Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards Reliability and PRA Subcommittee

Docket Number: (n/a)

Location: teleconference

Date: Wednesday, June 22, 2022

Work Order No.: NRC-2018 Pages 1-176

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1716 14th Street, N.W.
Washington, D.C. 20009
(202) 234-4433

1
2
3
4 DISCLAIMER
5
6
7 UNITED STATES NUCLEAR REGULATORY COMMISSION'S
8 ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
9
10
11 The contents of this transcript of the
12 proceeding of the United States Nuclear Regulatory
13 Commission Advisory Committee on Reactor Safeguards,
14 as reported herein, is a record of the discussions
15 recorded at the meeting.
16
17 This transcript has not been reviewed,
18 corrected, and edited, and it may contain
19 inaccuracies.
20
21
22
23

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

RELIABILITY & PRA SUBCOMMITTEE

+ + + + +

WEDNESDAY

JUNE 22, 2022

+ + + + +

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

COMMITTEE MEMBERS:

VESNA B. DIMITRIJEVIC, Subcommittee Chairman

JOY L. REMPE, Chairman

WALTER L. KIRCHNER, Vice Chairman

DAVID A. PETTI, Member-at-Large

RONALD G. BALLINGER, Member

VICKI M. BIER, Member

GREGORY H. HALNON, Member

JOSE A. MARCH-LEUBA, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANTS:

DENNIS C. BLEY

STEPHEN P. SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

HOSSEIN NOURBAKHSH

ALSO PRESENT:

VICTORIA ANDERSON, NEI

TREY HATHAWAY

ALAN KURITZKY, RES

EDWIN LYMAN, Union of Concerned Scientists

JOHN NAKOSKI, RES

CONTENTS

P R O C E E D I N G S

(8:30 a.m.)

CHAIRMAN DIMITRIJEVIC: Okay. It's 8:30 and this meeting will now come to order.

This is Reliability and PRA Subcommittee meeting in preparation of the Advisory Committee on Reactor Safeguards review of the NRC Level 3 PRA project.

I'm Vesna Dimitrijevic, Chairman of today's subcommittee meeting.

Members in attendance today are Ron Ballinger, Greg Halnon, Jose March-Leuba, Dave Petti, Vicki Bier, Joy Rempe, Matt Sunseri. And we have our two consultants Dennis Bley and Steve Schultz present, so.

Did I miss somebody? If I missed, please let me know. But maybe this is all of us for today.

Okay. So, we have off, Member Brown excused himself. He may join remotely later as he has a doctor appointment this morning.

Okay. We hold this topic meeting to get information to support our review of the NRC Level 3 PRA Project. The ACRS section of USNRC public website provides our charter, bylaws, agendas, letter reports, and full transcripts of all, of all full and

subcommittee meetings, including slides which will be presented here.

The meeting notice and agenda for this meeting were also posted there.

We have received the request from Victoria Anderson from NEI to make another statement during the public comments portion of this meeting.

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

A transcript of this meeting is being kept and will be made available.

Due to the COVID pandemic, today's meeting will be held both in person and remote Microsoft Teams capabilities.

There is also a bridge line number allowing participants over the phone.

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

Okay. So, we will now proceed with the meeting. And I will call upon John Nakoski, PRA

Branch Chief of the NRC Office of Nuclear Regulatory Research, to begin today's presentation.

Good morning, John.

MR. NAKOSKI: Good morning.

CHAIRMAN DIMITRIJEVIC: Turn it over to you.

MR. NAKOSKI: Thank you.

As was mentioned, I'm John Nakoski. I'm the Chief of the Probabilistic Risk Assessment Branch in the Office of Research at the Nuclear Regulatory Commission.

The research staff and others that have contributed to the Level 3 PRA Project appreciate this opportunity to brief the ACRS Subcommittee on the current Level 3 PRA Project. We'll provide projects --

Alan, can you bring the slides up, please, and share your screen.

MR. KURITZKY: Yes.

MR. NAKOSKI: Just give us a second.

CHAIRMAN DIMITRIJEVIC: Sure.

MR. NAKOSKI: And while he's bringing that up, today you will be hearing from myself to provide some introductory remarks. But the bulk of the presentation is going to be given by Alan Kuritzky in

the Division of Risk Analysis, Office of Nuclear Regulatory Research.

Next slide, Alan.

So, today's presentation, an outline of the presentation, we'll give you a project status, kind of the status of the Level 3 Project public reports, an overview of the project objectives. And then we'll get into the meat of the presentation to provide presentation on the project overview report for the reactor at-power internal events and floods.

Those we typically call Volume 3 reports. Also, we'll talk about future interactions.

So, if we can go to the next slide.

So, I'd like to acknowledge the support that we have received from other offices. This has been a long-term project and has involved technical support from staff in NSIR, NRR, NMSS, the regions, the NRC's Technical Training Center.

We've also had support from several national laboratories, Idaho National Labs, Sandia National Labs, Pacific Northwest National Labs, and Brookhaven National Labs.

We've also had support from several contractors, ERI, ARA, and IESS.

And we had substantial support early on in

the project from the PWR Owners Group that helped us by conducting some peer reviews following the JCNRM PRA standards for Level 1 PRA. I think it was limited to Level 1. Alan can clarify that for me later.

MR. KURITZKY: Yeah. On Level 2 and 3. Sorry, John.

MR. NAKOSKI: Level 1, 2, and 3, okay.

And then Westinghouse supported us in participating in the Technical Advisory Group, as well as a representative from EPRI.

And then, of course, we've had substantial interactions with the ACRS Subcommittee on the technical background for a lot of the internal reports. All of the internal reports were shared with ACRS during closed meetings to discuss the technical content that you'll be briefed on in the overview report today.

Next slide.

There are some caveats that we need to be aware of. We did attempt to adhere to state-of-practice for most of the technical aspects of the report. However, this was a long-term project that required a matrix staffing. And so, there was some limitations on time, resources, or plant information.

So, some aspects of the study were subject

to simplification or were not fully addressed.

So, as such, inclusion of the approaches in the Level 3 PRA Project documentation doesn't necessarily imply endorsement of these messages -- of these approaches for regulatory purposes.

The other thing is --

CHAIRMAN DIMITRIJEVIC: John

MR. NAKOSKI: Yes, go ahead, Vesna. I'm sorry.

CHAIRMAN DIMITRIJEVIC: Yeah. Can you tell us a little more about these limitations on this because you have so many different, you know, subject and area cover. Are they connected specifically or this is general statement that everything?

MR. NAKOSKI: At this point it's a general statement. There are some specifics that we can get into as we go through the presentation.

This was, as you know, this was a very complex project. And the volunteer licensee provided us a tremendous amount of information. But it's not like we were at the plant and could go walk something down if we needed to.

There was also some information that we had to accept from the volunteer licensee to use without a whole lot of independent verification. So,

there were some limitations on what we were able to do.

And the other thing to keep in mind is we froze the design that we were looking at to circa 2012. So, this doesn't represent, the results of this project don't represent any actively operating plant. It's more of a, of a point in time back in 2012.

The overview report has been updated to reflect some more of the current operational practices, in part to demonstrate the capability of the models to look at changing operational practices, and also to bring it into more of a up-to-date operational framework in our current environment.

The other thing is I greatly appreciate --

CONSULTANT BLEY: John.

MR. NAKOSKI: Yes, go ahead.

CONSULTANT BLEY: Dennis Bley.

MR. NAKOSKI: Yes, sir.

CONSULTANT BLEY: I'm assuming that the key parts that you were just talking about are your update to include FLEX in its applications. Is that it? Or is there some other areas?

MR. NAKOSKI: There are other areas that we'll touch on. We also incorporated the advanced reactor cooler pump seals, blind heating or feed and

bleed with aux feedwater. And there were some other sensitivity cases.

And Alan will go into that a little bit as we go through the presentation.

CONSULTANT BLEY: Okay. My memory is a little off. I would have thought the advanced seals were out before you did the work. But maybe not.

MR. NAKOSKI: They, they weren't. So, we updated it to include that. So, and we'll share the results of that with you during this, this meeting.

I also appreciate the openness of ACRS to focus primarily on the overview report, given the extensive review that was done of the internal reports previously, and the time frames that both ACRS and the staff have to bring this to closure, this project to closure.

So, with that, if there are no further questions for me, I'd like to turn it over to Alan to continue the presentation.

MR. KURITZKY: Okay. Thank you, John, very much for that introduction.

I'm Alan Kuritzky. I'm the Program Manager for the Level 3 PRA Project. And I also want to echo John's appreciation for the ACRS' time. I know that there's a lot of things on your schedule.

And it's sometimes hard to squeeze everything in. So, we appreciate the time that you can afford us.

I also want to mention that while I'm the primary presenter today, as John mentioned, I'm not the one who did the impressive technical work for this project. I was very fortunate to be supported by an impressive array of subject matter experts, both staff and contractors.

Unfortunately, because the time line of this project has been so long, several of the staff have retired or moved on. Some of the contractors are no longer under contract. We are, we are fortunate to have several of the team members available today. But even they, because of the time line, some of the work that they had performed for the project was completed several years back and so they may not be -- have all the minutiae available at their fingertips right now.

Again, that's why John mentioned we're really focusing on the overview report today, which is what we requested public comment on, and focusing on messaging, the kind of messaging that will be out in the public domain, not so much on the technical details of the models.

But we will attempt to answer any questions that we can from the committee members.

With that, oh, I also wanted to mention -- sorry -- that the, as I previously mentioned to the subcommittee offline, because of the change in schedule -- this meeting was originally scheduled for July, got moved back to June -- so, therefore, our Level 3 lead, the lead for our consequential analysis, because of a personal commitment is not able to join us today. So, unfortunately, we will not have him available.

But any questions that you have along or dealing with the consequence analysis part of the project, either I or someone else here can attempt to answer. If not, we'll take the feedback back and have, have the lead address it as part of the updates to the reports.

Okay. So, the first slide I want to bring up here is just something that I can't remember whether this is something that the committee, subcommittee has seen before.

Prior to summer of '19, we were briefing the subcommittee around two times a year. And then we had a bit of a hiatus because we wanted to get stuff out into the public domain before a meeting with the subcommittee in open forum. So, this, this side, there's been a lot of presentations in recent years.

I don't know how far back it goes.

But I just really wanted to, before going into the status part that I have, I wanted to kind of lay out the parts of the, of the project, how each model gets developed and what the different phases are.

So, in Phase 1 we performed the initial PRA model. We have several internal reviews that it goes through. And then we send it out for, it goes to what we call the external to the project team review. And there are several aspects to that.

For some of the initial models, as John mentioned earlier on, we were fortunate to have the PWR Owners Group sponsor and lead some peer reviews in accordance with the PRA standards, just like they would do for utility PRAs. And so, that was very beneficial.

We also have our Technical Advisory Group, and that is a team of senior-level advisors across the agency in PRA and related disciplines. It also includes, as John mentioned earlier, one member from Westinghouse, and one member from EPRI. So, they provide input on all of the models and the reports.

And, of course, we had many interactions with the ACRS Subcommittee. And though we have not

received the formal feedback in terms of letters, we've received a lot of oral feedback during those subcommittee meetings and some individual members comments.

Once we get all that feedback we move on to Phase 2 where we incorporate that and the other changes that we intend to make to the models.

Once they're revised and the reports are updated, we go through the internal reviews again and then sign the reports out as final.

And so, Phase 1 is before the external-to-project reviews, which is the bulk of the work. And then Phase 2 is afterwards.

So, just keep that in mind as we go to the next slide, which is the project status.

Let me also for just to remind people, committee members who've seen this before, also to introduce any new committee members who haven't been around the whole time, the scope of the project is to consider not just a single reactor. It looks at both reactors on site.

Well, first of all, the reference plant for this is a 2-unit Westinghouse pressurized water reactor, four loop reactor. And it has a large dry containment.

As John mentioned, the study was based on no plant that exists and is operated today. Though we got a lot of information from the reference plant.

We also have the scope covers, as I was saying, not just a single reactor but both reactors on site, both spent fuel pools, and dry cask storage.

We also look at both at-power operation as well as low power shutdown. And we look at all internal and external hazards.

So, if you, if you look at this chart, the left column, the leftmost column, you will see the various areas of, you know, the PRA model. So, that's the radiological source, the power state and the spent operating state, and the hazard or hazard groups. And then across the top you have the different PRA levels.

The last column you see, the 2020 FLEX column, that goes to what John was mentioning before. That's not within the original scope of the project. Back in 2019, when we were originally going to start releasing information to the public and we were going to start briefing the subcommittee in open meetings, during a set of management reviews that summer it was decided that because the plant was based, as John said, on information from 2012, and at that time did not reflect any operating plant, we decided to produce

an overview report which summarized the results of the base study, but also looked at some of the more recent features which could have a significant impact on the plant risk profile.

And that's what we call the 2020 FLEX case.

So, that's in addition to the initial scope, but something that we feel is very important to, to have out there.

So, given that if we look at the initial scope, which is the Level 1, 2, and 3 columns, we can see that virtually all the technical areas, all the PRA models are either complete or they're in Phase 2. The only, the only models remaining in Phase 1 are the Level 3 model for the spent fuel pool and integrated site risk model.

And the integrated site risk, naturally, is going to be the last thing to be completed because it takes as input stuff from all the other models. So, it necessarily has to be completed at the end.

CONSULTANT BLEY: Alan.

MR. KURITZKY: Yes.

CONSULTANT BLEY: Dennis.

Some years ago my memory was that the integrated site risk was really one of the big things

we wanted to accomplish, and that you were pretty well down that road. But from this, it looks like you didn't make it very far down that road.

Can you tell us a little bit where that stands? Or is that coming up later in your talk?

MR. KURITZKY: No, no, no. Oh, I mean later, on this slide, so, later in terms of seconds or minutes, not later. I'll address it right now.

Yes, Dennis. So, you're correct. But you're correct in the fact that we were talking, we had a lot done some years back. But what that was was looking at an approach for accomplishing that work, not actually doing that work.

The actual limitation of the approach we have to, necessarily, wait for the other models to complete. And we're doing that in stages. We're, obviously, going to look at, well, all of them, obviously, but we're going to look at the multi-unit risk first because that's the piece that's first completed in terms of the single-unit models. And then we'll move forward to look at spent fuel for other, other site radiological sources.

ACRS CHAIRMAN REMPE: Alan.

CONSULTANT BLEY: Yes.

ACRS CHAIRMAN REMPE: Before you move on to

the next topic, I have a curiosity question.

My understanding is the definition of FLEX has always been diverse and flexible coping strategy. The report presents two definitions.

Is that a typo, or is there a movement underway to call it diverse and flexible mitigation capability? Because I saw that definition in the report, too.

MR. KURITZKY: Yeah, if you saw a different definition, that was unintentional. We --

ACRS CHAIRMAN REMPE: Okay. That's what I wanted to hear. Thank you.

You might want to fix that. But I just was curious when I saw it.

MR. KURITZKY: Yeah. Actually, let me just make a note. That's not the right definition on the project. Let me just make a note to myself to --

ACRS CHAIRMAN REMPE: It's only, again, there's two different definitions. Sometimes they use the definition I gave that. So, it's just sometimes it appears.

MR. KURITZKY: All right. Okay.

MR. NAKOSKI: So, while Alan is taking that note, the other thing I want to note, Dennis, in response. This is John Nakoski again.

On the integrated site risk, you know, when we started this project and got to the point where we wanted to pilot or give, develop our concepts, there wasn't really a whole lot of other organizations that had looked at integrated site risk. Since that time, both EPRI and the IAEA have come out with multi-unit guidance that since then we've looked at and integrated into our thinking.

So, we've tried to take advantage of some of the international work that's been done and the work by EPRI that's been done to inform how we are going to approach this.

CONSULTANT BLEY: Both of you have said some things that imply this project, rather than being done in two or three years, it may take you all the way to retirement.

Is it continuing? The things you talk about not having done, is there an intent to do them? Or where do we stand on that?

MR. KURITZKY: So, if I could, Dennis, I didn't get a chance to complete my reply to your, to your original question.

CONSULTANT BLEY: Yes, right. That's right. Thank you.

MR. KURITZKY: All right. So, back several

years ago we had come up with an approach that we were pilot -- as John mentioned, we piloted, dealing with combining cut set piles for two different units and then applying rules based on dependencies because it was recognized early on that the important contributors to integrated site risk or multi-unit risk were going to be based on dependencies. Because if you're looking at multiple accidents independently, the likelihood is so low it would not nearly compensate for the, for the higher consequences.

And so, the focus had to be on the dependencies.

Well, as John was mentioning, in the ensuing years we -- and by the way, the lead for that work moved on, and another lead came and they moved on, and a third lead and they moved on -- so, our fourth lead, hopefully our last lead for this work is Susan Cooper.

So, in any case, in those ensuing years, as John mentioned, there was a lot of work started being done in the international arena, oh, domestically and international. So, you had both EPRI and IAEA doing work in this area.

And so, one of the first things that Susan did when she took over was she wanted to go through

all the different work that had been done elsewhere and see whether or not our approach was consistent with what was coming through those documents. And if not, were there things that we wanted to change in our approach, or just acknowledge that there were inherent differences?

And the main focus that Susan's been working on for the last year or so that she's been on the project has been on this dependency analysis. Because regardless of what approach we use to estimate the integrated site risk, or the multi-unit risk, we need to have a very strong, solid, you know, rationale for how we address dependencies.

And that's really been a large effort. And we're coming to the conclusion of that effort. And we're about to start working on the applica -- or the implementation of the approach to actual quantifying risk.

And, in fact, we also have another member on the team that's been in parallel working on approaches for implementing this work. But what we realized as we started to get into the implementation was the original approach we had probably wasn't going to work that well for looking at all the different external hazards, which would likely be some of the

more dominant contributors.

And so we've had to change course a bit in that regard, also.

So, yes, the work, we're still in Phase 1. We'll be in Phase 1 for the rest of the year for sure.

However, we do see this work coming to fruition over the next year or so, including implementation. And we don't expect that our evaluation of integrated site risk will be the way everybody does integrated site risk for time immemorial or forever. But I think it's a good, a beachhead here for how you can address some of these things. And over time, I'm sure people will, will work to improve it. They may have completely alternate ways of addressing it, or they may take this approach and needle it or work with it to improve it.

So, in any case, in terms of schedule, like I -- what we expect by the end of this year, we hope to have completed the Phase 1 spent fuel for the Level 3 analysis for Phase -- for, you know, Phase 1 for the spent fuel pool, as well as all the in-process Phase 2 work that you see here on this chart.

And then next year we hope to complete the Phase 2 of the Level 3 spent fuel pool work and both Phases 1 and 2 of the integrated site risk.

So, so, hopefully, after next year all we have is really documenta -- you know, converting things to public reports and wrapping up documentation.

Oh, by the way, we also hope this year to complete the, as you see, the yellow entries, the FLEX. We hope to complete the FLEX sensitivities for the reactor power, seismic, and wind this year. And then next year complete the FLEX studies for low power shutdown and for the spent fuel pool.

CONSULTANT BLEY: Alan.

MR. KURITZKY: So, again, all the technical work should be done in the next couple years.

CONSULTANT BLEY: That, that helps a lot.

I'm wondering if, given where you are and what you described about the integrated site risk, if you have an internal position paper or guidance document on how you plan to continue that work. I think the committee would be really interested in that if you do.

MR. KURITZKY: So, right now we -- in fact, we have a meeting, oh, I think a couple of people met yesterday. I was busy preparing for this meeting, so I didn't attend it. But we have another meeting tomorrow. That's very actively being worked right

now.

So, we don't have anything -- we don't really have things that we've shared with either John or the rest of the team yet. But a couple of the key personnel, Susan Cooper, Susan Jack are working on those approaches right now. So, we do have some initial sense but we haven't come to consensus within the team on the exact approach. But I think we're, we're getting very close.

So, it's a little premature to share anything with the ACRS, but I will note your interest so that we'll have to -- we can explore, you know, sharing some information with you as it becomes available.

CONSULTANT BLEY: So, I'd like to just pursue one last question, linked to what Joy asked you about. Not so much what the acronym FLEX stands for, but the philosophy that the industry's taking with respect to FLEX, evolved as FLEX evolved, from an almost post-core melt application of coping strategies for situations where that would be necessary, to some more general, broad use of FLEX.

And I think that's kind of what was implied in the I'll call it erroneous definition of the acronym.

But in your FLEX work I assume you followed what the reference kind of here is doing, or did you use a more generalized approach to the FLEX analysis?

MR. KURITZKY: So, thanks, thank you for the question.

So, we actually based it on what the plant has done. We based it on their FLEX implementation plan, their FIPS public document. So that was, it was prime -- and I'm going to get into this in a few minutes when I talk about how we addressed FLEX in the model.

But just a short answer to your question, it's based on what they currently have procedures for.

CONSULTANT BLEY: Okay.

MR. KURITZKY: Which is in response to an extended loss of DC power in ELAP. So, but I'll talk more about that in a few minutes.

CONSULTANT BLEY: Thank you.

MR. KURITZKY: Sure.

Okay. So, I think that pretty much wraps up what I wanted to say about the project schedule. If there are no further questions on that, let me talk a few minutes about the public reports.

That previous chart was focused on the

internal models and the internal reports. Again, internal because of the prevalence of proprietary information in them.

So, in terms of public reports, we are trying to issue them as a series of NUREG volumes, eight volumes in all, a total of 22 individual reports.

As you can see from this chart -- it might be small; I don't know how big the screen is where you are -- but there's subvolumes for all the named volumes.

Just to kind of go over what, what we have on here, the first volume up top in the green, the summary volume, Volume 1, that is going to be a summary report that addresses all the major results, and insights, perspectives, et cetera, from, from the study. It will be produced last because it will have to be done after all the rest of the reports are complete.

