Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
Regulatory Policies and Practices

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Tuesday, June 9, 2015

Work Order No.: NRC-1640 Pages 1-135

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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REGULATORY POLICIES AND PRACTICES SUBCOMMITTEE

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TUESDAY

JUNE 9, 2015

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dana A. Powers, Chairman, presiding.

COMMITTEE MEMBERS:

DANA A. POWERS, Chairman

HAROLD B. RAY, Member

DENNIS C. BLEY, Member

MICHAEL T. RYAN, Member

GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIAL:

QUYNH NGUYEN

ALSO PRESENT:

CHRISTOPHER BENDER, Taylor Engineering

DANIEL BLOUNT, PSEG

NELSON BRETON, PSEG

ANDY CAMPBELL, NRO

PROSANTA CHOWDHURY, NRO

STEPHEN CRISCENTO, PSEG

KEN ERWIN, NRO

JOSEPH GIACINTO, NRO

DAVID HARRIS, PSEG

PAUL JENSEN, PSEG

HENRY JONES, NRO

ANDREA KEIM, NRO

JAIME MELLON, PSEG

DAVENDRA PIMPALE, NRO

MEHRDAD SALEHI, PSEG

ALDO RIVERA, NRO

DAVE ROBILLARD, PSEG

GARY RUF, PSEG

MICHAEL SALISBURY, PSEG

MICHAEL SHERVIN, PSEG

MICHAEL WIWEL, PSEG

GEORGE WUNDER, NRO

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P R O C E E D I N G S

(8:29 a.m.)

CHAIRMAN POWERS: Let's come into session here. This is a meeting of the Regulatory Policies and Practice Subcommittee, and Advisory Committee on Reactor Safeguards. I'm Dana Powers, Chairman of the Subcommittee. The ACRS Members in attendance today include Dick Skillman, Mike Ryan, myself, Dennis Bley may join us as his Vice Chairman duties permit.

As announced in the Federal Register on May 22, 2015, the subject of today's briefing is a review of hydrologic engineering of the safety evaluation report associated with the early site permit application for the PSEG site. This is the third, and we certainly hope the final, Subcommittee briefing on this particular application.

The rules for participation in today's meeting were also announced in the Federal Register Notice. We do have a bridge line, I'm told, for the public and stakeholders to hear the deliberations. This line will not carry any signal from this end. I need to tell who you are. You want to introduce yourself?

MR. NGUYEN: Go ahead.

CHAIRMAN POWERS: Mr. Quynh Nguyen is the

designated federal official for this meeting and he will ably assist me as required, right?

MR. NGUYEN: Right.

CHAIRMAN POWERS: Okay. Well, there's a lot of stuff about the fact that we have a phone line here. Also, to minimize disturbance, the line will be kept on the listen-in-only mode until the end of the meeting when ten minutes are allocated for public comments. At that time, any member of the public attending this meeting in-person or through the bridge line can make a statement or provide comments if they so desire.

As the meeting is being transcribed, I request the participants in the meeting use the microphones located throughout this room when addressing the Subcommittee, and certainly, do not follow my poor example of you need to tap your thing to get it to activate and you need to tap it again to get it to deactivate so the young lady sitting to my left can hear us.

If she doesn't hear us, she gets to write what you said, and she's vindictive, I'm told. Participation in all cases, first, identify themselves and speak with sufficient clarity and volume so that they can be readily heard. I'm cautioned to please

silence all cellphones. We have a special room for those people that don't do that. It is unpleasant, I'm told.

We will now proceed with the meeting and I guess we'll start the meeting off with an introductory and overview status report from Prosanta.

MR. CHOWDHURY: Right.

CHAIRMAN POWERS: The floor is yours, sir.

MR. CHOWDHURY: Okay. Good morning, Chairman, and good morning, Committee Members, and --

CHAIRMAN POWERS: See, I give you instructions.

MR. CHOWDHURY: It's now turned on. I'll repeat what I said. Good morning, Mr. Chairman and Members of the ACRS Subcommittee, and good morning all present this morning at this ACRS Subcommittee meeting on PSEG site, early site, permit hydrologic engineering review by the NRC staff.

My name is Prosanta Chowdhury. I'm the lead project manager for this project and I have been involved with this project since May 2010, when the application was tendered. As for my background, I was a state government employee in Louisiana at the Department of Environmental Quality and Radiation Protection for 18 years.

And then I moved to the NRC in 2005, so I have been at the NRC a little over ten years now, and as far as the project manager position goes, I moved from the Security and Instant Response Office to Office of New Reactors in 2008. Since then, I have been project manager, so it has been almost seven years as a project manager.

I have a Master's Degree in Electrical Engineering from Moscow, Russia, and I have a Master's Degree in Nuclear Engineering from Louisiana State University. And I have been managing this project since May 2010 and the project, when we came to today's meeting, which is the last Subcommittee meeting on the last piece of the application, so I'm going down to the next slide.

The purpose of today's meeting is to brief the Subcommittee on the status of the staff safety review and also support the Subcommittee's review of the application and subsequent letter from the ACRS to the Commission, and address the Subcommittee's questions.

On this agenda, on my part of the agenda, I have the introduction, schedule milestone, status of safety evaluations, and today's key review area is hydrologic engineering. Okay. I'm being helped

here. Just bear with me. Thank you so much. And then we will present the advanced safety evaluation with open items conclusions presentation, conclusions, and I will briefly go over and recap what has been completed by the staff and also what has been presented so far to the Subcommittee, and then any discussions and questions thereafter.

So the Applicants, once again, are PSEG Power, LLC, and PSEG Nuclear, LLC. The Applicants' proposed ESP site is located in Lower Alloways Creek Township, Salem County, New Jersey, 30 miles southwest of Philadelphia, Pennsylvania, and 7-1/2 miles southwest of Salem, New Jersey.

It's located on the upper Delaware Bay adjacent to and north to the Hope Creek Generating Station. The two-unit Salem Generating Station is co-located on this site to the south of Hope Creek Station. PSEG, just to refresh everybody's memory, PSEG developed Plant Parameter Envelope using one-unit U.S. EPR, one-unit ABWR, and one-unit U.S. APWR, and two-unit passive AP1000 technologies.

PSEG requests permit approval, early site permit approval, for a 20-year term. Does not seek a limited work authorization approval for activities, and then seeks approval for complete and integrated

emergency plans with ITAAC as part of ESP.

So the milestones that have been completed so far is, the application we received on 25th of May 2010, acceptance review completed, and the application docketed on 4th of August 2010. We issued a schedule and completed Phase A, which is all REIs to be issued in September of 2013. This is a four-phase schedule and Phase B is advanced safety evaluations with no open items to be issued by end of June 2015, that was the public milestone, and we achieved that 45 days in advance.

And I must thank to all technical staff and technical branches for that achievement. Chapters presented to ACRS on March 19, 2014. As Dr. Powers mentioned, there have been two Subcommittee meetings already, so first one on March 19, 2014, we presented Chapters 3.5.1.6, has to do with aircraft hazards, 11.2 and 11.3 combined, 13.3, 15.0.3, and 17.5.

Chapters presented to ACRS on September 29 and 30, 2014 is 2.1 and 2.2 combined, and 2.3, and 2.5. Now, one thing I would like to mention here is that, we recently issued, publicly, Chapter 20, which has to do with the implementation of the Fukushima recommendations. And this Chapter 20, for the PSEG early site permit, simply points to other safety

evaluations where applicable, Fukushima NTTF, Near-Term Task Force recommendations, are evaluated.

Chapter 20 does not contain the staff's evaluation as such, because the staff evaluation for the only recommendation, which is 9.3, has to do with emergency planning, staffing, and communications, has been addressed in the ASE, and then the seismic and flood hazard related to the recommendation 2.1 have been already addressed in the respective SE chapters, so the Chapter 20 points to those areas.

There are no surprised in Chapter 20, by the way. It has a long background and regulatory basis. So the remaining milestones, Chapter 2.4, hydrologic engineering, which is being presented today, and then the ACRS Full Committee meeting, it was a challenge for me, I took it, and I think we will be ready tomorrow at 8:30, and the conclusion of ACRS meetings, as well as ACRS letter, Phase C will be completed, and the public milestone is July 31, 2015.

And then the Final Safety Evaluation Report, FSER, completion date is September 30, 2015, which is Phase D, the last phase of this review before hearing. Just to --

CHAIRMAN POWERS: I hasten to point out that it will be up to the ACRS Full Committee itself

to decide whether a letter is -- the Subcommittee only collects information and makes hints and recommendations to them. They make the decision. Okay. Well-known to be pig-headed and hard to get along with.

MR. CHOWDHURY: Understand. Just to remind everybody once again that, the staff had a pre-application site visit in 2008, January 2008, another PM was involved at that time. We had emergency planning site visit. Folks actually went around the site, looked at all the elements that pertain to emergency planning and preparedness. That was May of 2010.

Hydrologic engineering site visit and audit was in 2011, February of 2011, that was an elaborate site visit and audit. Quality assurance audit was done in May -- end of May, early June of 2011. Geology site visit and audit was done in September of 2011, and that was quite an adventure because of the rain the night before, but we took it and we made through.

And there's a meteorology site visit in May of 2012. Seismic software audit was done in September of 2013. This is a list of acronyms for the record and with that, are there any questions on the introductory

remarks? Okay. If none, then I think by the agenda, PSEG is going to --

CHAIRMAN POWERS: Yes, we'll now turn to a presentation from PSEG. The staff will come back later this morning to discuss their view on the material that's presented. And so, Jaime, I think you're on.

MR. MELLON: Okay. My name's Jaime Mellon. I have over 30 years of experience in the nuclear power industry. I've worked in licensing, reg assurance, training, and radiation protection. I've worked at operating reactors, decommissioning reactors, and also in the construction of some facilities.

I have a Bachelor's Degree in Physics from Franklin and Marshall College in Lancaster, PA, and I have a SRO Cert from Peach Bottom. And with that, we're going to get started and I will -- okay. Going to move down here and hit Page Down? There we go. Is that the mouse? There it is. And I'd like to introduce Dan Blount. Dan has over 12 years of experience in the nuclear power industry, design engineering, engineering support of regulatory and licensing actions.

His design engineering experience includes major mods to both primary and secondary

portions of the power plants. Dan is a qualified 5059 evaluator at our nuclear facilities, PSEG's facilities. He has a Bachelor of Science Degree in Mechanical Engineering from York College of PA, and is a registered PE in the State of Delaware.

MR. BLOUNT: All right. Good morning, everyone. Thank you, Jaime. Today our presentation will be divided into three areas. We're going to go over a general hydrological background and talk about some of the smaller floods that we evaluated, then we'll move to discuss our design basis flood, which is the problem, maximum hurricane, for this site, and finally, we'll talk about our ground water analyses and accidental releases analyses.

This slide lists the regulatory guidance that we used in developing the early site permit application. Reg Guide 159 was used to establish the floods considered for the design basis flood. NUREG CR 7046 was issued after the early site permit application was submitted, however, that captures much of the ANC 2.8 guidance that we used in our application related to combined events that we'll discuss later.

This slide presents the PSEG site and its location within the Delaware River Basin. This site is located about 52 miles upstream of the mouth of the

bay. I'll try to, I don't know if the mouse is -- there we go.

MR. MELLON: So there's the mouth of the bay, right?

MR. BLOUNT: The site is the pink dot there. Seven miles north of this site is the Reedy Point NOAA Tidal Gauge, and that is the closest tidal gauge to the site, and the gauge we used for a lot of our data at the site location.

This slide depicts a picture of the current site. We have Salem Unit 1 and 2 in the foreground, Hope Creek to the north, and then further to the north there is our location for the new plant, just to the, excuse me, west of the cooling tower, north of Hope Creek. This slide is effectively looking northwest across the site.

The river at the site is about two and a half miles wide. Next slide. All right. In this slide we show the actual, the reaches of the Delaware River Basin itself. It goes from the Catskill Mountains in New York to the north, and all the way drains to the Atlantic Ocean in the south.

The site's located at the transition zone between the Delaware Bay and the Delaware River. The tidal flows at the site greatly dominate the freshwater

flows. And the river's actually tidally influenced all the way up to Trenton, New Jersey. There are no dams on the main branch of the Delaware River. The reservoirs that you see on this slide are all on tributaries that feed the Delaware River.

Next slide. Historically, storm surge events have dominated the flood causing mechanisms and in the vicinity of the site, the hurricane of 1933 produced the highest recorded water level at Reedy Point, which is our closest tidal gauge. The design basis flood determination is made by obtaining a number of different flood-causing mechanisms, which we've listed on this slide, and also, the applicable combined events criteria associated with these events that we'll talk about as we go through the various floods.

First off, we have the local intense precipitation event, which is local just to PSEG's site itself. We used NOAA's hydrometeorological reports number 51 and 52 to develop the rainfall intensities over a one-square-mile area at varying durations. We've built an Army Corps HEC-HMS Model and divided the site up into subbasins to determine the peak flow rates between the various subbasins in the model.

At the ESP stage, that's, effectively, as far as we can take the analyses because we don't have

a finalized site grading plan with a final site technology selected, so this analysis will be revisited at the COLA stage to assure and refine that the local intense precipitation flooding does not impact safety-related structures.

MEMBER RAY: Do you do these calcs into the probable maximum or do you get the Corps to do this for you?

MR. BLOUNT: For these analyses, we used a NOAA HMR 51 and 52 are the publications that are regionalized and show you per a certain amount of area what the rainfall intensity is over a certain duration, so it's from an existing analysis.

MEMBER RAY: Okay.

MR. BLOUNT: Yes. Section 2.4.3 of the SAR is the first of the river floods we'll discuss here. For all of the river floods within the Delaware River Basin, we developed a U.S. Army Corps HEC-HMS and HEC-RAS model system that supported our analyses for the rivering environment. The model was validated against historical events and also the tidal aspects that are seen continuously at the site.

We used, once again, NOAA HMR 51 to establish our two possible probable maximum precipitation events. One is a larger lower intensity

event that's centered over Doylestown, Pennsylvania, and the second is a smaller higher intensity event that's centered over Philadelphia.

We simulated those events in our model, combined that with the ANS 2.8 combined events criteria, and ultimately, arrived at a total water surface elevation of 21 feet NAVD at the PSEG site. The water surface elevation from the PMP, the probable maximum precipitation, event itself was actually less than three feet at the site. So the significant drivers are the combined events.

Section 2.4.4 of the SAR discussed potential dam failures. Our first step in this analysis was to screen the U.S. Army Corps national inventory of dams. We identified four 6000-acre-foot reservoirs near the site within a 70-mile vicinity of the site, and we also identified seven greater than 60,000-acre-foot reservoirs, really, in the upper Delaware River Basin, in the Catskill Mountains and the Pocono Mountains of Pennsylvania.

With those reservoirs identified, we develop four scenarios where we combined the dams regionally in those various areas, and then assumed a seismic event would instantaneously break the dams, release the reservoirs contents to the main branch of

the Delaware River at exactly the same time to maximize the potential flooding at the site.

The failure of the two largest reservoirs in the Catskills produced the highest water surface elevation. You can see here is only 3/10 of a foot from the dam -- or the reservoir inventory versus the combined events value of 9.4 feet.

MEMBER RAY: Just a question.

MR. BLOUNT: Sure.

