UNITED STATES OF AMERICA

U.S. NUCLEAR REGULATORY COMMISSION

SEISMIC INFORMATION WORKSHOP

DAY 2

SESSIONS 5 & 6

September 9, 2010

8:00 A.M.

TRANSCRIPT OF PROCEEDINGS

Public Meeting

San Luis Obispo, CA

APPEARANCES

Panel:

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P R O C E E D I N G S

MR. MAIER: Welcome everyone to the second day of the Seismic Information Workshop. My name is Bill Maier. For those who weren't here yesterday, I'll go through a couple of the logistics and safety issues before we get started with the program.

I am Bill Maier. Again, I am with the Nuclear Regulatory Commission's Region IV office in Arlington, Texas, and it's my pleasure to be the facilitator. Helping me with facilitation duties is Butch Burton. Butch is a branch chief in our Office of New Reactors in NRC headquarters in Rockville, Maryland.

And before we go into introductions, I want to go over a few safety and logistic things for those who were not here yesterday. First of all, for fire alarms, we have doors right here and on the other side there. If you'll please file out, go into the parking lot, move away from the building, give other folks a chance to get out, we would appreciate that. CPR; would the CPR certified folks please raise your hand so that we can provide that level of comfort? Restrooms you should've seen on the way in as you were coming in from the main entrance. They are out on this direction past the Edna Room [spelled phonetically].

Today, I want to point out that AGP Productions is videotaping. They request that cell phones be put on vibrate or taken off and a special request for folks -- and this is almost an impossible request to ask -- the use of BlackBerrys and laptops with wireless connectivity create a little bit of distortion, a little bit of interference with the visual and the audio presentation, so AGP asked folks to do a special effort to try to keep your BlackBerry use and your laptop use to a minimum if you're using wireless. Since it will be videotaped, they ask that folks not shout out from the floor because you won't be heard on the audio. We request that you -- if there is a question that people raise their hand, wait for us to come around. Only one person speak at a time, and, you know, the person with the microphone will have the floor.

Okay. For those who did not attend yesterday, I have an apology to make and that is we had thought we had printed up enough of the copies of the slide presentations for everyone to use but for some reason, they all walked away. And I should have mentioned yesterday if you were here yesterday and were coming back today to please bring your slide presentations with you. We currently are on a mission of mercy at Staples next door to try to get some printed out. We should have them here by the first break, so hopefully if you don't have a copy you'll be able to get a copy then.

I would like to point out the displays that are in the Los Osos Room [spelled phonetically] and I don't know if we have any in the Edna Room but there are certainly some displays in the Los Osos Room and invite you to check those out on the breaks or any time that you feel that you need to walk around. Refreshments are at the back. We've got the two water stations. And I think that's it as far as logistics and safety.

And I think we'll get to introducing to the -- we'll get started with introductions and I will introduce the person who is going to provide the opening remarks for today's session. And I have a mea culpa to make. Your agenda is incorrect. We -- originally when we started advertising this workshop, we had tried to get Commissioner James Boyd of the California Energy Commission to kick off the second day discussions. Unfortunately, Commissioner Boyd was called away to a renewable energy citing hearing, which is apparently a command performance for the Energy Commission these days. And as such, he sends his regrets, and Barbara Byron, who is representing the Energy Commission on one of the panels, will convey some of the statements that Commissioner Boyd wished to make if he were here.

But we -- your agenda said that Roy Caniano was going to fill in as the welcoming speaker, but that's not correct. When Commissioner Boyd cancelled I threw out a Hail Mary pass in the form of an e-mail to a gentleman who I thought would be far too busy to be able to be here today, but at the last minute -- and I found out yesterday that he is able to come here, so it's my pleasure to introduce Senator Sam Blakeslee, the most recently elected senator for the state of California and the author of several of the legislation bills that will be discussed in future sessions here today; most notably, AB 1632 and AB 42 -- is that the correct? So, I don't think I need to give any more introduction to Senator Blakeslee. Here is your Senator, Sam Blakeslee.

[applause]

DR. BLAKESLEE: Thank you, Bill. Evidently, my duties include welcoming you and I [break in audio] welcome to everyone, especially the second day, where we'll have an opportunity to discuss and review some of the more specific applications of seismology to the Central Coast and one facility in particular, which I know is of interest to everyone in this room.

I just wanted to share a couple of quick thoughts. As the discussions we're having deal with a very momentous issue, which is the safe operation of an aging nuclear power plant in the vicinity of and close proximity to a number of faults -- which, at this stage, are still in the process of being understood and characterized; one fault in particular which has been identified only recently within the last two years located very close to a plant of unknown length and seismic potential.

Right now, there's local public -- there is a local public that is very concerned about the facts as they -- as we understand them and as they exist, and they are right to be concerned. It's their households, it's their families, it's their children, it's their livelihood; it's their entire lives that are on the line for the NRC making the right decisions in these upcoming processes. And they also require -- they also depend very heavily on the employment provided by this facility. Many people's livelihoods depend upon being able to continue to work at an environment providing energy for the state of California.

And it's right that PG&E would be concerned about the coming proceedings. As the nuclear power plant provides a significant addition of electrons to their customers that are sorely needed at a time when baseline -- baseload power is in short supply and state's moving more to a renewable portfolio standard with intermittent power, which can be costly and less reliable than baseload. So, PG&E obviously has a very, very big stake and is concerned about the proceedings here, as they should be. And of course, they are concerned for the safe and reliable operation of the plant because there's consequences to their shareholders, so they have concerns.

And the state has concerns. The state of California is very mindful, especially in its current precarious financial situation, of the potential impact of a Katrina-like disruption. We certainly saw in Japan the past couple of years the financial impact to ratepayers in the many billions of dollars for the sudden and unintended and unsuspected cessation of operation of a facility which provided a significant component of the power to Japan.

Those ratepayer impacts of course are within the prevue of the state of California but ultimately, all of the most important duties that connect with the question of seismic safety go to the question of what the NRC is going to do as they evaluate the risks and the setting on which the facility is operating.

So perhaps a little bit off script, my comments are not as much to the assembled audience, whether it be members of the public, PG&E, or the state of California, as much as my comments are directed to the NRC.

I remember growing up here on the Central Coast as a young man in the late ‘70s -- I think I was in my 20s -- attending NRC -- I believe it was an NRC hearing on whether or not a nuclear power plant would be licensed. And I knew little about it; I think I went to the Vets Hall just as a kid who wanted to learn more. And I remember hearing a seismologist talk about the effects of focusing and the directivity effects that can occur when a fault propagates, rupture propagates along a fault in one direction versus another direction. And I remember being perplexed when the assembled panel dismissively contended that because such effects -- this is of course the late ‘70s -- were more speculative and less well observed and difficult to quantify that it wouldn’t be appropriate to put too much weight on that hypothetical phenomenon.

And I remember sort of scratching my head at that point as a 20 year old not knowing much about this field, why those comments would be forthcoming given the gravity of potential threat of not understand the potential ground motion.

Now, years later, I ended up going to Berkeley, ended up doing a degree with Professor Bruce Bolt on [unintelligible] -- who worked the area of [unintelligible]. And it became abundantly clear that this was not a hypothetical phenomenon; it was in fact an area of active research and is now completely understood and accepted and included in virtually all modeling.

Why do I share that recollection from almost 30 years ago? Because although much has happened in the intervening 30 years with regard to our ability to do robust modeling, especially numerical modeling -- I think Professor Ralph Archuleta was here yesterday and talked about some of his very impressive work -- much has been done to understand the existing faults. Much more is known today certainly than was known 30 years ago when we first embarked on this journey.

What is equally important is what is not known, and our level of knowledge, although it has advanced significantly, still remains woefully inadequate to fully understand the potentialities of the fault systems that exist and operate here in the Central Coast.

So the reason my comments are to the NRC is because I believe that the NRC has a duty to go beyond a check box approach when it comes to relicensing. There are many simple and straight-forward actions which entail looking at metal fatigue and very well understood, quantifiable questions which can be asked and answered. And those are the sorts of questions that are probably the funnest to ask because you can get a quick answer and it fits on a spread sheet easily. But there are still more important questions that deal with what we don't know that need to be asked and pursued by the NRC with great vigor.

It is not, I think, up to the public or the state or PG&E to prejudge the outcome of those robust investigations. We need to allow the facts to inform our decisions. But those decisions will not be robust if they are not informed by the facts, which means we have to ask the right questions.

In conclusion, we have just experienced the most significant environmental disaster in the history of the nation and that disaster did not occur because the workers didn't work hard, because BP didn't care about safety, or because the concept of drilling was so fundamentally flawed it should never be done anywhere. The failure that we experienced was largely a regulatory failure, a failure that involved a check-the-box mentality, a mentality which may work 90, 95, 99 percent of the time. But there are certain special, unique instances where a regulatory entity needs -- has higher duty to ask harder questions and be sure their analysis is rigorous, robust, and goes beyond checking the box. And that is certainly true in the case of deepwater drilling and it's probably even more true in the case of an aging nuclear power plant in close proximity to large and still-being-quantified faults that are under investigation.

So, my comments to the NRC are that they treat this work before them with an extra level of care. That this not just become one of the many scores of plants which are scheduled to be relicensed or scheduled to have certain safety issues looked at routinely, but with an understanding that the stakes are extremely high in a case like this. And I stand ready to work with the public and work with PG&E and work with the NRC and work with the state to help ensure we get good answers.

But I also wanted to share that if it becomes clear that that level of duty is not being taken by the NRC, the state of California will act to protect the public, to protect ratepayers, and to make sure that we have a reliable power source in the state of California. And we need to be a partner in this and go beyond a check-the-box approach. Let's ask the right questions and get good, solid answers. Thank you very much.

[applause]

DR. PECK: Good morning. We're assembling the panel here for the fifth session. I'll make some brief introductions. We need one more panel member. Just by way of reminder, our IT folks in the back have reminded us that some of the crackling that we're observing with the microphone is a result probably of interference from the use of BlackBerrys, so we might ask to help improve the quality and the fidelity of the recording as well as the ability to communicate to all of you this morning, we ask that maybe the BlackBerry use be suspended here.

Well, my name is Michael Peck. I am one of two NRC resident inspectors assigned to the Diablo Canyon Nuclear Power Plant. I think you met Tony Brown yesterday; he was -- is the other inspector. And I have the opportunity this morning. Now, this session has really two objectives; the first is to provide a review of the timeline of the Diablo Canyon Power Plant licensing, revisions, and plant modifications made after the Hosgri Fault was identified.

During the construction of the nuclear power plant, the original construction, about halfway through, a new geological feature was discovered off-shore. This geological feature subsequently became known as the Hosgri Fault and provided numerous both engineering challenges and licensing challenges to the plant, and that's going to be discussed in detail.

The second objective is to provide a summary and historical incurrent, a summary of Pacific Gas and Electric seismic monitoring programs. And I think, as we talked about yesterday, today is Diablo Canyon day, so Diablo Canyon Pacific questions are not only welcomed but encouraged.

And with that, I will introduce the panel. First, on my left, is Lloyd Cluff. Lloyd is the director of the PG&E Geoservices [sic] Department and is responsible for the Earthquake Risk Management Program. Mr. Cluff also serves as an advisor on seismic safety to government agencies throughout the world regarding the evaluation of earthquake and geological hazards and developing risk measures. And as my role as a regulator over the last several years, I have had an opportunity to directly interface with Mr. Cluff and I can tell you that I've walked away from that experience learning a great deal about seismic interactions and how that applies to the design of nuclear power plants.

Also to my left is Marcia McLaren. Marcia is a seismologist with PG&E, the Geoservices [sic] Department, where her primary responsibility includes earthquake emergency response, performing seismic hazard studies, and managing the PG&E Strong Motion Program. Marcia also manages the Geoscience's Central Coast Seismic Network.

