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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUTURE PLANT DESIGNS SUBCOMMITTEE

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THURSDAY

FEBRUARY 20, 2020

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2D10, 11545 Rockville Pike, at 1:00 p.m., Dennis Bley, Chair, presiding.

COMMITTEE MEMBERS:

DENNIS BLEY, Chair

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR., Member

VESNA B. DIMITRIJEVIC, Member

WALTER L. KIRCHNER, Member

JOSE MARCH-LEUBA, Member

DAVID PETTI, Member

JOY L. REMPE, Member

PETER RICCARDELLA, Member

MATTHEW W. SUNSERI, Member

ACRS CONSULTANTS:

MICHAEL L. CORRADINI

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

C-O-N-T-E-N-T-S

Opening Remarks - Dennis Bley 4

DG-1364 "Volcanic Hazards Assessment for Proposed New and Advanced Nuclear Power Reactor Sites" 7

Adjourn 223

P R O C E E D I N G S

1:01 p.m.

CHAIR BLEY: Good afternoon. The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, excuse me, Subcommittee on Future Plant Designs. I'm Dennis Bley, Chairman of the Subcommittee.

ACRS members in attendance are Joy Rempe, Ron Ballinger, I think Charlie Brown will be back with us, Walt Kirchner, Dave Petti is here, Vesna will be back with us, Vesna Dimitrijevic. And I think Jose March-Leuba will be back with us.

I forgot Matt. I've got him written on the side here, Matt Sunseri, and Pete Riccardella, and our consultant, Steve Schultz, and possibly our consultant, Mike Corradini. I'm not sure if he'll be here or not. Derek Widmayer of the ACRS staff is the designated federal official for this meeting.

The purpose of today's meeting is to discuss the draft Regulatory Guide 1364, Volcanic Hazards Assessment for Proposed New and Advanced Nuclear Power Reactor Sites.

As the NRC staff was preparing to review and regulate this new generation of non-lightwater reactors, it appeared that one of the developers might

site a reactor in an area of potential volcanic activity.

While the staff has conducted reviews of volcanic hazards for several existing facilities, including one nuclear power plant, it has not issued guidance on considering these hazards using a risk-informed methodology. That's what this reg guide is proposing.

The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate. This matter may be presented to the subcommittee again after the public comment period if decided by the subcommittee consistent with the committee's reviews of regulatory guides.

I lost my place. The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA. The NRC implements FACA in accordance with its regulations found in Title 10, the Code of Federal Regulations, Part 7.

As a FACA committee, we can only speak through our published letter reports. We hold meetings to gather information and perform preparatory work that will support our deliberations at a full committee meeting.

The rules for participation in all ACRS meetings, including today's, were announced in the Federal Register on June 13th, 2019. The ACRS section of the US NRC public website provides our charter, by-laws, agendas, letter reports, and transcripts of full and subcommittee meetings, including the slides presented there.

The meeting notice and agenda for this meeting were posted there. As stated in the Federal Register notice, and in the in a public meeting notice posted to the website, members of the public who desire to provide written or oral input to the subcommittee may do so and should contact the designated federal official five days prior to the meeting.

Today's meeting is open to public attendance, and we have received no written statements or requests to make an oral statement. We also set aside ten minutes in the agenda for spontaneous comments from members of the -- of the public who are attending our meetings or listening to them.

Today's meeting is being held with a telephone bridge line allowing participation of members of the public over the phone. a transcript of today's meeting is being kept. Participants in the

meeting should use the microphones located throughout the room and speak with sufficient clarity and volume so that they may be readily heard when they're addressing the subcommittee.

At this time, I ask that the attendees in the room please silence all their cell phones and other noise makers. And I remind speakers at the front table to turn on the microphone, the little button nearest you will turn it on, when they're speaking and to turn it off when you're not speaking. But since we only have one presenter, it can stay on all the time.

We will now proceed with the meeting, and I call on Jenise Thompson of NRR to begin the presentation.

Jenise?

MS. THOMPSON: Thank you. Good afternoon, my name is Jenise Thompson. I'm a geologist in the External Hazards Center of Expertise in NRR. And I'm here today to present to you the details contained in draft Guide 1364, the Volcanic Hazards Assessment for Proposed New and Advanced Nuclear Power Reactor Sites.

This draft guide was the result of a staff working group that met to determine the regulatory need, decide on an optimal path forward, and then

finally to produce the technical content and process that is in the draft guide that is before you today.

As stated in the title, this draft guide applies to new and advance reactor sites or applicants applying for a NRC license under their applicable regulation.

CHAIR BLEY: The guide makes a specific point of doing a guide for reactors, but I don't see anything in the guide that wouldn't apply to other facilities that might, had to do a volcanic assessment.

MS. THOMPSON: And that is correct. So there's nothing in the guide that would preclude a perspective applicant for another type of application to use this Volcanic Hazards Analysis approach for another licensing activity or another application. But for the time being, the staff and the working group focused just on the reactor, because that was the near term need.

MEMBER REMPE: So along those lines, I know it's just at the end of the draft guide, it talks about that just a few miles away, with alternative sites, you might see a considerable difference in the hazard associated or posed by volcanoes. So along those lines, if they were to site a new or advanced

reactor near another reactor on a site that might not be, well, anyway if they were to do that along another site, do they have to consider co-located hazards in this draft guide? Because I didn't see that notice.

And so it's like even though this new site that's on a site, or this new plant that's on a site might not pose a hazard, the volcano might hit another facility, and that could cause a hazard. And has that been considered in the approach or will it be?

MS. THOMPSON: I'm actually going to toss that over to our volcanic hazards expert here, Britt.

MEMBER REMPE: Does the question make sense, what I'm trying to ask, first of all? Because I didn't say it as well as I could have.

MS. THOMPSON: Are you getting at, like, a back fit, would a co-located nearby site have to reassess their hazard based on what a new site would have to do?

MEMBER REMPE: No, I'm putting a new reactor on a site with other facilities. And as part of that assessment, the volcanic flows would maybe go by the co-located facilities where you might have a hazard. So in addition to considering the new location with the new facility, do they not need to do sort of a back fit, but it's because it's co-located,

is what I'm getting to.

MS. THOMPSON: So the intention of the guide is not to impose a back fit on any of the existing facilities. Because the draft guide that we have developed we believe is consistent with the prior licensing actions that the NRC staff have taken for the current operating facilities. So I don't know if anything ---

MEMBER DIMITRIJEVIC: Our concern is that this can create additional hazard. Let's say that you have a chemical factory with the lava, we can create debris, can create some additional hazard.

MS. THOMPSON: Oh, so you're talking about not just an NRC facility but ---

MEMBER DIMITRIJEVIC: Right.

MS. THOMPSON: -- any other facility --

MEMBER DIMITRIJEVIC: Which can create additional concern.

MS. THOMPSON: -- located near the proposed site.

MEMBER REMPE: That's true, it might not just be a reactor. But my thought process, I'm thinking of a large site with a lot of facilities. And you might want to put a new facility, as indicated in your upcoming slides, on that large site. And

there's a lot of other facilities there.

And, okay, so maybe you need to consider those co-located facilities and the hazard posed by the volcano for those other facilities in addition to the new facility location.

I can get more explicit if we want to talk, Idaho, for example, but there are a lot of other facilities out there. And so maybe where the new facility is is not so bad if you have a boundary. But there's other facilities where the lava might flow and could cause a problem.

MEMBER BROWN: But you're implying then, that because you put this new facility there, the other ones are going to have to back fit themselves and --

MEMBER REMPE: No. I'm saying with the new facility they need to consider more than the lava flows from that facility. There might be other co-located hazards that they need to consider. And so it's not really a back fit for the existing facilities, but you need to consider where the lava --

CHAIR BLEY: I think I understand what you're --

(Simultaneous speaking.)

CHAIR BLEY: Let me try it a little

different way?

MEMBER REMPE: Okay.

CHAIR BLEY: Because I thought at first it was thinking of a back fit. But if there's a hazard nearby that could affect the new reactor that could be activated by the volcano, then that knock-on effect ought to be considered.

MEMBER BROWN: Lava stream effect, in other words.

MEMBER REMPE: Yes. And I don't see that in the guide. But because of the way this discussion was going, I thought I'd bring it up now.

DR. CORRADINI: Well, particularly if it's regulated or had been licensed by a different group.

MEMBER REMPE: Yes.

MR. MARSHALL: If I can, this is Jane Marshall, NRR Deputy Director of Division of Engineering and External Hazards. Nearby facilities are considered in the EIS development, so they are considered. We'll take it back and see if we can put a note somewhere in the reg guide to flag your particular concern. But nearby facilities, whether they're chemical plants or other nuclear sites, are considered as part of the EIS.

CHAIR BLEY: Yes. They are but they

probably weren't, well, it's interesting where it shows up. Because if the volcanic activity can affect them, and they in turn can affect the plant, other sorts of things fall into that category that would be picked up. So it kind of means when they do that analysis they need to have this in mind as well. I don't know where that --

MEMBER REMPE: An environmental impact statement --

MEMBER KIRCHNER: More specifically --

MEMBER REMPE: -- may not address volcanic hazards.

MEMBER KIRCHNER: -- for a while there was consideration of high temperature reactors for hydrogen production.

CHAIR BLEY: Yes, there was.

MEMBER KIRCHNER: And that would present an interesting combination from an external hazards standpoint.

MEMBER PETTI: Because I think the question really is how nearby is nearby? The Idaho site is quite large. If they wanted to site 40 miles from their reactor, that doesn't sound nearby to me.

CHAIR BLEY: Well, you're going to hear more about how far away is nearby.

MEMBER PETTI: Yes, right.

MEMBER BROWN: And I'm still trying to understand Joy's comment. In other words, I put a new reactor in. This is a lot larger site with other facilities on the site.

DR. CORRADINI: You want to get specific? I know what she's going at.

MEMBER BROWN: Well, but her comment was other volcanic hazards. She just made that statement.

MEMBER REMPE: A volcano comes by, it hits the new reactor, okay. And also, maybe it misses the new reactor, because it's up high. Oh, I'm sorry, I didn't have my mic on. Maybe the new reactor site is up high. But the volcanic flow goes to the site, hits another facility.

MEMBER BROWN: You're talking about it becomes now a hazard for the reactor plant because it wasn't before because of its distance. But now, because of the volcano, and whatever it does to it, now it becomes a hazard to the new one.

MEMBER REMPE: To the new facility.

MEMBER BROWN: That's what I was trying to get at, what she was driving at.

MEMBER REMPE: Sorry, I wasn't very clear on what I asked.

(Simultaneous speaking.)

MEMBER REMPE: But I think the discussions made my point clear.

MS. THOMPSON: Yes, and I've made a note to look at that, as you called it, the knock on, you know, kind of that domino effect of hazards. So I'll make a note and take that back to the working group.

MEMBER REMPE: Thank you.

MS. THOMPSON: You're welcome. So today, the presentation will give you a background of how the staff assessed the regulatory need and determined that developing a reg guide was the optimal path forward. This was accomplished through the performance of a regulatory analysis which I will share with you.

I will then provide you an overview of volcanic hazards and some of the unique demands that they may place on a nuclear power reactor. I will then discuss the proposed approach in the draft guide to perform the Volcanic Hazards Analysis or VHA.

I will discuss the harmonization of this draft guide with the existing international guidance document that is available with respect to volcanic hazards. And then I'll share with you our next steps and timeline for completion.

CHAIR BLEY: I hope we can pronounce that

acronym?

MEMBER BROWN: Which one?

CHAIR BLEY: VHA, ha, ha, ha.

MS. THOMPSON: So the staff working group consists of staff.

MEMBER BROWN: Could I ask you one more before you ---

MS. THOMPSON: Of course.

MEMBER BROWN: Obviously, we've been building plants since the '60s.

DR. CORRADINI: Not long enough.

MEMBER BROWN: Well, we'll debate that, obviously. At least two of them were being built. And this is a new reg guide, and it doesn't sound like anybody worried about volcanos for the last 60 years.

CHAIR BLEY: You weren't listening when we --- oh, you weren't here when we ---

MEMBER BROWN: I wasn't here.

CHAIR BLEY: Ha, ha, ha.

MEMBER BROWN: I was in the ---

CHAIR BLEY: Are you going to talk about that?

MS. THOMPSON: I am. It's going to come up.

MEMBER BROWN: About why we need one now.

MS. THOMPSON: Yes. So I will ---

(Simultaneous speaking.)

MS. THOMPSON: -- in just a few slides, I will discuss why the working group made the decision to assess the regulatory need and decide whether or not action needed to be taken. I will give you a summary of the ---

MEMBER BROWN: We'll get to background in a little ---

MS. THOMPSON: We'll get there, yes.

MEMBER BROWN: Why we're doing a new regulation.

MS. THOMPSON: I think it's on the next slide actually, they why.

MEMBER KIRCHNER: Jenise, just along those lines, since you already did it, actually, the NRC for the Columbia plant, so will this be in the spirit of other actions that the Agency is taking, technology neutral?

Where I'm going with this is I don't know why you're labeling it for advanced nuclear power reactor sites.

MS. THOMPSON: That was the discussion that the working group went back and forth on for a fair amount of time, discussing whether the draft

guide should apply to any nuclear facility or just focus on reactors for the time being.

MEMBER KIRCHNER: No, I'm keying on the word advanced.

MS. THOMPSON: Advanced.

MEMBER KIRCHNER: Because I would think this is a perfect candidate for technology neutral regulation, not something that just gets a carve out for new advanced plants. So I'm objecting to the title.

MS. THOMPSON: You're objecting to ---

MEMBER KIRCHNER: But I've looked through it. I didn't see anything, in my opinion, that made it specific for advanced reactors.

DR. CORRADINI: If a new light water reactor were to appear somewhere in the zone of interest, does this apply? That's another way of asking the question.

MS. THOMPSON: Yes. Because it would be considered a new reactor. We specifically included advanced reactors, because in some discussions saying a new reactor seems to imply a light water reactor. So new and advanced we felt adequately captured any of the potential applicants for a Part 50 or Part 52 license that we may anticipate in the future.

MEMBER KIRCHNER: Yes. I just would seem to me that I'm quibbling on the margin --

MS. THOMPSON: Okay.

MEMBER KIRCHNER: -- if you'll bear with me. But I would just strike --

MS. THOMPSON: Strike advanced?

MEMBER KIRCHNER: -- new and advanced. It's new sites that you're really --

MS. THOMPSON: Correct.

MEMBER KIRCHNER: -- thinking about, not the reactor technology. It's for reactors, obviously.

CHAIR BLEY: Well, even that, you guys are convincing me we ought to wait until everybody's back before we start a session.

(Laughter.)

CHAIR BLEY: This could apply to any nuclear facility.

MEMBER KIRCHNER: Yes, that's what I was thinking.

CHAIR BLEY: Could, they've written it to apply to reactors.

MEMBER KIRCHNER: Yes, but example, it should work for a fuel fabrication facility.

MS. THOMPSON: Correct.

MEMBER KIRCHNER: It could work for a

medical isotope facility.

MS. THOMPSON: Yes.

MEMBER KIRCHNER: So again, that's just a top level comment.

MS. THOMPSON: And the working group actually had many conversations that sounded just like this about whether we should include this to include everything, especially because that IAEA Guide that I will discuss later is designed for the full spectrum of nuclear facilities. So that was something that the working group did consider.

DR. CORRADINI: So let me ask now, a quick, oh, I'm sorry.

MEMBER DIMITRIJEVIC: Sure, you started so --

DR. CORRADINI: No, no, you first.

MEMBER DIMITRIJEVIC: Oh, ladies, all right. Jenise, I'm sort of curious about the structure of your team. Is it mostly geologists, have you got a PRA expert, the seismic content, or what ---

MS. THOMPSON: That's the next thing I was going to get to.

MEMBER DIMITRIJEVIC: Oh, okay. All right.

DR. CORRADINI: So my question is, is

there any other technology that has to worry about volcanoes?

MS. THOMPSON: By technology, that's regulated by the ---

DR. CORRADINI: Any sort of manmade technology in the United States that has to worry about volcanoes other than nuclear?

MS. THOMPSON: I would say that any facility sited near a place where volcanic hazards may impact your facility, they should be considered. I think a great example is a new high school built in Hawaii. I think that should consider ---

DR. CORRADINI: But I'm asking, I know what should be, I'm asking are they? I don't think chemical facilities are.

MS. THOMPSON: I would have to look that up unless, Britt, do you, this is Dr. Brittain Hill. He's the consultant to the staff.

DR. HILL: Brittain Hill, NRC consultant. There are a number of facilities around the United States that take into account the potential for volcanic hazards. Jenise was mentioning certainly in Hawaii, a geothermal power plant is located in the East Rift, has active lava flow mitigation to it. Around Mount Rainier there is debris flow monitoring,

debris flow remediation all around the suburbs east of the Olympic Sound, Puget Sound.

DR. CORRADINI: Is this ---

DR. HILL: Many ---

DR. CORRADINI: -- state regulated or is it federal?

DR. HILL: -- facilities though are not built in areas of potentially active volcanism.

DR. CORRADINI: Okay.

MEMBER REMPE: But I think Mike's question was different. Does another agency require those facilities to consider, does the EPA require it, does the state require that they consider volcanic activity?

DR. CORRADINI: I understand it might be prudent, but I'm just trying to decide is it a federal mandate, is it a state mandate, is it, I was going to use the word arbitrary, but that's not the word I'm looking for.

PARTICIPANT: Local.

DR. CORRADINI: Local, thank you very much, a local requirement. That's where I was going. Because I was going to think of chemical plants. But I see some of your examples. But are those examples coming out because it's a federal requirement? Or is

it a state requirement? Or is it a locale?

DR. HILL: I'm not aware of an overarching federal requirement to explicitly address volcanic hazards in planning.

DR. CORRADINI: I didn't think so.

DR. HILL: That usually is left at the state level.

DR. CORRADINI: Okay.

DR. HILL: I know there is guidance at the state level in, for example, Oregon, about potential volcanic hazards. But I'm not aware if it has any statutory authority behind it.

DR. CORRADINI: Okay. All right, thank you.

MEMBER DIMITRIJEVIC: Well, this could be, I mean, those questions could be really relevant when we are discussing mitigating measures to divert the lava. Because you cannot just run a mitigating measure to build these lava diverters. You have to watch out where you're diverting them if there is a state regulation of it.

MS. THOMPSON: Yes. So to get back to your question about the composition of the working group, the working group is composed of numerous technical and project management staff from NMSS and

from NRR.

Within NRR, the staff on the working group come from the Divisions of New and Renewed Licenses from Advanced Reactors and Non-power Production and Utilization Facilities, and the Division of Engineering and External Hazards.

We also have research involved as the project management support for the draft guide and, as I previously mentioned, we have contracted with the Center for Nuclear Waste Regulatory Analyses to obtain the consultation services of Dr. Hill here as an expert volcanologist consulting the staff.

MEMBER DIMITRIJEVIC: Do you have a PRA expert?

MS. THOMPSON: We do not have a PRA expert on the working group.

So I think there was another question of why did we pursue this action now. Oh, okay, sorry, two different screens showing me two different things.

So the working group was formed based in response to several factors. Most notably was that recently Congress funded the Department of Energy through the Nuclear Energy Innovation and Capabilities Act of 2017 to develop advanced reactor projects at the National Laboratory sites.

The Idaho National Laboratory site was selected by the Department of Energy for the home of the National Reactor Innovation Center which has recently opened and was funded in this fiscal year. DOE is also authorized, under the Atomic Energy Act, to build and operate nuclear reactors which the NRC has the licensing authority over.

DR. CORRADINI: If I might just ask.

MS. THOMPSON: Okay.

DR. CORRADINI: Historically, Idaho had what is called the Test Station. And on the Test Station was ATR, SL1, et cetera, et cetera, et cetera. Were those all state regulated in terms of any sort of this activity? Or it was just never recognized that, because it was DOE orders that regulated the facilities, that this was never considered before for those facilities?

MS. THOMPSON: When you say this, do you mean volcanic hazards?

DR. CORRADINI: Yes.

DR. HILL: Brittain Hill, NRC consultant. Idaho National Environmental Engineering Lab, as it used to be called, had an active program of volc hazards analysis since about 1990. It's undergone several major revisions since then. So volcanic

hazards in INL --

DR. CORRADINI: Does exist.

DR. HILL: -- have been well recognized by the DOE and associated entities.

DR. CORRADINI: Okay.

MEMBER REMPE: So along that line of questioning, I'm interested in exploring what's going on with DOE and NRC, if there's an MOU, and if this guidance might be passed on to DOE, and they might want to adopt it as part of their orders.

Because in addition to the existing facilities, my understanding is DOE's interested in authorizing the start-up of the VTR. And it's a new facility that would be a test reactor. And would they apply this guidance with it? Or would they use this since 1990 guidance that they have?

DR. HILL: Brittain Hill, the 1990 onward was more the Volcanic Hazards Analysis. It wasn't guidance.

MEMBER REMPE: Yes.

DR. HILL: The application of the Volcanic Hazards Analysis to safety decisions would occur through DOE's internal standard, STD 1020, which was most recently revised. It has its own criteria for what would be an acceptable volcanic analysis for DOE

regulated facilities.

MEMBER REMPE: And how does that compare with what's in your guidance? Is it more limiting, or less limiting, or do you know?

DR. HILL: It's hard to draw a direct comparison. In many of the areas that we are focusing in a bit more detail, the DOE analyses really are focused more on design basis development rather than siting decisions.

MEMBER REMPE: Okay.

DR. HILL: I think we have a more risk-informed performance based framework to implement a variety of safety decisions more openly.

MEMBER REMPE: Thank you.

MS. THOMPSON: So the NRC and the Department of Energy have both recognized that there are volcanic hazards at the INL site. Additionally, the staff also considered that there are other areas of the United States, that may be considered at some time in the future for a new reactor site, that may also have the presence of known or potential volcanic hazards that would need to be assessed in the site characterization for that new reactor application.

And this draft guide would apply equally to any site located within the United States, not just

within the Idaho National Laboratory area.

Additionally, the NRC has regulatory requirements for site characterization, one of which specifically calls out volcanic activity. But we do not have specific guidance on how to assess those volcanic hazards and what an acceptable approach would look like for a Volcanic Hazards Assessment.

Those regulatory requirements are shown here. I'm actually going to rely on my notes and read these off so that I get the exact quotes correct. For Part 52, General Design Criterion 2 states that structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomenon without loss of capability to perform their safety functions.

Those S.C. design bases should reflect appropriate consideration of the most severe of the natural phenomena that have historically been reported for the site and surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

This language is then echoed in Part 52 for both an Early Site Permit application and Part 5279 for a combined license application. And within

this characterization, a severe natural phenomena would include something like volcanic hazards.

And then finally, the only specific mention of volcanic activity within the siting regulations for reactors is in Part 100.23, Reactor Site Criteria, which states that each applicant shall investigate all geologic and seismic factors, for example, volcanic activity, that may affect the design and operation of the proposed nuclear power plant, irrespective of whether such factors are explicitly included in this section.

So despite the specific inclusion of volcanic hazards within our regulatory requirement, we don't have guidance. But the staff has undertaken several reviews in the past on an ad hoc basis for sites that did consider volcanic hazards.

These prior reviews or licensing actions are shown here on the figure in yellow. There are six prior licensing actions that on some level considered volcanic hazards. The reviews for these sites included facilities that ranged from nuclear power reactors, spent fuel storage, enrichment facility, and nuclear waste.

These sites in yellow, you'll notice they are only four, although there were six reviews, that's

because three of the reviews were conducted for facilities at the INL location, two for independent spent fuel storage installation and one for an enrichment facility.

The blue pin toward the top shows you the location of Mt. St. Helens, which last erupted in 1980 and, as you can see, is located between the only two reactors that were sited in the United States that considered volcanic hazards.

MEMBER DIMITRIJEVIC: Well, how about the ash ---

MS. THOMPSON: Yes, I'm going to --- so the Columbia site is located 217 kilometers east of Mt. Helens which, as I said, last erupted in 1980. At the time of licensing, the Columbia plant considered a design and operational basis volcanic event for volcanic ash fall. And Columbia is the only operating reactor that has a design basis for a volcanic event.

The staff's conclusions for the Columbia site were based on a demonstration of the plant's ability to withstand the wet and dry loads of potential ash fall deposits at the site, operational considerations for mitigating the effects of ash fall on plant structures, systems, and components, and the installation of oil bath air filters, excuse me,

during an ash fall event. And this represents the last time that the staff conducted a review for volcanic hazards at a reactor site.

MEMBER KIRCHNER: For the record, those were the emergency diesel generators, aren't they?

MS. THOMPSON: Yes.

MEMBER KIRCHNER: Okay

DR. CORRADINI: That was the, I guess Walt is more familiar, those were the only active changes to the plant design is, essentially, the air filtration going into the diesel generators, or were there other things besides that?

MS. THOMPSON: I know of the air filters for the diesel generators. And, Britt, did you want to expand on that?

DR. HILL: This is Brittain Hill. There are some operational considerations for ash removal from, say in the electric switchyard, enhanced maintenance cycles on some of the other air filtration systems.

DR. CORRADINI: So it would be operator actions?

DR. HILL: Operation actions, yes, sir.

DR. CORRADINI: Okay.

MEMBER DIMITRIJEVIC: How about control room, control room air filters.

MS. THOMPSON: The control air filters?

MEMBER DIMITRIJEVIC: And then also, if there is operator action --

PARTICIPANT: Green light on.

MEMBER DIMITRIJEVIC: -- we can pursue many LOCA operator actions --

MS. THOMPSON: I don't have anything on the control room in my notes.

MEMBER DIMITRIJEVIC: I know, I know.

(Simultaneous speaking.)

MS. THOMPSON: But I can take that back to look into it.

MEMBER DIMITRIJEVIC: We're not expecting answers. I think the operator action is the one thing, that's why I asked you do you have PRA people. Because then you will know about the crucial --

MS. THOMPSON: And looking at the Columbia mitigation actions and the procedures that would be implemented in the warning time is something that the staff considered in the VHA approach, which I'll discuss later when I get to the mitigation action stuff within the VHA approach outlined in the draft guide. So we're coming back to Columbia and the

actions taken there.

The Trojan site is or was located 55 kilometers southwest of Mount St. Helens. At the time of licensing, both ash fall and debris flow from the Cascade volcanoes were considered.

At the time of licensing, the potential effects of these future volcanic hazards were determined to have an insignificant effect on the design and operation of the facility because of the low frequency of occurrence and the characteristics of the potential phenomena expected at the site as a result of a volcanic eruption.

Following the 1980 eruption of Mount St. Helens, a debris flow in-filled the Columbia River channel downstream of the Trojan intake valve and several millimeters of ash were deposited at the facility. Following this eruption and the receiving of these volcanic hazards close to the Trojan site, the hazards were re-evaluated based on the 1980 eruption characteristics, but no changes were made to the design basis, excuse me, the plant operating basis.

CHAIR BLEY: That's interesting. There was minimal ash fall there.

MS. THOMPSON: Yes.

CHAIR BLEY: There was minimal ash fall around Pasco and Richland, but further east, I think beyond Columbia Station, there were several feet of ash fall out that far.

MS. THOMPSON: There were favorable winds, or Britt can explain it.

CHAIR BLEY: Yes, there were.

MS. THOMPSON: Essentially that's what it comes down to. But, Britt, did you want to add anything to that?

DR. HILL: Yes, Brittain Hill. The 1980 eruptions at St. Helens, there was really only one day, I believe it was June 3rd, where the ash plume was directed to the southwest towards Portland and the Trojan Power Plant. All the other eruptions, the main eruption of May 18th, it all went out to the east. And so you were getting tens of centimeters, to almost 100 centimeters in some locations, of that ash fall during the main event.

The volcanic hazards before that eruption really didn't consider large volume debris flows either. And of course, with the collapse of the north face of Mount St. Helens, a huge amount of material and debris was thrown into river drainage which ended up at the Tootle River flowing into the Columbia and,

because of a combination of density and tidal effects, traveled about nine miles upstream from the entrance of the Tootle River into the Columbia.

But that debris was confined to the central part of the Columbia River channel, whereas the Trojan intakes were up towards the bank. So the debris from the 1980 eruption didn't actually get taken in to the intakes for the Trojan Water System. Trojan was offline at the time for refueling during the 1980 eruption.

MS. THOMPSON: And Trojan was decommissioned in 1992.

The Idaho National site, as I mentioned before, was subject to three different prior reviews by the NRC staff. Two of these were for the TMI2 and the Idaho spent fuel facility ISFSIs. And the third review was conducted for the Eagle Rock enrichment facility.

At the INL site, the staff determined that lava flows and ash fall hazards were the primary volcanic hazards under consideration.

MEMBER DIMITRIJEVIC: How far is the volcano?

MS. THOMPSON: I'm sorry?

MEMBER DIMITRIJEVIC: How far is it from

the volcano?

MS. THOMPSON: Oh, for INL, I don't have --

MEMBER DIMITRIJEVIC: So Columbia is ---

(Simultaneous speaking.)

MS. THOMPSON: So Columbia's 200 kilometers, so INL is somewhere between, I would say, depending on where you are on the site, yes, probably 600, 700.

DR. CORRADINI: It was a different potential volcano.

MS. THOMPSON: Yes.

DR. CORRADINI: It's not the same one.

MEMBER BROWN: It's not the same, I mean, there are lava flows all around ---

(Simultaneous speaking.)

MS. THOMPSON: I was going to say, to clarify, the ash fall hazard considered at the INL site was looking at the Cascade volcanoes and ash from an eruption there reaching the INL site. The lava flow hazard is sourced in the eastern Snake River Plain where the INL site is physically located. So it's two hazards from two different sources that were considered at the time of licensing ---

DR. CORRADINI: Thank you.

MS. THOMPSON: -- for the INL site. And the acceptability of these volcanic hazards at the INL site was demonstrated at the time of licensing from the appropriate design and operational bases for ash fall, again from these further located volcanoes, the low likelihood of lava flow inundation from lava flows on the eastern Snake River Plain, and confidence in the licensee's ability to divert potential lava flow.

MEMBER REMPE: I have a dumb question just counting. I know about the TMI S.C. in Idaho. I know about the proposed Eagle Rock facility. You said there's a third facility, the Idaho spent fuel facility. What is that?

MS. THOMPSON: Yes, so this was a proposed ISFSI that was, an application was submitted, but the facility was never built.

MEMBER REMPE: Okay, so there's only one that's there, and the other two are ---

(Simultaneous speaking.)

MS. THOMPSON: Yes, so the review was conducted.

MEMBER REMPE: Okay.

MS. THOMPSON: The review considered volcanic hazards, and the working group considered any review that was conducted, whether or not the outcome

was a constructed facility.

MEMBER REMPE: Thank you.

MEMBER DIMITRIJEVIC: May I ask why didn't you, on Page 6, identify it as a volcano?

CHAIR BLEY: You need your green light on, Vesna.

MEMBER DIMITRIJEVIC: Green light on. Now I see. Why didn't you, on Page 6, identify all other volcanoes considered?

MS. THOMPSON: The key consideration in that is that the Mount St. Helens location is essentially a point source of one volcano. The eastern Snake River Plain is an area over which there have been numerous flows in geologic history. So I don't have a pointer, but I could point it out if you wanted me to go back and do that.

