are for exposures that are in those, you know, low dose ranges, whatever works.

MEMBER BALLINGER: Yes. You would have an expectation based on an LMT model. And then you could compare it with what actually happens.

MR. COMPTON: Right. So I'm going to be careful, because I used the results of the health physicists and the radio biologists, but I'm not an expert on it. But I have not -- I know that, you know, there's a lot of factors that or there's a lot of cohorts that do contribute to generating the cancer risk coefficients.

I don't know off the top of my head if Fukushima or Chernobyl cohorts have been studied and their doses quantified, and their cancer risk tracked enough --

(Simultaneous speaking.)

MEMBER BALLINGER: The Fukushima ones might have been, but I don't know.

MR. COMPTON: Yes. So I don't know. But the way that it would feed in, again, to me, because I would want to be careful about staying within my subject matter expertise, that would feed through the, you know, we would look for -- is there consensus guidance on what the cancer risk coefficients would be, if that makes sense. So I would still follow, kind of, the guidance of federal guidance reports and, you know, those who are qualified to make those judgements.

MEMBER BALLINGER: You know the old

saying, if you have the data use it. If you don't have the data use color.

(Laughter.)

MR. COMPTON: We do have a lot of colors in our report, so we've at least done that.

CHAIR DIMITRIJEVIC: Okay, Dennis, you have a hand up.

MR. BLEY: I couldn't get my mic open. This is follow-up probably for Keith, maybe others. Some time ago I thought I'd seen a draft Br8 report from the National Academy. But there was never a Br8 published. Do you know anything about that? Is there something underway? I'm not sure of that.

And the second thing is who are the dose experts at NRC? I'm not sure I know.

MR. COMPTON: Well, again, I'll be cautious. I've not heard anything about a Br8. I do know that there was a Br7.

MR. BLEY: That's been over ten years ago.

MR. COMPTON: Yes. And the question is who much do things, you know, change. They changed a lot back in the early decades, and then they're continuing to get reexamined.

We're basing our models of some reports that were done by Keith Eckerman for the SOARCA

project, which are kind of circa 1990s, early 2000 vintage, that were used for Federal Guidance Report 13. So in answer to -- so hopefully that somewhat responds to that question.

But in terms of who are the people at the NRC, I will say that the person at the NRC that I typically talk to, to kind of make sure that we're staying reasonably abreast with the professional community, would be Terry Brock. I know that there is others that also have some expertise, but Terry is the one that I kind of rely on to keep me honest.

MR. BLEY: Okay. Thanks. You said Federal Guidance Report 13? Is that the name of it?

MR. COMPTON: Federal Guidance Report 13, it's an EPA publication. It's a federal guidance report published in 1999. Some extra detail came out a few years later. And, again, I need to be careful, to not misspeak. But I think it's, I'll just say broadly consistent with ICRP 60.

So it's, you know, it's produced by the same community, the same technical community that works on the ICRP reports. And I think that there's probably overlap. And, you know, that community is much more tied into the BR community.

So the sources, communities of expertise

would be, to me, would be ICRP, EPA's Federal Guidance Report, they produce WISC coefficients for radionuclides, and then also the BR community. So we try to, you know, keep an eye out to see if there's a big shift in those. But I'm not aware of any, you know, kind of, no pun intended, no seismic shifts --

(Laughter.)

MR. COMPTON: -- in how that, you know, in the numbers or how that would be done. But we're always trying to make sure we're not surprised by anything.

MR. BLEY: Okay, thank you. And I personally have never seen that EPA report, so I'll go look for that. Thank you.

MR. COMPTON: Yes. Federal Guidance Report 13, and then, yes, it's in the references. It should be in the references. I should just double check that.

MR. KURITZKY: Yes, I think in Volume 4(e). I think Volume 4(e) or certainly Volume 3(d), I think you'll see a reference to those, to federal guidance.

MR. COMPTON: Yes. And that would also give the reference to, I think, the Eckerman report that we, you know, so you can follow the reference

chain back from what we did to where it came from.

CHAIR DIMITRIJEVIC: Okay. Scott has a hand raised. Scott, please?

MR. MOORE: Yes. Thank you, Chairman. Just in answer, Dennis, to your question, there are radiation protection experts, senior level radiation protection experts, HPs, throughout the agency in the office of Research, in NMSS, and in NRR. And in some of those organizations, they're actually sub-units that specialize on Rad Pro. So it's throughout NRC.

MR. BLEY: Thank you.

CHAIR DIMITRIJEVIC: Thanks. Okay, next slide, Alan?

MR. KURITZKY: So this is the last slide for this presentation. It's just really a roll up of the results that we have discussed over the previous couple of hours. So this summarizes the Level 1, 2, and 3 results. We have core damage frequency, we have the LRF, the L-R-F, individual early fatality risk and individual latent cancer fatality risk for both the circa 2012 and 2020 FLEX cases.

And you can see from this chart that the core damage frequency, the large release frequency, and the individual latent cancer fatality risk all reduced by just about the same amount. And again,

that goes back to what I was saying before. Essentially the profile of accidents contributing to these are pretty much the same as mostly these station blackout sequences. You have the same general effect on, you know, the FLEX has generally the same effect on these, all three of these metrics.

For large early release frequency, it's a little bit lower. It's 29 percent. Again, that has to do with some of the fact that, as we mentioned before, you have contributions from some of the techs in sequences that FLEX is not really designed for, and even moreso for individual early fatality risk where you're really being driven here by those containment bypass, you know, the interfacing system LOCAs that don't -- for which the FLEX and the extended turbine driven aux feeder don't have much impact.

So I think that the bottom line is that all these results show that, when you consider this plant at this site, there was substantial margin to the QHOs. There was those green numbers you see down in the bottom two rows.

But you also have to recognize that, looking at the purple numbers up above, that there is a lot less margin to the surrogate risk metrics, you know, CDF and LRF. Now what you make of that and what

you want to do with that information is not part of this project. But it is certainly interesting information, as I think, Dr. Dimitrijevic, you had mentioned before. It's certainly interesting insight.

CHAIR DIMITRIJEVIC: Exactly, very interesting insight. This slide is actually telling us a lot. Well, okay. Great, I want to thank you so much. I just want to point something which was missing from our discussion.

You know, you said there were numerous meetings, and Hossein has summarized history of our interaction. But we only wrote the one letter after the first meeting when this project was approved. And there we said that -- one the things that ACRS said in this letter that this project needs to have an extensive characterization and quantification of uncertainties.

And we have not touched uncertainties in this presentation. So I hope we will change that when you present to us in the full committee in November. Because it is -- some very interesting things happened there which are really mind-boggling for me. And I'm very curious what's going on.