And on my right is Goutam Bagchi. Goutam is a senior advisor with the Nuclear Regulatory Commission, Division of Site Environmental Evaluations, which is part of the Office of New Reactors, which is in the process of -- currently in the process of reviewing the license applications, combined license applications of the new plants. Goutam brings over 43 years of plant-specific experience in the review of components, systems, and that in the relationship to seismic design.

And with that, I'll turn it over to Mr. Cluff.

DR. CLUFF: Thank you, Dr. Peck --

[break in audio]

-- I am the first speaker but I am going to talk about the history of Diablo Canyon Nuclear Power Plant starting with the Long Term Seismic Program, which began in late 1984. The earlier history that Dr. Peck referred to will be covered by the last speaker, Goutam Bagchi, and Marcia will follow me in talking -- continuing over the activities that have to do with the Long Term Seismic Program. Oops -- ah. It's on the other side. Okay, thank you very much. And she assists in making presentations.

[laughter]

It's unfortunate that anyone in the vicinity can't see this plant on one of the most beautiful coast lines in California, but there it is. So, the -- 1983 to 1985 is when the Advisory Committee on Reactor Safeguards recommended back in the '70s, late '70s that in about 10 years, a comprehensive seismic evaluation be done of Diablo Canyon.

On November 11, 1984, the PG&E got the full-power operating license issued with a condition required: That the Long Term Seismic Program -- we call it the LTSP -- be carried out. And I joined PG&E in February of 1985 to carry out that program. The ACRS committee approved our plan in March of '85 and then Unit 2's operating license with the seismic safety condition was given in August.

So to be brief, the four elements of the license condition, shown on the slide, and the first item was to take into consideration all the data that had been developed over the years on seismic sources in the central California coast and look at all the interpretation that had been developed since the ASLB hearings were done in the mid to late '70s and then gather additional relevant data where appropriate -- so, I am going to talk about that and the conclusions of that in future slides -- and then take the activities and the result from item one and reevaluate the magnitude of the earthquake that was used for the seismic design basis at the power plant. And then, given that evaluation, to take all three of the items and excess -- assess the significance of all the conclusions drawn from the previous assessments and utilize both deterministic and probabilistic seismic margin to make sure they were adequate.

So, the LTSP reevaluation extended over almost seven years, with numerous technical review groups and the NRC was advised by the U.S. Geological Survey and academic advisors and all four of the national laboratories. We had 64 public meetings and here is the PG&E program leadership. I won't take time to go through all this. Many of the people named on here have spoken at public meetings in the past and the consulting team that I established for PG&E, and then we had an independent consulting board. Only Dr. Allen [spelled phonetically] is still alive; the other members -- Bruce Bolt, Allin Cornell, and Tom Leps, and Cole McClure, and Harry Seed -- have all unfortunately passed on.

The advisors to the NRC that not only were advising and reviewing the work that we did during the program but carried out independent studies simultaneously with studies we were doing. Burt Slemmons at the University of Nevada Reno is in charge of Geology, Seismology, and Tectonics, Ken Campbell with Ground Motion, and Andy Velutsos [spelled phonetically] in Soil Structure Interaction, and so on and so forth. Ralph Archuleta, who was here yesterday and one of the speakers, he was one of the advisors on Ground Motions, as well as Kay Ockie [spelled phonetically] and Steve Day. And then all of the National Laboratories.

The scientists at the USGS are shown here. All of these individuals are from Menlo Park except James Divine, who still resides in that position as advisor to the director of the USGS.

And then this is a simple chronology showing the 64 workshops that we had that between PG&E and NRC and many of them in this very room were carried out through time. I won't go through all of this, but that ended with PG&E's final report in July of 1988. And then after that report was submitted, the request for additional information with activities in NRC-convened meetings, workshops, field trips, and so forth, and then the final SSER written by the Nuclear Regulatory Commission was completed in 1991. And then there were some commitments made by PG&E referenced by this letter on top about continuing LTSB activities.

So the conclusions that we develop from element one on Geology, Seismology, and Tectonics -- and this is all taken out of the SSER 34 -- that in that element one, we collected thousands of additional kilometers of new geophysical data and we did detailed mapping of the coastal wave-cut marine terraces and I will talk in great detail about that in the next session.

A lot of faults were excavated and logged across faults that we had identified so we could make assessments of those. And a lot of borings were made for various regions and logged and interpreted. And then we set up a Central Coast Seismic Network and enhanced the strong motion array at Diablo Canyon, and Marcia McLaren will speak about that, the next speaker.

And here are some quotes out of SSER 34: that, “the results have greatly improved the understanding of the geology and seismology and tectonics of central California coast important to assessing earthquake potential of the region and to allow confident assessment of the design basis earthquake and associated ground motions.”

The NRC recognized the possibility of an undetected coast-parallel small fault near Diablo Canyon. And in the next session, Session Six, Dr. Abrahamson and I will talk about the Shoreline Fault, as we named it. But back in 1990 in our workshops, we realized, and the NRC asked PG&E, “What about the potential for -- in the surf zone, where you can’t do detailed geophysics because of shallow water and the surf action? What about the potential of a small fault or a fault existing in that area?” And we addressed that in our response to their questions, and I will summarize the results of that in Session Six.

And the conclusions. The NRC said that they find that the geological and seismological and ground motions and the probabilistic seismic hazard assessment as well as the engineering investigations are the most extensive, thorough, and complete ever conducted for a nuclear power facility, not just in the U.S., but -- I can speak from an international perspective -- in the world. And the PG&E has significantly advanced its state of the knowledge in all of the disciplines and they declared that the license conditions had been satisfied.

The lessons learned in post-SSER 34 development in the investigation of earthquakes. During the Long Term Seismic Program, the Loma Prieta earthquake occurred up in Santa Cruz mountains and we took advantage of that in collaboration with the U.S. Geological Survey and various universities to understand that earthquake and how the data coming from that applied to Diablo Canyon, and some of the remarks by Senator Blakeslee come in to play there.

And we focused on fault segmentation characteristics and interpretations, and Dr. Abrahamson and I will talk more about that in Session Six. And new empirical ground motion models were developed based on a tremendous data set from Ground Motion since 1991, and Dr. Abrahamson will talk a lot about that in Session Six. And the near new -- near fault ground motions that are called directivity and fleeing that Dr. Bolt at Berkeley and Dr. Abrahamson developed to the state of the art that we now have them today, and Dr. Abrahamson will describe those in Session Six. And then we have updated the Tsunami Hazard Assessment since the LTSB was completed in 1991, and Dr. Nishenko in Session Seven this afternoon will summarize the results of that activity.

So, lessons from earthquakes: Our goal is to understand and characterize the hazard effects and we found that if you look at the performance of critical facilities like dams, power plants, transmission, [unintelligible] both gas and electric and so forth, allows you to understand the hazards and manage the risks.

Here is a listing of specific earthquakes that the Geosciences Department has specifically evaluated. I won't go through all the details on this, but the Landers earthquake in 1992 is a very important earthquake that gave us some very near fault ground motion data due to a southern [unintelligible] and strong motion instrument that was located very close to the causative fault for the Landers earthquake.

The 1993 Hokkaido earthquake was a fairly large earthquake and there was a very significant impact and destroyed a good deal of the communities on Okushiri Island, where parts of the low-lying island were totally inundated. But the Hokkaido Electric had an operating nuclear power plant on shore of -- near Sapporo and I went over there, me and several of the PG&E engineers, to look at the effects of that tsunami that came into the power plant, and the power plant continued to operate through the tsunami emergency. And they did close it for a couple of days for inspections, but there were no effects at all at the power plant.

The Northridge Earthquake in '94 was a very important earthquake in that it did not rupture to the surface, although there was ample evidence in the geology and geophysics in that region to suspect that there was a buried fault at depth, and some important lessons came out of that.

The 1995 Kobe, Japan earthquake was simple but in some ways complex when it traversed beneath Kobe, did not break to the surface under

Kobe, but it did break to the surface on the island off shore. And that had some very important lessons.

In 1999, the Kocaeli earthquake in Turkey was a very important earthquake with a very numerous near field ground motions that Dr. Abrahamson will talk about in six, Session Six. And then the big earthquake in '99 in Taiwan was an important earthquake that had a lot of characteristics of thrust and reverse fault. And then also in '99, Hector Mine earthquake. Another important strike-slip fault out in the Mojave Desert. And then due to stress transfer 1999 in Duzce, Turkey, on the eastern end of the Kocaeli rupture, a 7.2 earthquake occurred, and again we got some very valuable near fault effects of ground motion from that earthquake.

In 2001, the Kokoxili, Tibet earthquake occurred and unfortunately, there were no ground motion records because it was out in the middle of Tibet, but there were some very important lessons from the faulting effects.

Not unlike the next earthquake, the 2002 Denali earthquake that occurred in Alaska in a sparsely populated area. But as Tim Dawson may have talked yesterday -- I didn't get to the meeting until after he had talked -- but because of the good work in studying the fault that I had some responsibility for with a number of people in this room and working with Dr. Numar, the pipeline was developed to not be ruptured in an earthquake. There was 18 feet of surface fault rupture beneath the Trans Alaska Pipeline and not a drop of oil was spilled.

Had that pipeline ruptured, with a nearby Delta River, the maximum capacity of the pipeline is 2 million barrels a day. That would have just overshadowed anything that happened in the Gulf Coast in terms of an oil spill had the pipeline broke. It would have been at least three to five times the amount of oil spilled had that pipeline ruptured and it did not because of the good work done to design to keep it from rupturing.

Then in 2003, San Simeon earthquake occurred at some distance from Diablo Canyon, but that was an important earthquake. The ground motions at Diablo Canyon were very small; it will be shown later in Session Six.

And then the Parkfield earthquake in the San Andreas Fault had some very important ground motions that varied from small amount to up to 2g in very close proximity to the San Andreas Fault.

And then the big Sumatra earthquake in 2004; I took a small team to Sumatra to -- you see -- all we see in television the worst things that happen, and we went over and documented where a lot of industrial facilities, like power plants and a big cement plant that was totally over topped by the tsunami, were undamaged structurally. So if things are built right, you can even over top a major facility and even though flooding might shut off the electrical circuits, the structural damage did not occur in that event.

So, the update of the seismic hazard assessment is now going on. We started that in 2007, and a lot of information has become available that we've gathered from a lot of these earthquakes since 1991. And we're now in the process of looking at the source characterization from all sources along the central California coast. And out of that, we're building alternative tectonic models to find out which one best fits the facts through seismic monitoring and geologic mapping and a lot of off-shore and on-shore geophysical data that is going on now and will go on for the next couple of years.

And then taking that information, new ground motion characterization that Dr. Abrahamson will talk about and we are doing in conjunction with the PEER Center at Berkeley. And then out of that, numerical simulation models that Ralph Archuleta talked about yesterday, and these activities have been going on in collaboration with DOE, the USGS, and the Southern California Earthquake Center. And then out of that, PG&E will do an update of the hazard calculation. This is done specifically by PG&E and by the Geosciences Department. We are not collaborating with any of the other scientists because they need to be involved in advising the NRC in a review capacity.

So we have a PG&E and USGS Cooperative Research and Development Agreement that we've been operating under since 1992. And we focused this starting in 2007 in the area of Diablo Canyon along the central California coast to look at improved tectonic models for this region. And that's based on regional tectonic earthquake hazard studies both off shore and on shore. And then as I mentioned before, PG&E will independently do the hazard assessment for submittal to the NRC and other state regulatory agencies.