MEMBER DIMITRIJEVIC: No, that's all right. I was just thinking that the feature will be better if you sort of identify all other hazards ---

CHAIR BLEY: Well, and there are other Cascade mountains up there that are potential sites. They're just showing us ---

MS. THOMPSON: We were trying to focus on roughly where things were, and particularly Mount St. Helens because that was a volcanic eruption that did

affect two reactor facilities. And I see that Britt has something to add.

DR. HILL: I was just going to point out there are about 500 volcanic eruptions in the eastern Snake River Plain for the last 500,000 years. So there are many, many dots that would kind of clutter up the map for all of that.

MEMBER DIMITRIJEVIC: I just want to say when we go through your guide, we will see that they are required to identify the range of the hazards.

MS. THOMPSON: Yes, and ---

MEMBER DIMITRIJEVIC: And without those 500 dots, they will not be able to do this.

MS. THOMPSON: And we'll get to the range of the hazards to be considered. And something that I did look up anticipating a question like that is that, according to the United States Geologic Hazards Monitoring Program, there are 169 active volcanoes capable of producing a wide range of hazards within the United States alone. So not wanting to ---

(Simultaneous speaking.)

MS. THOMPSON: One hundred and sixty-nine. So not wanting to cloud the figure any more than we already had, we went with Mount St. Helens as the most relevant to the discussion of volcanic hazards

affecting a nuclear reactor.

CHAIR BLEY: Jenise, since Yucca Mountain is showing up here, during the ASLB hearings on Yucca there were a number of contentions filed with respect to volcanism. And 25 of them were deemed admissible contentions.

I know DOE responded to them. I'm not sure if staff reached the point they responded. And I don't think they were ever resolved by the ASLB. They're still dangling there. Did you consider those? Are any of those having any impact on the information you're identifying for applicant's to use in this reg guide?

MS. THOMPSON: So I see Britt standing at the microphone.

CHAIR BLEY: I bet he is.

DR. HILL: Brittain Hill, NRC consultant. In a former life I was the senior level advisor for Repository Science. One of my principle areas of responsibility was the Yucca Mountain Safety Analysis proposed closure. I can say quite confidently that none of those issues have been adjudicated by the Atomic Safety and Licensing Board.

The NRC staff though was able to reach a technical conclusion on acceptable safety for volcanic

hazards with full knowledge of the content of those technical objections or contentions.

CHAIR BLEY: Thank you.

MS. THOMPSON: And that's a perfect bridge to the discussion of Yucca Mountain that the working group considered in the guide.

CHAIR BLEY: But my question wasn't what's the status of it. I kind of knew that. My question was did any of the underlying technical issues raised in those contentions find its way into the reg guide?

DR. HILL: Brittain Hill, consultant. The short and simple answer is no.

MS. THOMPSON: The working group was primarily focused on prior NRC staff review actions. So that was the focus of our background gathering of these prior licensing reviews to inform the draft guide for future licensing reviews.

So for Yucca Mountain, the staff considered two periods, the pre-closure or operational period, and the post-closure period. For the operational period, the occurrence of a new volcano was screened out for the operational period. And it was determined by the staff that ash fall could be mitigated.

DR. CORRADINI: Help remind me, I forget

what's the pre-closure period.

MS. THOMPSON: So the pre-closure period is when the --

DR. CORRADINI: No, I know what it is, but what's the time window? That's what I was --

MS. THOMPSON: Oh, the time window. Okay.

DR. CORRADINI: Is it 300? I was thinking 100 years.

MEMBER KIRCHNER: If my memory serves me well, it's 300 years. But anyway, it's --- Mike, what?

DR. CORRADINI: No, no, that's fine.

MEMBER KIRCHNER: It's 100 to 300. It was when the hot fission products, the strontium and all those dissipated their heat before closing. So obviously --

DR. CORRADINI: It's when it was ventilated.

MEMBER KIRCHNER: -- the long timeframe was the actinides.

MEMBER REMPE: In all these, I've never seen one of these studies, and I'm just curious on how you decide that it's a negligible amount of consequences or increased in risk. Is it quantitative?

You can say, well, the frequency is less than ten to the minus 13, so we don't care. And well, if there's one that's within ten to the minus four that might occur, do you look at the consequences and say the increase in source term is less than whatever, or how do you go?

MS. THOMPSON: So there were three key components to the conclusions for Yucca Mountain that were made by the staff. And those were based on a low likelihood of a volcanic event occurring. I don't have if there was a number, but it was determined to be sufficiently low.

The second component was that the amount of high level waste, at least for the post-closure period where the occurrence of a new volcano was considered as the primary volcanic hazard, the high level waste that would be entrained or ejected during that new volcano would be sufficiently small.

And then the third component was that the combination of natural and engineered barriers would be sufficient in the occurrence of a new volcano to limit the radio nuclide release. So it was a three-part conclusion. I don't have what those thresholds were. But those were that ---

(Simultaneous speaking.)

CHAIR BLEY: That's for Yucca, but if I might, if any of our questions are going to be answered later in your slides, ask us to wait.

MS. THOMPSON: Well, that one was right there on this slide.

MEMBER REMPE: Okay. Well, in the case of the reactors, I'm wondering if you ever got to where you got quantitative and said that ---

(Simultaneous speaking.)

MS. THOMPSON: So the process which I will get to and discuss, it allows there to be a demonstration that you have reached a sufficiently low risk at numerous steps in the process where you can complete your analysis and be done.

(Simultaneous speaking.)

MEMBER REMPE: But I'm asking in the past, like for Columbia and Trojan. Did you just follow this process, or did you actually do some sort of quantification and say it's less than a curie that gets out or something like that, or a millicurie. Did they go that far in the evaluations?

MS. THOMPSON: I'm going --

DR. HILL: Brittain Hill, I can speak to Yucca Mountain which had a full blown probabilistic risk assessment, it was called the Total Systems

Performance Assessment, that considered both the likelihood of events, and the consequences, and associated radiological doses into the accessible environment.

In the post-closure period, the two-leading sources of risk were disruption by volcanoes and by earthquakes. But even when you factored in the amount released and the likelihood and timing of that release, the release levels were less than one millirem per year. The standard for Yucca Mountain was 15 millirems a year. So these were quantified.

MEMBER REMPE: So that's good for Yucca Mountain. I'm just curious about the --

MEMBER KIRCHNER: The siting of the other two sites pre-dated PRA.

MEMBER REMPE: Yes, but they probably didn't go into that level.

MS. THOMPSON: And the working group did not consider that, whether there was a bounding number that the applicant got to that the staff determined was sufficient.

MEMBER REMPE: Thank you.

MS. THOMPSON: So considering all of the prior licensing reviews, the staff wondered whether this past approach of performing an ad hoc review was

sufficient and was adequately reflective of the NRC's principles of good regulation, of openness, sufficiency, independence, clarity, and reliability.

So to answer this and other questions, the working group performed a regulatory analysis to consider five different alternatives to both assess the regulatory needs and determine the optimal path forward.

The regulatory analysis, these five different alternatives considered were to take no action or, in other words, to keep doing these ad hoc reviews as sites came in that needed to consider volcanic hazards, to develop and issue guidance, to endorse the existing IAEA safety guide which I will discuss later in the harmonization section, to wait, review, and consider for endorsement the development of a consensus standard that is ongoing, and finally to review and approve for use a topical report submitted by an applicant.

To date, no applicant has indicated their intention to submit a topical report. We just included that as one of the possibilities that could happen.

The staff also considered the schedule for completion, a cost benefit analysis, the technical

content, control of the document as additional factors, as well as the principles of good regulation and risk-informed decision making in determining which would be the optimal path forward. Following this regulatory ---

DR. SCHULTZ: What was the fifth?

MS. THOMPSON: The fifth option was to develop, or excuse me, to review and approve for use a topical report submitted by an applicant. But no applicant has submitted a ---

DR. SCHULTZ: No, I thought that was ---

MS. THOMPSON: -- a topical report or indicated their intention to do so. We just included it for the sake of considering every available alternative that could happen.

The optimal path forward as determined by the working group was to develop a regulatory guide. Part of the reason for this is that not only does it fit the schedule that we have outlined for ourselves, it allows us to harmonize or draft guide with the existing IAEA safety guide. It provides a mechanism by which the staff can consider in the future any consensus standard that becomes available for a volcanic hazard assessment. And it also provides us with multiple opportunities to interact with the

public and external stakeholders on both the content of the guide and how the guide is working.

DR. CORRADINI: If I might just ask --

MS. THOMPSON: Yes.

DR. CORRADINI: So the IAEA guide and just simply accepting it straight up was not considered why?

MS. THOMPSON: I will get to that in the harmonization section.

DR. CORRADINI: Okay.

MS. THOMPSON: But to give you a preview, there were three key components that the staff ---

PARTICIPANT: Wanted.

MS. THOMPSON: -- yes, identified.

DR. CORRADINI: All right, thank you.

MS. THOMPSON: But we'll get to that towards the end.

Recognizing the interest and importance for some perspective applicants of a process to assess volcanic hazards, the working group issued a draft outline of the draft guide and solicited public comments and feedback. We even held a public meeting in October to meet with perspective applicants and gain their feedback on some of the content proposed in the draft outline.

In moving forward with the draft guide, the staff identified several goals that should be met by the regulatory guide, including to protect public health, safety, and the environment, to provide an open and traceable basis for regulatory decision making.

We also considered what would be the appropriate burden on an applicant using this draft guide to assess volcanic hazards at their site and to ensure that that burden should be commensurate with the risk posed by the facility.

And we also wanted it to ensure that the draft guide was consistent with the NRC's risk-informed, performance based framework as well as the prior licensing actions and reviews that the staff had undertaken.

DR. SCHULTZ: Jenise?

MS. THOMPSON: Yes?

DR. SCHULTZ: Just to back you up a bit, no need to go to the slides, it wasn't on there, but you said that you identified potential applicants and got together with them to discuss going forward plans. How were they identified, and how many came to meet?

MS. THOMPSON: So we held a public meeting in October. We noticed it through the NRC pubic

meeting notification system so that any, whether they were a perspective applicant or a member of the public, they were welcome to attend.

We had one person attend in person, and we had about 25 people call in on the phone. Many of them were from advanced reactor organizations, perspective vendors for advanced reactor technologies. There was at least one that's considering a site for, I'm not sure what type of application.

And the way that we interacted and identified these people, in addition to making a public notice, is through our working group contact in the Division of Advanced Reactors and Non-power Utilization and Protection Facilities. I think I got that right.

We went to the advanced reactor stakeholder meeting the month before out public meeting to present, at a high level, the draft outline is coming. This is the public meeting notice, and we would look forward to you attending and providing us your early feedback on this draft outline of a draft guide. So we leveraged the PMs that are on the working group --

DR. SCHULTZ: Sure.

MS. THOMPSON: -- and the contacts that

they have.

DR. SCHULTZ: So you had an appropriate outreach for the event ---

MS. THOMPSON: Yes. So the public meeting notice went out through the advanced reactor ListServ, I'm not sure, their mailing list that they have.

DR. SCHULTZ: Good.

MS. THOMPSON: And their stakeholders, their monthly stakeholder's meeting.

DR. SCHULTZ: Sound's good, thank you.

MS. THOMPSON: The staff also identified challenges associated with developing this draft guide, most notably that there is no generally accepted approach for developing or performing a Volcanic Hazards Analysis or VHA. This is compared to something like seismic hazards where many people are familiar with the Probabilistic Seismic Hazard Assessment, or PSHA.

The draft guide would also need to support both siting decisions and potential design bases. The staff and the working group also identified that volcanic events are rare events with appreciable uncertainties in the timing and nature of those volcanic events.

And finally, the working group also

acknowledged, and I'll share with you on the forthcoming slide, that there are a wide range of demands placed on facilities from a volcanic event. And there are limited design analyses available to assess those particular demands from those hazards, with the exception of ash fall, which I mentioned has been considered in prior reviews.

So some of the volcanic hazards that the working group considered important that would need to be considered, as well as the associated demands, the first that I'll share with you is ash fall. The photo here shows a worker in the background, and the worker is blowing the ash fall deposits off of the insulators in an electrical switchyard. This is following a volcanic eruption in Japan.

So unlike fly ash or what's in your fireplace, volcanic ash is a mix of pulverized rock and minerals, so it ranges in size up to about two millimeters. And it's hardness is comparable is most metals or alloys, so we're talking about things that are very heavy.

They also can be conductive, especially when they are damp from fog or a light rain, hence the reason why this worker is blowing the ash fall deposits off of these insulators so that they prevent

the arcing from the volcanic ash in the switchyard.

The airborne particle concentrations for volcanic ash can be on the order of up to 100 milligrams per cubic meter. This will decrease typically in the days or weeks following an eruption. The physical loads resulting from the deposition of volcanic ash at a site can range from 100 to 1,000 kilograms per square meter. This is comparable to a snow load event at a facility. And this can increase when the volcanic ash is wet.

And finally, volcanic ash can linger for days or weeks after an eruption. And as we saw following Mount St. Helens, volcanic ash can travel not just tens or hundreds of kilometers but thousands of kilometers affecting sites well removed from the location of the ash source.

CHAIR BLEY: One thing you didn't talk about there, and in the reg guide when you go through the methodology, you don't give a lot of advice about what failure modes could be induced by these events.

But when you get to the very tiny volcanic ash, a thousandth of a millimeter, this stuff's so small it could get into equipment in ways we don't normally have to think about and probably interfere with the equipment but possibly really damage it as

well.

Are you thinking of any other additional information to be provided to applicants to have them think about specific, how to think about, for all of these hazards, the specific damage mechanisms that might occur to SSCs at their site?

DR. SCHULTZ: And are there specific threshold effects within that large range?

MEMBER DIMITRIJEVIC: That's missing from the guide. And that's one of my biggest comments, that there was no discussion about the connection of SSCs in the failure modes connected with different hazards, ash and all other hazards which you identify. And that's where you actually have the nuclear facility connects to this hazard through the failure modes associated with different type of components and --

CHAIR BLEY: Your simplified, well, you're going to get to the methodology later.

MS. THOMPSON: Yes, we're going to get to that.

CHAIR BLEY: But your simplified PRAs, and I wish you had had a PRA person helping with this, they have some problems we'll talk about later, but they assume that the vulnerable SSCs fail.

MS. THOMPSON: Okay.

CHAIR BLEY: Which makes it easy.

MS. THOMPSON: Yes.

CHAIR BLEY: As long as the person doing the analysis understands what the challenge is to their SSCs.

MS. THOMPSON: Will be.

CHAIR BLEY: -- and, you know, the heavy weight, that's an obvious one. Some of the others maybe are more subtle. And if you don't give them guidance on that, it'll be a toss-up while they think about it.

MEMBER DIMITRIJEVIC: That's a big piece in this guidance, because you have a two screening, one when there's 200 percent failure and one when you're adding these two probabilities of hazards and eruption to put as a failure probability.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: But the failure modes and related SSCs are not in there.

MS. THOMPSON: Okay.

MEMBER KIRCHNER: Jenise, do you, in your center or activities, put out some kind of, I'm trying to think about vehicles you have at your disposal to communicate to the industry. But do you give

guidance, say, pick on something like seismic analysis, something comparable, is there, to address Dennis and Vesna's concern, do you put out any kind of guidance that would suggest, separate from this reg guide which is primarily citing how to protect, you know, SSCs and especially safety-related or, so I guess it's not all safety-related. This is not necessarily safety-related. It's just power. But do you see where I'm going?

MS. THOMPSON: Whether we issue --

MEMBER KIRCHNER: Just power.

MS. THOMPSON: -- something more specific?

MEMBER KIRCHNER: Yes.

MS. THOMPSON: The external hazard COE has not done that. But I can take that back as a comment to consider.

MEMBER KIRCHNER: I was just thinking that the reg guide might get unduly complicated if you tried to do equipment failure modes and effects kind of analyses as, you know, guidelines and so on, like you were asking.

CHAIR BLEY: Well, maybe it would be an appendix or a separate document. But there ought to be something. I read through the IAEA stuff, but I haven't read it carefully enough to know if they dig

into that. But I didn't see it.

MEMBER DIMITRIJEVIC: Well, my personal thinking is just a high level, there's a lot of technical equipment will be susceptible to ash. In the case of lava, you have to worry about the things on the ground level, you know, like electrical, and more operator actions can be affected. It can be just a couple of paragraphs of general guidance, and then they can do the full analysis when they submit them.

MS. THOMPSON: So that is part of the reason why, in the draft guide, we included specific information about hazards like volcanic ash so that an applicant following this guide would look at the particle size and consider the range of particles sizes of ash that may affect that site.

So you'll see that that is captured in the draft guide. I understand your point that we didn't take it that step further to consider the failure modes from those specific particle sizes within specific SSCs.

MEMBER DIMITRIJEVIC: What's the type of limit could be considered a factor with this, you know?

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: The same thing with

the lava flow. So whatever, you have this next, you know, in the third slide you will have this pyroclastic flow which I'm not sure I ---

MS. THOMPSON: And when we got into the volcanic hazards assessment, the physical approach, and the flow chart in the presentation here, there is a step in the process where an applicant can choose to do an additional analysis considering specific physical properties of specific structures, systems, and components within their proposed facility, given the volcanic hazards that screen in and have not been ruled out at that point in the analysis. So there is a place where this more detailed site-specific analysis would occur.

MEMBER DIMITRIJEVIC: But you have a step, and we will get to that.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: Where you have initial risk here, based on this initial risk, you think you should put everything failed, then from there. It doesn't have to go ---

MS. THOMPSON: Right. So ---

MEMBER DIMITRIJEVIC: So you have to select what's ---

MS. THOMPSON: Yes. And we'll get to

that, because there are actually three different steps where this may be addressed with increasing detail.

MEMBER DIMITRIJEVIC: Okay.

CHAIR BLEY: I would just say if you don't do it attached to your reg guide ---

MS. THOMPSON: Consider an appendix?

CHAIR BLEY: -- you will eventually do it, because you won't be happy with what you get. And you'll be doing lots of RAIs, and that sort of thing.

MS. THOMPSON: Okay.

MEMBER BROWN: I don't know. I'd be careful. I mean, it's starting to sound like we want to provide all the design information inside the reg guide and become very prescriptive about what they have to look at, and how they look at it, and what the potential mitigating actions ought to be. And that's the same thing we face about trying to be too prescriptive on designing some of the systems, particularly the protection and safeguard systems that we've looked at.

I think there's a balance in there. We just can't fill this thing up with prescriptive information. You want it covered, you want them to evaluate the potential hazards and tell you, but not try to tell them what they have to look at. That's

just my thought on it. It's just a little counter --

MEMBER KIRCHNER: I tend to agree with Charlie too, because I'm thinking of the diesel generators. When you see this threat to operating your diesel generators then you go into a much more detailed analysis as to whether I need oil filters or not, as an example.

But to pile that all into the reg guide might be asking for a lot --

MEMBER DIMITRIJEVIC: Well, because they will have a step. We will get to the steps --

MS. THOMPSON: We'll get to the steps.

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- development.

MS. THOMPSON: And that point was something that the working group considered, is we wanted a guide that was broad enough that could be considered at any site that may have volcanic hazards present and making it not so descriptive that it became cumbersome. You know, that was one of our goals, was to be commensurate with risk and appropriate burden.

So new vent opening, this shows a new vent erupting in Hawaii. The opening of a new vent is usually proceeded by several days or several weeks of

precursory earthquakes which is triggered by magma or molten rock rising from a duct beneath the surface.

The opening of a new vent results in ground deformation, usually a rift will be one to several kilometers long and somewhere between on and ten meters wide. So we're talking about a significant gash in the surface of the earth.

If that magma then erupts along that new rift, there will be lava flows which may erupt on one to two main vents in this new ground opening in a day. The continued eruption would result in volcanic ballistics and other ejecta. These may be up to several meters in diameter and occur within about several kilometers of the vent opening. So this is not a point hazard right at the opening of the new vent but can be a hazard from some distance away as well.

It may result in the creation of a scoria cone, and I was told to mention this, because today is the 77th anniversary of the eruption of Paricutin, a scoria cone in Mexico, so very timely for us.

There also may be a smaller volcanic edifice as a result of the opening of a new vent. If there are interactions with shallow ground water, there also may be small blasts or surges also within

several kilometers of the vent. So the opening of a new vent is a spatial consideration for some diameter away from the new vent opening.

CHAIR BLEY: Tephra is ash or ---

MS. THOMPSON: Ash, small---

CHAIR BLEY: -- something like ash?

MS. THOMPSON: Small volcanic particles, yes.

DR. SCHULTZ: Jenise, you mentioned that there is usually some precursory indication that something is going to happen. But that's usual, it's not always.

MS. THOMPSON: It's not always, but it would be more unusual for there to be no indication than it would be unusual for there to be indication.

So typically, most likely there would be precursory activity -- no activity, and then a volcanic event where the new vent opening would be a rare occurrence.

DR. SCHULTZ: All right. Okay. Thank you.

MS. THOMPSON: Lava flows are another hazard with significant demands placed on surrounding facilities. The photo here is from Hawaii, the 2018 Kilauea East Rift eruption.

The steaming vent in the background is the two-kilometer-long rift from which that main lava flow is erupting coming into the foreground of the photo.

Lava flows are molten rock at the surface of the earth. They are very dense, up to 2,500 kilograms per cubic meter. And we're talking about very hot molten rock, 1,000 degrees Celsius or more.

The heat capacity of a lava flow is comparable to most metals. And the flow rate can vary from about one until about 10 meters per second, or about 22 miles per hour. And the flow rate will depend on the local topography and other factors.

Although most lava flows will follow topography, lateral breakouts can be common. Additionally, lava flows have been known to damn waterways resulting in localized flooding.

Another flow hazard that should be considered are pyroclastic flows, which you may sometimes see referred to as pyroclastic density currents. And the photo here shows a mall pyroclastic flow on Mount St. Helen's from 1980.

Pyroclastic flows are mixtures of pulverized rock and gas -- excuse me -- they are hot, greater than about 300 degrees Celsius, with deposit densities that range from 1,000 to 2,000 kilograms per

cubic meter.

Unlike a lava flow, which is moving up to about 10 meters per second, a pyroclastic flow is very fast moving at hundreds of meters per second.

Additionally, pyroclastic flows, similar to volcanic ash, can travel longer distances looking at tens to upwards of a hundred kilometers from the source vent.

And they also -- although smaller flows will tend to stick to their topographic channel, a larger flow may overtop barriers that could be hundreds of meters high.

CHAIR BLEY: I assume they're called "density currents" because they flow from high density to low density; is that right?

MS. THOMPSON: I have seen both flow and density currents.

CHAIR BLEY: Okay.

MS. THOMPSON: There are other volcanic hazards that would be considered within the scope of the volcanic hazards assessment outlined in the draft guide.

These hazards would tend to be located near the volcano or the source vent, except for debris flows, which can flow tens of kilometers from event.

And the photo here shows the debris flow from Mount St. Helen's. This is along the Toutle River and shows the deposit of the debris flow, sometimes called a "lahar."

The bridge in the background, it's kind of the green figure, is destroyed. And the rock in the foreground is about two meters in diameter and was carried in this debris flow.

And if you look very closely, there is a small rock hammer on that rock for scale.

MEMBER DIMITRIJEVIC: How far is the Toutle?

MS. THOMPSON: The Toutle River?

MEMBER DIMITRIJEVIC: Yes.

MS. THOMPSON: So, this did not reach Trojan. So, this is within -- less than 50 kilometers from the ---

CHAIR BLEY: Two things. I want to ask you something about the list, but ---

MS. THOMPSON: Okay. I'm going to get to the list.

CHAIR BLEY: -- for my colleagues, if you ever get a chance to go visit Mount St. Helen's, do it. The blast went about 20 miles.

The trees are laying flat 20 miles away

years after the event.

DR. CORRADINI: Not anymore.

CHAIR BLEY: Huh?

DR. CORRADINI: Not anymore.

CHAIR BLEY: Yeah, they are. I was there just a couple years ago and they were --

DR. CORRADINI: But I thought there is new growth.

CHAIR BLEY: There is new growth coming back, but the old tress 20 miles out you'll see them laying down.

I took your list against -- on your slide against the list in the reg guide and against the list in the IAEA-specific safety guide.

MS. THOMPSON: Uh-huh.

CHAIR BLEY: And pretty much the list and your guide has picked up almost everything they talk about there. It's kind of rearranged some of the maybe lesser things in the group down here.

I had a question about the -- in the reg guide, it says the earthquakes are typically less than M5.

Is that always or what's "typical" mean or generally -- generally less than M5, how big an earthquake could we have?

MS. THOMPSON: I think greater than 5 would be a very rare occurrence as to what a possible --

CHAIR BLEY: Well, the whole thing's --

MS. THOMPSON: Maximum magnitude --

CHAIR BLEY: -- pretty darn rare anyway.

MS. THOMPSON: -- I'm going to defer to our volcanologist.

CHAIR BLEY: Sure.

DR. HILL: Brittain Hill.

It's a little difficult to put a maximum magnitude because it scales to the size of the eruption and there have been some huge eruptions in gas.

But typically --- for example, the 1980 eruption of Mount St. Helen's ---

CHAIR BLEY: Yeah.

DR. HILL: -- the May 18th was triggered by a magnitude 5.1 earthquake, which the seismologists said that was a fairly significant earthquake for that part of the Pacific Northwest, magnitude 5.1.

CHAIR BLEY: Is it usually the earthquake triggers the volcano or vice versa?

DR. HILL: The -- it's a combination because the one at St. Helen's was more of a tectonic

earthquake than one of molten rock.

Paricutin, when that one started, there were magnitude 3s and 4s as the magma moved up from depth.

There's another well-instrumented eruption in Russia, 1975. The Tolbachik eruption was, again, magnitude 4 to about 4-1/2 as molten rock moved up from tens of kilometers depth.

So, unless you're talking about an extremely large eruption, something much larger than Mount St. Helen's, the local earthquakes, the moment magnitudes would be -- a magnitude 5 or less would be a very good rule of thumb, but you can't rule out that something bigger could happen in a giant sort of an eruption.

Very typical like you would do for a seismic hazard analysis, I'm not aware in the United States that anything has a background source that has a maximum magnitude of less than 5.5.

So, it seems very reasonable that a volcanically sourced earthquake would be captured within the regional seismic zones in the US seismic source model.

CHAIR BLEY: Uh-huh.

MEMBER KIRCHNER: Can I ask a specific

question about a -- it's site-specific. So, forgive me, but Hebgen Lake outside of Yellowstone had a significant earthquake in '59. It's worth visiting as well to see what happened.

How do you sort out maybe cause and effect after what you just said about Mount St. Helen's? Do you -- would you -- if you have a situation like that in an active zone -- and I'm not a geologist, so I may not use the right clinical terminology -- how do you -- would you enhance your assessment of the probability of a volcano-like event as a result of, you know, you had this rather massive earthquake there and it's not that far, or do the seismic people do their thing and the volcanologists do theirs, or is there some coming together?

CHAIR BLEY: Well, they're mixed together. The person we were talking to does both. I mean, that's her field.

MEMBER KIRCHNER: But this is explicitly a volcanology hazards ---

MS. THOMPSON: Yes.

MEMBER KIRCHNER: -- assessment and I'm just wondering how you match the seismic if indeed there's a situation where you might have cause and effect, you know, one comes first and, boom, then

comes the volcano or vice versa.

MS. THOMPSON: So, the consideration of the working group was -- assuming the moment magnitude of less than or about 5, was that that moment magnitude from the volcanic earthquakes would be adequately captured in a seismic source model performed by our seismology counterparts for the specific site.

MEMBER KIRCHNER: Okay. All right.

CHAIR BLEY: I have a couple more questions.

MS. THOMPSON: Okay.

CHAIR BLEY: Not on your slide, but in your reg guide, one of the things grouped together at the end are two things associated with debris avalanches, and I have a question about each. Let me put them both on the table.

One is if it's underwater, goes into water, it could create a seiche ---

MS. THOMPSON: Yep.

CHAIR BLEY: -- or a tsunami.

MS. THOMPSON: I was just about to get to that.

CHAIR BLEY: I was assuming that the people who look at seiches and tsunamis would always

ask, is there a volcano or defunct one that could have a debris avalanche?

And for just the debris avalanche above ground, not here, do you get something like the ash falls associated with that?

Do they lead to a lot of ---

MS. THOMPSON: They will lead ---

CHAIR BLEY: -- dust and particles in the air?

MS. THOMPSON: They will lead to dust and particles in the air, but unlike ---

CHAIR BLEY: Are they local?

MS. THOMPSON: -- unlike ash fall it's not going to be a hundreds-of-kilometer hazard.

CHAIR BLEY: And it doesn't have the heat to lock it.

MS. THOMPSON: Yes.

CHAIR BLEY: Okay.

MS. THOMPSON: And compared to something like a landslide that would just occur in, let's say, a granitic mountain, you would have dust in the air following the landslide, but you would not find dust in the air several hundred kilometers away.

CHAIR BLEY: Okay. So, it would have to be right on top of you.

MS. THOMPSON: Yes. So, a debris avalanche from a -- the collapse of a volcanic edifice, you'll see dust.

But unless it's occurring contemporaneous with the eruption of additional ash, you would not see that ash fall traveling the distances that we see in ash fall that's erupted from a volcano.

CHAIR BLEY: And two more small things. On your slide, you list lightning. You don't list that in your reg guide.

MS. THOMPSON: Oh, okay.

CHAIR BLEY: You might make them consistent.

And the last thing is, and this is one I know nothing about, the SSG21 ---

MS. THOMPSON: Uh-huh.

CHAIR BLEY: -- the IAEA report, also mentions mud volcanoes, which aren't really volcanoes, but then it says you can use the same kind of analysis.

Are they anything to care about? I don't know what they are.

DR. HILL: Mud volcanoes?

CHAIR BLEY: Mud, M-U-D.

DR. HILL: Yeah. Yeah. I know.

CHAIR BLEY: I don't know what they are, but they mention it. And then they say it's out of -- it's out of the scope of their document.

NRC staff doesn't mention it in there document and then they say, oh -- the IAEA says, well, although it's out of scope, you can use the same techniques to look at these.

Is it --

MS. THOMPSON: I see Britt holding the microphone.

CHAIR BLEY: Yeah. Britt, tell us, all right, because I have no idea about that one.

DR. HILL: Brittain Hill.

The mud volcanoes I believe that IAEA was referring to are the ones that can occur where you have trapped over-pressured fluid in a large sedimentary basin and they erupt, if you will, without a seismic trigger.

So, they're not like sand blows that you see, but they can just kind of spontaneously happen under certain hydraulic conditions.

They are not volcanic phenomena. That is why we didn't choose to do this.

CHAIR BLEY: Fair enough.

But if they can do damage, somebody else

ought to be looking at this and --

DR. HILL: I believe IAEA was putting it in there because the methodology for looking at the likelihood of a new mud volcano forming is very similar to the methods that you would use for a new volcano forming in, say, the Eastern Snake River Plain.

CHAIR BLEY: Okay. Thanks.

MS. THOMPSON: And to address your question about debris avalanches entering a body of water and --

CHAIR BLEY: Yeah.

MS. THOMPSON: -- resulting in a seiche or tsunami, that is a consideration that our counterparts, the hydrologists, would consider in their review.

In the review of tsunami and seiche they consider -- they consider landslide-induced, which would include the collapse of a volcanic edifice.