And it's one that you have concluded that too many -- including too many basic events,

uncertainties, masks events, masks parameters which breed uncertainties. Because all uncertainty results, as you presented with those volumes, are very narrow. There is no large uncertainty which is really strange, and especially I know that you address some modeling uncertainties through the sensitivity study, so alternative studies.

But these conclusions, the number of the basic event uncertainties which include the masks, the large uncertainties is extremely interesting to me. So I hope that we will have a chance to have a discussion on your uncertainty results and what does this actually mean.

And also I'm very curious, you know, how did you consider the modeling uncertainties. And are the sensitivity studies on the different assumptions enough to address that. So if you want to just tell me this conclusion on the too many uncertainties mask the large ones, ha, ha, I am very curious about it.

MR. KURITZKY: Okay, so fair enough. We're at a loss for time, but I don't want to go into a lot of detail. And honestly I probably -- even if I had more time there's only so much detail I can go into. This is not my area of expertise.

But in discussing this at the time I was

with Saleem, who knows much more about it than I do, but our pre-supposition, you know, we were trying to figure out why we were having such a tight parameter on uncertainty distributions.

And we had supposed that it might be due to, as you were mentioning, the fact that there are so many basic events, and when you're sampling from so many events, that it tends to mask, even if you were to pull something from the tail of one event, you have other things that have to fail in the cut-set and you can generally pull more from the -- statistically you'll pull more from the center of those distributions, and it kind dampens out, you know, the tails on the distribution.

If that's true, why is that not true for every PRA? That one I have a hard time answering. So is it --

CHAIR DIMITRIJEVIC: Because logically it doesn't make sense, because we could just do uncertainty distribution just based on those requirements, then don't consider the other ones which we don't think they contribute. And then we try to reach results of two.

You know, you don't have to have 1,000 basic events. If we are concerned, like your

parameter for ELAP, and to the agreement extended to the driven operation, this P obviously has a large uncertainty. It's probably uniformly distributed between zero and one.

That itself has a big impact on the result distribution. Do we gain by including the 2,000 other basic events. I mean, you know, there are so many questions to address that.

MR. KURITZKY: Right. And the whole idea of uncertainty analysis, and in this particular case for parametric uncertainty analysis, it is something that would be its own project. It's not something we're going to resolve here. We just notice that the results are very tight. We took a little look into it. We tried to figure out, you know, guess why we thought it was happening.

There are a couple of things that we thought about. The one about the basic events, we did do a, you know, Saleem had done a little bit of checking that by -- you know, the whole model for internal events, I think, the ratio from the 95th to fifth percentile was like around a factor of eight. And Saleem went and did it for just the weather related loop events. So we greatly reduced the size of the model.

And when he ran the uncertainty analysis for that, he got a ratio from the 95th to the fifth percentile almost a factor of six -- around a factor of 16, so twice as wide a distribution. And so that, in that one case, which could be an anomaly, but in that one case it made us, like, hey, the more you reduce the size of the model, now you're starting to get that bigger spread in the results.

But that's far from a scientific proof. We don't have anything written up on that, because, you know, it's just one example. And we have no idea whether that would hold in a more broad sense. So unfortunately we're not, as far as this project, going to have a good answer for that.

I did take a look at to see what type of spread you had 95th to fifth for some other periods. I looked at the NUREG 1150 models, and those, for the PWRs you were, you know, Surry, Sequoyah and Zion, you were looking at numbers that were in that ballpark somewhere between eight and 20. And we had, you know, our spread was eight.

For the BWRs, Peach Bottom and Grand Gulf, you had much bigger ones. You had, I think, 40 for Peach Bottom, and I think 70 for Grand Gulf. And they have much lower CDFs, but also they have much bigger

spreads. So I don't know exactly why ours is on the low end of that. But it's not unrealistic compared to what we've seen for the other PWRs and NUREG 1150.

I couldn't find that information in the NUREG 1560 in the IPEs but --

CHAIR DIMITRIJEVIC: I know that we haven't too much time now left for us, but I think that's one of the discussions I would like to have, because I think the uncertainty treatment in the PRA is one area which definitely can benefit from the many insights.

You know, I noticed that you didn't really consider the uncertainties in max input parameters, in that, you know, the uncertainties connected with, like, containment failure location, size, things like that. I'm very curious how they can be considered.

Sometimes we do, like, it will be nice to see the summary sensitivity cases. The sensitivity cases just show us something sensitive or not. But it doesn't really address uncertainty associated with that.

Because they somehow stand on the side of the -- and this is one of the issues which I have in many of our reviews, is what is the good uncertainty analyzed, you know, if you do the 20 sensitivity

cases, each for each other, but they don't show as uncertainty contributor, you know.

Because we see a lot of the passive systems which we don't really have enough data. But then we show very -- model uncertainly distribution. And there is a -- I think the uncertainty analysis can contribute a lot from this project and others maybe. So maybe that's too much burden for this project. But anyway, okay.

So Members, do we have any additional comments?

Should we call for public comments? The people on the public line, if you would like to make a comment, then unmute yourself, and introduce yourself. I see two people, Edwin and Victoria. Edwin Lyman, please?

MR. LYMAN: Yes, hi. This is Ed Lyman from the Union of Concerned Scientists. Can you hear me okay?

CHAIR DIMITRIJEVIC: Yes.

MR. LYMAN: All right, thanks. Yes, a couple of comments. The first, on the issue of the LRF versus the QHOs, and it seems to me, I didn't hear this brought up, maybe I wasn't listening, but the working definition of LRF, and I'm reading it here

from NRC document, is that it's core damage accidents that can lead to large unmitigated releases from containment before effective evacuation of the nearby population.

But it sounds like, from Dr. Compton's response, that they are considering essentially an effective evacuation and crediting it. So if that's true, it seems like there's an inconsistency between what they call LRF and what the standard definition is. So I'd appreciate some clarification on that.

MR. KURITZKY: So if I could, just on the one first, Dr. Lyman, so what Keith is talking about is in the --

CHAIR DIMITRIJEVIC: Alan, we don't really necessarily respond here --

MR. KURITZKY: Oh, okay.

CHAIR DIMITRIJEVIC: -- to outside comments. We will just accept them. But we don't really get in discussions.

MR. KURITZKY: Okay, sorry.

CHAIR DIMITRIJEVIC: Sorry about that, and sorry I didn't -- So Victoria?

MR. LYMAN: No, I'm sorry, ma'am. I have a couple more questions.

CHAIR DIMITRIJEVIC: Oh, sorry.

MR. LYMAN: Sorry. You know, on the use of thresholds and the general application of risk coefficients, it seems like this work is rapidly going in the direction of the dinosaurs.

Well, first of all, as it was pointed out, the Commission itself rejected a petition on revisiting the meaning of threshold model. And it would seem like why are any offices in the NRC still continuing to use that, even in sensitivity cases.