MEMBER RAY: That's not something to write home about, but you said if they all fail simultaneously, that's the highest water? I would have thought a cascading effect would have led to a higher water level.

MR. BLOUNT: Probably should have mentioned that. There are no cascading dams within the Delaware Water Basin.

MEMBER RAY: Okay. So these are all --

MR. BLOUNT: Yes. So they're all on different branches and then they merge together, and we timed them, kind of, artificially, actually timed them burst together.

MEMBER RAY: So they all come together. Okay.

MR. BLOUNT: Yes. Section 2.4.6

discussed the probable maximum tsunami analysis. Our analysis followed the guidance of NUREG CR 6966. First, we reviewed the historical record of the tsunamis affecting the East Coast to establish our source characteristics for modeling the probable maximum tsunami. We next used NOAA's MOST model to simulate the PMT event and how it impacted the site through the Delaware Bay to our site location.

Next slide. The La Palma event in the eastern Atlantic Ocean and the Hispaniola trench subduction event in the Carribean Sea were both modeled. Neither of these events represent the probable maximum tsunami at the site. The results were approximately half of a foot of elevation change in the water level, drawdown and runup, so very minor impacts at the site from these two events.

MEMBER SKILLMAN: Dan, before you change that slide, the text of the safety evaluation, 124 pages, indicate that at least early calcs showed a wall of water of about 88 feet from La Palma.

MR. BLOUNT: The --

MEMBER SKILLMAN: Okay. And you just mentioned a very minor effect on the bay. Speak to that in terms of reconciling that difference.

MR. BLOUNT: The 88 feet of water, I

believe, is in Europe, so the effects of the tsunami as it went to the East and into Europe versus the effects of the tsunami as it propagated to the West, towards the Atlantic, or our East Coast of the United States, the value -- I apologize. I don't have that here. I'll have to get that for you, but I believe we had presented that in our SAR. I can't speak specifically to the SER text. I apologize.

MEMBER SKILLMAN: I read it very carefully.

MR. BLOUNT: Okay.

MEMBER SKILLMAN: I think you will find that the text essentially says, some predictions could be as great as 88 feet at the site. Now, if you've sailed across the Atlantic a number of times you know she's a wide ocean and it's hard to believe that if there were that event in the Canary Islands that 88 feet could find its way 2500 miles to the West, and if it did, I would think what happens at Salem Hope Creek site may pale compared to what is happening elsewhere on the East Coast. That's a different issue.

But I think you need to take a look at the way the text is presented in the safety evaluation because it's quite clear that early calcs showed 88 feet arriving at the site, then there are some words in there

that indicate later calculations suggest it's a fraction of a meter, which is approximately what you just mentioned.

MR. BLOUNT: We'll certainly take a look at that, yes.

MEMBER SKILLMAN: Thank you.

MEMBER RAY: I've seen other calculations of La Palma that generate very high water on the East Coast. I can't remember the details, but I think, somehow, they left out the effects of superposition on that with the multiple waves canceling out each other, but there might be a hint there if you dig at it.

MR. BLOUNT: We'll take a look. Okay. In the SAR analysis, the Currituck landslide event ultimately represented our probable maximum tsunami event. The runup and drawdown without considering the tidal effects was just slightly over one-foot elevation at the site. With tide, as you can see there, it's approximately six-feet positive and negative NAVD.

2.4.7 of the SAR discussed ice effects and to evaluate ice effects, we reviewed the historical ice jam data and actually found no ice jams downstream of Trenton, so no ice jams in the tidal portions of the Delaware River. To simulate a flood from an ice jam, we took a historical 1904 event at Trenton, modeled that

in our HEC-HMS, HEC-RAS software, combined that with the effects of tide, the spring river flood, and then waves to establish 8.1 feet NAVD.

A new intake structure at the site will be designed to address both surface and frazil ice, as both are possible at the PSEG site.

MEMBER BLEY: Have you ever had frazil ice there?

MR. BLOUNT: Yes.

MEMBER BLEY: You have.

MR. BLOUNT: Yes.

MEMBER BLEY: Did it affect any of the cooling systems?

MR. BLOUNT: It caused some blockages on the circulating water intake structure, so the non-safety-related streams for --

(Simultaneous speaking)

MR. BLOUNT: Yes, it's kind of like grass or something that builds up.

MEMBER BLEY: I've seen it further north. I didn't realize we got it down in this area.

MR. BLOUNT: It's certainly not common, but it has happened once or twice. Section 2.4.8 discusses cooling water canals and reservoirs, which are actually features that we do not have at the PSEG

site, so it's not really applicable. 2.4.9 goes into channel diversions.

As we saw on the picture previously, the site is a very flat, very open area. There's no recent historical evidence of the Delaware River or bay changing course in any significant manner to either cause a lack of cooling water to the site or cause a flooding condition on the site, so there's really no seismic or severe weather event that might cause those types of issues.

Section 2.4.11 was low water considerations and there were three primary events we considered for low water. First is low flow conditions in the Delaware River, second, we've already discussed, was the drawdown from tsunami events, and third was drawdown from a severe windstorm, which, in our case, is a hurricane event.

The negative surge from the hurricane could produce drawdowns as low as -15.9 feet NAVD when we consider the combined effects of a very low tide as well. A safety-related intake structure will be designed such that the low water does not cause any operational problems for the plant.

MEMBER SKILLMAN: Explain that last phrase that you communicated.

MR. BLOUNT: So the lower invert of the intake structure would be set such that the pumps would have sufficient NPSH to, basically, continue pumping water through the duration of a low-water event if one were to occur.

MEMBER SKILLMAN: What would that duration be?

MR. BLOUNT: We've estimated approximately six hours and that is related, of course, to the tidal cycle at the site, combined with the hurricane passing by.

MEMBER SKILLMAN: Okay. Thank you.

MR. MELLON: And with that, I'm going to ask Mike Salisbury to come up and he's going to talk to us about the probable maximum hurricane storm surge. And, Mike, your cord is right there. So Mike has served as the project manager and lead modeler for a number of tide and storm surge modeling related projects throughout the United States and abroad.

He has over ten years of experience working on coastal related projects, including expertise in developing storm surge models for risk assessment, floodplain mapping, and long-term climatology studies. He's published several peer-reviewed articles detailing the development and validation of various

numerical models, and is chair of the Coastal and Estuarian Hydrosciences Committee for the Coasts, Oceans, Ports, and Rivers Institute of the American Society of Civil Engineers.

Mike has his Bachelor's and Master's Degree in Civil Engineering from the University of Central Florida and is a PE in the State of Florida.

MR. SALISBURY: Thank you, Jaime. Good morning, Committee Members. Thank you for taking the time for this presentation today. So for probable maximum surge, the basis methodology that we used is the probable maximum hurricane and it's based off of the NWS 23 technical publication. And the root of this methodology is it looks at various combinations of the important parameters necessary for hurricane formation and propagation.

With that, and so some of these important parameters are central pressure, radius of maximum winds, forward speed, et cetera. Using the information in this technical document, we performed a storm surge screening assessment and what this assessment did is it looked at the different combinations. You know, some of the parameters gave a range of possible possibilities, such as forward speed, radius of maximum winds, so what we wanted to

do is look at all possible reasonable combinations of these parameters using a screening methodology, and that screening methodology is use the Bodine storm surge model to bring the surge from the open deep water ocean to the open coast at the mouth of the Delaware Bay.

From the mouth of the Delaware Bay, we relied on the HEC-RAS model that was developed for Delaware Bay, Delaware River to propagate the surge from the mouth of the Delaware Bay up to the site. With that, it was also superimposed on top of that is wind setup from the Kamphius wind setup methodology, and then lastly, getting local to the site, wave runup was calculated based on these conditions using Coastal Engineering Manual methodologies.

Using that screening assessment, like I said, we looked at a number of different combinations and arrived at the peak water surface elevation at site resulting from a storm that had a radius of maximum winds of 28 nautical miles, and a forward speed of 26 knots. And this resulted in a total water surface elevation of the site of 42.4 feet.

Now, just to give you a frame of reference for this probable maximum hurricane event, it had a central pressure of 902 millibars. This is

approximately a strong Category 4 storm, on the Saffir-Simpson scale, and further with that, along New Jersey, they've only ever had a Category 1 storm make direct landfall, so to give you a frame of reference of how intense and big of a storm this is that we're dealing with.

MEMBER SKILLMAN: Let me challenge you there, Michael, why would we find any comfort that the greatest storm has been a Cat 1 when you say the design envelope is a Cat 4? Why shouldn't we think, one of these days there might be a Cat 4 that comes that far north?

MR. SALISBURY: Well, to the point I think, you know, that that's why we're wanting to look at a storm of this magnitude, you know, there is some literature out there that suggests the sea surface temperatures in the mid-Atlantic region of the ocean won't allow a storm to get that intense or that strong in this area, but, you know, to be conservative, you know, we decided since it's possible, according to that technical literature for an NWS 23 method, that a storm could be this intense.

MR. MELLON: So this is a deterministic model and we're plugging it into the NWS 23 methodology, and we're just following it, even though reality looks

very different. So we're accepting that conservatism, especially post-Fukushima, it's appropriate to overdesign in this area because the impacts would be significant of a flooding event, so we'll get into what site grade is, and as we go, how we use the screening to perform a more refined two-dimensional model, because HEC-RAS is a one-dimensional model, and it is overly conservative when modeling what happens in the Delaware Bay.

MEMBER SKILLMAN: Let me ask this, for a storm that's not a Cat 4, it's a Cat 2, he said the worst appears to have been a Cat 1, for a Cat 2 or Cat 3 that's sitting either due east with that anti-cyclic rotation, or particularly, sitting to the southeast, where the northern cusp would drive up the bay, what is the approximate variation in the water level for those scenarios; for a slightly higher than a Cat 1, not a Cat 4, but the center of the storm, the eye of the storm, is sitting at that location that causes the site to be most vulnerable?

MR. SALISBURY: I guess, let me answer that in two parts. One, that scenario you're talking about, the orientation, is exactly what the orientation we're modeling in this probable maximum hurricane analysis. The second part is to your question of the

relativity of Category 2 or 3, et cetera, we -- I don't have those numbers on me, I'd have to get back to you on that.

MR. MELLON: So to the path of the storm, we took a storm out in the open ocean, starts a parallel to the bay path to the south, and it makes landfall, roughly, Ocean City, Maryland, to drive the water up the bay, so again, deterministic, this path is chosen to maximize that storm surge at the site.

A 2 or a 1 would be less water and so we will raise the site grade to be above the flood height, but it would be less water, even if it was on that same path.

MEMBER BLEY: And you overlaid the high tide.

MR. SALISBURY: Yes. Sorry, some of these details are coming up in other slides, but if all other parameters are the same, according to scientific literature, from that point, it's just a ratio of central pressure difference. You can scale the surge almost directly associated with that correlation. So it would be less, but I can't speak to what that exact number is right now. I'd have to look that up.

MEMBER SKILLMAN: Off the top of your head, what did Sandy do to the site?

MR. SALISBURY: Sandy, at the site, produced a water level of 7.7 feet NAVD. And, you know, some of that had to do with it was occurring on a downward timing with the tide when it reached the site, but when it got to the site, it was, I want to say -- was it still a Cat 1 or wasn't it a Category 1 at that point?

MR. MELLON: It wasn't even Cat 1. It dropped out of Cat 1 before it made landfall. Sandy made landfall north of Atlantic City. It did not -- there was no flooding on site. The existing site grade is about 10 to 12 feet NAVD, so we did see higher water levels. Most significant was the wave action at the circ water, the non-safety-related intake structure for Salem, which caused them to have to trip the unit. One unit was in a refuel outage. The other unit tripped and Hope Creek remained online through Sandy.

MEMBER SKILLMAN: Okay. And a trick question, I don't know if anybody will remember it, I certainly do, Camille, 1969, walloped the East Coast. I mean, really, really pummeled the East Coast. Any history or any information? It doesn't show up on your data.

MR. SALISBURY: We looked at the whole record at every tide gauge in Delaware Bay, not the

Delaware River, and looked at all the historical water levels and --

MEMBER SKILLMAN: That one didn't show up?

MR. MELLON: Wasn't Camille a rain event, basically, in the Susquehanna River Basin?

MEMBER SKILLMAN: Well, it moved off to the east because I was stuck in Newark on an airplane and I remember it was one of the baddest days I've ever had in an airplane. All you can see was elbows and rearends with people getting off that plane. I will tell you, it was deadly. It was really bad.

MR. SALISBURY: Yes, like I said, we did look at all the historical water level data that was available in the Delaware Bay region. The exact number for that time period, I don't recall off the top of my head.

MEMBER SKILLMAN: Fair enough. That was a trick question. I didn't expect any answer.

MEMBER BLEY: And if I remember right, that's the one that really hit Wilkes-Barre, and then got even up into Elmira, New York. It was a tremendous rain.

MR. MELLON: I remember the Governor's Mansion in Harrisburg flooded and was not habitable for years. They didn't open it back up for, you know, five,

six years.

MEMBER SKILLMAN: Thank you.

MR. SALISBURY: So like I said, the first step that was presented on the previous slide was the screening methodology. Once we arrived at the conditions that produced the peak surge at the site, we moved to a two-dimensional model, storm surge model, and with that, it's widely regarded in technical literature that two-dimensional models are much more accurate for these types of simulations.

They much better describe the nuances of the bathymetry and topography in the area, the two-dimensional structure of the wind fields of the hurricane event, so because we organized that, we were able to get the recently completed ADCIRC and SWAN model that was developed for FEMA Region III, they're coastal flood study updates that they have done in the last few years.

This mesh, ADCIRC mesh, has about 1.8 million computational nodes, so each vertex of the triangles on that image you see is a computational point of interest. The advantage of these large-scale models such as this is it better describes propagation of the surge when it's out in the deep ocean, Western North Atlantic Region, propagates up onto the shelf,

and then into the coastal flood plain, and spreads out in the coastal flood plain.

It provides a much more accurate and realistic assessment of that surge flooding in a spatial two-dimensional sense.

MEMBER BLEY: Just to help me understand that, if you'll draw a distinction between accuracy and precision for me, I can see you getting very precise with this type of model, but when you compare it against, have you run it against historical or have you read reports of running it against historical storms and it more accurately portrays the kinds of things we're interested in?

MR. SALISBURY: Yes, so on the validation side, there's actually two fronts. One was done before we obtained the model. It was thoroughly validated by FEMA. They looked at a number, I want to say it was three or four historical events, Isabel, they looked at nor'easters, Nor'easter Ida was one of them, and they compared that to historical water level data to validate it.

MR. MELLON: Those three were for the Delaware Bay, as opposed to other hurricanes that FEMA validated this model against across the Eastern U.S.

MR. SALISBURY: Correct. And then once

we got it and refined it locally, which, I'm going to get to that refinement here in a little bit, we also then re-validated it to make sure we're still comparing well to historical tide gauge records. And I forget what the delta is, but on the order of, you know, 1/10 or two of a foot, I think, is the difference between model results and measured data.

And so, you know, what this is modeling, this coupled system, it's modeling a storm surge coupled with -- storm surge, which is the ADCIRC model, which simulates tides and storm surge, or can simulate tides, then it's coupled with SWAN, which is a wave model, so as it's going through the simulation, those two processes are intertwined with each other, you know, wave model simulates the waves, communicates that information back to the surge model, surge model calculates the water levels and currents, and feeds that back to the wave model.