And so our goal is to ensure adequate seismic safety in accordance with the regulations and involve the broader science and engineering communities, both the consultants to PG&E, the USGS, PEER and SCEC, and then technical reviews by our PG&E independent seismic hazard advisory board; that consists of Kevin Coppersmith, Julian Bommer, Steve Day, Ray Weldon, and Bob Kennedy. And then we will look at the impacts at Diablo Canyon. We have the seismic strategy team, which I chair, and we provide recommendations to senior management, and that includes the Diablo Canyon engineering and licensing groups.

So out of this update, we will look at the source characterization and we will cover this more in Session Six. And then we will follow the same procedure, the ground motion characterization, and then make an update of the hazard calculation. Thank you.

[applause]

Got you.

DR. MCLAREN: Good morning. This morning, I am going to talk to you about, primarily, the seismic instrumentation that PG&E is in charge of for both the region around Diablo Canyon as well as at the Diablo Canyon plant site.

I'd first like to acknowledge three gentlemen on my -- sort of on my team: Jim Cullen [spelled phonetically], who is the chief contractor for the Central Coast Seismic Network, the regional network, which I will talk to you about. Kevin O'Neil [spelled phonetically] is the Diablo Canyon project manager of the consolidated seismic monitoring system that -- it represents the upgrade. Both of these systems were upgraded in the last few years, so that's primarily what I am going to be discussing. And then Bill Horstman, who is Diablo Canyon's senior civil engineer who's been a primary person for me to get information on what the engineers actually do with the data that is recorded primarily at Diablo Canyon. And myself and these three gentlemen will be available to all at the break. We have a little poster in the room right next door, so anything that I'm not able to answer at the Q and A afterwards, then we will --

I can certainly talk to you all further in the break room.

So I'm going to start with the Central Coast Seismic Network, the regional network. It was started in 1987. Lloyd eluded to that it was part of -- originally part of the original LTSP study and it's an installation that we decided after the plant licensing was approved to keep it running, that it was important to monitor seismicity in the region. It consists of 20 seismic stations. It is an analog what we call "short period network," primarily to record on scale small earthquakes and at least P-wave data for recording and locating larger earthquakes. The data are telemetered from the region. The stations go from about San Simeon down to Pointcelle [spelled phonetically] and the data are telemetered using the PG&E microwave system up to San Francisco. And then in about 2003, we were able to automatically in real-time send the data directly to the USGS using their -- through their Earthworm system. So -- and we have been able to do a much better job of integrating the data immediately, getting better locations, and recording overall smaller magnitude earthquakes.

This is a map of the network in the region. Diablo Canyon located sort of in the middle of the map on the coast. Schematically shown on the east side is the San Andreas Fault Zone and then on the west, the off-shore Hosgri and San Simeon Fault Zones.

The triangles are the locations of the seismographic stations. The little green ones are most of the USGS stations and the larger yellow are the PG&E. So we are primarily hugging the coast to locate earthquakes close to the coast as well as in the off-shore region. These are primarily vertical only instruments basically for getting the P-wave information, but we also included the five -- three component stations which are marked by the tic marks, the three tic marks. And again, these were analog stations.

So they were put in in the ‘80s and since then, digital recording is now a very good way to and a better way to record and to telemeter the data. So the project that we embarked on in about 2006 was to replace the old telemetry with digital velocity and acceleration recorders. We wanted to be able to record smaller earthquakes and larger earthquakes on scale, and this was particularly noticed in -- after the San Simeon earthquake. There were several thousand earthquakes aftershocks, which continue today, and many of the larger events, the magnitude threes and fours we were not able to record the entire wave form due to the nature of the analog short-period recordings. So we added the accelerometers to get on-scale recordings of the large earthquakes. And by telemetering the data to the USGS and PG&E using digital, it improved the smaller ones as well.

The -- having remote access then to the data allowed us to quicker -- more quickly find out what was -- if the station was in trouble, what the problem was, do battery checks, and that type of thing. So it cut down on our maintenance costs. And having the recorders at the stations, recorders and sensors, provided a back-up in case there was a problem with the telemetry.

This is another map of the stations, sort of a Google Earth map showing the original locations. Then I have circled what we have done and what we have yet to do. So the red are the completed stations. We concentrated first primarily in the Diablo Canyon region and then the green are what we want to finish this year and next year. There’s a few that don’t have circles on them.

They were -- they had -- they either turned out to be not very good stations and we'll retire one of them. There's another couple of stations that when switching to digital we were unable to get good transmission of the data. So for now, we will keep them and keep them as analog, but we are not going to upgrade at this time.

There is two new ones that we put in, the two blue digital sites, the squares; one's just due northwest of Diablo Canyon along the coast there and then the other one to the northeast. And the one to the northeast is located at the emergency operations facility that's located on Kansas Street in town. And that's the facility that co-locates both PG&E and the county emergency facilities. So, we felt that was a good location. I might also point out that in the -- as part of our future endeavors for installation, we are planning on putting a couple ocean-bottom seismometers off shore near Diablo Canyon and sort of between west of the Hosgri Fault Zone and the Shoreline Fault Zone to better locate the earthquakes that are off shore.

This is an example of what the data looked like and the improvements in the data. When the -- so what I have shown here is sort of color -- let's say color organized different stations. So the two yellow squares at the top, the two traces with the yellow square on the far right, are two close-by stations so that I could show you the difference between analog velocity and digital velocity.

Then the red are -- the red and the green are each from two stations to show the difference between analog velocity, which we had before, and then the digital acceleration. So the main point is you can see in all three of the analog velocity recordings, they're clipped, especially the top one. So we can get the P-wave data; we can locate the earthquakes pretty well. But we don't get the S-wave data because it's clipped. It's hard to see it, it is not on scale; so by doing the digital velocity and acceleration, we're able to see the whole wave form and much better utilize the data and improve the locations.

This is a picture of a ShakeMap -- I am sure most of you are familiar with this -- from the USGS. One of the advantages, an added value to our network is that because our data go directly to the USGS, the acceleration data for magnitude three and a half or greater earthquakes, for basically anywhere in the San Luis Obispo area will be included -- are presently included in the ShakeMaps. You can then go to the ShakeMaps on the USGS site. Click on the site; you can see what the values are and also see what the data are. So it's a way for us to provide our information not just to PG&E, but also the community. And for PG&E for our transmission lines and pipelines and other key facilities to help us estimate possible damage after a significant earthquake.

This is a pretty picture of one of our installations at San Luis hill to show basically what it looks like. We have solar power generally for power. There is an antennae for GPS for timing and also for the data transmission itself. And then the sensors and the digital recorders are buried separately in vaults nearby.

This is a map then of what we have recorded with the USGS since 1987. The San Simeon earthquake is the larger yellow dot with the -- up in the San Simeon area. So that big blob of earthquakes near the yellow dot are primarily the aftershocks from the San Simeon earthquake, and there have been about 15,000 earthquakes from about magnitude one and greater since 2003.

The main points of this map are to point out that -- and also up in the upper-right corner is the San Andreas Fault; you can see the strike-slip nature of the San Andreas Fault, the earthquakes align right along the fault. So, most of the earthquakes are occurring near the San Simeon earthquake area that's along the San Lucia Range. There are also earthquakes in the vicinity in Diablo Canyon, and Jeanne Hardebeck showed more of a close-in version of that yesterday. And then down in the south, in both the off-shore and on-shore, we also see activity.

And a point to make is that this has been the patterns that we've seen over the last 20 years; there's been no significant change in the overall seismicity patterns. Again, the San Simeon earthquake aftershocks are larger, they cover more of the space, but in general, they are still consistent with the patterns that we were seeing before.

So now, I wanted to turn and talk to you more specifically about Diablo Canyon and talk to you about the new consolidated system and the two parts of that system, which are the basic and the supplemental.

To step back a little bit, the former system was the -- there was a formal basic system that was first put in in about 1973 or 4, and then the supplemental system, which was later put in in about 1978. The former basic system was -- is what the NRC dictates that the power plants do and what kind of instrumentation. So, years ago, we had put in three recorders through the clinometric [spelled phonetically] system and that was one at the base of containment, one in the auxiliary building, and one at the top of the containment.

They also included other instrumentation, [unintelligible] the peak recorders, and a shock recorder. Later on, we added -- in about the '90s, late '80s, we added the -- we added a digital recorder and a free field was added.

The former supplemental system, there were more; we had 23 of the recorders and then other peak recorders similar to the type of recorders that we had in the basic system.

The supplemental system, there are -- this was not dictated or it is not part of the Reg Guide from the NRC; this was a commitment that PG&E made after the basic system was put in in order to give us a little bit better coverage for studying of the structural aspects of the critical facilities, foundations, different levels of the facilities.

So again, this is sort of to summarize the -- why we wanted to do the update. These instruments were also -- they were obsolete. The parts no longer -- some of the parts were no longer available. These -- the recorders were centralized with the sensors being out at the different locations and then cabled in, and then that was a source of possible failure. If the central system recorder system failed, then you would not get recordings. It also required vendor calibration, it was hard to get the data, and it took quite a while for analysis.

So the new consolidated seismic system was authorized in 2003 and completed in November of 2004. It replaced the former basic systems with what we call a "consolidated system." We also, instead of having for the -- we kept the idea of the basic and supplemental, because they were still -- and I'll explain that in a minute -- but there were still different trigger levels for the basic system and the supplemental. But we had -- but now we have a central area for processing and we have separate recorder sensor packages that are at each location.

We increased the amount of instruments that went into the basic system. Instead of three, we have now six, including a free field. The control room computer interface is connected directly to the basic system and the supplemental so that we can get the information -- the control room can get the information more quickly. And then there is an interface that allows us to get the data -- allows Geosciences to more quickly get the data through the PG&E intranet.

So again, the system is decentralized; the processing rack manages the recorders in the auxiliary room and transmits the information to the computers. The EFM, which is the earthquake force monitor in the control room, is connected exactly to the basic and supplemental systems. And then we have a new free field recorder that was put in a better spot to more reflect the actual rock type that the power block is sitting on.

This is a little map showing -- a schematic showing the locations of the basic and supplemental system. The little circles are Unit 1 and Unit 2. Unit 1 is on the left and the auxiliary building would be right above the two circles and then below them are the turbine building where there are supplemental instruments at each end. These green circled are circling the free field. So we have the one red free field on the far left of the Unit 1 circle. And then right above, where there is a blue circle, it says, “Near the raw water reservoir,” that is a relatively temporary site and that will be soon co-located to the -- as a free field

-- right above the new dry cast storage at the [unintelligible] site.

In the control room, the guys in the control room are looking at a screen -- and I'll show you an example of that in a second -- but these are the three sort of levels of indications or alarms that they -- or alerts that they look at. An unusual event is described as 0.01g; the alert is -- after the design earthquake is a 0.2 or 20 percent g, and then the DDE quake is equal or greater to 0.4g. These were all -- these are all equal or greater, and that is approximately the double design earthquake.

These systems are a common triggering system. So for the basic system, the trigger levels have to be either -- if the trigger levels -- if these indicators are exceeded at either the free field or the base of containment, the basic system will trigger and all of the systems in both the basic and the supplemental will trigger. The supplemental system and the basic is set to trigger at 0.01g. The supplemental system is set to trigger a little less, at 0.008g, to get some of the smaller earthquakes.

Okay, if that happens, in order for that to trigger both the two -- one of the two free fields, they both have to trigger and then the whole supplemental system will trigger, but it will not trigger the basic system. So the only way the basic system is going to trigger is if the larger trigger value of 0.01g is met. And then again, in that case, the whole system is triggered.

And then I wanted to note that each of the recorders will self-trigger. So if a truck rolls by one of the units and it goes off, it won't trigger the whole system because we don't want to let a truck noise triggering the entire system. But they will trigger if there is noise to make them trigger. Now, part of the maintenance is to acknowledge that, log it, clean it out.