It's kind of like analogous to, if people are familiar with the NUREG-1150 studies, you had the NUREG-1150 report itself, which was more of a summary document, and then you had a series of contractor reports, NUREG/CRs, the 4550 series which deals with the Level 1 PRAs, the 4551 series which deal with the

Level 2 and 3 PRAs.

So, essentially, this summary volume would be like the NUREG-1150 volume. And the other technical reports, Volumes 3 through 8, would be more like the NUREG/CR volumes, more detailed technical analyses.

Volume 2 is just a small volume that kind of provides some of the background for the project. It also describes the similar information on the reference plant and design and the site characteristics, and also includes a very high level overview of the approach that we're taking. The details for the approaches are in the, in the other volumes.

So, as I was saying, Volumes 2 through 8, that's the meat, that's where the real technical detail, technical information exists. If you look at Volume 3, which is for the reactor at-power for internal events and floods, that's the set of volumes that we just sent out for public comment, particularly the overview volume, Volume 3x.

So, initially we have a separate volume for the Level 1 for internal events, Level 1 internal floods. And then the Level 2 and 3 analyses had combined internal events and internal floods together.

So, there was, there was four subvolumes, 3a, b, c, and d.

And once we went back and decided that we would need to have some overview volume that would incorporate a lot of the information using FLEX and some other more updated plant changes -- I don't remember everything, so I gave it the letter "X." So, it's 3x, all the multi-volume volumes have now an X version in the beginning. And so, that's the overview report.

So, you see similarly for Volume 4 for reactor, at-power, internal fires and, essentially, seismic events, and high winds, there's the same split. The Level 1 models all have separate reports, except for high wind and other hazards are combined together.

And then the Level 2 and 3 reports combine the fire, seismic, and wind as you'll see in the report. And, again, an overview report will be produced for that series.

Volume 5 is for lower power shutdown. Separate volumes for Level 1, 2, and 3, and the overview.

Spent fuel pool, Volume 6, has a combined Level 1 and 2 model, and then a separate Level 3

model. So, two reports there.

And then dry cask storage and integrated site risk will both be single volumes. Everything, Level 1, 2, 3, and all hazards will all be rolled up into the single volume for those two reports.

Our intention is to publish all these reports as NUREGs, as I mentioned earlier on. However, initially we're putting them out for public comment as just draft, non-NUREG technical reports. That way it saves us a lot of time and effort in terms of getting the appropriate NUREG formatting, and doing a lot of technical editing, which we can do later on when we have more time.

Oh, sorry. Totally unrelated, but I just wanted to mention this. So far, it's been working well with Dennis, or Dr. Bley and Dr. Rempe speaking up. But because I'm looking at a screen that has the slides and the camera, I don't see the actual Teams screen. So, I can't tell if someone raises their hand or puts something in the chat.

I'd ask John to kind of keep an eye on that and let me know if someone does that. But would really be helpful is if people just, just speak up. So, as we've been doing so far is great. Just speak up if you have any comments. Feel free to interrupt

me at any time.

So, so thank you for doing that.

Okay. Now I just want to mention a few of the things that are involved in going from those internal reports to the public volumes. We're the Government, everything takes time. Everything has, actually, a bureaucracy.

So, some of the things that we have to do, first, of course, is to remove the proprietary information. Again, to put these things in public there's a lot of proprietary information, a lot of plant-specific information in the interim reports that has to be scrubbed out before we can put it out in the public domain.

And then we also have to run the reports through a gauntlet of internal management reviews. At the same time, we send the draft copies to the volunteer licensee so they can fact check things, and make sure we haven't inadvertently left some proprietary information in the reports.

Once we get that feedback, we update the report, we prepare a Federal Register Notice which announces the availability of the reports for public comment. So, when that notice goes out we also issue the reports for public comment in ADAMS and identify

that it's publicly available.

And that's when we can brief the ACRS Subcommittee in an open meeting as we're doing today, for Volumes 2 and 3.

Once we get feedback from the public, or the ACRS, or anybody else to do items that we have on our list ourselves, we'll go ahead and update the reports, do the appropriate formatting and final editing, and then submit them to publications for final publication as NUREG reports.

So, all of that, obviously, takes, takes a bit of time, but those are the steps that we will go through.

So, in terms of schedule, if you look at this, this chart or this slide, the first set of reports -- and these are aligned to the volumes that I pointed out before on the previous chart -- so, Volumes 2 and 3 which were the, kind of the background volume and the reactor at-power internal events and internal floods, those went out a couple months ago, in April. Actually, the public comment period just ended yesterday for those.

The rest of the reports, you'll see two dates down here. The blue date, which is a target date which is something that if everything goes well,

that's the date we hope to make. We also have in red a more realistic date that's by no means a worst case scenario, but it does allow for some things that might not go so smoothly to get those reports out.

Even in that, even in those realistic cases there are certain considerations that could upset that schedule. The primary one, which is one that we've been dealing with all project long, is the key personnel.

We, as John mentioned before, we used a matrix approach to this project because we didn't have a dedicated team. And some of the key people have other priorities, you know, other activities that are a higher priority than this. So, they'll get pulled off to work on that for days, weeks, or months at a time.

And so that, obviously, can throw the schedule into disarray. So that's something we just have to manage and work with.

But, in any case, these are the dates that we're hoping to meet. So, if all goes according to plan, we'll have all the reports done before the end of 2024.

ACRS CHAIRMAN REMPE: So, Alan, this is Joy again.

MR. KURITZKY: Yes.

ACRS CHAIRMAN REMPE: I'm curious about Slides 9 and 10 and where ACRS would fit in. I assume you'd like to have some sort of letter before you complete and issue all these documents as final.

What's your plan for that? And is it going to give us adequate time to do any sort of thorough review and comment?

MR. KURITZKY: So, thank you very much, Dr. Rempe, for that question.

So, if you'll just allow me to hold off, actually the last slide of the whole presentation is about future interactions. And it includes, actually, a repeat pretty much of this, of this slide, and talks about what would be the good point to interact with the ACRS Subcommittee or Full Committee based on this schedule.

So, if you don't mind holding off, we can address that --

ACRS CHAIRMAN REMPE: Sure.

MR. KURITZKY: -- later in the presentation.

CONSULTANT SCHULTZ: Alan, this is Steve Schultz.

Just on dry cask storage, is that a typo

on the year, or do you have a headstart on that one?

MR. KURITZKY: No. Okay, so, thank you for bringing up that, that question.

Originally I had planned to go through these bullet by bullet. I was just taking a shortcut and flew through the slide.

But, yes, so I was going to mention that the dry cask storage, it's not a typo, it is the dry cask storage is a common outlier in the sense that it's not on the project critical path, it's risk implications are low, it isn't really tied to any other reports.

So, many other models, something had to be done to feed into other models. Obviously, you have to have an internal events model done before you can do a fire or seismic model. You have to have a Level 1 model done before you do a Level 2 model.

Even the spent fuel pool needed certain things done from the low power shutdown model.

So, the dry cask storage kind of stands by itself. So, it really can be done at any time. Right now it has been -- that report was, was inches from being completed years ago. Unfortunately, through some unfortunate circumstances, key people on that project, the person who was leading the work, as well

as the person leading the review of the work for management, were constantly out of sync and off for months at a time. Until eventually both of them are no longer with the agency anymore.

So, that just dragged on and on.

We now have a new individual, Brian Wagner, who has taken the lead for that work. But he has a lot of other responsibilities. And so, he's been getting to it as time permits. He, hopefully, will be done shortly with the internal report.

And once that is done we can go ahead and produce the public version relatively quickly, I think. So, it's we would not have a whole separate meeting and a separate Federal Register Notice and ask to make some addition to that one report. So, what we want to do is put it out at the same time as whenever the next set of reports that would go out after it's completed.

So, if we can get that work done in the next several months, which I'm cautiously optimistic we can, then we would probably put it out when we, when we put out the next set, the internal fire, the seismic, and high winds, Volume 4 in later this year.

So, that's why you see the October 22 date is the target, just like we have October 22 is the

target for Volume 4.

However, if for some reason we don't get that, unfortunately, Brian is moving to a new position. I think it's actually this week he's already moved to a new position, though we're getting to borrow him back temporarily. If we should not get that work done and have to bring someone else in to complete it, then it could drag on quite a bit. And so, that's why we have that later date.

But, in reality, I'm hopeful that it will go out, if not in time for the Volume 4 release, hopefully, certainly by the time of Volume 5. But we allow for the fact that it could drag to later in the project.

CONSULTANT SCHULTZ: Yeah. Realize the complications.

Do these dates consider response to public comments?

MR. KURITZKY: So, a very good, -

CONSULTANT SCHULTZ: And so this is you deriving.

MR. KURITZKY: -- a very good question, because that was one thing I meant to mention and I didn't.

So, this is actually the schedule for

releasing the draft reports for public comment. This is not for the final reports.

CONSULTANT SCHULTZ: Okay.

MR. KURITZKY: So, this does not account for that.

The completion of the final reports would be some months after these dates, and it would depend really on how much feedback we receive and, and what the other responsibilities are. As this project gets later into it, there's going to be less and less people around to work on it outside of yours truly. And there will be multiple things to be worked on at the same time.

We'll be working on trying to wrap up all the technical models, trying to finalize public versions that we have received feedback on, as well as getting out into the public versions that we have yet to issue in drafts. And so, there's going to be a lot of overlaps in the schedule. So, it's hard to identify dates.

But it would, it would generally be, for lack of a better estimate, somewhere probably three to six months after these dates we would hope to have the, the final versions submitted for publications.

CONSULTANT SCHULTZ: Thank you. I

understand the management challenge here.

Thank you.

CONSULTANT BLEY: Alan, it's Dennis. I have two things I wanted to bring up.

MR. KURITZKY: Sure.

CONSULTANT BLEY: The first one has to do with something John Nakoski said early on which is at least a little troubling.

One of the driving forces for this entire study was the fact that 1400 put down NRC's first attempt at what to be on a PRA. 1150 came 20-some years later. The idea was it's probably time for NRC to once again show the world what a good PRA ought to look at and the guidance.

But John mentioned that people shouldn't take it that anything in this study is a view of what NRC expects in a PRA. And that seems to me a little odd since we're putting this out as an NRC state-of-the-practice kind of document. And is that clarified somewhere?

I think it's going to be hard for people not to look at this as staking out NRC's position on how a good PRA ought to be done.

And then I have another follow-up on that after you address that first one.

MR. KURITZKY: Okay. All right. So, thank you.

So, let me put a slightly different spin on that statement. More than saying that there's nothing here that can be relied on in terms of how a PRA should be performed, it's more than we have a very expansive scope for this project. We were probably a little like the kid who cut himself too big of a piece of cake. So, now our stomachs are stuffed, there's still a lot of cake on the plate, or at least there's some cake on the plate.

So, really the reality is we have put a lot of rigorous analysis into this study. And in most cases, things have gone the way we would expect them to be done -- in the vast majority of case, vast, vast majority of cases. However, the caveat really is that in not every case have we been able to bring this to a point that we would say, yes, this is the way we would like to see things done from a regulatory perspective.

So, the caveat just says don't necessarily assume that because something was done a certain way in this study that that's approved, an NRC endorsed and approved approach for some regulatory application. In many cases it is. In most cases it will be. But

the caveat don't just presumptively, you know, assume that that's the case.

And so, there are going to be some things that we clearly know might need more work, where we've made simplifications either because we did not have access to complete plant information. As John mentioned early on, we were actually very fortunate. The volunteer licensee was tremendously helpful in providing information. We have terabytes of information from the licensee.

They gave us tremendous access to the plant. We went on many, many trips.

The problem is the scope of this project is so large that if you break it down into integral pieces and sum it back up again, it dwarfs what people's thoughts of what would be involved in doing a PRA up to now have been. It really is a extremely large project.

And so, what would normally seem like an adequate number of plant trips, or adequate access to information, or adequate time to investigate technical issues under normal circumstances, in most case we did have that, it was adequate, but in some cases it just wasn't.

And so, there are just going to be certain

things that we were not able to, you know, run to ground. And so, we don't want people assuming just because we didn't put the full effort into every single item, that that means that they don't have to either, if they're doing some type of regulatory or licensing application.

So, that's really the only caveat.

CHAIRMAN DIMITRIJEVIC: Yes. Sorry, Alan, but that was one of my questions connected with this slide. Would you try to limit this to a specific case when I asked John, and John responds that this is a general statement.

So, this is a -- and, you know, I know that your next slide you will talk about objectives, you know, of the project and how they are met. But if you, if you say it will be applicable in most of the cases, and some specific cases will not be applicable, will you try to define those specific cases that, you know, that it's there was too many simplification and, you know, not all aspects were addressed?

Would you try to define what specific steps that will be taken as, you know, regular for the endorsement for regular study purposes?

MR. KURITZKY: Okay. So, thank you, Dr. Dimitrijevic.

So, what we have done is in each of the reports you will see, in the detail report, you will see sections on modeling uncertainties. And in some cases they're exceedingly long. If you look in the Level 2 or Level 3 reports in particular, you see a lot of modeling uncertainty items.

And, also, we have sections that identify -- and we performed sensitivity studies for some of those items, other we, we did not have time to, or we felt that there wasn't sufficient bang for the buck to further pursue them -- but we also have a list of candidates for future work, or candidates for future research.

And those are things where we recognize that we were not able to fully address either because they were beyond the state-of-practice, or we didn't have the time or resources to further pursue them.

But we recognized that they were something that would be good to pursue if someone were going to use the approach for a particular licensing or regulatory application, or just even for the interests of research to get a better understanding of a particular issue.

So, those are things, really, that highlight, and also were ones that we felt were

important enough. I mean, it's obviously a judgment call, but if we felt that something would potentially have a significant impact on the risk results, the risk profile, then, then it was a candidate for future work.

If it was something that we were not certain about, there were different ways to treat it, we picked one or we did a simplification, but we felt that the end result wasn't going to make much difference to the risk results, then it wouldn't necessarily be a candidate for future work.

So, really, the candidates for future work would probably be the best source of those items where we feel more work is necessary. But that doesn't mean that everything in those lists needs to be completely run to ground or resolved to use PRAs for regulatory applications. That's not our intention at all.

But those are three areas where we felt we were limiting in how well we could address those issues and that they might have some, you know, reasonable impact on the risk profile.

So, model uncertainties exist in all PRAs and they will continue to exist in all PRAs, and it's a question of how your decision makers consider those until and as they make their decisions. We have means

of compensating for uncertainties. And I'll discuss some of that, as you mentioned, when I get to the objectives of the project.

But the best source for those, those items that we feel could use more work would be those lists of candidates for future work. And a more expansive list would be the list of model uncertainties.

CHAIRMAN DIMITRIJEVIC: Thank you. I mean, actually, I really think that was the important thing. You know, you haven't disbanded the project. And now how will that be used, and what has been accomplished, which I hope will be discussed in your next slides. What your objectives and how those objectives are met are, from my perspective, the most important aspects in this moment of the project, so.

MR. KURITZKY: Okay, thank you.

CONSULTANT BLEY: Alan.

MR. KURITZKY: Yes.

CONSULTANT BLEY: Alan, the second thing I wanted to ask you about -- and thanks for that explanation, that was very good -- you will have noticed that, sort of like your project, membership on the ACRS has changed dramatically. I have notes going back to November of 2010 of meetings with your group. And there are very few members of the committee -- I'm

not a member anymore, I'm a consultant -- who were here during that whole period, or even a substantial part of that period.

And I guess for both the staff and for the committee, the committee over those years decided generally not to be writing letters, but we had regular meetings. And the staff decided they'd like to meet with us very often and discuss where the project was headed and details of technical comments, but take them as individual comments from the members of the committee, and use that to adapt how they moved forward.

The downside is there was no long record of committee letters that documented the where the committee stood on various issues along the way.

So, as the committee decides whether to or what to include in letters in the future, they're a little short on the history, and will remain that way.

S, I think from the staff to guidance on -- or not guidance, suggestions on where and why letters from the ACRS might be useful or helpful would be important. And from the committee's side there's some history of this that they can tap into.

But I just wanted to note that there is not a well-documented history of committee positions

on the evolution of this project. We always thought it was a year or two away from the point at which there would be a letter, and it never got there.

Anyway, I just wanted to get that out for people to think about.

MR. KURITZKY: Thank you, Dr. Bley. I remember those days and, yes, we always did think the letter was coming shortly.

But, again, you know, we had, like you said, we met quite frequently in the early years. We had a delay once we decided, decided to have open meetings from that point forward with public information. And then we ran into the issue with the other report that knocked us off track for a while.

But, yeah, the last, again, when we go to the section on future interactions at the end of the presentation, that's when I would hope that we could have a little more detailed discussion about what's the optimal path forward. What, you know, with consideration of the time demands of both the subcommittee members as well as the staff, project staff, in trying to get work done, what is the, you know, optimum path forward in terms of interactions to get both the work done and get suitable feedback from the ACRS.

So, yes, that's something that we would like to discuss at the end of the presentation.

ACRS CHAIRMAN REMPE: So, Alan, this is Joy. And I have one comment that you can decide whether to address not at all, or in the next slide of this slide. It's up to you.

But because you mentioned how the dry cask storage sample report said that, you know, the risk is so low. And knowing that one of your objectives is to look at the feasibility and cost of doing a Level 3 PRA, I'm wondering if you've developed some insights that could -- and will they be documented on certain aspects of the Level 3 PRA that you've learned are just so much in the noise level that it really wasn't worth pursuing, that could be used for guidance for future folks who might want to do one? And has that come up in your discussions?

MR. KURITZKY: Let me just think here. That's a good point. I want to just make a note on that.

So, right now we haven't gotten to that stage. In Volume 1, the summary NUREG volume, that's going to have the section on the insights. And that will include perspectives in things like what we learned from imagining the project, what things we

feel were important in terms of expending resources, and what things were important to include in the model versus what things might be of lesser importance.

So, we have not had that discussion in any type of detail to date. It will be a major area of focus when we prepare the summary NUREG in the Volume 1.

ACRS CHAIRMAN REMPE: Okay. That's for the response back.

CONSULTANT BLEY: And, Alan.

MR. KURITZKY: Yes.

CONSULTANT BLEY: You haven't talked about this yet, but I just wanted to kind of telegraph it for some time later.

I think you talk about using some detailed uncertainty analysis in the various parts of this study, and the use of sensitivity analyses. And somehow blending epistemic and aleatory uncertainty is what you ended up having to do, and that that isn't ideal.

When we get to that I guess, first, I would say, well, it's not that it's not ideal, it's that mathematically it's wrong, and it leads to somewhat, sometimes more than somewhat different final statements of uncertainty.

When we get to areas where that might come up I just wanted to flag that that's something that would be of interest to delve into a little further.

MR. KURITZKY: Okay. Thank you. I'll be the first to admit that's not my area of expertise. It's also an area where unfortunately one of our key players has left the Agency, but we will try to address anything we can. And any feedback we get from you in that area would be something that we would love to have, and we can try and fold it into however we document things going forward in the report. So I look forward to those discussions.

Okay. So if there are no more questions on that schedule, people have already been alluding the discussion of the project objectives. So if I could take a minute just to remind those people who have been along for the whole ride what those objectives are, maybe a first introduction for those who are newer to these briefings.

So there are four main project objectives. It's been over 30 years since the NRC last sponsored a Level 3 PRA. That was the NUREG-1150 studies that were mostly completed in the late 80s, published around 1990.

And so we really wanted to come up with a

more current risk profile for a plant that was based on more recent PRA practices as well as more recent design operational plants, you know, looking at changes that have occurred in the plants over those ensuing years.

And in addition, we also wanted to expand the scope. NUREG-1150 was a very detailed study, a very good and broad study. And it looked at five different plant designs, but it also focused mainly on internal events. There were two of the plants that looked at, I think, fire and seismic. And there were some later studies that looked at a couple of shut down states for a couple of plants.

But by and large, it was more limited in scope than what we are looking at now. And for instance, we're looking at, you know, risk. We're looking at spent fuel pools. So we wanted to get that more broad risk profile as compared to NUREG-1150.

Secondly, we also wanted to obtain new insights to help us in doing risk-informed decision-making and focus ABC resources on those areas that we felt were most important to public health and safety.

Third, we wanted to expand the depth and breadth of the staff's PRA capability. There is a somewhat limited number of PRA experts -- not

experts, but experienced PRA analysts at the NRC. Since the beginning of this project, some have already left the Agency and new ones are coming in place. But we really wanted to try and beef up our capabilities in this area to allow us to make maximum use of the risk-informed paradigm framework that the Agency is going forward with so that was an essential objective of the project as well as improving the PRA information, both making the PRAs more transparent and user friendly, being able to get the information and understand the rationales more easily for the decisions that we made.

Lastly, as has already been alluded by someone, we wanted to get at least some insight into the feasibility and cost of developing new Level 3 PRAs. And I will go over in the next few slides, at least initially this is preliminary, but there are some initial thoughts on how well we're meeting these objectives.

So I'm looking at the first objective, which was to get, you know, a current state of practice of a full scope PRA. I just listed a few examples of some of the PRA modeling advances since the time of 1150.

Some of the key things that we looked at

in this study versus 1150 was the analysis of post-core damage operator actions in the Level 2 PRA. That isn't something that really had been addressed before. We looked at actions, you know, based on looking at the severe accident management guidelines or the extensive damage mitigation guidelines, the SAMGs and EDMGs, different actions that can be taken post-core damage.

And we primarily looked at one action prior to vessel breach and one action at or shortly after, several hours after vessel breach. So that's something that is a new development. That's something we actually pushed the state of practice.

We also, because some of the data we were looking at early in the project for interfacing system LOCAs was showing to be very uncertain, and it was coming in at some significantly high and somewhat unreasonable looking numbers. We felt it was important to get a better handle on those frequencies. And so impaneled -- we did an expert elicitation. And so we were able to use a more update IS LOCA information than what would had been used at 1150.

In terms of severe accident progression analyses, since 1150, we have the MELCOR code now, a fully integrated systems level code that can give, you

know, best estimate analyses for both the reactor and the spent fuel pool.