I'd also like to point out that a recent study, a very large study in the British Medical Journal, the INWORKS study, is now suggesting not only is there no apparent threshold but the use of a dose and dose rate effectiveness reduction coefficient may not be appropriate. It's not being seen in the data.

And that is pretty much uniformly tied in the MACCS models that are used to estimate these risks. So there may be something like a factor of two already that's being underestimated.

And finally, given that the agency is supposed to be taking a harder look at environmental justice issues, and I've raised this in other venues before, the use of these average risk coefficients which make assumptions about the ratio of mortality, cancer mortality to cancer incidents, are very much

dependent on the population that you're considering. And there are disadvantaged groups where the potential for a cancer mortality, given cancer incidents, could be much greater than is assumed on the average.

And by not taking these factors into account, the NRC is really becoming out of step with the greater emphasis on environmental justice in regulatory analysis for our federal government.

One other factor is cardiovascular risk which is not being considered, but again, there is emerging data. Another British Medical Journal study is indicating that the cardiovascular mortality risk from low level ionizing radiation may be on the same order of magnitude as the cancer mortality risk.

So there are several factors that aren't being accounted for. And given what's already been pointed out, the safety margin, you don't know what the safety margin is -- if you don't really know or quantify the uncertainties, these safety margins are meaningless unless you have better uncertainty quantification, also taking into account these other emerging factors.

Thank you, those are my comments.

CHAIR DIMITRIJEVIC: Thank you. Victoria?

MS. ANDERSON: Yes, Victoria Anderson, for

the Nuclear Energy Institute. I wanted to reflect some of the feedback we'd gotten from our members in the nuclear industry. One thing that we notice is that a lot of the insights from this project were achieved without exercising the Level 3 portion of the study. So in other words, they were produced during the Level 1 and Level 2 PRA portions of the work.

This really illustrates to us that there may not be any insight to be gained from devoting resources to doing a Level 3 PRA for an operating reactor at this time.

We also noted that the insights from the study can necessarily be applied on a generic basis, particularly the FLEX insights. And I appreciate that the committee picked up on that. But I think it is extremely important that, as they say, this is just one plant, one study. And we can't necessarily draw wide conclusions on it.

CHAIR DIMITRIJEVIC: Thank you. Thank you very much. Any more comments from the members?

Okay. Well, actually this was all of the technical prat. Alan, you still have a slide on our future interactions, right, if I'm right.

MR. KURITZKY: Yes. Yes, we do.

CHAIR DIMITRIJEVIC: Yes, let's --

MR. KURITZKY: So I guess first off, there's a number of meetings that we, both subcommittee and full committee meetings that we discussed previously about adding, with the whole project being now condensed into essentially one more year.

So it's going to get tough to do all these meetings. So we may have to do some further co-actions. You know, we don't have to come up with a decision now, but it might be that we want to take Volumes 5 -- just like they were going to do with the full committee, combine Volumes 5, 6, and 7 all together and then have Volume 8 and 1 together, just to reduce the number of meetings. But that we can interact and discuss later, though I'm open to any comments you have.

But the one thing I do want to get out before we run out of time is for next week, or not next week, but our November 1st full committee meeting. You know, I think it's going to go for two hours which is not that much different than this meeting. Well, it's definitely shorter than this.

So did you want -- what would you be looking for for that meeting? Do you want a presentation similar to the one that I had for this

meeting? Are there things that we should leave out of that meeting? I know you wanted --

CHAIR DIMITRIJEVIC: Yes.

MR. KURITZKY: -- a board discussion.

CHAIR DIMITRIJEVIC: I would sort of concentrate on the, I mean, obviously some of the summary slides, you know, the sky level summary slides. But I would like more to concentrate on how you're planning to satisfy your Goal Number 2, what is the important insights from those.

Okay. So one of things is uncertainty analysis which was one of our first comments which we didn't touch in this in this meeting.

Another thing is the important insights and maybe important sensitivity studies, more concentrating on the things which will make to your summary report from those volumes.

MR. KURITZKY: Okay. So we can definitely talk about some of that. Much of that information we will not have yet. Much of that information is not going to be generated until we start doing the summary of --

CHAIR DIMITRIJEVIC: Right. But you have it through those reports. You have an important insight, you have things which have not been done, you

have things which require future work. I notice these things all, you know, sprinkled, as I said, through the report.

MR. KURITZKY: Right.

CHAIR DIMITRIJEVIC: So if you can sort of, like, from those sections -- I am not interested in errors made in the things like that, but some things which, in your opinion, require the future work, which are important insights, and some of the important conclusions from dose alternative around what your sensitivity runs.

MR. KURITZKY: Okay.

CHAIR DIMITRIJEVIC: And then uncertainty, you know, even in this uncertainty, so not finish in one direction and removing.

So, you know, the thing is maybe this will require some effort. And I'm sorry about that, but definitely will be helpful for you also when planning your summary report.

MR. KURITZKY: No, it definitely will.

CHAIR DIMITRIJEVIC: Yes.

MR. KURITZKY: The timeframe --

CHAIR DIMITRIJEVIC: So something that would not be, you know, worked on in vain, you know, something which would be useful for you too in that.

And also when you are writing the shutdown spent fuel pool you will see we can see what type of insights and conclusions are coming from here. And that will be, you know, maybe we can discuss that next week also. And I may send some email to --

MR. KURITZKY: Hossein?

CHAIR DIMITRIJEVIC: Hossein. So I already sent one, but it was too late for this. I only sent this after I saw the slides, because in this moment discussing that difference between, you know, base model and FLEX, you know, we saw some summary results. But now I'm more interested in how are we going to meet the Goal Number 2, you know, to expect new insights and enhance the general knowledge of a PRA. Okay.

MR. KURITZKY: Okay. So thank you for that. That'll help us prepare for next weeks meeting. Again, with the limited time involved, we will --

CHAIR DIMITRIJEVIC: Right.

MR. KURITZKY: -- start to dig up some that information.

CHAIR DIMITRIJEVIC: I'm sorry about that. And if you don't have a time to do this too much, that's all right. I mean, we will plan, you know, to write the letter saying anything further, how much you

can do good, so will be interesting to have a discussion about it.

MR. KURITZKY: Okay. Yes, we'll definitely try, we'll have that in. And as far as the existing presentation, do you want me to still include the project status information for the full committee, you know, at the beginning at the presentation?

CHAIR DIMITRIJEVIC: No, no, no.

MR. KURITZKY: Okay, don't need that.

CHAIR DIMITRIJEVIC: We have distributed it.

MR. KURITZKY: Okay. And then for the other stuff just kind of, just cut it down to just have the high level insights, right, that was -- for all the --

CHAIR DIMITRIJEVIC: Yes, high level insights, yes.