CHAIR BLEY: That's some of the biggest -- tsunamis have occurred --

MS. THOMPSON: So, that is considered within the hydrology review.

CHAIR BLEY: Hydrology, okay. Perfect.

MS. THOMPSON: Yeah. So, a debris flow,

for those who are unfamiliar with them, is a flow of greater than 50 percent suspended solids.

As you can see from the photo, the material that is carried in this debris flow can be very large and, as you can see, they destroy a fair amount of infrastructure in their path.

They're also capable of going over the outside of their channels. So, although a flood may stick to the channel and slightly over top of, a debris flow often overtops the existing channels, yes.

And then we already discussed debris avalanches as well as earthquakes. There are additional interactions to consider from hydrothermal systems, the emission of volcanic gas and then we also mentioned lightning.

And, again, these are looking at hazards that are close to the vent. So, within about ten kilometers is where these would typically be occurring.

So, now that we've given you a background of the volcanic hazards, it's time to get to the meat of the draft guide and the lovely flowchart outlining the general approach for the volcanic hazards assessment, or the VHA.

There are --

CHAIR BLEY: I'm going to interrupt you here --

MS. THOMPSON: Okay.

CHAIR BLEY: -- because I want to say a few things about this ---

MS. THOMPSON: Okay.

CHAIR BLEY: -- and about the whole methodology.

First is, and your words in the text kind of acknowledge this, acceptable/unacceptable, U and A, are kind of misnomers.

Especially the unacceptable really isn't unacceptable. It's more likely it's not yet screened or not yet dealt with.

The acceptable isn't really defined anywhere except in the text, and it's really no further analysis. So, those words at least set me off a little bit.

I'm going to just mention something to you. As I read through it all, it struck me one could put labels on each of your stages.

And the first one is really an existence issue, is what you're looking for, is this a possibility.

The second one, it says, screen, but

really all of them are kind of screening in different ways below this, but it's really a distant screen on that one.

The next one is really a "no damage leading to release" kind of thing. It's sort of the first risk-oriented thinking.

And then you get a couple that are really frequency. They aren't risks, but they're saying just the frequency is too low to matter.

And finally, you get down to No. 6, which is really a real PRA by that point. And 7, the same way. So, something to think about.

And then when you get into the details, I'm going to ask you about your PE and your PH, the probability of eruption and probability of the hazard reaching the site, and what kind of criteria you have.

And as you move from one to the other, you're attaching what you say is essentially the same functional simplified PRA, and I think that's not -- it's not clear to me, reading it, how the criteria for acceptance change, as you go from having just a PE or a PH and some associated damage, all the way down through the others.

So, I'll raise that when you get to particular places, but I just wanted to give an

overall comment on the layout.

I think it's a very sensible idea, it lets you progress into more and more work as you need it, and it lets you keep as simple as possible, but the simplicity in the text is oversimplified.

I don't think it gives people the idea of how to evaluate where they are.

DR. CORRADINI: I guess I wanted to ask -- Dennis is much more astute about how you do this, but I guess I was going to use your examples and ask how far down the chain each of those would have been analyzed.

In other words, pick Yucca Mountain. As I understand the probabilistic analysis for Yucca Mountain, it essentially went through all six of your steps whereas Columbia or Trojan would not have.

They would have stopped somewhere in the middle and done something that covered them enough that they would -- they'd stop the process.

It strikes me that I would have some sort of practical examples of how you pass through these.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: Yeah. Actually, I thought --- and I have similar comments to Dennis. I don't think you need to have a six and, you know,

develop --- because the six is the part of developing the detailed risk insight.

But that's why, Dennis, there is no really --- I mean, evaluating design basis would not be separated from this.

The other thing which I just think, which Mike just said, whenever we come to one step, let's have an example of what that step will do.

And we can choose Columbia as an example and say what would that mean for that site if they are applying this reg guide.

MS. THOMPSON: All right.

MEMBER DIMITRIJEVIC: Something like that.

MS. THOMPSON: I will say that Columbia got all the way to Step 7 because Columbia did develop, and still has to this day, mitigating actions that they take.

MEMBER DIMITRIJEVIC: Let me be specific. We would just use as an example.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: We don't need to know what they did actually.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: But use as an example of --

MS. THOMPSON: And we have some examples for the steps that I will walk through. None of them are reactor examples because we were trying to be neutral in --

DR. CORRADINI: Sure.

MS. THOMPSON: -- providing examples for each of the steps, but we do have examples that --

DR. CORRADINI: Okay.

MS. THOMPSON: -- I will share.

DR. CORRADINI: Good.

MS. THOMPSON: So, Dennis already mentioned that we have the off-ramps for each of the -- most of these steps here. So, the steps are listed on the slide here.

I'm not going to read them to you, but what I would like to point out is that most of these steps allow for the application of risk insights and then the option to determine if the hazard is potentially significant.

And if it is, to continue the analysis. And if the hazard is not significant, to document the results and end the analysis.

So, again, looking back to that goal that we had set for the draft guide to make sure that the burden on an applicant using this VHA is commensurate

with the rest, so we've captured that through the application of risk insights and these numerous off-ramps so that the analysis can be complete before you reach mitigation actions if the risk is deemed to be not significant.

We will now walk through these initial steps, which I think is what everybody is interested in.

So, the first step is to gather the initial information. This can be summarized as three key points; and those are to consider the time period of interest, the region of interest, and the tectono-magmatic model.

For the time period of interest the draft guide outlines the Quaternary period, or 2.6 million years old, as sufficient.

This is consistent with the standard review plan, SRP, Section 251 for the geologic site characterization that we currently do for new applications.

And the staff determined that the Quaternary period would capture the uncertainties in the timing and character of past volcanic events.

DR. CORRADINI: Well, there's nothing -- there's nothing new about that.

MS. THOMPSON: No. The Quaternary period for geologic site characterization is something that we have been using and continue to use.

So, that was the working group's decision that the 2.6 million year period of interest would be sufficient for this as well.

DR. CORRADINI: Okay.

MEMBER DIMITRIJEVIC: So, do we have a map of United States with that period showing all the sites? Do we have a map like, you know.

MS. THOMPSON: A geologic map?

MEMBER DIMITRIJEVIC: Yeah, geologic volcano-related map.

DR. CORRADINI: Yeah. I guess she's going where I was ---

MS. THOMPSON: Oh.

DR. CORRADINI: -- going, which is now you ---

MS. THOMPSON: Do we have a map of every ---

MEMBER DIMITRIJEVIC: Yes.

MS. THOMPSON: -- Quaternary volcanic feature in the United State?

MEMBER DIMITRIJEVIC: Yes.

DR. CORRADINI: Yes.

MS. THOMPSON: I don't have one, but there are -- I will say that Quaternary geology is captured in geologic maps that are available for the entirety of the United States.

So, a geologist would be able to obtain a geologic map for a given area, and that geologic map would have any Quaternary volcanic deposits mapped on it.

MEMBER DIMITRIJEVIC: That's what I'm asking you.

MS. THOMPSON: So, we --

MEMBER DIMITRIJEVIC: So, somebody has to go and find out --

MS. THOMPSON: No. These are geologic maps that are in existence, and we would be able to identify the volcanic units on any geologic map produced for the United States.

MEMBER DIMITRIJEVIC: Okay. In this period, Quaternary --

MS. THOMPSON: Yeah. They don't produce specific maps just showing Quaternary volcanic features in the United States, but those can be deciphered from a geologic map.

MEMBER DIMITRIJEVIC: Okay.

MS. THOMPSON: So, that is a capability

that we have as the geologic staff here --

MEMBER DIMITRIJEVIC: Whoever wants to --

MS. THOMPSON: -- at NRC.

MEMBER DIMITRIJEVIC: -- site the nuclear plant will be able to see, should we worry about volcano or hazard.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: All right.

MS. THOMPSON: Yes. So, the second component of gathering initial information is to consider the region of interest, or what we've been calling the ROI, for this initial screening.

And, again, consistent with SRP Section 251 for geologic site characterization, the working group determined that for surface hazards a 320-kilometer radius from the site would be sufficient.

Recognizing that the ash fall hazard can travel much further than 320 kilometers for ash fall hazards, the draft guide recommends that the radius be extended to capture the Quaternary volcanoes that might affect the design or operation of the facility.

And this is consistent with what we do for other hazards, how we would capture a large seismic source outside of the 320-kilometer radius that may have the ability to affect the design or operation of

the facility.

MEMBER MARCH-LEUBA: Yeah. I'm looking at the ash cloud for the 2010 Iceland eruption.

MS. THOMPSON: Okay.

MEMBER MARCH-LEUBA: And it made it all the way --- it came up from Iceland and made all the way --- halfway to Siberia, to Italy, to --- I mean, it covered half the world.

MS. THOMPSON: Mm-hmm.

MEMBER MARCH-LEUBA: So, the 320 kilometers looks a little small for ---

MS. THOMPSON: Which is why, for ash fall hazards, we recommend the extension of that radius to include ---

MEMBER MARCH-LEUBA: Yeah, but this is ---

MS. THOMPSON: -- the potential area.

MEMBER MARCH-LEUBA: -- like 5,000 kilometers.

MS. THOMPSON: And we will actually get to that in Step 2 where an applicant would perform a deterministic screening for the hazard that may affect the site where they would consider the most ---

MEMBER MARCH-LEUBA: This was a problem for flying airplanes, not for a stationary pump ---

MS. THOMPSON: Yes --

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: -- can't have a filter, but 320 looks awfully small for something that happen ---

MS. THOMPSON: Yeah.

PARTICIPANT: Well, 320 is surface.

MS. THOMPSON: Yeah. 320 is just for the surface hazard. So, this is for things like ---

MEMBER MARCH-LEUBA: Okay.

MS. THOMPSON: -- lava flow, the new vent opening, the debris flow.

MEMBER MARCH-LEUBA: I see.

MS. THOMPSON: So, we specifically call it ash fall hazards as being separate and different from this 320-kilometer radius.

MEMBER DIMITRIJEVIC: You have here something which I strongly object in any PRA work. I don't really like where they're short two decimal places in high uncertainty.

You have here 320 kilometers because it obviously comes from 200 miles.

MS. THOMPSON: Mm-hmm.

MEMBER DIMITRIJEVIC: This is a huge uncertainty thing. We are showing like we know something so it's 320.

And then if you put 322 kilometers, you will be absurd. 320 is absurd, too. Either put 300 kilometers or 200 miles.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: Because 320 kilometers, it seems like we really know --

CHAIR BLEY: But it's not PRA. It's significant figures --

MEMBER DIMITRIJEVIC: Yeah.

CHAIR BLEY: -- which you did a long time ago.

MEMBER DIMITRIJEVIC: Right. So, the other thing is like --

MS. THOMPSON: Okay.

MEMBER KIRCHNER: So, Vesna, the next time we see 1.783 times 10 to the minus whatever, would you correct those people?

MEMBER DIMITRIJEVIC: Probably not.

(Simultaneous speaking.)

MEMBER BALLINGER: I call it the TI-89 syndrome.

MEMBER DIMITRIJEVIC: You know, like this was about this dinosaurs, you know, million and six years ---

MS. THOMPSON: Mm-hmm.

MEMBER DIMITRIJEVIC: -- so, you know, old because somebody is working --

MS. THOMPSON: And I've made a note. Okay. So, the ---

MEMBER DIMITRIJEVIC: You can use miles. I mean, I don't see why you don't use the miles.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: At least it's probably 200 miles.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: Yeah.

MS. THOMPSON: So, the third component in gathering initial information is to consider the tectono-magmatic model.

The tectono-magmatic model is a large-scale understanding of the geologic processes that are controlling volcanism in the region of interest over the time period of interest.

The example shown here is from the essential part of the Oregon Cascades. Each of the stars represents a volcano. They're labeled as "N," "M," "S" and "BT."

For those familiar with the area, these are North Sister, Middle Sister, South Sister and Broken Top.

The black dots are volcanic vents, and the lines shown on this figure are fault lines.

DR. CORRADINI: This is by Sisters, the town.

MS. THOMPSON: Yes.

Every feature shown on this figure is less than half a million years old. So, all of them are within the Quaternary period of interest, are a hypothetical site, they are within the region of interest.

But if we look at the tectono-magmatic model for this region, it would show us that only the two youngest volcanoes, those labeled as "M" and "S," or South and Middle Sister, are consistent with our understanding of the processes driving volcanism in this area.

So, if we were considering this potential site, a VHA would only need to consider the two volcanoes, Middle and South Sister, that are within the region of interest, are of the age within the time period of interest and are consistent with the tectono-magmatic model.

CHAIR BLEY: I hate to ask you two questions on the models. In the Reg Guide --

MS. THOMPSON: Yes.

CHAIR BLEY: -- under Step 1 ---

MS. THOMPSON: Uh-huh.

CHAIR BLEY: -- which is where you are, there's two, to me, contradictory statements. The first is, if there's evidence of the Quaternary volcanism in the regions of interest, a conceptual model of tectono-magmatic processes should be developed.

The next paragraph says, if the hazard can --- if you're not consistent with the model, screen it out.

So, do we develop a model or do we believe the one that's there or why do you have those two statements?

You know, if you're going somewhere where you don't have a model you believe in, I guess you'd have to develop one, but then much of the rest of that section keeps saying if you're not consistent with that model, screen it out.

Nothing warns you to double-check the model to see if it's right, to see if you've got some problem.

MS. THOMPSON: I'm just reading the section that you're referring to --

CHAIR BLEY: Oh.

MS. THOMPSON: -- so that I can --

CHAIR BLEY: Okay. It's paragraph 3 and 4.

MS. THOMPSON: On page 12?

MEMBER DIMITRIJEVIC: Yes.

CHAIR BLEY: On page 12.

MS. THOMPSON: Okay.

CHAIR BLEY: And then it comes up three paragraphs later --

MS. THOMPSON: Okay.

CHAIR BLEY: -- in the last paragraph, but it's just those two paragraphs that bothered me.

MS. THOMPSON: Okay.

CHAIR BLEY: Because I read the first one that said, develop your model, and I read the next one and it says, if you're not consistent with the model, screen it out.

MS. THOMPSON: I'm going to take a note to bring this back to the working group and ---

CHAIR BLEY: I think that's best.

MS. THOMPSON: -- determine whether this was just an oversight or a typo, but we'll ---

CHAIR BLEY: What you really wanted to say, yeah.

MS. THOMPSON: We'll confirm this.

CHAIR BLEY: Okay.

DR. CORRADINI: Is there --- I'll wait until you're done.

MS. THOMPSON: Okay.

DR. CORRADINI: Is there something --- the way you describe this, certain things are in and certain things are out.

And that's because of age or because of severity of the eruption known within the age limit?

MS. THOMPSON: It's because of the processes that are resulting in the volcanism in the area. So, in the tectono-magmatic model, another example of this would be volcanism in Hawaii.

So, the hot spot there is currently on the big island. So, on the island of Hawaii. You wouldn't consider a new vent opening on Kaua'i because although there is evidence of volcanism there, it's a volcanic island arc, there is no active process under the island of Kaua'i that would be consistent with volcanism likely to occur in the future.

So, that's what the --

DR. CORRADINI: That's based on a geologist's judgment?

MS. THOMPSON: Yes.

DR. CORRADINI: Okay.

CHAIR BLEY: Well, and the history, you know --

MS. THOMPSON: Yeah.

DR. CORRADINI: No, I understand.

CHAIR BLEY: -- that they started over here and ---

DR. CORRADINI: I understand that.

CHAIR BLEY: -- now they're over here.

DR. CORRADINI: I understand that. But I guess with all the little black dots, I first thought they were outside of the time span ---

MS. THOMPSON: No.

DR. CORRADINI: -- but you're saying it's not just outside of the time span, they're outside of --- they're not being considered because of something about the physical mechanism ---

MS. THOMPSON: Yes.

DR. CORRADINI: -- which caused the event.

CHAIR BLEY: Uh-huh.

MS. THOMPSON: So, eruption along any of the vents to the east in this photo -- so, between BT, or Broken Top, and the fault zone --- any of those vents are not consistent with what is driving volcanics in that area.

CHAIR BLEY: Within the time period of --

MS. THOMPSON: Within the time period of interest, yes.

DR. CORRADINI: Okay. That's fine.

MS. THOMPSON: So, we're looking at -- it's a three-pronged consideration. It's what is within the Quaternary period, what is within the region of interest, and then what is consistent with the geologic processes going on in that area for the time period that we're considering.

MEMBER DIMITRIJEVIC: And how would one know those geological processes?

DR. CORRADINI: You have to be a geologist.

MS. THOMPSON: Yes.

DR. CORRADINI: You have to be a geologist and studied it.

MEMBER DIMITRIJEVIC: Okay. All those dots will be on the maps for the geological region, right?

MS. THOMPSON: Yes. Yes.

DR. CORRADINI: But her point was only the two or three to the ---

MEMBER DIMITRIJEVIC: No I know, but I just try to see from the two -- like you want to screen all these 300 kilometers.

So, I was wondering can you screen without having a geologist? That's my question.

MS. THOMPSON: It would be very difficult to go through this process without a geologist. It would be nearly impossible to ---

MEMBER DIMITRIJEVIC: If I am in Massachusetts, would it be difficult if there is nothing around -- I mean, there have to be areas of the United States where you don't need the geologist.

DR. CORRADINI: I assume you have your green light on.

MS. THOMPSON: There are regions of the US where there are not volcanic hazards that would be considered, and that would be a determination made by the geologists as part of the geologic site characterization.

If there are potential sources of volcanism in the region, this would be the approach that that geologist would then take to assess those potential volcanic hazards.

But if we're looking at a hypothetical site in Massachusetts, there are going to be other geologic hazards to consider other than volcanism that would be captured ---

MEMBER KIRCHNER: I could say firsthand I

was in a Hyatt Regency ---

MS. THOMPSON: -- within the geologic site characterization.

MEMBER KIRCHNER: -- in Cambridge and I got a wake-up call one morning. The bed started going back and forth.

So, you may not have any volcanic threats, but the seismologists or geologists are going to point to other --

MEMBER DIMITRIJEVIC: You know, in seismic we have that map of United States which clearly defines region where there is high risk, low risk, you know, and there is the four region of United States.

I was wondering if something like that exists for ---

MS. THOMPSON: There are numerous geologic hazard maps that the United States Geologic Survey produces and updates.

There are earthquake hazard maps. There are landslide hazard maps. There are floodplain maps. There are -- I'm trying to think of the other ones that I have seen.

There are many different geologic hazards in geology. It's not just -- we're not just looking at an earthquake or we're not just looking at a body

of water.

We're looking at sinkholes. We're looking at rockslides. We're looking at rockfalls. We're looking at volcanoes. We're looking at faults. We are looking at a number of hazards that may occur based on the geology at that specific site.

So, if the site has a potential source of volcanism, this is an appropriate method. If there is no source of volcanism, that site would still be subject to the regular geologic site characterization and review by the geology staff.

Did that answer your question?

MEMBER DIMITRIJEVIC: Yeah.

MS. THOMPSON: Okay. So, if after the initial screening there are no sources of volcanism that are within the time period of interest occurring within the region of interest and that are consistent with the tectono-magmatic model, an applicant using the VHA would have the option to complete the analysis and document their results.

if there are sources of volcanism that are of Quaternary age, within the region of interest, and consistent with the tectono-magmatic model, an applicant would proceed to Step 2, which is to perform a deterministic screening.

This deterministic screening would consider the characteristics --

CHAIR BLEY: I'm going to interrupt you for two reasons.

MS. THOMPSON: Yes.

CHAIR BLEY: You're about halfway through.

MS. THOMPSON: Yes.

CHAIR BLEY: And we've only been here an hour and a half, but the coffee shop closes at 3:00.

(Laughter.)

CHAIR BLEY: So, why don' we take our break now ---

MS. THOMPSON: Okay.

CHAIR BLEY: -- and then we can come back and finish up the whole thing later because I think we're now moving into the meat of the ---

MS. THOMPSON: Yes.

CHAIR BLEY: -- methodology and it's kind of different. So, if that's okay, we will recess until five til.

(Whereupon, the above-entitled matter went off the record at 2:38 p.m. and resumed at 2:56 p.m.)

CHAIR BLEY: We are back in session. All members, please come to your seats and you're back on.

MS. THOMPSON: Okay. So, we left off at

Step 2, which is the performance of the deterministic screening.

So, this is considering the characteristics of the Quaternary volcanoes that are within the region of interest and are consistent with the tectono-magmatic model.

Within the deterministic screening an applicant would evaluate uncertainties in the buried or eroded record.

They can use information from analogs or from numerical modeling to quantify and further reduce uncertainties in the available information.

This may include how far a hazard could credibly travel from the source to some distance and whether that hazard would reach the site.

This may be used --- a bounding evaluation may be used to determine that distance from the volcano to the farthest extent of the hazard and whether that would have effect on the site.

And if there is an associated uncertainty, how uncertain is that credible distance?

CHAIR BLEY: That may involve some atmospheric modeling as well as ---

MS. THOMPSON: Depending on the ---

CHAIR BLEY: -- volcanic.

MS. THOMPSON: Yeah.

CHAIR BLEY: Okay.

MS. THOMPSON: So, the example that I have for a deterministic screening is from lava flows that were measured off of Mt. Cameroon in the Republic of Cameroon in Central Africa.

So, the measured flows are shown as the lava flow length in kilometers on the x axis, and the frequency of occurrence of a lava flow of that length is shown on the y.

This data allows an analyst to fit a statistical function to histogram data to develop a likelihood estimate for the maximum length of the lava flows from Mt. Cameroon.

So, if we were to consider a site near Mt. Cameroon within ten kilometers, based on the data shown here we would assume that the lava flow hazard would most likely be considered in the VHA and considered for additional analysis in the subsequent steps.

Similarly, if we were considering a site that was 20 kilometers or more away from Mt. Cameroon, based on this data here our deterministic screening may tell us -- well, would probably tell us that lava flows from Mt. Cameroon do not pose a credible hazard

to the proposed site assuming that the mechanisms that were driving the lava flow lengths produced in the mapped data are those same mechanisms that will produce future lava flows.

MEMBER DIMITRIJEVIC: How about lava flow for this site?

MS. THOMPSON: Huh?

MEMBER DIMITRIJEVIC: How about lava flow for this site? Do we have information of that?

MS. THOMPSON: I do not have information on that with me today, but --

MEMBER DIMITRIJEVIC: I know, but does it exist?

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: Lava flow --

MS. THOMPSON: So, we would find -- lava flow information, yes.

MEMBER DIMITRIJEVIC: Yes.

MS. THOMPSON: If it's available.

MEMBER DIMITRIJEVIC: And all other hazards associated.

MS. THOMPSON: Yes. So, lava flows are a hazard that -- I won't say that it's the easiest one to find data for, but a field geologist would be able to go out to the site and walk the area and determine

what are the flows.

There would also usually be geologic maps available that would show the ages of those respective flows that would be considered. And that is how the data was obtained for this example here from Mt. Cameroon.

MEMBER RICCARDELLA: Isn't lava flow directionally dependent?

MS. THOMPSON: It can be. Lava flows will be channelized based on topography. So, some of these will be -- could be flow covering flow, which is why something to be considered is the buried or eroded record that may be missing.

MEMBER DIMITRIJEVIC: Do you know what hazard was analyzed for the Columbia?

MS. THOMPSON: For Columbia, they considered volcanic ash. So, that was the hazard that screened in as credible for the site, while the flow did not, because of its location far from a source.

So, in a deterministic screening for Columbia given the location, a surface hazard like a debris flow or a lava flow would not screen in because of the distance that it's located from the source volcano.

But an ash fall hazard would screen in

because realistically in our geologic record, and from direct observation of the 1980 eruption of Mount St. Helen's, we have seen volcanic ash reach the Columbia site.

MEMBER DIMITRIJEVIC: Well, you have said that we have within 300 miles, but it's my feeling that we deem these 300 miles like between hundred miles and 300 only thing to consider would be the ash and everything -- all other hazards will be less than maybe 50 or 100 miles.

MS. THOMPSON: It is going to depend. Because, as I discussed with the pyroclastic flows, there is a possibility for larger volume pyroclastic flows to travel further.

So, that is what the deterministic screening would allow an applicant to do is to consider the spectrum of volcanic hazards that could result from the volcanic source and whether those volcanic hazards could credibly reach the proposed site.

DR. CORRADINI: So, to say it another way -- I think I know where Vesna's going.

CHAIR BLEY: Uh-huh.

DR. CORRADINI: To say it another way, is it -- to go back to your examples of the various

hazards, each one of these hazards would have to have some sort of deterministic length scale to say either you're in or you're out.

MEMBER DIMITRIJEVIC: Right.

MS. THOMPSON: Yes. And that would be performed at this step.

DR. CORRADINI: And if all of them are out, then you're out.

MS. THOMPSON: Yes.

DR. CORRADINI: But if some are in, you have to consider that hazard.

MS. THOMPSON: Yes.

DR. CORRADINI: Okay.

MS. THOMPSON: Yes.

CHAIR BLEY: But if you don't have enough data, then you take what you had and do a SSHAC process with it?

MS. THOMPSON: Yeah. And we will get to that.

PARTICIPANT: Do a what?

MS. THOMPSON: Do a SSHAC process, the Senior Seismic Hazard ---

PARTICIPANT: Oh, SSHAC.

MS. THOMPSON: -- Analysis Committee.

PARTICIPANT: Oh, okay. Yeah. Sure.

PARTICIPANT: Not seismic anymore ---

MS. THOMPSON: Yeah.

PARTICIPANT: -- but they're doing the same thing for floods and ---

PARTICIPANT: Okay.

MS. THOMPSON: Yeah. And we'll get to that in a later set, but that is the general idea that --- assess whether a hazard potentially exists, whether it's --- it has to be the Quaternary age, and the region of interest consistent with the tectono-magmatic model.

If the hazard does exist consistent with those three factors, then you would perform the deterministic screening.

For the example here, if you're within ten --

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- determine the distance between those two because you already put 300 kilometers in the first one, right? So, now you want to screen all that.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: You have to find the place where the ash will not get 300 kilometers from the place.

MS. THOMPSON: Not necessarily not get there. You can still move through the process with a volcanic ash fall hazard, and then you reach either Step 6 where you evaluate your design bases to see if your facility could withstand the loads from that volcanic ash, or you proceed to Step 7 ---

MEMBER DIMITRIJEVIC: That makes sense.

MS. THOMPSON: -- and consider mitigation actions, which is what was done for Columbia.

MEMBER DIMITRIJEVIC: I was only trying to establish difference between 1 and 2 because that's not really clear.

You already put some distance of 300 kilometers and now we are ---

MS. THOMPSON: So, the distance for 300 is to capture the volcanic source. The screening here is to consider individual hazard.

So, in the 320 -- or the 200-mile radius we're looking at any source within that radius that is of Quaternary age and consistent with the model.

And then based on that source at the deterministic screening level, we consider the individual volcanic hazards that may occur from that source and consider their maximum credible distance and whether the site is within that distance and would

be affected by that hazard.

So, if we wanted to use the Columbia example, we would screen in the Cascade volcanoes like Mount St. Helen's, we would then consider the volcanic hazards from Mount St. Helen's with the pyroclastic flow --

MEMBER DIMITRIJEVIC: I understand that.

MS. THOMPSON: -- reach to the site.

MEMBER DIMITRIJEVIC: My question is, are you going to screen anything in additional in Step 2? Because you already putting within 300 kilometers which assume that's average hazard -- longest hazard distribution.

MS. THOMPSON: So, I think the key point in the 320 or 200-mile radius is that is the source of the hazard, and then the deterministic screening is for the hazard itself.

So, we're looking at the source in Step 1, and then we're looking at the likelihood of the hazard reaching the site in the deterministic screening.

DR. CORRADINI: It makes sense.

CHAIR BLEY: Well, except for one thing. If ash can go further --

MS. THOMPSON: Uh-huh.

CHAIR BLEY: -- as your slide shows, than

the 300 kilometers, then you ought to be looking further away than that for a source.

DR. CORRADINI: But her point --- I thought her point was that all the --- yeah, all the volcanic hazards have to be individually assessed in terms of distance out to --- not out to, beyond.

MS. THOMPSON: So, for surface hazards it is the ---

DR. CORRADINI: Okay.

MS. THOMPSON: -- 200-mile radius. For ash fall hazards we extend it beyond as to what is credible for that volcano and for the distance that the ash fall ---

DR. CORRADINI: Okay. But you got to ---

MS. THOMPSON: -- could credibly travel.

DR. CORRADINI: -- find that volcano, yeah.

MS. THOMPSON: And that's what you do in Step 1.

DR. CORRADINI: Okay. That's where I'm kind of hanging because in Step 1 it kind of says look out to 300 ---

MEMBER DIMITRIJEVIC: Yeah.

DR. CORRADINI: -- kilometers.

MS. THOMPSON: Look out to 300 for surface

hazards. And then for ash fall ---

CHAIR BLEY: How far do you look?

MS. THOMPSON: -- consider further.

CHAIR BLEY: How far?

MS. THOMPSON: Well, that would be based on site-specific considerations of volcanic sources outside the 200-mile radius.

So, if you're looking ---

CHAIR BLEY: So, you've got to ---

MS. THOMPSON: So, if you're looking at a site in Iowa ---

CHAIR BLEY: To do that, you have to find them.

MS. THOMPSON: So, looking at a site in Iowa, you would have to determine whether to extend that region of interest to include Cascade volcanoes.

CHAIR BLEY: Yeah.

MS. THOMPSON: Could a Cascade volcano ash fall reasonably arrive at a site in Iowa and --

CHAIR BLEY: In sufficient quantities of matter.

MS. THOMPSON: -- in sufficient quantity to affect a facility.

DR. CORRADINI: If you find a presidential candidate under the ash --- sorry.

MS. THOMPSON: So, for ash fault the 200-mile radius is extended to what is credible.

MEMBER DIMITRIJEVIC: To 300?

MS. THOMPSON: Huh?

MEMBER DIMITRIJEVIC: To 300.

MS. THOMPSON: Well, to what is credible.

MEMBER DIMITRIJEVIC: Well, this is what we --- if my -- the volcano is further from 300, I will screen it in Step 1.

That's what you are saying? That's what I am trying to tell you.

PARTICIPANT: Just for surface hazards.

MS. THOMPSON: Just for surface hazards.

MEMBER DIMITRIJEVIC: Oh. So, now I have to look again in all volcanoes even I determine it ---

PARTICIPANT: Some distance further.

MEMBER DIMITRIJEVIC: That doesn't make any sense that I have to look in all the country again. That's totally senseless.

MS. THOMPSON: Well, it's based on our geologic knowledge of the volcanic sources. So, the surface hazards we consider those closest to the proposed site, which is the 200-mile radius.

Many of those surface hazards, you think about a debris flow or a --

MEMBER DIMITRIJEVIC: I understand you completely.

MS. THOMPSON: Yeah. Okay.

MEMBER DIMITRIJEVIC: So, there are things that we understand. Let's talk about what I don't understand.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: If I'm in Vogtle, somewhere there is not any volcano on the site, right, I'm already out in the first step because I don't have anything within 200 miles. I'm out.

Why would I go on Step 2?

MS. THOMPSON: If you were at the Vogtle site, you --

MEMBER DIMITRIJEVIC: Or on some site there is --

MS. THOMPSON: Yeah.

MEMBER DIMITRIJEVIC: -- no volcano within 200 miles. I already exceed this process.