It incorporates a whole slew of advancements in the knowledge of and research into very severe accident phenomena and things that deal with radiological release. So that was a big improvement.

And likewise for consequence analysis, there is the advent of the MACCS code that we now use. It also involves a whole host of improvements in accident analysis that have occurred over the decade since NUREG-1150.

Most of these items are reflected in the SOARCA project, the state of the art reactor consequence analysis project that the NRC has been working on for quite some time. And we were able to leverage most of the best practices from SOARCA into this project.

In addition, there is a much improved understanding of model uncertainties. We were discussing just a little while ago about the many areas where there might be things that will still need to get more attention. But nonetheless our understanding of what many of those modeling uncertainties are leads us to a much better

appreciation and ability to estimate the risk and understand where things may, you know, be uncertain.

So those are some big advancements since 1150 in terms of a state of the practice for PRA.

Similarly for the plants themselves, there have been a number of changes.

CONSULTANT BLEY: Hey, Alan.

MR. KURITZKY: Yes.

CONSULTANT BLEY: Could I break in with one thing, just what you're talking about? This will be a PRA of a light-water reactor, but there will be PRAs possibly of new designs, alternative designs coming up. And some of the areas you were just talking about, those codes are currently being refined and expanded to cover the ability to do the same kinds of analysis for those new plants. I just wanted to set that in.

MR. KURITZKY: Thank you for that. Because, again, that's stuff I'm not that plugged in with, but yes, that's a very important point so thank you.

Okay. So going back to the plant improvement. So as you mentioned before, the severe accident management guidelines, the extensive damage mitigation guidelines as well as other mitigation

strategies that came about following, you know, post-911 in addressing, "losses" of large areas of the plant due to fires and explosions. So there is a lot of stuff here that wasn't, of course, around in the NUREG-1150 time which has led to significant changes at the plants themselves, additional capabilities to reduce risk.

Also, there have been a number of NRC rules and generic communications over this time frame that have led to changes of plants again to improve their risk posture. For example, 10 CFR 50.60 through the station blackout rule as well as the maintenance rule are two examples of where I think have led to plants being safer than they were previously.

And then there's also, as we were discussing earlier on, there's the new reactor pump seal designs, the shutdown seal designs for the Westinghouse pumps as well as the FLEX strategies that have come about post-Fukushima.

And these we addressed in the sensitivity analysis, but they're also important risk contributing, you know, risk mitigation items that are available now that were not around back in the time of 1150. So all of those things are justification for why we want to have this more up-to-date modeling.

Lastly, the scope, as we discussed already previously, this scope here is very broad. It includes all the reactors, spent fuel pools, dry cast storage, all internal electronic hazards. We're looking at all modes of plant operation.

I do need to point out that because of issues with timing and resources, again, we bit off a little bit more than we could chew quite honestly. And so we had to make some cuts. And what we ended up doing is only focusing the low power shut down on internal events. We no longer are planning to look at the other hazards for a low power shutdown. That was unfortunately one scope limitation or reduction that we had to take. Okay. So that's the first objective.

The second objective we want to obtain insights to support risk-informed decision-making. So there was a number of insights that have already come up. I list a few examples here. This by no means should you view it as being exhaustive.

But some of the initial insights of pertinence are the fact that substantial margin exists to the safety rules. We have the two quantitative health objectives associated with the Commission's safety goal policy statement. The individual early fatality risk of individual latent cancer fatality

risk. And we see substantial margin to those goals.

For the prompt fatality risk, that's one of the reasons that there is substantial margin there is because there was sufficient warning times to effectively evacuate all the close in population.

For the latent cancer fatalities, the bulk of the latent cancer fatality risk comes not from the exposure to the initial plume but from long-term reoccupation of the land. When the powers that be determine that the people can go back to their homes and their businesses, et cetera, once the background radiation levels are low enough and then they proceed to spend the rest of their lives, decades hopefully, in those areas, with a slightly elevated background radiation.

So with use of the linear no threshold low dose response model, you end up getting a certain number of statistical cancers. Nonetheless, even with that the number of cancers is not expected to be statistically detectable over normal, you know, cancer levels. So even though we report additional cancers, in the grand scheme of things, they're not that prominent.

Another thing that we did recognize is that the circuit risk metrics that have been used for

these quantitative health objectives, the core damage frequency, generally 1E minus 4 per reactor critical year and large early release frequency of 1E minus 5 per reactor critical year appear much more restrictive than the actual QHOs themselves. And you'll get a better feel for that when I go over some of the results later in the presentation.

MEMBER BIER: Excuse me, Alan?

MR. KURITZKY: Yes?

MEMBER BIER: This is Vicki Bier. With regard to latent cancers, you talk about long-term reoccupation. But in fact there can -- in order to meet, you know, EPA dose limitations, there can be very significant areas that are not reoccupied on any timely basis, you know, as we've seen after Fukushima.

And the safety goals, you know, reducing the dose imposes a socioeconomic burden on all those people that are relocated. And is there any consideration as to whether the current EPA dose criteria are too stringent given that? Whether there may be room to have some areas of, I would say, you know, modest contamination be kind of discretionary where people might be given assistance to relocate away if they want to but also allowed to continue to live or work there if they don't want to relocate?

Has that been discussed at all in this process or you are really just taking those limits as given?

MR. KURITZKY: So thank you very much for that question, Dr. Bier, because you reminded me of something I was going to mention, and I forgot to.

So, yes. The fact that we have relatively low latent cancer fatality risk is mostly because of the long-term protective actions that are assumed, you know, keeping people away from the contaminated areas.

We did not -- and so then you have that classic trade-off of economic costs versus safety and health effects. And where that balance is is way above my pay grade. So in our modeling, we have based on it on, I think, the MACCs code. And it's based on the PAG, the EPA Protective Action Guideline, limits. I don't remember exactly what they are. I think, it's -- I can't remember. These are actually rem numbers. So that is just a fixed input into our modeling. And so that dictates when you come back, when people can come back to the land and then what kind of exposure they get from that time forward.

It was beyond the scope of this project to -- whether those were the appropriate thresholds, who would make those decisions, what decisions they should

make, that's really not covered under this project.

MEMBER BIER: Well --

MR. KURITZKY: So we just take that as a given. We use the EPA PAG Guidelines.

MEMBER BIER: Sure.

MR. KURITZKY: And then the cost and the exposures are just based on that.

MEMBER BIER: Obviously, I think it's beyond the scope of the project to re-evaluate what the guidelines should be. That's, you know, above all of our pay grades.

But once you're doing this analysis, there could be sensitivity analysis to say, okay, what would the differential impact be if they were to lower that -- I guess increase the allowable dose slightly, what would be the increased in cancer and the reduction in economic impact or whatever would be something that could be done as part of that process. Anyway, just a suggestion.

MR. KURITZKY: Again, thank you. That's a very good idea. So we have not run that sensitivity as part of this study. We've done quite a number of sensitivities but that was not one of them.

We do, again, have a list of future modeling uncertainties and cancer future work. I

don't know offhand if that is one that's on the list already. But it certainly is one that we will add to the list if it's not there already. Because, yes, that's a very NRC idea. And that's one of the benefits of having a model like this is because we can run such a sensitivity and see what those impacts might be. So, yes, I made a note to make sure that it's on the list.

MR. NAKOSKI: Alan, this is John. I just want to also make the point, and we haven't mentioned this, the Level 3 PRA models will remain living models. And our intention is to have this available to do the kind of studies that you are suggesting consistent with NRC priorities and resources. So to have a better informed list of candidate activities where we can go and exercise these models is a good initiative. So thank you for that.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Also Alan and John, I notice that your Level 3 volume, you have analyzed also land area, the location and economic effects, but you choose not to present them and entrust them to somebody. I was wondering why is that, you know, done, but actually never mentioned in your summaries.

MR. KURITZKY: Yes. That was just a

resource decision. We wanted to limit the overview report in terms of its size and scope. So we felt that -- as you mentioned, we do look at a number - we have, I think, 13 different risk metrics that we report in the Level 3 report, but we wanted to just focus on the two that related to the QHOs figuring that those are the ones that would be of most interest to people in a broader audience.

So there was no reason except for that why the other ones aren't in here.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. I mean, it's interesting that actually completes the risk associated with, you know, the loss of land area, the location, economic cycle, that was interesting I was looking, and I sort of thought it should be at least mentioned somewhere.

CONSULTANT BLEY: Alan, I agree with Vesna on this. Whether you actually write it into the report or not, at least mentioning that you have considered these other factors and analyzed them I think would be important to include in the summary report, which might be all many people look at.

MR. KURITZKY: Yes. Thank you both. Yeah. I'm taking notes. So certainly that stuff that in the actual summary of the NUREG Volume at the end,

we will be addressing the more complete set of risk metrics. I don't know at this point, how much detail we will go into describing down the contributors to them all, but we'll certainly have the results for the various risk metrics. And so that's certainly something we would want to have in the summary report.

Again, right, now, these overview reports we're really just here to fill a need to get these reports out in the public domain because there was such concern over reporting base case results without discussing at least the impact of FLEX and some of these other more recent changes.

So these reports aren't meant to be surrogates for the summary report. They were just -- for each sub-piece of this project, they are here just to help get the results out the door.

CONSULTANT BLEY: So I understand --

MR. KURITZKY: Because right now it's the thing that we're having people focus on so obviously there are other things that in hindsight it would be nice to have in here. But the summary volume at the end, which at that point, these overview reports are not going to be what people will be looking at. They will be looking at that summary volume. And that will address that whole spectrum of risk metrics that we

reported.

MR. NAKOSKI: So, Alan, if I could, this is John Nakoski again. I think, Dennis, your point about the fact -- maybe in these overview volumes, we could identify there are other Level 3 results that we analyzed, but we are focusing in on the two related to the QHOs. I think that's a suggestion that we will talk internally and see how to incorporate that into the overview reports as a comment that we get from this meeting.

CONSULTANT BLEY: Okay. Thanks, John. Alan, something you just said made me curious. When you have that final summary report, will these dot X summaries remain or will they disappear?

MR. KURITZKY: No. They will still be there. I mean, they're going to be official documents.

CONSULTANT BLEY: Okay.

MR. KURITZSKY: And also because they're really the only place where we talk about the FLEX case and some of the other sensitivities that I'll go into shortly.

But, you know, the summary reports will, of course, have that information too. But in terms of, you know, kind of volume by volume basis, you

know, I think it's still worthwhile to maintain these reports.

CONSULTANT BLEY: Yeah. So although you're probably right, most people will go to that main summary report. I think people who are concerned with issues related to societal risk might go straight to the consequence volume and take a look.

So having a pointer there that says you've looked at other measures I think is important in those as well as in the main summary.

MR. KURITZKY: Yep. You know, I had already written, when you first made the comment, I made a note to put that into the summary report, to the overview reports. So, no, that's a good comment. We will definitely have -- I think as John was mentioning, having a list of what all the different metrics are but then mentioning that this report only focuses on these two and pointing people back to the full report, you know, in this case Volume 3D for a discussion of all the other metrics. So, yes, a very good comment. We will definitely take care of that.

Okay. Let's see, where did I leave off? Okay. So I think I finished the first main bullet. So the second bullet -- so it's a fact that and this ties to something that I mentioned in the previous

objective, but we have a more complete understanding of the uncertainties. And with that, it really underscores the need to be risk-informed as opposed to risk-based.

Because we did -- I mean, even myself who spent my whole career in PRA, I was exposed to a lot more uncertainties than I ever knew existed. And therefore, it's really important that we maintain the deterministic pillars of safety margin and defense-in-depth to help compensate for those uncertainties in the risk estimate. So that was obviously something very important.

In terms of large releases, we also identified that how long you take the severe accident progression analysis out to is very important. In this study, we generally take it out to around seven days. But we looked at some shorter time frames, which we'll discuss later. And that was a pretty -- it had a pretty important focus on the results.

The next item is actually a very interesting one. This actually is -- it's specific to this plant though it could in fact apply to other plants that have similar design situations.

And so one of the things that -- one of the assumptions in our study is that you need to have

DC power available to recover offsite power. And so once you run down your batteries, you can no longer recover off that power. You have an unrecoverable station blackout. And you're going to be going to core damage.

So one of the things that we identified in this study was that there were some critical breakers needed to recover offsite power who did not get their control power from the 1E safety batteries but in fact were from turbine building batteries, non-safety batteries that a 2 hour design lifetime.

And so there were essentially two hours in order to -- you had to recover offsite power within two hours or you were out of luck. And there were no procedures for -- we could find out what would -- discuss shedding loads from those batteries to extend their lifetime.

In addition, the procedure for recovering offsite power had a prerequisite for certain actions that you could not attempt to close certain breakers if you did not have DC power. So we do not know what operators would do. You know, it's uncertain what they would do if they can't meet that prerequisite but obviously realize that they need to get offsite power back to avoid a severe accident.

And so in both cases procedures, either, you know, for shedding, you know, to shed batteries, to shed loads from the terminal building batteries to extend their lifetimes or if possible action to be taken to reclose breakers without DC power.

You know, obviously different situations it may or may not be possible. You may be able to bring in some remote charging capability, et cetera, this is not including FLEX. But any of these procedures in these regards could really help to reduce a station blackout risk.

That becomes a little less important in the FLEX case as we'll talk about later because that accomplishes some of these very same things.

Another item that was very specific to this plant was that we discovered certain component failure modes that were very risk significant. The example given here is the high side input breakers to the reserve auxiliary transformers, which provide power to the safety loads once the unit trips.

So there are failure modes that because of the resolution of the data it was not clear whether or not these failure modes would be recoverable or not. And in particular these failure modes led to a non-recoverable loss of offsite power. And, in fact, the

failure mechanisms or causes if you got into the details, may or may not have prevented recovery.

And so this is a case where if there was more detailed analysis of the data, if it could be parsed more finely, then you might be able to again risk benefit from separating out the failure modes from the collective failure mode that we have in the PRA, which we naturally have to model as being non-recoverable since there are at least some cases where it is. And so with the appropriate assumption for us to make for this modeling. But nonetheless, more detailed analysis, you know, into the specifics of the failure causes or mechanisms could be beneficial.

And the last item on the list, I just want to, as we have discussed already, the FLEX equipment, the new RCP seal design, both of those can significant reduce risk. This is again very plant specific because really, going back to the discussion early on, I think Dr. Bley had brought up about the use of FLEX equipment and for what cases. And so right now it's for the extended loss of AC power.

So plants that have a large station blackout contribution to the risk profile are the ones that we'll really see a big benefit from FLEX and plants that don't have a station blackout, the

contribution will not see nearly as much benefit. And similarly for the RCP seal design those plants that had a large risk contribution from RCP LOCAs will obviously benefit much more from the new seal design.

Okay. So that's objective 2. Moving on to the third objective. This is the one where we want to beef up our staff PRA capabilities and improve the PRA documentation.

So in terms of the staff capabilities, we had a very large team on this project. We involved all of the divisions in the Office of Research, NRR and previously NRO all had staff involved in the project, the same for NSIR, NMSS, the regions that could be involved in the technical training center. So there was a lot of people involved in this project.

CONSULTANT BLEY: Alan?

MR. KURITZKY: Yes.

CONSULTANT BLEY: Can I take you back to the reactor coolant pump seal? There was a big effort by the vendor to redesign seals and to come up with a new look at how likely they were to survive an accident. Did you develop your own -- and I don't remember if we talked about this along the way and I didn't have time to dig it out.

Did you come up with your own model for

reactor coolant pump seal failure or how did you handle that in this report?

MR. KURITZKY: Now, are you talking about the original seals or these new shutdown seals?

CONSULTANT BLEY: The new seals.

MR. KURITZKY: The new seals. Okay. So, no, I do have a bullet, I think, later on. But no, we did not come up with our own model. We made an assumption as to what the failure probability would be for both the seal failing to close or were enclosed. And it was very consistent with some of the information that we had been provided on such seal failures.

The information that we had was proprietary so we don't directly take it and use it or reference it, but we used a value that was in the ballpark of that. I think it was .01 was the failure probability. It's in a later slide.

CONSULTANT BLEY: Okay. I'll wait for it.

(Simultaneous speaking.)

CONSULTANT BLEY: Okay. Thanks.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Alan, since you already went back to this, I was thinking while you were transferring to the next slide. A lot of things that you mentioned, you said some things

which actually, we just discussed. It happened yesterday, this recovery, this loss of power. You know, I always thought that this is one thing which was never really covered well enough in the existing PRAs.

And the same thing is with the seals. So you have covered a lot of things where the existing PRA know they have a problem. But those are not exactly insights to intense regulatory decision-making as you call it.

It's more about PRA completeness or PRA quality or something, you know, a lot of things that you discuss here are there to make the PRA, you know, better, more complete, you know.

So the thing is I'm not sure they, you know, will exactly enhance regulatory decision-making. You know, the transformer or breaker failing to open may screw your recovery, you know. It's sort of like so maybe it should be in the category with the completeness of the PRA. So that's just my comment, my personal comment on this. Okay?

MR. KURITZKY: Thank you, Dr. Dimitrijevic. You know, I agree, some of these things, I was coming up with some of the insights from the project. I didn't necessarily totally tie them

specifically to any particular regulatory decision-making. You're right. Some of these things are indirectly -- anything that improves the PRA and the quality of the PRA and the confidence in the PRA will allow it to be used more readily for risk-informed applications.

But you're right. Some of these things don't have a direct tie to a particular regulatory decision. So, yeah, I'm not exactly sure. I don't really have another category for these things. But I took down your comment, and we will try to see if we can come up with more germane examples for the final report.

ACRS VICE CHAIRMAN KIRCHNER: Well, Alan, this is Walt Kirchner. Vesna, I agree with you. The RCP seal design improvements really isn't a regulatory decision-making issue. It's more of an improvement at the plant.

But certainly, Alan, one thing to consider down the road is there has been a lot of discussion over the years about the LNT model. And this is maybe with the MACCS code and the consequence and analysis a place where one could do a sensitivity study so to speak on LNT versus other statistical cancer-like radiation exposure models that lead to cancer because

it seems to me this is an area where the uncertainty of the statistics is very large when it involves the actual quantitative health objectives.

MR. KURITZKY: Yes. So thank you. That's true. The LNT has a big impact. I'm going to talk more about that in a later slide. If you look up at the first major bullet, the second sub-bullet, I tried to highlight the fact that it really is the use of the LNT that gives you those latent cancer fatalities.

I'll discuss it a little more later on. But a very good point. That is a very influential assumption, as you're going to see -- as I'm going to show you later.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yeah. You have some sensitivity studies that are showing the margins to cure just goes above 800, I mean, because of somebody's misassumption about LNT lets us, you know, often I think those so. So you have done some sensitivity studies as I can see on there. At least I found them in the report so.

MR. KURITZKY: Yes. Sorry. Yeah. Thank you, yes, we do. And there is a slide on it later on in the presentation. Okay. So if I can -- just to go back to the staff, enhancing staff PRA capabilities.

So, again, many of the staff not only got

involved in the project, but they actually got to roll up their sleeves and actually perform certain tasks, you know, modeling, developing models, et cetera. And for many of them, it was their first time that they actually got to really perform PRAs, accomplish actual PRA tasks, as opposed to just reviewing something or reading about it.

Even some of our more experienced PRA analysts, because of the broad scope of this study, they got to work in areas that they might not have had much previous experience into. So there was a lot of benefit gained from being able to do that, to actually do the work.

Also if we are developing a model, we would run into some complex technical issues. And we would have to do a fair amount of rigorous analysis to try and resolve those and so that added to our knowledge base in some cases, actually requiring us to advance the state of practice. You know, the Level 2 HRA being one example of some of the items with the integrated side risk or spent fuel pool being some other examples.

And also we really had the opportunity to apply a lot of the best practices that came from SOARCA into an actual PRA framework. So SOARCA was

more of a consequence study. This allowed us to really incorporate those best practices into a Level 3 PRA.

The staff also got to not only observe but also got to participate in some of the PRA standards based peer reviews that the PWR Owners group very graciously supported and led for us. So that was a big opportunity for the staff.

And similarly, we got to be involved with two expert elicitations that we held for key issues. The first was the interfacing system LOCA frequency that we discussed previously.

The other issue that we addressed with an expert elicitation, really a phenomena identification and ranking table, a PIRT process, that was used to identify the most important combinations of plant operating states and initiating events or hazards for low power shutdown. The number of combinations was just too exhaustive to do in its entirety so we need to kind of prioritize which ones we focus on. So we held an expert elicitation to try and get us insight on that.

And so all of these areas helped improve our PRA knowledge base and the breadth of our experience for the staff.

In terms of documentation practices, we had made use of the standard Agency systems. We use ADAMS for documents both internally and externally, you know, for public documents.

For internal use also, for the working files, we have used the SharePoint system. And we also are making use of the Agency's File Center because that's where we would store on disks files that are just too big to go into ADAMS. And that would be things like the input and output files from MACCS or MELCOR that we want to retain so that we can recreate the results or be able for someone to go back and recreate the results or confirm where the results came from. So those would have to be stored in the File Center.

We also assigned a documentation coordinator for the project because we had so much documentation that needed to be addressed and managed. And much of it we've used to the extent we can templates and forms to kind of standardize how we made key decisions and so to allow people to go back and see how we made those decisions.

So most of that information, both how we control the information processes, et cetera, and the documentation are in the project's quality assurance

plan, which is, I think it's Appendix A. I think it's the only appendix, that Volume 2 that we put out just recently in April. The Volume 2, I think, has an Appendix for the QA plan. And there are more details there.

Okay. The last objective that I'm going to talk about is trying to come up with some insight into the cost of practicality of performing Level 3 PRAs. And this is one I think that was more of importance early when this project was being developed because I think the chairman at the time and maybe another commissioner were thinking of the possibility of having issue-wide Level 3 PRAs performed. I don't think that's really something that is on the horizon at this point. So it is probably less of a concern. But nonetheless, we wanted to at least see what insights we could obtain regarding the practicality of performing Level 3 PRAs.