MR. KURITZKY: Okay. And that's all I had. If there's anything else that the subcommittee wants to mention --

MEMBER REMPE: Vesna, just to make it clear, since we are writing the letter on Volumes 3 and 4, he should include these higher level -- I support what you're saying big time about the higher level insights, but he should think about that for

Volume 3 and 4, right?

CHAIR DIMITRIJEVIC: Well, I just connect it to this work which is the, you know, Level 1, Level 2 for internal events and hazards.

MEMBER REMPE: Yes.

CHAIR DIMITRIJEVIC: Just for the Level 3 and Level 4, I mean the Volume 3 and Volume 4.

MR. KURITZKY: Yes. So, Dr. Rempe, yes, the answer is yes to that question, yes.

MEMBER REMPE: That's what I heard Vesna say, but I just wanted to make sure we're all on the same page. Thank you, Alan.

CHAIR DIMITRIJEVIC: I just thought that would also help thinking for the next volumes. You know, when you think of documentation and organization you will see how easy it will be to extract this now for this one. And you say all right, maybe we can do the better job in Volume 5.

All right. Well, thank you so much. For me that was very enjoyable. And I really appreciate your incredible work in this presentation. So thank you very much.

MR. KURITZKY: Our pleasure, and thank you very much. Thanks to the subcommittee for all your feedback.

CHAIR DIMITRIJEVIC: Okay. All right, guys. So enjoy your afternoon, all right.

MR. KURITZKY: Take care.

MEMBER REMPE: So members, could I ask you to stay on the line for just a minute for a discussion about this afternoon. But I'll be careful to make sure that someone else is listening that we don't say anything we shouldn't. But it shouldn't take more than a couple minutes. I just want to make sure we're all on the same page of what we're going to do this afternoon, okay.

CHAIR DIMITRIJEVIC: All right.

MEMBER REMPE: So as you probably know, we have two retreat items we're going to be discussing. And I don't want to say what they are. But there's one that Alicia sent out that started actually at noon.

And I guess I'd like to make sure members are okay. Do you want to take a break for an hour and come back at 1:00 and we'll start with the new member, the solicitation discussion? Or do you want to --

MR. MOORE: Joy, can I interject for a second, please?

MEMBER REMPE: Yes.

MR. MOORE: There are people online that

are not members, or NRC, or ACRS employees. So if you're still online, please log off.

MEMBER REMPE: And the court reporter, of course, we're done for the day for you.

MR. MOORE: Thank you, court reporter.

CHAIR DIMITRIJEVIC: Thank you.

(Whereupon, the above-entitled matter went off the record at 12:05 p.m.)

Level 3 PRA Project Overview for Internal Fires, Seismic Events, and High Winds

Advisory Committee on Reactor Safeguards
Reliability and PRA Subcommittee

October 19, 2023

Alan Kuritzky
Division of Risk Analysis
Office of Nuclear Regulatory Research
(301-415-1552, Alan.Kuritzky@nrc.gov)

Outline

- Level 3 PRA project (L3PRA project) status
- L3PRA project public reports
- L3PRA project overview report for reactor, at-power, internal fires, seismic events, and high winds
- Future interactions

Acknowledgements

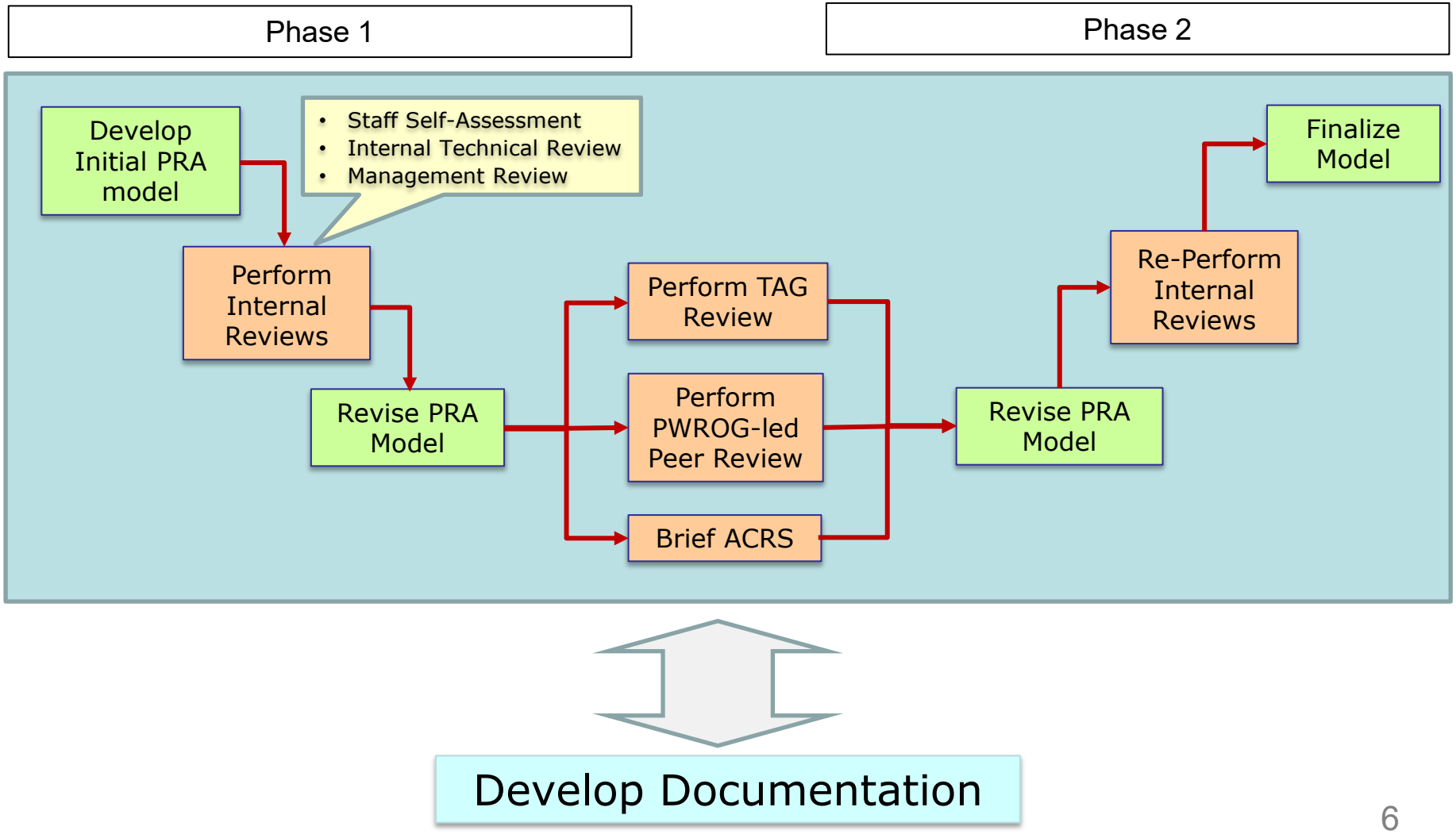
- NSIR, NRR, NMSS, Regions, TTC
- National Laboratories (INL, SNL, PNNL, BNL)
- Commercial Contractors (ERI, ARA, IESS)
- PWR Owners Group
- Westinghouse
- EPRI
- ACRS

Caveat

- The L3PRA project adheres to the state-of-practice for most technical aspects; however, due to limitations in time, resources, or plant information, some aspects of the study were subjected to simplifications or were not fully addressed.
- As such, inclusion of approaches in the L3PRA project documentation does not necessarily imply endorsement of these approaches for regulatory purposes.