MS. THOMPSON: Mm-hmm.

MEMBER DIMITRIJEVIC: So, why would I go now and check for ashes?

MS. THOMPSON: Because within Step 1 we're looking at the 200-mile radius for surface hazards and extending beyond that for the ash fall hazard.

MEMBER DIMITRIJEVIC: But do you understand if I am not within 200 miles of any volcano, I will already exceed in the first step and say no and here I am. I will never go to Step 2.

MEMBER REMPE: So, Vesna, if you look at Slide 23, she's got two things. You got to go for not only the surface hazards, you also got to look for ash fall. You're not out of it.

MEMBER DIMITRIJEVIC: I understand all these hazard perfectly. I already read that, I just want to say I will never come to the Step 2.

CHAIR BLEY: You will. Read the text and not the slide.

MEMBER DIMITRIJEVIC: Because I screen and I am not within 200 miles.

MEMBER REMPE: The text for Step 1 --

MS. THOMPSON: I'm looking at Slide 23 and I don't see that.

MEMBER DIMITRIJEVIC: Okay.

MEMBER REMPE: Yeah, but the slides are cartoons for us. The text says, look out to 320 kilometers for --

MS. THOMPSON: And then we say we should extend that distance -- extend a sufficient distance beyond 200 miles to encompass those Quaternary

volcanic systems that have the potential to effect the design or operation of the proposed reactor.

CHAIR BLEY: So, just a simple question that would help us get our arms around how far away do you look.

When you get a giant volcano that puts stuff up in the stratosphere, it messes up the air everywhere, but you don't get substantial amounts of ash coming down anywhere.

In Mount St. Helen's, for example, it lofted over much of the State of Washington ---

MS. THOMPSON: Uh-huh.

CHAIR BLEY: -- and fell in large quantities out -- getting toward the Idaho border.

MS. THOMPSON: Uh-huh.

CHAIR BLEY: There must be some level of experience to say you never have to look beyond 300 miles, 500 miles, something like that.

MS. THOMPSON: So, I'm actually --- I see Britt holding the microphone again.

CHAIR BLEY: Or do you have to look everywhere and then say for that particular volcano, can the ash --

MS. THOMPSON: Well, you don't need to look everywhere. We're looking at finding a

reasonable distance based on the system-specific characteristics of that particular volcano and that particular site.

CHAIR BLEY: That volcano is the one you have to find. That's why we're being a pest on it.

MS. THOMPSON: Okay. But did you have more to add?

DR. HILL: We are trying to implement this in a risk-informed framework and we're faced with an information gap and having no real good understanding about what's the minimum level of ash that could affect the design and safe operation of any proposed facility.

Now, if we had a technical basis to say that, yeah, we are looking at one millimeter of ash with a threshold below which we'd have no structures, system or component that's important to safety would be adversely perfected by the presence of one millimeter of ash.

If we had that, we could develop some sort of a more prescriptive screening criteria that said credibly for US volcanoes X distance away seems very unlikely to produce one millimeter of ash.

Unfortunately, we don't have that sort of a design basis.

DR. CORRADINI: But can't you work the problem backwards?

Instead of worrying about how the source loss -- this whole thing, ask the question for structure, systems and components, at what point would they start not performing.

DR. HILL: That's an excellent question. We just don't have the technical information from -- either in the US or around the world to make an informed decision about that.

CHAIR BLEY: They didn't have systems people --- oh, go ahead.

MEMBER DIMITRIJEVIC: But wouldn't the 200 miles be enough for one millimeter of ash?

DR. HILL: No, it would not.

MEMBER DIMITRIJEVIC: The only --- the most --- I mean, you know, I don't think that the --- I mean, you may lose offsite power, but we can say that in data of loss of offsite power already.

I don't think the less than one millimeter will affect anything, but we --- you know, subsystem people can look at that.

That means different facility design, right?

MEMBER MARCH-LEUBA: These generators are

sucking air through a big pump to make them work.

CHAIR BLEY: ISFSIs you plug up all the vents.

MEMBER MARCH-LEUBA: Yeah.

CHAIR BLEY: You don't have natural circulation anymore.

MEMBER MARCH-LEUBA: When we were in the Framatome enrichment facility where they dump, I don't know, a foot of ash at Mount St. Helens, they showed us everything they put on their systems and they have these oil filters that they have to replace every three hours if there is a --

MEMBER DIMITRIJEVIC: But this complicates things so much more. It's just unbelievable because a screening becomes so --- you know, just in these first two locations screening becomes totally ---

MEMBER MARCH-LEUBA: If I was designing --

-

MEMBER DIMITRIJEVIC: -- unpractical.

MEMBER MARCH-LEUBA: -- the plant, what would be useful for me would be you tell me how much ash is going to fall in my site. And then I'll design the field just to protect against that.

And I'll decide, well, if you're sending me three feet of ash, there ain't no way I can protect

it. If is half a millimeter, I may.

DR. HILL: And that is incredibly straightforward problem to look at. Once you know these are the volcanoes we have to consider, these events, eruptive record, the science is sufficient to do very good supportable modeling that can give you an exceedance probability that counts for not only a thickness being exceeded, but the annual likelihood of it occurring due to eruption frequency, but that's a more detailed analysis. It doesn't occur at the screening stage.

MEMBER MARCH-LEUBA: But I cannot tell you what my plant will be able to support because I haven't decided yet.

If I put oil filters, I can support ten times more.

DR. HILL: Yeah.

MEMBER MARCH-LEUBA: So, I think that from a designer point of view, I want to know what I have to design my diesel generators against, and then make a decision can I make it or not, or is it not workable, it's not economical to do it.

MS. THOMPSON: And I ---

MEMBER MARCH-LEUBA: You can filter everything.

MS. THOMPSON: And I think something that you touched on is you said that knowing for your design, and this approach is designed for siting.

So --- and when it comes to design factors, that will come in at a later step. But if you were using this for design, you would still go through this process to determine your design characteristics --

MEMBER MARCH-LEUBA: There is something --

MS. THOMPSON: -- but you would still have to do the siting consideration as well.

MEMBER MARCH-LEUBA: There is something wrong with the approach. I cannot --- you cannot give me criteria for siting if you don't know what I'm putting there.

If I have --- if I'm driving a car into a stream, okay, and I'm driving my car into a stream, I can go in the stream this deep because the water will start getting into the carburetor --- not that anybody has carburetors anymore.

If I'm driving a high car with an intake out here, I can drive into a stream that is this tall. So, the issue of siting depends on what car I'm driving.

Same with the fuel, those four diesel

generators --

DR. HILL: Wait a minute. But the same ---

MEMBER DIMITRIJEVIC: But the main comment is you cannot screen from the first step. It maybe makes sense for you guys to combine both steps.

DR. CORRADINI: Well, I think -- I thought that's what -- I'm sorry, now I've forgotten -- you keep identifying yourself for --

MS. THOMPSON: Britt.

DR. CORRADINI: Britt, I thought that's what you were saying, this is a screening first step. You might have to do a more detailed one as you go down two or three levels in the ---

MEMBER DIMITRIJEVIC: No. No. Already here, they cannot screen based on 200 miles.

DR. CORRADINI: No. 200 miles is specific ---

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- your screening make that one step, yeah.

MS. THOMPSON: Okay.

DR. CORRADINI: If it's quiet, start going.

MS. THOMPSON: Okay.

(Laughter.)

MEMBER DIMITRIJEVIC: Yeah, you can grab that chance.

MS. THOMPSON: Yes. All right.

MEMBER RICCARDELLA: Kind of making an analogy to seismic, you know, it seems like we have a seismic hazard -- something like a hazard probability curve, but we don't have a fragility curve to compare that against.

We need to -- maybe people need to do some volcanic qualification testing of various types of equipment.

(Laughter.)

MS. THOMPSON: So, if after performing ---

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- define safety completely as ash-resistant.

MS. THOMPSON: So, if after performing the deterministic screening the potential volcanic hazard is determined to not present a credible hazard based on some deterministic screening criteria or the distance which the hazard could credibly travel from the source and would not affect the site, an applicant using this VHA would document their results and the analysis is complete.

If not, the applicant would proceed to

Step 3 to consider initial risk insights. The initial risk insights would include a suite of risk-informed information, not just the plant's PRA, that would be used to judge the safety significance of information.

This information may include the sensitivity of the new information in the facility's PRA, the degree of uncertainty in the new information, the consideration of available alternatives and the confidence in the supporting investigations.

For the initial risk insight step using the plant's PRA, an applicant could assume that the probability of an SSC failure or unacceptable performance would be equal to one if the screened-in volcanic hazard occurs at the site.

They would then evaluate the results in the PRA and consider additional risk insight information.

This would help to determine if the volcanic hazard is significant to safety with no credit for the likelihood or magnitude of occurrence of that hazard.

If the insights show that the risk or the hazard is not significant, the applicant would document the rationale and complete the VHA. Otherwise, they would proceed to the next step.

DR. CORRADINI: So, basically the consequence is failure.

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: This is where it's important to add the SSC susceptible to identify hazard.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: If you put all SSCs to be one, then, I mean, you know, you are just going to --

DR. CORRADINI: You're done.

MEMBER DIMITRIJEVIC: Yeah, you're done.

So, that's why it's very important to understand susceptibility, you know.

MS. THOMPSON: Yes. I think that's a key clarification to make.

CHAIR BLEY: But with all due deference to my colleagues here, some hints about what kinds of structures, what kinds of components are susceptible to what kinds of ---

PARTICIPANT: Examples.

CHAIR BLEY: -- hazards would be very helpful. Otherwise, you know, it's --- you're asking people for a rock. And when it comes in you'll say, eh, it's the wrong rock, go do it again.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: So, it could be table -- a table of hazard and what type of components could be susceptible to that.

MS. THOMPSON: Okay. I'll take that note back to ---

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- plant.

CHAIR BLEY: And that requires you to having some PRA people and, more importantly, some real plant people who know what things are where and what they're vulnerable to.

MEMBER DIMITRIJEVIC: And in addition to SSCs, there should be human actions also. Because if you have to get rid of operators because they have to evacuate.

MS. THOMPSON: Okay.

CHAIR BLEY: And when you get to Step 6 or 7, you have to model ---

MS. THOMPSON: And that's something that we have, as a working group, included in the mitigating actions is being able to demonstrate or show that the actions are practicable given the hazard. So, we'll get to that.

So, if the applicant still has a hazard

that is significant to safety, they will proceed to Step 4 where they will evaluate either the probability of eruption, which is PE, or the probability of the hazard reaching the site, which we call PH.

In a traditional VHA, an applicant would calculate both of these probabilities; the probability of the eruption and the probability of the hazard.

But in the draft guide --

MEMBER DIMITRIJEVIC: The frequency of eruption. Frequency of eruption, probability of hazard.

That's a very important distinction because eruption doesn't have a probability. It has a frequency.

MEMBER BALLINGER: And shouldn't evaluation of eruption be further up? Because if there's no likelihood of an eruption, you're done, right?

MEMBER DIMITRIJEVIC: What's the probability to calculate that frequency accurately?

CHAIR BLEY: They've got an embedded assumption that it's -- and they don't have PRA people. They've got an embedded assumption that it's easier to calculate the conditional probability of core melt or release given failure of a set of SSCs

than it is to calculate either PH or PE.

And in a moment, Jenise will get to saying whichever one's easiest to calculate, calculate that one first and then see if you can pass, and then calculate the other one.

So, that's kind of the ---

MEMBER DIMITRIJEVIC: Because it ---

CHAIR BLEY: -- assumption.

MEMBER DIMITRIJEVIC: You cannot say probability of this eruption is one in million. What, within a year, within ten years, within the next thousand years, next million years. That's why it's frequency. You cannot give probability.

However, you can tell probability of ash getting in a given eruption because that's an event. So, it's probability.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: So, the various frequency event. If you want to call it probability for PE, you can say per year. Probability per year and then it's the -- you know, then you are sort of calling probability, but it's actually closer to frequency.

MS. THOMPSON: All right. So, in the draft guide the staff allows for the applicant to use

-- or to calculate either PE or PH first, and then use risk insights to determine if additional probability calculations are warranted.

The justification for this is that the staff recognizes that volcanic events, the character of past volcanic events may be more certain than the timing of these past volcanic events.

So, calculating PH, or the probability of the hazard reaching the site, may produce results that have lower uncertainties and, therefore, provide higher confidence in any risk insight decisions that are made based on that calculation.

CHAIR BLEY: I think -- I have to go back and look real carefully. I think the guidance you give the user on doing a simplified PRA given either PE or PH is the same guidance you gave them before you knew PE or PH. Then knowing this probability doesn't help you.

So, I think you need to give a little more thought to how you mix -- how you make use of this frequency or this probability, whichever one you're doing.

MEMBER DIMITRIJEVIC To make it risk-informed.

CHAIR BLEY: And once you try to get to a

simplified PRA, it probably needs to be a little more than, you know.

And you get this somewhere, and somewhere in there you imply if PH is small enough, you're done. And then you say, and then if PE is small enough, you're done.

MS. THOMPSON: So, if --

CHAIR BLEY: And if the product of the two is small enough, you're done. And then you do a simplified PRA to go with it if it's not small enough, but you don't give people a hint of how they use that risk measure that's coming out that has a frequency and a probability of failure to make a decision.

MS. THOMPSON: So, I think we're going to get to that. We don't have an option in the calculation of PE and PH to end the analysis.

Once this step is completed, an applicant proceeds into the detailed risk insights where --- I will get to this, but PE and PH, or both, are assumed in the PRA to equal failure.

So, we'll get to that in ---

MEMBER DIMITRIJEVIC: But a comment that Dennis ---

MS. THOMPSON: -- Step 5.

MEMBER DIMITRIJEVIC: -- is giving you is

to --

MEMBER RICCARDELLA: Is PH a conditional probability?

MEMBER DIMITRIJEVIC: Yes.

MEMBER RICCARDELLA: Conditional probability given ---

MEMBER DIMITRIJEVIC: Conditional probability given eruption.

MEMBER RICCARDELLA: -- eruption. All right.

CHAIR BLEY: And given the hazard you're talking about.

MEMBER DIMITRIJEVIC: Right. And given the hazard.

CHAIR BLEY: You have to do it for each hazard.

MEMBER DIMITRIJEVIC: Jenise ---

MS. THOMPSON: Yes.

MEMBER DIMITRIJEVIC: -- what Dennis is proposing, and this is how we become risk-informed, you can also exit here if frequency of that occurs once in hundred million years and, you know, it will be a probability or hazard combined if that is smaller than once in ten million years, you can exit here. No need to go --

DR. CORRADINI: But I guess I'm kind of with them. You would have never gotten this far if what you just said is true because you already have the time period and you already have the magnitude.

MEMBER DIMITRIJEVIC: But you know the time period is 2.6 million years.

DR. CORRADINI: Yeah. So, it's already been screened in based on that.

MEMBER DIMITRIJEVIC: Well, in that case it can be screened out from the -- you know, a lot of PRA --

DR. CORRADINI: But if the frequency of eruption is --

CHAIR BLEY: You don't have the frequency of eruption yet until you calculate this.

DR. CORRADINI: Oh.

MS. THOMPSON: That's the step we're at.

DR. CORRADINI: So, I apologize. I know we're taking you off track, but you can save this one. I want to know the level of when you fall out, whether it's FE or PH or the product of FE and PH.

How low does it have to get when it essentially says it's so low it's residual risk?

MS. THOMPSON: That --

DR. CORRADINI: I didn't find that.

MS. THOMPSON: So, that's because it's not in there. So, we didn't provide a "this is your limit."

There isn't a limit in here because we're using the risk insights to create a risk-informed approach to this volcanic hazards assessment.

DR. CORRADINI: But now that I'm risk-informed, at some point I can ignore the risk because it's so small as to be residual.

MS. THOMPSON: Correct. And that's in going through the steps.

So, once we get into Step 5, the detailed risk insights, that's where, as I mentioned before, we're using the facility PRA to assume that PE, PH, or both of them equal failure. And so, that is where that stuff would be.

And if those results are not significant, then an applicant would complete the analysis.

DR. CORRADINI: Okay. But that's what I'm trying to understand -- if you tell me to wait, I'll wait. Is there you're going to tell me what's significant and what's not significant?

MS. THOMPSON: We don't have that threshold in the draft guide.

DR. CORRADINI: Okay. Then let me offer

you a threshold.

You already have a licensing modernization program that says anything below 5, 10 to the minus 7th is residual risk.

Seems to me if this falls below 5, 10 to the minus 7th of the thing, I ignore it.

CHAIR BLEY: They don't have that process yet.

MEMBER DIMITRIJEVIC: No. That's not part of ---

DR. CORRADINI: But if it's one of the external hazards --- if it's one of the natural external hazards you have to calculate anyway for advance reactor, it's automatically in there based on the logic of the LMP.

CHAIR BLEY: The LMP isn't real yet.

DR. CORRADINI: Well, it's getting close.

MEMBER RICCARDELLA: The LMP isn't what yet?

CHAIR BLEY: Real.

DR. CORRADINI: Well, I thought commission was approving it.

CHAIR BLEY: I certainly haven't heard that -- no, I heard yesterday that they have not yet.

DR. CORRADINI: Okay. All right. But

that's where I was going, but thank you.

MS. THOMPSON: Okay.

DR. CORRADINI: Thank you very much.

MS. THOMPSON: So, in --

MEMBER DIMITRIJEVIC: It's extremely important actually for you guys since you are the PRA people, when you are having risk-informed application, doing PRA is last step.

So, you cannot really screen it through the PRA because you are already doing PRA which is very complex model.

So, you will try to screen it like assuming everything failed, which is alright. But normally when you failing everything, you have to have some frequency of the "when" to analyze that.

Because if you are failing everything with frequency of one, it's different than when you're failing everything frequency of ten.

So, this type of thinking has to come somewhere through, you know.

MS. THOMPSON: Okay.

MEMBER DIMITRIJEVIC: Because if you fail everything and nothing happen, that's only way you can screen, actually, if you fail everything in the --- whatever that stack was, and then nothing happen in

the plant because you don't have a frequency.

So, screening --- I understand uncertainty the frequency is -- I don't want to think about, I have no clue, you know. It will be equally as unlikely of predicting future volcanoes, but --- so, it was very difficult, but maybe we can have some threshold for definitely is not bigger than ten to the minus four for the screening purpose or something.

MS. THOMPSON: Okay. I'll take that note back to the working group. I'll take that note back.

MEMBER BROWN: How can you do all this stuff that you're all talking --- no, not --- this is a general question.

How can you do all this stuff when you don't --- early site permit, you don't even know what the plant's going to look like, and how do you screen out a site without going through all this rigmarole.

I mean, is there a 100-mile radius from an active -- a potentially active site? You say if you're outside of 100-mile or 200-mile radius and you just don't do any of it?

I'm just listening to the discussion and worried that you apply this and we'll never build another plant anywhere.

MS. THOMPSON: So --

MEMBER BROWN: It just -- it's becoming complex, you got to do this, you got to have probabilities to this and that and everything else. You'll never get there.

DR. SCHULTZ: It also seems like --

MEMBER BROWN: I'm being somewhat of a skeptic right now.

DR. SCHULTZ: It also seems that rather than have every applicant get started on Part 1, that it could be done geographically across the United States to identify places where vulnerabilities might be important ---

MEMBER BROWN: Yeah. Exactly.

DR. SCHULTZ: -- and get that done right off the bat --

MEMBER BROWN: Exactly.

DR. SCHULTZ: -- so the map for Nos. 1 and 2 --

MEMBER BROWN: There's nothing that says, how can I avoid this? One way of phrasing it.

DR. SCHULTZ: -- so that geologists don't have to be hired by every applicant.

MEMBER BROWN: Exactly.

DR. SCHULTZ: I mean, the applicants you had come to the meeting from the public sounded like

they were the developers.

MS. THOMPSON: We also had several ---

DR. SCHULTZ: Geologists?

MS. THOMPSON: -- on the phone that were doing siting.

DR. SCHULTZ: Geologists?

MS. THOMPSON: They're geologic consultants.

DR. SCHULTZ: Uh-huh.

MS. THOMPSON: I'm not sure what their job title is, but I have interacted with them in the past in the capacity of ---

DR. SCHULTZ: It seems like that could be ---

MS. THOMPSON: -- being a geologist at the site.

DR. SCHULTZ: -- a onetime thing for the United States and not an individual applicant's task ---

MEMBER BROWN: Well, that's similar ---

DR. SCHULTZ: -- to get started, but.

MEMBER BROWN: I mean, with the seismic when we do the ESPs, there's a --- the seismic issues get addressed right up front based on the configuration of ---

DR. SCHULTZ: Correct.

MEMBER BROWN: -- land --- and you can do that without knowing what the plant looks like. Here, when you start --- are we going to just do safety systems or is it everything on the plant site?

I mean, where do you screen --- where do you draw that line?

PARTICIPANT: They're doing boundary analysis up ---

MEMBER RICCARDELLA: But seismically you just come up with a ---

MEMBER BROWN: Not with the PRAs you-all want to do --- not that we're proposing.

PARTICIPANT: So, you're just ---

CHAIR BLEY: You're jumping way ahead of yourself.

MEMBER BROWN: I'm just looking at complexity and how do we ever get started.

CHAIR BLEY: It's not there yet.

MEMBER BROWN: Seismically it seems like there's a process to go through for an early site permit.

This sounds like another one of those things where you want to try to discount it immediately off the bat that you don't have a problem.

MEMBER RICCARDELLA: But seismically it just comes up with a response spectra that you're going to use that that's ---

MEMBER KIRCHNER: That's fine if you have firm ground to design against.

MEMBER BROWN: You wouldn't build a plant on the San Andreas Fault today. Regardless of what you did with your seismic spectra, you would not build one.

So, we did it the old days, but we wouldn't do it today.

MEMBER BALLINGER: But in this case you would have like a two-map problem. The eruption problem is a good enough -- one you can do, but the ash/plume problem, that's a different story.

MEMBER BROWN: But even that in the past circumstances has been 100 miles ---

MEMBER BALLINGER: I don't know.

MEMBER BROWN: -- 150 miles.

CHAIR BLEY: We know more now.

MEMBER DIMITRIJEVIC: Charlie, let's not be negative. They're trying to do something good.

MEMBER BROWN: No, I'm just -- I'm worried --- I think the good is often the --- something nasty for okay. And I'm not hearing any okay. It's just

more analysis and more details.

CHAIR BLEY: I've heard several okays. If there's no volcano near enough, it's okay. If there's no volcano in the area ---

MEMBER BROWN: I would never --

MS. THOMPSON: I would also add that for geologic site ---

(Simultaneous speaking.)

MEMBER BROWN: I'd like to read the transcript on this meeting.

MS. THOMPSON: So, for geologic site ---

MEMBER BROWN: I will, you won't.

MS. THOMPSON: -- characterization for non-vocalic hazards for ESPs, the staff does have experience with revisiting things once a site --- once a site has been approved and after a technology has been selected at the COL stage.

So, if we're in that position with respect to volcanic hazards, it would not be unprecedented for the staff to assess what can be assessed at the ESP stage and defer what reactor or design-specific information needs to be assessed at the more detailed COL stage. So, there is that possibility.

PARTICIPANT: Jenise ---

MEMBER BROWN: Let me finish my last

thought that I didn't say. I went through --- I read the draft ---

MS. THOMPSON: Uh-huh.

MEMBER BROWN: -- and one of the things I noted here was ---

PARTICIPANT: Charlie, is your mic on?

MEMBER BROWN: Oh, I'm sorry. I read he draft and I --- the only words I ever saw were "safety significance," not you need to take care of safety systems, those necessary to take --- to shut down the plant, put it in a safe condition.

It was -- the "safety significance" had a broader context, in my opinion, as I read through the draft.

So, to me, our focus ought to be on shutting the plant down, safe condition, what are the systems needed?

Those are the ones you -- you know, you start screening for the "how do you do that" or whatever it is. That's -- that was -- that's just a thought, that's all.

And Mike's going to disagree with me again because he doesn't like projectiles going --

DR. CORRADINI: I don't think they're at the system stage yet. I'm not sure --

MEMBER BROWN: I'm just saying the reg guide ought to provide a second level of screening relative to saying, what do we expect them to look at once they get there.

DR. CORRADINI: Okay.

MEMBER BROWN: That's all I'm trying to say. It doesn't say that right --- it's very, very broad.

MS. THOMPSON: Okay. And I made a note of that here.

MEMBER KIRCHNER: Jenise ---

MS. THOMPSON: Yes.

MEMBER KIRCHNER: -- it seems to me, though, that the problem really is not the surface phenomena, but this ash issue because it could come from anywhere, you know.

So, my question to you and the experts, and I guess this would involve your meteorologist as well, are there any maps that they've -- kind of rules of thumb or something where they look at a volcano as putting this much material in the air?

What are the dispersion characteristics? Are there, you know, like plume maps or something that would allow you to screen against that is more than --- more finite and look at every volcano that could

ever put up a lot of ash in the air ---

MS. THOMPSON: I believe that there ---

MEMBER KIRCHNER: -- and sort that out.

MS. THOMPSON: -- there are plume maps available. I'm not sure to what extent they're available for every volcano that may be within ---

MEMBER KIRCHNER: No, but I ---

MS. THOMPSON: But I know that ---

MEMBER KIRCHNER: -- I would think that --

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MS. THOMPSON: -- there are maps that could be used. And that would be something that would inform the deterministic screening in Step 2.

MEMBER KIRCHNER: But I'm still having a problem with this because it seems to me there's infinite variability out there in terms of how you do a cutoff on where to expect the ash fall to be.

So, where I was going is, are there enough -- has there been enough experience mapping the output and results of a volcano to understand that, you know, this deposition of ash is a 400-mile phenomenon, is it -- whatever, you know.

So, it seems to me anything --- any guidance along those lines would leave it less open-ended about what --- how many volcanoes from --- how

many sources --- do we have to worry about Iceland volcanoes when we site a plant in the US?

My intuition says no ---

MS. THOMPSON: And that's a good ---

MEMBER KIRCHNER: -- but is ---

MS. THOMPSON: That's a good segue.

(Laughter.)

MS. THOMPSON: There are dispersion maps. One of the ways that a lot of this can be addressed and reach consensus on what is credible, what is not credible, is through using the SSHAC process, which we mentioned before.

The SSHAC process, the goal is to determine the center body and range of the technically defensible interpretations.

So, using the SSHAC process to consider the extent to which ash fall should be considered from a volcano 200 miles away versus 500 miles away could be resolved using the expert elicitation in the SSHAC process.

DR. SCHULTZ: Jenise, when does that get done? I mean, you can't lay that process on top of every licensee that is considering siting a nuclear plant.

MS. THOMPSON: So, this would be -- this

is where --

DR. SCHULTZ: Yes, my light is on.

MS. THOMPSON: This step using the SSHAC process is included in Step 4 specifically for calculating the PE and PH -- so, the probability of eruption or the frequency of eruption -- and the probability of the hazard reaching the site.

So, if at this point you do have ash fall as a hazard that you are considering, the SSHAC process would help you determine what would be the credible range for that ash fall.

MEMBER KIRCHNER: Can you move this up? Because if you make the analogy with seismic hazards analysis, you start almost right away with maps of the seismic zones that you're in and then go from there.

Doing this so late in the process seems, to me, to drive, as Charlie was concerned, a lot of uncertainty, which opens you to a lot of intervention and a lot of wasted effort if indeed you would screen out with this step in the SSHAC process.

MEMBER DIMITRIJEVIC: I have a proposal. I think that you should stay in 200 miles. That's it. And then have a general consideration and say, if design is specifically susceptible to ash-related type failures, because ash can come from the big fires,

blah, blah, blah, then, blah, blah, blah, the next thing can be done.

Just stay in 200 miles, screen off the 200 miles, say that that's also things for ash, and then have some paragraph to address if the specific design, you know, is expected to be susceptible to ash-related failure do additional analysis.

MEMBER BALLINGER: But isn't there a parallel to this in severe accident analysis?

MEMBER KIRCHNER: No.

MEMBER BALLINGER: Don't we look at ---

PARTICIPANT: But there is a parallel in seismic.

MEMBER BALLINGER: -- distributions of wind and everything if we get a large, early release.

CHAIR BLEY: You have to analyze that.

I want to remind you of something I said in the very beginning. The ACRS only speaks through its letters.

(Laughter.)

CHAIR BLEY: You're hearing a bunch of comments from individual members.

DR. CORRADINI: Yeah. So, don't write it down necessarily.

MEMBER BROWN: Well, from wild-eyed

skeptics.

MEMBER MARCH-LEUBA: Let me qualify that. You hear a bunch of uninformed comments.

(Laughter.)

MEMBER DIMITRIJEVIC: Everybody is very opinionated.

CHAIR BLEY: And perhaps some informeds.

MS. THOMPSON: I'm just making notes of --

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CHAIR BLEY: Grain of salt.

MS. THOMPSON: -- some of the pertinent points that you're making because not all of our working group members are here today. So, I want to be able to convey what the full scope of the discussion was to them as well.

PARTICIPANT: You can get a copy of the transcript, also.

MEMBER KIRCHNER: It seems to me that if you move this up --

MS. THOMPSON: Uh-huh.

MEMBER KIRCHNER: I'm wearing my hat as a reactor designer. I'm not going to spend a lot of money on oil filters and such unless I really convince myself I have the hazard.

And to convince myself I need to protect

against this particular hazard, I need to do this ash fall analysis first.

Otherwise, I'm wasting my time because I may design something and it may turn out to be inadequate if I do the ash fall analysis later in the process.

A lot of these advanced reactors are cartoons early on. So, they may want to have a site chosen, but they are not going to have the maturity to do a full-blown PRA that shows them how vulnerable they are to these kind of threats.

MS. THOMPSON: I will say that the SSHAC process, we put it here in the presentation because we recommend it for calculating PE and PH.

There's nothing in the draft guide that would preclude an applicant from deciding to use a SSHAC-like process to perform their deterministic screening or even their initial characterization of potential sources of volcanism.

So, the SSHAC could be used at any step and I don't even think we listed it in the draft guide. It's not even in the steps.

It's listed separately so that the SSHAC process can be used at any step along the way to inform the process.

And maybe that's not clear in the draft guide, but the SSHAC process could be used at any step along the path.

DR. CORRADINI: I guess -- so, another opinion you could not write down, I like how you've done it.

MS. THOMPSON: Okay.

DR. CORRADINI: I think if I were the engineer that had to worry about this or decide not to worry about it, I would think Steps 1 through 3 ought to be done quickly and efficiently and only spend the money on bringing in a bunch of high-priced experts that aren't really sure what they are doing until I really need to do it.

So, I like the fact that you've waited until whatever step we're on ---

MS. THOMPSON: 4. We're on Step 4.

DR. CORRADINI: -- before you bring in what could be a cadre of individuals ---

MS. THOMPSON: Right.

DR. CORRADINI: --- that have to kind of chew this over.

MS. THOMPSON: And that was the working group's perspective as well that an initial screening would be a relatively quick process for an informed

geologist to do. The same thing with a deterministic screening.

But once you get to looking at PE and PH, this is where you need to reach a wider consensus based on the hazards that you have at your site.

And I have some examples that I can share with you in the next flew slides of why this is important, and why at this particular step the SSHAC would be particularly appropriate to be used.

So, I will move along.