So this is and -- this is what the basic system indication looks like. So in the control room, this is what the guys are looking at. So at the top there, sort of the top middle under the words “system status indications,” there is a line of numbers; those are the six basic system instruments. And what I have circled in red then, if you’ve got the free field, would be -- is number one and the containment base is number six. And then the red circles below are saying that those are the two for the basic system that have to have an “or,” an “either,” if either of those trigger. And if there’s a trigger at whatever that level is, there will be a “Y” that will appear. And then on the left, on the right-hand side, where I have the little windows, “base of containment,” “peak values,” and “the free field peak values,” -- is this on? Okay -- those will -- the actual values will appear to the control room operators.

When there is a trigger of an event, there is certain output that is created. There is a summary of all of the trigger information and then also there are some other pages of information including -- I just put here as an example -- where we’re showing the containment base response spectra for the actual event -- and in this case, this is just a TAP test -- versus Diablo Canyon’s Safe Shutdown Earthquake and the OBE for each of the three components: vertical and two horizontals. And so you’ll get that for both the containment base and the basic.

This is -- and then for the supplemental, there is a similar window. So, this is just a quick summary of the different triggers that have been measured on the earthquake force monitor. So again, the system was put in in the ‘70s and it wasn't until 2003, October 2003 before the San Simeon earthquake that there was a magnitude 3.5 event about five kilometers south of the plant that caused a 0.02 measurement, g measurement on the earthquake force monitor.

And then just listening for the San Simeon earthquake, we recorded four percent g and then -- and that was before the upgrade. And then the upgrade happened, was completed in about September 2004, and then we had the Parkfield earthquake, which was recorded on the new system and recorded about one percent g.

So now really quick, what do the engineers do with this information? Well, for the free field, the engineers like Bill Horstman will analyze the recorded ground motions. He'll look at the data. He'll consider the elevation and the rock type. He'll also then compare that against the OBE exceedance, checking the response spectra and also looking at a feature called the "cumulative absolute velocity."

He'll then do a plot of his own and comparing the actual response spectrum for each of the components to the Hosgri earthquake, which is our Safe Shutdown Earthquake, and the design earthquake. So, this is an example using -- this is an actual plot of the San Simeon earthquake. So as you can see for the San Simeon earthquake, the magnitude is 6.5, the actual -- the black, the very low spectrum at the bottom is the San Simeon earthquake. And so for this recording, this was -- it was well below the design spectra.

Okay, then for the different instruments in the building foundation. So what the engineers will do is they'll look at the motions they need to look at the motions at the different levels of the different buildings, critical buildings such as containment turbine building and the auxiliary building. And then these motions are then compared to the free field.

They also look at amplification. So for example, at the top of the containment or at different levels of the different buildings, such as a different level of the auxiliary building, and you compare what's above down to the foundation so there's a comparison of free field to foundation and foundation to upper levels. And then, again, he uses all of the data to -- for the seismic analysis.

So in conclusion, are -- we have two main networks: We've got a regional network, which has provided greatly improved recordings for both small and larger events, and the consolidated seismic system at Diablo Canyon. It's robust. The quarters have been shake table tested to 14g in a simulated installed state to make sure that they don't bounce off their foundation. It satisfies regulatory requirements, provides valuable information with respect to the seismic analysis of the buildings, and provides critical information for restart after a seismic event. Thank you.

[applause]

DR. BAGCHI: Good morning, ladies and gentlemen. It was an impressive discussion about the attempt to get at the truth, if I can call it that. How else would you do it without this kind of geophysical examination and processes that have been put in place by the licensee? What they gather is the beginning of what is handed over to the engineer. And I'm here; my talk is intended to represent what an engineer does with that information to produce a robust design, of course.

I had participated in many of the key seismic reviews for this Diablo Canyon plan, and to some extent, I have some personal knowledge about how the Long Term Seismic Program went on, some of the issues that arose from the Hosgri upgrades to the plant. And through my slides, I will try to present some of these things to you today.

In this coastal view of the plant, we can see white rocks and the plant is founded on rock. Rock foundation is very beneficial to seismic response for foundation structure interaction and so forth. And compared to weak soil supporting critical structures and so forth, the amplification through the soil that raises the ground motion in the range of building natural frequencies is not going to happen in this kind of a foundation condition.

And there are plenty of example of that, of -- rock-founded sites perform better in actual earthquakes. Yesterday, Professor Moss gave us some wonderful examples. Well-designed, well-constructed entities really withstand the effect of earthquake very well.

The Haitian earthquake was a magnitude seven. The Chilean earthquake was a magnitude 8.8. The difference in energy release between the two events is 500 times, or thereabouts. And you did not see all the destruction that we saw in Port au Prince, for example, where many of the structures were founded on soil. In Chile, there were damages, but, you know, far few. They also have a very strong building code. And we hear that in Christchurch, New Zealand the 7.1 earthquake fortunately did not produce any loss of life. They have a very strong building code, as well.

Now the outline of my presentation; just a little bit of licensing history. I think my previous speakers have gone over many of these things in some detail. I don't want to present that aspect of the detail, but what I want to do get across to you is that there was a very sincere, intensive effort on the part of the NRC to engage in detailed review as some of the information was being developed and studies were being conducted and brought to a conclusion. NRC was engaged all along the way.

There was a little bit of discussion about the advisory committee on reactive safeguards; I'll get to that in a few slides later. Then, I will present the Long Term Seismic Program response spectra, individual plant examinations; this is an initiative by the NRC in order to ensure that there are substantial margins beyond the design basis earthquake for which the plant was licensed.

I will describe to you some significant plant upgrades and post-Long Term Seismic Program licensing history, current geophysical investigations. I will try to shorten this because my time left is a residual amount of time, probably not enough, but please bear with me. I'll try to get us there.

And I do -- lastly, I do want to convey to you the conservatism of nuclear power plant seismic design; the core principals of seismic design safety, in general safety of nuclear power plants that NRC follows.

I will skip this. Dr. Kammerer has spoken to you about what a response spectrum is. Here I do want to show that a design response spectrum may be represented by the red curve and the black curve is a recording from one single earthquake. No single earthquake will produce the response spectrum as broad the red kind of a curve. Most of the response spectra that are used for existing nuclear power plants and the new plants, they are quite broad. And note natural time history will produce a response spectrum that matches that and yet our design requirement is such that we have to produce a time history of acceleration for the design analysis that envelopes even the broadband spectrum. So that is a little bit of conservatism built in there.

I wanted to present this little bit of a short list of the construction permit times and operating license, commercial operation, and so on. I don't want to belabor this, but as you can see, during the operating license review phase, the Hosgri Fault was known, was reviewed, and incorporated into the consideration of the operating license for this plant.

And just as a point of note, commercial operation is not a simple matter. There are lots of low power tests that are conducted at site in order to make sure that the plant can be put on the grid and that's when the commercial operation begins.

So, Hosgri Fault was identified in 1971 and incorporated in the 1973 FSAR submitted for operating license for the NRC. And this is all old news for you. The controlling earthquake on Hosgri was 7.5 and the closest proximity to the site [unintelligible] ground acceleration of 0.75g. I will show you the response spectrum and you will see the entire nature of how punishing that is to a design. This plant also has seismic trip to automatically shut down the reactor in the event of a seismic occurrence that comes to a preset value. I think in this plant it is about 0.3g.

PG&E performed major plant modifications in order to meet the requirements of the Hosgri ground motion. It was not just a performer review, perform a modification to the plant itself; it was substantial. Later on in my slides, I am going to present some of the modifications that were done and you'll see how substantial they were.

I don't want to belabor this point. These are the license conditions for the Long Term Seismic Program. And in -- momentarily, I will get to the point where I will describe to you how the NRC staff went from the deterministic seismic hazard analysis into a probabilistic seismic hazard analysis.

NRC's review occurs at several levels. We talked about the Advisory Committee for Reactive Safeguard. This is a completely independent body that receives the staff safety evaluation at least a month before the public meeting. They review it. They sometimes hire their own consultants even though NRC engaged renowned consultants to produce independent studies, independent verification of what the applicant or the licensee has done.

The ACRS, Advisory Committee for Reactor Safeguards, has the responsibility to do a complete review of what the staff has done and in the end, before the safety evaluation proceeds to the commission, each receives a recommendation from the Advisory Committee. And many times, the Advisory Committee does not just simply pass it on. In this case, all these Long Term Seismic Program license conditions were suggested by the Advisory Committee.

I really don't have a lot of information to provide to elaborate in this case. I just wanted to say that we had independent investigations, as my previous speaker talked about, in geology, seismology, earthquake engineering, deterministic seismic analysis, planned PRA, including complete Level 1 seismic PRA.

This part needs to be emphasized: that there was extensive independent verification of geology, seismology, vibratory ground motion, soil structure, foundation structure, interaction analysis, deterministic structure analysis, seismic capacity calculations for the PRA evaluation, and then, of course, complete Level 1 seismic PRA. This involved looking at the plant system logic, which leads to the plant level seismic capacity of the plant, which usually is expressed in terms of high confidence in low probability of failure, or in jargon, [unintelligible] value.

Interestingly, I want to pass on to you -- many of you probably know this -- we have a new commissioner, Professor Apostolakis from MIT. He was on the Advisory Committee for Reactor Safeguards and he is very much interested in probabilistic analysis. And he has recently asked his staff to look at implementation risk-informed criteria for staff reviews for, you know, licensing decisions.

What do I want to emphasize here? There was a plant walk down; you know, this is not just a performer review of the systems, performer review of the structural capacity. Actual plant was walked down to look at whether or not there is any potential for either interference or seismic anchor as being inadequate.

Some of these dates were given by my previous speaker. But one thing I do want to emphasize here, and I think this was spoken to by Dr. Cluff, in the safety evaluation supplementary report number 34, this is a direct quote, that there was an undetected coast barrel fault [spelled phonetically] and the staff thought that the slip rate may have been accommodate by fault slippage, undetected fault slippage on the southwest boundary zone faults.

Given some of the uncertainty that still existed, it was wise for the licensee to commit and support key technical seismic activities in the future. As you can see, it has actually been carried out or being carried out right now.

Now, this is the response spectrum I needed to show you earlier, but nevertheless, the black one is the Hosgri spectrum. The dotted, thick, blue one is the Long Term Seismic Program spectrum. And the lower response spectra are the deterministic evaluation of the potential for the Shoreline Fault to produce a conservative event that would give us a response spectrum of that sort.

I do want to explain a little bit to you what it means if you look at the spectrum and you see the Hosgri's here. Let's see if I can get the -- yeah. See, right around here, here is the Hosgri coming down and here is the LTSB spectrum exceeding a little bit. It's about 15 hertz or so; 15 hertz meaning one divided by 15 would be the period in terms of seconds, if you're familiar with that. I am very familiar with frequency in terms of hazard so allow me to speak on in terms of hazards -- in terms of hertz.

Long Term Seismic Program motion exceeds Hosgri at greater than 15 hertz. At 15 hertz -- and you saw the spectral ordinate was 1.5g -- the relative displacement is only 0.065 inch. This is non-damaging; it doesn't produce any structural damage. But it can produce relay chatter and that was reviewed during the PRA analysis and some accommodation was made in restoring, recognizing what could stop by relay chatter, and then being able to take care of -- and bring the plant to shut down condition without relying on those.

So by describing this slight spectral exceedance in the high frequency range -- in the high frequency range, the relative displacement I could go on and show you that -- I am going back -- yeah, I show you that up to 100 hertz, you go to 100 hertz, the relative displacement becomes proportional -- inversely proportional to the square of the frequency. So those are smaller and smaller and smaller; so insignificant they don't cause any damage.