And what that does is it, like I said, further represents reality in the physics involved with the surge flow around the site.

So as I alluded to before, once we obtained this storm surge model from FEMA, we recognized that it wasn't quite as resolved around the site as we'd like. There were site-specific features that weren't

represented in the FEMA data that were pertinent to really locally describing the flow around the site.

So some of these features are things like sea walls, you know, sheet pile sea walls. At a few locations, there's berms along the site, and, you know, just to the south of the image you see here on the screen there's a line of sunken barges to act as breakwater for incoming waves. And, you know, so taking that understanding, coupling it with the latest data sources we had available, such LIDAR, but, you know, even as accurate as LIDAR is, it doesn't pick up things like, you know, sheet pile sea walls, so we also relied on as-built construction drawings to supplement those site-specific information.

With that, we also refined the resolution of the node spacing in the area. In the FEMA Region III mesh, node spacing was on the order of 75 to 100 meters in the area, with this refinement, we went down to 30 to 50-meter resolution in the area to really describe the flow around the site.

So that was the surge aspect. You know, moving on to the next variable in the equation, wave runup. Wave runup is dependent on significant wave height, wave period, wave direction, it's also dependent on site-specific information such as what's

the slope of the embankment that it's running up on, what's the material of the embankment that the wave is running up on?

So as you see here in this schematic on the upper right, at this juncture, the side slopes of the proposed site are 1 to 3, so every foot up vertical, it goes three-feet horizontal. You'll also note the site grade on this schematic of 36.9 feet, just keep that number in mind when we get to the next slide, but using that information, that localized information, you know, the embankment is, at this point, proposed is concrete riprap material.

Using that information and then with the output from the ADCIRC and SWAN models, the ADCIRC and SWAN model produces time series information of water levels, and also, time series information of wave data, so time series of significant wave heights, wave periods, et cetera.

And using that wave information and the local site characteristics of the proposed site, we were able to calculate the wave runup throughout each simulation at the site using Coastal Engineering Manual methodologies.

And so one last note, if you see the four green points surrounding the proposed site there,

basically what that is is to factor in directionality of the waves. We look at representative points on each side of the structure and by doing so, you know, like, we are able to look at any potential variability in, you know, is the eastern side the worst case scenario, the western point, et cetera, so we're able to look at, sort of, the spatial distribution of what that wave runup and total water level would be around the site as opposed to just one representative location.

So with that, when you factor in the two-dimensional surge model, the wave runup, the surge modeling had an antecedent in water level condition of 1.35 feet, which represents the project 100-year sea level rise in the area. That produces a still water level of 20.2 feet, and when you couple on top of that, superimpose, the wave runup, and then 10 percent exceedance high tide, that represents a total surface elevation of 32.1 feet, which is the design basis flood total water surface elevation at the site.

And if you compare that to the proposed site grade of 36.9 feet that was on the previous slide, you'll see that we're well underneath the top of the site relative to the design basis flood level.

MEMBER SKILLMAN: Michael, what establishes the maximum still water level?

MR. SALISBURY: Is the peak surge level at the site that's recorded throughout the simulation.

MR. MELLON: That's the SWAN output?

MR. SALISBURY: Still water, that's the ADCIRC component of the output, but yes. So we simulated, produced time series information at these points around the site and then with that, you know, if you look at the hydrograph at the time variant data, it's the peak point associated with that.

And in this particular case it's, you know, worth noting that, you know, we're concerned more about the total water level side of things, so it's really the superposition of the time variant wave runup with time variant surge, and, you know, the peak wave runup doesn't necessarily coincide with the peak still water, so we calculated the total water level, which is more important to understand that dynamic that's at play there.

MEMBER SKILLMAN: Okay. So for this slide, antecedent is the night before the quiescent level at the site, then there are a series of events that drive the bay elevation, and that is the series of events that you've just described. And the consequence of that is approximately a rise of 18-1/2 feet. It goes from 1.35 to 20.2, and then you put on

that, the wave runup, and you've added margin on that exceedance for the height for the tide, that gives you 32.1.

MR. SALISBURY: Yes.

MEMBER SKILLMAN: So 24 hours later, if all is calm, you're back to 1.35 feet, or 36 hours, whatever it is.

MR. SALISBURY: Yes.

MEMBER SKILLMAN: Now I understand. Thank you.

MR. SALISBURY: Okay.

MR. MELLON: And this is just to note that we don't know if we have a passive system, then the intake structure is not safety related. If we have an active, you know, emergency cooling systems, then we need a safety related intake structure, then that will have to be designed for this flood. The new plant grade is above that flood level, so we remain a dry site.

A lot of this is driven because the design certs assume that the plant grade is one-foot above your maximum flood, so as opposed to Salem and Hope Creek, which have flood protection at their current site grade, they have water-tight doors, and they take the actions, which they did at Sandy, to close them, and make ready for that.

We have to raise this site or else take a departure from the design cert, but for the purposes of our ESP, we're describing raising the site. And the riprap protection is part of what we would have to do on the site to maintain those slopes so that the wave actually would keep the site grade intact.

And with that, we're going to move on to ground water and accidental releases of liquid effluents. Thank you, Mike.

MR. SALISBURY: Thank you.

MR. MELLON: And Nelson Breton is going to talk to us. Nelson has over 28 years of experience conducting environmental, geologic, and hydrogeologic site investigations. He's led a number of environmental field investigations, including multimedia environmental and radiological site characterization at sites under both state and federal regulatory review.

Nelson's a Connecticut licensed environmental professional in the State of Connecticut and he's a certified geologist in the State of Maine. Nelson has a Bachelor's Degree in Geology from the University of Maine. Thanks.

MR. BRETON: Thank you very much, Jaime, and thanks for having us. Good morning. The

groundwater section, we'll talk about the regional hydrogeology groundwater use and effects on your water when you're doing construction. This slide here, we talk about the regional hydrogeology locally and in the region. Characterize the hydrogeology as water-bearing coarse-grained units intervened with finer grain confining units.

The thickness of these is approximately over 1000, 1500 feet total over bedrock units. The PRM aquifer system is important to water supply, both in the region and at the site, and --

MR. MELLON: PRM stands for?

MR. BRETON: Potomac, Raritan, and Magothy. The next slide will show the position of these units; relative position. And the nearest public water supply is approximately 3-1/2 miles from the site. In this slide, we took out the relative position of the various hydrogeologic units. The upper units, shown here, local hydrologic fill, alluvium, and the deeper units below that are regional units, blue representing the water-bearing zones, and the white representing the confining thickness of these units; relative thickness.

Again, the confining units between the upper zones, locally, and the deeper PRM lower units

is approximately 400 feet, so you have about 400 feet of confining unit thickness of relatively impermeable units.

MEMBER RYAN: Just out of curiosity, what's the depth of all of these individual units combined?

MR. BRETON: Just over 1000 feet.

MEMBER RYAN: Thousand feet?

MR. BRETON: Yes. And the upper units, that are saline, are 100, 150 feet in depth.

MEMBER RYAN: Thank you.

MR. BRETON: Again, we talk about the PRM, the Potomac, Raritan, Magothy aquifer. Based on prior studies, there's sufficient capacity for future use. Investigations were completed in around 2009 to evaluate the local hydrogeology to support construction and accidental release scenarios. Again, the shallow aquifers are saline, not suitable for potable use.

The plant area information was collected, including ground levels that helped us with evaluating groundwater flow. In the shallow units, that being the Alluvium and Vincentown aquifers. The next slide will depict that. This is an average flow condition in the shallow water-bearing zone, the alluvium. A similar

characterization is arrived at for the next deeper unit, the Vincentown.

MEMBER SKILLMAN: Let me ask, what forces that flow? What is the hydrology behind the drift to the west? Is there an elevated aquifer further to the east that is draining to the west or what causes that flow?

MR. BRETON: Mostly precipitation. It's imposing on top of the alluvial material and the overlying hydrologic field. So accretion of infiltration from precipitation drives that flow direction.

MEMBER SKILLMAN: Okay. Thank you.

MR. BRETON: A groundwater model was developed to support the dewatering during construction as well as evaluating post-construction hydrostatic loading, which fed into the geotechnical evaluation. Modeling results show dewatering requirements that consistent with Hope Creek's station nearby. Post-construction, local mounding was possible, so that was revealed in the results of the modeling as well, in the shallow units, that is, again, the Alluvium and the Vincentown.

We talked about accidental release, previous slide, two release scenarios were envisioned.

From the prior slides, we show the predominant flow direction to the west. One scenario, release occurring on the western edge of the power block and migrating towards the Delaware River, and as a result of placement of silt retention barriers, relative mounding, another release scenario was envisioned towards the northeast, towards the Fishing Creek, water body that discharges into the Delaware River.

For each scenario, the shortest transport pathway was chosen as the Alluvium, the shallowest water-bearing zone, higher permeability than the hydrologic fill, and the underlying Kirkwood Unit. Next slide. In this here, we depict each location of the releases, on the west side towards the Delaware and to the northeast towards Fishing Creek.

MR. MELLON: So the pink block is the power block.

MR. BRETON: That's it.

MR. MELLON: It would be the 36.9-foot elevation that we've built the plant up on. And the two, then, release pathways.

MR. BRETON: That's right. In each case, in each flow, we considered the effects of mounding, which is important, because you have pre-construction water levels measured, and we looked at the effects of

mounding effects post-construction, again, due to the placement of retention walls. Concentrations for each compared to the ECLs, again, we assume maximum groundwater velocities in each case with maximum hydrologic conductivity values, which is a property of each of the aquifers.

And when you're factoring in dilution, in each situation we beat the Unity Rule. Surface water, and there are no potable surface water supplies down gradient of the site, and control measures will be in place to prevent accidental releases, and those measures will be further described in the COLA stage.

MR. MELLON: That's the conclusion of our presentation. Do you have any questions?

CHAIRMAN POWERS: Members have any additional questions? Okay. In that case, we will take a respite of 15 minutes in order to allow the staff to setup and make their presentation, and --

MR. MELLON: Just me.

CHAIRMAN POWERS: Yes, and the rest of your staff's free. You have to work. And we will resume in 15 minutes.

(Whereupon, the above-entitled matter went off the record at 9:31 a.m. and resumed at 9:45 a.m.)

CHAIRMAN POWERS: Let's get back into

session. I think Mr. Mellon wants to make an amendment to some of his comments.

MR. MELLON: We did, to your question, Dick, about other hurricanes and as part of Fukushima response for Salem and Hope Creek, we evaluated other hurricanes to understand the probability, how possible it is that a hurricane would break grade. A Cat 1 hurricane results in a 6.35 feet of NAVD surge, so there would be additional wind setup, wave runup on top of that, a Cat 2 was 11 feet NAVD, and again, also wind setup, wave runup on top of it, and a Cat 3 was about 14-1/2 feet NAVD.

And if you remember from our slide, I think our still water level from just the surge alone was about 20 feet, so these would be less significant events.

MEMBER SKILLMAN: Thank you.

MR. MELLON: Sure.

MEMBER SKILLMAN: Thank you.

CHAIRMAN POWERS: Good. Now we turn to the staff, and, Prosanta, you'll --

MR. CHOWDHURY: Yes. I'll introduce. Thank you. On this slide, you will see that we are presenting Chapter 2 Section 2.4, hydrologic engineering safety evaluation. The publicly

available advanced safety evaluation with no open items was issued on April 22, 2015, and the Adams Session Number is listed here. And two principle contributors are present with me today, Joe Giacinto and Dr. Henry Jones.

So with that, I will flip the slides and, Joe, you can go first.

MR. GIACINTO: Okay.

MR. CHOWDHURY: You do this yourself.

MR. GIACINTO: All right. I'm Joe Giacinto. I'm the hydrologic engineering lead for the PSEG project. I've been with the hydrology/meteorology branch for six years, with 25 years of industry and regulatory experience. I'm a certified professional geologist and I'd like to introduce Henry, my colleague.

DR. JONES: I'm Dr. Henry Jones. I've had eight years here in the hydrology, meteorology, oceanography branch. Prior to that, 28 years in the United States Navy, 26 years of that as a geophysicist and meteorologist. I have degrees from the United States Naval Academy, a Master's in Meteorology, Oceanography, and a Doctorate in Oceanography, with a specific specialty in ocean waves from the Naval Post-Graduate School.

MR. GIACINTO: Okay. Thank you. We'll start out with some background. The hydrologic engineering staff conducted a visit at the PSEG site in February of 2011. The topics include the site setting, hydrologic site characteristics and associated document reviews and calc packages. The staff coordinated the review with state and federal agencies, including the New Jersey Department of Environmental Protection, U.S. Geological Survey for Surface Water and Tsunami, the U.S. Army Corps of Engineers, and NOAA.

The staff performed independent review and confirmatory analysis, as explained in the upcoming slides. Before you go to the next slide, I'd like just to point out the proposed PSEG site layout. As PSEG pointed out, the rectangle there in red is the power block area. It's approximately 70 acres. And to the left of that is a light-blue rectangle, which is the intake structure area, and various other areas around the site as well, but those two areas are where we'd have our safety-related SSCs. Okay. Next slide.

As far overview, as you've heard, the PSEG site is located on the eastern shore of the lower Delaware River, the upper Delaware Bay. The watershed for the Delaware River is approximately 13,600 square

miles and about 11,500 of that is upstream of the PSEG site.

As expected, the tidal flow dominates the freshwater flow at the site and there's a wide and open connection to the Atlantic Ocean. The existing site grade is about 5 to 15 feet and proposed site grade is 36.9 feet. The storm surge is the design basis flood level determining event at 32.1 feet. And to the right is an image of the Salem, Hope Creek operating plants, and the location of the PSEG site alongside the Delaware River.

CHAIRMAN POWERS: They arrived at this storm surge level using a fairly elaborate two-dimensional computer code that they subsequently did a bunch of refinement. Will you discuss what the staff did in connection with that computational vehicle?

MR. GIACINTO: Yes, at the storm surge, we have a slide coming up on that.

CHAIRMAN POWERS: I'd like to understand because they made the point in their presentation that two-dimensional modeling was widely viewed as more accurate than is the one-dimensional screening modeling. And one can certainly believe that. The trouble is that two-dimensional modeling requires more

input and more skill from the user and user inputs than does the one-dimensional screening modeling.

And I'd like to understand how the staff looked at that and quite frankly, I would have enjoyed understanding better how they validated that modeling in a more quantitative sense. I mean, they made statements to the effect that they looked at various data points and they got close. Well, this is not either horseshoes or hand grenades, so close doesn't necessarily mean good.

DR. JONES: We'll get to that one --

MR. GIACINTO: Yes, and we'll talk about that when we get to the storm and surge slides coming up shortly. Thank you. For the flood analysis summary, in terms of local intense precipitation, as was mentioned, the site drainage design is dependent on reactor technology selected. So the local intense precipitation review will be deferred to the COL stage, and as a result, we have COL Action Item 2.4-1, whereas a COL or a construction permit applicant referencing the ESP should design the site grading to provide flooding protection to safety-related structures at the ESP site based on a comprehensive flood water routing analysis for a local PMP event, or LMP, without relying on any active surface drainage systems that may

be blocked during this event.