Project Status Overview

Generic Process for PRA Model Development



Level 3 PRA Project Status

	Level 1	Level 2	Level 3	2020-FLEX*
Reactor, at-power, internal events	Complete	Complete	Complete	Complete
Reactor, at-power, internal floods	Complete			
Reactor, at-power, internal fires	Complete	Complete	Complete	Complete
Reactor, at-power, seismic events	Complete	Complete	Complete	Complete
Reactor, at-power, high winds	Complete	Complete	Complete	Complete
Reactor, at-power, other hazards	Complete	N/A		N/A
Reactor, LPSD, internal events	Complete	Phase 2 L3PRA management review	Phase 2 Revised model/documentation	Phase 1 Initial model/documentation
Spent fuel pool (all hazards)	Phase 2 L3PRA management review		Phase 1 Initial model/documentation	N/A
Dry cask storage (all hazards)	Phase 2 L3PRA management review			N/A
Integrated site risk (all hazards)	Phase 1 Initial model/documentation			N/A

*Not part of original project scope.

Level 3 PRA Project Public Reports

<table>
<tr><td rowspan="2">Summary (Vol. 1)</td><td rowspan="2">Back-ground (Vol. 2)</td><td colspan="5">Reactor, At-Power, Internal Events and Internal Floods (Volume 3)</td></tr>
<tr><td>Overview-IE/IF (3)</td><td>L1-IE (3a)</td><td>L1-IF (3b)</td><td>L2-IE/IF (3c)</td><td>L3-IE/IF (3d)</td></tr>
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<table>
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Level 3 PRA Project Public Reports

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Overview-F/S/W (4)	L1-FIRE (4a)	L1-SEIS (4b)	L1-HW/OH (4c)	L2-F/S/W (4d)	L3-F/S/W (4e)

Reactor, LPSD, Internal Events (Volume 5)			
Overview-LPSD (5)	L1-IE (5a)	L2-IE (5b)	L3-IE (5c)

Spent Fuel Pool (Volume 6)			Dry Cask Storage (Volume 7)	Integrated Site Risk (Volume 8)
Overview-SFP (6)	L1/L2 (6a)	L3 (6b)	L1-L3 (7)	L1-L3 (8)

Level 3 PRA Project Public Reports

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Reactor, LPSD, Internal Events (Volume 5)			
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Preliminary Schedule for Releasing Draft L3PRA Reports for Public Comment

- Reactor, at-power, internal events and internal floods **(Vol. 2 and Vols. 3x, 3a-3d) (4/22/2022) – comments resolved and currently with ADM for final publication**
- Reactor, at-power, internal fires, seismic events, and high winds **(Vols. 4x, 4a-4e) (8/18/2023)**
- Reactor, low-power and shutdown, internal events **(Vols. 5x, 5a-5c)** **(Q2-2024)**
- Spent fuel pool, all hazards **(Vols. 6x, 6a-b)** **(Q3-2024)**
- Dry cask storage, all hazards **(Vol. 7)** **(Q1-2024)**
- Integrated site risk **(Vol. 8)** **(Q4-2024)**
- Summary report **(Vol. 1)** **(Q4-2024)**

Overview of Reactor, At-Power PRA Results for Internal Fires, Seismic Events, and High Winds

2020-FLEX Case

- Base case model (Circa-2012 case) reflects plant as designed and operated in 2012
- 2020-FLEX case includes:
  - New RCP seals (shutdown seals)
  - FLEX strategies and equipment for responding to an extended loss of AC power (ELAP)
  - Credit for continued turbine-driven auxiliary feedwater (TDAFW) pump operation given a complete loss of all installed AC and DC power

FLEX Strategies

- FLEX strategies for coping with the plant conditions that result from an ELAP event involve a three-phase approach:
  - Phase 1 - Initially cope by relying on installed plant equipment and on-site resources
  - Phase 2 - Transition from installed plant equipment to on-site FLEX equipment
  - Phase 3 - Obtain additional capability and redundancy from off-site equipment and resources until power, water, and coolant injection systems are restored or commissioned
- 2020-FLEX case only considers Phases 1 and 2

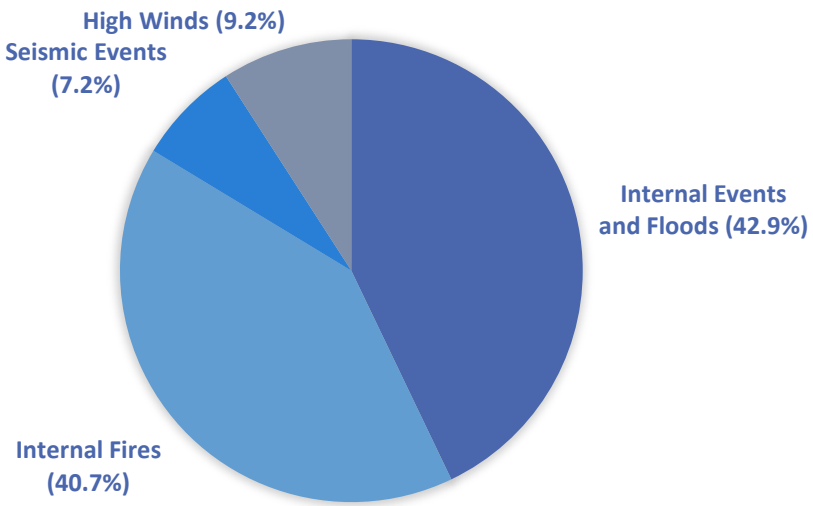
2020-FLEX Case Results Level 1 PRA (1 of 4)