One thing I think that it's very important to caution is that it is very project specific. Because it really determines -- it's dependent on the number and experience of the people working on the project.

And it's, what's your starting point? How many models already exist? Is there a very good Level

1 or Level 2 model? Are you looking at just internal events and flood or are you looking at other hazards, et cetera? So there are a lot of issues that go into the level of effort to perform this PRA.

And then the question is how familiar are your team members with those other models or with the plant itself? And how much access do they have to the plant, the information on the plant?

So there are a lot of project specific factors that would make any results or, you know, level of effort or cost results for this project not necessarily applicable for the next project to be considered, particularly one that was being considered by, for instance, somebody in the industry.

One of the insights personally that I, having been the lead for this project for 10 plus years, yeah, something like that, this idea of matrixing, matrixing staff.

You know, they have other priorities. And you can't control their schedules and their commitment to the project. It is very difficult. You really need to have a dedicated team. If you're going to do a large project like this, you need a dedicated team if you want to have any type of control over the schedule.

Not only does your schedule suffer from them being pulled off at random times to go work on other projects, but when you have a lot of interconnected tasks where you need Person A to complete something that feeds into Person B's work, if Person A goes away, Person B doesn't have what they need. So Person B goes off and does something else.

Person A comes back. They finish their work, but now Person B isn't available. So now Person C, who wanted stuff from Person B, they can't get it because Person B is not there. It's just a scheduling nightmare.

And also the fact that over this timeline, you're starting and stopping work, it's just you don't get the momentum. You're constantly having to refamiliarize yourself with what you were doing the last time you looked at it. As we all know, if you have to pick something up again months later, it's just not very effective. So really having a dedicated team to perform such a project in my mind is really key.

ACRS CHAIRMAN REMPE: Alan?

MR. KURITZKY: Yes.

ACRS CHAIRMAN REMPE: This is Joy. I'm sympathetic to your issues with this matrix team, but

I also am thinking about thinking about the duration of when this project was initiated and what has happened in the last decade.

Even if you had a dedicated team, don't you suppose that because of Fukushima you would have lost that staff because of higher priorities even if they had been dedicated to you?

I mean, when you have a project that extends this long, I'm not sure if it would have made much difference.

MR. KURITZKY: Very good point. But I will counter a little bit in the sense that if you had a dedicated team and could have finished this project in four or five years, then you are less vulnerable.

ACRS CHAIRMAN REMPE: Point well taken.

MR. KURITZKY: But in reality, you're right because Fukushima occurred right at the time this project started. So even if we had a dedicated team in this particular case, you're right.

However, I would also counter that I'm hopeful the next time someone tries a Level 3 PRA, if someone does, that there will not be another Fukushima at the same time.

ACRS CHAIRMAN REMPE: I share your hope.

MR. KURITZKY: But, yeah, your point is

very (simultaneous speaking). In this case, had we had a dedicated team in 2012, we still would have been in trouble, but maybe not. We might not still be here 10 years later, but we would have been in trouble.

The other thing I do want to mention, too, is in terms of estimating the schedule and the cost. Trying to rely -- with such a large project, trying to rely on some kind of top down or high level estimate of what it would take to complete the project, I don't think is very reliable. I think you really need to break the thing down by task and then sum those pieces back up to see what you're talking about.

That's the first thing I did when I was assigned this project. And I quickly realized that what was estimated to complete the project was just wholly unrealistic. And so I really -- and to be fair, the people that were originally providing those estimates, this wasn't the recommendation they had made to the Commission. They didn't intent to go ahead and do the project right then. They had another option in mind.

So I don't think they necessarily put the level of detail into estimating that they would -- I think they figured the estimates that they gave were sufficient to steer the committee away from this or

the Commission away from this, but that didn't work.

In any case, I think it's very important to spend the time to really break it down and get an accurate estimate because otherwise you're always behind the eight ball trying to get stuff done and trying to explain yourself why you haven't gotten more done.

The last thing I'll just mention is that whenever you have a complex project that has a very big time arc, you are inevitably going to encounter things that are going to get in your way, whether it's staff moving on, transferring, retiring, whatever. Whenever you have a lot of models that are built on other models, no matter how much you try and review and perfect your work, down the road, you're very likely to find something in a model that makes you then pull the string and go back to an earlier model and find out that something was not done totally correctly in the earlier model and then you're stuck with the idea of, do I rework all the models? Do I live with the incorrectness or whatever?

So it's just something that you've got to recognize. There is going to be rework. There is going to be some tough decisions any time a project is going to go over that much time.

Anyway, those are just some preliminary thought at this point. Obviously when we get to the summary NUREG, we'll have more to put in there.

ACRS VICE CHAIRMAN KIRCHNER: Alan, you could -- this is Walt Kirchner. I mean, you could take PRA out of the slide, and you're just talking about a perfect case study for project management. This is why it's so difficult to execute a large construction project these days. All these things are, like you said, I mean, like estimating, that's often missed very badly at the start and then you never recover in terms of a successful project as a result.

So, yeah, what you're showing has nothing to do with PRA per se and everything to do with executing a complex project over a significant time period. It's just an observation.

MR. KURITZKY: Yes, exactly. And that's why that last bullet does say projects. It doesn't say PRA. But for any of you who are in the -- I know a lot of you come from other places. But for any of you in the area, let's go ahead and see how long it takes to complete those toll lanes on I-270 here based on what the estimate was from whatever the Australian company was until they're actually in operation. So

it will be a perfect case study. I guaranty, you're right. It will be a lot longer than they are estimating.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: We have our examples in Boston, you know, in the big, big area.

MR. KURITZKY: Yeah, the big, big, exactly, right, there you go. Yes.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: But I want to ask you, Alan, something very basic of this. Who are those insights for? I mean, obviously, when you guys finish this project, NRC is not going to be doing Level 3 PRAs anymore. So is this insight for visibility and costs of Level 3 PRA for who? For applicants to be used in regulation? Who do you see what these objectives are to be?

MR. KURITZKY: So good point. And I tried to address this at the beginning. So I'm saying that this one really is not that important anymore because initially when this objective was identified early on, the chairman and another member of the Commission at that time I think had thoughts that maybe industry would end up pursuing Level 3 PRAs. The NRC might try to push industry to do that.

And so they really wanted to get -- that

was the purpose of this objective was just so they could provide industry information, hey, yeah, these are feasible. They are reasonable. The costs of effort are not that bad and so, yes, it's worth it to -- for the information you could obtain, it's worth it to put in the effort.

But since that's no longer, I don't think the current Commission's thinking as far as I know or anybody else's thinking, then you're right. This objective is not really that important anymore. So we're not going to spend a lot of effort obviously.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: But it could be an important objective if this is question is about because currently the Level 3 results are not required in the regulation, right? The NRC licensing of advanced reactors just requires the Level 2 results, right?

So the question is -- I mean, this could be applicable for the future regulation. How complex PRA model would you require in the future licensing, you know? Is that important for visibility, you know, because we want to have a streamline in the future?

So if you look -- in that case, you are not just looking in your project management issues, but you're also looking in the technical issues how

much is available, you know, and currently known in certain areas and things like that. You are looking in really the visibility and the value of the results and associated uncertainties so. That could be added to the, you know, the objective to extract insights to enhance regulatory decision-making so, you know, so that's just my comment on this.

MR. KURITZKY: And thank you. I made a note, too, because I'm not sure what the -- I'm not involved in the Part 53 or whatever regulations are for the advanced reactors and whether or not they have to do Level 3 PRAs or just Level 2.

I know there is some Level 3 PRA work incentive for, I think, license extensions or power upgrades or something, I can't remember, as part of environmental analyses. I don't know the details.

But, yes, for the current reactor fleet, which this was originally focused on, I don't think it's a real issue anymore. But for advanced reactor designs, I don't know, there might be some benefit to some of these insights.

MEMBER BIER: Alan, this is Vicki Bier again. This is in a way, you know, following up on Vesna's comment, but also your observation about just how long this process has taken that, you know, since

this was initiated, you know, now sort of the hot topic is advanced reactor designs or novel reactor designs that may not be traditional LWRs or may be much smaller scale, et cetera.

And it would be interesting to have a reflection at some point about any lessons learned from this for that exercise. And, you know, I don't expect you to have a pat answer to that ready today. But, you know, a lot of the detailed lessons learned we're seeing are, as you said, for the current fleet. And are there any general lessons learned that might be applicable as we go forward with a new fleet hopefully?

MR. KURITZKY: Yes. Thank you, Dr. Bier. Right. So I'm not in a position to speak to that. But, yes, that's something that there might be some applicability, again, depending. I don't know offhand what the PRA requirements are for the new designs.

But, yes, certainly if Level 3 PRAs are required, then there is stuff to be learned here. And we've already -- you know, some of the people on the staff that are more involved in Part 53 and other things are involved in this work and are monitoring it. And so we're working with them to try and get whatever information they might want to see out of the

project.

In fact, one of the things that we've already used some of the preliminary project results for was a pilot application of the LMP, the Licensing Modernization Project approach, which was a risk-informed approach, a licensing approach.

And so Matt Humberstone, now with research, I think, was the lead for that work. I think he's done two applications. One using internal event and flood results and another one using the fire, seismic and wind results also to see how well that approach might work with Level 3 results.

So, yeah, there is definitely potential application there for advanced reactor designs for future reactors. And it really will be incumbent on the people involved in that work to see what they can use this model for. But any insights we can provide while we're documenting this study, we would certainly like to do.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Well, you also said that you have documented the area where there is no need -- where there is a need for future research, and areas which are not ready because, you know, as you said in your Slide Number 4, you said there is too many -- simplifications have to be made

and things like that.

So out of this project we would see, I mean, you know, we should see is the state of knowledge ready for some of those applications and assumptions and things like that? There are too many uncertainties related to this so.

MR. KURITZKY: Yes. And I don't want to overplay it. I mean, there is always going to be uncertainties. There are always going to be modeling uncertainties, completeness uncertainties and certainly parameter uncertainties. And it doesn't mean that you can't use it. It doesn't mean that it's not ready to be used in a regulatory application.

We use PRAs in the regulatory space all the time. It's just that the decision makers need to consider that there are other uncertainties and make their decisions accordingly and have things that compensate for those uncertainties or at least characterize those uncertainties, recognize them and be comfortable that whatever decision they are making isn't jeopardized by those uncertainties.

So, yeah, we identify a lot of uncertainties in the reports. It doesn't mean that --

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: In the area which needs the -- for the research you said

in the beginning.

MR. KURITZKY: Yes. The ones that we think would be good candidates for more research we identify. That doesn't -- don't read that to mean that necessarily that if you don't do that research you can't use the PRA. That's not our intent. It's just that if you're going to spend more money on PRA research, here are some areas that we think are the most important ones to pursue.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. Hey, I mean, you know, there is question of using PRA not just because, as you already say, PRA is widely used in the research. I just want to say in certain specific areas, you know, because, you know, you said that you don't necessarily endorse many of the approaches here.

And I assume that this lack of endorsement is because there is need for the future research which can conform, you know, using this. So I just want to say there are certain limitations from here which can also hamper making a decision, you know, how to approach future regulations.

MR. KURITZKY: Yeah. And I don't want to play semantic games. But you said many, there are many areas where we feel that there is simplification,

how to do -- I want to say -- I don't know about many. I mean, a relative term. There are definitely some. But as I said earlier on, the vast majority of areas, I think are adequate.

There are some places where we had to make some simplifying assumptions because of lack of information or time and resources. But for the vast majority of modeling areas and decisions, I think we are on solid ground.

But, yes, you are right. There are definitely still some things that are not, you know, completely tied up that could benefit from our work. And depending on what the application is, the decision maker has to determine whether those particular items are critical to that application or decision or whether they are not. And so that is something that will always exist when making risk-informed decisions. But, yes, thank you. I do agree with your point.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. Well, thanks, I this could be the good place because then we are switching to results after this. So I think this would be a good place to -- we are a little behind in the schedule. But this would be good place to make a break. So I have 10:25 here. So let's make a 20 minute break and get back at 10:45, 15 minutes

before 11. Okay?

MR. KURITZKY: Okay. Thank you.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: All right. So see you back at 15 before 11.

(Whereupon, the above-entitled matter went off the record at 10:25 a.m. and resumed at 10:45 a.m.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay, so we are ready to start the second part.

We are running a little on the late side because but, so let's try to streamline to those slides and we have a public comment, and we want to discuss future work.

So, keeping this in mind, let's move through the slides, Alan.

Thank you.

MR. KURITZKY: Okay.

We planning to be done this at 11:20. Okay, I will pick up the pace.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes, thanks.

MR. KURITZKY: All right, so let's move on to the main topic, which is the overview of the reactor at power PRA for internal events and floods, that was the volume 3x that we asked for public

comment on.

And, that's what addresses both the original model, and the updated FLEX case.

And, was mentioned previously, I think John may have may have mentioned, I may have mentioned, I don't recall.

But the original models were based on the plant design, the reference plant design information from back in 2012, it's design operation. And, a lot has obviously happened in the ensuing years.

So, the original model, which we call the Circa-2012 case, did not consider things such as the new reactor coolant pump, seal designs, as well as FLEX strategies, and a few other things.

And, so we have performed a sensitivity analysis, which we refer to as the 2020-FLEX case, which looks at some of those newer developments at the plant, and also has, uses some newer assumptions.

And, requantifies the risk for all three PRA levels. And, this serves not only to give us an evaluation or examination, of the current risk at the plant, but also serves to demonstrate how the model can be used to evaluate plant design changes, or be used for other risk informed applications.

So again, the specifics for the 2020-FLEX

case, we incorporate the new shutdown seals, the new RCP shutdown seals.

We also consider a FLEX implementation for, again for ELAP, for the extended loss of AC power.

Certainly, the strategies and the equipment for FLEX, well I'm sorry, the equipment, the FLEX equipment, can be used for other things besides ELAP, if the plant has sufficient procedures and training to take advantage of that.

But for this study, we're only looking at the ELAP situation.

In addition, if the FLEX is not successful, we also give credit to continued operation of the turbine-driven aux feed, to feed the steam generators in an extended station blackout situation, where all AC and DC power have been lost.

This is what previously is sometimes termed as blind feeding of the steam generators. And, this is something that we did not credit in the base model, the 2012 case, because we felt the likelihood of success was very low. And, also wouldn't necessarily lead to a stable condition.

But however, for the 2020-FLEX case, we felt that, you know, in the interest of best

estimates, we will go ahead and give some credit to this operation. Particularly now that the FLEX equipment is available, too.

ACRS CHAIRMAN REMPE: So, Alan, this is Joy. And, to honor trying to expedite, I've got some questions about this turbine-driven auxiliary feed water pump operation.

The BWR Owners Group, and organizations, couple of other organizations including some from Japan, because of what happened with the rig C at unit 2 of Fukushima, sponsored a lot of terry turbine testing that was done at Texas A&M. And in conjunction with some folks from Sandia, perhaps.

And, it's my understanding insights from that testing, could also be used to improve the extended operation for the auxiliary feed water.

And, I was curious if this new model considered some of those insights. Is this something that the PWR Owners Group used that information? And, I emphasize that it's important.

The BWR Owners Group actually used it in a, to respond to, I'd probably say, a derecho event at Duane Arnold couple of years ago.

And, so anyway, I'd like to know more about that. And, maybe you're not the right person,

but is there someone who could talk a little bit about what was done, and how far that this has been incorporated in the PWR Owners Group's revised strategies for accident mitigation.

MR. KURITZKY: Okay, so one of the answers to one of the questions that was yes, I'm not the right person to talk to this.

But I would also mention that really, in the interest of keeping things moving forward, this is not really the forum for that, that discussion.

For this project as I'm going to mention shortly, we used a very rough model for incorporating the FLEX, and the extended turbine-driven aux feed.

So, the level of detail that would be influenced by that research, isn't really applicable here most likely.

But again, I'm not the person to talk to that, and I would further mention that this is probably not the right forum either.

ACRS CHAIRMAN REMPE: Okay. It's something that I think might be important, and so perhaps it would be good to investigate it at a later discussion with this new FLEX update.

MR. KURITZKY: Okay, yes. I took that and I put down a note about that, the research you

mentioned, and we can certainly look into it after the meeting.

ACRS CHAIRMAN REMPE: Okay, thank you.

MR. KURITZKY: Sure.

ACRS CHAIRMAN REMPE: That's fine.

MR. KURITZKY: Okay.

So, going on to the FLEX, so most of you of course, are familiar with the FLEX strategies. I just want to just to reemphasize there's three basic phases for dealing with ELAP event.

In phase one, you're really just using the plant installed equipment. Maybe doing a few additional things, like shutting DC loads to extend battery lifetime.

Phase two is when you start to actually use the FLEX equipment that's onsite.

And, phase three is when you start to bring things in from offsite. For instance, from the safer centers, or other offsite equipment.

And, this analysis, what we've done here just focuses on the first two phases. We're not looking into the offsite equipment.

And, I also want to remind everybody that this is just looking right now, at internal events and floods.

We will do the same thing for the other hazards later, but in this presentation, the results are just for internal events and internal floods.

CONSULTANT SCHULTZ: Alan, this is Steve Schultz.

As you go forward to do those other evaluations, are they going to be limited to the ELAP event and --

(Simultaneous speaking.)

MR. KURITZKY: Yes.

CONSULTANT SCHULTZ: -- the time frame?

MR. KURITZKY: Yes, right now --

CONSULTANT SCHULTZ: So no changes there?

MR. KURITZKY: -- the same thing. It's just because the procedures we have since I only address ELAP, and so that's all we'll of course, credit it for.

And, it's the same thing. The time frames aren't really changing when we look at some of the other hazards.

I mean obviously when you look at things like seismic, other things where you can't expect to get offsite power back for quite some time.

But our mission time is really looking the 72-hour time frame, so it's really covered by phases

one and two.

CONSULTANT SCHULTZ: Okay, well that's our expectation.

Thank you.

MR. KURITZKY: Uh huh.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Well, Alan, isn't your containment late failure longer than 72 hours, right?

MR. KURITZKY: Yes, containment, yes.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So, why didn't you consider then, phase three for those cases?

MR. KURITZKY: Okay, so we'll discuss coming up shortly, the credit for the FLEX primarily is impacting the level one PRA. It's the frequency of core damage.

We don't really consider it for the level two and level three, except for the impact on the, and for level two, the impact on the release category frequencies.

And, really the same for level three. It's just the impact on the release category frequencies.

So, there is not really procedures there for specifically for precluding containment failure.

That's really contained in the SAMGs, you know, mostly maybe some of the EDMGs.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay.

MR. KURITZKY: So, at least for us, we didn't see any real implication for level two.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay, so recovering containment heat removal was not the issue in this.

You have this really high, you know, frequency, or high probability of a containment late failure.

Almost all, you know, sequences, like 80 percent of them or something, leads to containment late failure. So, I was wondering, I mean, would.

And more so, those are coming from loss of offsite power, right?

MR. KURITZKY: Yes, many of them. Not all, but a high percentage of them.

And, but we will, as we'll go through the slides, you'll see that we do look at an alternative analyses where we look at actions, longer term actions.

And, I mentioned before, for the level two post-core damage, we only look at one action prior to a vessel breach. And, we look at one action within a

few hours of vessel breach.

But we do a sensitivity case where we look at some longer term actions to control containment pressure, for instance, then other things.

So, it's not tied specifically to the FLEX, but we will look at what the potential impact could be if other actions are taken longer, in the longer time frame.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: All right, okay.

MR. KURITZKY: All right, so how do we model the FLEX. Again, this is as I mentioned, a fairly coarse modeling.

What we did was we just added three new nodes to the station blackout event tree. One for each of the main strategy areas here, which is the RCP seals, the new shutdown seals.

Declaring ELAP and implementing FLEX, and then the continued operation of a turbine-drive aux feed, the blind feeding.

And, each one of these event trees is really just a single, there's just a single basic event associated with those event tree nodes.

As we talked about previously, for the seals we just had a, assume a .01 failure probability

for the shutdown seals to close and remain closed.

For each of the other two actions, the operator actions for the FLEX and the turbine-driven aux feed, we assigned an all-encompassing human error probability of .3, just using expert judgment.

And, that HEP is assumed to account for any other electrical or mechanical failures that would be associated with, with those actions with the idea that that .3 would be much higher than the contributions from those other failure modes.

I think some of the initial FLEX data coming out of industry actually might, you know, it was higher than some people may have initially thought.

But I still think the .3 is, adequately covers that. And, we're going to discuss in a slide or two, we do a sensitivity on that .3 guide to determine how much it influences the results.

So, that's essentially how we incorporated it into the model, with the exception that this shutdown seals also can impact sequences beyond just station blackout.

So, the reactor coolant pump seal integrity of entry node, which exists over in the other event trees, we in the fault tree for that node,

we have incorporated the shutdown seals, and in with the original seal.

So, we can take credit for the new shutdown seals for these other sequences also, not just station blackout.

The last thing I want to mention here, too, is that since we make the changes to the station blackout of entry, there are also cases where we have a loss of offsite power, not as an initiating event, but consequential to some other initiating event.

And, in those cases, since they would not be, they could benefit from the FLEX equipment, or the extension of turbine-driven aux feed, but it wouldn't get picked up just from the changes to the station blackout of entry.

So, we used post-processing rules on a cuts it by cuts it basis, to apply this credit. And, that's kind of a manual operation, so we work our way down the list of dominant cut sets looking for patterns that would be indicative of a consequential loop, and station blackout.

But looking at some of the actual results that we have for, first were level one PRA. If you look at the left pie chart, which is for the Circa-2012 case, the CDF 6.5 10 to the minus 5 for reactor

year, that was the core damage frequency we had for internal events and floods.

And, you can see that a loss of offsite power, I don't know how big this chart is or how well you can see it, but loss of offsite power, the dark blue on the right, is clearly the dominant contributor. Over 60 percent of CDF.