CHAIR BLEY: Actually, just to put you squarely, you talk about SSHAC before you get to the methodology.

MS. THOMPSON: Yeah.

CHAIR BLEY: It's an introductory section.

MS. THOMPSON: Yeah. It's not in Section 3 --- or Section C ---

CHAIR BLEY: That's right.

MS. THOMPSON: -- with the actual guidance itself. It's separate. So, it can be used at any step along the way.

So, one of the key challenges with the probability of eruption --- or the frequency of eruption would be defining what is an event.

An example is shown here on this slide

from the 1955 eruption on the Kilauea East Rift. This eruption occurred over an 88-day period along a 15-kilometer rift with four major vents.

Because of direct observation, we know that this was one event. But if this event had occurred 100,000 years ago, it may not be as clear based on the available data.

So, we would need to reach a consensus within the VHA of what constitutes an event and how each event would be interpreted.

Would this 1955 eruption be considered one large event along four events effecting about 50 square kilometers, or would we consider this instead to be four separate events?

The point is that the SSHAC process would allow us to reach a consensus on what is considered an event and then to ensure that that event definition is applied consistently across the analysis.

Additional challenges with calculating the PE include reaching a consensus on the goal, whether we are looking for the probability of occurrence, the probability of exceedance or both.

MEMBER DIMITRIJEVIC: How would you know this was something happened million years ago?

MS. THOMPSON: We would have to consider

that within the SSHAC process.

PARTICIPANT: Called educated guessing.

CHAIR BLEY: You'd look at what material is coming out, is it ---

MS. THOMPSON: Yes.

CHAIR BLEY: -- the same character all the way along.

MS. THOMPSON: Yes. So, we would have to look at the characteristics. We would look at field interpretations. We could look at laboratory test results.

There are a number of ways to characterize past volcanic events and reaching consensus on how similar does something need to be to be considered the same event.

Additional uncertainties may be associated with the timing and number of past events. And then volcanic systems have the potential for non-stationary recurrence rates.

So, the SSHAC process would also help reach a consensus on what period of a volcano's history should be considered representative of its future potential activity.

We also see similar challenges in the calculation of the probability of the hazard, or PH.

The example here is from modeling data, which is the key challenge in the calculation of PH.

There's a general lack of accepted models and there's also a need for robust model support. The examples shown here are three different models of pyroclastic flows on the Soufriere Hills volcano on Montserrat. This was a 1997 eruption.

The black line outlines the actual pyroclastic flow. The colored areas represent the modeled areas for the pyroclastic flow.

And, as you can see, each model captures some part of the flow relatively well, but there are significant differences in places where the pyroclastic flow was not adequately captured by each model.

So, this is an illustration of the need for the SSHAC process to evaluate these models to determine which of them appropriately capture the hazardous aspects of the volcanic phenomena that may affect a site.

It also emphasizes the need for model support so that the model uncertainties are appropriately captured.

MEMBER RICCARDELLA: Where was -- you mentioned where this --

MS. THOMPSON: This is the Soufriere Hills volcano in Montserrat. It's a Caribbean island.

MEMBER RICCARDELLA: Oh, okay.

MEMBER KIRCHNER: Just for scaling purposes, how many kilometers or miles are we looking at in each box?

MS. THOMPSON: Oh, I think I cut the scale off. Do we -- do you have the scale for this?

MEMBER KIRCHNER: It's not a big island.

DR. HILL: It's roughly 10 kilometers from the source out to the northeast.

MEMBER KIRCHNER: That's what I was saying.

So, here's an example where common engineering sense would just tell you, I'm not going to try and accurately model for these flows, I'm going to stay outside a 10-kilometer radius and move on.

MS. THOMPSON: And that's a decision that an applicant using the VHA could choose to make.

MEMBER KIRCHNER: Yeah.

CHAIR BLEY: Now, you haven't told us, and I think some people would be -- it might help, for different geologic structures and zones there are different kinds of eruptions that might occur.

And some of those are more likely to

create a lot of ash, others are more likely to create the other hazards.

MS. THOMPSON: Yes.

CHAIR BLEY: And you guys are able to -- I mean, it's not just a blind shot what's going --

MS. THOMPSON: Yeah.

CHAIR BLEY: -- to come out of the ground at a particular ---

MS. THOMPSON: And that's a very good point. Volcanic systems, while dynamic, they are also variable depending on the setting.

Not every volcano is going to erupt a pyroclastic flow. Not every volcano is going to result in, you know, ash that reaches the stratosphere.

So, that setting is something that will be considered early on and the different volcanic hazards are what will be considered at the deterministic screening.

So, if you have a -- let's say you have the Eastern Snake River Plain. If you have a basaltic volcano source, you're probably not going to be looking at catastrophic pyroclastic flows off of that volcano source.

At the deterministic screening you most

likely will not have any geologic evidence supporting of a pyroclastic flow occurring in that location. So, you could screen that out very early on in the process.

CHAIR BLEY: Uh-huh.

MS. THOMPSON: But if you get to a point here where you have specific volcanic hazards that are likely to occur given the volcanic setting, then we could use this process.

But that's a good point to make that the hazards that I mentioned at the start are not a comprehensive list that must be considered for every location.

They are very site-specific and geologic-specific to what the processes that are driving volcanism, which is why we consider that tectono-magmatic model at the very first step.

MEMBER KIRCHNER: So, I hate to regress, but you do have some examples and Columbia is one. Maybe there were no other plants in a direct atmospheric flow pattern downstream of Columbia at reasonable distances, but why was -- why were not other commercial plants -- I don't know, I'll say something ridiculous -- in Wisconsin required -- were they -- when you decide that Columbia had issues with

ash fall, why did that not have a much larger radius of impact -- what do you call it?

MS. THOMPSON: Region of interest?

MEMBER KIRCHNER: Region of interest, yeah.

MS. THOMPSON: Again, this would be looking at the geologic information. If there is a credible level of geologic information that would suggest that ash falls from, let's say, a Cascade volcano, would reach a facility in Wisconsin, then that would be considered.

If there's not geologic information to support the likelihood that there would be significant ash fall deposits at a site, then that would screen out.

MEMBER KIRCHNER: But I would wager that what happened historically with the agency was even though Columbia had to deal with a consideration of ash fall ---

MS. THOMPSON: Uh-huh.

MEMBER KIRCHNER: -- the agency did not ask the Midwest plants to worry about ash fall, that I recall.

DR. CORRADINI: They made a judgment.

MS. THOMPSON: Yeah.

CHAIR BLEY: I sort of want to apologize because I kind of got this thing --- I was hoping there would be a way to get a clearer definition in the guidance.

But I think if you sat down with one of these people and looked at a site and looked at these maps, it wouldn't be a great mystery how far out beyond 200 miles you might have to go.

DR. CORRADINI: Okay. All right.

CHAIR BLEY: And if you look at -- yeah, we don't know if it's a millimeter or a foot, but we know that volcanoes like the Cascades have thrown ash more -- well over 200 miles away and it ended up in several feet, not just a few millimeters.

DR. CORRADINI: I know.

CHAIR BLEY: But not, you know, 2,000 miles away all plopping in one place, you know, unless something really bizarre happens.

MS. THOMPSON: Something that the staff discussed initially very early on in the process is what could reasonably be excluded.

And so, what is reasonable to exclude as a hazard and what is reasonable to include, which is why we start with considering the region, the time period of interest and the tectono-magmatic model.

And that example that I gave you, everything in that figure is less than half a million years old, but there are only two features in that figure that should be considered because they're the only two that could reasonably result in volcanic hazards at this site or at a proposed site in that area.

So, we're looking for -- we were looking to focus on what could be reasonable, what would be credible, not what is in the realm of possibility as anything that may happen.

MEMBER KIRCHNER: Because I'm looking over Jose's shoulder here, and he's showing a map with the dispersion from the Iceland volcanoes. But the fact is that although the dispersion is many thousands of kilometers, a reasonable analysis of the situation would suggest that the ash fall problem is not that -- it's an airplane issue, but it's not a credible threat to a nuclear --

MS. THOMPSON: And there's a difference between dispersion, where the ash could go in the atmosphere, versus where the ash could be deposited on the surface. So that's a consideration as well.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: -- not a mass release

to cover all that area.

MEMBER KIRCHNER: No. No.

MEMBER MARCH-LEUBA: However, can be a thunderstorm right here that deposits a lot while it's raining. If you have a --

CHAIR BLEY: If it goes that far, it's much higher than a thunderstorm. I just want to make a comment while you have this picture up here. Back when SSHAC was dreamed up, one of the reasons was -- and you can get a simple idea of it from this figure. Suppose each of those models are three different people who's developed them, and they believe in their own model very strongly. And so they don't want to give you much credit.

And now you sit down. How do we come up with what's right? And I finally said two things. Get the people together, but we don't just let them say, my model's right. You come forward and you lay out the evidence for why your model might be right, and you seek not your own personal probabilities but what you think is the -- what is a group, you think is the state of knowledge of the community, the technical community.

And they were able to then get through this knot and weight each of these a reasonable

amount. And everybody finally agreed on the joint result that came out of the process. Now, that's the kind of thing they would do here. And maybe somebody really thought they were onto something, especially if that bottom one, say, was separated a lot more. And they really were pushing their model.

But when they finally talked about it, yeah, the other ones are much more likely to happen. But under rare conditions, mine could be the right one. So you weight them appropriately, and that's what the process is designed to do, to bring all the evidence together, share it, and come up with a joint view of what's most likely.

DR. SCHULTZ: But my question, Dennis, is who are the they that are going to do this, and when is it going to be done? Because the way it's written, it sounds as if the licensee is going to get a SSHAC team together and do the work for their local site.

CHAIR BLEY: The truth is very rarely. Most people aren't going to build something right near a volcano, even within a couple hundred miles of a volcano. But it's going to happen rarely, and you do it, and you need to.

DR. SCHULTZ: Washington state is 400 miles across. So --

CHAIR BLEY: Well, and the ash went.

MEMBER RICCARDELLA: But it was a SSHAC process that led to the CS report, right? The seismic?

CHAIR BLEY: Yeah.

MEMBER RICCARDELLA: They came up with the seismic map for the whole central and eastern United States.

DR. SCHULTZ: That's what I was talking about before. I think that's an appropriate way of knowing.

CHAIR BLEY: There was a basis for looking at all that together. Here, it's a little one, but I think they're going to do it when they have to. I would think their geologists may be able to do the first several steps very quickly to a level they're quite comfortable. Then you get to the step where you say, what of my stuff if it breaks could get me in trouble?

And that's not those people. That's somebody else. And that might be released. It just depends on what that hazard is that's likely to get there. So I think we're over-stewing on this.

MEMBER DIMITRIJEVIC: Maybe doing this map makes the most sense before the guy --

(Simultaneous speaking.)

MEMBER RICCARDELLA: I'm sorry. I didn't hear what you said.

MEMBER DIMITRIJEVIC: I was saying maybe building his volcano hazard map for United States will make more sense before --

MEMBER RICCARDELLA: Suppose I told you one millimeter was the problem. One millimeter of ash deposit is a problem. Could you make a map of the United States with the probability of or frequency of areas that would have one millimeter, maybe a color-coded map like that with different frequencies of getting one millimeter?

DR. HILL: Yes. The map currently exists. The US Geological Survey is on its second revision of it for ash fall hazards from Cascade volcanoes. So you could easily go out and look at an exceedance probability for one millimeter. I believe they did 110 and another thickness and an annual likelihood of occurrence.

MEMBER RICCARDELLA: But does that map include Wisconsin?

DR. HILL: I can't recall. I don't think so. I'm not aware of recorded deposits for quaternary volcanoes in Wisconsin of any kind. There's always a

threshold of initial credibility. Come back to our initial siting criteria of phenomena that have been occurring at the site during the historical period with some uncertainty about the timing and uncertainty of the event, but it still is -- it happened in the past around here.

It's not speculating that it might be from the future that the Iceland volcano gave us a trace amount. It's possible, but really, do you see any evidence of this occurring in the past at the site? So we're not really starting an analysis from speculative trace distribution of deposits. These are deposits that have a really credible basis in being there. They're either mapped or, in a broad-brush analysis by the US Geological Survey, have a credible likelihood of occurring.

That's the initial step. Then you do the detailed analysis to look at the specific volcano near your site and see, well, rather than an order of magnitude, what are we really dealing with?

CHAIR BLEY: You remember when we were doing seismic for various sites, Jerry was here. So they do a lot of digging. They dig up old stuff because he was there. I mean, they don't just guess at it.

MS. THOMPSON: Yes. So --

MEMBER DIMITRIJEVIC: But maybe uncertainty is equal in both cases because that's not going to represent any realistic frequency of seismic beneath the volcano because we cannot predict the future based on past events.

MEMBER RICCARDELLA: Well, that's why you've got a series of tests.

MEMBER DIMITRIJEVIC: That's not really the issue, right?

MS. THOMPSON: So that highlights another set of challenges in calculating the probability of a hazard reaching the site, which is that the character of volcanic systems can -- or the character of volcanic hazards can change with distance from the source. So ash fall hazards, it's going to differ whether you're on the slope of that mountain or if you're 1,000 kilometers away.

There also are different interpretations, or there may be different interpretations on the preserved deposits that are in the geologic record. And then, as I mentioned before, a challenge with PE as well as PH is that the characteristics of volcanic systems can change through time. So we're dealing with non-stationary systems that should be considered,

and reaching consensus on that is, like I mentioned, something that can be accomplished using a SSHAC-like process.

MEMBER DIMITRIJEVIC: The last eruption was just New Zealand had all these -- whatever you call it, explosion with no ashes.

MS. THOMPSON: So yeah. The White Island eruption from last December, just a few months ago, was preceded by a slight increase in earthquake activity at the volcano before the eruption. And then there was that pyroclastic flow off of that, off of the cone, and unfortunately, lives were lost.

The following step for once PE and PH have been determined, an applicant would proceed to step 5, which is the Detailed Risk Insights. This uses a similar approach to step 3, which were the Initial Risk Insights. We're again using PRA, and we're assuming that the probability of the SSC, having unacceptable performance or failure, will be equal to PE or PH or both.

We would then evaluate the results in the PRA and determine if the resulting hazard is potentially significant to safety, taking no credit for the likelihood or magnitude of the occurrence. So if these insights then show that the hazard is not

significant to safety, an applicant would document their rationale and complete the assessment. If not, they would proceed to step 6.

MEMBER DIMITRIJEVIC: This is very mathematically incorrect. So -- and we can help you put that so it makes sense because the fail probability -- fail SSCs always probability. So it cannot be PE. But PE can be considered if you are satisfied with your uncertainty range. So this can be definitely put in that one back there.

MS. THOMPSON: Okay. So at the Evaluate Design Bases step, it's important to note this is the only optional step in the Volcanic Hazards Analysis, in the VHA. However, the working group encourages an applicant to perform this step because this is the step that could provide additional performance insights from a focused evaluation of the SSCs' individual design bases that would be considering the unusual demands of the volcanic hazards that would be affecting the site. However, an applicant could decide not to consider their design bases and proceed directly to Mitigation Actions.

So an applicant may come to a decision that volcanic ash is still a credible hazard for their site, and rather than reevaluating their design bases,

they've determined that they will move straight to Mitigating Actions and implement those. So instead of reevaluating the design bases to determine if the ash fall could be -- if the facility could withstand the ash fall hazard, they may instead proceed directly to Mitigating Actions and determine that they're going to install air filters and implement mitigation procedures.

MEMBER RICCARDELLA: This is the Volcanic Qualification Program. Just put a piece of equipment in the chamber and blow it back, and the chamber keeps working.

(Off-microphone comments.)

CHAIR BLEY: It's not. Thank you. On page 15, you get to the point of saying you've maybe calculated PH, maybe calculated PE, maybe calculated both of them. If either PH or PE shows that potential volcanic hazards did not significantly affect safety -- it's just PH and PE, nothing else -- then additional analysis would not be warranted. I would say and the combination of the two.

So if your frequency's very low, you're kind of done. But then, if you're not done and you have either PE or PH calculated, you tell people to do a simplified PRA using the same techniques you used in

step 3. Well, that one assumed that the appropriate SSCs failed, and then you say either the plant's okay or it's not.

Here, we've got now a likelihood. There, we assumed the stuff got there. Here, we're saying, no, we don't assume it gets there. There's some likelihood that it gets there. And either we assume it's guaranteed that we blew the thing up and now we have a probability that it got there, or the frequency was such we know that and we assume that it gets there, or we calculated them both and we multiply them, and we have a likelihood that the stuff gets to the site.

Now, if we do the same thing as we did in step 3, we aren't taking advantage of having calculated either of those two probabilities. So you have to do something a little more once you get there, or you wouldn't have bothered to calculate PH and PE. You don't use them.

MS. THOMPSON: So we do use them. So in the Initial Insights, we're assuming failure equals one, and the Detailed Risk Insights, we're assuming that the failure equals PE or PH.

CHAIR BLEY: Or you're doing both. But you're not using them. You've calculated them, but

you say now go do the same simplified theory you did before? No. You need something a little more than that now. Or you just need those frequencies and say that's good enough. It's not going to happen at a rate I care about.

(Simultaneous speaking.)

CHAIR BLEY: Somehow, I'm not communicating to you. But --

MEMBER DIMITRIJEVIC: There's an additional problem which is very important. You cannot do that because you cannot do even the first screening, because you cannot put SSCs to run without knowing what the initiating event is. If you're going to put this to run and use the --

(Simultaneous speaking.)

CHAIR BLEY: If you've got -- what it means is -- and they didn't really say this. What it means is you have a PRA model, and you know what the SSCs are. And you've looked at the hazard coming here, and you say that hazard can affect these two SSCs.

MEMBER DIMITRIJEVIC: Causing what? Transient? Loss of off-site power, that's very different.

CHAIR BLEY: No, not causing. It can

affect these. Now, I fail those and say, can I do anything to the plan? If it doesn't do an initiating event, nothing happens.

MEMBER DIMITRIJEVIC: Well, that's what I'm saying.

CHAIR BLEY: So you need that whole PRA model.

MEMBER DIMITRIJEVIC: Because I don't want to challenge.

(Simultaneous speaking.)

CHAIR BLEY: -- a simplified one. But none of that's spelled out. You assume somebody knows how to use these probabilities you've just calculated and how to come up with some meaningful pseudo-PRA calculation without telling them how to do it.

MEMBER DIMITRIJEVIC: Well, they might know the problem which we identified before, and that's why much more discussions around the PRA label. And you definitely need the PRA person on your team is -- let's say that we assume that that all is going to cause a loss of off-site power like we did in the seismic.

In that case, if my diesel generators are vulnerable, my risk is one because I have to assume the loss of off-site power happened. Until you have

a frequency of occurrence, which is your PE, the thing is I have to assume some type of challenge to the plant operation. If there is nothing to challenge, we can assume the operator will manually trip because volcano exploded --

MS. THOMPSON So in step 5, the assumption is that instead of the failure at 1, the failure's at PE, PH, or both. So --

MEMBER DIMITRIJEVIC: Initiating event.

MS. THOMPSON: So yeah. We are using PE and PH in step 5.

CHAIR BLEY: You don't tell people what to do with it.

MEMBER DIMITRIJEVIC: Yeah. Yeah. That's true.

MEMBER RICCARDELLA: I think in step 5, they assume the probability of failure of the SSC is one, the conditional probability given PE or PH.

CHAIR BLEY: That's what they did up above.

MEMBER DIMITRIJEVIC: No, PE.

MEMBER RICCARDELLA: No, no, no, because up above they didn't have a PE and a PH.

CHAIR BLEY: They assume those happened up above.

MEMBER RICCARDELLA: Yeah.

CHAIR BLEY: In 3, they assume that both happened. In 4, they calculate one or the other, and in 5, they now start looking at the plant and saying, gee, if this is going to affect these vents, do I need to do a calculation on what the risk is, or can I protect the vents somehow from the fallout?

So there's an engineering step there that works very nicely, but there's no hint about what to do with those numbers. Why do you calculate them if you don't use them? You're not any better off than you were. You could have gone right from step 3 to 2, to the protective action.

MS. THOMPSON: So we're using them as the assumption that if PE -- we're using PE or PH or both to equal failure. That's what we're doing in step 5.

CHAIR BLEY: Right. So in the first case --

MEMBER RICCARDELLA: Yeah. That means that the conditional probability of failure given that is one.

CHAIR BLEY: Yeah. That's exactly right.

MEMBER RICCARDELLA: But then if that's low enough, if it's below ten to the minus seventh, you're --

CHAIR BLEY: You just made that up. But show me in here.

DR. CORRADINI: They don't have a threshold below which residual risk is ignored.

CHAIR BLEY: If it's ten to the minus seventh, do they have a criteria? What if it's ten to the minus fifth, and what do you do with it then? What if it's ten to the minus three? What do you do with it then? There's no hint about how to use it.

MEMBER RICCARDELLA: I would say if it's greater than ten to the minus seventh, then you go on to step 6. Right? Then you go to the PRA.

CHAIR BLEY: You'll have to. If you're going to use that as a criteria --

MEMBER KIRCHNER: Dennis has a point. You don't have the do loop that you need. The first time at 3, step 3, you assume it fails as one. Now, all of a sudden, you come up with some measure of the frequency which would reduce that one some percent. You're saying use the PH and the -- what's the other?

MS. THOMPSON: The PE.

MEMBER KIRCHNER: PE. Then you do it again. But where is the cutoff? How do you know? Why can't you just stop then? Where's the point where you say stop?

MS. THOMPSON: Well, through the use of the risk insights, after you've determined your results, you would then determine whether the result is insignificant to safety or if it is significant to safety. We're not providing a cutoff threshold because, again, we're looking at a wide variety of hazards. So what may be an acceptable threshold for one volcanic hazard may not be the same threshold for a different hazard.

This is not a one size will fit all for all of the potential volcanic hazards that may occur within the United States at varying locations. But we don't have that threshold cutoff in here for that reason.

MEMBER KIRCHNER: Does it go back in any way to the safety goals or the Commission's policy?

MS. THOMPSON: We believe this is consistent with the risk-informed performance-based framework. So --

MEMBER KIRCHNER: Yeah, but that's jargon. Yeah. The thing is I guess I'm back in Charlie's camp in the sense that if you're a designer, you want to either change the plant design as a result of your PRA informing you, and/or you come to a point in this process where you just say, stop.

MEMBER BALLINGER: Applicants are looking for finality --

MEMBER KIRCHNER: Yeah.

MEMBER BALLINGER: -- period.

MEMBER KIRCHNER: There's uncertainty here.

MEMBER BALLINGER: Yeah, and employees -- there's a 9th Circuit for every plant.

MEMBER KIRCHNER: On the seismic side, you can do all this, and then you can show what the probability is, say, of a core disruption or whatever as a failure rate -- as a result of a failure in a SSC or et cetera. Here, I don't see exiting the loop, the do loop.

DR. HILL: If I might interject --

MEMBER RICCARDELLA: If we'll go back to step 5, if we could, the second bullet says -- you make that assumption on the first bullet, and then the second bullet says you evaluate the results from the PRA. So you got a PRA with initiating event, and you say, okay, now I'm going to assume that certain equipment fails at the probability of PE and PH here, or the frequency of PE and PH. What impact does that have on the PRA? What's the delta risk? And if the delta risk is small, then it's acceptable.

DR. CORRADINI: But what's small enough?

MEMBER DIMITRIJEVIC: And you can --

CHAIR BLEY: I think there's -- the answers come.

DR. HILL: I just wanted to bring one or two relevant points. First of all, I appreciate the difficulty in trying to relate this to seismic hazards. There's been decades' worth of engineering analysis, both empirical and modeling, that has gone into understand seismic demands and how structures that are important to safety respond to these different demands.

There is a wealth of engineering information for, really, a demand that falls in a very narrow physical window. We're trying to make a technology-neutral approach for a demand, the volcanic hazard, that spans orders of magnitude more variation than the demands coming in from seismic.

Yet in the literature, we have almost nothing about the engineering response of SSCs that are important to safety and how they respond to volcanic events. There's even -- the most common one is volcanic ash, and there's an extremely limited amount of information on the impacts of volcanic ash. Most of that's occurred within the last five years.

So we're faced with this challenge of -- I appreciate the need that it would be so nice if we could come up with a clean number that says, below this likelihood of occurrence, it's not significant to safety. But unfortunately, we lack a technical basis to make that safety kind of decision.

So we fall back on the risk insights, which uses not just the sensitivity of the new information in the existing PRA but additional information considering the uncertainties, the confidence in the models, the overall scope of information used to say whether this is significant to safety or not. And as that metric for significance to safety changes, as we're seeing right now, the rationale can be easily marshalled by an applicant to say, based on NRC's current view of what is significant, we believe these numbers for volcanic hazards are or are not significant.

DR. CORRADINI: But are you -- let me ask a question of the staff so that at least -- because I think we're all kind of troubled by the same thing. Are you saying you'd let the applicant come and suggest what's a residual risk that's ignorable and not provide them a suggestion as to what that level is?

MEMBER DIMITRIJEVIC: Yes. That's good. That's not bad. I'm --

DR. CORRADINI: Let him answer. I want them to answer.

DR. HILL: Yes. That's correct. So you do not have an established criteria that says, this is what would be the acceptable risk for volcanic hazards for any facility in the United States.

DR. CORRADINI: Last time we did that was risk significance in terms of a figure -- I can't remember what those things are called when we had Member Stetkar going crazy. The ESBWR had one level of measure and AP1000 had another level of measure and EPR had another level of measure, and I thought the Committee was going nonlinear about that.

It strikes me that you want to have some sort of at least straw-man level of significance below which it's not necessary to look at it. Whether it's PE or PH or the product of PE/PH, it strikes me if I fall below some sort of level as a straw-man starting point, then it's ignorable.

And the only one that's out there as a straw man right now -- I'm back to my LMP -- is the Licensing Modernization Program that they basically said, with a series of frequencies, if the frequency

of this with uncertainty falls below some level, I don't consider it.

MEMBER DIMITRIJEVIC: This is why I was going to suggest that you remove SECY-98-144 because it doesn't say anything about this inform, and you put the reg guide 1.174, which will tell you about how to consider the risk report.

There is something which I heard they will update because there is a difference between relative and -- the regulator didn't make decision about that. We're just discussing ten to minus seven, which we said is not really significant when it comes to the -- value minus seven when you're talking about CDF or value minus nine, that will become a most important event. May not be significant from safety goal but it may be significant from the risk insight.

So let's reference reg guide 1.174, and then the NRC's going to keep up with their opinions on that subject.

DR. CORRADINI: The only reason -- I just want to make sure because I think Vesna's -- makes a much more logical way of saying it than I did. What only troubled me about when you said you leave it up to the licensee is that you could have a multiplicity of values that are all over the map, and we've seen

this happen before with other things that you leave to the licensee. And at least you want to provide them some sort of guidance on how to attack it to begin with. That's what --

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- will do that for them. Reg guide 1.174 will do that.

DR. HILL: One final comment just specific to volcanic hazards. I have to reiterate that the very large uncertainties that we're dealing with here in calculating an eruption probability -- when we talk about thresholds, the term that's commonly used is an expected value of, say, ten to the minus seventh, which implies you have an understanding of the central tendency of the probability.

Now, I can make a number up for volcanic hazards, but you really have to come through and do a fair amount of work to have an understanding of whether your expected value probability is going to be at ten to the minus seventh, which -- to get to that expected value means you're considering events that are going to be down ten to the minus eighth and potentially even ten to the minus ninth per year to have an effective understanding of the mean value of probability.

So this is a very significant challenge to use -- you can present a criterion of, let's say, the ten to the minus seventh threshold. But in this particular instance, the epistemic and aleatory uncertainties that have to be evaluated are going to be a very significant technical challenge to defend to say, I'm at a threshold; therefore, I do not need to go forward and multiply.

DR. SCHULTZ: That's why the definition and the mechanism by which that uncertainty is going to be treated needs to be well defined as part of the process. And it can't be something that is going to be established by licensees A, B, C, D. It has to be well established as to how that's going to be treated. Otherwise, we'll never get to agreement.

MEMBER KIRCHNER: Just not the licensee in terms of regulatory certainty. With all due respect to how uncertain this particular challenging problem is, you open the door for intervention that you may have a hard time closing.

DR. SCHULTZ: That's right, intervention or just technical agreement.

CHAIR BLEY: This is akin to the SSHAC process being used to come up with a seismic hazard curve for an area that's not central and eastern US.

I mean, they used it for that whole area, but -- and, of course, it's not a plain estimate. The SSHAC thing is designed to look at --

MEMBER KIRCHNER: A whole series of hazards there, not just one.

CHAIR BLEY: -- the things that could drive it in different directions. So it's a probability of frequency, which has a mean value as an expected value. And the best you can probably do is some sort of expert group looking at the kind of pictures you have and then trying to assemble them into an uncertainty distribution, come up with a mean.

MEMBER KIRCHNER: And is it better, in your mind, Vesna -- because you deal in this space. I don't normally deal in this space. Is it better since there's -- as was very eloquently said, this probability of eruption number is going to be difficult to achieve or you have to appreciate it's going to have large uncertainty. Can you do a better job on probability of ash deposition and mapping versus where do you put the --

CHAIR BLEY: The experts in this area say yes. That's what they say. And if that's the long-range hazard, it seems to me that's where I would put my efforts.

MEMBER KIRCHNER: Yeah. That's where it's going.

MEMBER DIMITRIJEVIC: Yes, but the ash distribution is given eruption. So, therefore, that's going to be not able to be -- this is not going to be a small number. It's not going to be ten to minus five. It's given eruption. So that's not going to stream.

MS. THOMPSON: It's also important to know that not every ash eruption is going to be the same volume. So what may be modeled may be the maximum credible extent of an ash fall hazard as opposed to what actually occurs in the future in an eruption. So, again, we're dealing with something that is very nonstationary. It's a very dynamic system, and what we model may not be what occurs.

So even if we reach that consensus, there's still a fair amount of uncertainty just because of the nature and the changing nature of these volcanic systems.

MEMBER KIRCHNER: Let me press a little further, then. I'm showing my deterministic side today, determined to get an answer as an engineer so I can design my plant. But seriously, if there are such good USGS maps for the Cascadian system, how

would -- walk us through how we ought to use those maps in this process.

MS. THOMPSON: Within this process?

MEMBER KIRCHNER: Yeah, within your process.

MS. THOMPSON: Okay. So if we assume that we have evidence of a quaternary volcano, it's within our region of interest and it is within the time period if interest, and it is consistent with our tectonic magnetic model, and we look at the distribution of ash fall, most of the -- the use of that hazard map would be used at the Screen Volcanic Hazard step. That's where we would first use it.

We would consider those maps with respect to our site. Could the modeled ash fall from that map reach our site? If we're considering a site in New Jersey, the answer is probably no. If we're considering a site in Montana, we'd have to look at that.

So that's where we're at, the deterministic screening, looking at what could credibly reach the site. If we determine yes, it is a credible -- it's credible that an ash fall deposit would be reaching our site, we would move on to step 3, consider our Initial Risk Insights assuming that if

the ash fall arrives at the site, we have failure of an SSC.

We continue on. If that result is that the failure of that SSC from the arrival of ash fall at the site would be significant to safety, then we would move on, calculate the PE and PH for the source volcano of this ash fall, which would be step 4, and then we would get into step 5, where our -- most likely PH. The probability of the hazard reaching the site would be considered in our Detailed Risk Insights, where we would assume that failure will occur at PH in our system.