So now I come to the individual plant examination for external events. Unlike other regulators worldwide, NRC had a very long time ago considered -- and to some extent, this was really put on the staff by the Advisory Committee. And they said, "There ought not to be a cliff where the plant can fall off if the SSE is exceeded." So there was the concept of seismic margin.

How much further can we go to show that the Safe Shutdown Earthquake is not the end of the plant? There is substantial margin beyond that. In order to do it, there was a concept of Review Level Earthquake. It is set high enough so that given that high ground motion, you can look at the plant and start to decide that, "No, this structure -- this sheer wall is so strong that I don't need to calculate the capacity." So that was primarily the purpose of setting the review level earthquake at high enough value compared to SSE.

Most of the eastern plants were at that point designed to SSE values of the ground acceleration no more than 0.2g; substantially less than that. And the Review Level Earthquake was about 0.3g. So that was the basis for examining the plants for potential vulnerability and whether or not some plant improvements that could be made.

It was recognized that for some plants, there is no alternative to doing a seismic PRA, and our -- this particular site was one of those. And Diablo

Canyon had done such a thorough and complete seismic Level 1 PRA that they looked at the little seismic hazard for this site and determined that the best examination was done during the Long Term Seismic Program so they turned in their evaluation based on the PRA that was done at the time. So the results of this IPEEE were published in a CR, CR-1742. Yesterday, some question came up with respect to the seismic margin for this plant, and if you look at that 1742, you'll find that for Diablo Canyon, it's 1.56g.

Significant plant upgrades: the added buttresses and concrete walls to the turbine building, the reinforced main columns, strengthened floor diaphragms, and roof and wall bracings. Six piers were post tensioned and the turbine pedestals to building separations were increased. Fire pump controllers for plant interior systems were upgraded to class 1E. You can read this and you can see that there was a substantial effort to do some of these things. And field handling crane and structure: This was upgraded to become a single failure proof. And there were other continued improvements and this included addition of yet another diesel generator set.

Post-LTSB licensing history; you heard from previous speakers about this Shoreline Fault-related geophysical examination that is going on. And I don't have really any more information to add except to say that our Office of Research did an independent deterministic evaluation and the response spectra that I showed you in Slide 13 of your handout is from this research information letter that the Office of Research provided to our Office of Nuclear Reactor Regulation.

So, the large Hosgri earthquake ground motion remains valued and effective. I would skip some of these things. And as my understanding is that PG&E will report by the end of this year an update to seismic hazard in the future.

These are the two remaining slides. Please give me a little bit of time to get into some of these things. Backbones of safety: What are they? Quality, defense in depth, redundancy, diversity, while the plant is operating, requirements for in-service inspection, regulation for maintaining the passive entities of seismic category I structure systems: All these form the backbone of the safety concept of nuclear power plant design.

And there is a general design criterion which is very old, and although it is deterministic, nevertheless, it had always recognized uncertainty. It had always recognized the need to have a margin. I really urge all of you to take a look when you can to our regulation Appendix A to Code of Federal Regulation, Title 10, Part 50 and this is called “General Design Criterion 2”. It requires explicit consideration of the most severe of the natural phenomena that have been historically reported for the site and the surrounding area with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Examination of all existing plants to identify potential safety improvements for beyond design basis earthquakes: All these go on to show that NRC has been forward thinking, forward looking in some other countries even where earthquakes are very prevalent. These kinds of forward-thinking programs were not undertaken. I am proud of the way these programs have come out and NRC has really been most forward looking in this regard.

Some of the other sources of conservatism: essentially, lasting response of design basis earthquakes. You are not going to find that in normal building structure design even to the best of the current requirements. They rely on ductility; we do have ductility. Nevertheless, the way it is designed, the structures respond essentially elastically so they have plenty of margin beyond that limit.

Several extreme loads are combined. For example, the containment structure is designed for not only the earthquake load but also, you know, associated dead load, live load, and all of that stuff. But in addition, the design basis accident load, the internal pressure, I don't remember exactly what it was, but something in the order of 45, 46 PSI on top of the earthquake load. So there is no concern about just an earthquake causing a failure of containment -- in my mind, anyway.

Actual concrete thicknesses are greater, reinforcing bars are bigger, and steel members are larger than the nominal demand. All of these things go on to give us higher capacity. The [unintelligible] walls for example are three and a half to four feet thick, not for resisting earthquake load, but for providing shielding. And even the nominal reinforcement will withstand the Hosgri-type of earthquake quite easily. And the [unintelligible] walls are provided with stainless steel liners and there is no way they can leak because of cracking, if there is any cracking.

So there is substantial strength in our reserve strength beyond what was considered in design. And this -- I'd like to add, nuclear power plant structures have gone through actual earthquake. They performed admirably.

There was hardly any deformation, hardly any crack to see. The structures withstood two or three times the design basis load. And Thank you.

[applause]

MR. MAIER: Okay, here is the point where I wish I could talk as fast as those guys at the end of the car commercials. Two words of -- two notifications here: The hard copies of the slides are back from Staples, so they're available for your review. And once again, if you hear the crackling on the speakers, please refrain from any BlackBerry or wireless computer use. That is apparently the cause of that interference.

Okay, for those who were not here yesterday, I'm somewhat obliged to go over some of the protocol or ground rules for the question and answer sessions. Recognize that AGP Productions is videotaping the question and answer sessions, so please wait for a microphone. Raise your hand if you have a question that you'd like to ask; Butch and I will acknowledge you. We'll alternate between opposite sides of the room. And we ask you to stand when asking your question; direct it to the panel member that you think is most appropriate for answering the question. We invite you to identify yourself. If you have any concerns about being taped or don't want to ask your question orally, you are invited to use one of the three-by-five cards that Butch and I have on our persons. We can come around and give you a card; just raise your hand and ask for a card.

We ask you that if you have a question that you put on a card that you please put your contact information legibly, e-mail and/or phone number, and put your question on the card and we will try to get an answer to your question back to you.

For those who were here yesterday, if you thought Butch and I were rude yesterday, we will be absolutely insufferable today. Once again, we have only 15 minutes, precious little time to ask questions. So we ask a couple things of the audience and we ask a couple things of the -- ask something of the panelists as well. We ask you to try to keep your question focused on the session that just took place, which is history of seismic evaluation at Diablo Canyon. Recognize that the following two sessions will have a study or a discussion of the current seismic studies. We ask that you focus your question as succinctly as possible in the interest that we can get as many questions in during the 15 minutes as possible.

And as I did yesterday, I'll ask the panel members to try to focus your answers and keep them as succinct as possible, as direct to the question as possible to allow additional questions to be asked.

That's about all I have. Butch, is there anything I forgot?

MR. BURTON: I think you got it covered.

MR. MAIER: Okay. Well, then, let's start with the questions, please.

MR. WARDELL: Ferman Wardell; Diablo Canyon Independent Safety Committee. Dr. McLaren, you mentioned the design basis earthquake and the double design basis earthquake. Could you relate those to the Safe Shutdown Earthquake and the Operating Basis Earthquake we heard yesterday?

DR. MCLAREN: I don't know if I am the best person to answer that. Let's see. Okay, your question was the difference between the Safe

Shutdown, Operating Basis, and the design earthquake and double design earthquake. I'm going to defer that question because that is more specific to Diablo Canyon, and I am going to defer it to Dr. Bagchi.

DR. BAGCHI: Before the formal statement of what is a Safe Shutdown Earthquake was incorporated into regulation that was in 1971 when the general design criteria were developed, two levels of earthquake were used: design earthquake, which is really the Operating Basis Earthquake, and at that time, there was a factor of two on top of that.

Actually, double design earthquake was really the biggest earthquake that could supposedly occur in that area, minus the knowledge of Hosgri Fault, of course. So therefore, the design earthquake, OBE, Operating Basis Earthquake, was really half of that value.

And what Dr. McLaren may have said as an SSE is the Hosgri ground motion, I think. The Hosgri ground motion is an Evaluation Basis Earthquake and the licensing basis was never changed, based on my understanding of the licensing. But they do have to review and ensure that the Hosgri response spectrum is met.

MR. MAIER: We have one over here.

MS. BECKER: Rochelle Becker, the Alliance for Nuclear Responsibility. Hello? Hello? Hello? Yes? No? Okay.

I read the agenda for today and I thought that this workshop was going to provide us with a timeline of the controversial history of Diablo Canyon, both -- and mostly surrounding seismic areas. And I have heard a lot of speeches of what has been done for mitigation with the timeline, but I think the basis for this entire meeting, for the cost of this entire meeting, for all of you coming together, is the fact that the history of this nuclear plant is rather controversial.

And so we would like to offer to put into the record, the transcript of today's meeting, the history that the public read of this timeline the controversial missteps, the lack of finding certain faults, the denial of certain faults; when they were found, they were still difficult for the NRC to realize and to review.

We took four extra years to do this, billions of extra dollars to do this. There is a great deal of testimony at the Public Utilities Commission to what these costs were. And I think if we're going to talk about the history of Diablo Canyon, we should talk about the history of Diablo Canyon and not what Mr. Bagchi would like the history to be, or Mr. Cluff or Ms. McLaren.

These are mitigation things that you have done that have made the plant safer and we are grateful for everything that makes this plant safer. But if we forget history, we are going to repeat it, and this is not the time to do that.

Thank you.

MR. MAIER: Okay. Did you want to -- you'll provide that to us? Okay. Great, thank you.

MR. BURTON: A question over on this side.

MR. GREENING: Thank you. Eric Greening [spelled phonetically]. Do we have any way to judge the relationship between this sort of outer Hosgri envelope and its impacts on the plant with what would have been the impact of the 1812 quake that took down the missions in what are now San Luis Obispo and Santa Barbara County? I know that there wasn't scientific data being gathered then, but do we have any way to assess that earthquake relative to the line we seem to have drawn around what the Hosgri Fault is capable of?

MR. MAIER: Is that question pretty much directed to Mr. Cluff?

MR. GREENING: It's directed to whoever can answer it because I realize none of them have done any scientific investigation in 1812 but it's something we need to be thinking about here. Structures came down in a whole two county area -- [break in audio] -- final envelope for what this area is capable of.

DR. CLUFF: Yes, I think without having some graphics that we can address that in the next session with what I will be presenting there and what Dr. Abrahamson will be presenting in the next aspect. And it comes back to someone who mentioned the various earthquakes like the one in New Zealand that occurred this past weekend and so forth.

What you see happening in all of those earthquakes, and I would say it's true for 1812 with the missions, was that the capacity of those old buildings to withstand even minor amount of earthquake shaking was nothing nearly probably 500 times less than what a critical facility like Diablo Canyon is.

So, I would assume that since we don't know a lot of details about the 1812 earthquake, just because old missions were damaged doesn't mean it was a very powerful earthquake.

DR. BAGCHI: Can I add one more observation to that? In San Luis Obispo town there are still some unreinforced masonry buildings and the county or the town has posted signs there that they are not safe. Old mission building was probably unreinforced so it's not a wonder that they got damaged.

MS. HANSON: My name is Lauren Hanson [spelled phonetically]. I am an interested citizen. I have a question about the Hosgri response spectrum for Dr. Bagchi. You talked about the spectrum applying to the plant and you said that with regard to the spent fuel pools that because the walls are so thick, they must be okay. Can you say definitively whether the Hosgri response spectrum applies to the spent fuel pools and to the dry cask storage?

DR. BAGCHI: Certainly, the Hosgri earthquake was evaluated for the capacity of the spent fuel pool and it was so strong that it didn't need to go any further. With respect to the dry cask, it is evaluated and designed for much bigger earthquake than even that. That's all I know. It is not an area of my expertise. It is evaluated by a completely independent office, Office of Nuclear Materials and Security [sic] and Safeguards, NMSS -- Safety and Safeguards.