The next biggest contributor is loss of nuclear service cooling water, that's the orange slice. That's almost 14 percent.

And, you also can see that internal flooding, for example, at the very top thin dark red or brown slice, is only about 1 percent of internal event CDF.

So, internal flooding not really a big issue here.

If you go look at the right chart for the FLEX case, you'll see that CDF comes down to 2.7 10 to the minus 5 per reactor year, so that's a reduction of around 60 percent.

You still see that loss of offsite power is a dominant contributor, little under 50 percent here, but recognize that while it's still relatively a big contributor, it's absolute contribution has come down significantly.

It's a large, it's the largest piece of the pie, but the pie is much small now, even though it's the same size on this chart. But in fact, it's a much smaller pie.

And, the other thing that you see in a big reduction, is the loss of nuclear service cooling water, which now is a 5.5 percent contributor. And, that's 5.5 percent of this smaller pie.

And, that is not to do really with the FLEX changes, which the FLEX and the turbine-driven aux feed are very effective at reducing LOOP contribution.

But the NSCW reduction really comes from the new seals. Because the loss of NSCW is dominated by RCP LOCAs, and so the new shutdown seals are, is what really, or what really knocked that CDF contribution down.

Digging a little bit deeper into the level one results using my favorite importance measure, Fussell-Vesely, here are some of the dominant contributors at a basic event level.

So, the top contributor is operator failure to restore the systems after AC power is recovered.

So, once you have a LOOP or an SBO, as I

mentioned before, at this plant you have two hours, in our model you have two hours to recover offsite power before you lose DC power.

If you recover the offsite power in that time frame, you still need to restore the systems, because now they're not going to automatically load up on the diesel, or on the emergency buses.

So, there is some actions that have to be taken and --

(Simultaneous speaking.)

CONSULTANT BLEY: Is this the point three, Alan?

MR. KURITZKY: Yes?

CONSULTANT BLEY: Is this your point three for the operator effective?

MR. KURITZKY: Oh, no, no, no, sorry. This is not. That is the fourth bullet down.

This is just --

(Simultaneous speaking.)

CONSULTANT BLEY: Okay.

MR. KURITZKY: This operator action exists in the initial model two. At least any time you have a LOOP, there's a chance that you'll recover offsite power.

And, then you have to consider the fact

that once you recover offsite power, you may not restore the systems.

So, this is not FLEX specific.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So, all right. This is just a PRA question. I mean you know, but the thing is like this operator to restore the systems, those are, you know, are you applying this generally, or are you system specific that some systems may not need this action, right?

A lot of separate systems already connected to emergency buses, would not require this action, right?

MR. KURITZKY: No, no, this is in the original station blackout tree. If you have a station blackout, if you have a LOOP and a station blackout, you're, if you have a station blackout, you're not going to load any of the emergency equipment onto this, onto the emergency buses.

Or if it had been loaded and the diesels then failed, then it's going to get tripped off.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: It will --

(Simultaneous speaking.)

MR. KURITZKY: It's not going be operable.

So, when you do recover, if you can

recover offsite power at that point, at some point forward before the DC batteries run out, then you need to take actions to reinitiate that equipment.

It's not going to come on --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: I see, so this is basically equivalent just to recover the loss of power after a certain time, right?

It's equivalent to the what you --

(Simultaneous speaking.)

MR. KURITZKY: Yes, yes, you recover offsite power, then you need to take these actions also, yes.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: All right.

MR. KURITZKY: Yes.

And, this contributes, oh and sorry. So, these results I'm providing now are just for the FLEX cases. These are not for the base case.

In some cases, there could be similar results for the base case, but these are just for the FLEX case.

And, so this contributes around 25 percent of CDF, so that I think it was 2.7 e minus 5, 25 percent of it involves this particular failure.

And, there's not really a cognitive component here. It's really, it's just the sheer number of actions, it's really a implementation failure because of all the actions that need to be taken in the time frame.

So, that's the biggest contributor. The next biggest contributors are the failures of the diesel generators A and B, to run for their mission time.

Eighteen and 16 percent contributors as you see. And, those, that's not in addition to the one above.

Actually, those failures tend to be in the same cut sets with the, with that operator action from the first bullet. All part of those station blackout sequences, and then recovery of offsite power but failure to, to initiate the appropriate safety equipment.

The next biggest contributor is the consequential LOOP following a transient, as I was just mentioning I think on the previous slide.

You can loose offsite power subsequent to some other transient. You know, for instance, if you just have a reactor trip, you're going to tax the local grid because you've lost this, the voltage

support from the, from the operating unit, which is a big hit to the local grid.

In addition, you're going to transfer the non-safety loads from the unit auxiliary transformer, over to their reserve auxiliary transformers, which get their power from the grid. So, that further taxes the grid.

And, if the grid voltage sags low enough, such that you trip the under voltage protection relays for the emergency AC buses, then you end up getting a, what we call a consequential loss of offsite power.

And, even though these events are recoverable by the FLEX equipment, but you still see a fair amount of contribution from either failures that are not, for which FLEX cannot recover, or also as I mentioned before, this was something that was addressed through post-processing, and the manual process as we worked our way down the top cut sets.

And, so some of this contribution could be coming from cut sets that were low enough down the list, that we never bothered to go correct for them to apply to recovery.

And, so this number could be somewhat of an over estimate of the actual consequence, or LOOP contribution.

The next bullet is specifically the actions for implementing FLEX, or the continued turbine-driven aux feed.

They both have an 11 percent contribution. It's the exact same contribution because they occur together and all cuts sit together. Both events so joining one to be successful, both occur in all cuts sits together, and that's an 11 percent contribution.

The next biggest contributor are, is the failure to trip the reactor coolant pumps, if you lose all seal injection and cooling.

And, we actually have two human failure events in the model for this. There's one event, HFE, which applies just to the loss of nuclear service cooling water, or loss of auxiliary component cooling water.

Because in both of those cases, there's a big focus on, those systems are what are used for seal injection of cooling, and so there's a big focus on tripping those pumps right away so it's a very reliable action.

Whereas for all the other initiating events, there's many other things the operators are directed to try and deal with first.

And so by the time they get to this action

to trip the pumps, there's a very tight time frame. And, so the failure probability is much higher.

Nonetheless, the two events together contribute around 11 percent of CDF in the FLEX case.

The last one I want to mention, which only contributes about 8 percent each to the FLEX case, but I want to mention it just because they are huge contributors to the base case that the 20, the Circa-2012 case, they were contributing nearly one-third of CDF.

And, that's common cause failures of either the high side input breakers to the RATs, or common cause failure of the diesel generator load sequencers.

In both those cases, you get non-recoverable station blackout situations, and those, luckily those failures are, you know, can be recovered by FLEX and so the contribution drops significantly.

But they still make an 8 percent contribution each. Even after accounting for the FLEX and the turbine-driven aux feed.

So, that was a little more of the detail information. I want to just one other thing on the level one I want to bring up, and this goes back to the point three that we talked about before, for the

human error probability for implementing FLEX, or implementing or continuing to operate the turbine-drive aux feed without AC or DC power.

So we looked at trying to get, gauge how influential that was for the CDF. We looked at several other cases.

If you look at the chart, a relatively busy but the last, this last row in white p equals f times t. This is a parameter we define, which is just a failure of probability to implement FLEX, times the failure probability to continue the turbine-drive aux feed.

As I mentioned, you just need one or the other, so you have to fail both to lead to core damage. So, p is the combined failure probability.

Since we assigned a .3 for each as you see in column four, p is .09. So essentially 91 percent success rate for one or the other.

And, that reduced the CDF from 6.5 10 to the minus 5, down to around 2.7 10 to the minus 5.

If, and we looked at several other values, if you go all the way to the right column 6, if FLEX were to be implemented perfectly, in other words, you'd have zero failure probability for either of those two actions, or actually since they're

multiplied you just need zero for one of them.

And, therefore, p is zero, you can see that the CDF really only goes down another 10 percent, to 2.37 e minus 5. So it's not that sensitive to improved performance of FLEX.

And, on the other, going the other direction and look at column 3 where we raised the failure probabilities each to .5, so p goes to .25, therefore we only have 75 percent likelihood of one or the other action.

But CDF really only goes up another 20 percent, to 3.2 e minus 5. So, either direction we see that the CDF is not really very sensitive to whatever value we pick for, for those ACPs.

And, so therefore, that really justifies for us that there was no need to put a lot of effort into a more rigorous analysis.

That's not to say that for some other application, you know, for example a event assessment, or some other regulatory application where a more refined number is necessary, that it shouldn't be done.

I mean for some of those cases, you might want to use something like the ECA, the IDHEAS-ECA tool, or some other means to get a more accurate HEP.

But just for the purposes of this project, it wasn't necessary to go the extra step.

So, that's all I want to say --

(Simultaneous speaking.)

ACRS CHAIRMAN REMPE: So, Alan --

MR. KURITZKY: Yes?

ACRS CHAIRMAN REMPE: These are point estimates.

MR. KURITZKY: Yes.

ACRS CHAIRMAN REMPE: And, you talked a little bit about propagating uncertainties in the main report.

Do you want to summarize of your giving best estimate and point estimate values in these tables, and why uncertainties weren't propagated, or mean values used?

MR. KURITZKY: Okay, so these are point estimates, but we did propagate uncertainties. It's not on this slide. If you look in the actual, I think the report itself, the OV report has a uncertainty curve. Because we did propagate uncertainties for these events, too.

This table, like all the results we provide point estimate results, but then we also performed uncertainty analysis where we going to do

Monte Carlo sampling, and we come up with uncertainty distributions. And, mean is 95th percentile, is et cetera.

So, we did propagate forever uncertainty for all these cases. Excuse me, not for all these cases in this chart, but for the base case results and for the 2020-FLEX results, we did propagate parameter uncertainties.

ACRS CHAIRMAN REMPE: Okay, I thought I read somewhere where there was an issue with trying to propagate some of the uncertainties due to a lack of knowledge.

But perhaps I need to re-read that part.

MR. KURITZKY: Yes, I mean we did run into some problems with because of the curb, where some of the events that have very high failure probabilities. The Monte Carlo sampling technique used in the sapphire code, will throw out events from the tails if they exceed 1, if a probability exceeds 1, or is below zero, right. So, physically meaningless numbers.

And, so it tosses those out. And, some of the cases where we had fairly high failure probabilities that you get in sometimes in level two modeling, or in seismic modeling, for instance, you can toss a lot of events out.

And, so, you know, we might try and run say 5,000 Monte Carlo samples as a base number to use, but in many cases, we only were able to get a much lower number of samples because so many of them would get thrown out.

And, so we did take some steps to reduce that by tightening up the distributions on the upper end, but nonetheless, it was still an issue.

But in general, we had to propagate the uncertainties for --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So Alan, did you see difference between mean value and point estimate in that, those uncertain a significant difference?

MR. KURITZKY: Not generally. And, again, in the actual reports itself, you'll see tables that list the point estimate, and then the means, and some of the other percentiles.

And, you can see if the point estimates and the means are in fairly decent agreement. I mean to me, in pair --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Well, that's not really surprising, because you have one of

your main contributors to be individual these are generator failures.

And, if you have individual these are generator failures sampling from the same distribution, that will have a significant impact of state of knowledge relationship.

And, I would expect to see, so one of the question is, did you sample all parameters as independent?

MR. KURITZKY: So --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Or how do you sample them? Or you sample them based on the failure rates that are the common cause? How did you sample them?

MR. KURITZKY: Okay, so --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: I mean, you see state of knowledge when you are using the, you know, the same distributions in the cut sets?

MR. KURITZKY: So, I'm not --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: In part of the --

MR. KURITZKY: So I'm not the expert in this area.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay, we don't really have time for this discussion, but I'm just want to tell you I was surprised that you have individual these generators contributing in the Fussell-Vesely significantly.

I would expect to see the big difference in the mean, and point estimate. That's my comment, all right?

MR. KURITZKY: Okay, so thank you.

So, just again, I'm not the expert here. Someone else could weigh in if we wanted to spend the time, but just as a quick answer, particularly for the diesel generators failure to run.

Because that state of knowledge correlation is very important.

So, that is accounted for in the model. So, when we look at the individual diesel generator failure to run combinations, we do consider the state of knowledge of correlation there. So, that's accounted for in those values.

And, yet and still, the fail to run for the 24-hour period, the individual ones, independent ones, still because of that, it's a higher failure

probability than the common cause failure to run for those two.

But nonetheless, we have accounted for that in that case.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay, all right.

MR. KURITZKY: Okay, so moving on to level two, just a little bit of some of our interim level two results.

We have looked at several risk metrics. We have looked at the total release frequency, which is just the sum of all release category frequencies.

And, then we looked at two other surrogates here, which is the large early release frequency, which you're very familiar with, defined in our project as anything where the release was large enough and soon enough, that you could expect the potential for early fatalities.

And, then we also have LRF, large release frequency, which really is defined as any of the release categories where you would have failed containment unless the, because of scrubbing or some other mechanisms, the release magnitude would be, you know, the source terms would be down around the same that you would get from a non-failed state.

So, those would not fall under the LRF category.

And, as you see, LERF is a very small contributor, even for the Circa-2012 case. It's only about 1 percent of CDF, so not a big contributor.

On the other hand, L-R-F as was mentioned earlier, is a big contributor, around 60 percent of CDF results in one of these large releases.

And, while large releases don't result in any PROM fatalities, they do, can result in latent cancer fatalities, and severe economic consequences. So, it's not a no never mind. So, that was one insight from the Circa-2012 case.

And again, that's because as was mentioned earlier, we carried out the severe accident progression analysis for seven days. And, we'll talk more about that in the next table.

CONSULTANT BLEY: Alan?

MR. KURITZKY: Yes?

CONSULTANT BLEY: When you say the L-E-R-F is not a significant contributor, that's to core damage frequency. That's not to overall risk, right?

MR. KURITZKY: Yes, that's frequency. So in level two now, we're just talking frequency and you're right, that's a good point.

You know, we're going to talk about some of these things from a risk point of view, which is going to change things a little bit.

Because obviously, you know, release categories that are a low frequency that have high consequences, can be more significant from a risk point of view.

So, yes, it's a good point.

Okay, so --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So, Alan, so how do you define CCFP in the table below?

MR. KURITZKY: No jumping ahead, I'm sorry.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: No, no, because I want to tell you what I see here is that this doesn't meet the safety goal of NRC from the containment informants for advance reactors where the, the report largely and CDF, right? And, you have a .6 and it's required to be below .1.

MR. KURITZKY: Yes, so, CCFP is conditional containment failure probability.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Right.

MR. KURITZKY: And, yes, and these cases we have a much higher failure probability for the containment.

Again, but again, I'm going to go over a couple of sensitivity cases and the one you see at the bottom here, as well as one on the next page, the next slide, which will talk about some of the key assumptions that go into that value.

And, so then you can take that for what it's worth. So, let me if I could, just finish up with this first table and then we'll get into those issues.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay.

MR. KURITZKY: So, just real quickly. You see on the first table, go to the second column, the FLEX case, you see that that total release frequency comes down around a little over 60 percent, consistent with the CDF reductions. It's not surprising.

The LERF only goes down around 40, less than 40 percent because you're getting a significant contribution to LERF from interfacing system LOCAs.

And, the IS LOCAs are not, you know, the changes that are in the 2020-FLEX case, don't impact IS LOCAs so you don't, so you have a limit to how much that FLEX will reduce the LERF.

So, that's around 40 percent.

L-R-F you also see around the 60 percent contribution because those have a very large station

blackout component, so you get more, more fully the benefit of the changes that are in the FLEX case.

Now, going down to that second table, when we, we wanted to get a good understanding of long term severe actions behavior, and radiological releases.

And, so we modeled the, you know, in our severe accident analysis, we took things out until a safe, excuse me, to a stable state, we tried to model things to a stable state, with the seven day backstop. Obviously we can't run them forever.

And, so many of the cases made up the representative sequences for the release categories go out the full seven days.

Some became stable, or excuse me, became, yes, became stable before that.

So, if you can also recall, I mentioned we only consider post-core damage actions to terminate or mitigate releases.

One action before station, one action before vessel breach, one action within a few hours of vessel breach. Nothing in the long time frame. And, also nothing for station blackout because of loss of instrumentation.

So we wanted to see, okay, well, what if other actions could be taken to ameliorate things in

the longer time frame, then let's see what the impact would be first off, by looking at a shorter time frame.

What if we stopped the analysis at a couple earlier points in time? So, the two that we looked at were pegged to the entry into the Severe Accident Management Guidelines, which occurs at core damage.

So, we looked at 36 hours after a SAMG entry, and 60 hours after a SAMG entry. And, of course, core damage or SAMG entry is very sequence specific.

But in general, for most of the cases, it was generally somewhere between a few hours after event initiation, up to about 12 hours after event initiation.

So, these two, so SAMG plus 36 hours, and SAMG plus 60 hours, roughly two to three days after, after event initiation.

So, the first thing we see is for LERF, there's no impact. Because the LERF occurs early on, before any of these actions are going to happen. Before SAMG plus 36 hours. No impact there.

But we can see for the L-R-F and the conditional containment failure probability, there's

obviously an impact from these earlier time frames.

Looking at L-R-F for both of the early time frames, you see a fairly significant reduction in L-R-F.

And, that's because one of the biggest frequency contributors to L-R-F, is the release category late containment failure. And, that's a failure that occurs tens of hours after vessel breach, due to static overpressure.

And, that representative sequence that was qualified in medical for that release category, doesn't actually get up to what we would, our threshold for a large release until almost the full seven day period.

So, at both of the earlier time frames, you have a release going on, but not nearly what we would quantify, or characterize as large.

So, you see a fairly substantial reduction in L-R-F for those two cases.

For the conditional containment failure probability, SAMG plus entry plus 60 hours you still have a fairly large CCFP, but if you look at SAMG entry plus 36 hours, it's very much reduced.

And, that's for pretty much the same reason, the L-C-F release category, that late static

overpressure failure.

In the case of SAMG plus 36 hours, you haven't even failed to contain yet. The representative sequence doesn't actually fail containment until I think, about eight hours after that. So, I think about 44 hours after SAMG entry.

So, SAMG entry plus 36 hours you have a much lower CCFP, and then it jumps up in the later time frames.

And, so there's two really big takeaways from this analysis. One is, if you can take action to prevent a containment failure in two to three days after the event initiation, you can potentially avert a large release. So, definite potential benefit there.

On the other hand, what this tells us is if someone were to submit an analysis, a level two, a severe accident analysis to the NRC or for any other purpose, and they only took their analysis out 24, 48 hours after event initiation, they could be vastly underestimating what the true risk is.

So, you know, both sides of that coin.

So that --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: For

example, containment analysis goes to 72 hours, you know, you're familiar with that so it's three days. So it will cover your first and second, second and third entry.

So, this is what my question was. When I saw this, you know, because all, you are, you know, I know you guys have been very busy, but you haven't been living in Cancun. You know the advance reactor requirements are, you know, that for CDF, LERF, and CCFP.

And, it seems like here you are showing that that safety goal of .1 supersedes CFP, is not met.

Because you know the advance reactors don't report large early release. They just report large release frequency.

So, CDF, large release frequency, and CCFP, so there is something here which is an interesting.

Obviously, it seems based on this the advance reactors are underestimating large release frequencies.

Something is, I find that interesting. So, I mean, you know, informative from regulatory point of view.

MR. KURITZKY: So, sorry, let me, Vesna, if I, did you say that for advance reactors, they are told to take the analysis out for 72 hours?

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes.

MR. KURITZKY: For containment analysis?

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes.

MR. KURITZKY: Okay, all right.

No, I haven't been living in Cancun, believe me, I wish I was living in Cancun. But I have not been involved at all, in advance reactors.

My day job here with this project keeps me pretty occupied. But that's interesting that --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes, but you have to keep them straight in this regulation thing. Based on your experience with these things.

So, okay, so because that's always was very interesting question, what is actually CCFP because for the operating reactor, it was CDF versus SLRF, and then for advance reactors suddenly it becomes CDF versus large release.

And, you know, and nobody ever bothers to put those definition now for the, you know. But the thing is like one of the requirement the containment performance is always, you know, the early fail 7

percent of the cases.

So, that's not even in the best case here, we don't see that. So, there must be some assumptions in this release category so I'm not sure about.

Okay, all right, proceed because we don't have too much time. But there is so much interesting discussion can be, we can have in this.

MR. KURITZKY: Okay, yes, and thank you for that insight. And, again just to be clear and I'll go on the next slide too, to talk about some more uncertainty with this analysis.

But this is for the, you know, the existing reactor. This is for this particular plant. And, so advance reactor and the performance of their containments, you know, the approaches that are used here could be useful in, to some extent for looking at advance reactors.

But I wouldn't necessarily want to translate the results from, this to an advance reactor design.

But in any case, moving on to the next slide if I click on the right spot, there is as I mentioned before, we only consider two upper actions in level two space post-core damage.

We consider one prior to vessel breach,

one some hours after vessel breach. And, though we take the analysis out and oftentimes to seven days, we don't consider any other longer term actions.

And, so in reality, other actions, you know, could potentially be taken. And, so we want to get an idea of how they might influence the results.

So, we looked at three different potential recovery, types of recovery actions. Preventing significant combustion events; controlling containment pressure; and, funding containment to prevent a base mat melt through.

And, these results if you look in this table, you can see, and for each of these things we evaluate it be assuming a failure probability of .1, just a judgment call just to get a value.

And, we also do not consider the negative impacts of some of these actions, because in level two space the actions you take that you think are helpful, could be detrimental.

So, it's not as clear cut as in level one space.

But nonetheless, looking at the impact of some of these actions, we can see that first off for LERF, there's no impact.

Again, because these actions are in the

long term, so the LERF has already occurred.

But for L-R-F and CCFP, you do have some impact. If you look at the light blue rows, you can see that the actions to control pressure, like venting or restoring containment cooling, or containment heat removal, those can have a significant impact on LRF. Knocks it down you can see by almost a factor of three.