CDF by Hazard Category

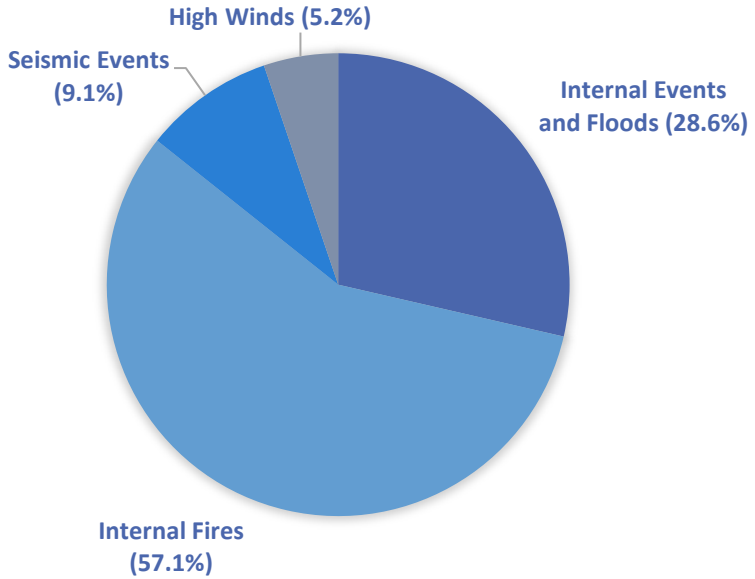
Hazard Category	Circa-2012 CDF (/rcy)	2020-FLEX CDF (/rcy)	CDF Reduction
Internal events and floods	6.47E-05	2.67E-05	59%
Internal fires	6.14E-05	5.34E-05	13%
Seismic events	1.08E-05	8.49E-06	21%
High winds	1.38E-05	4.85E-06	65%
Total	**1.51E-04**	**9.34E-05**	**38%**

2020-FLEX Case Results
Level 1 PRA (2 of 4)

CDF % CIRCA-2012 CASE (1.51E-04/RCY)



CDF% 2020-FLEX CASE (9.34E-05/RCY)

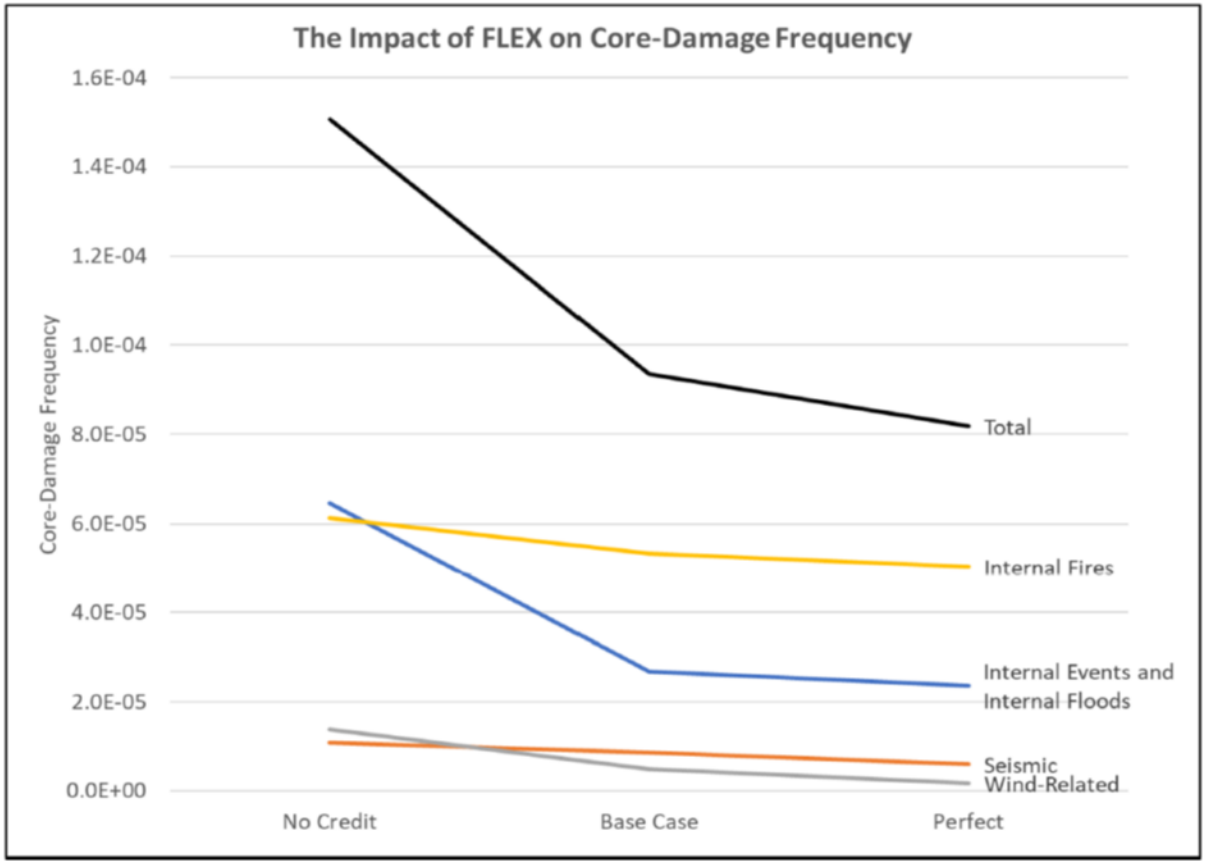


2020-FLEX Case Results Level 1 PRA (3 of 4)

FLEX Failure Probabilities by Hazard Category

	Basic Event Name	Failure Probability			
		Internal Events	Internal Fires	Seismic Events	High Wind Events
F	1-FLEX-FAILS	0.30	0.7	0.7	0.5
S	1-RCS-SDS-FC	0.01	0.01	0.01	0.01
T	1-AFW-SBO-NO-FLEX-FA	0.30	0.715	0.715	0.5
	Combined FLEX failure probability (p = F*T)	0.09	0.5	0.5	0.25

2020-FLEX Case Results Level 1 PRA (4 of 4)



Level 2 PRA Results (All Hazards Combined) (1 of 2)

	Circa-2012 Case	2020-FLEX Case	Risk Metric Reduction
LERF	1.9E-06/rcy	1.3E-06/rcy	29%
LRF	1.1E-04/rcy	6.7E-05/rcy	38%
CCFP	0.680	0.764	N/A

Level 2 PRA Results (All Hazards Combined) (2 of 2)