CHAIRMAN POWERS: Assuredly, the draining analysis does require the technology to be in place to evaluate, but how did you feel about their source term?

MR. GIACINTO: They did analysis all the way up to the point, a standard analysis, which was adequate up to the point of evaluating the site drainage. I mean, we have a plant grade of 36.9 feet, but we don't know how the site's going to be configured in terms of drainage ditches, culverts, and that sort of thing.

CHAIRMAN POWERS: But you didn't have any trouble for the amount of rain that they got?

MR. GIACINTO: No, the PMP derived was through standard methods, HMR 51 to 52, and so on, to the routing. For the flood analysis summary for probable maximum flood, that resulted in a value of 21 feet per ANSI/ANS 2.8 combinatory events, which included the probable maximum precipitation, runoff and infiltration conservatively estimated, and surge and seiche from the worst regional historical hurricane, which was Hazel, and 10 percent exceedance high tide.

I would say that the probable maximum precipitation was actually very conservative and they

could have used a 500-year flood, but this was actually greater than the 500-year flood, and they used this. And the result was that, the maximum calculated water level is actually 15.9 feet below the proposed site grade.

Okay. And here's where we get into the probable maximum surge and seiche, which, Henry can talk to in terms of the details that went in. I'll just give you a quick overview and hand it off to Henry. The initial screening method, which was a one-dimensional model of HEC-RAS, and integrating the wind model, it resulted in an extremely conservative, beyond the world record surge of 42.4 feet. Never been seen before.

So at that point, we move to a more realistic approach, which incorporates physics, and which is the two-dimensional model, and incorporates conservatism as well, with the resulting design basis flood of 32.1 feet. And at this point, I'll hand it off to Henry and let Henry and Chris explain some of the particulars about the physics and what went into the --

DR. JONES: You asked about the details, what I have here, who I have here, is Dr. Chris Bender. He's from Taylor Engineering, who performed the analysis and the review of the storm surge. I'll let

him speak to this.

MR. BENDER: Hello. As Henry mentioned. I'm Christopher Bender. I work with Taylor Engineering. We've been working with the NRC on this project. I have a Master's Degree in Coastal Engineering from the University of Florida and a PhD in Coastal Engineering from the University of Florida as well. I worked with Henry to review the analysis that was conducted for the ESP application and also to do an independent confirmatory analysis as well.

And I guess stepping through, the first step was to review the model that was applied by the licensee, and that was the FEMA Region III model. Taylor Engineering has worked on several of the recent FEMA re-analysis studies in the southeast U.S., starting in South Carolina and working down through Florida, including the Gulf of Mexico, and Louisiana, and Texas.

And the SWAN plus ADCIRC model is the model of choice right now that is being used in those studies. And having worked on those studies, there's a significant quality control and validation that goes through the DEM development, the digital elevation model, the model mesh is, Dr. Salisbury mentioned, the 1.6 million nodes. There's a significant review that

goes in there. And then there's a review of the model settings and then the model validation.

And FEMA is very specific in their guideline so you don't calibrate the model. You don't just change the model parameters however you feel in order to get good results. It's called a validation, not a calibration, so you keep those model parameters within an acceptable range and try to show over a series of, you know, three to five storms that your model reproduces the measured water levels for the historical events.

And one thing that, you know, I spoke with Henry about and you're limited by is, you can't create historical events. The historical record is what it is, so you have to find the storms that have data, both meteorological, and water level, and wave, and then those are what you can validate to.

So we reviewed the validation that was done for the FEMA Region III model and it showed good, you know, unbiased results for the historical data that was available and, you know, the validation looked similar to the other FEMA studies that we worked on.

MEMBER SKILLMAN: Can you please explain how many samples?

MR. BENDER: There were, as was mentioned,

I believe, five storms. There were, I believe, two nor'easters and three tropical storms that were looked at as part of that FEMA study, and that's pretty typical for a FEMA study. There's between three and five storms that are looked at. And southeast, there's no extra tropical storm, so northeast, you might have a couple extra. There would be extra tropical.

MEMBER SKILLMAN: Yes, sir. Thank you.

MR. BENDER: The next part of our analysis that I worked with with Dr. Jones was to re-validate the model that was developed by the Applicant. As was mentioned, there was resolution added near the site, which makes sense. The FEMA studies are looking over hundreds of miles over, in some cases, multiple states, or large portions of states, so they're not focused in on one specific plant.

So it does make sense to add in this extra resolution and we were able to, on a separate computer cluster, reproduce within 1/10 of a foot, the water levels that were produced by the Applicant's model that included the additional resolution, so Henry and I discussed that. It gave us comfort that their model changes didn't introduce any different model results, or any instabilities, or anything that was of concern.

And, you know, with the extra resolution,

provided a better tool to actually look at the results at the site. And then as was mentioned earlier, the screening was done by the Applicant where they apply this one-dimensional approach based on the NWS 23 results, and they came up with a set of storms that were run through the very refined SWAN plus ADCIRC model.

And what we did is, we were able to, on a separate cluster, replicate their PMH results after reviewing the NWS 23 guidance to document that they had chosen the correct ranges of parameters that are listed within NWS 23, so Henry and I, you know, went through the documentation, confirmed that they were using the right values, and then were able to replicate those values on the Taylor Engineering high-performance computing cluster.

And then the next step was, since they had applied a screening tool that was a one-dimensional model that, as has been stated, doesn't included, necessarily, all the physics. You know, for part of it, it doesn't account for the shape of Delaware Bay, or some of the nuances that a two-dimensional model can.

We did a sensitivity study where we varied the storm track that they applied, we varied the storm's forward speed, then we looked at some of the model settings that they had applied to just evaluate the

sensitivity to see of there would be large changes in the maximum surge level that was produced in their model. And there were some small changes, one foot or so, but no really large changes in the still water levels that were created by shifting the storm, or speeding the storm up, or applying some of those changes.

So that got us to the still water elevation. That doesn't include the wave runup. Then we looked at their wave runup methodology, and what they applied, Corps of Engineers, Coastal Engineering Manual, a standard that is used by our firm and by many other firms in terms of wave runup analysis.

And using their wave results and comparing those to the wave results from our model, we got very similar runup levels for their PMH storm to where, you know, the final water levels were within a foot for our completely independent analysis using our cluster and our wave results in those models.

So that, you know, Henry and I discussed, gave us comfort in those values, and it should be noted that not only is there conservatism in the two-dimensional modeling, but within runup, you have choices too about how the riprap will affect the waves and what wave height to even apply. And there were

noted, and, you know, we agreed, conservative approaches even within the runup analysis as well that led to the final value that they had, so that was the process that we took to verify the modeling that was conducted.

I know it was a lot. I'm open to any questions if any of that was unclear.

CHAIRMAN POWERS: Well, I'm going to just inject, Prosanta, this is excellent. This is the kind of stuff that many people don't see. It's high quality confirmatory analysis and that's what I was looking for. Thank you very much.

MR. CHOWDHURY: Thank you.

CHAIRMAN POWERS: Henry, I think you're responsible for this and it sounds like you did a good job there.

DR. JONES: Well, thank you, sir.

MEMBER SKILLMAN: I would like to ask, you've used the term Taylor Engineering high-performance computer cluster several times.

MR. BENDER: Yes.

MEMBER SKILLMAN: Would you explain what you mean by cluster?

MR. BENDER: That is the ADCIRC model and the SWAN model are written in a way that allows it to

run in a parallelized mode, which means that the domain is split-up into different regions that all run at the same time, and it greatly improves the efficiency of the numerical model so that it runs --

CHAIRMAN POWERS: And with 1.6 million nodes, you better --

MR. BENDER: Might run a little faster. So the Applicant had the random model in a parallel mode on their cluster, which, I'm not sure which one it was, but they had a high-performance computing resource that they used, and Taylor Engineering has their own cluster. It's got 200 and -- well, it's got 512 nodes if we run it in a certain way, and what that means is we could take that 1.6 million node domain, which includes the Carribean, the Gulf of Mexico, and the Eastern Coast, and separate that into 512 little models that are all running at the same time and communicating at the boundaries.

So instead of it running on, you know, a single computer like that, ours should rung, you know, hundreds of times faster by running it in a parallelized mode, and that's what's important for -- it's used for these FEMA studies where they're running hundreds of these models on these very refined meshes in order to meet the schedule for the FEMA studies.

They're using these high-performance computing resources and Taylor Engineering has its own cluster, relatively small compared to a research institution or a university, but still, you know, greatly improves the efficiency over a single computer.

DR. JONES: And the other thing too, is that, you could also have computer errors, depending on what the cluster you have, so by them both having independent separate clusters and reaching, essentially, the same result, actually reinforces it.

MEMBER SKILLMAN: Thank you.

CHAIRMAN POWERS: Now, that's the kind of stuff that people don't see in summary presentations that I think needs to get highlighted, and especially when it's done, as you say, independent cluster, or independent examination, and the input review of the methodologies get, kind of, the same results, maybe not after the third significant figure, but reasonably close, gives confidence to what the staff does.

And I think many people don't appreciate this because it doesn't get highlighted and I appreciate it very much.

MEMBER SKILLMAN: I do too, thanks.

DR. JONES: Another slide.

MR. GIACINTO: Well, we have a few more.

Yes.

MR. CHOWDHURY: Anything else with this one?

DR. JONES: Not really. No.

MR. CHOWDHURY: Okay.

MR. GIACINTO: We talked a little bit about the intake structure and for flood protection, the site created 36.9 with a design basis flood of 32.1. There's obviously sufficient margin for safety-related site grade structure, system, and components. At the intake structure design associated with flood protection would be considered at the COL stage simply because it's dependent on the technology.

And as a result, we have a COL Action Item 2.4-2, whereas, a COL or CP Applicant referencing this ESP should address whether the intake structure of the selected design is a safety-related SSC. If so, the Applicant should address the necessary flooding protection for a safety-related intake structure at the ESP site based on the design basis flooding event and associated effects.

As for groundwater, the maximum groundwater level taken was ten feet, with a proposed site grade of 36.9 feet. There will be a monitoring program implemented during construction and operation.

As a result, we have COL Action Item 2.4-3, whereas a COL or CP Applicant referencing this ESP should refine hydrogeologic parameters and model estimates of dewatering rates and drawdowns beneath the existing site structures after determination of the final excavation geometry, consistent with the selected reactor technology.

So at the COL stage, there'll be significant changes to the site, obviously, and additional data gathered during that time will help us characterize the response to the site and refine our understanding of the hydrogeology.

Oh, and to the right, just to mention that, that's the site-wide September water levels for the Alluvial aquifer, and you can see around the operating plants, there's somewhat of a mound there, it's only three feet maximum, but as their Applicant's modeling showed, there may be a mound at the new site after the COL stage, and that was accounted for in terms of the release scenarios as well.

Okay. As for the plant parameter envelop, our bounding maximum flood level would be one foot below site grade and our maximum groundwater level bounding value would be 3.3 feet below site grade for the technologies selected. Okay. Next slide.

And just to summarize our water levels and the PSEG site grade, we have our site grade at 36.9, our screening, one-dimensional storm surge analysis, at 42.4 feet, the design basis flood at 32.1 feet, the PMF at 21 feet, maximum groundwater at 10 feet, probable maximum tsunami at 5.6 feet, and for comparison, we've listed two hurricanes to compare to the water levels at the site.

The U.S. record, of course, is Hurricane Katrina at 29 feet measured at the Gulf Coast. Hurricane Sandy is measured at Oyster Creek, which is about 75 miles east, northeast of the PSEG site. As for the accidental release of radioactive radionuclides, the scenarios account for potential post-construction flow directions, both towards the Delaware River towards the west and the marshlands towards the northeast, which in effect, drain into the Delaware River.

The bounding PPE and conservative hydrologic characteristics were incorporated in the simulations and the results, concentrations of each radionuclide were less than the associated limits in 10 CFR 20, and the sum of the ratios for all the radionuclides in the mixture was less than Unity.

Conclusions from the hydrogeologic

engineering review is that the Applicant has provided sufficient information about the site, description, satisfied the requirements, and considered the most severe natural phenomena that have been historically reported for the site and surrounding area, and appropriately estimated the design basis flood elevation. And that concludes our slides. I think you have one more.

MR. CHOWDHURY: Yes, I have, but let's see if there are any questions.

CHAIRMAN POWERS: If I can come back a little to these radioactive liquid effluent analysis. The Applicant indicated on his Slide 23 and assuming maximum groundwater velocities, and solely a vector transported decay, some radionuclides would exceed ECLs for each release scenario. Then he says, factoring in dilution results and levels up to several orders of magnitude below ECLs, Unity Rule is met for each release scenario. Can you explain more what he did and what you did to review that?

MR. GIACINTO: Sure. What was done is, being conservative, the maximum groundwater velocities were taken towards the Delaware River, which is the short pathway to the west, and the marshlands towards the northeast, so the release was conservative on

several levels, in terms of the fastest pathways possible towards these locations.

Now, these pathways are considered through brackish water aquifers, which would not be used for, obviously, drinking water or anything else. So what was done is, when the release points are assumed to be the river, which, the alluviglock (phonetic) for subcrops into the river. And after the site is built, obviously, they'll have a bulkhead along the river, which would impede flow, which is another conservative.

But in addition to those pathways, the maximum gradient assumes that you take the water level that's measured in a well and then the river level, but the thing is, with the Delaware River, it's tidal, so it's going in and out, so the groundwater isn't actually moving to the river and then back in. It's moving back and forth, back and forth, so those travel times that are calculated are actually very, very conservative.

In reality, they'd be much, much longer than they actually are in both directions because this marshland is also tidally influenced. But at the point, assuming it goes through the alluvial aquifer, which is the fastest path, there's no credit taken for what's called retardation, in terms of absorption by the radionuclide metals onto sediment, which will

typically happen to have very high absorption retardation values, but no credit is taken for that.

What is taken is that when it reaches these locations, there's a very minimal amount of dilution that would be necessary in order to meet the ECLs, whereas, at Marsh Creek, I mean, we're talking cubic feet per day magnitude. And the Delaware River, as you saw, the tidal flow is on the order of hundreds of thousands of feet per day, whereas, to meet ECLs, they would only need, like, 112 cubic feet per second, which is less than 1 percent of the tidal flow.

And then towards Fishing Creek, which is the marshland, that transport would have to go through layers of organic sediments, which would, again, retard that. And then at Fishing Creek, there's a very minimal amount of flow that's needed to reach ECLs, which is on the order of a fraction of a cubic foot per day, or maybe a foot, or I forget the number, but I can get that for you, but a few cubic feet per day of water.

Now, this all assumes that the tank is released in the concentrations that are in the tank to the aquifer. In reality, for the tank to leak, you'd have to have water coming into the containment, and then it would leak out, and you'd have more dilution before it even started. So those are the things we looked at

in terms of the transport and the conservatives built into that.

CHAIRMAN POWERS: Okay. Your slide wasn't very clear. You didn't explain it very well. He did a good job.

MR. CHOWDHURY: Any other questions before I move to the next slide?

CHAIRMAN POWERS: Any other questions on this subject? Let's continue.

MR. CHOWDHURY: Okay. Now I take over from Dr. Jones and Joe. This is a standard sample that we used before for the first general regulatory and conclusion regarding the site safety and suitability to the final safety evaluation because that will include ACRS findings too. That's in Phase D, which, by the way, has September 30, 2015 public milestone.