Also, if you combine that with the combustion, you know, action to prevent combustion, you can get a further reduction.

You don't see much reduction just from the actions to control combustion, or actually to prevent significant combustion early on, because if you prevent the combustion event, those sequences in our model end up going to the late, the LCF category. They go to the static overpressure failure.

So, you're delaying the release, but you're not preventing it. And, so from an LRF point of view, there's no additional benefit.

But from someone who has mentioned before, from a risk point of view, there are still benefit to be had, because the magnitude of the release would be lower under the LCF condition, than it would be from the combustion, the burn. The gas burn failure.

So, again LRF isn't really impacted, but overall risk could be impacted.

The base mat melt through one doesn't show much of a benefit, because we only look at aqueous releases. Actually, we only look at airborne releases. We don't look at aqueous releases.

So, preventing base mat melt through, the base mat melt through has a very low release magnitude anyway. It doesn't qualify as LRF to begin with, so reducing it isn't going to really buy you anything.

But it does reduce the conditional containment failure probability, but it does not reduce the LRF.

Okay, so that's it for level two. I just now I want to move on to and quickly, just some quick level three insights.

So, again for this presentation and in the overview report, we really only look at the two risk metrics that are associated with the QHOs.

The individual latent cancer fatality risk, and individual early fatality risk, though we have evaluated many other risk metrics in the reports.

And, so what I want to show here is that the dominant release categories that contribute to the first QHO, the early fatality risk, it's really

there's four release categories that really contribute.

The first one being event V, which is an interfacing system LOCA. In this case, the aux building has failed and so you don't get, you don't get the filtration from the aux building.

And, also the release point is not scrubbed. It's above water, and so there's no scrubbing from an overlying pool of water.

The second release category that's here is the same thing, but you now have the release point below the water level so you do get some scrubbing.

The third contributor is a temperature induced steam generator tube rupture, that occurs after core damage. Again, there's no scrubbing, no scrubbing from either sprays or overlying pools of water.

And, the last one is just a steam generator tube rupture that occurs before core damage, that results in the core damage.

But you also have a release that the water level, and the affected steam generator is below the release point so there's no scrubbing.

And, also one or more secondary side valves are either failed open, or intentionally put

open and so you have, you know, that exacerbates the release.

As you can see, the first two, the interfacing system LOCAs are by far the dominant contributor to the base case. But you do have a 10 percent contribution from the induced steam generator tube rupture.

If you go to look at the FLEX case, again there's very little impact on this risk metric, because IS LOCAs do not benefit from the strategies that are implemented in the 2020-FLEX case.

But the induced steam generator tube rupture, does have a fairly significant contribution from station blackout, so it gets a 60 percent reduction.

And, since it's a 10 percent contributor, you see overall a 6 percent reduction in this risk measure.

For other, for the other --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Alan, I just want to mention I am trying to see this in the report while you're talking.

But one of the steam generator tube rupture was followed by consequential LOOP, right?

MR. KURITZKY: No, no.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Because I thought I saw that in description of release category.

MR. KURITZKY: And, it said --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: And that, okay, are you able to situate the tube rupture initiative, and consequential LOOP occurs for the generator? I mean the last one.

MR. KURITZKY: Okay, so --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: It says -- so therefore, that's the one I mean you can see there's some FLEXing part under, you know, because it's followed by the LOOP.

MR. KURITZKY: Right, so if you recall for consequential LOOPs, because that's not picked up automatically --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes, yes. Okay, you don't really lose. Okay, I see.

All right, plus in addition, all of those events are just direct containment bypass, so.

MR. KURITZKY: Yes.

Okay, so and I just want to mention, the other early, early risk metric, which is total early fatalities, has essentially the same dominating contributors. They're pretty much the same for both early risk metrics.

Moving on to the QHO for latent cancer fatality risk, here in the table it's just all the contributing release categories that contribute at least 1 percent to this risk metric. But again, you can see it's really dominated by two, two of these categories.

It's this late containment failure due to static overpressure, which we talked about previously, and this intermediate containment failure due to a either global deflagration or detonation, that fails containment in the, some hours after, after vessel breach.

Not as long term as the first release category. And, this one has a higher, you know, has higher source terms than the first one.

But as you can see, they, over 90 percent of the risk metric come from those two release categories.

And, they have a fairly substantial reduction in the FLEX case, because there's a large

component from station blackout in both of these release categories.

In fact, most of the ones on this table, in this table. So you see a fairly big reduction, 60 percent are still in this risk metric.

The other, you know, something you mentioned before about all the other risk metrics. For instance, the total doses, and the affected populations for evacuation, and the economic cost, et cetera.

So, all the other risk metrics that are not associated with early health effects, have pretty much the same contributors.

You'll see this LCF and ICF burn as being the dominant contributors in all those cases. And, percent wise, they contribute somewhere between the upper 70s and mid-90s for all of those risk metrics.

The contribution from, but it makes up around. And, some of them, the LCF is by far the dominant contributor like here. Others, it flips and the ICF burn is the much bigger contributor.

The ISGTR, which is a low frequency contributor but has high consequences, that one is only two percent here, but in some of those other non-early risk metrics, it will go up to as much as 13

percent. So, it varies between 2 and 13 percent.

Now, I just want to real quickly just show you how these things match up to the QHO. So, the early --

(Simultaneous speaking.)

CONSULTANT BLEY: Before you go on, Alan.

MR. KURITZKY: Yes.

CONSULTANT BLEY: And, I didn't have time to dig this out, and I don't know if we talked about it a couple years ago.

Can you flip back two slides, one slide, to slide 26? When we look at core damage frequency and LERF and LRF, the frequency of those range between almost tens of minus 4 down to tens of minus 7 kind of range.

The chance of an early fatality risk is like 10 to the minus 6 lower than any of those, or more.

Can you explain why that is? That really seems a tremendous drop, especially from the L-E-R-F, the LERF cases. They must not be generating any fatalities, in your model.

I'm kind of confused about it.

MR. KURITZKY: Okay, so first off, for future you can take a look in line 3D, the level three

one in chapter 4, there's up in the beginning of the chapter before it starts to break down the different risk metrics, there's summary tables for all the risk metrics.

CONSULTANT BLEY: Okay.

MR. KURITZKY: And, it gives you the conditional risk values so you can see for each of the release categories, what that condition, like you said, you know, 10 to the minus 6, whatever the number is. So, that's just for future reference.

But, in terms to your question, so and you're stealing my thunder from later in the presentation, but we're running out of time.

CONSULTANT BLEY: I didn't mean to do that. You just threw these results up and I, they just started to really sink in.

MR. KURITZKY: Yes, so that was actually the talking point I had for the next slide.

So, actually, let me just --

(Simultaneous speaking.)

CONSULTANT BLEY: I can wait for your next slide. Go ahead.

MR. KURITZKY: Okay, so I was going to mention, the risk metric for early, individual early fatality risk in the model of the plant, is 5 times 7

minus 7 per reactor year, as you see the dash line on this chart.

And, then you see both the Circa-2012 and 2020-FLEX cases, you got a value way, way, way down below that. You're talking at least orders of magnitude margin between that, and the QHO.

And, so that gets right to your question, Dr. Bley, why is that so low? And, the reason is I mentioned one reason early on, which was the effectiveness of evacuation.

But it really four main contributing factors to why this value is so low. First is that the --

(Simultaneous speaking.)

CONSULTANT BLEY: Before you tell us those four, I'm just anchoring to values like 5 times 10 to the minus 7th for LERF.

So, we have a large early release at 5 times something like 10 to the minus 7, and now then the chance of getting one or more fatalities drops like six orders of magnitude.

So, go ahead.

MR. KURITZKY: Yes.

Okay, so from the LERF, from the LERF, so the dominant contributors are, and the things that

will lead to individual early fatality risk are primary the bypass sequences.

So, it's the event Vs. Or some of the steam generator tube ruptures, whether they are pre-core damage, or, you know, thermally induced after-core damage.

So, those are the contributors that lead to these early, potential early fatalities. And, the frequency of those sequences are very low at this point.

And, you mentioned the LERF the number is down 10 to the minus 7 or whatever, and I don't remember exactly what the, I could go back to see what the highest LOCA contribution was, but in that ballpark. So, you're talking fairly low frequencies.

On top of that, we also have a fairly low probability of adverse neurological conditions. So, and that's primarily stable, low wind speed conditions.

And, that's when you're going to --

CONSULTANT BLEY: And, this part is site specific, so go ahead.

MR. KURITZKY: Yes, so yes.

So, that is another major contributor to why this value is so low. Also, very site specific,

is the very low density close in population. Very sparsely populated around this site.

And, so then the likelihood of having those adverse meteorological conditions blowing directly in the, having one of those low frequency sequences, and then having the wind conditions to blow in the direction of the sparse, and where these sparsely populated people are, is all very low.

And, then lastly, there's also a very low likelihood in this case, and this site, of a delayed or slow evacuation.

So, there's very little --

(Simultaneous speaking.)

CONSULTANT BLEY: So, give me, to help me think about this for other places then the reference site, roughly what kind of population do you have within 20 miles of the site? Do you remember?

MR. KURITZKY: No, I certainly don't. I don't not remember, I never knew.

CONSULTANT BLEY: And, the level three doesn't appear, so.

MR. KURITZKY: And, again, our level three, unfortunately like I said early on, our level three expert could not make it today because of the change in schedule.

We do have other people here that might know, but I don't know if they necessarily were looking at it for other, you know, since we only looked it for this site, I don't know if they have just general knowledge of, for some other sites or not.

Trey Hathaway for one --

(Simultaneous speaking.)

MR. NAKOSKI: So, Alan, this is John Nakoski.

MR. KURITZKY: Yes.

MR. NAKOSKI: Would that information be in the internal report?

MR. KURITZKY: No, not for other sites.

MR. NAKOSKI: No, no, no. For this site.

MR. KURITZKY: Oh, I thought Dr. Bley was asking, you know, what was --

MR. NAKOSKI: No, but he -- I thought your question, Dr. Bley, was whether or not to give you a rough estimate of the population around this site so you could do your -- you know, kind of a --

CONSULTANT BLEY: To let me think of the significance of these results somewhere else other than where this place is.

MR. NAKOSKI: Right.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: This is just --

(Simultaneous speaking.)

CONSULTANT BLEY: What kind of population density are we looking at around this site?

MR. KURITZKY: Okay. So that -- I don't know whether Trey can pipe in on that or not, but it's low, it's very low. And so, again, my final conclusion on this was going to be that this is very site-specific, there are certain factors here that are very site-specific, and that the wind conditions -- or the meteorological conditions -- and the population density, and therefore the likelihood of successful evacuation are all very site-specific.

CONSULTANT BLEY: I haven't looked at the Level three stuff, but --

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: I just want to point out that this is between zero and 1.8 miles, and I'm trying to look in the report, you have it between zero and 10 miles -- this is just within less than two miles radius.

MR. KURITZKY: So this one -- individual early fatality risk is for within one mile of the plant boundary, and so the reactor actually is about three-quarters of a mile from the plant boundary. So

that's why it's 1.8 miles, it's one mile past the plant boundary. The latent cancer fatality metric is where we go up to --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: I see you (inaudible) --

MR. KURITZKY: It's a societal risk up to 10 miles outside the plant boundary.

CONSULTANT BLEY: I'm assuming the Level 3 Report would have a description of the population density around the site, so when I look at that I can see it.

MR. KURITZKY: Yeah, the 600-page Level 3 Report probably has everything you want.

CONSULTANT BLEY: Fair enough.

MR. KURITZKY: If it doesn't, come back to us, we'll give you a few more hundred pages.

CONSULTANT BLEY: Okay. We had a pretty good answer, I just want to understand it a little better because I think in a lot of sites, this -- we might not be seeing this kind of --

(Simultaneous speaking.)

MR. KURITZKY: Margin (inaudible) --

CONSULTANT BLEY: Tremendous drop for the early effects.

MR. KURITZKY: Yes, exactly. Very site-specific. Okay. Last slide, I just want to look -- or, last Level 3 slide here -- I want to just look at the other QHO, the individual latent cancer fatality risk, the QHO value was two times to the minus six per reactor critical year. You can see the Circa-2012 case, there's a margin of around 80 to the QHO, when we go to the FLEX case that increases to around a margin of around 200.

Also, if you remember, we looked at the different shorter time frames for the accident -- the severe accident analysis, so we go with the SAMG plus 36 hour cutoff for the FLEX case, we see a further reduction in this risk metric. So now the margin is up to around 800. And the last case we looked at, as Dr. Dimitrijevic mentioned before, was the -- or, no, it may have been Dr. Bier -- was talking about the linear no-threshold, and we used the linear no-threshold model -- that's the NRC standard, certainly for in licensing space.

However the Health Physics Society advises against attributing cancers -- radiogenic cancers -- at very low dose levels that are at or near background radiation levels, because there's such high uncertainty associated with those. In a 2010 paper

they had a threshold criteria that they had considered and so we, as a sensitivity analysis, we applied those threshold criteria for the low dose response, and as you can see there is a significant further reduction in latent cancer fatality risk.

And that's not unsurprising because, as I mentioned earlier, the risk is really coming from people moving back after the powers that be said that can, and then they're spending the rest of their lives with a slightly elevated background radiation level. And so if you put some threshold on that very slight elevation -- elevated background level -- you're going to remove those statistical cancers from the equation.

CONSULTANT BLEY: I have two questions, or a comment and a question here. What you say is true, about the Health Physics Society, however the National Academies BEIR VII Addendum Report doesn't agree. I thought I saw a BEIR VIII Draft Report some years ago but there's never been a BEIR VIII, did you guys delve into the academy stuff in this area?

MR. KURITZKY: No. So, again, our base case -- consistent with NRC policy -- was to use the LNT. For this alternate sensitivity, we just picked a value -- in fact, even the Health Physics, I think they have a 2020 paper that has a different set of

criteria, but this is based on -- at the time the one we had available was the 2010 paper. So we say in the report, we mention that there's different camps on this, there's people that say the LNT is the way to go and there's people that say no. And so, we're not going to resolve that issue in this project, we just want to show what the potential range could be absolutely --

(Simultaneous speaking.)

CONSULTANT BLEY: Okay. And the related comment I had is, when ACRS first proposed safety goals, they included a societal goal -- the commission decided not to do that after Fukushima, they again decided not to do that, to add it back in -- did you folks -- I don't want you to get into the political side of this -- did you talk about the idea of a societal goal or how that might affect things?

MR. KURITZKY: We did not explore any alternative safety goals, (inaudible) --

(Simultaneous speaking.)

CONSULTANT BLEY: That's fair enough, I won't push you to go further than that.

MR. KURITZKY: Okay. All right

ACRS CHAIRMAN REMPE: Excuse me?

MR. KURITZKY: Yep?

ACRS VICE CHAIRMAN KIRCHNER: I was the person who brought up to the LNT versus the -- and this is what I had in mind, the Health Physics Society. Now, you say in 2020 they revised their position, was it significant or -- for illustrative purposes -- it would be a comparable result?

MR. KURITZKY: So, again Keith Compton--

(Simultaneous speaking.)

ACRS VICE CHAIRMAN KIRCHNER: That's a significant reduction (inaudible) --

(Simultaneous speaking.)

MR. KURITZKY: Keith Compton -- Sorry. So Keith Compton, who was our lead here, would be able to tell you specifically what the change was. I don't know offhand, I think I remember it not being anything, you know, majorly, substantially different, but I don't recall the specifics, so I couldn't -- I don't think it would be something that would be significantly different. I don't know if Trey Hathaway -- if he's still here -- has any thoughts on that, but I don't think it was a major change but I couldn't tell you for sure.

CONSULTANT BLEY: Hey, Alan, I know you're about to jump into future interactions, if we have future interactions it'd be nice to hear from Keith on

some of these things.

MR. KURITZKY: Yes. In fact, that's -- we scheduled the meeting to make sure everybody was available but, I guess, your schedule was such, you know, you -- personally, but the -- subcommittee schedule was such that you had to make a change to move the meeting up, and that unfortunately conflicted with a personal commitment that Keith has, he couldn't be here. Which I made clear when we were rescheduling, that we were going to lose Keith, but I guess the decision was to still move forward with the meeting.

MR. HATHAWAY: Yes, this is Trey Hathaway, Office of Research, I don't remember the exact wording of the 2019 update but they essentially said, with low doses it's very hard to attribute to dose due to uncertainties. And they changed it to give you, like, a lifetime threshold, if I recall, but I would have to refer to the actual document to be able to recall what that was. So I think they were removed the yearly threshold.

MR. KURITZKY: Thank you, Trey. So, yes, as Trey mentioned, the 2010 paper, there was both, an annual limit -- which I think is, I can't remember now, five rem per year, and a lifetime of 10. So I

think you have to get more than five rem in a year and more than 10 lifetime in order to meet the threshold. And as Trey was saying, he thinks in the later paper they made that where the annual restrictions, so you don't have to get at least five rem in a given year as long as you get maybe 10 over your lifetime -- or whatever the new guiding might be. Okay, so --

CONSULTANT SCHULTZ: Alan, this is Steve Schultz. Before you go on -- this is somewhat connected here -- I know this is going out for public comment and when one looks at a report like this, summary report, you look for what the public might examine first and I would go right to your key messages section, and I've got a couple comments associated with that.

In the key messages you provide a lot of information in summary form, and I think that's good, but you're trying to combine a lot of information from many different types of studies. And for example, in the key messages you provide results which discuss information from a 100 mile radius, a 50 mile radius, 10 mile radius, one mile radius, and I'm just concerned that the public might get confused on those summary bullets that come from different aspects of analysis within the report.

My other comment would be that there are generic kinds of phrases which have been used in previous reports, such as that the radiogenic cancers are still not expected to be statistically detectable above norms. I think that's a far understatement of what the comparative results that you're showing here would in fact relate to anything associated with a detectable -- a statistically detectable cancers. It's something to be thinking about how that information is expressed.

In another area with regard to early fatality, there's a statement that says that compared to safety goals, the results are far below the safety goals. And it's referring to a 10 to the minus six delta between the safety goal and the result. If I'm the public reading those comments, I get the impression that I think maybe I should be concerned because we're making comparisons to statistically detectable cancer results and so forth.

Knowing what the likely of cancer is in society today I might get concerned, I'm not sure that's exactly what we're showing here, is the overall result. I think as we go forward and we look at other examples and events, the external events, for one, we need to be cautious about how we combine results and

how we present them as well, knowing that the public is going to be focused on these results.

I just heard recently that there's another proposal for a 15-year epidemiological study which is going to cost perhaps hundreds of millions of dollars, and the focus of the study is to look at the -- it almost sounds like a scare tactic -- it's going to look to make sure that the radiological impact associated with any activity -- industrial activity -- is not harmful to society. But the clear indication is they're hoping to find something that will indicate that there's a harm to society from radiation effects. So everything is still out there and I think we need to be cautious on how we present these results.

MR. KURITZKY: Yep. Thank you very much. Good points, we'll try and see if we can word that a little better to try and get a little clearer message on what we're trying to say there. So thank you.

MEMBER BIER: If I can interrupt, one additional comment which is kind of in the direction of what Joy called a curiosity question, back in the early round, almost 20 years ago or so, I remember hearing that there may eventually be biomarkers that enable detection of whether a particular cancer was due to radiation, or due to a chemical exposure,

etcetera, etcetera.

And I haven't kept up to know whether that's still anticipated but, if so, would that affect the determination of the this is low relative to background rates of cancer, but if it's easy to determine that it was caused by radiation that may change the judgment of what's considered low enough. And has anybody been looking at that?

MR. KURITZKY: Okay so, to respond to that I would say, remember I showed that there's six orders of magnitude difference between the early fatality risk and the QHO? Okay, the distance between my knowledge of that topic and the answer is more than six orders of magnitude.

(Laughter.)

MEMBER BIER: Okay.

MR. KURITZKY: I have no answer for you there.

MEMBER BIER: That's fine. Thank you.

MR. KURITZKY: Sure. Okay. So I know we're running late, just one last slide -- it's just a quick summary slide -- it just mentions -- it shows some of the key results that we just talked about. So if you look at the core damage frequency, the LERF: the large release frequency, and the two risk metrics,

we see that the FLEX case generally reduces things by around 60 percent, except for the LERF which is only about 40 percent because of the IS LOCA contribution. And we don't even report the early fatality risk because it's so low, but as you saw before, again, because of the dominance of IS LOCA, there wasn't much of a drop.

And the overall takeaway here is that this combination of plant design and site location had substantial margin to the QHOs when looking at internal events and floods, and so that goes to, again, the site-specific aspects that we were discussing with Dr. Bley about the low fatality risks -- again, this is a plant and site-specific conclusion.

Though you would expect that plants with similar designs would share some of the insights here and, from a risk point of view, they would have to have somewhat similar things in terms of local populations and weather conditions, and ability to evacuate the population. So that's all I wanted to say on the results from that document, so if there are no more comments then we can just jump to the last slide on future interactions.

(No audible response.)

MR. KURITZKY: Okay. So I just -- again, this has come up a number of times throughout this morning, you know, how best to interact with the subcommittee going forward, and with the committee, and in terms of when we could get letters. And so, if you look at the top here, we have the same -- it was from an earlier slide -- these were all the volumes that we hope to put out. And that's really -- in these various, you know, volumes or batches, is the key inflection point to the interaction point with the subcommittee.

And so theoretically we would brief the subcommittee as each set goes out into the public domain, however, you know, we need to strike a balance between the time commitments on the subcommittee and on the staff, to get our respective workloads accomplished. And so it might be that we want to combine some batches together, even though it makes for a fairly dense meeting. Certainly dry cask storage, as I mentioned before, that one could probably get lumped with something else.