MEMBER KIRCHNER: Let me pursue this.

MS. THOMPSON: And then do you want me --

MEMBER KIRCHNER: I'm sorry, Dennis. If I can go one more step. Okay, because I want to go back to where Vesna might have been starting.

So okay. Most of the plants are in the eastern US, east of the Mississippi. So if we were to just take this reg guide right now and -- let me just throw this out arbitrarily. Anything east of the Mississippi, how quickly would we screen out the volcanic hazard?

MS. THOMPSON: Most likely in step 1 or 2. I would say the --

MEMBER KIRCHNER: And how much effort would that take?

MS. THOMPSON: -- surface hazards would screen out in step 1. So lava flows, pyroclastic flows, those would all screen out at step 1. Ash fall, we would consider the hazard map and look at our deterministic screening and look at the geologic record to see if there are ash deposits within the quaternary period at that specific site.

And I would say, most likely, you would screen out as well, and then you would be done. And if it took a -- I'm trying to imagine how much time. If you are familiar with the area that you are working in --

MEMBER KIRCHNER: You were part of the Clinch River ESP.

MS. THOMPSON: Yes.

MEMBER KIRCHNER: So give us a feeling. How quickly would we get through this for Clinch River?

MS. THOMPSON: It would probably take me more time to write the report than reach a conclusion.

MEMBER KIRCHNER: All right.

MS. THOMPSON: I don't mean to be funny, but that's --

MEMBER KIRCHNER: No, I know. I'm just --

MS. THOMPSON: It would take me more time to document the results than to reach a conclusion.

MEMBER KIRCHNER: That's good to know.

MS. THOMPSON: Yeah. This is not a burdensome thing if you are well removed from volcanic hazards.

MEMBER KIRCHNER: That gives me a little more certainty.

DR. CORRADINI: But I think we're --

MEMBER DIMITRIJEVIC: Okay, but let's look from the design perspective.

MS. THOMPSON: So that's actually what we're stepping into next, which is step 6, to evaluate the design bases once we have determined PE and PH and moved in after our Detailed Risk Insights and we're at the optional step of considering the design bases where we are looking to develop a more accurate limit state for the SSCs that would be affected by the potential volcanic hazard reaching the site.

So, specifically, we're looking at exceedance likelihoods given the demands of the volcanic hazard that reaches the site. And if you remember the range of different demands that may be impacted on the site based on what the hazard is, the

demands of a lava flow are very different from the demands of an ash fall hazard.

We would also at this step consider the actual material properties that would be affected and looking at facility-specific information related to the SSCs that would be affected by the hazard. So this is the stage where we're looking at what can the actual facility withstand, and can it withstand the particular demand of that specific volcanic hazard?

And this is a place where the conclusion reached for ash fall may be different than the conclusion reached for a lava flow, so again considering the dynamic nature of volcanic hazards and their varying demands. So once that is done, we would look at reevaluating risk insights based on this new facility-specific information, and then this may allow us to enhance the design bases if an applicant chooses to go that route.

MEMBER DIMITRIJEVIC: This is -- sorry. I was trying to say something before for this design similar to her hazard. So let's say that we want to build NuScale next to Columbia. I would say go ahead. There is nothing which can -- I mean because the only important things are ECCS components and the passing cooling. There is absolutely nothing I can think from

volcano.

So that would be example of a design that's not really vulnerable to this type of hazard.

MS. THOMPSON: And that's exactly what would happen at this step where an applicant would consider the specific systems and the effect of the volcanic hazards on those specific systems. And if they do reach a conclusion that given the design of the facility, the volcanic hazard would not affect the site, they can at this point screen out or complete the analysis because no further analysis is needed. The volcanic hazard, although reaching the site, will not affect the facility, given the site-specific and facility-specific parameters. And they would be done with their analysis, and they would be complete.

DR. CORRADINI: Okay. So let's play this one out. I think what you guys have done is very good. I just am looking for examples so that if I'm an applicant, I would see an example for step 1, an example for step 2. So let's take an example here. I've got all these supposed advanced reactors with supposed passive decay heat removal systems that either have air heat exchangers or water heat exchangers that ash deposits will follow them.

So do I assume one millimeter thousand?

Do I do a parametric on that? At what point do I say that that's an unacceptably large amount of following factor on these passive heat exchanger systems? Strikes me I'm going to have to make a judgment. So that judgment would be probably based on frequency, which is the chance of this happening compared to all the other things I'm worrying about on getting rid of my passive decay removal system is zero.

CHAIR BLEY: Yeah, but if you can't do it on frequency, then you get some guy like you to evaluate how your heat exchangers will do in this environment.

MS. THOMPSON: And that decision to determine what the effect would be, what the volume of ash could be given the passive systems, that is another question that could be posed. And you could use a SSHAC process to consider, what volume of ash could we reasonably expect to reach the site? And should we consider that to be our failure state, or is this amount of ash that we've come to a consensus on -- let's say it's two millimeters.

Well, the engineers have decided that two millimeters is something that this facility can withstand, and that would be done at this stage, evaluating your design bases. So if you can make the

justification and document the rationale for that conclusion, you could end the volcanic hazards analysis and be done.

DR. CORRADINI: I see where you're going. I'll point to the empty chair. Now I'm starting to become like Charlie that I am imposing requirements on this technology that I'm not imposing on any other technology to a level that the uncertainty -- if I started thinking about other ways to make electricity and I say, well, I'm worried about a volcanic eruption on all these solar arrays and all these wind turbines --

CHAIR BLEY: Wait, wait. No, no. Come on. You don't -- so you lose production. That's different than having a nuclear release from a nuclear plant. That's why we've got all the regulation we have.

DR. CORRADINI: Okay. But if I go through from a frequency standpoint, if it's a low enough frequency, it's still a residual risk.

CHAIR BLEY: Well, that's true.

DR. CORRADINI: But that's got nothing to do with a coal plant or a solar plant.

MEMBER MARCH-LEUBA: The risk is a product of the frequency testing consequences. I mean, a

solar plant is supposed to --

(Simultaneous speaking.)

CHAIR BLEY: Well, if the consequences of losing electric power are higher than --

(Simultaneous speaking.)

DR. CORRADINI: I'd probably kill more people losing electric power and have a loss of refrigeration than all the stuff I'm worried about here.

MEMBER PETTI: If there's nothing else you've learned from this almost three-and-a-half-hour exercise is that some examples that are really different, right, I think would help clarify all these.

MEMBER DIMITRIJEVIC: You mean the examples only on the --

MEMBER PETTI: Of using the process.

MS. THOMPSON: Of using the process. Okay.

MEMBER MARCH-LEUBA: By the way, I sent you a link to the US Geological Survey of 160 US volcanoes and the risk.

MEMBER DIMITRIJEVIC: They can only do hazard analysis. They're not going to take some PRA to run data.

MS. THOMPSON: I'll take that note back to the working group. Yeah.

MEMBER REMPE: Some of the examples with the non-ash cases are perhaps less dependent on the design. It's just the site. And so, then, in some of the examples, you're going to have to say, this will depend on the design details, and just cut it off. Right?

MS. THOMPSON: Mm-hmm.

MEMBER REMPE: With all the work you've done, we're -- I mean, this was started out because of what's going on in Idaho. Can you even rule out the surface ones, but you can't do the ash ones at this time or at least give some insights for that site? I mean, you've heard Steve and a bunch of people saying, when does this get done? Have you gone far enough?

And you talked about on the East Coast, you can just rule them out. Have you done enough that you can say certain things are not ruled out?

MS. THOMPSON: It would depend on site. Again, it's very site-specific. There are some hazards that you can rule out almost immediately based on geologic setting alone and the characterization of the volcanic system. Whether we could as a staff put together an appendix saying, if you're located here or

there, you don't have to consider this, may take some additional time as we move our way west. But --

DR. SCHULTZ: I think it could be well worth it.

MS. THOMPSON: Okay.

CHAIR BLEY: The other side of that is, how many people are going to come up with a siting requirement that's going to put them in need of considering this? In 60 years, we've had 2 plants.

MEMBER REMPE: The other thing I guess I was thinking about is, often, you refer to the PRA. Some of these things are going to be so simple they're just going to have a maximum -- or a hazard assessment. Right? They're not going to have much of a simplified -- yeah. And so those kind of questions, I think are -- we need to broaden it a bit.

MS. THOMPSON: Okay. That's something we'll take back, too. So if after evaluating the design bases there is still a credible hazard, an applicant can choose one of two actions. They can go back and reevaluate again, or they can proceed to Mitigating Actions. And this is kind of an iterative. As we get towards the end, you can evaluate your design bases, evaluate mitigation actions, and let's say your mitigation actions still do not resolve the

risk posed by the volcanic hazard.

You could then go back to step 6 several times if you wanted to, to perform even more detailed analyses to get additional information based on your specific site and your specific design. So moving on to Mitigation Actions doesn't necessarily mean that you're committed to those actions. This is just an iterative process that an applicant can take.

So, as I mentioned before, most volcanic eruptions are preceded by precursory earthquakes or other activity. This warning time can occur over several hours. More commonly, you get several weeks of elevated activity. And Mitigation Actions may be practicable in the warning time that you have between when there is a change to the volcanic system and when the hazard arrives at the site.

An example of this is, again, the Columbia Nuclear Generating Station. As I mentioned before, it's the only current operating reactor that has design bases volcanic hazard for ash fall. It's located more than 200 kilometers away from the source of that ash fall in the Cascades. So the Columbia site has several hours to prepare for an ash fall event.

And as I mentioned before, there are

maintenance procedures, and air filtration is installed in that warning time, which the staff at the time of licensing reviewed and determined that was sufficient time to implement all of these mitigation actions. It's also worth noting that volcanic ash fall is a commonly mitigated hazard around the world. So, as I mentioned before, we have more data for ash fall than we have for any of the other volcanic hazards with respect to mitigation and evaluation. So --

MEMBER MARCH-LEUBA: Would you say that the other hazards are deadly? If you get caught in the lava flow, forget it.

MS. THOMPSON: So that's the -- the next thing I'm getting to is that, as you mentioned, some surface flows, their properties are much different. They are much more deadly, and -- but some of them have been successfully mitigated worldwide. Other attempts have not been successful.

The photo here shows one such attempt. This is from the 1960 eruption on Kilauea. You can see a little bulldozer in the center. That bulldozer is constructing a five-meter-tall diversion for the lava flow.

MEMBER MARCH-LEUBA: Which no longer

exists.

MS. THOMPSON: Exactly. This barrier was successful in diverting the lava flow for several weeks, but it was ultimately overtopped. But if you're considering several weeks of successful mitigation of a flow hazard, if you're looking at evacuation times for people or other factors, several weeks can be very important for some of these locations. So --

MEMBER BALLINGER: My directive is don't build a power nuclear plant on Hawaii.

MS. THOMPSON: I would say consider the tectono-magnetic model when siting on the Hawaiian Islands.

MEMBER BALLINGER: I'm looking at the tectono-magnetic model right here.

MS. THOMPSON: So if mitigation actions are proposed, there should be appropriate monitoring in place so that there is forewarning or early warning of an eruption. Any mitigation action should also include clear criteria for when to start those actions based on a change in the monitoring, and there should be a basis to demonstrate that the mitigating actions are practicable in the warning time between notification of a potential event and the arrival of

the hazard at the site.

CHAIR BLEY: Somebody at this table brought up something that's happened with floods and that when to protect the nuclear facility, they wanted to drain water through a dam, people downstream of the dam objected that they didn't want to be inundated. And if you're going to have a plan for diverting the stuff if you decide to live close enough to need it, you might have other political problems that keep you from carrying out your plan.

MS. THOMPSON: That's an excellent point.

CHAIR BLEY: Does NRC look at that? You hadn't before the flood stuff came up.

MS. THOMPSON: I will take that back and check on that for you.

CHAIR BLEY: Okay.

MS. THOMPSON: So the last step in evaluating the mitigation actions is to reevaluate the risk insights taking credit for the mitigation action.

So if after all of the steps have been completed, a hazard is still not able to be mitigated through design or operations, an applicant has two choices. They can go back into the process and continue to iterate, getting more and more detailed analyses, or they can proceed to Siting

Considerations, where an alternative site may need to be considered.

As we mentioned before, volcanic hazards are spatially restricted. So one site may be unsuitable while another site located several kilometers away would have less risk significance or a more acceptable risk.

So now that we have been through the staff's approach, I promised you I would address IAEA SSG-21, the Volcanic Hazards Guide, and how we have harmonized with that. And we are there.

Specific Safety Guide 21 is for volcanic hazards in site evaluation at nuclear installations. This IAEA guide considered a range of facilities, from fuel installations all the way up to light-water reactors. The NRC's draft guide is consistent with the IAEA approach, which includes an initial screening for volcanoes, although the IAEA guide uses 10 million years instead of the quaternary period of 2.6, which is consistent with the NRC's geologic site characterization.

The IAEA approach also uses the tectono-magnetic model, and it stops at a detailed evaluation of hazards at the site. And again, because it's covering a range of installations, the hazard approach

is scaled to those installations.

The NRC staff's VHA approach integrates risk insights throughout the analysis, which is consistent with the graded approach that the IAEA guide uses, and it's also providing a practical and transparent basis to determine if volcanic hazards are significant to risk within the NRC's framework.

As I mentioned before, there are three key differences with the IAEA safety guide, which is why the staff did not choose alternative 3 in the regulatory analysis, which was to adopt this guide. The first is that the IAEA safety guide outlines specific site exclusion criteria for some volcanic hazards. So if the hazard were to occur at the site, the site is deemed not suitable for use.

However, the NRC staff determined that that is not consistent with our risk-informed, performance-based framework, and we allow the possibility for design basis or mitigation actions to address the hazard.

DR. CORRADINI: Just so I understand, this means after they look at step 1, if they didn't pass step 1, they were out?

MS. THOMPSON: Yes.

DR. CORRADINI: Okay.

MS. THOMPSON: So this would be -- an example of this, one of the exclusion criteria for a site is a debris flow. So if a debris flow would occur at a site under the IAEA guidance, that site would be not suitable. It does not consider whether the depth of the debris flow that reaches the site is one inch or ten feet. It doesn't give consideration for the hazard significance. So --

MEMBER BROWN: Let me springboard off of Mike's comment. The site exclusion criteria inconsistent with risk performance, does that mean the IAEA approach is more prescriptive or more restricted than what you're proposing in the --

MS. THOMPSON: Yes.

MEMBER BROWN: That's what it sounds like:

MS. THOMPSON: Yes. It's more restrictive. So if a lava flow could occur at the site, the site is excluded.

MEMBER BROWN: Within what? A ten-million-year period?

MS. THOMPSON: I don't recall the period of time. It's just, if it occurs, the site is out.

MEMBER BROWN: If it could, but for whatever --

MS. THOMPSON: Exactly. Regardless of

magnitude. So a pyroclastic --

MEMBER BROWN: Or time.

MS. THOMPSON: Yes. If it occurs, the site is unsuitable.

MEMBER BROWN: You mean occurs or occurred in the past?

MS. THOMPSON: Occurs. If it could reach the site, if that hazard could occur at the site, the site is unsuitable.

DR. HILL: If I could clarify, the IAEA couches it in terms of a capable volcano, which has a credible -- it could be a new volcano in the future or an existing volcano. So if a capable volcano has the potential to erupt a hazardous phenomena that reaches the site, and that phenomena is a lava flow, the site is not suitable for development.

So the capability has no probabilistic connotation. It's just this is credible in the island.

MEMBER BROWN: In other words, sometime, somebody has determined it might have been there, and it might be again, and therefore, we can consider it credible, and therefore it's excluded.

DR. HILL: It sounds a little silly until -- we're facing this exact problem in Japan right now

where a nuclear power plant is being potentially shut down because of the danger from a pyroclastic flow that may be from a volcano 150 kilometers away, even though the best science would say by the time that pyroclastic flow got to the site, it would be very dilute and you could probably stand up in it if you had a respirator. It'd be low temperature. It'd be like an ash fall more than anything else.

But nevertheless, it meets the criteria of -- it's a pyroclastic density current, or pyroclastic flow. Therefore, under IAEA guidelines, any pyroclastic flow at the site means the site cannot be used. So it's very restrictive in viewing it's all or nothing for some phenomena.

(Simultaneous speaking.)

MEMBER BROWN: -- occurring now, but --

MS. THOMPSON: That it could.

MEMBER BROWN: -- if it could.

DR. HILL: It has a credible potential to occur.

MEMBER BROWN: What has happened five million years ago, it could still credibly.

MEMBER DIMITRIJEVIC: But does it apply only for new plants?

MEMBER BROWN: No. They're talking about

shutting down a plant.

MEMBER DIMITRIJEVIC: I know he said that, but the guide, I don't know what she's talking --

MS. THOMPSON: It is for any nuclear installation.

DR. CORRADINI: Current or future.

MEMBER DIMITRIJEVIC: Current or future.

DR. HILL: That depends on its use by a member state.

(Simultaneous speaking.)

MEMBER DIMITRIJEVIC: -- the title of it?

MS. THOMPSON: So the title is just any nuclear installation. And the application to new or current facilities is a country-by-country basis.

MEMBER MARCH-LEUBA: But the new reg guide from NRC, it applies to new plants?

MEMBER DIMITRIJEVIC: Only for new plants.

MS. THOMPSON: This draft guide would only apply to new plants, new applications.

CHAIR BLEY: Reactors.

MS. THOMPSON: Reactors.

CHAIR BLEY: Jenise, I don't recall another reg guide going to the extent you're going here to harmonize with IAEA standards. Is this something new, or do you just feel moved to --

MEMBER BROWN: I can -- I think a couple of the reg guides we've done in our area have had harmonization where they have springboarded out of international standards.

CHAIR BLEY: And explain in detail why they differ?

MEMBER BROWN: Or why they're similar. I'm trying to remember which ones, but we've done several of them over the last few years. And harmonization has been they considered those things in the development of the new reg guide, and they didn't talk about exclusions. They didn't reference -- in fact, it was on the -- which one is it?

CHAIR BLEY: You don't need to --

MEMBER BROWN: Okay. There's one coming up that says, hey, they're just incorporating the IAEA or some international standard as the reference.

MS. THOMPSON: The harmonization section with international standards is a requirement for new regulatory guides that we're issuing. The reason that we went to so much detail is because there is an existing standard, and we do take certain exceptions to some of the content, and we wanted to spell that out clearly.

CHAIR BLEY: And you didn't have one to

start with.

MS. THOMPSON: Yes. Yeah. So we didn't have a reg guide to update. So the new requirement for reg guides includes this section, and we went to the level of detail that we did to call out the specific differences.

The second difference is that IAEA accepts deterministic analyses for the detailed VHA, but for the approach that we've outlined in the draft guide, we only use deterministic for a screening and then use probabilistic risk insights for the more detailed analysis.

And, finally, the IAEA safety guide requires licensees to conduct monitoring of the sources of the potential volcanic hazards at their sites. But the NRC concludes that the function of monitoring and issuing eruption warnings is the purview of the US Geological Survey as part of their statutory role here in the US.

CHAIR BLEY: And you have some kind of joint agreements or meetings with them, right?

MS. THOMPSON: We -- yes.

CHAIR BLEY: I mean, in a lot of areas --

MS. THOMPSON: Yes.

CHAIR BLEY: The staff works with other

agencies.

MS. THOMPSON: Yes, and the key takeaway here is that an NRC licensee with a volcanic hazard would not need to implement their own independent volcano-monitoring program, which is what would be prescribed if they were following the SSG-21 issued by IAEA. So that is the key difference there.

Now that we've discussed the harmonization, home stretch. Future plans. We will be issuing the draft guide for public comment and interim use later this spring. The reason for this is so that we can solicit both stakeholder feedback and public comment but also get some feedback from prospective applicants that are using the draft guide, so getting some hands on the ground. This is what worked. This is where things weren't clear. Getting some very critical feedback of the process outlined in the draft guide.

We also have a staff member who's involved in the working group for ANS 2.34, which is a consensus standard under development for volcanic hazards. And we also --

MEMBER REMPE: I haven't heard of that one. Is that actually in process now?

MS. THOMPSON: So the most recent

information we have from our member on the working group is that we anticipate a draft guide -- or not a draft guide. Sorry. We anticipate the final standards sometime in 2022, at which time the staff will review.

CHAIR BLEY: Will this be one of the PRA standards, or is it a completely separate standard?

MS. THOMPSON: It's a separate standard.

MEMBER REMPE: Is it applicable to all plants or new facilities?

MS. THOMPSON: I am not the working group representative, so I'm not sure where the current scope is with the standard. So I can make a note and get back to you.

MEMBER REMPE: Thank you.

MEMBER BROWN: What is ANS 2.34? I missed that.

MS. THOMPSON: It is a consensus standard under development for assessing volcanic hazards.

MEMBER BROWN: Oh.

DR. CORRADINI: I was just going to say if Budnitz is not on it, let's nominate him.

MEMBER BROWN: I guess my question would be, if ANS is going to issue a standard and you get this reg guide out, are you then going to be faced

with revising your standard for consistency or whatever with the ANS standard? Why are you that far in advance?

MS. THOMPSON: I'm actually going to get to that. So part of the reason that we are this far in advance is because we anticipated a prospective applicant developing an application, and we wanted to have some kind of draft guidance available for that applicant to use in the development of an application using what the NRC considers to be an acceptable approach for assessing volcanic hazards. And I'll get to some of that in the time line.

MEMBER BROWN: You answered my question.

MS. THOMPSON: Okay.

MEMBER BROWN: Thank you.

MS. THOMPSON: The staff also opened a comment capture email so that regardless of where we are in the reg guide development process, members of the public can provide us their feedback. This is especially true for stakeholders who may be implementing the draft guide as they develop their applications. And the staff will address any of the comments received through this comment capture email as though they were received as part of the formal public comment period. And to date, we have already

received two comments through our comment capture email.

The comment capture email, we opened that when we issued the draft outline to the public in early October of last year in -- we did a public meeting in October with the outline of the draft guide, seeking initial comments and feedback from interested stakeholders. And we've left the comment capture box open, and we will continue to keep the comment capture box open as long as the draft guide is still in draft form.

DR. SCHULTZ: Is there a time schedule for that?

(Off-microphone comments.)

DR. SCHULTZ: No, but -- okay. I saw that. I thought we might have a month somewhere in --

MS. THOMPSON: So some of these do have months. So next month, we will be presenting a digital exhibit at the Regulatory Information Conference. The purpose of that exhibit is to announce the hopefully imminent release in the Federal Register of the draft guide, and --

CHAIR BLEY: Digital exhibit's new to me. Is this like a poster session but on a computer screen?

MS. THOMPSON: Yes. The working group took inspiration from a movie trailer. So ours has videos and animations in it. So if you're at the RIC, please stop by and see us. It'll be worth the two and a half minutes of your time.

MEMBER KIRCHNER: Are the animations going to scare the general public? You're going to put illustrations of volcanoes erupting and nuclear plants together?

MS. THOMPSON: We did not put nuclear plants in the animations, but there are animated examples of volcanic hazards.

CHAIR BLEY: Make sure you have the one where people are touring the Icelandic magma flows that are going into the water, and you can watch the boat bounce around as the things go in the water.

MR. WIDMAYER: ACRS and two and a half minutes don't go together in a sentence.

MS. THOMPSON: I'm just going to continue on. Later this spring, we anticipate the issuance of the draft guide for public comments, and we anticipate receiving public comments throughout the remainder of this year. Next year, in 2021, we look to address these public comments, and we will at that time, we hope, be receiving some initial feedback from

prospective applicants that are using the draft guide to develop an application.

And then, based on the public comments that we receive and any feedback from prospective applicants implementing the guidance, we may decide to revise the draft guide based on what we receive.

Looking ahead to 2022, and to ensure that we remain consistent with the content of the ANS standard currently under development, we anticipate that that standard will be issued in 2022, at which time the staff will review and then finalize and issue the regulatory guide.

Last slide.

DR. SCHULTZ: Jenise, does that mean that you're planning on considering the ANS input?

MS. THOMPSON: That is the working group's current intention. Yes.

DR. SCHULTZ: Okay. Thank you.

MS. THOMPSON: So finally, at the start of the presentation, I outlined several goals that the working group set for the draft guide. Our conclusions are that we've met these goals and we've developed a draft guide on volcanic hazards that's consistent with the risk-informed, performance-based framework that we have here at the NRC.

The draft guide provides opportunities for an applicant to evaluate the risk significance of potential volcanic hazards and end the analysis if the hazards are not significant. So, again, we were considering the burden on an applicant as one of our goals, and we believe we've met that.

And, finally, the working group recognizes that although only a few sites in the US might need to evaluate volcanic hazards, the draft guide provides a practicable, open, and traceable approach that is appropriately protective of public health, safety, and the environment.

That is all.

CHAIR BLEY: Thank you very much, Jenise.

Are there any more questions from the Committee?

Derek, would you get the phone line open for us? We had a plan. I don't know if we still have it, and we don't get a hint. Just double-check, please.

Is there anybody in the room who would like to make a comment? If so, please come to a microphone. Nobody?

Is there anybody on the phone line who would like to make a comment? If so, please tell us

your name and what your comment is.

Derek? It's open?

It sounds like nobody's there. We'll go around the table. But first, the staff has not asked us for a letter at this time. I'd be interested in any summary comments the members have and if any of you think we ought to write a letter at this time or wait until the public comment period is over, or maybe write one during that time period.

I'm going to start with Vesna.

MEMBER DIMITRIJEVIC: You mean of a letter or general comment?

CHAIR BLEY: General comments, and do you think we ought to write a letter now or later or ever?

MEMBER DIMITRIJEVIC: I think we can provide -- this is obviously written -- it's not written by a nuclear PRA person, parts of it. So it has some terminology which is not applicable to the risk-informed nuclear things, and therefore, we can propose some editing changes which will change that.

So from the point of the editing changes, I don't know, how is it done in general? I mean, I know that you said the data instead can use to provide their own notes. I will be willing to provide those, my motes, after we finish the PRA section or

something. I mean --

CHAIR BLEY: We don't know yet if that's appropriate --

MEMBER DIMITRIJEVIC: I think that is appropriate. That would be my editorial notes. On the high level, now I think -- I cannot really decide, should we write the letter now or after? Maybe we can give it some general direction if we can --

CHAIR BLEY: We can't do that.

MEMBER DIMITRIJEVIC: No? So --

CHAIR BLEY: As a committee, we either write a letter or we don't.

MEMBER DIMITRIJEVIC: No, no, no. I know. But meaning the letter, do you think we can write a letter which will be useful for them?

CHAIR BLEY: I think we could write a letter that we would think would be useful for this.

Any more?

MEMBER DIMITRIJEVIC: Well, the only other things which I want to say which I learned through my very old practice here is one of my -- one other person I cooperate on my very complex application. If things are more complex, more simple should we keep. So instead of concentrating on things which we don't know, and there are so many things which we don't know

how this will work, we can concentrate on the things we know so we have a really good frame without making it too complex.

So I will in general simplify and concentrate on the things which we know. And you use uncertainty so many times in this thing, so it's taking in account uncertainty, taking account uncertainty, taking account -- but that doesn't mean too much, I mean other than if we don't say use 95 percent or something. But we take account uncertainty how? We just acknowledge its presence. I mean, so I think maybe we should actually write the letter.

CHAIR BLEY: Thank you.

Charlie?

MEMBER BROWN: Number one, I wouldn't write a letter right now. It's very much in fluid. That was a good meeting, a lot of good information. But based on doing several of these myself, I've found it useful to get the public comments, particularly since the ANS standard is being developed as well as the -- incorporate the public comments and see how this thing moves.

The transcript is always available to this team to see if they think -- if they deem any of our suggestions and observations during the meeting are

useful. But I would not write a letter right now. It's just too fluid.

CHAIR BLEY: Thank you.

Pete?

MEMBER RICCARDELLA: That was a very, very interesting presentation. I liked the analogy with the seismic risk evaluation. And I'm kind of uncertain as to whether to write the -- I think we should eventually write a letter on this, but whether we do it now or after the public comment, I'm not -- I don't have a strong opinion.

CHAIR BLEY: Thank you.

Jose?

MEMBER MARCH-LEUBA: Yeah. I don't have a truly informed opinion, but that hasn't stopped me before. So just pointing out that since the RG is out for public comments, any person interested can provide --

CHAIR BLEY: It's not out yet.

MEMBER MARCH-LEUBA: Whenever it's out. I thought you provided the email.

MS. THOMPSON: It will be soon.

MEMBER DIMITRIJEVIC: You said that you put it in October.

MS. THOMPSON: No. That was the draft

outline of the guide. So we issued an outline to the public along with a public meeting to solicit initial comments just on what we were thinking of doing for the draft guide. But the formal public comment period has not started.

MEMBER MARCH-LEUBA: But you provided an email where we could send you information.

MS. THOMPSON: Yes.

MEMBER MARCH-LEUBA: So as an interested member of the public, I could send you anything I want.

MS. THOMPSON: Yes.

MEMBER MARCH-LEUBA: And so I don't think we need to write the letter if one member would like to provide a comment.

On the long term, this has such limited applicability. I mean, I've been looking at all the volcanoes. Unless you want to go to Hawaii or Alaska, that's about it. So I don't see a need to write a letter.

CHAIR BLEY: Thank you.

Walt?

MEMBER KIRCHNER: Thank you for the presentation, and I think we could wait until after the public comment period. But I do appreciate the

sentiment with Vesna to perhaps get the terminology consistent with the PRA practice. Thank you.

CHAIR BLEY: Okay.

Matt?

MEMBER SUNSERI: So as I read through the background material on this and the draft that already got out, I was thinking to myself, gee, what an eloquently straightforward seven-step approach to address a very low-frequency event. This can't take more than a couple hours to -- thank you for the presentation. I found it very good and informative. You all have done a lot of hard work. That's all. And I don't think we need to write a letter at this time. Maybe later.

CHAIR BLEY: Joy?

MEMBER REMPE: I'd like to sort of second what Matt said. I think that the presentation and the individuals involved with it were very well informed and gave us some very good, helpful information, and I appreciate their endurance and patience with our questions. And so I think you deserve some compliments on that.

I don't think we need to write a letter at this time, but I do think that there were several comments. Of course, they're just from individual

members, and I hope you'll consider, if you can, some of it before it's issued for public comment.

In particular, as one member who shouldn't be taking too much credit, I'm interested in if the reg guide could even comment about other nearby hazards that might be posed that were not evaluated for volcanic hazards if that exists. Thank you.

CHAIR BLEY: Thanks.

Dave?

MEMBER PETTI: Yeah, I want to thank them. They did a great job. I learned a lot. But I tend to agree with Charlie. I think it's too early to write the letter now. I would wait to see what happens with ANS, and then I wouldn't necessarily say yes. I'd just reevaluate at that point whether we need to have a letter.

CHAIR BLEY: Thank you.

Ronald?

MEMBER BALLINGER: I guess I'm a little bit torn because on the one hand, I don't think this has -- this has very limited applicability. Like Jose was saying, unless you want to build a reactor in Alaska or Washington or Oregon, it's not likely to be an issue.

But on the other hand, if applicants

perceive this to be an issue that they're going to have to deal with, the public comment period could get pretty interesting. So I think, based on the public comments, we may or may not want to write a letter. I'm ambivalent on that.