So today, we presented advanced safety evaluation with no open items on Chapter 2 Section 2.4, which is hydrologic engineering. And just to recap that this SE does not contain any permit conditions and it does contain three action items that have to be addressed by a COL or CP Applicant referencing these early site permit.

Now, I'd like to recap, because this is the last Subcommittee meeting, for the benefit of the

Members and the audience-at-large, and members of the public, for that matter, the summary of what we have done so far, and I'll be brief. And if you have any specific questions on subject areas, we do not have those subject area experts or technical staff present today.

However, it's just a summary. We have already presented to you and we answer your questions. So I'll verbalize. One of the important things I would like to mention is our interaction with other agencies. We have mentioned that, but we have taken significant effort, made significant effort, to interact with other agencies very closely to the extent we needed. That includes the Federal Emergency Management Agency, who is a partner with the NRC in terms of the emergency planning review for offsite emergency plans.

United States Army Corps of Engineers, as Joe mentioned, Coast Guard, U.S. Coast Guard, NOAA, National Oceanic and Atmospheric Administration, New Jersey Department of Environmental Protection, the hydrology folks, interacted with them, and then the U.S. Geological Survey.

So although these are just a few names, but the interaction made our independent analyses, getting insight, discussing with them, matters of interest, was

significant in reaching the conclusion that the staff did in various aspect of review.

I already mentioned on March 19th, we presented several pieces of the safety evaluation with no open items, aircraft hazards, radiological effluent release, those consequences from normal operations, which is 11.2 and 11.3. We presented emergency planning, which is Section 13.3. Included in there was 14.3.10, which is emergency planning, the ITAAC. And it's a long list of ITAAC that has been presented also.

Chapter 15, we presented 15.0.3, which is radiological consequences of design basis accidents. Chapter 17, 17.5 in particular, quality assurance program description. And in September 2014, specifically on the 29th and 30th, we presented geography and demographic, nearby industrial transportation and military facilities. That's 2.1 and 2.2 combined, and then meteorology, which was a big chunk of our review, Section 2.3.

And on that same timeframe, we also presented Chapter 2.5, which is a significant chapter also, geology, seismology, and geotechnical engineering. On June 9, which is today, we presented to you the last piece of our advanced safety evaluation with no open items, that's on hydrologic engineering,

2.4.

Site location and description of some of the areas I'm going to mention that had no action items or permit conditions, they were clean to the extent that the ESP scope allows. The Applicant met requirements in describing site location description. In the exclusion area, or third gamm (phonetic) control, with respect to ownership and control of arrangements of 85 acres of land from the U.S. Army Corps of Engineers, there is a permit condition, it's quite detailed, and that permit condition is -- they are in the SE, because the arrangement has not been finalized when the SE was published and presented.

So population distribution, the Applicant met the requirements that the staff found. Identification of potential hazards in the site vicinity, all requirements for the ESP have been met. Now, evaluation of potential accidents. There is a permit condition, which is Permit Condition 2, we presented to you earlier in March, I believe, or September, September, it has to do with the effects of potential explosions associated with the new located gasoline storage tanks and gasoline delivery tanker truck on the nearest SSEs, structure systems, and component with regard to safety.

So that permit condition is there. For the meteorology, there are no permit conditions and there is, for regional, local, meteorology and onsite meteorological measurement program, all requirements for the ESP have been met.

Short-term diffusion, the Applicant met the requirements, as the staff found out. Long-term atmospheric dispersion estimates for routine release, the staff proposed a COL Action Item, which is 2.3-1. Regarding identification and condition of any difference in exported factors and most susceptible locations, including those in sectors adjacent to the Delaware River.

I don't need to go over the hydrologic engineering because we already covered it today. Once again, there are no permit conditions, three COL Action Items. The site grade is 4.8 feet -- the proposed site grade it 4.8 feet above the design basis flood of 32.1 feet NAVD.

Overall, for hydrologic engineering, the Applicant has provided sufficient information, satisfied the requirements, and appropriately estimated the design basis flood elevation, less the staff's findings. Geology, seismology, and geotechnical areas, there are two permit conditions.

One is related to the geological mapping for documenting the presence or absence of false and shear zones in dam foundation materials.

Migratory ground motion that now this includes aspects of Virginia earthquake evaluation as well as the Fukushima Near Term Task Force 2.1 seismic evaluation that has been done. The staff did not need a separate question and evaluation for that matter. And stability of subsurface materials and foundations, there is a permit condition concerning the need for additional geotechnical investigations and leak protection assessments.

That will be done once the Applicant chooses the reactor technology. And then the staff, in geology, seismology, and geotechnical engineering, has identified several COL Action Items, quite a few, in various areas that we presented to you. Stability of slope will be evaluated after selecting a reactor technology, so that evaluation is not stated.

The aircraft hazard has the COL Action Item that concerns compliance with the design basis. I'm reading this part, or all of this, taken from the public development safety evaluation, so there's no surprises here, except, I will not be able to explain if you have a question on some specific pieces, but I can try my

best.

Radiological effluence release dose consequences from normal operations, that's Chapter 11.23, there is a COL Action Item concerning effluent dose calculation based on site-specific information, specific details, and those will be available at the COL stage, and the Applicant will have to address.

Emergency planning has five permit conditions, okay? Two of those, if I'm not mistaken, are related to how the Applicant will address certain aspects of Fukushima Recommendation 9.3. So those two permit conditions are there and there are others, so permit conditions, some of them, at least two of them, have to do with emergency action levels which are not the details and parameters are not available at this stage.

MEMBER BLEY: Just a process question. With a permit condition, I'm assuming what that means is, when there's a COL, they'll have to just show that they meet those conditions, and they will review it.

MR. CHOWDHURY: That is correct.

MEMBER BLEY: Okay.

MR. CHOWDHURY: And those conditions will be part of the permit even when issued.

MEMBER BLEY: Oh, they will.

MR. CHOWDHURY: Yes. And then the reg provides adequate guidance for the Applicant, otherwise, there is guidance for establishing a quality assurance program that complies to 10 CFR Part 50. By following the guidance in our ASME Standard, NQA-1-1994.

The bottom-line is that the staff completed advanced safety evaluation for all chapters and sections associated with PSEG site, early site permit application, and there are no open items. With that, does the staff have any concluding remarks? Any questions?

CHAIRMAN POWERS: Members have any additional questions to pose? At this point, I will --

MR. CHOWDHURY: One other thing, Dr. Powers, just to mention to complete my slide is that our next interaction is tomorrow with the Full Committee on this project.

CHAIRMAN POWERS: And I believe you and Quynh have discussed which will present there and I would not hesitate at all to highlight where you have done independent confirmatory analyses so that the Full Committee can understand that. Jamie, you too, I think, have discussed with Quynh what will be cited for

Full Committee?

MR. MELLON: Yes.

CHAIRMAN POWERS: It's a little late to make changes so I'm not going to ask the Subcommittee to give you any advice. And, Prosanta, I would not hesitate, also, in your presentation to the Full Committee to highlight your interaction with other agencies. The ACRS has been positively impressed with the ability of the staff to coordinate and I'm quite certain that the Applicant appreciates that as well, since it gives him one point of contact rather than multiple points of contact.

So I would not hesitate to at least orally highlight your interactions with FEMA, USGS, the Army Corps of Engineers, and other agencies, both state and local, because I think that's -- I know how difficult interagency interactions are, and when you do it well, it's a real service to the public.

Okay. At that point, I will ask that the line be opened, but before I solicit comments on the telephone line, I'll ask if there's anyone in the public that wants to make comment. I don't see a flock of people streaming to the microphones. Disappointing as that may be, I will now ask if there is anyone on the telephone line that wants to make a comment or other

contributions.

You have obviously not drawn a crowd. A little more outrageousness on your part might have. I hear no additional comments and hear none, we have no advice to offer you for tomorrow. You're on your own.

MEMBER BLEY: Are you going to come around to us or not?

CHAIRMAN POWERS: I asked if there were other comments from the Members.

MEMBER BLEY: Well, questions, but comments, despite your words, I'm going to offer just a little advice, and you don't need -- you would never need to touch a slide for this and you're probably already doing it. I was just looking back over my notes and I think for the Full Committee, there'd be some interest in your organizational arrangement that you explained to us at the first meeting, I think, with the PSEG Power and the eventual shift over to PSEG Nuclear, and the development of the plant parameter envelope and how that works.

You're probably already planning to do that, but just in case you weren't, I wanted to throw that on the table. And I wanted to second what Dana said about the independent review stuff. That was very good.

CHAIRMAN POWERS: Dick, do you have any --

MEMBER SKILLMAN: I do. I reviewed the 2.4 safety evaluation very, very closely, 124 pages, I think that that was very well done. I compliment you. There's some things that are in that document that you didn't talk about today. For instance, the oscillatory seiche and how you determined that there will not be an additional runup or additional increase in water level.

How you calculated the impact on the lower Delaware for the Doylestown heavy precipitation and the Greater Philadelphia heavy precipitation, how you determined that the last conduit on the Delaware is really up in Trenton, and that once the water is below Trenton, it opens up into this vast reservoir and there is no real increase in elevation for whatever might have happened upstream.

And so the thoroughness of the safety evaluation is commendable. Thank you.

CHAIRMAN POWERS: Mike, do you have anything that you wanted to add?

MEMBER RYAN: Well, I'm sure you probably counted it, but I appreciate the --

COURT REPORTER: Sir, is your microphone on?

MEMBER RYAN: I'm sorry?

CHAIRMAN POWERS: You've got to turn your microphone on.

MEMBER RYAN: Oh, I'm sorry.

CHAIRMAN POWERS: Otherwise, she puts your words in.

MEMBER RYAN: I'd just like to comment that I think the staff's done a terrific job on bringing this all together and all the speakers today did a nice job in presenting the details. It's clear you've got a good understanding of how things work and I'll look forward to your next briefing. Thank you.

CHAIRMAN POWERS: All right. So no further comments, I think we can bring this Subcommittee to a close. We are adjourned.

(Whereupon, the above-entitled matter was concluded at 10:34 a.m.)

PSEG Early Site Permit
Advisory Committee on Reactor Safeguards
Subcommittee Meeting
SSAR Section 2.4

June 9, 2015

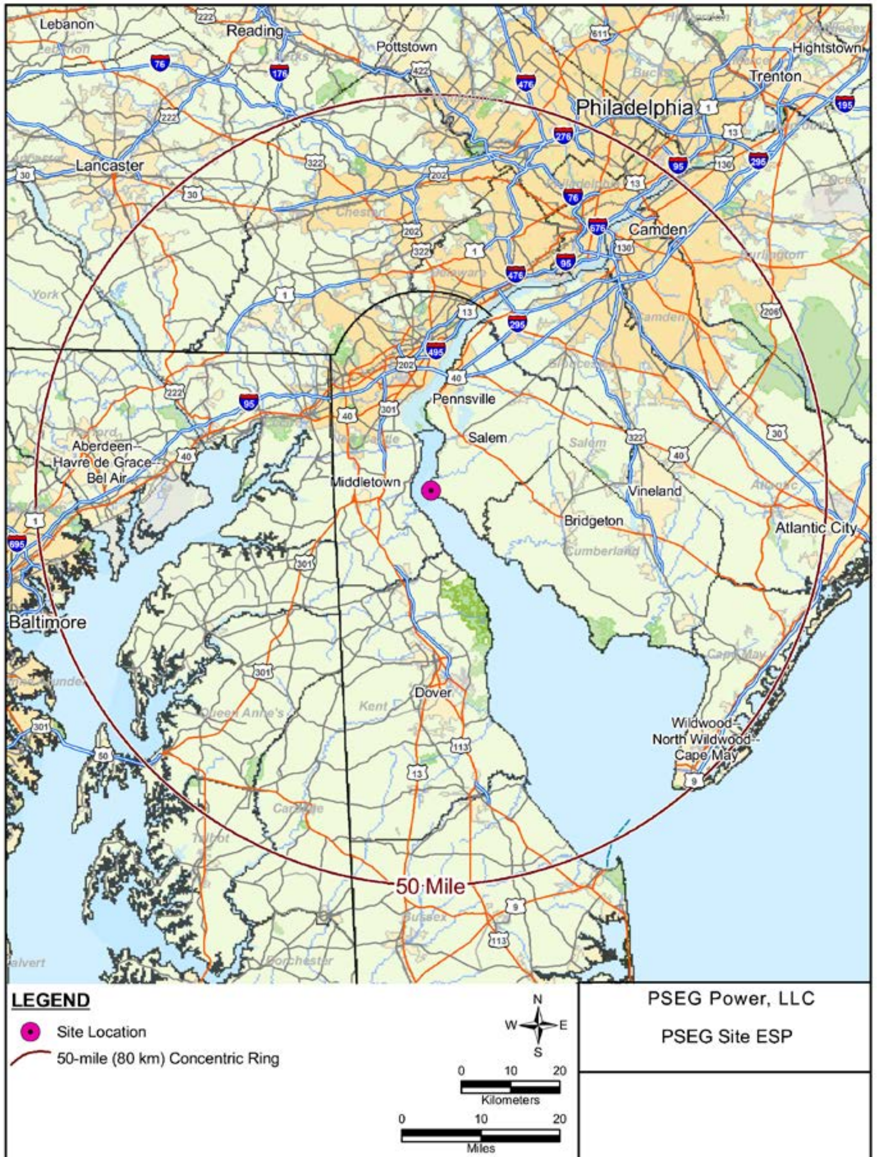
PSEG Power LLC

Chapter 2 – Section 2.4
Hydrologic Engineering

Areas covered in ESP same as for COLA

- RS-002 outlines NRC review approach
- Regulatory Guidance
  - RG 1.27
  - RG 1.29
  - RG 1.59
  - RG 1.102
  - RG 1.206
- NUREG/CR-7046
- NUREG/CR-6966
- QA requirements apply – 10 CFR 50 Appendix B

2.4.1 Hydrologic Description



PSEG Site

- 52 river miles (RM) upstream of the mouth of Delaware Bay.
  - 17 RM downstream of the Delaware Memorial Bridge (RM69)
  - 40 RM southwest of Philadelphia, Pennsylvania (RM 92)
- Head of the Delaware Bay (RM 48)
- Chesapeake and Delaware (C&D) Canal channel entrance (RM 59).