Integrated site risk and summary reports -- particularly the summary report, and probably integrate site risk -- they may require their own meetings just because of the interest and the amount

of information involved there. So I don't know what the subcommittee's thinking on this is -- I do think, in order to make these meetings practical -- again, we don't want to go back and re-dig out all the details of the technical analyses which have been briefed to the subcommittee in the years gone by, we need to focus really just on the high level results and the public messaging, otherwise we'll never get done.

But as terms of when and how often we should come to the subcommittee, and/or the full committee, that, you know, it's open for discussion. From the schedule from before--, you saw that the Volume 4, we probably -- we're looking at late this year would be the next time we probably get reports out in the public domain.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Well we have a, you know, we might have a full committee through all of this and then we had the summer subcommittee discussion, and we discuss it with full committee. The just writing the one letter on this, it will be, you know, by the time this all finished there will not be even same members in the, you know, subcommittee and full committee, and this may be, you know, just too big task.

So we propose to split it in three parts,

you know, to do the -- what we're doing now, internal events, internal flood, the next meeting to be on external events, you know, fire, seismic events. And then have full committee to cover this, you know, the internal and external events, and then have the next meetings on shutdown, the spent fuel pool, and dry cask storage. And then have a full committee the shop meeting on that and, you know, later to come, and then in the end have a integrated risk and any other, you know, special, specific comments, special topics, and the summary report. So that was our thinking, to split it in three parts.

MR. KURITZKY: So sorry, excuse me -- I was typing, let me -- so one would be after -- this was a full committee -- first full committee would be after Volume 4 is released, and then did you say another full committee after Volume 5 was released, or five or some --

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes. After Volume 4b is released, I think, the dry cask storage. Because that's what I have in my notes but I have to look back in the latest numbering -- let me just take a look, right. So we will be -- we have one meeting on the two, and then we have a meeting be, you

know, on four. So then Volume 4, which will be external event, is 4x -- so 4x and the 3x would be one-- likely one full committee, right?

MR. KURITZKY: Mm-hmm.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: And then we will have a 5x, and the spent fuel pool which is your 6x, and seven, that would be a second meeting, and the third meeting would be on integrated site risk and your total summary report.

MR. KURITZKY: Okay. So yeah, we can consider that. Now --

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So, after we meet the next time on external events, you know, when your -- the 4x report is released -- then we will -- after that we'll have the full committee meeting and write a letter, and then, you know, the shutdown, spent fuel pool, dry cask storage, and then we will also have a full committee meeting, write the letter.

And the last one is the one which is sort of like in the, you know, never landed this moment, you know, the integrated site risk. Because, as I understood the, you know, that's why we have those deadlines which are not really, you know, 24 -- that go to, yeah, 24, so.

Okay. Did -- sorry I was mumbling in that, but I just want to say, the first one is very clear and we should be done by the spring, let's say, next year, right? Of addressing internal and external events, right? So that's a pretty clear scale.

The low power shutdown on internal events, doing spent fuel pool with dry cask storage, they maybe hold by the dry cask storage because you postponed that, now I see, to the March of '24. So maybe --

MR. KURITZKY: Well, no, don't -- sorry. Don't go by that because we're hopeful to get the dry cask storage out this year, that was just -- because it's kind of untethered to the other things, we're going to push that out whenever it's ready and just tack it on to whatever other meeting we have coming up, it'll just go out with that. So it might actually be discussed even when we put out Volume 4 on the fire, seismic, and wind.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So is this it now that 2022, I mean, which may go in the beginning of '23, will cover the internal/external events, and then in '23 would we cover low power shutdown, dry cask, and spent fuel pool, and then '24 we will cover this integrated site risk and summary

report?

MR. KURITZKY: Yeah. And -- and, let me just make a-- and so, let me just be clear, so for the one that covers this low power shutdown, spent fuel, and dry cask storage, that's the --

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: You will also have full committee and write the letter --

MR. KURITZKY: Right. And full committee, so--

(Simultaneous speaking.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: We will have the one annual letter in the, you know.

MR. KURITZKY: Right. So would that be, in terms of subcommittee being, so if we come out with a subcommittee meeting -- and actually let me go back up to this, because this, you know, I realize this slide doesn't have the dates. Let me go to the one that had the dates.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: So we will have two subcommittee meetings for each of those full committee meetings, except for the last one. Maybe even for last one, I'm not sure. So we already have one on internal events, we will have one on external events, and then full committee. And then we will have one for low power shutdown, and the spent

fuel pool, and dry cask storage can be covered together, and then we will have full committee. And then the last one is depending on you guys, we can have two, one on integrated site risk and one on the summary report, or we can put them together.

You know we can be made that from Hoassein to you because we have already discussed this schedule on full committee.

MR. KURITZKY: Well --

(Simultaneous speaking.)

PARTICIPANT: Yes sir?

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes.

MR. KURITZKY: We've had some discussions on it but I -- we never finalized anything, because we also have to consider the number of subcommittee meetings and full committee meetings, both, the impact on your schedule and on ours.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Right. Well you proposed one --

(Simultaneous speaking.)

MR. KURITZKY: --and I think you guys are aware of the level of effort it takes to get ready for these meetings, so I mean, you know, obviously the number one priority is to get the work done, so. We'll have to take this back and discuss it internally

with management to kind of see what can work, and then interact, you know, through Hossein to --

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Well you proposed to us seven subcommittee meetings, we did not increase that number when we met informally.

MR. KURITZKY: Right. Seven subcommittees and one full committee.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes. And we are proposing to you, five subcommittees and three full committees -- we didn't really change much, your report, because when you come to full committee you're already prepare for that through subcommittees.

So we actually reducing subcommittee meetings and just adding some full committees because we didn't really think that makes sense to wait for another, you know, three years to write the letter, because we will forget everything we just talk now, you know, so. And it will not be the same group of people and things like that, so we try not to add to your burden.

MR. KURITZKY: And I appreciate that, and like you said, we'll -- because I just -- I'm not in a position now to say, yes, that's definitely what we'll do. But, I mean, it seems reasonable but we need to I'll have to discuss it and --

MR. NAKOSKI: So, Alan, this is John. You know, I think, Vesna, what you proposed is reasonable -- like Alan said, we'll have to make sure that we can fully support the needs of the ACRS as we factor that into our planning. But, like I said, I agree with Alan, I think this is reasonable and we appreciate your openness to help minimize the impact on the staff resources. So thank you for that.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. So we can really discuss -- Joy, you wanted to say something, you -- I know you--

(Simultaneous speaking.)

ACRS CHAIRMAN REMPE: I know-- I know we discussed this informally I had not thought about public comments and changes that might occur, and maybe that can easily be incorporated at the end, in that integrated site-risk topics and summary report discussion. I just wanted to bring that up, you know, there might that occur and when we finally do the final letter, we might want to consider changes due to public comments? Or, how would that be accommodated in what you've proposed?

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yeah well that's true, I mean, you know, they just closed today for public -- I don't know how many public

comments have been received on this report, and I don't know how that will look like in general but we should definitely consider that.

MR. NAKOSKI: So I think that's a fair comment, Dr. Rempe, that we provide some feedback on how we addressed public comments we've received on the earlier volumes, so perhaps we can include that in discussions with the subcommittee. As we go into the next report we can maybe include a section on, here's the feedback we've got from our previous volumes -- let me just use an example, volume three -- here's the public comments we got, here's an overview of how they've been dispositioned. That may add some time to the presentation to the subcommittee, and then also we can maybe include some feedback on ACRS full committee comments, how they were addressed. I think that would be an appropriate use of time.

ACRS CHAIRMAN REMPE: That sounds great. Thank you. I just wanted to make sure we considered that.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay so speaking about public comments, do we have a request for Victoria and Mr. -- the NEI -- to make public comments? Victoria, are you there?

MS. ANDERSON: Yes, I am.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. So we will open now floor for public comments, and please -- floor is yours.

MS. ANDERSON: Great. Thank you. So I appreciate the opportunity to make a comment on behalf of the Nuclear Energy Institute. As you may be aware, the Volume 3, large portions of Volume 3 were just released for public comment, and the public comment period closed yesterday, so we've very recently taken a look at some of this information.

We in particular were very encouraged by some of the insights that have come from this report to date, for example, the observation that there is substantial margin QHO when considering internal events and floods. That aligns with the conclusions from NEI 20-04, The Nexus Between Safety and Operational Performance in the US Nuclear Industry.

We also are encouraged to see the acknowledgment of the value of FLEX in the period models, and how that can substantially reduce total plant risk. This comports with our operating experience and having both these insights supported by an NRC study and an industry study is helpful for all involved.

We do believe that, in the future it would

be helpful to perhaps focus some of the future work on the most pressing regulatory issues -- I realize that this study has been going on for close to a decade at this point and there's been quite a bit of progress, but we may be able to see which areas of continued work would give the most benefit to the NRC and its stakeholders.

For example, there are some specific conservatisms that remain in this study and we've seen some of these conservatisms carry over in recent discussions related to Reg Guide 1.183, which is Alternative Radiological Source Terms for Evaluating Design Based Accidents at Nuclear Power Reactors. So we would like to see the NRC staff engage with stakeholders at some point in the near future, to see if maybe we can provide some input on how to best focus the remaining work and perhaps remove some of the remaining conservatisms to best support regulatory best practices, moving forward. Thank you.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Thank you, Victoria. So, anybody else on the public line wishes to make a comments?

MR. LYMAN: Yes, this is Edmund Lyman from Union of Concerned Scientists. Can you hear me?

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Yes.

MR. LYMAN: Yeah. Thank you. Yeah, a couple of comments. First, on the question of this gap between the LERF and the early fatality risk, I was hoping the committee would probe that more deeply because it seems to me there's a logical inconsistency in the way LERF is being applied here. If you read the definition of LERF -- and let me just read it for the record. This is from NUREG-2201, it says, the frequency of a rapid, unmitigated release that occurs before effective implementation of off-site emergency response and protective action, such that there is a potential for early health effects.

Now when Mr. Kuritzky talked -- gave credit to effective evacuation, is one of the explanations for why that early fatality risk was low, that's a logical inconsistency because if that is the case then the LERF should be zero. If the LERF is not zero, that means there are sequences where evacuation was not effective, and so it just seems to me that that is a logically inconsistent application of this principle here.

The second comment I'd like to make is, I think the observation of the level of effort and resources necessary to do this kind of activity completely and correctly, is the fact that that is a

very formidable task, I think is very important for the new reactor applicants. Because I know there's the discussion of whether or not PRA is required for Part 53, at least according to current version, my understanding is, under Framework A, a PRA will be required and that it is going to have to have many of the aspects with level three, including the computation of the latent cancer and possibly early fatality risks summed over all these risk significant events. And we'll also have to look at all radiological release points on the site, including spent fuel and other large sources, for some of these advanced reactors.

So I think the popular perception is that if you just risk-inform everything, it's going to make licensing quicker, cheaper, and easier. But I think that the fact that, to do this correctly, especially incorporating incompleteness, uncertainties, in order to do that correctly, that is a big effort and it shouldn't underestimated. And if an applicant does less than a complete job to try to support an application, that is of limited value and I am concerned about the potential for licensing. These advanced reactors, based on PRA, if they are not done in accordance with the highest standards, and the

rigor that this project entails. So those are my comments. Thank you.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Thank you for your comments. Anybody else from public wishes to make comments?

(No audible response.)

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. Since, if not -- I see that Mr. Lyman has his hand raised. Okay, it was--

(Simultaneous speaking.)

MR. LYMAN: Just lowered it right now.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. All right, so then I will ask the members, before we close it, anybody from members has any additional comments?

PARTICIPANT: So this -- oh, go ahead.

MEMBER BIER: Since this is one of those initiatives that started before me, and I'm just now getting educated on it, at some point maybe even do this over lunch or in the hallway, or whatever. It would be helpful for me to understand more because even though the task is labeled Level 3, there is obviously a lot of work on Levels 1 and 2 that are going on in this process. And was that done in order to support, you know, new analysis that would be

needed for state-of-the-art Level 3 or did they just decide to start from scratch with a blank sheet of paper, so to speak, and do the full scope? I'm kind of unclear on the goals of the whole exercise, but.

ACRS CHAIRMAN REMPE: Okay.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay.

ACRS CHAIRMAN REMPE: My comment is, I just wanted to comment about, with the changing of staff, it was really nice to see that Alan is still there all these years and we appreciate it. Thank you.

MR. KURITZKY: Thank you. It has been a long run.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Joy, you were obviously here for a -- yes. Is there other -- it's good that somebody in here because we had a really, like, numerous meetings as our historian has point out in these 12 years, and that we have somebody to keep continuity, I think -- I don't know when you and Dennis start participating in that but this is my second meeting, it's Victoria's first one, so it's good that even committee can keep up with the project development, so.

CONSULTANT BLEY: I think Joy and I were the only ones who were at the meeting today who've

been there all along, and who participated in the only letter written on this, back in 2011, I think.

ACRS VICE CHAIRMAN KIRCHNER: Dennis, this is Walt. I was going to ask earlier, did we write a letter -- when I came on the committee in 2016, was about the time you started having the briefings on SOARCA -- did the committee write a letter on the SOARCA work?

CONSULTANT BLEY: Yeah, I think we wrote more than one -- we wrote several letters on SOARCA.

ACRS VICE CHAIRMAN KIRCHNER: Yeah then I remember the pump seals, so we had several presentations on that subject as well.

CONSULTANT BLEY: That's true, and I think we wrote a letter on that one too. I think we--

(Simultaneous speaking.)

ACRS VICE CHAIRMAN KIRCHNER: I think so. That's what I remember --

CONSULTANT BLEY: We kept putting it off because he kept waiting for the next step, which just always too longer.

ACRS VICE CHAIRMAN KIRCHNER: Right. But -- so I was just going to point Vesna to -- so you mention a letter in 2011, and I do remember a SOARCA letter. That might be worth looking at, Vesna, just

as a model for how you want to approach documenting anything from the committee on this project.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: Okay. That's definitely good suggestions, I am looking some of the letters, and even to some, you know, the separated opinion of the members on the Level 3, it's an interesting history.

Okay. But we have to let these people go for lunch there in the headquarters, so -- because we have -- Walt, is our next meeting at 1:00 o'clock?

ACRS VICE CHAIRMAN KIRCHNER: Yes, that's correct. We have a meeting at 1:00.

SUBCOMMITTEE CHAIRMAN DIMITRIJEVIC: All right. So if nobody has any more comments then I will have to declare this meeting adjourned. Thank you so much for a wonderful presentation and discussion, and we are looking forward to continue and bring this together to the end. Okay. Thanks. Everybody, have a good lunch.

CONSULTANT BLEY: Thank you.

MR. KURITZKY: Thank you very much.

(Whereupon, the above-entitled matter went off the record at 12:19 p.m.)

Level 3 PRA Project Overview for Internal Events and Floods

Advisory Committee on Reactor Safeguards
Reliability and PRA Subcommittee

June 22, 2022

John Nakoski
Division of Risk Analysis
Office of Nuclear Regulatory Research
(301-415-2480, John.Nakoski@nrc.gov)

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 objectives
- L3PRA project overview report for reactor, at-power, internal events and floods
- Future interactions

Acknowledgements

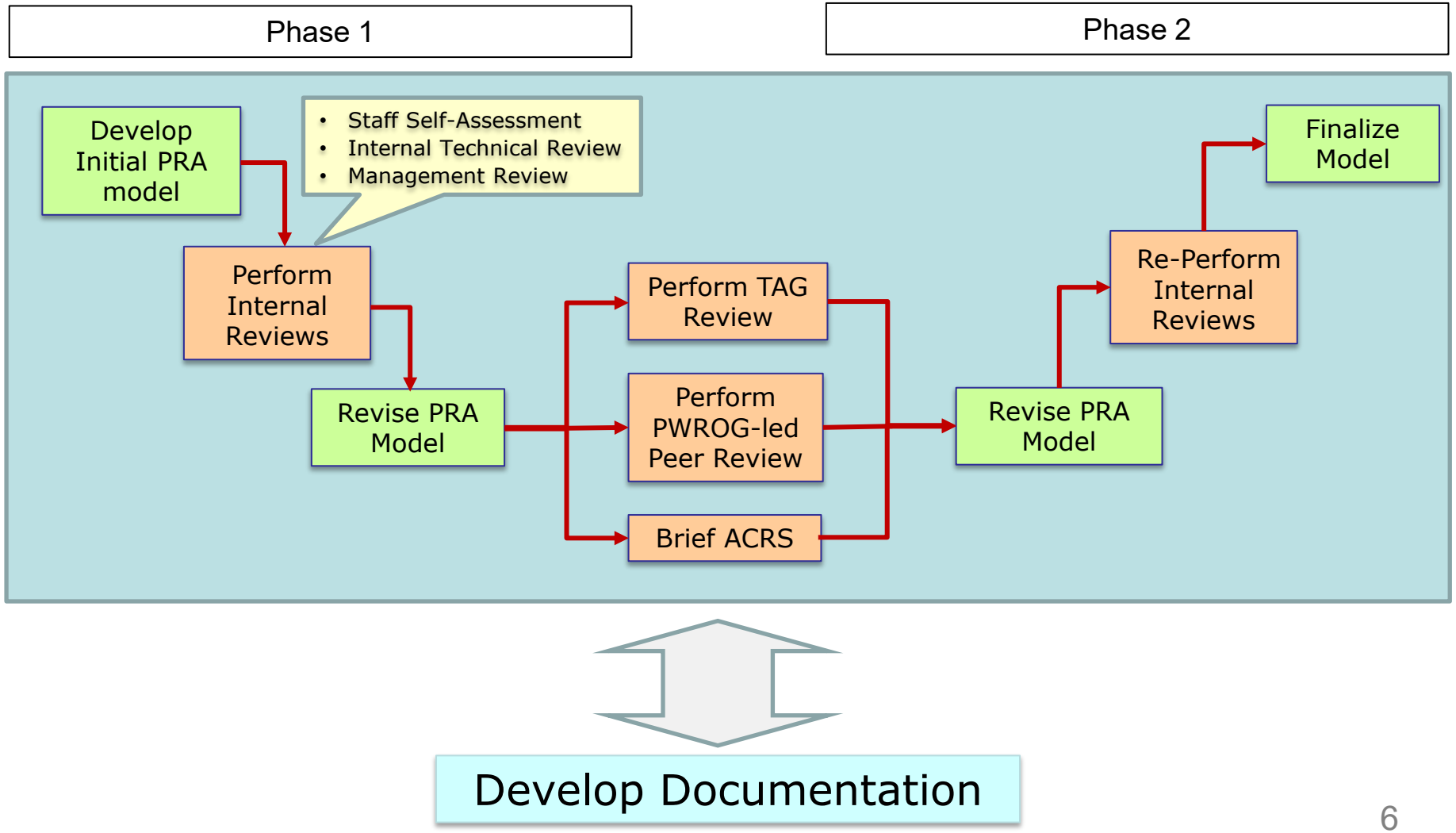
- NSIR, NRR, NMSS, Regions, TTC
- National Laboratories (INL, SNL, PNNL, BNL)
- Commercial Contractors (ERI, ARA, IESS)
- PWR Owners Group
- Westinghouse
- EPRI
- ACRS

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	Phase 2 Revised model/documentation	Phase 1 Initial model/documentation
Reactor, at-power, seismic events	Complete	Complete	Phase 2 Revised model/documentation	Phase 1 Initial model/documentation
Reactor, at-power, high winds	Complete	Complete	Phase 2 Revised model/documentation	Phase 1 Initial model/documentation
Reactor, at-power, other hazards	Complete	N/A		N/A
Reactor, LPSD, internal events	Phase 2 L3PRA management review	Phase 2 Revised model/documentation	Phase 2 Revised model/documentation	Not yet initiated
Spent fuel pool (all hazards)	Phase 2 Revised model/documentation		Phase 1 Initial model/documentation	Not yet initiated
Dry cask storage (all hazards)	Phase 2 Revised model/documentation			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

Summary (Vol. 1)*	Background (Vol. 2)*	Reactor, At-Power, Internal Events and Internal Floods (Vol. 3)				
L1-L3 (1)	N/A (2)	Overview-IE/IF (3x)	L1-IE (3a)	L1-IF (3b)	L2-IE/IF (3c)	L3-IE/IF (3d)

- Summary report (Vol. 1) includes results, insights, perspectives, comparisons to previous studies, uses, and potential future research.
- Background (Vol. 2) includes background, site and plant description, and technical approach.

Reactor, At-Power, Internal Fires and External Events (Vol. 4)					
Overview-F/S/W (4x)	L1-FIRE (4a)	L1-SEIS (4b)	L1-HW/OH (4c)	L2-F/S/W (4d)	L3-F/S/W (4e)

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

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

Publication Process

- Remove proprietary information
- Submit for internal management review and licensee factual and proprietary information review
- Incorporate review comments
- Prepare *Federal Register Notice*
- Issue draft reports for public comment
- Brief ACRS Subcommittee
- Address comments from all stakeholders
- Perform NUREG formatting and technical editing
- Submit final report to Publications

Preliminary Schedule for Releasing Draft L3PRA Reports for Public Comment

(Released) (Target) (Realistic)

- Reactor, at-power, internal events and internal floods **(Vol. 2 and Vols. 3x, 3a-3d)** **(April 2022)**
- Reactor, at-power, internal fires, seismic events, and high winds **(Vols. 4x, 4a-4e)** **(October 2022)** **(December 2022)**
- Reactor, low-power and shutdown, internal events **(Vols. 5x, 5a-5c)** **(January 2023)** **(June 2023)**
- Spent fuel pool, all hazards **(Vols. 6x, 6a-b)** **(August 2023)** **(December 2023)**
- Dry cask storage, all hazards **(Vol. 7)** **(October 2022)** **(March 2024)**
- Integrated site risk **(Vol. 8)** **(December 2023)** **(September 2024)**
- Summary report **(Vol. 1)** **(January 2024*)** **(December 2024)**

***Assumes substantial parallel pre-work performed and limited diversion to completing final NUREGs**

L3PRA Project Objectives

1. Develop a Level 3 PRA, generally based on current state of practice methods, tools, and data, that (1) reflects technical advances since completion of the NUREG-1150 studies, and (2) addresses scope considerations that were not previously considered (e.g., multi-unit risk)
2. Extract new insights to enhance regulatory decision-making and to help focus limited agency resources on issues most directly related to the agency's mission to protect public health and safety
3. Enhance NRC staff's PRA capability and expertise and improve documentation practices to make PRA information more accessible, retrievable, and understandable
4. Obtain insight into the technical feasibility and cost of developing new Level 3 PRAs

Objective 1 – Develop Modern Full-Scope Level 3 PRA

- Examples of PRA modeling advances since NUREG-1150
  - Analysis of post-core-damage operator actions
  - Expert elicitation for interfacing system LOCAs
  - Use of MELCOR code to perform best estimate analyses
  - Improved consequence analysis modeling (most of which reflects best practices adopted from SOARCA)
  - Improved characterization and understanding of parameter and modeling uncertainties
- Examples of plant improvements since NUREG-1150
  - SAMGs, EDMGs, and other B.5.b mitigation strategies
  - Responses to NRC rules and generic communications
  - New RCP seal design and FLEX strategies (addressed in a sensitivity analysis)
- Project scope includes all major radiological sources on the site (i.e., reactors, spent fuel pools, and dry cask storage), all internal and external hazards, and all modes of plant operation.