But I think the applicants are going to be looking for off-ramps that are very well defined with finality. If those aren't there, then your public comment period will get very interesting.

CHAIR BLEY: Thank you.

Our consultant, Steve?

DR. SCHULTZ: I also appreciate the presentations and all the work that went into the development so far, as well as what you described as your early involvement with both the public as well as applicants in the overall process. That is very important.

And in that regard, the comments that have been made this afternoon about trying to develop elements of examples, I think, would be very helpful going forward. And I'd be surprised if the public comments don't also ask for that. So if you've got time to get a head start on that, it might be useful, certainly.

The other thing I'd recommend, Jenise, is

that you stay in close-cut touch with the ANS Standards Committee because you've got them on your schedule, and they don't always complete their standards when time is on calendar. So I think it's important that that connection be made, but you might need to lean on the Standards Committee's to make sure it gets done on your schedule.

CHAIR BLEY: Mike?

DR. CORRADINI: I think the staff did a very nice job. I personally think that the draft reg guide is quite helpful in trying to screen it out. I think the point about bringing examples into each of those steps so that you can identify from a practical, concrete basis what moves you on, what takes you off the steps, would be very useful. And the more specific those examples can be, whether they be specific plants or specific installations, I think the better off it would be.

My personal view still is that somehow, somewhere in this, you're going to have to point to some sort of go/no-go risk-informed value. Even if you don't have one at this point, you at least should recommend or at least acknowledge the fact something at some time is going to have to be recommended, that at some level, it's either from a relative risk

standpoint or an absolute risk standpoint. It's of no consequence. Otherwise, this becomes a burdensome activity.

CHAIR BLEY: Thank you. I'd appreciate if any of the members or consultants have other things that come to mind, drop me a note. I'd like to keep them.

I'd like to thank you very much, and Brit gave us a lot of good help along the way here. And the whole staff who's been involved in this, I think you've done a really great job of organizing it.

I think I'm concerned about the risk-informed part of this, the risk side of this, and I'm pretty nervous about it. And I myself was leaning toward an early letter rather than a late one before things get cast in concrete. The standard, Lord knows when that will get done. The last one that was in a new area was the shutdown risk, and that took ten years before it got voted out, at least ten. And this is a new area for most people, so it could take a very long time. So I think going ahead with it is good.

The applicability is rather limited, but if you're going to use -- the structure is right. The ideas are right. The specific way you use those steps is you begin to quantify the two probabilities that

you come up with. That's where it gets a little fuzzy, and either I'll write something personally or I'll circulate something, and we might want to write a letter on this.

I'll play with my own notes and then see what the subcommittee thinks later. And I'm not turning loose of that just yet because I think there are some things that just don't quite work right from the risk-informed point of view and those steps 4, 5, 6 that just need a little polish.

In any case, thanks very much to everyone. Thanks to the Committee and everyone else here. We are adjourned.

(Whereupon, the above-entitled matter went off the record at 5:09 p.m.)

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United States Nuclear Regulatory Commission
Protecting People and the Environment

DG-1364 - Volcanic Hazards Assessment for Proposed New and Advanced Nuclear Power Reactor Sites

NRC Staff Presentation to the ACRS Subcommittee

February 20, 2020

Presentation Outline

- Background
- Overview of Volcanic Hazards
- Discussion of proposed approach for Volcanic Hazard Analysis (VHA)
- Harmonization with International Guidance

Volcanic Hazards Working Group

NRC Staff

- Laurel Bauer, M.S.
- Luissette Candelario, M.E.
- Allen Fetter, Ph.D.
- Cliff Munson, Ph.D.
- Ed O'Donnell, Ph.D.
- James Rubenstone, Ph.D.
- Gerry Stirewalt, Ph.D., C.E.G., P.G.
- Jenise Thompson, M.S., PMP

Contractor/Consultant

- Brittain Hill, Ph.D.
- Miriam Juckett, M.S. (SwRI)

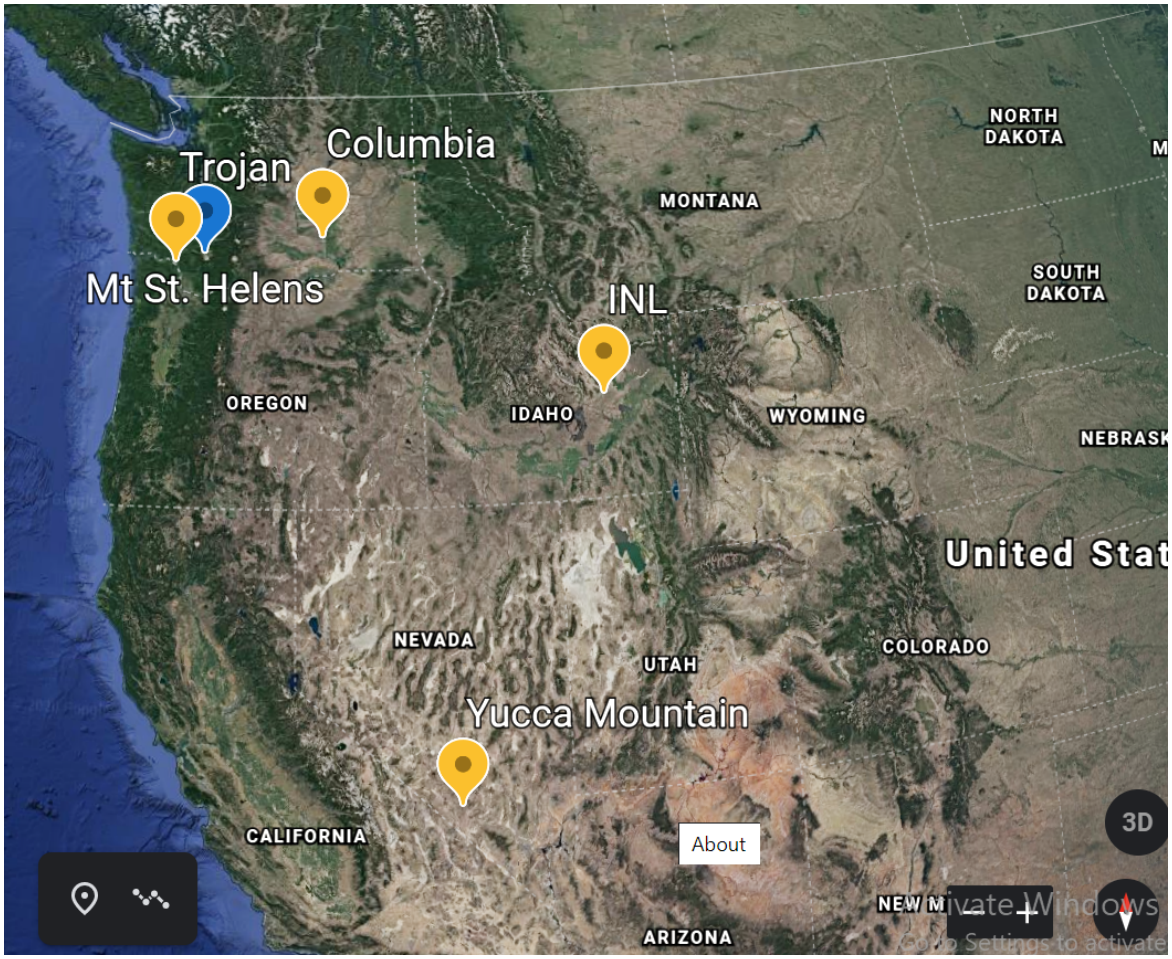
Why now?

- DOE was recently authorized to develop advanced reactor projects at the Idaho National Laboratory (INL); NRC will have licensing authority
- DOE and NRC recognized that there are volcanic hazards at INL
- NRC has regulatory requirements to assess geologic hazards at a proposed site but has no specific guidance on acceptable approaches to assess volcanic hazards

Regulatory Requirements

- 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” General Design Criterion 2
- 10 CFR 52.17(a)(1)(vi) for an early site permit and 10 CFR 52.79(a)(1)(iii) for a combined license
- 10 CFR 100.23, “Reactor Site Criteria”

Prior Reviews



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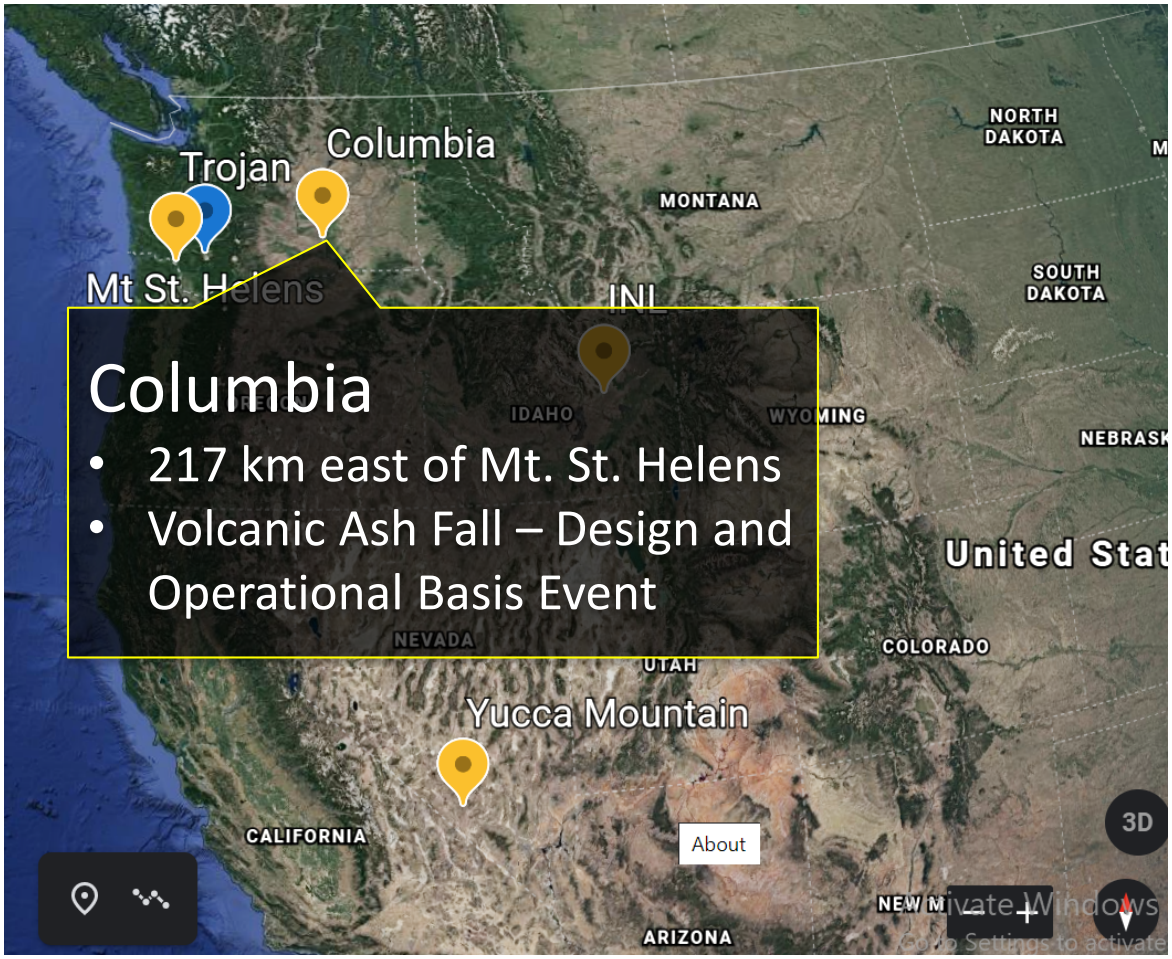
Prior Reviews



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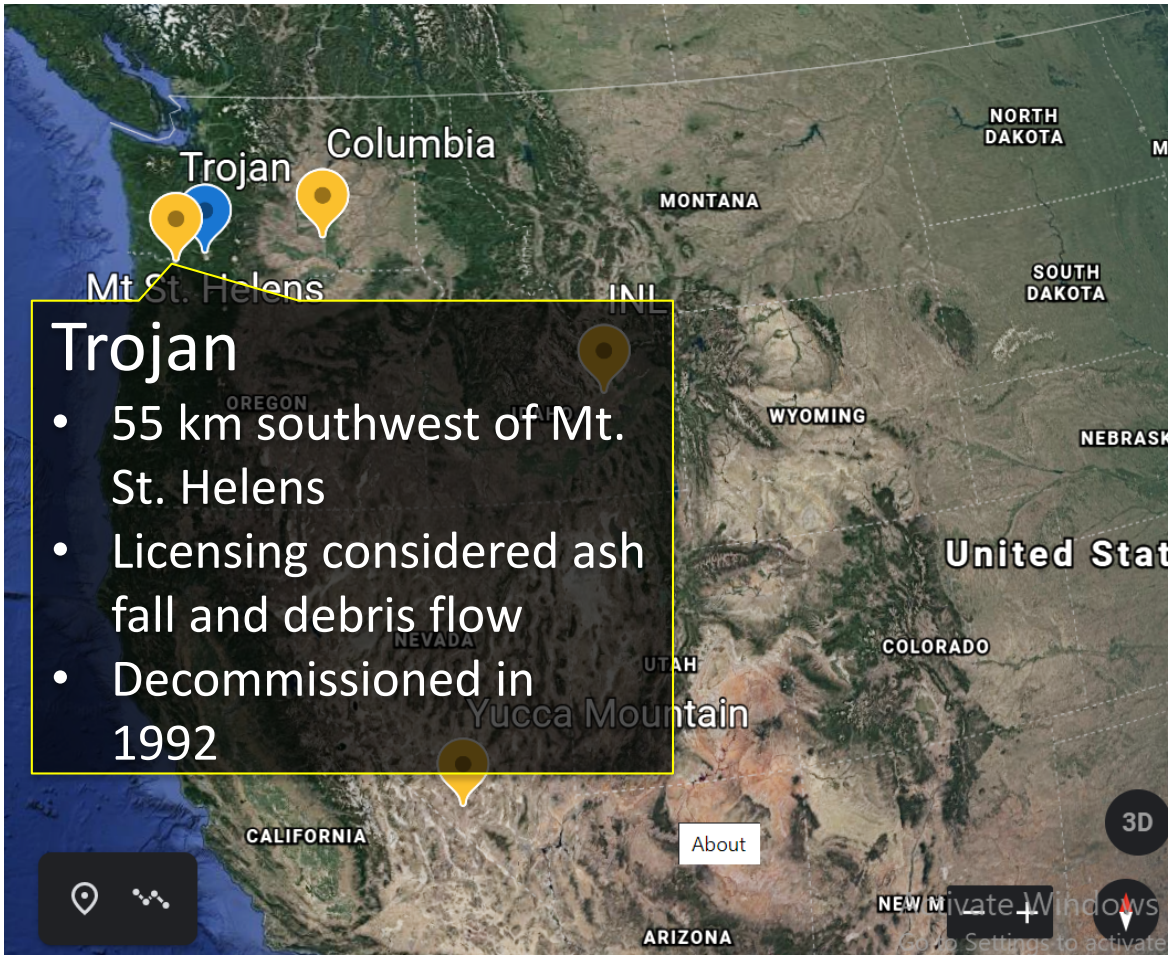
Prior Reviews



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Prior Reviews

Prior Reviews

Use of Prior Approach

- Staff questioned whether the past approach for volcanic hazards reflects NRC's principles of good regulation.
  - Openness
  - Efficiency
  - Independence
  - Clarity
  - Reliability

Regulatory Analysis

- Staff considered five alternatives to assess the regulatory need
- Schedule, cost-benefit analysis, technical content and document control were additional factors under consideration
- Principles of good regulation and risk-informed decision making

Optimal Path Forward

- Regulatory Guide was the optimal path forward
- Includes harmonization with existing IAEA Safety Guide
- Mechanism by which to consider endorsement of consensus standards under development
- Multiple opportunities for public interactions

Goals of the Regulatory Guide

- Protect public health, safety, and the environment
- Open and traceable basis for regulatory decision making
- Appropriate burden on applicants, commensurate with risk
- Consistent with NRC's risk-informed, performance-based framework and prior licensing actions

Regulatory Guide Challenges

- No generally accepted approach for VHA
- Support both siting decisions and potential design bases
- Rare events, appreciable uncertainties on event timing and nature
- Wide range of demands from volcanic events, limited design analysis (except ash fall).

What are Volcanic Hazards?

- Volcanic Ash
  - 0.001 to 2 mm
  - Hardness comparable to most metals and alloys
  - Conductive, esp. when damp
  - 0.1 to 100 mg/m^3 airborne common
  - Lingers days-weeks after eruption

What are Volcanic Hazards?

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- New Vent Opening
  - Ground deformation
  - Lava flows
  - Ballistics
  - Tephra Fall

What are Volcanic Hazards?

- Lava Flows
  - Dense (2,500 kg/m^3, 156 lb/ft^3)
  - Hot (1,000 to 1,200 C, 1,830 to 2,200 F)
  - Heat capacity comparable to metals
  - Flow rate can vary between 1 to 10 m/s
  - Follow topography, lateral break-outs common

What are Volcanic Hazards?

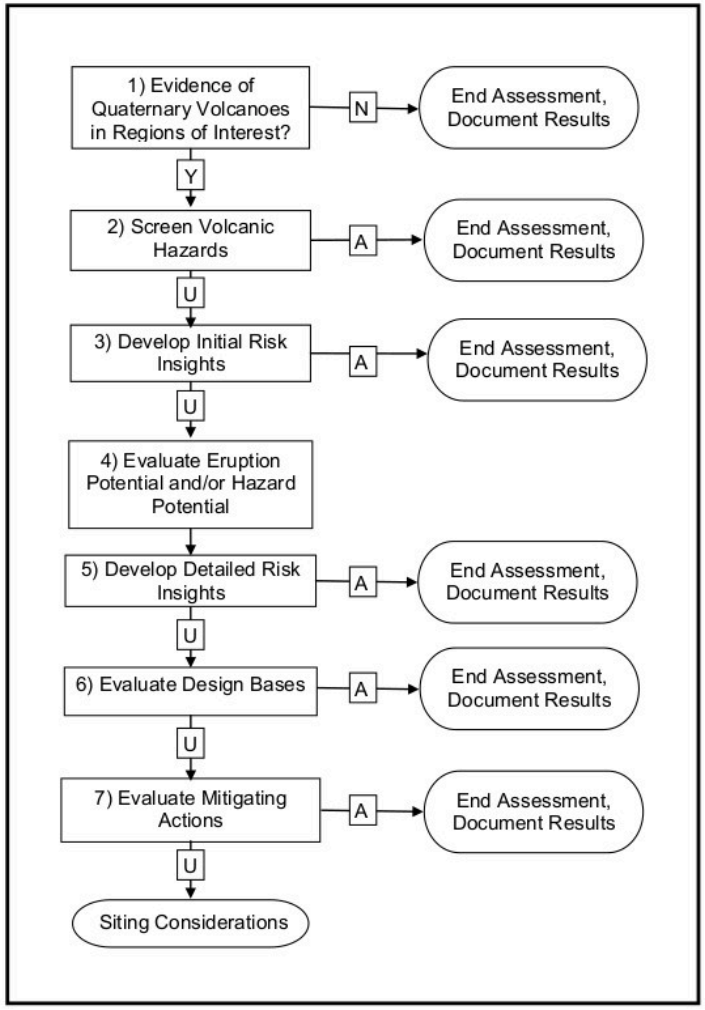
- Pyroclastic Flows
  - Hot (> 300 C (570 F))
  - Deposit densities from 1000 to 2000 kg/m^3
  - Fast-moving (100s of m/s)
  - Can travel 10s to 100s of km from vent
  - Can overtop barriers 100’s m high if large volume

What are Volcanic Hazards?

- Other hazards
  - Debris flows
  - Debris avalanches
  - Earthquakes <M5
  - Hydrothermal systems
  - Volcanic gases
  - Lightning

volcanoes.usgs.gov

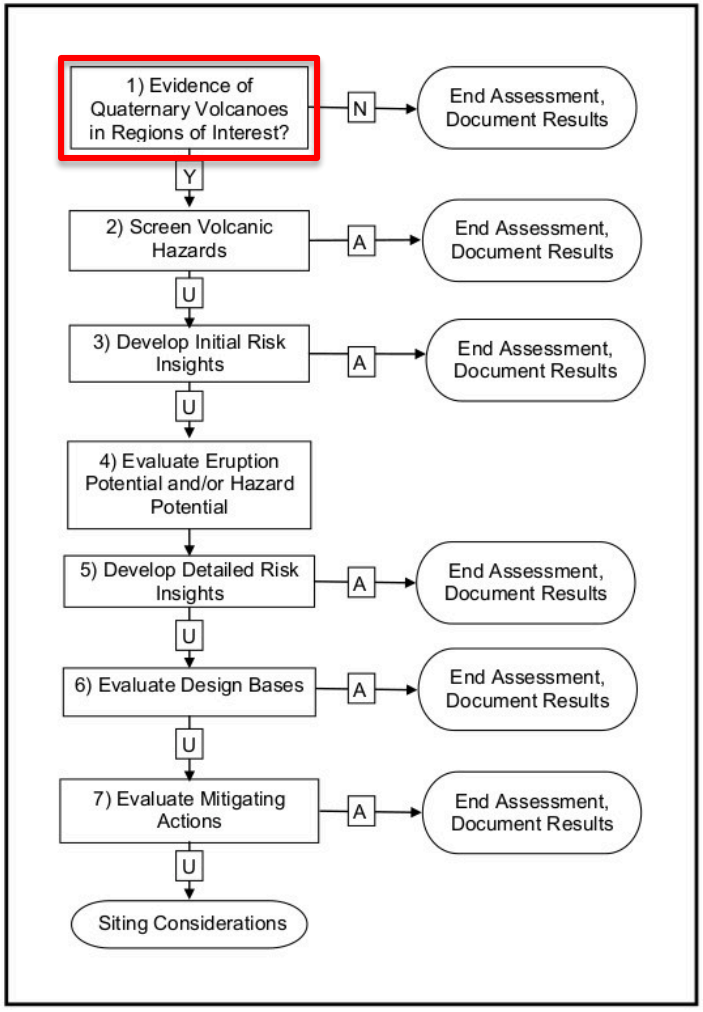
General Approach for VHA



- Gather information
- Initial screening**
- Detailed analysis of relevant hazards**
- Evaluate design bases**
- Develop mitigation approaches**
- Siting considerations

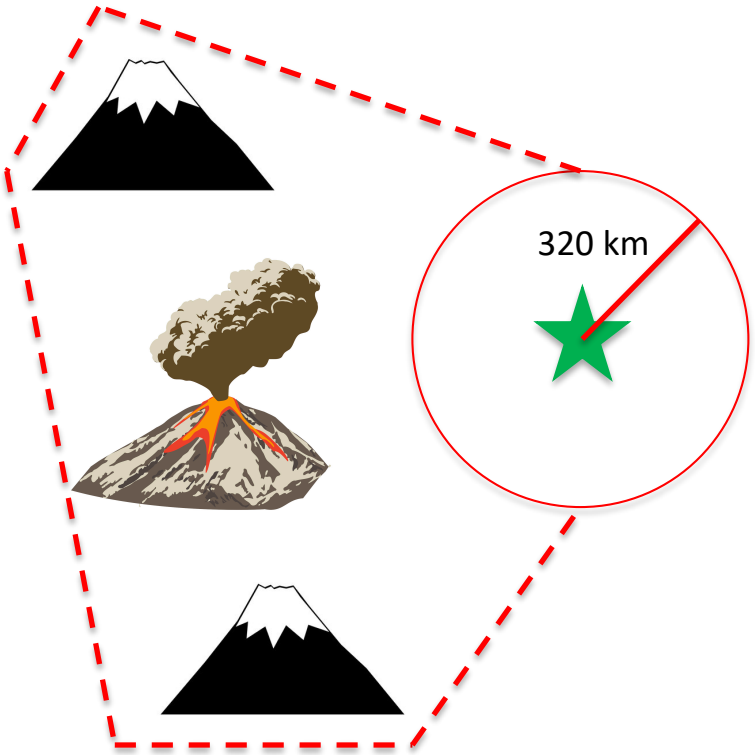
***Apply risk insights*

1) Gather Initial Information



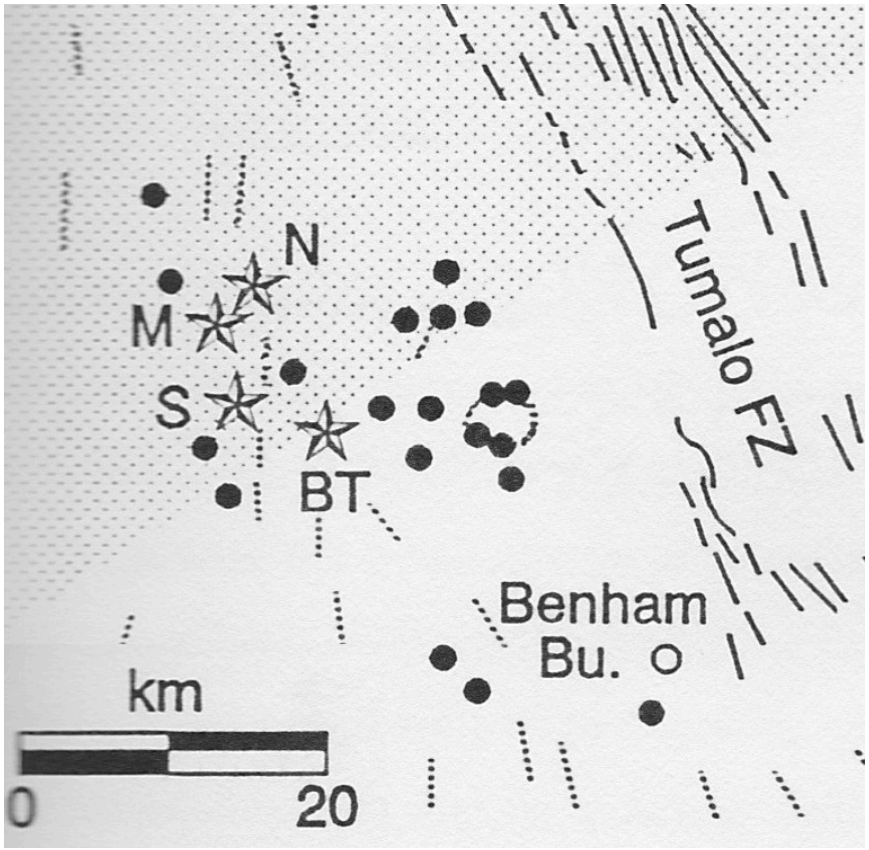
- Time Period of Interest
  - Last 2.6 Myr (Quaternary Period)
  - Consistent with Standard Review Plan (SRP) 2.5.1 (geologic site characterization)
  - Captures uncertainties in timing and character of past volcanic events

1) Gather Initial Information



- Regions of Interest (ROI) for initial screening
  - 320 km for surface hazards (i.e., SRP 2.5.1)
  - For ash-fall hazards, extend to capture 2.6 Myr volcanoes that might affect design or operation of facility (e.g., SRP 2.5.1)

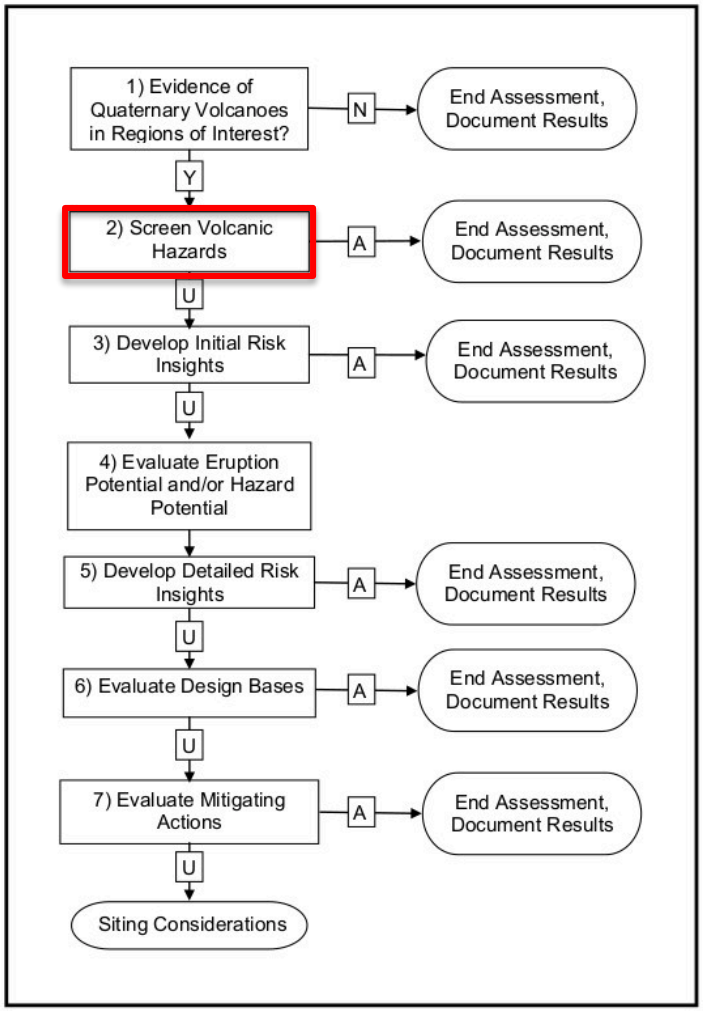
1) Gather Initial Information



Hill (1991)