2.4.1 Hydrologic Description

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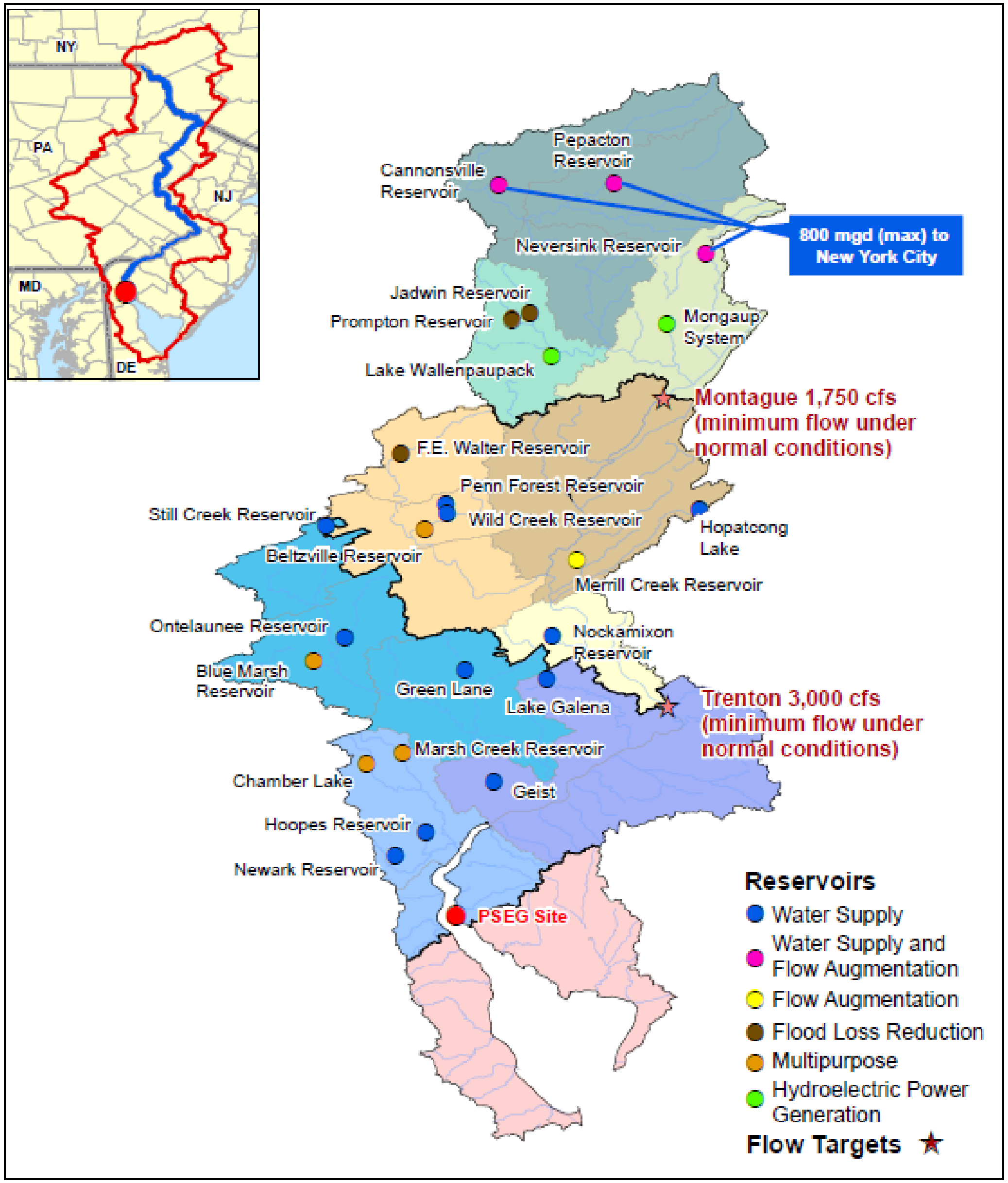
2.4.1 Hydrologic Description

- Delaware River Basin covers 13,600 square miles (sq. mi.)
- Tidal flow ranges from 400,000 cubic feet per second (cfs) to 472,000 cfs
- Freshwater flow is approximately 15,000 cfs
- Delaware River is the longest undammed river east of the Mississippi River



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2.4.2 Floods

Historical records show highest flood events recorded near mouth of Delaware River and within Delaware Bay are caused by storm surge

Events Resulting in Storm Surges in the Delaware River near the PSEG Site

Storm Event	Year	Estimated Storm Surge, ft.[a]	
		Reedy Point	Philadelphia
Hurricane of 1878	1878	5 to 8	5 to 8
Chesapeake-Potomac Hurricane	1933	7.7	7.1
Hurricane Hazel	1954	n.a.[b]	9.4
Hurricane Connie	1955	n.a.[b]	5.0
Hurricane Floyd	1999	2.9	4.0
Hurricane Isabel	2003	5.0	5.4

a) surge above predicted tide
b) n.a. = not available

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2.4.2 Floods

Flooding scenarios investigated for the site include:

- Local Intense Precipitation
- PMF on rivers and streams
- Potential dam failures
- Maximum surge and seiche flooding
- Probable maximum tsunami
- Ice effect flooding
- Channel diversions

2.4.2 Floods (Cont.)

Local Intense Precipitation

- NOAA Hydrometeorological Reports
- HEC-HMS is used to simulate the precipitation-runoff processes in watershed systems to determine peak discharge
- The resulting peak flows are used to determine the maximum WSEL resulting from the PMP event
- Analysis can be refined once a technology is selected and site grading and drainage systems are designed
- Site will be designed to ensure PMP event will not cause flooding events or operational problems

2.4.3 Probable Maximum Flood on Streams and Rivers

Methodology and Inputs

- USACE HEC-HMS and HEC-RAS Model developed and validated for the Delaware River System upstream of the PSEG Site
- Two probable maximum precipitation events considered
  - 15,000 sq. mi. storm centered over Doylestown, PA
  - 2150 sq. mi. storm centered over Philadelphia, PA

Results

- Maximum WSEL is 21.0 ft. NAVD due to PMF combined with 10% exceedance high tide, worst regional surge, and wave runup
- PMF at site is not expected to cause flooding events or operational problems

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2.4.4 Potential Dam Failures

Methodology and Inputs

- Screening of dams and regional combinations developed for failure scenarios
- Seismic failure of dams assumed for immediate breach
  - Dam failures are sequenced, such that flood waters converged at the DE River at the same time

Results

- Failure of Cannonsville and Pepacton Reservoirs produces greatest WSEL of 0.3 ft. NAVD
- Combined events of 10% exceedance high tide, 500 year flood, and wave runup produces a WSEL of 9.4 ft. NAVD
- Dam failure runup at site is not expected to cause flooding events or operational problems

2.4.6 Probable Maximum Tsunami Flooding

Historical Tsunami Record

- Documented seismic events (Puerto Rico, Lisbon 1755)
- Documented landslide events (Grand Banks, 1929)
- Landslide events in geologic record (Currituck, Cape Fear, other sites along east coast continental margin)
- Volcanic cone collapse events in geologic record (Canary Islands)

Modeling Approach MOST (Method of Splitting Tsunami)

- Solves nonlinear shallow water equations
- Used extensively in tsunami forecasting and inundation studies

Probable Maximum Tsunami events

- La Palma Landslide in Canary Islands
- Hispaniola Trench
- Currituck Landslide

2.4.6 Probable Maximum Tsunami Flooding (Cont.)

La Palma Landslide in Canary Islands

- Usual worst case scenario for most coastal areas in the Northeast
- Impact inside Delaware Bay reduced by refraction of incident waves to areas north and south of bay entrance

Hispaniola Trench

- Largest subduction zone in Atlantic Ocean
- Plausible tsunamigenic region based on geological processes and history of events
- Results show slightly larger impact than La Palma case, with more wave penetration into Bay

2.4.6 Probable Maximum Tsunami Flooding (Cont.)

Currituck Landslide

- Representative of large East Coast slide events found in geological record
- Sensitivity tests show wave conditions in Delaware bay are largely insensitive to shifts in assumed slide location along continental shelf margin
- Represents the PMT event for the PSEG site

Model results:

- All tsunami-generated runups and drawdowns at site are not expected to cause flooding events or operational problems
- Maximum runup with 10% exceedance high tide is 1.15 ft. (5.65 ft. NAVD)
- Maximum drawdown with 90% exceedance low tide is -1.16 ft. (-6.16 ft. NAVD)
- Tsunami-induced velocities at site are not large compared to maximum observed tidal currents

2.4.7 Ice Effects

- Historical ice jam information review and model simulation of a major historic ice jam event
  - Flooding potential from historic ice jam discharge is elevation 8.1 ft. NAVD
- Intake structure will be designed to address ice effects, including surface ice, frazil ice, and other dynamic forces and blockages associated with ice effects
- Ice effects at site are not expected to cause flooding events or operational problems

2.4.8 Cooling Water Canals and Reservoirs and 2.4.9 Channel Diversions

2.4.8 Cooling Water Canals and Reservoirs

- These features are not present at PSEG Site

2.4.9 Channel Diversions

- Shoreline near PSEG Site is flat and low and neither a seismic nor severe weather event result in a major shoreline collapse

2.4.11 Low Water Considerations

- 20-year low flow conditions with 90% exceedance low tide simulated in HEC-RAS model result in a WSEL of -5.0 ft. NAVD
- Negative surge from hurricane reduces WSEL in vicinity of the PSEG Site by 10.9 ft.
- Coincident with a 20-year low flow in the Delaware River at Trenton and 90% exceedance low tide, WSEL could be as low as -15.9 ft. NAVD
- A safety-related intake structure designed to operate during low water conditions identified
- Low water conditions at site are not expected to cause operational problems

Chapter 2 – Section 2.4.5 Probable Maximum Surge and Seiche Flooding

2.4.5 Probable Maximum Surge and Seiche Flooding

Probable Maximum Hurricane (PMH) Storm Meteorological Parameters based on NWS 23

- Central pressure, P_0 = 26.65 inches of mercury (Hg)
- Pressure drop, delta-P = 3.5 in. of Hg
- Radius of maximum winds, R = from 11 to 28 nautical miles (NM)
- Forward speed, T = from 26 to 42 knots (kt)
- Coefficient related to density of air, K = 68
- Track direction, from 138 degrees (moving northwest)

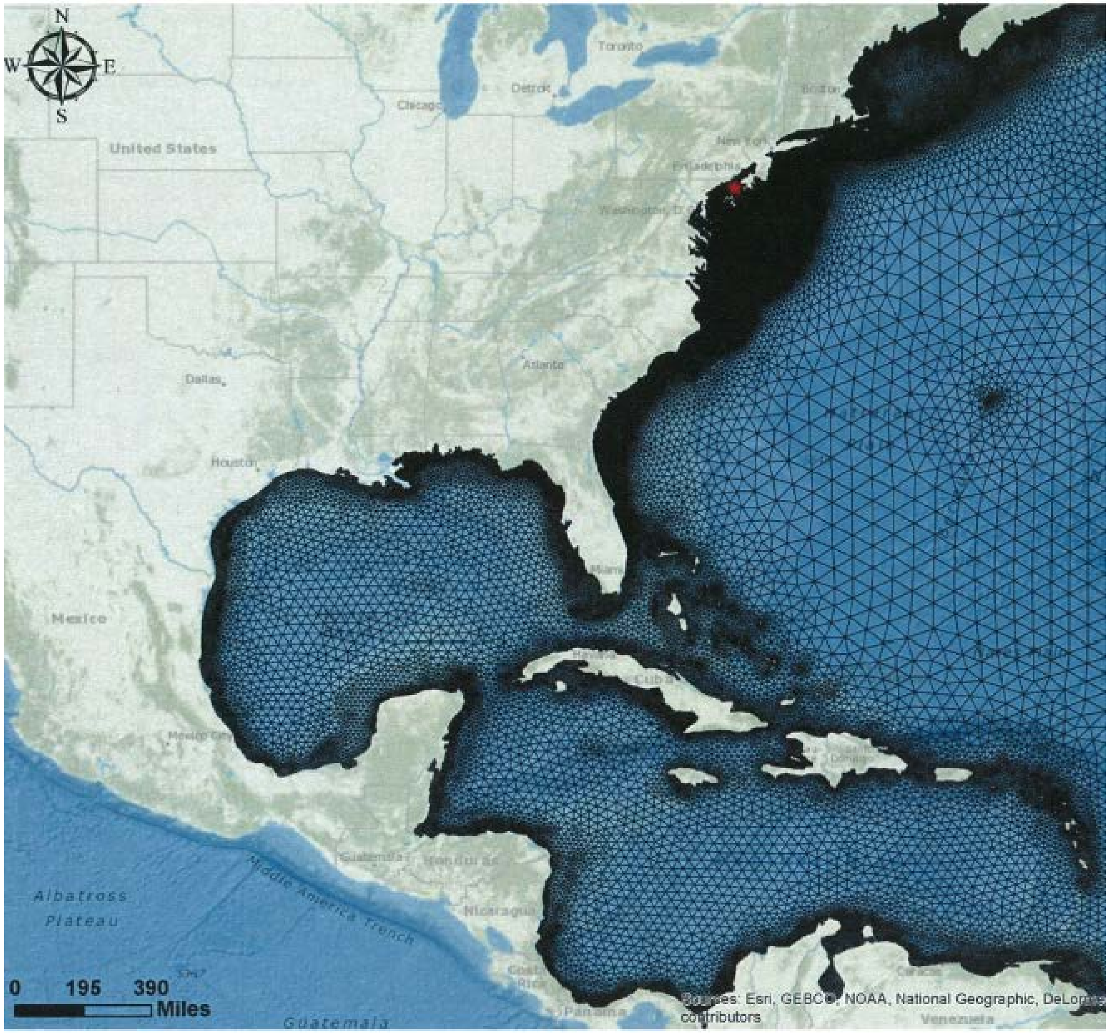
PSEG ESPA Storm Surge Screening

- Modeled with Bodine storm surge method
- Coupled with HEC-RAS; Kamphuis wind setup method; and Coastal Engineering Manual wave runup method
- Parameters Resulting from Screening: R = 28 NM; T = 26 kt
- Produces total Water Surface Elevation (WSEL) of 42.4 ft. NAVD

2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

PSEG developed a high resolution 2-D storm surge model (ADCIRC+SWAN) to support development of the response to RAI No. 67