MR. MAIER: I have a question from Jane.

FEMALE SPEAKER: Thank you. I do ask you not to be rude. I am within the confines of the purpose of this workshop, which says, "is to provide a forum for members of the public to gain a basic knowledge of seismic hazards and its applications for the safety and operation of commercial nuclear plants, including Diablo," so that's -- my question -- [break in audio] -- and it's addressed to anybody in the room. Perhaps PG&E and NRC people would want to contribute to this.

So I do appreciate the work of the professional geologists and seismologists that have been at this workshop so I am not being negative about them. However, the findings of science must be applied in order to be useful. My concerns relate to the capability of the Diablo Canyon plant to manage a safe shutdown of reactors in the event of a major seismic event. The record is not reassuring. I am going on the basis of NRC inspection reports, especially over the last two years. They show repeated problems with such safety related systems as -- this is not a complete list, just a few -- offsite power delivery to Diablo Canyon; this power would be essential to be in control of the plant under a variety of situations, including a major seismic event.

Some of the specific examples that I have seen in these reports include the 500 kilovolt switch yard and the emergency diesel generators and various components that control the emergency core cooling system.

So with that background to define of what I am speaking and where my source is -- my source being the Nuclear Regulatory Commission -- my question is what evidence can PG&E and/or the NRC offer to show that these problems impacting safety systems will be resolved in a timely way? They seem to drag on and on and on and each inspection report refers to the ongoing problem of. So I am interested to know if there is any reason why those of us from the public should assume that these will actually be taken care of.

MR. MAIER: Thank you, Jane. Is that directed to anyone in particular?

FEMALE SPEAKER: Anyone in the room has knowledge to respond. Mr. Peck is smiling and waving, so maybe he has something to say.

DR. PECK: I actually was a primary author in that report so I would like to respond to it if I could. And I want to deal specifically with your question on offsite power. We make an assumption that offsite power does not survive the earthquake. We rely on six emergency diesel generators to supply emergency onsite power, to ensure that the reactor is safely shut down, and that the spent nuclear fuel is cooled. So in a very brief answer, the offsite power system is assumed not to survive the earthquake.

MR. MAIER: Okay, we've got about three minutes left. Anyone want to --

DR. CLUFF: Let me respond because I know the NRC has appointed three administrative law judges to address this very issue. I know you and I were at that same meeting. And so that process is going on, and I believe the next meeting is in October. Is that correct?

MR. MAIER: Any other questions?

MR. BURTON: Another question from Mr. Wardell.

MR. WARDELL: Dr. McLaren mentioned the seismic instrumentation within and around the plant. Yesterday, we talked to the [unintelligible] representative. He described the instrumentation that would automatically shut down the reactor. Could you describe that for Diablo?

DR. MCLAREN: Are you talking about the reactor trip? Okay. We have -- let's see. They have four; we have three different instruments. And ours is a two out of three would trip and these are -- so it would be two out of three in the same direction. So, two out of three vertical components, two out of three of the same horizontal at point three, 0.3g.

MR. WARDELL: [inaudible]

DR. MCLAREN: It's point -- you were asking if that's the Operating Basis Earthquake?

MR. BURTON: Is the Operating Basis Earthquake, the level in which these instruments would trip the reactor. You say 0.3g.

DR. MCLAREN: It's 0.3. I don't believe that it is the -- exactly the Operating Basis Earthquake. Can you give Kevin O'Neil or Bill the microphone right here? Yeah. Thank you.

DR. HORSTMAN: Is this on? Hello, I am Bill Horstman, the civil engineer for the plant. Hi, I'm Bill Horstman, the civil engineer of the plant and our reactor trip is set at 30 percent of a g. The Operating Basis Earthquake, which Dr. Bagchi referred to also as the design earthquake, is 20 percent of a g, so it's slightly above that value.

MR. MAIER: We've got about time for one more question to get the full 15 minutes in and Sherry [spelled phonetically], I see your hand first, so --

FEMALE SPEAKER: Okay, let's see. All of this information, this deluge of information is extremely hard for me to assimilate. I'm not a scientist. I know this is a workshop dedicated to calming the fears of the people and it's difficult to calm my fears when I can't really understand all of that. I don't know how to get around that, you know, but I have been trying to study it.

The graph, for example, that Mr. Bagchi showed, maybe that was Slide Number 13, where the hard line of the Hosgri Fault seemed to be above the specifications. I couldn't quite follow that. So he commented on to the right side, but to the top of it, so that is an example. Let me skip that right now anyway. I want to address particularly to --

MR. MAIER: Do you have a question, Sherry?

FEMALE SPEAKER: I may or I may not but you've got to let me talk. I want to address particularly today the tone that I hear from both PG&E

and the NRC that they've got everything covered, that we don't have to worry, that I don't have to worry about a thing because everything is watched over. They seem very confident. I am skeptical of that confidence. It almost approaches arrogance from my point of view.

And let's see; I better get to something more important. Let's see. And I know that one of the reasons for the upgrades that they have been boasting about was -- one of the reasons is the objections brought up by members of the public, like Mothers For Peace and other organizations have required them to make these adjustments and upgrades.

So if your point is to get us to trust you, the tone of many of -- a couple of the deliveries today certainly do not encourage me to trust you. The slides were hard for me to understand. The presentation was hard for me to understand, although I could get some of it. Well, I guess I'm not saying that much.

I am disturbed by the lack of information about offshore studies. Apparently, there are two that are going to be made offshore now about faults under the water, but I am surprised that there is so little offshore work being done. Can a question come out of that?

MR. MAIER: Maybe not. I think I will just go out and say the purpose of the workshop was not meant to be palliative; it was meant to be informative. It was not meant to be pharmaceutical; it was meant to be cerebral. It was meant to convey information about things and for folks, if they took something out of it, they would hopefully, you know, make it worth their while to come out here for these two days.

I think that ends our question and answer for this session. We'll take a little break and be back at 10:15. I invite you to check out the Los Osos Room where some of the posters and visual displays are located if you are interested in doing that.

Please start moving back towards the room and towards your seat a little bit before 10:15. Thank you.

[break]

DR. KAMMERER: Thank you, everyone. Let's get started with Section 6, Progress of Current Seismic Studies at Diablo Canyon. We have three speakers today. We're going to be starting with Barbara Byron. Barbara has worked for the California Energy Commission since 1977 in a variety of nuclear energy waste transportation and disposal issues. She was the project manager for the California Energy Commission's 2007 to 2008 assessment of California's nuclear power plants. That was completed in response to Assembly Bill 1632. And there is an additional longer bio, of course, in the short program if you would like to read that.

There is going to be a slight change of program after Barbara speaks. Dr. Cluff, who of course presented in the last session, will follow Ms. Byron. Following that will be Dr. Norm Abrahamson, also of PG&E. Dr. Abrahamson is part of PG&E's Geosciences Department, where he is involved in the technical management of PG&E's seismic research programs at the Pacific Earthquake Engineering Research Center, the Southern California Earthquake Center, and the USGS. His work focuses on the practical application of seismology to the development of deterministic and probabilistic seismic criteria for engineering design or analyses. So, without further ado, we'll ask Ms. Byron to start her presentation. Thank you.

MS. BYRON: Thank you. Good morning. I would like to thank the Nuclear Regulatory Commission for this opportunity to talk with you about California's policies and recommendations for advanced seismic research at Diablo Canyon. I am here today with Kevin Crowley with the Energy Commission, and Casey Weaver [spelled phonetically], and before I begin my talk, I wanted to -- as Bill Maier mentioned, Commissioner Jim Boyd was planning to be here this morning to speak to all of you, and unfortunately wasn't able to come, but he did ask me to make a few comments on his behalf, and he had some more extended comments, and I have copies here if any of you are interested.

First of all, Diablo Canyon and San Onofre are significant, very significant to California's energy supply mix, and provide about 12 percent of the state's electricity supply at relatively low operating costs, with relatively low carbon emissions. Seismic events are a major source of potential disruption for these plants, and as demonstrated by the 2007 earthquake in Japan and its impacts on the Kashiwazaki-Kariwa nuclear plant, which we talked about yesterday, the State of California is concerned about the reliability of Diablo Canyon and SONGS because of their importance as being base load plants, and their location in highly seismically-active areas near population centers and our extremely valuable, rich, coastline. It would be extremely costly to California rate payers should a major seismic event result in an extended plant outage, or result in expensive plant seismic retrofits.

Recognizing the importance of seismic hazards for California's plants and the potential impact on plant reliability costs and public safety, the California legislature and three California agencies have called for additional seismic research at Diablo Canyon to assess the seismic hazards and plant vulnerabilities at this site, and we're very pleased to see that PG&E is initiating these studies. This information is needed for the state to fully evaluate the costs and benefits of continuing to operate these plants for an additional 20-year license extension.

The California Energy Commission and the California Public Utilities Commission recommended in 2008 and 2009 that PG&E complete a number of these advanced seismic studies for Diablo Canyon and San Onofre, and they concluded that these studies are needed to help insure plant and grid reliability, and for the Public Utilities Commission to reach a decision on whether to pursue plant license renewal. We've recommended that the utilities make their advanced seismic research findings available for consideration by the Energy Commission and the Public Utilities Commission and the NRC during their license renewal reviews.

Now, to begin my presentation. First, I do plan to cover some of the brief history. We've heard some important seismic history from Lloyd, but I had a few other issues that I wanted to just mention, and then also I wanted to talk a little bit about the two California pieces of legislation that were authored by Senator Blakeslee. The first was AB 1632, and the second is AB 42.

And then I wanted to very briefly talk about a study that we conducted as required by AB 1632 in 2008, and then what is the status of these studies that we recommended be completed. I'm going to skip through some of the things that we have already covered during our presentation -- earlier presentations. The discovery of the Hosgri Fault and the disclosure of major safety related plant design and construction errors and other factors resulted in a very long, contentious licensing process, and the State of California was an intervener in these proceedings.

As we heard, we heard about the Hosgri Fault and the 7.5 magnitude, but the culmination of the discovery, of the discovery of the fault, the retrofits, and a number of other factors resulted in about 15 years between when the license, construction license was issued and when the plant's operating license was issued, and the cost to California rate payers exceeded the initial $320 million estimate, in 1968 dollars, by more than $5 billion, in part due to seismic and other upgrades at the plant.

PG&E didn't conduct offshore fault studies, because at the time, these studies weren't required -- in 1968. Instead, the consultant focused on on-shore faulting, and they considered the historic offshore seismicity. In 1984 the NRC made a condition, as we heard earlier, of Diablo Canyon's operating license that PG&E shall develop and implement a state-of-the-art program to revalidate the seismic design bases for Diablo Canyon. PG&E's Long Term Seismic Program has extensively explored the seismology and geology of the Diablo Canyon site.

In the late 1970s, the Congressional Subcommittee on Energy and the Environment, as well as California legislators raised major questions about whether Diablo Canyon, as designed, would withstand major earthquakes.

Following the disclosure of serious design and construction errors at Diablo Canyon, in 1982 the California governor and interveners, including Mothers for Peace, filed motions with the Atomic Safety and Licensing Appeal Board to reopen the Diablo Canyon record to take evidence on certain plant quality assurance matters.

In addition, local governments including San Luis Obispo, Pismo Beach, Merrill Bay city councils in the early years urged the NRC to look more carefully at seismic safety, and not license Diablo Canyon until the safety questions were resolved. As a part of Diablo's licensing proceeding, the NRC conducted an independent design verification program for design and construction errors associated with the design of the plant to restore the plant such that its construction satisfies the approved seismic design criteria.