Objective 2 – Extract Insights to Enhance Regulatory Decision-Making

- Substantial margin exists to safety goals (quantitative health objectives [QHOs])
  - Sufficient warning times for effective evacuation greatly reduces likelihood of prompt fatalities
  - Latent cancer fatalities occur from long-term reoccupation of land and use of the linear no-threshold (LNT) model
  - Surrogate risk metrics (CDF and LERF) appear more restrictive
- More complete understanding of the extent of uncertainties (both parameter and modeling) underscores need to maintain Commission's policy of risk-informed regulation
- Large, late release frequency depends heavily on severe accident progression modeling time
- Procedures for extending battery lifetimes and recovering offsite power without DC power can be important
- Some potentially risk-significant component failure modes (e.g., transformer input breakers fail to open) could benefit from more detailed analysis
- FLEX and new RCP seal design can significantly reduce risk (very plant-specific)

Objective 3 – Enhance Staff PRA Capability and Improve Documentation

- Enhance NRC staff's PRA capability and expertise
  - Over 50 staff have participated in L3PRA project (all RES divisions, NRR/NRO, NSIR, NMSS, Regions, TTC)
  - NRC staff ***performed*** many or all tasks associated with most of the PRA models
    - In many cases, this was the first time the staff member developed that type of model
    - Staff encountered many modeling issues that required more rigorous analysis
    - Some areas required advancing the state-of-practice
    - Staff was able to apply best practices from SOARCA into a PRA framework
  - Staff observed or participated in ASME/ANS PRA standard-based peer reviews
  - Staff were involved in two expert elicitations to address key PRA issues
- Improve documentation practices to make PRA information more accessible, retrievable, and understandable
  - Used agency documentation systems (ADAMS, SharePoint, File Center)
  - Assigned a Documentation Coordinator for the project
  - Used templates/forms to document key decisions (e.g., meeting summaries and issue tracking list)
  - Documentation control processes described in detail in project quality assurance plan

Objective 4 – Obtain Insight into Feasibility and Cost of Level 3 PRAs

- Performance of the L3PRA project confirmed the feasibility of performing Level 3 PRAs; however, insights into the cost of such studies are limited due to:
  - Make-up of project team (i.e., need to juggle more experienced staff and focus on training less experienced staff)
  - Unique starting point (in several instances, needed to rely on and get familiar with reference plant models)
  - Lack of full access to reference plant and associated information
- Importance of dedicated team – matrixing with staff with other priorities
  - Lack of schedule control
  - Discontinuities in task interfaces
  - Loss of momentum and need for refamiliarization
- Resource estimates require detailed task-by-task analysis (i.e., don't rely on "holistic" estimates)
- Large, complex, long-term projects will inevitably encounter significant time and resource impacts due to unexpected technical issues, re-work, and diverted or lost staff

Overview of Reactor, At-Power PRA Results for Internal Events and Floods

2020-FLEX Case (1)

- Base case model reflects plant as designed and operated in 2012
- Base case (Circa-2012 case) model does not reflect the plant as it is currently designed, licensed, operated, or maintained
  - For example, model does not reflect current reactor coolant pump (RCP) shutdown seal design nor the potential impact of FLEX strategies
- 2020-FLEX case reevaluates plant risk based on a set of new plant equipment and PRA model assumptions for all three PRA levels

2020-FLEX Case (2)

- 2020-FLEX case includes:
  - New RCP seals (shutdown seals)
  - FLEX strategies and equipment for responding to an extended loss of AC power (ELAP)
- In addition, if FLEX not successful, potential credit given for continued turbine-driven auxiliary feedwater (TDAFW) pump operation given a complete loss of all installed AC and DC power

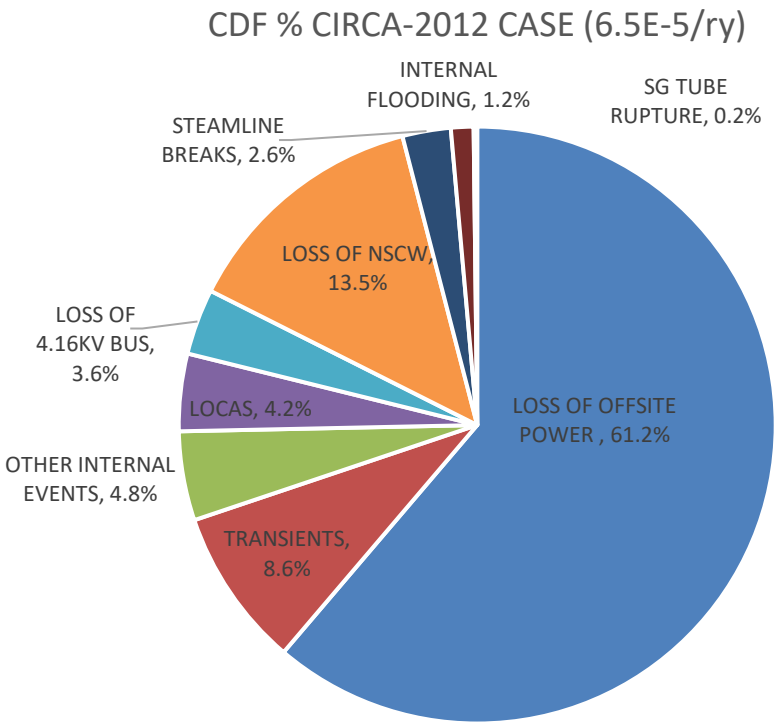
FLEX Strategies

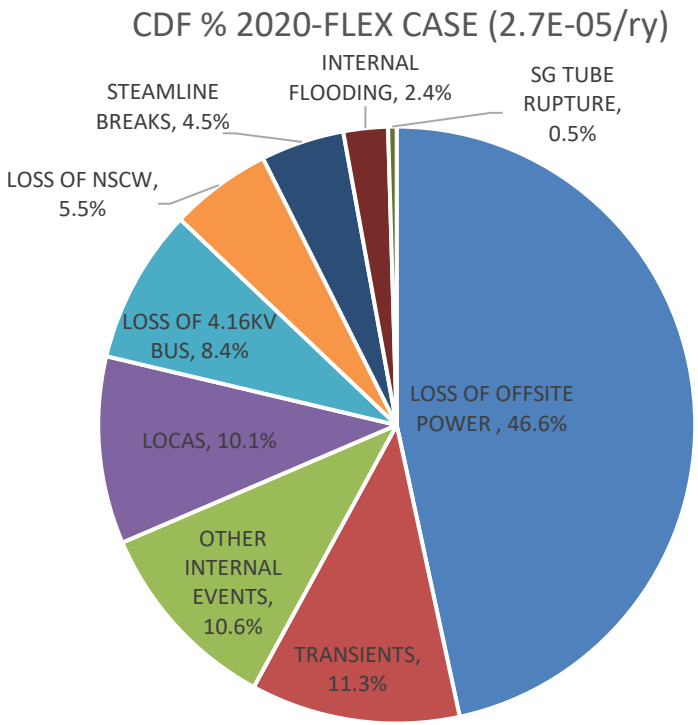
- FLEX strategies for coping with the plant conditions that result from an ELAP event involve a three-phase approach:
  - Phase 1 - Initially cope by relying on installed plant equipment and on-site resources
  - Phase 2 - Transition from installed plant equipment to on-site FLEX equipment
  - Phase 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 (and, to-date, only considers internal events and floods)

FLEX Modeling

- Three new nodes added to existing SBO event tree:
  - RCP shutdown seal successful (placed before the conventional RCP seal model nodes)
  - ELAP declared and FLEX successful (after failure of the offsite power recovery node, but only if minimal seal leakage)
  - Continued TDAFW Pump Operation in SBO
- Each event tree node is represented by a single basic event
  - Shutdown seals assigned combined failure probability of 0.01 to close and remain closed
  - FLEX and TDAFW “all-encompassing” HEPs each assigned failure probability of 0.3 (based on expert judgement)
- FLEX/TDAFW credit applied to consequential LOOP sequences via post-processing rules

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





2020-FLEX Case Results Level 1 PRA (2 of 3)

- Risk-significant basic events (Fussell-Vesely importance):
  - Operator failure to restore systems after AC power is recovered following an SBO (contributes over 25% to total CDF from internal events and internal flooding)
  - Independent failure of emergency DGs 1A and 1B to run for the 24-hour mission time (18%, 16%)
  - Consequential LOOP following a transient (13%)
  - Failure to declare ELAP or successfully implement FLEX or failure to continue TDAFW under extended SBO conditions (11% each)
  - Failure to trip RCPs following reactor trip and coincident or subsequent loss of all RCP seal injection and cooling (two events – 11% combined)
  - Common-cause failure of reserve auxiliary transformer breakers to open following a LOOP or CCF of DG load sequencers to operate following a LOOP (8% each)
    - Collectively contribute nearly one-third of total internal event CDF in Circa-2012 case

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

	Case # →	1	2	3	4	5	6
		Circa-2012	**No-FLEX (shutdown seals only) (Note 1)**	**FLEX-1**	**2020-FLEX**	**FLEX-2**	**Perfect-FLEX**
F	FLEX failure probability	1.0	1.0	0.5	0.3	0.1	0.0
S	RCP shutdown seal failure probability	1.0	0.01	0.01	0.01	0.01	0.01
T	TDAFW failure probability (Note 2)	1.0	1.0	0.5	0.3	0.3	0.0
	p = F * T (Note 3)		1	0.25	0.09	0.03	0
	CDF (/ry)	6.47E-05	5.68E-05	3.20E-05	2.67E-05	2.47E-05	2.37E-05
	CDF Reduction	N/A	12%	51%	59%	62%	63%

Notes

1. As used in the column headings for this table, "FLEX" refers to both FLEX strategies and continued TDAFW pump operation given a complete loss of all installed AC and DC power.
2. "TDAFW failure probability" refers to the failure probability for continued TDAFW pump operation given a complete loss of all installed AC and DC power.
3. The joint failure probability (p) that neither the FLEX strategies nor the continued operation of TDAFW (if FLEX is not successful) is capable of preventing core damage for station blackout sequences.

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

Level 2 PRA Surrogate Risk Metric	Circa-2012 Case	2020-FLEX Case	Risk Metric Reduction
Total Release Frequency	7.2E-05/ry	2.6E-05/ry	63.5%
LERF	9.3E-07/ry	5.7E-07/ry	38.8%
LRF	4.4E-05/ry	1.7E-05/ry	59.9%

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	5.7E-07/ry	5.7E-07/ry	5.7E-07/ry
LRF	1.7E-05/ry	5.0E-06/ry	5.0E-06/ry
CCFP	0.785	0.707	0.281

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

2020-FLEX Level 2 PRA Surrogate Risk Metric Results for Alternative Accident Recovery Assumptions

Postulated Recovery Factors			Resulting Risk Surrogates		
$RF_{combust}$	$RF_{pressure}$	RF_{BMT}	LERF (/ry)	LRF (/ry)	CCFP
1	1	1	5.7E-07	1.7E-05	0.785
1	1	0.1	5.7E-07	1.7E-05	0.758
1	**0.1**	1	5.7E-07	6.3E-06	0.785
0.1	1	1	5.7E-07	1.7E-05	0.785
1	**0.1**	0.1	5.7E-07	6.3E-06	0.374
0.1	1	0.1	5.7E-07	1.7E-05	0.758
0.1	**0.1**	1	5.7E-07	3.1E-06	0.785
0.1	**0.1**	0.1	5.7E-07	3.1E-06	0.194

$RF_{combust}$: Actions that prevent significant combustion events in the intermediate and long term

$RF_{pressure}$: Actions that successfully control containment pressure through restoration of containment heat removal or containment venting

RF_{BMT}: Actions that flood the cavity with timing and flow rates that are sufficient to arrest basemat ablation prior to basemat failure

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

Population-Weighted Early Fatality Risk, by Release Category, for the 0 to 1.8-mile Interval for the Circa-2012 and 2020-FLEX Cases

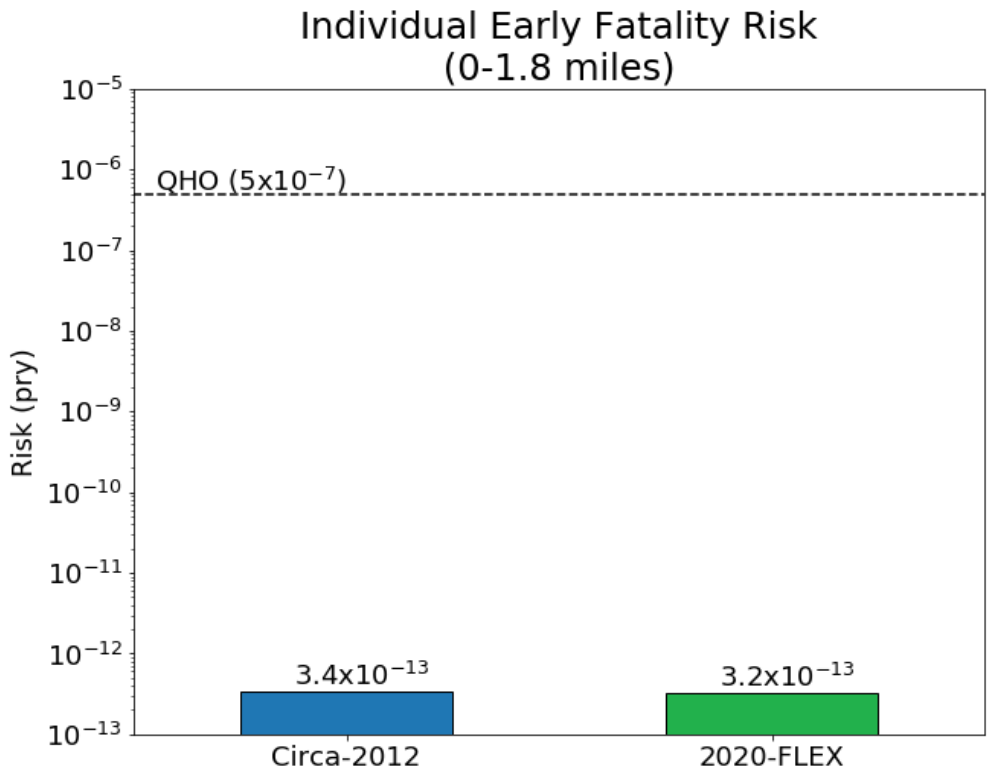
	Circa-2012 Case		2020-FLEX Case		FLEX Impact
Release Category Name	**Early Fatality Risk (/rcy) (a)**	**% of Total**	**Early Fatality Risk (/rcy) (b)**	**% of Total**	**(a-b)/a %**
Total	**3.4E-13**	**100%**	**3.2E-13**	**100%**	**6%**
1-REL-V-F	2.1E-13	62%	2.1E-13	65%	–
1-REL-V-F-SC	9.1E-14	27%	9.1E-14	28%	–
1-REL-ISGTR	3.4E-14	10%	1.4E-14	4%	59%
1-REL-SGTR-O	6.0E-15	2%	6.0E-15	2%	–

2020-FLEX Case Results Level 3 PRA (2 of 4)

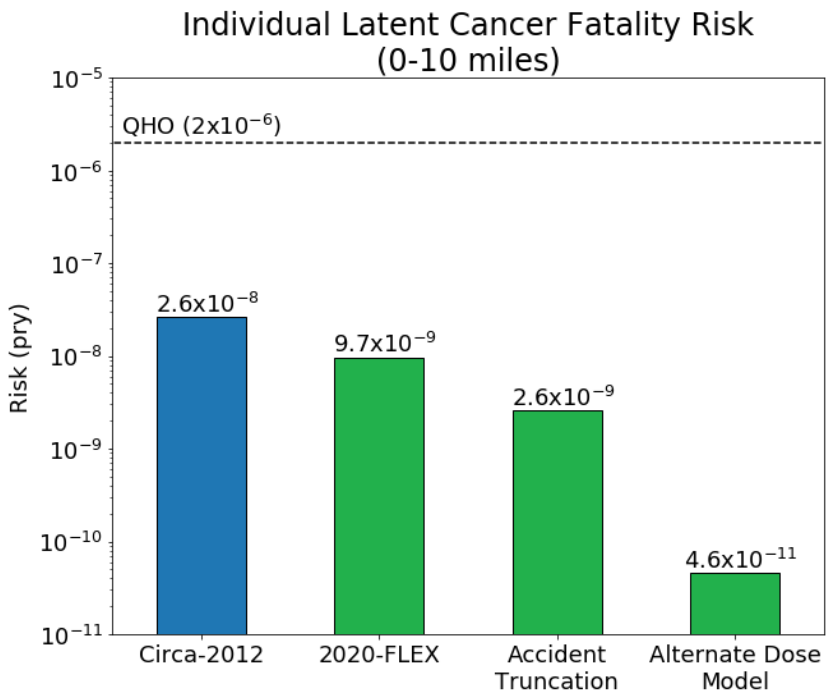
Population-Weighted Latent Cancer Fatality Risk, by Release Category, for the 0 to 10-mile Interval for the Circa-2012 and 2020-FLEX Cases

	Circa-2012 Case		2020-FLEX Case		FLEX Impact
Release Category Name	Latent Cancer Fatality Risk (/rcy) (a)	% of Total	Latent Cancer Fatality Risk (/rcy) (b)	% of Total	(a-b)/a %
Total	**2.6E-08**	**100%**	**9.6E-09**	**100%**	**63%**
1-REL-LCF	1.8E-08	69%	6.1E-09	63%	66%
1-REL-ICF-BURN	6.1E-09	23%	2.7E-09	28%	56%
1-REL-ISGTR	5.0E-10	2%	2.0E-10	2%	60%
1-REL-LCF-SC	4.8E-10	2%	3.0E-10	3%	38%
1-REL-NOCF	3.6E-10	1%	8.0E-11	<1%	78%

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



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



- Accident truncation – airborne radiological release termination time reduced from 7 days after accident initiation to 36 hours after SAMG entry
- Alternate dose model – 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

Risk Metric (per reactor-year)	Circa-2012 Case	2020-FLEX Case	Risk Metric Reduction
Core damage frequency	6.5E-05	2.7E-05	59%
Large early release frequency	9.3E-07	5.7E-07	39%
Large release frequency	4.4E-05	1.7E-05	60%
Individual early fatality risk	~0	~0	–
Individual latent cancer fatality risk	2.6E-08	9.6E-09	63%

Overall, the results show that the combination of this plant design and site location has substantial margin to the QHOs when considering internal events and floods.

Future Interactions

Future Interactions

- Future public reports
  - Reactor, at-power, internal events and internal floods **(Vol. 2 and Vols. 3x, 3a-3d)** - **COMPLETED**
  - Reactor, at-power, internal fires, seismic events, and high winds **(Vols. 4x, 4a-4e)**
  - Reactor, low-power and shutdown, internal events **(Vols. 5x, 5a-5c)**
  - Spent fuel pool, all hazards **(Vols. 6x, 6a-b)**
  - Dry cask storage, all hazards **(Vol. 7)**
  - Integrated site risk **(Vol. 8)**
  - Summary report **(Vol. 1)**
- Process
  - Brief Subcommittee on each batch of reports (may combine some batches)
    - Focus on overview report and public messaging
  - Brief Full Committee at end of project (Volume 1)
    - Subcommittee may request additional Full Committee meetings

Acronyms and Definitions (1 of 2)

AC	alternating current
ACRS	Advisory Committee on Reactor Safeguards
ANS	American Nuclear Society
ARA	Applied Research Associates
ASME	American Society of Mechanical Engineers
BNL	Brookhaven National Laboratory
CCF	common-cause failure
CCFP	conditional containment failure probability
CDF	core damage frequency
DC	direct current
DG	diesel generator
EDMG	extensive damage mitigation guideline
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
LOCA	loss-of-coolant accident

Acronyms and Definitions (2 of 2)

LOOP	loss of offsite power
LPSD	low power and shutdown
LRF	large release frequency
NSCW	nuclear service cooling water
PIRT	Phenomena Identification and Ranking Technique
PNNL	Pacific Northwest National Laboratories
PRA	probabilistic risk assessment
PWR	pressurized-water reactor
PWROG	PWR Owners Group
QHO	quantitative health objective
RCP	reactor coolant pump
Rx	reactor
SAMG	severe accident management guideline
SBO	station blackout
SFP	spent fuel pool
SG	steam generator
SNC	Southern Nuclear Operating Company
SNL	Sandia National Laboratories
SOARCA	State-of-the-Art Reactor Consequence Analysis
TAG	Technical Advisory Group
TDAFW	turbine-driven auxiliary feedwater