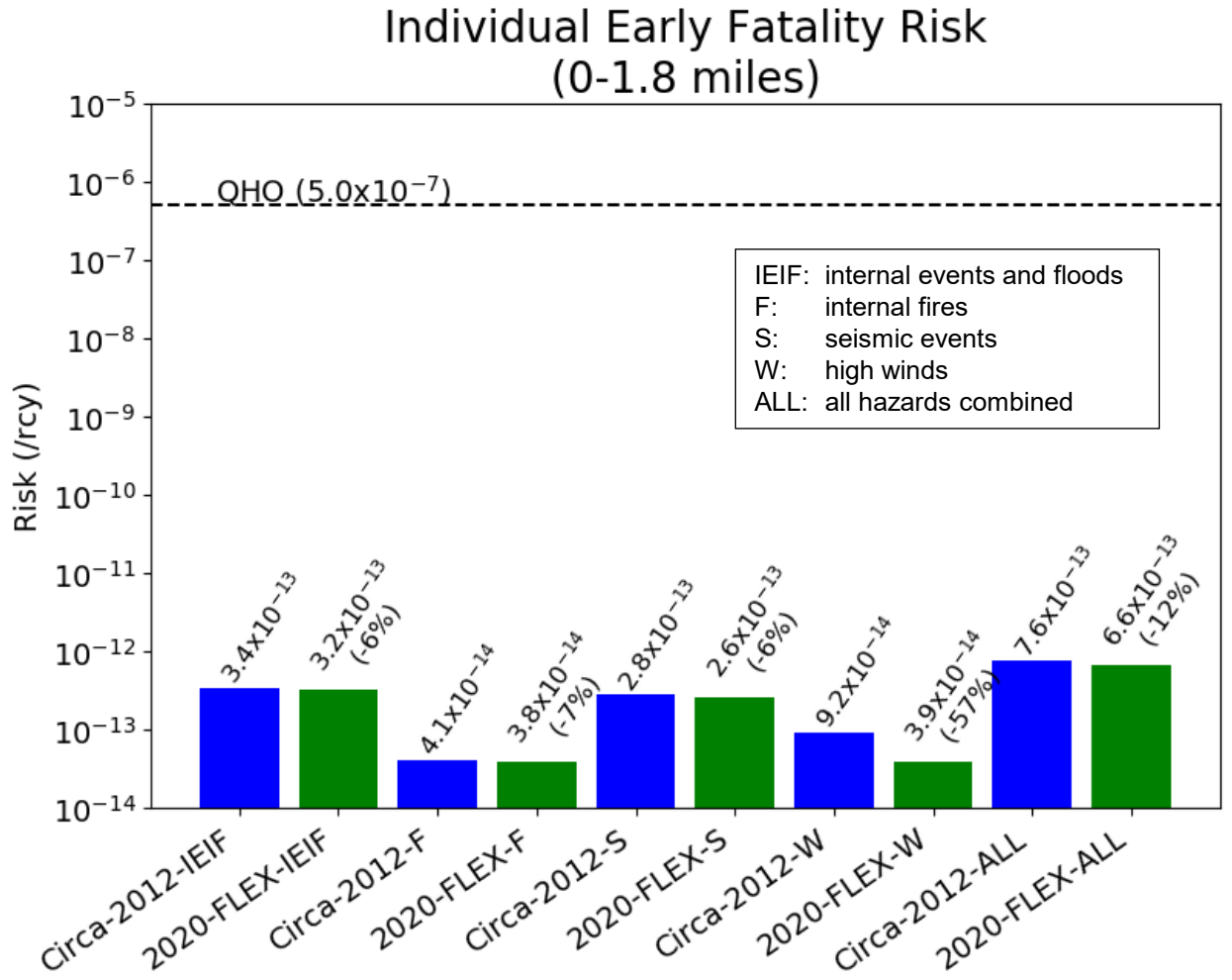
Circa-2012 Case

Level 2 PRA Surrogate Risk Metric	Time at which airborne radiological releases are terminated		
	7 days after event initiation	SAMG entry + 60 hours	SAMG entry + 36 hours
LERF	1.9E-06/rcy	1.9E-06/rcy	1.9E-06/rcy
LRF	**1.1E-04/rcy**	**3.5E-05/rcy**	3.5E-05/rcy
CCFP	0.680	0.620	**0.235**