Now, fast forwarding to more recent years, in 2006, Senator Blakeslee authored -- a bill that was authored by Senator Blakeslee was enacted and it is called the AB 1632 study, which called for the Energy Commission to complete a seismic vulnerability study for California's large base load plants -- which are Diablo Canyon and San Onofre -- and adopt the study as part of the Energy Commission's Integrated Energy Policy Report. This is a report that we are -- our state agency produces every two years, and summarizes the supply/demand picture and provides recommendations to the Governor and the legislature.

The second piece of legislation I wanted to mention is AB 42, which our legislature passed, and required PG&E to conduct seismic research at Diablo Canyon, and for the Energy Commission in consultation with the California

Geologic Survey and the California Seismic Safety Commission to perform an independent peer review of PG&E's work, and include the findings in our Integrated Energy Policy Report.

The governor vetoed this bill, but in the veto language he mentioned that it wasn't needed because of the AB 1632 seismic study that had already been done, and that the Public Utilities Commission and the Energy Commission were already taking certain actions.

Now, just a little background on AB 1632 and what we were required to do. We looked -- using existing scientific studies we assessed the potential vulnerability of large base load plants to a major disruption due to a major seismic event or plant aging. We were also asked to assess the impacts of such a disruption on electrical system reliability, public safety, and the economy, also assess the costs and impacts from nuclear waste accumulation at these plants, and evaluate other major issues related to the future role of these plants in the State's energy portfolio. We adopted these assessments with our 2008 Integrated Energy Policy Report, and a final requirement was that after we completed the study, the Energy Commission is required, as part of the IPER, to perform subsequent updates as new data or new understanding of potential seismic hazards emerge.

Now, the study that we conducted in 2008, it was a large multi-disciplinary research team led by MRW & Associates, and we produced two reports, which later in my presentation there is a web site, if you are interested in getting copies of them. It involved a large public process, with workshops held in 2007 and 2008, and it was an independent assessment based on information the utilities provided, and our study team then independently reviewed additional scientific and government reports. We also established a seismic vulnerability advisory team that was made up of the California Seismic Safety Commission, the Coastal Commission, and the California Geologic Survey and the Energy Commission, and they reviewed the study plan's findings and recommendations. So, in general, the study took place over 2007 and 2008, and provided an independent scientific assessment of the seismic hazard at these two plants, and it was adopted in 2008.

Then as this study was being -- was underway, the Japanese earthquake in 2007 occurred, and we heard a lot about that yesterday. And then the Shoreline Fault, as the study was being finalized, and in November, when the study was being formally adopted, we learned that PG&E -- that there was the discovery of the previously unknown, significant offshore fault. PG&E and the NRC concluded, as we have heard, that Diablo Canyon's design would withstand the potential ground motions from this fault. However, the fault's major characteristics are largely unknown, its length, its proximity to the plant in relation to the Hosgri Fault, whether an earthquake beginning on the Hosgri Fault could continue on the Shoreline Fault or vice versa, causing a larger earthquake than if either fault broke on its own, and whether this fault or fault displays could extend beneath the plant.

Now, let's look at some of the findings, seismic findings from the AB 1632 study. The offshore Hosgri Fault is the primary seismic hazard at Diablo Canyon. PG&E's Long Term Seismic Program extensively explored the seismology and geology of the Diablo Canyon site. The geometry of faults bounding the San Luis Pismo structural block, where Diablo Canyon sits, is not understood sufficiently to rule out a San Simeon type earthquake directly beneath the plant. Although PG&E has considered such an earthquake in their analyses, our study found that PG&E, at least at that time, had not assessed the expected ground motions and plant vulnerabilities from such an earthquake. The study also found that important data on Diablo Canyon's seismic hazard and plant vulnerabilities are incomplete, and three-dimensional geophysical seismic reflection mapping may help resolve questions about the characterization of the Hosgri Fault, and might change estimates of the seismic hazard at the plant.

Recent studies have found that ground motion near a fault could be stronger and more variable than previously thought, which could be important at Diablo Canyon in light of its location near the fault. Now, the recommendations from this report included that PG&E and Southern Cal Edison should use three-dimensional seismic reflection mapping and other advanced techniques at both Diablo Canyon and San Onofre, and report on their progress in our 2009 report.

And in upcoming energy policy reports, PG&E and Edison should provide updates on their seismic research findings, including their tsunami hazard assessment, as well as assess the degree to which non safety-related plant components comply with current seismic standards. And we recommended that they assess the seismic vulnerability implications of evolving seismic standards since both plants were designed and built, and finally, to evaluate the implications for California plants of the 2007 Kashiwazaki-Kariwa earthquake in Japan.

Now, then, one year later, the seismic recommendations in the Energy Commission's energy policy report included that to help insure plant reliability and minimize costs, PG&E and Edison should complete and report in a timely manner on all of the AB 1632 recommended studies, including those the Public Utilities Commission had identified for completion as part of license renewal review. Another recommendation was that the utilities should reassess whether plants and access roads surrounding the plants following a major seismic event and a plant emergency are adequate for emergency response, and protecting public and workers and plant assets.

And finally, we also recommended that the Diablo Canyon Independent Safety Committee should evaluate reactor pressure vessel integrity at Diablo Canyon over a 20-year license extension, and recommend mitigation plans if needed. This review should consider the reactor vessel's surveillance reports for Diablo Canyon in the context of any changes to the predicted seismic hazard at the site. And we understand that the Diablo Canyon independent safety committee has this investigation underway. We also recommended that the utilities should make their findings available for consideration by the Energy Commission, as well as the Public Utilities Commission and the NRC during their plant license renewal reviews. These utilities should not file license renewal applications with the NRC without prior approval from the California Public Utilities Commission.

Now, just going over what some of the other California agencies have -- the decisions they have made on seismic issues at Diablo Canyon, the Public Utilities Commission in 2007 required PG&E to complete a license renewal feasibility study that incorporates the findings and recommendations from the AB 1632 assessments, and submit an application by June of 2011. The Public Utilities Commission also in June of 2009 directed PG&E to report on the major findings and conclusions from the AB 1632 recommended studies, including the seismic studies, in order for the PUC to evaluate the economic and environmental costs and benefits of Diablo Canyon's license renewal, and they directed that these studies be completed as part of PG&E's license renewal feasibility studies for Diablo Canyon.

Now, turning to the California Coastal Commission, they informed PG&E in 2009 and the Nuclear Regulatory Commission this year that results from updated seismic studies, including PG&E's advanced three-dimensional seismic studies, are needed to complete the Coastal Commission's Federal consistency review for the proposed license renewal as well as the review of PG&E's application for a coastal development permit that is required for the project. Now, more recently, the Public Utilities Commission approved PG&E's application to use $16.7 million for the advanced seismic research at Diablo Canyon, as recommended in our study.

The Public Utilities Commission also has established an interagency seismic review panel to review PG&E's seismic research plans and findings, and the panel includes several California seismic agency experts, including the Seismic Safety Commission, Coastal Commission, the California Geologic Survey, the Energy Commission, and the Public Utilities Commission. The Energy Commission supported both of these recommendations, and we'll hear later from PG&E regarding their plans to begin these studies -- advanced seismic studies. Southern California Edison has not yet begun updates to their seismic hazard and vulnerability assessments, although they have established a seismic advisory board to guide and review their studies. Their plan for the board is to review the seismic hazard at SONGS and determine the need for new studies.

So, in summary, seismic hazard plant vulnerability issues have long been major issues for both plants. California depends on these plants for about 12 percent of the state's electricity generation. We feel that advanced seismic hazard vulnerability studies for Diablo Canyon and San Onofre are very important in light of the major seismic uncertainties for these sites, and the new seismic information that's become available since these plants were licensed. We also are recommending that these advanced seismic studies should be completed, independently peer reviewed, and made part of the NRC's and the Public Utilities Commission's license renewal reviews.

Now, if you would like to see any of the reports that we have prepared, the Energy Commission did two comprehensive reports on nuclear power in 2005 and 2007, as well as our various Integrated Energy Policy Reports, and they are available at this web site, although there are two typos. If you would, delete the words, please, "state," delete "state," and then it should be "index" -- I-N-D-E-X -- in the first link. And thank you, that concludes my presentation.

[applause]

DR. KAMMERER: Thank you very much. As noted, we are going to have a slight change in program, and Dr. Cluff, is this you here?

DR. CLUFF: Thank you, that's me. During this presentation, I will be able to present some data that I hope will satisfy or at least answer the questions that were asked in the question and answer session completed a little while ago. We are -- between Norm and I we will be reporting on our evaluations of the Shoreline Fault, and our goal was to look at the behavioral aspects of this seismicity lineation that we discovered at 20.08 [spelled phonetically] -- specifically, to look at the location and whether or not it is segmented and do geophysical profiling to help assess the fault's location on the ocean bottom, and then the use of wave-cut platforms that serve as tectonic string gauges to be able to characterize the activity rate on the fault if the fault reaches the surface. And then that puts constraints on the slip rate and then fault length and the rupture area, which relates to the magnitude of potential earthquakes, and then the contributions to the ground motions, and Dr. Abrahamson will talk about that in the next talk.

Let me come back to a map that was in the PG&E 1988 LTSP report, and then -- so from the period of review between 1988 and 1990, this was a map, and I plotted on this map the alignment of seismicity, these dashed lines, and I have the northern segment, the central segment, and the southern segment of the seismicity alignment.

And this was an area where in the questions that the University of Nevada and the NRC scientists asked us about. Can you preclude a small fault in the surf zone sub-parallel to the coastline? And we said, "No, we can't preclude it but based on the information that we have in this area, a fault in that region would have a very low slip rate." And we estimated between 0.01 and 0.3

millimeters per year, based on other small faults that we had found in that southwest boundary zone. And I'll talk about this in more length in a moment.

We have done a lot of offshore geophysics in the area during the LTSP, and then in working with the USGS on the Cradia [spelled phonetically] assessment, that first marine geophysics that was done by the USGS in cooperation with where we needed additional data. And then the one map on the right is -- you heard presentations yesterday about the aero magnetic surveys. These were all aerial and ground surveys.

And then right below that last -- the end of last year we organized a helicopter to help the USGS conduct integration of onshore and offshore magnetic surveys, and you heard some results of that yesterday. And then we discovered that the California State University at Monterey were doing multi-beam topographic mapping for fisheries along the California coast. They had done a little -- mostly off of Morro Bay, and so we looked at those data and then we engaged that group to do a massive study, completely offshore and all the way down to and beyond Pismo Beach -- to look at topographic features and see if we could find any matches of the topography and geomorphology that might shed some light on the Shoreline Fault as identified by the seismicity alignment.

And the key area that really constrains rates of activity is these ancient wave-cut platforms shown in this slide. This is looking at the coast. The power plant is in the far background. You can't quite see it, but it is way back here. And there is a whole series of these wave-cut platforms that go back, some of them off to the right, to about a million and a half years, and then there is a whole sequence of those offshore.

So, in the offshore environment, here is a sketch that shows how these wave-cut platforms are developed when the sea level is like it is now. As the surf comes in, it planes very sensitive wave-cut platforms that then, when tectonic activity occurs and the coastline is uplifted, then on the diagram the wave-cut platform is about sea level, and then -- and that may have some marine deposits on it. And then as time goes on, the alluvium and colluvial deposits cover the marine deposits, so you have a whole host of data, a wave-cut platform, and then materials that can help you assess the age of these platforms.

So, we found that in this area, these are our interpretations, all these lines on this map are our interpretations of possible lineations that could be faults, and then the alignment of the seismicity was through this area. And then we had a target area in this rectangle where we actually have identified multiple wave-cut platforms offshore, and you can see from this map that they range from -- this wave-cut platform out here is 50,000 years old. This one, at 32 meters, is 80,000 years old, at 25 meters is 70,000 years old, and another one over here at 60 meters, 30,000 years old, and then one here at 45,000 years old. And then the one that is all along the coast that we mapped during the Long Term Seismic Program is 120,000 years old. So, any time there is a fault that may intersect these wave-cut platforms, it is a beautiful way of looking at strain or displacements on this.