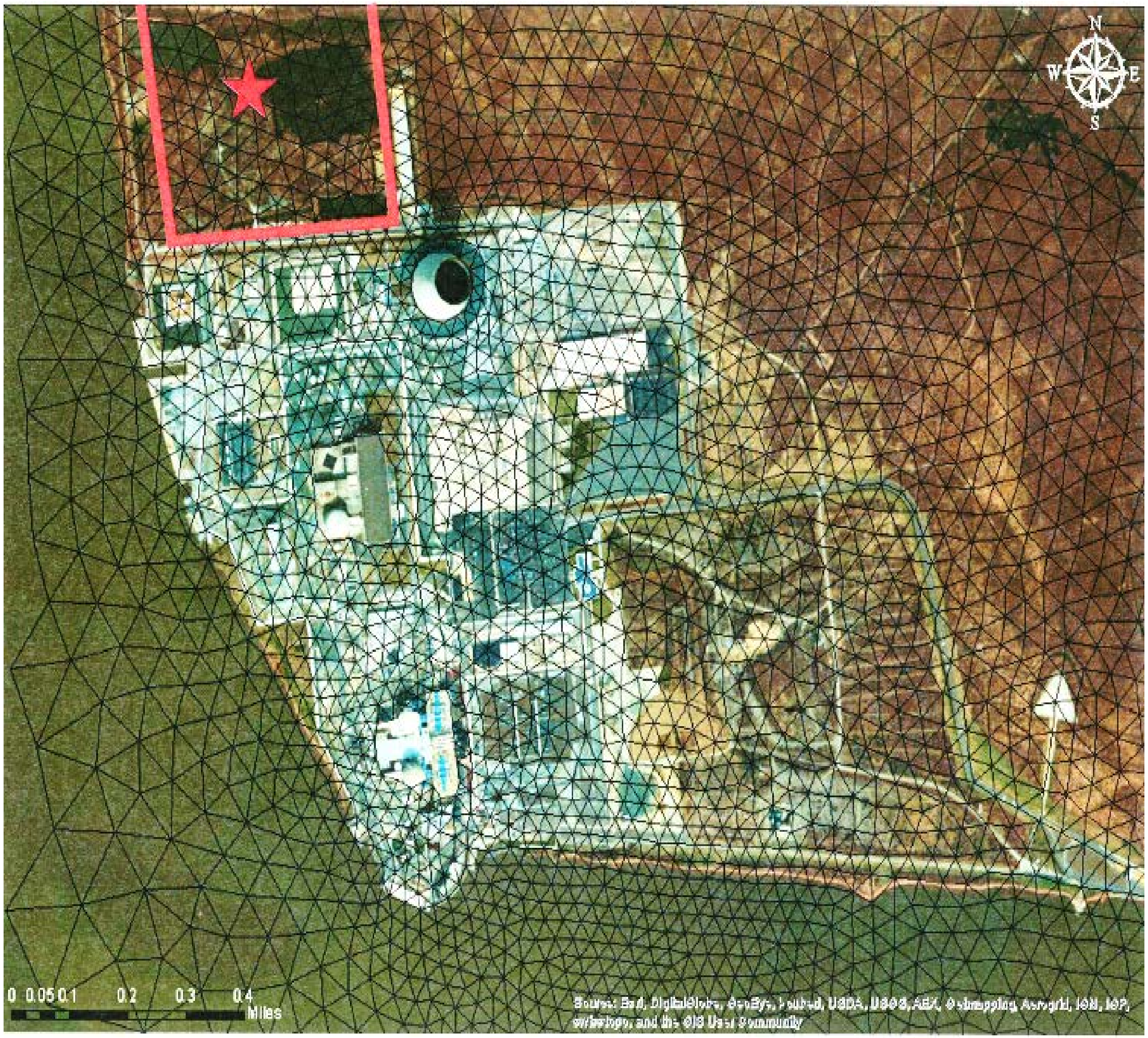
- 2-D models are recognized as a more accurate storm surge modeling tool
- FEMA Region III coastal flood study



2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

Use high resolution ADCIRC+SWAN Model to determine total design basis WSEL for the selected PMH storm

Finite element mesh refined at project site



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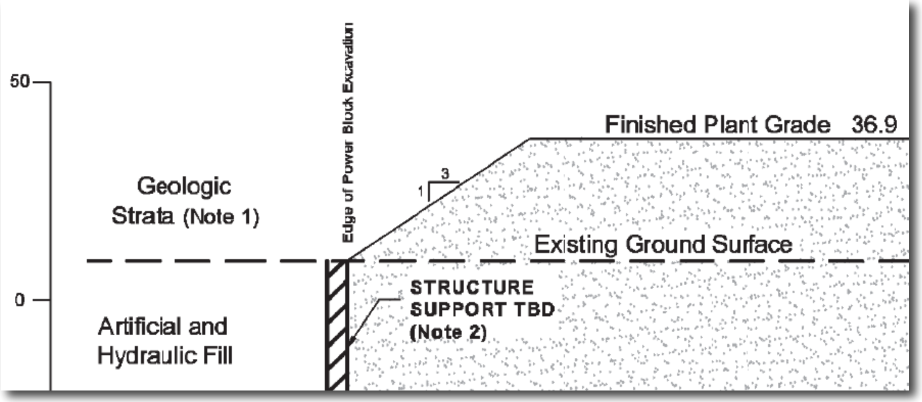
2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

Wave runup determined using USACE Coastal Engineering Manual (CEM) Methodologies

Output from ADCIRC+SWAN Model evaluated at four points around powerblock



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2.4.5 Probable Maximum Surge and Seiche Flooding (Cont.)

PMH Maximum Total Water Surface Elevation

- 2-D ADCIRC+SWAN Model Results:
  - Antecedent Water Level 1.35 ft.
  - Maximum Still Water Level 20.2 ft. NAVD
  - Wave Runup 7.4 ft.
  - 10% Exceedance High Tide 4.5 ft.
  - Maximum Total Water Surface Elevation 32.1 ft. NAVD

Design Basis Flood Total WSEL is 32.1 ft. NAVD

2.4.10 Flooding Protection Requirements

- All safety-related SSC (with exception of intake structure) for new plant will be constructed at least one foot higher than DBF
- New plant site grade is established at 36.9 ft. NAVD. This meets requirements of a dry site as defined in NRC RG 1.102
- Riprap protection will be provided on the slopes of the site to provide protection from wave runup

Section 2.4.12 Groundwater and Section 2.4.13 Accidental Release of Radioactive Liquid Effluents

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Regional Hydrogeology and Groundwater Use

- Regional hydrogeologic units are characterized as permeable coarse-grained materials separated by less permeable fine-grained materials within NJ Coastal Plain
- PSEG Site lies outside two Critical Water-Supply Management Areas designated in NJ
- PRM aquifer system (about 400 to over 1000 ft. below grade) provides majority of potable water for region and PSEG site
- Nearest off-site public water supply well is located more than 3.5 miles west of PSEG Site, across Delaware River, in DE

2.4.12 Groundwater (Cont.)

Regional Hydrogeology- Hydrostratigraphic Classification

Site Stratigraphic Unit	Hydrogeological Characteristics
Artificial & Hydraulic Fill	Leaky confining units.
Alluvium	Upper portion is a water-bearing zone; lower silts and clays, when present, act as a leaky confining unit.
Kirkwood Formation (upper)	Leaky confining unit.
Kirkwood Formation (lower)	Water-bearing zone; part of the Vincentown Aquifer.
Vincentown Formation	Water-bearing zone.
Hornerstown Formation (upper)	Upper portion is a water-bearing zone and part of the Vincentown Aquifer.
Hornerstown Formation (lower)	Lower portion, along with the Navesink Formation act as a leaky confining unit.
Navesink Formation	Leaky confining unit.
Mount Laurel Formation	Water-bearing zone, with the Wenonah Formation comprises the Wenonah-Mt. Laurel Aquifer.
Wenonah Formation	Water-bearing zone.
Marshalltown Formation	Confining unit.
Englishtown Formation	Water-bearing zone.
Woodbury Formation	Confining unit.
Merchantville Formation	Confining unit.
Magothy Formation	Water-bearing zone.
Raritan Formation	Confining unit.
Potomac Formation	Water Bearing Unit.

2.4.12 Groundwater (Cont.)

Local Hydrogeology and Groundwater Use

- The deeper PRM aquifer has sufficient capacity to provide potable groundwater to support new plant construction and future operations without inducing saline intrusion
- Investigations characterized shallower hydrogeologic units at new plant location to support construction and accidental release evaluations
- Shallow aquifers in vicinity of site are saline and tidally-influenced and not potable water sources
- In new plant area, predominant groundwater flow direction in shallower units (Alluvium and Vincentown aquifers) is westerly toward Delaware River

Local Hydrogeology

Average Groundwater Elevations (ft. NAVD) in Alluvium

Site Groundwater Modeling

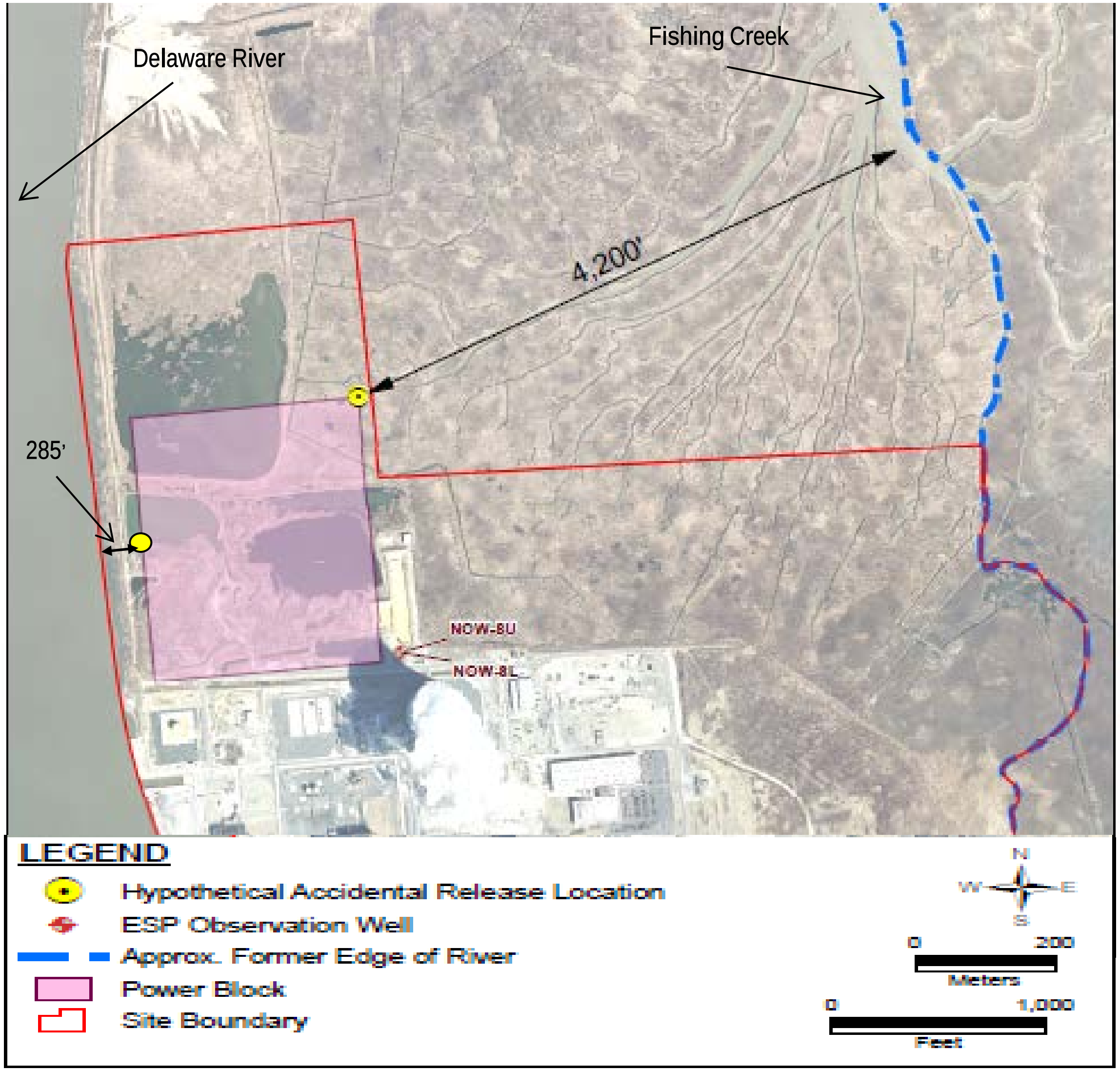
- Site-wide groundwater model developed, based on the PPE, to assess:
  - Dewatering requirements during construction
  - Effects of dewatering on shallow aquifers
  - Post-construction hydrostatic loading
- Site Groundwater modeling results:
  - Dewatering requirements consistent with HCGS construction
  - Groundwater levels in the shallow aquifer will return to a natural condition, which will be only slightly higher than preconstruction
  - Local mounding in shallow aquifers is possible due to soil retention wall placement
- Groundwater model will be refined once a reactor technology has been selected

Accidental Release in Groundwater

- Two accidental release locations are hypothesized at the edge of Power Block:
  - At western edge of Power Block assuming migration west toward the Delaware River
  - At northeast corner of Power Block, assuming migration northeast toward a Delaware River tributary named Fishing Creek
- Conservative hydrogeologic parameter values are used in the evaluation, as are minimum distances to two potential receptor locations
- Shortest transport pathway is taken as through shallowest unit (Alluvium)

2.4.13 Accidental Release of Radioactive Liquid Effluents in Groundwater and Surface Water (Cont.)

Accidental Release in Groundwater – Hypothetical Flow Paths



PSEG Power LLC

Accidental Release in Groundwater

- Exposure point concentrations compared to Effluent Concentration Levels (ECLs) defined in 10 CFR Part 20
- Assuming maximum groundwater velocities, and solely advective transport with decay, some radionuclides would exceed ECLs for each release scenario
- Factoring in dilution results in levels up to several orders of magnitude below ECLs and Unity Rule is met for each release scenario

Accidental Release to Surface Water

- No potable surface water bodies located downgradient of the PSEG Site

- Outdoor tanks containing radionuclides will have secondary containment to prevent catastrophic release of liquid effluent directly to surface water

- Controlled release points will be established for systems that could be in contact with radioactive liquids to prevent unmonitored discharges to surface water

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Presentation to the ACRS Subcommittee

Safety Review of the PSEG Site Early Site Permit Application

Presented by

Prosanta Chowdhury, Project Manager

NRO/DNRL/LB1

June 9, 2015

Purpose

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- Brief the Subcommittee on the status of the staff's safety review of the PSEG Site early site permit (ESP) application
- Support the Subcommittee's review of the application and subsequent interim letter from the ACRS to the Commission
- Address the Subcommittee's questions

Meeting Agenda

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- Introduction, Schedule Milestones, Status of Safety Evaluations (SEs)
- Key Review Area:
  - Hydrologic Engineering
- Advanced Safety Evaluation (ASE) with no Open Items (OIs) Conclusions
- Presentation Conclusions
- Summary of Safety Evaluations
- Discussion / Questions

PSEG Site ESP Application

- ESP applicants: PSEG Power, LLC and PSEG Nuclear, LLC (PSEG)

- Proposed ESP Site located in Lower Alloways Creek Township, Salem County, NJ (30 miles southwest of Philadelphia, PA, 7.5 miles southwest of Salem, NJ)

- Located on the upper Delaware Bay adjacent to and north of Hope Creek Generating Station (HCGS). The two-unit Salem Generating Station (SGS) is co-located on this site to the south of HCGS

PSEG Site ESP Application

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- PSEG developed Plant Parameter Envelope (PPE) using 1-Unit U.S. EPR, 1-Unit ABWR. 1-Unit US-APWR, and 2-Unit Passive AP1000

- PSEG requests permit approval for a 20-year term

- PSEG does not seek approval for limited work authorization (LWA) activities

- PSEG seeks approval for complete and integrated emergency plans with ITAAC as part of ESP

Schedule Milestones

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Completed

- PSEG Site ESP Application Received - 5/25/2010
- Acceptance Review Completed - 8/4/2010
- **Phase A** - RAIs Issued - 9/2013
- **Phase B** - Advanced Safety Evaluation (SE) with no Open Items Issued – 5/2015
- Chapters **Presented to ACRS** on March 19, 2014 -
  - 3.5.1.6, 11.2&11.3 (combined), 13.3, 15.0.3, 17.5
- Chapters **Presented to ACRS** on Sept. 29 & 30, 2014 -
  - 2.1&2.2 (combined), 2.3, 2.5
- Chapter 20 (Fukushima) points to other SEs where applicable Fukushima NTTF recommendations are evaluated

Schedule Milestones

Remaining

- Chapter 2.4 (Hydrologic Engineering) - Being Presented to ACRS Today (June 9, 2015)
- ACRS Full Committee Meeting - Scheduled for June 10, 2015
- **Phase C** - ACRS Meetings - Completion by 07/31/2015
- **Phase D** - Final Safety Evaluation Report (FSER) - Completion by 09/30/2015