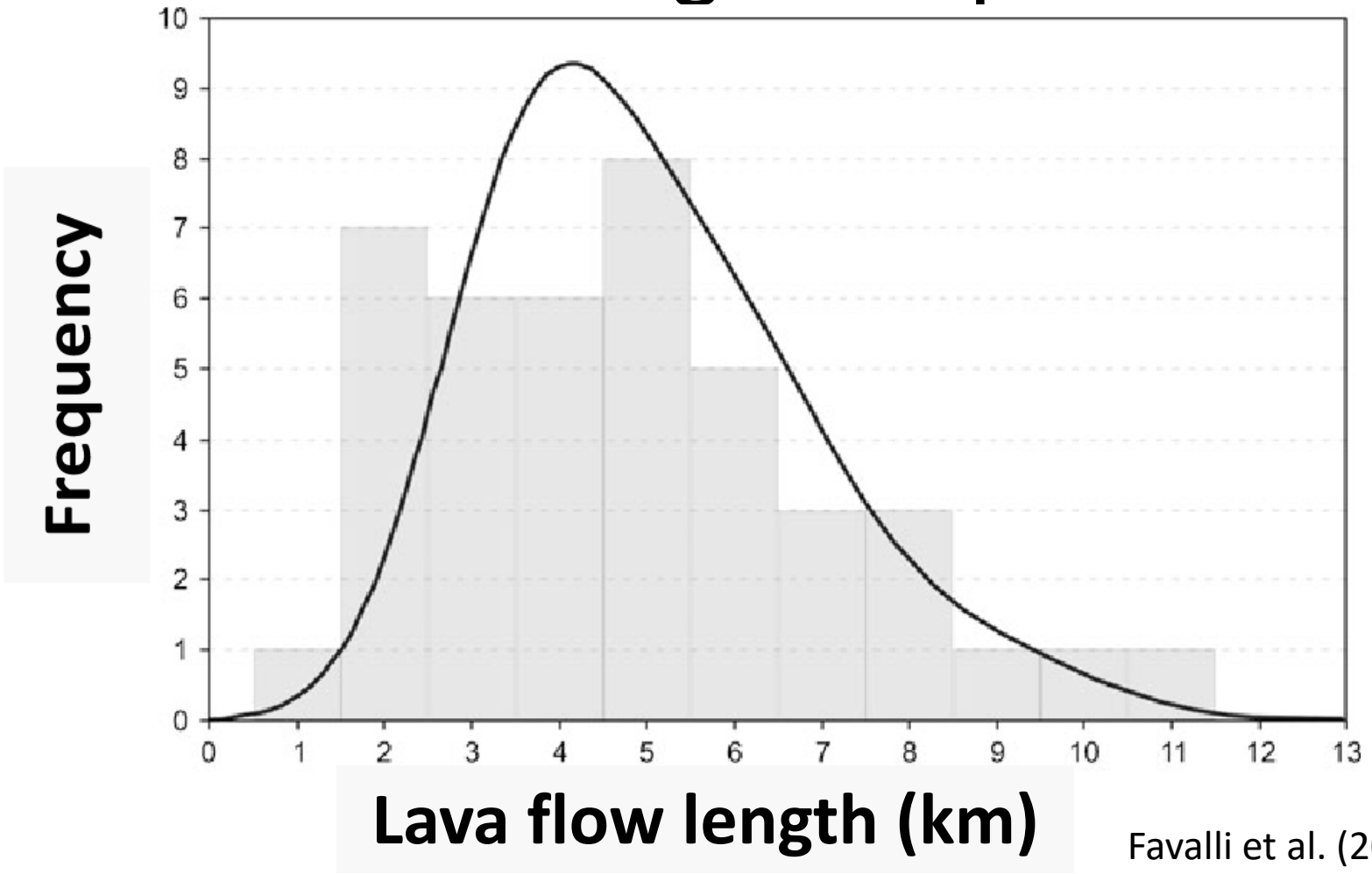
- Tectono-magmatic Model
  - Large-scale processes that control volcanism
  - Only consider <2.6 Myr volcanoes that are consistent with model

2) Deterministic Screening



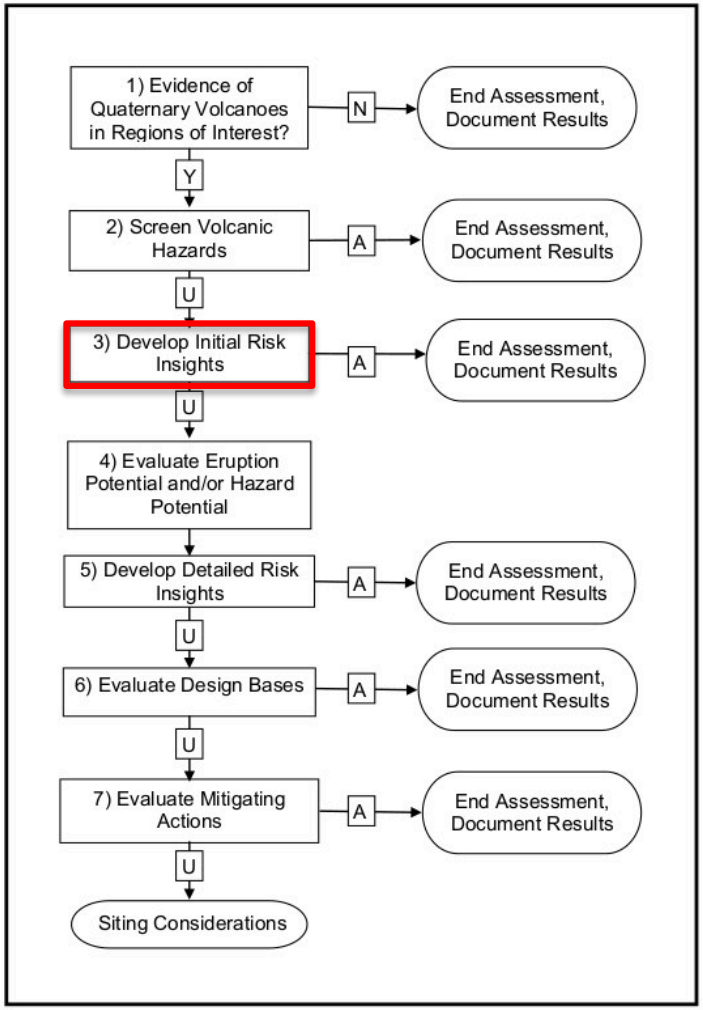
- Volcano characteristics in ROI
- Analogues or models to reduce uncertainties
- Screen based on maximum distance hazard could travel from source

Screening Example



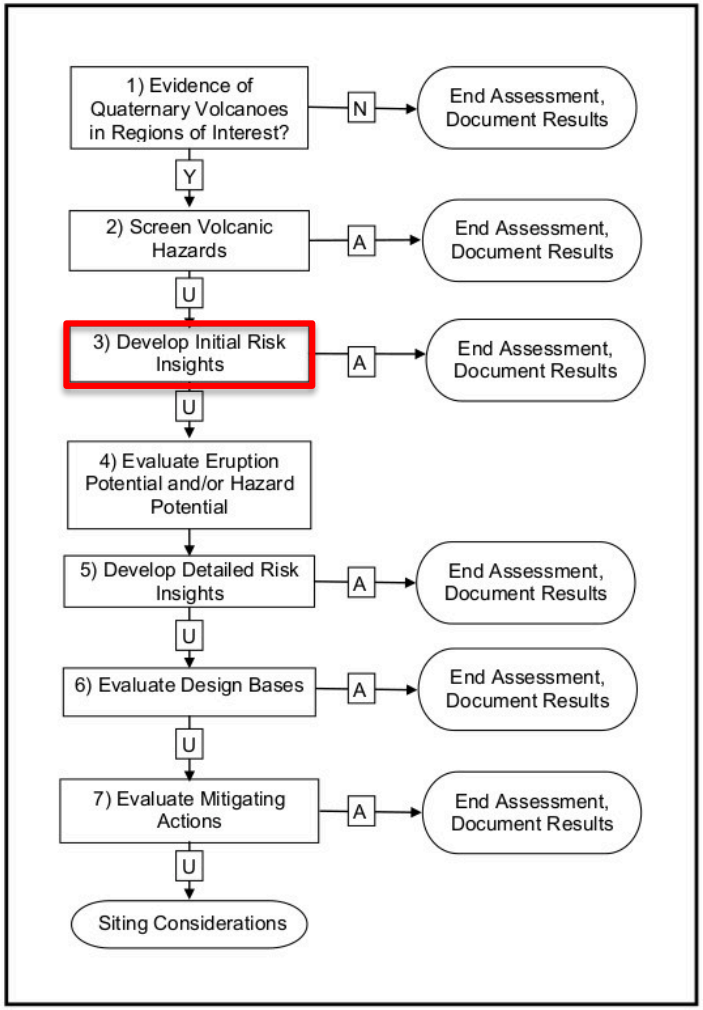
Favalli et al. (2011)

3) Initial Risk Insights



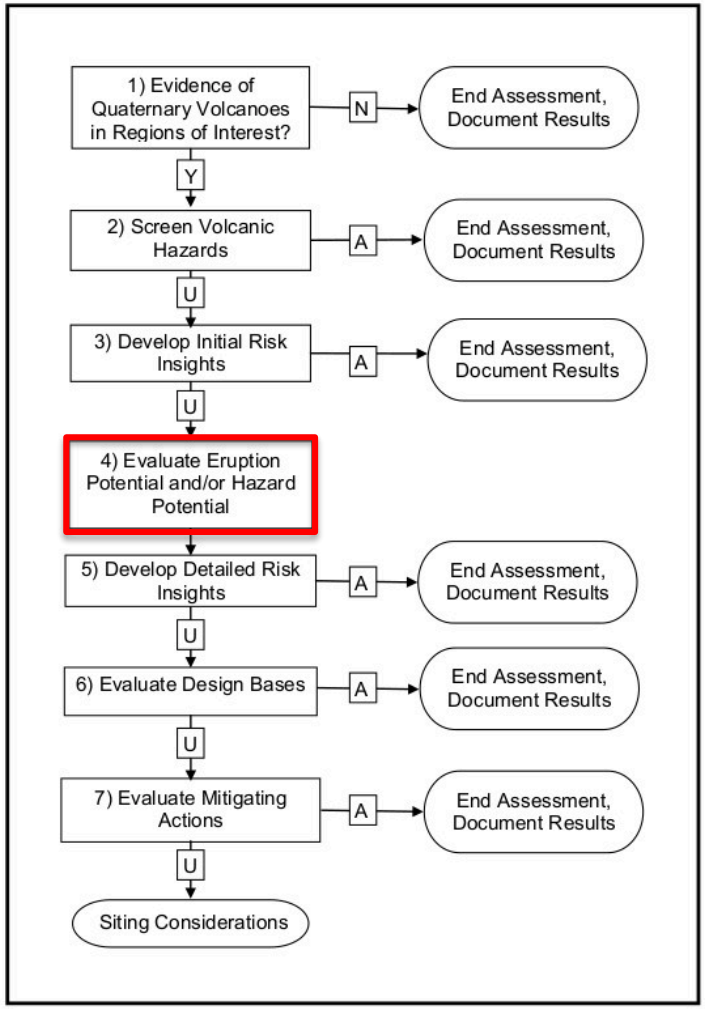
- Suite of information to support risk-informed safety decisions
- Risk-insight information
  - Sensitivity in plant PRA
  - Uncertainties
  - Available alternatives
  - Confidence in supporting investigations

3) Initial Risk Insights



- Assume SSC failure = 1 if hazard at site
- Evaluate results in PRA
- Consider risk-insight information, including uncertainty & alternatives
- If not significant to safety, document rationale and end VHA

4) Eruption or Hazard Likelihoods

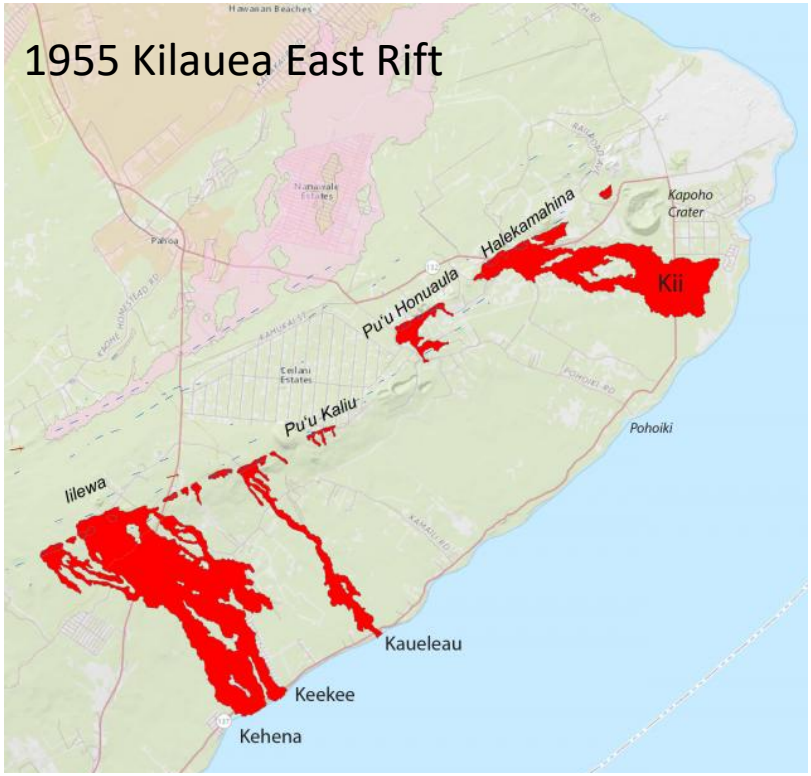


- Can first evaluate either Probability of eruption (PE) or of hazard (PH)
  - Character of past event may be more certain than timing
  - Uncertainties from erosion, burial, interpretation, modeling etc.

Applying the SSHAC Process

- Staff endorses the use of the Senior Seismic Hazards Analysis Committee (SSHAC) process to calculate PE and PH in the VHA
- Determine center, body and range of the technically defensible interpretations
- SSHAC study level based on
  - Source-term or fragility of proposed facility
  - Completeness and accuracy of geologic record
  - Number of hazards being considered
  - Significance of alternative hazards models

4) Evaluate Eruption Likelihoods



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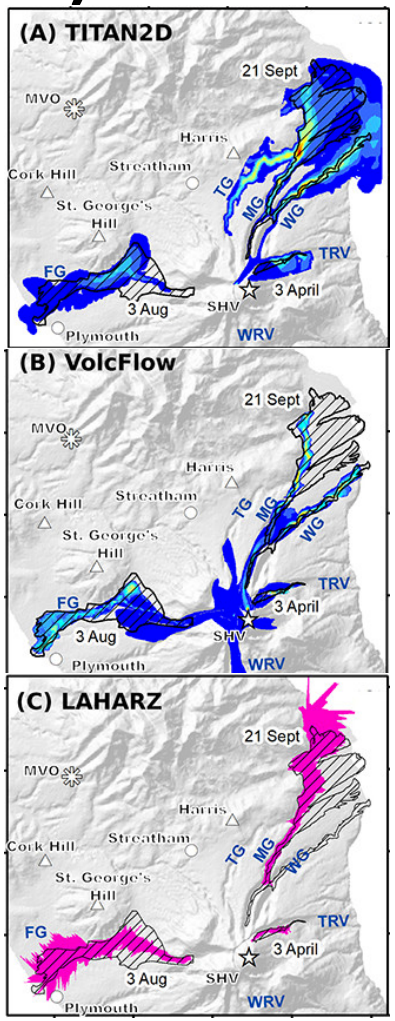
- Challenges for PE
  - Event definition
  - Probability of occurrence, exceedance, or both?
  - Uncertainties on timing and number of past events
  - Potential non-stationary recurrence rates

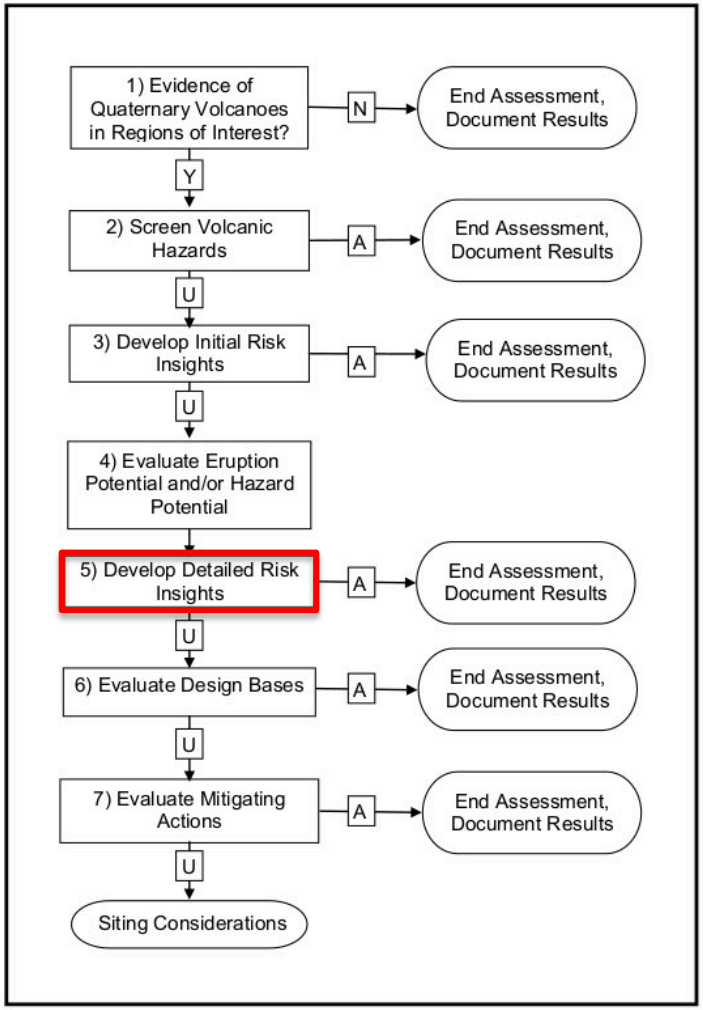
4) Evaluate Hazard Likelihoods



- Challenges for PH
  - Range of models, need for model support
  - Character changes with distance from source
  - Interpretations from preserved deposits
  - Characteristics can change through time

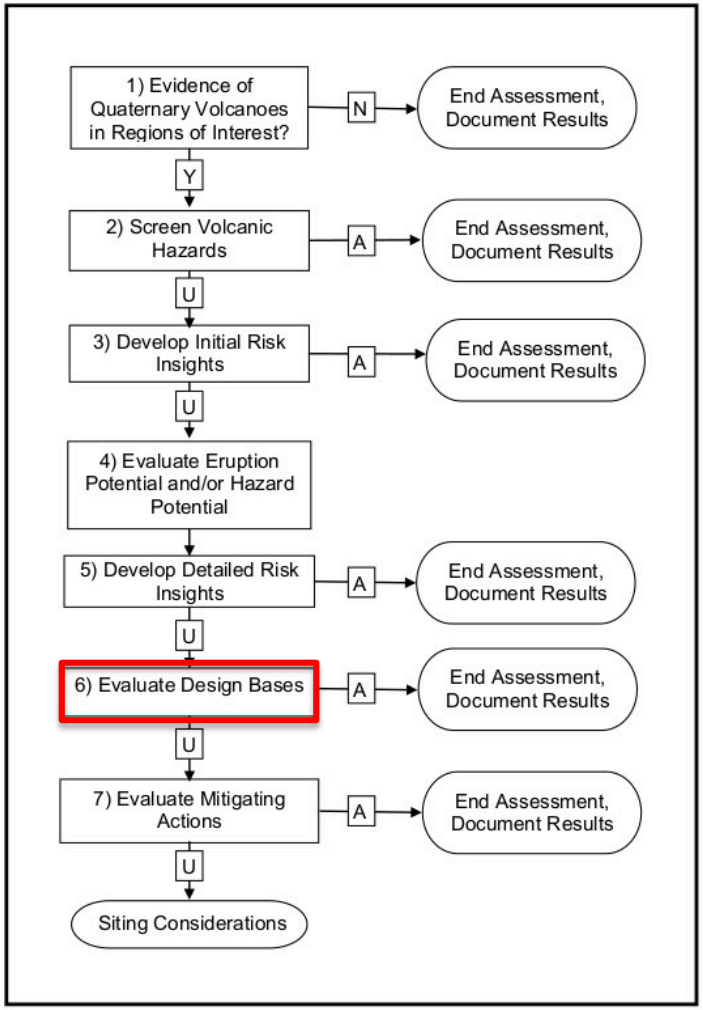
Ogburn & Calder (2017), fig. 7

5) Detailed Risk Insights



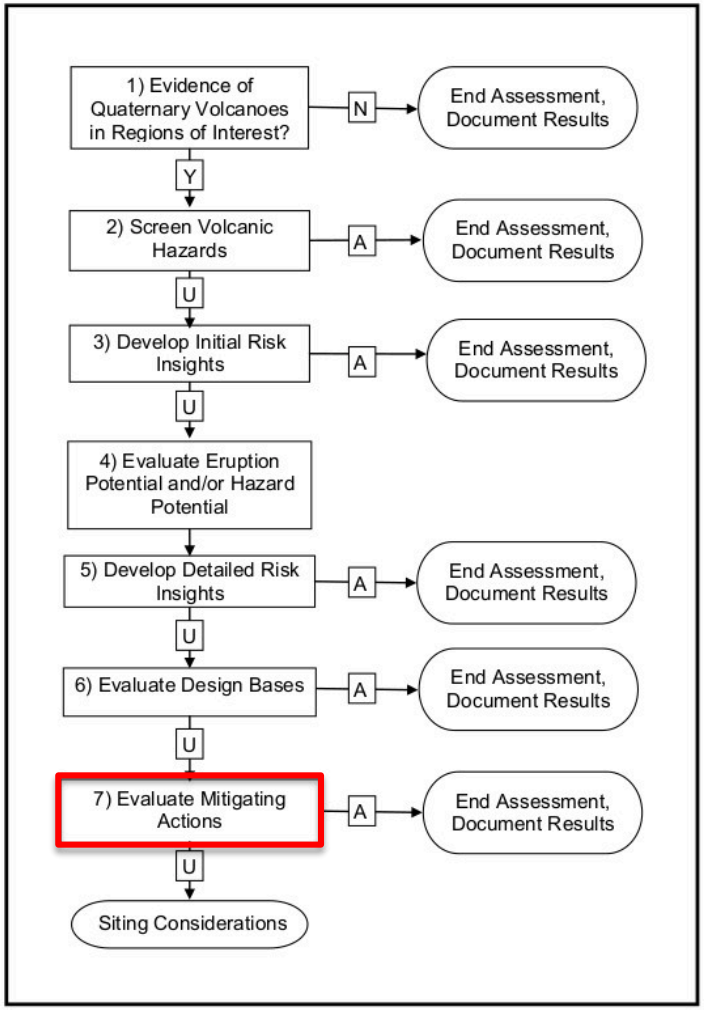
- Assume SSC failure = PE or PH, or both
- Evaluate results in PRA
- Consider risk-insight information, including uncertainty & alternatives
- If not significant to safety, document rationale and end VHA

6) Evaluate Design Bases



- Optional Step
- Develop more accurate limit states for SSCs
  - Exceedance likelihoods for hazard demands
  - Actual material properties
  - Facility-specific SSCs
- Re-evaluate risk insights
- Allows for enhancing design basis

7) Evaluate Mitigation Actions



- Hours to weeks of warning before eruptions
- Columbia NGS, WA
  - Ash-fall hazard from Cascades, >200 km away
  - Hours to prepare
  - Air filtration, maintenance procedures
- Ash-fall is a commonly mitigated hazard world-wide

7) Evaluate Mitigation Actions

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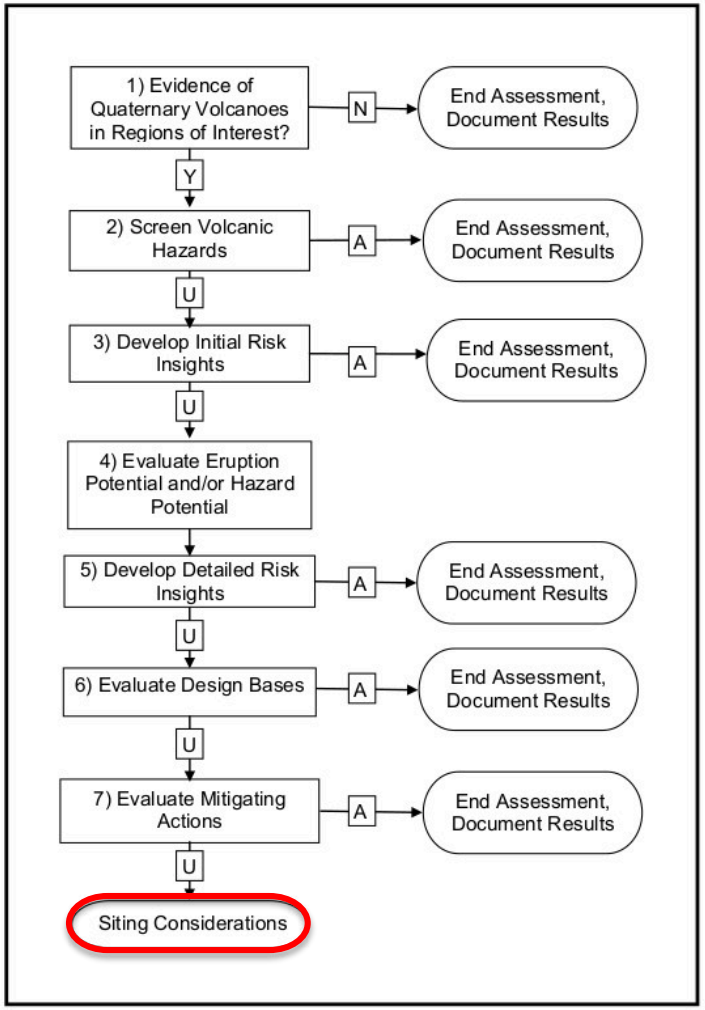
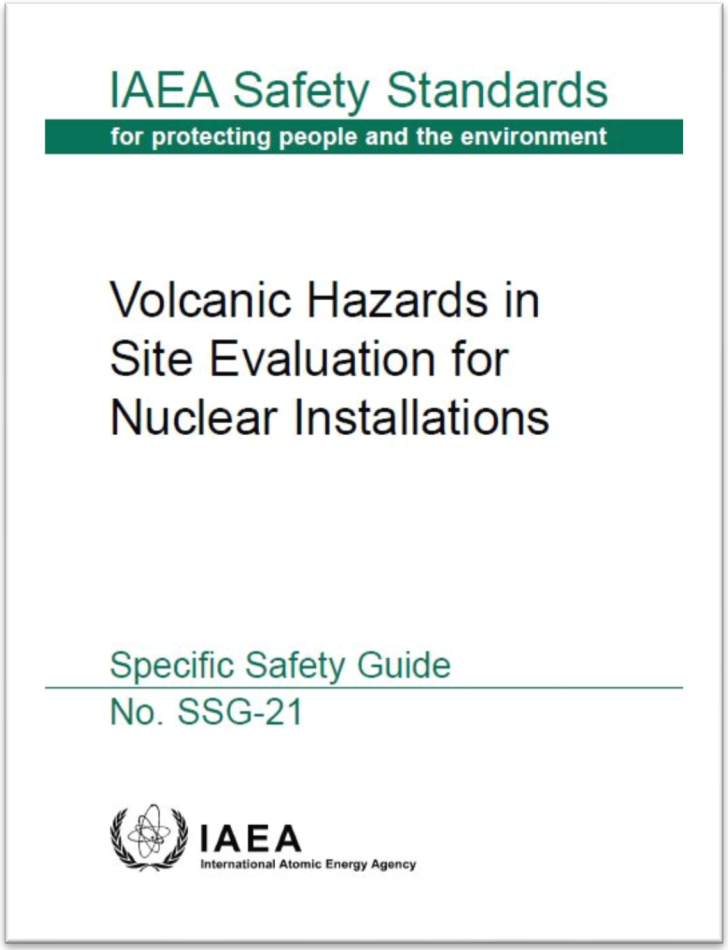
- Some surface flows have been mitigated
- Proposed actions
  - Appropriate monitoring in place
  - Clear alert levels
  - Practicable actions in time available
- Re-evaluate risk insights with mitigation credit

Siting Considerations



- If hazard cannot be mitigated through design or operations, alternative sites should be investigated
- Volcanic hazards often are spatially restricted
  - Sites with acceptable risk might be located within several km or less

Harmonization



IAEA (2012) SSG-21

- General consistency IAEA SSG-21
  - Staged approach
  - Screening
  - Detailed VHA
  - Graded to installation risk

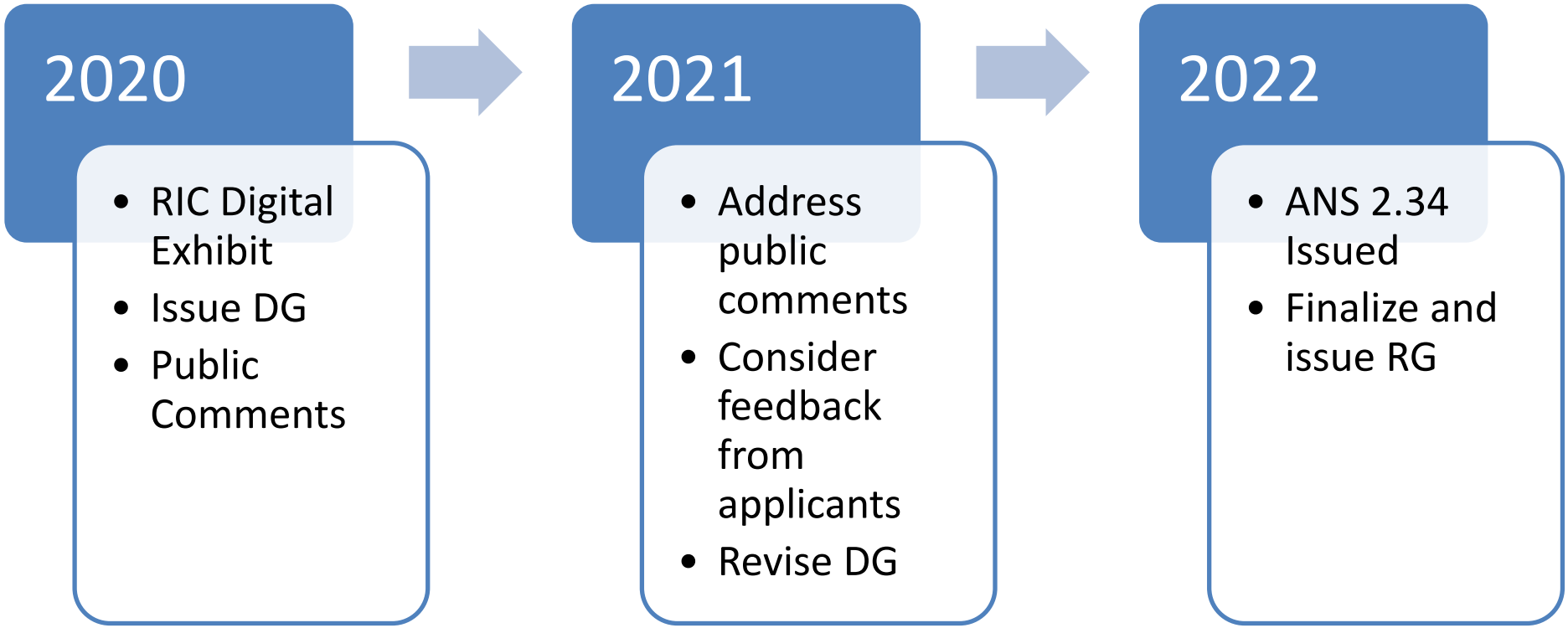
Alternatives to IAEA Approach

- IAEA considers some volcanic hazards as “site exclusion criteria.”
  - Inconsistent with a risk-informed, performance based framework
- IAEA accepts deterministic analyses for the detailed VHA
  - Inconsistent with probabilistic risk-insights
- IAEA requires licensees to conduct monitoring
  - Inconsistent with USGS statutory role in USA

Future Plans

- Issue draft guide for public comment and interim use
- Solicit feedback from stakeholders on content and use of guide to develop application
- Staff involvement in ANS 2.34 working group
- Comments will be received and addressed throughout the process – VolcanicHazards-RG@nrc.gov

Timeline


2020
RIC Digital Exhibit
Issue DG
Public Comments
2021
Address public comments
Consider feedback from applicants
Revise DG
2022
ANS 2.34 Issued
Finalize and issue RG

Conclusions

- The draft RG on volcanic hazards is consistent with NRC's risk-informed, performance-based regulatory framework.
- The draft RG provides appropriate opportunities to evaluate the risk significance of potential volcanic hazards, and end the analysis if hazards are not significant.
- Although only a few sites in the US might need to evaluate volcanic hazards, the draft RG provides a practicable, open, and traceable approach that is appropriately protective of public health, safety, and the environment.