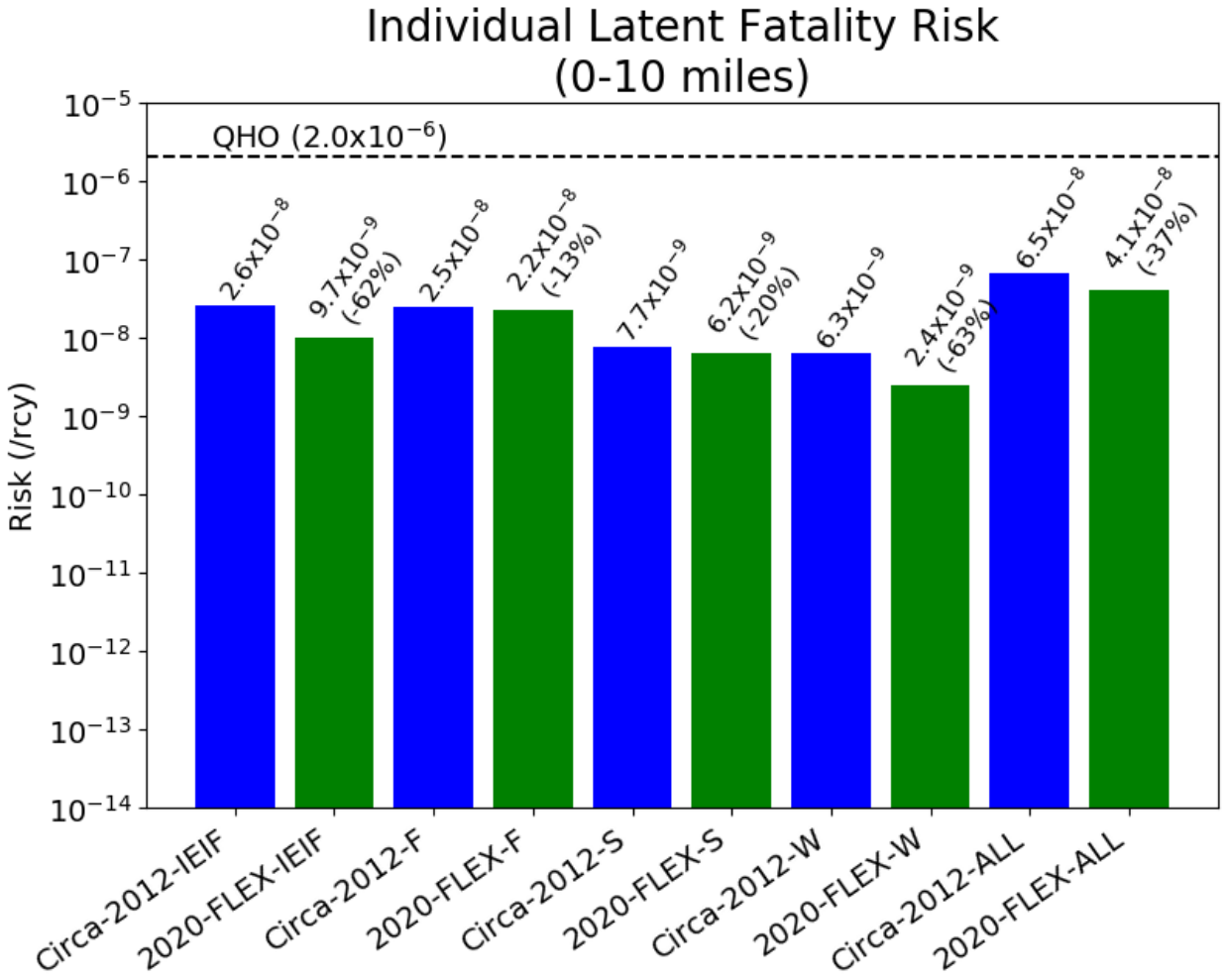
2020-FLEX Case

Level 2 PRA Surrogate Risk Metric	Time at which airborne radiological releases are terminated		
	7 days after event initiation	SAMG entry + 60 hours	SAMG entry + 36 hours
LERF	1.3E-06/rcy	1.3E-06/rcy	1.3E-06/rcy
LRF	**6.7E-05/rcy**	**2.6E-05/rcy**	2.6E-05/rcy
CCFP	0.764	0.679	**0.309**

Level 3 PRA Results (1 of 3)

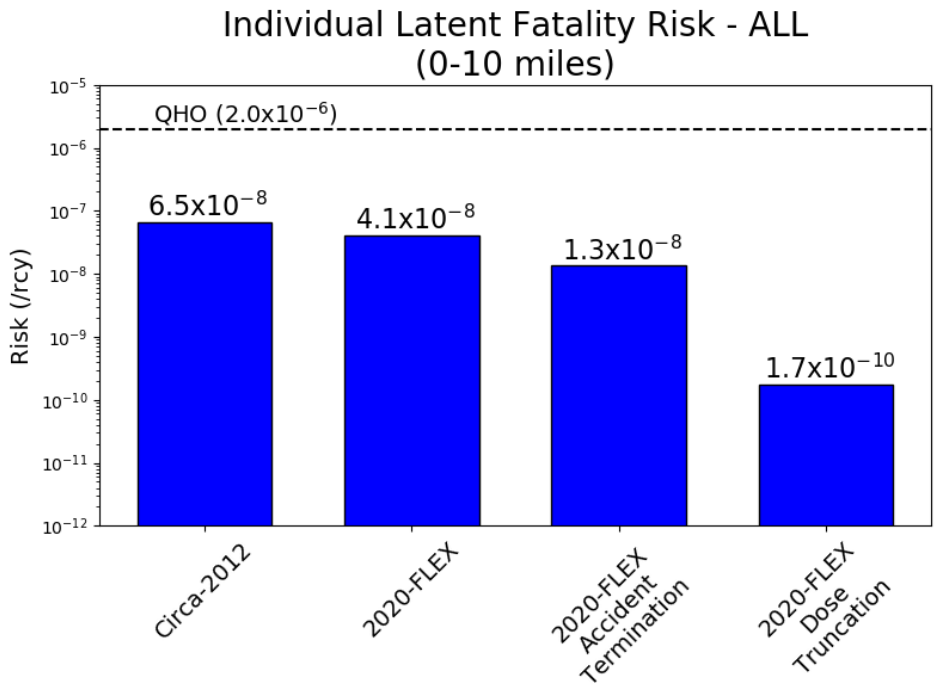


Level 3 PRA Results (2 of 3)



IEIF:	internal events and floods
F:	internal fires
S:	seismic events
W:	high winds
ALL:	all hazards combined

Level 3 PRA Results (3 of 3)



- Accident truncation – airborne radiological release termination time reduced from 7 days after accident initiation to 36 hours after SAMG entry
- Dose truncation – changed from linear no-threshold (LNT) to model based on Health Physics Society position paper, “Radiation Risk in Perspective: Position Statement of the Health Physics Society” (PS010-2), 2010

Summary of Results (All Hazards Combined)

Risk Metric (per reactor-year)	QHO or Subsidiary Risk Metric	Circa-2012 Case	2020-FLEX Case	Risk Metric Reduction
Core damage frequency	1E-04	1.5E-04	9.3E-05	38%
Large early release frequency	1E-05	1.9E-06	1.3E-06	29%
Large release frequency	N/A	1.1E-04	6.7E-05	38%
Individual early fatality risk	5E-7	7.5E-13	6.6E-13	12%
Individual latent cancer fatality risk	2E-6	6.5E-08	4.0E-08	37%

Overall, the results show that the combination of this plant design and site location has substantial margin to the QHOs associated with the NRC's safety goal policy (51 FR 28044), when considering all hazards combined, though the margins are noticeably less for the surrogate risk metrics of CDF and LERF that were endorsed by the Commission when it approved the issuance of Regulatory Guide 1.174 (SRM-SECY-98-015).

Future Interactions

Future Interactions

- Subcommittee meetings
  - Reactor, LPSD, internal events **(Vol 5)** – **TBD**
  - Spent fuel pool **(Vol. 6)** and dry cask storage **(Vol. 7)** – **TBD**
  - Integrated site risk **(Vol. 8**) and summary report **(Vol. 1)** – **TBD**
- Full Committee meetings
  - Reactor, at-power, all hazards **(Vols. 3 and 4)** – **Nov. 1, 2023**
  - Reactor, LPSD, internal events **(Vol. 5), s**pent fuel pool **(Vol. 6),** and dry cask storage **(Vol. 7)** – **TBD**
  - Integrated site risk **(Vol. 8)** and summary report **(Vol. 1)** – **TBD**

Acronyms and Definitions (1 of 2)

AC	alternating current
ACRS	Advisory Committee on Reactor Safeguards
ARA	Applied Research Associates
BNL	Brookhaven National Laboratory
CCFP	conditional containment failure probability
CDF	core damage frequency
DC	direct current
ELAP	extended loss of AC power
EPRI	Electric Power Research Institute
ERI	Energy Research, Inc.
IESS	Innovative Engineering & Safety Solutions, LLC
INL	Idaho National Laboratory
L3PRA	Level 3 PRA (project)
LERF	large early release frequency
LNT	linear no-threshold
LPSD	low power and shutdown
LRF	large release frequency
PNNL	Pacific Northwest National Laboratories
PRA	probabilistic risk assessment

Acronyms and Definitions (2 of 2)

PWR	pressurized-water reactor
PWROG	PWR Owners Group
QHO	quantitative health objective
RCP	reactor coolant pump
RCY	reactor-critical-year
SAMG	severe accident management guideline
SNL	Sandia National Laboratories
TAG	Technical Advisory Group
TDAFW	turbine-driven auxiliary feedwater