Inspections / Site Visits/ Audits

- Inspections / Site Visits/ Audits:
  - Pre-application Site Visit – 1/2008
  - Emergency Planning Site Visit - 5/2010
  - Hydrologic Engineering Site Visit and Audit - 2/2011
  - Quality Assurance Audit - 5, 6/2011
  - Geology Site Visit and Audit - 9/2011
  - Meteorology Site Visit - 5/2012
  - Seismic Software Audit – 9/2013

Acronyms

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- ANS/ANSII – American Nuclear Society / American National Standards Institute
- COL – Combined License
- CP – Construction Permit
- DC – Design Certification
- ESP – Early Site Permit
- HCGS – Hope Creek generating Station
- NAVD88 – North American Vertical Datum 1988
- NJDEP – New Jersey Department of Environmental Protection
- PPE – Plant Parameter Envelope
- SER – Safety Evaluation Report
- SGC – Salem Generating Station
- SSAR – Site Safety Analysis Report
- SSC – Structures, Systems, and Components
- USACE – United States Army Corps of Engineers

Key Review Area

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Chapter 2, Section 2.4
"Hydrologic Engineering"
(ASE Issued April 22, 2015; ADAMS Accession No. ML13211A144)

Principal Contributors

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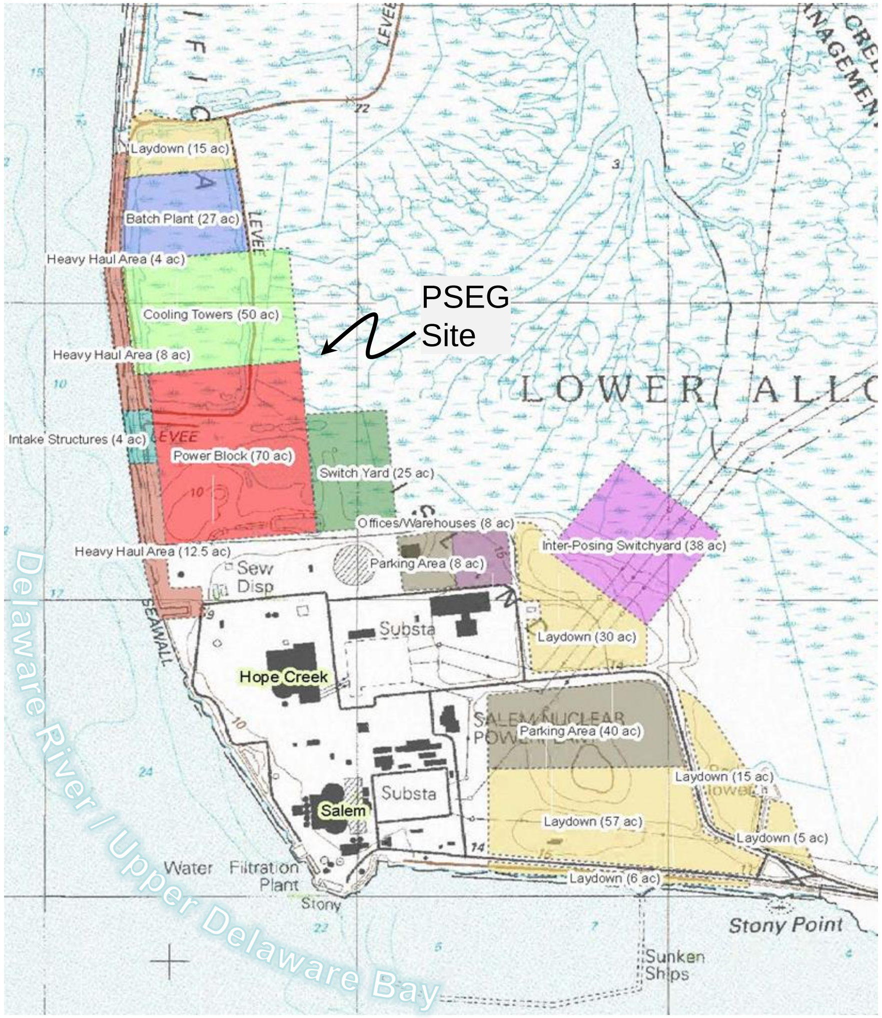
Henry Jones, Ph.D.

PSEG Site - Regional Setting.

Background

- Hydrologic engineering staff conducted a visit at the PSEG site February 2011
  - Topics included site setting, hydrologic site characteristics and associated document reviews
- Staff coordinated review with state and federal agencies
  - NJDEP, USGS (surface water / tsunami), USACE, NOAA
- Performed independent review and confirmatory analyses as explained in upcoming slides



Proposed PSEG Site Layout (from SSAR Rev 0 Figure 1.2-3).

Overview

- PSEG ESP Site located on eastern shore of lower Delaware River / upper Delaware Bay
- Approximately 13,600 mi^2 watershed
- Tidal flow dominates fresh water flow at the Site
  - Wide & open connection to Atlantic
- Existing site grade 5-15 ft
- Proposed site grade 36.9 ft
- Storm surge is DBF determining event at 32.1 ft

Looking north over Salem/Hope Creek.

Flood Analysis Summary
– Local Intense Precipitation

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- Site drainage design dependent on reactor technology selected
- Local intense precipitation review deferred to COL stage
  - **COL Action Item 2.4-1:**

    COL or Construction Permit (CP) applicant referencing this ESP should design the site grading to provide flooding protection to safety-related structures at the ESP site based on a comprehensive flood water routing analysis for a local PMP event without relying on any active surface drainage systems that may be blocked during this event.

Flood Analysis Summary
– Probable Maximum Flood

- **Probable maximum flood (PMF) 21.0 ft per ANSI/ANS-2.8-1992 combinatory events**
  - Probable maximum precipitation
  - Runoff and infiltration conservatively estimated
  - Surge/seiche from worst regional historical hurricane and 10 percent exceedance high tide

- **Results**
  - Maximum calculated riverine water level 15.9 ft below proposed site grade

Probable Maximum Surge and Seiche

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- Initial screening method (1D with wind model)
  - Results extremely conservative (42.4 ft NAVD88)
- Moved to current best practice approach
  - Physics-based 2D model added realism / incorporated conservatism
  - Resulting design basis flood (DBF) 32.1 ft NAVD88

100-yr Sea Level Rise[1] (ft)	1.35 ft
Ten Percent Astronomical High Tide[2] (ft)	4.5 ft
Maximum Still Water Level (ft-NAVD88)	20.2 ft
Wave Runup[2] (ft)	7.4 ft
Maximum Total Water Surface Elevation (ft. NAVD88)	**32.1 ft**

[1]Added prior to model simulation for initial sea level
[2]Added after model simulation to maximum still water level at site

Flood Protection
- Intake Structure

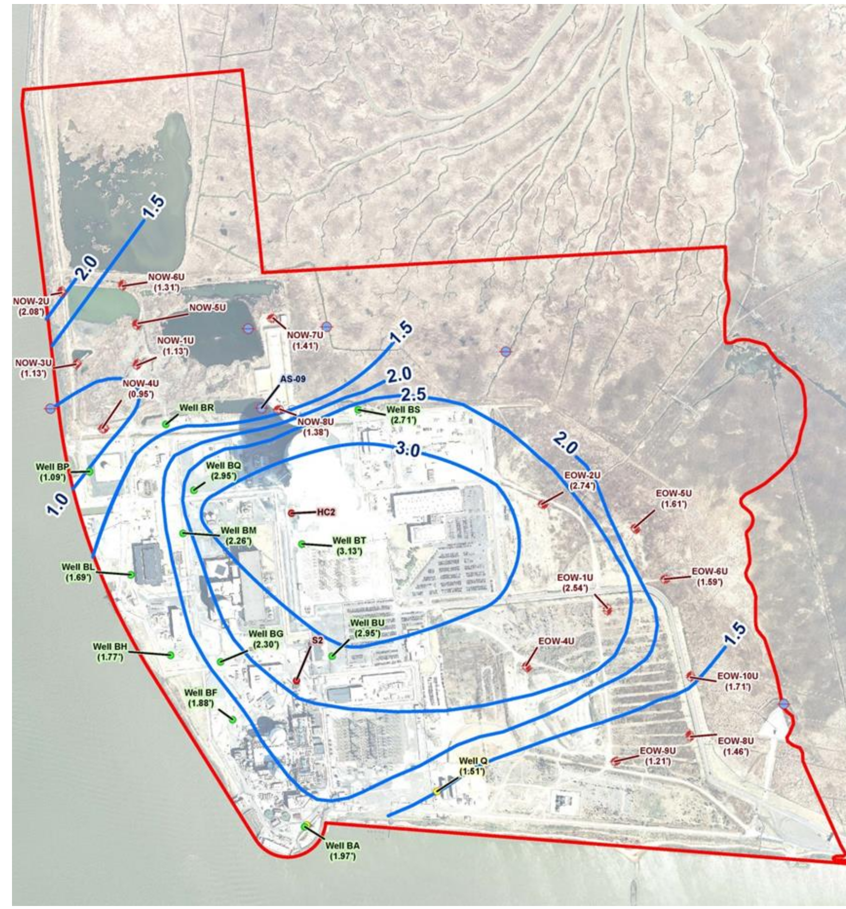
- Site grade of 36.9 ft
- DBF of 32.1 ft
- Sufficient margin for safety related site grade SSCs
- Intake structure design and associated flood protection considered at COL stage
  - **COL Action Item 2.4-2:**

    COL or CP applicant referencing this ESP should address whether the intake structure of the selected design is a safety-related SSC. If so, the applicant should address necessary flooding protection for a safety-related intake structure at the ESP site based on the design basis flooding event and associated effects.

Groundwater

- **Proposed site grade 36.9 ft**
  - Maximum groundwater level 10 ft
- **Monitoring program implemented during construction and operation**
  - **COL Action Item 2.4-3:**

    COL or CP applicant referencing this ESP should refine hydrogeologic parameters and model estimates of dewatering rates and drawdowns beneath existing site structures after determination of the final excavation geometry consistent with a selected reactor technology.



PSEG Site September 2009 Potentiometric Contours.
(from SSAR Rev 0, Figure 2.4.12-4).

Plant Parameter Envelope
- Site parameters

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Technology	Max Flood Level (ft below grade)	Max Groundwater Level (ft below grade)
U.S. EPR	1.0	3.3
ABWR	1.0	2.0
APWR	1.0	1.0
AP1000	0.0	2.0

Water Levels and PSEG ESP Site Grade

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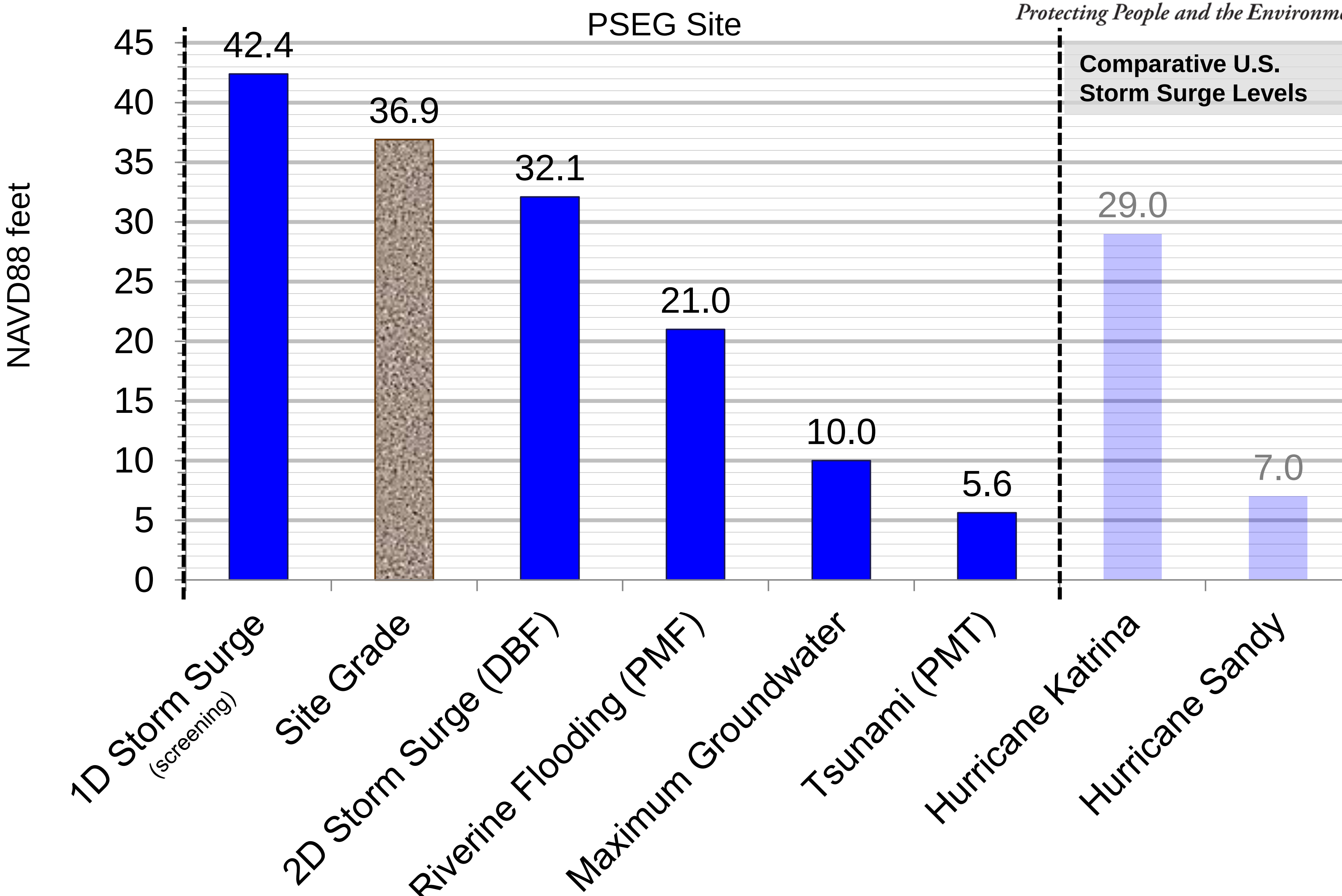

Accidental Releases of Radioactive Liquid Effluents

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- Scenarios account for potential post-construction flow directions:
  - Delaware River towards west
  - Marshland towards northeast
- Incorporated bounding PPE and conservative hydrologic characteristics
- Results
  - Concentration of each radionuclide is less than associated limit in 10 CFR 20.
  - Sum of the ratios (predicted concentration vs. 10 CFR 20 limit) for all radionuclides in the mixture is less than unity

SE Conclusions

- Conclusions from the Hydrologic Engineering review:

  The applicant has provided sufficient information about the site description, satisfied the requirements, and considered the most severe natural phenomena that have been historically reported for the site and surrounding area and appropriately estimated the design-basis flood (DBF) elevation.

Presentation Conclusions

- ASER defers general regulatory conclusion regarding site safety and suitability to FSER in Phase D
- ASE with no Open Items on Chapter 2, Section 2.4 –
  - Contains no permit conditions
  - Contains three (3) Action Items to be addressed by a COL or CP applicant referencing the PSEG Site Early Site Permit
- Summary of Safety Evaluations
- Next Interaction with ACRS – June 10, 2015