So, this is a summary of the alignment of seismicity in the northern end. The dashed-dotted line here is the seismicity that does not align with a topographic escarpment on the ocean floor, which we have shown here as the northern segment. And then in the southern part we have a small segment, C-1, and another small segment, C-2, and another one, C-3. And these are all identified with topographic expressions, and then a southern segment in the far south.

So, in this area -- and Diablo Canyon is right here -- we have these onshore and offshore wave-cut platforms, and as we look at these in detail, we find a whole host of these west of the seismicity alignment that we named the Shoreline Fault, and then a series to the northeast up near Estero Bay, and as we look at these and draw a cross-section across them we can say that there is no deformation of any of these wave-cut platforms within a resolution of one meter within the period of time we're talking about of anywhere from 30 to 120,000 years. Here is a fault we named the northwest striking fault zone that is in the vicinity and to the east of the seismicity alignment, and one can see on this that the wave-cut platform here with the northwest 40 fault do not deform that wave-cut platform with the resolution of about a meter.

We also found, down closer to the plant, these topographic features that we have marked as possible faults. There are places where there are two different rock types and erosion can produce that topographic escarpment rather than fault displacement. So there may not be any surface displacement at all -- and then here is another one. The inset here shows this is far to the south where we have several wave-cut platforms and this cross-section is shown in this upper left side. And again, we see no deformation within the resolution of one meter.

So, our conclusions with regard to the Shoreline Fault as of today -- and we are in the process of completing a report that will be available at the end of this year -- is that there is a northern segment that is defined only by the seismicity alignment. There is no geologic or geomorphic surface expression on the ocean floor -- a fault break to the surface -- and that the geometry of the Hosgri and the Shoreline Fault are not favorable for a continuous rupture. And Dr. Abrahamson will address this in more detail about that evidence for that conclusion. The central segment shows a strong alignment of the seismicity in -- with the surface expression of bathymetry, where different rock types are juxtaposed. And what we see is that these are old faults that may have been enhanced by erosion rather than by fault displacement.

The southern fault segment, there is weak alignment with the seismicity but locally there is a clear surface expression in bathymetry, and it is the same thing. Two different rock types and that whole alignment that is an old fault may be a reflection that is strictly produced by erosion and not fault displacement. We are still working on this in the new 3-D studies that we're starting next month, as soon as we have a contract signed, and we're right in the phases of completing the contract negotiations. We'll start that to see if we can gather additional data. So, we have several wave-cut platforms, and all are older than 40,000 years, and our analysis show that the wave-cut platforms across the southern segment of the Shoreline Fault, that there is less than a meter of vertical separation in more than 40,000 years.

And the evidence on the northern segment is only by seismicity. We see no evidence that there is any features that can be identified that come to the surface, and the geophysics that we have from the geological survey doesn't go deep enough to where the hypocenters of the earthquakes in the seismicity alignment to see the relationship of the northern segment of the Shoreline Fault with the Hosgri. And the presence of under formed [spelled phonetically] wave-cut platforms that cross this in places show that there is a lot of evidence for very small or no surface deformation on the Shoreline Fault. We have now estimated and reconfirmed, as we did back in 1990 and '91, that the slip rate on the Shoreline Fault can be no larger than 0.01 to 0.3 millimeters per year.

And Norm will show the significance of that in a probabilistic hazard evaluation. So the Shoreline Fault is a low activity fault compared to all other faults in the region, and we expect that single segment ruptures of the Shoreline Fault is most likely and a full three-segment multiple rupture is very unlikely. Thank you.

[applause]

Norm is going to change computers for his presentation.

DR. ABRAHAMSON: Good morning. I'm going to talk about the ground motions resulting from our current information on the faulting and attenuation relations. This is going to be technical information, so I will try to keep some of it simple, but it is intended for the technical people in the audience to be able to understand what we're doing and start to be able to evaluate the reasons why we consider the plant still to be adequately safe.

I have added some slides based on discussions yesterday. So some questions came up that weren't addressed in my previous presentation, so I have added some slides to do that as well as some slides to add some general information that didn't get covered by the introductory material. But we're starting from what you heard yesterday from Ralph and from Doug and Robb Moss on general seismology and ground motions and then heading into the hazard analysis. So what I will be showing you is both deterministic and probabilistic results.

One of the topics that wasn't discussed yesterday -- at least I didn't hear it -- was how do we get the activity rate on the faults, and the way we do this is we keep the faults in equilibrium. We know that plates are moving, and over the long-term the amount that the plates move have to be accommodated by how much the fault slips.

Okay, so here we would say the seismic moment, which you heard discussed yesterday, has to -- the accumulation has to equal the release from earthquakes over the long-term so the fault will be in balance. You also heard the moment increases -- you probably heard before -- by a factor of 30 as we go up one unit in magnitude. If a fault makes bigger earthquakes, for it to be in equilibrium it needs to be -- those earthquakes have to occur less frequently than if it makes smaller earthquakes. Now, remember when we talked about hazard yesterday, we talked about how strong will the ground shake, how often does it happen, and then the risk is what are the consequences?

So there is going to be some things that trade off here in terms of how we model earthquakes. So, what is conservative in terms of magnitudes is different when you are doing a deterministic analysis or a probabilistic analysis. And this can sound counterintuitive, but if we start out with a deterministic approach, bigger magnitude on the fault leads to larger ground motion, okay? That's easy and straightforward to understand.

In a probabilistic approach, a larger magnitude is going to give us a bigger ground motion, but less frequent, and for high frequencies, which is what is our main concern at nuclear power plants, the reduction in the rate of occurrence has a bigger impact on the hazard than the increase in ground motion. So, as we make bigger and bigger earthquakes on those faults, the hazard actually comes down. And you say, “How could that happen?” That is, the chance of getting a big ground motion is less because the earthquakes occur less often and I will show you examples of that.

So, when we try to do our analysis we’re not just looking at conservative, we’re trying to build our estimates of our best estimates of the behavior of the fault and tracking the uncertainties. So yesterday, Annie Kammerer also talked about deterministic ground motions and worst case. I teach graduate classes on hazard analysis, and the first thing I try to get through to them is not to use the word “worst case,” and I think in these public meetings we need to start to be clear about this, okay?

What do we mean on a deterministic ground motion -- it is not a worst case. We are dealing with worst case ground motions when we are trying to look at Yucca Mountain and things that have -- you know, probabilities of ten to the minus nine, 10 to the minus 10, very low values. But for what we’re doing here, it is not a worst case. What is it? In source characterization, we need a magnitude. It isn’t the largest possible. Even though we kind of talk about it, we use a word like “maximum credible earthquake,” and you think that must be as big as it gets, but in practice, really it’s not. It’s determined from the fault dimension, typically the area.

But, we might have multiple segment ruptures. You heard a little bit of this -- Tim Dawson talking about it yesterday, can one fault rupture and then jump to a neighboring fault and the rupture continues building up bigger and bigger earthquakes? Well, what is the limit of that? It is clearly possible. They happen sometimes. But how much can this occur? Also, when we estimate the magnitude from the area, there is a range. I might have a fault that is 50 kilometers long by ten kilometers wide, and I could have several earthquakes that were that same size in dimension but some might be a magnitude 7, some might be a magnitude 7.2, some might be a 6.7. There is a whole range there of variability. We use in practice the mean value.

So, in getting our magnitude, we are picking a magnitude, and I put here that is reasonable. It is large enough and rare enough and it is usually a number that is negotiated with the regulator. It is not simply a worst case, and I'll talk to you about an example at Diablo Canyon in a second. For the distance, we actually use the closest distance to the fault, so we bring that in as close as possible. On the ground motion we are not at all near a worst case. What is shown on the right-hand side is a distribution of ground motion from our models.

So there was discussion yesterday about attenuation models, or you will hear them called ground motion prediction equations, that give you a distribution. There is a whole range of ground motion. So the blue curve here has a peak so this earthquake -- this is our 7.2 -- at four and a half kilometers from the Hosgri Fault, but if we were using this, it would have a median value, or the center of this, at about 0.2, three, four, five, six, 0.7g. And there is a whole range, though, of possible ground motions.

When an earthquake happens at a particular site, sometimes they are high, sometimes they are low. What we've seen in the last 20 years is as we collect more and more data, we are seeing that this variability exists and it is large, even close into faults. That is what we saw from [unintelligible], Lloyd talked about all the data that was collected. That's what we saw in Turkey, that's what we saw in Parkfield.

All of the very well-recorded earthquakes with lots of close-in data show large variability and that variability is built into our models right now. The red line here shows the 84 percentile. If we are doing a deterministic approach, we use the ground motion given by this 84 percentile here at, say, 1.25g. That is not as big as it can get. This curve goes -- this blue curve goes well beyond that. When we run a probabilistic analysis, we allow for all of those possible ground motions, all the way up to the upper ends of this curve, to occur but we keep track of how often they occur. The whole reason for moving to a probabilistic analysis was a somewhat arbitrary decision of how do you pick a magnitude, and this picking of the 84 percentile ground motion and saying that's your design basis, that difficulty, again, that was a negotiation mainly with the regulator, and to try to get things on a more sound technical basis, we've moved to probabilistic approaches. But, I will show you the results for both the probabilistic and deterministic approaches.

First is source characterization. What has changed since our 1991 LTSP model? On the Hosgri Fault -- you saw yesterday Vicky Langenheim talked about the data that she had from gravity data, magnetic data that could be used to constrain the faults. And she showed there that the Hosgri Fault has to be a fairly steeply dipping fault. In 1991, we didn't have that information -- that high-resolution information to do that. So, this, the previous model, where there was a listric model for the Hosgri Fault, where it came at a very low dip back towards the east is not consistent with that data, so we have now been able to collect information and rule out or reduce our uncertainty to rule out a case that is not consistent with the data.

For the Los Osos, it is a similar thing. In the 1991 report, we had a whole range of possible dip angles, from a low of 30 degrees up to 75 degrees. Again, the new information that's been collected rejects this very low angle case and we're starting to be able to reduce our uncertainty. We still include a range of 45 to 75 degrees, and that is something that we're going to be focusing on in the next data collection effort in the next couple years. And we've added the Shoreline Fault that was just discussed.

I added this. This is one of the plots that you don't have. There was talk of logic trees, and just to show that you that we do have these kinds of logic tree models built for the Hosgri, this has been updated to just consider the strike-slip and the restriction of the dip to 70 to 90 that the new geophysical data tells us. The rest of the model is based on what was used in LTSP. That hasn't been updated yet. This will be updated as part of the new hazard update that is going on and will be completed in 2013. The models that we have, we look at what is the range of the crustal thickness along the Hosgri Fault.

What are the rupture lengths? What are the sizes of earthquakes that happen? Does the Hosgri rupture in a lot of smaller earthquakes, 20 kilometers long or 45 kilometers long, or does it rupture in big earthquakes? Remember, if there are smaller earthquakes, the ground motion is weaker on average, but more frequent. When we are going to be in this case, on the bottom here, 110 kilometers, I get a bigger magnitude, but it will happen less often. We also looked at methods of control, looking at the magnitude from what is the average size of the displacement on the fault. And several different methods were used, rupture length, rupture area, the total length of the fault, and the average displacement to get at the size of earthquakes. And then there is the slip rate. How fast is the fault moving in the long-term? And we have numbers as low as a half a millimeter a year up to six millimeters a year. The average value in here is just under three millimeters a year. So, this leads to large uncertainties and we track all of that.

This shows you the uncertainties in the magnitude for the Hosgri Fault. So, from those different ways of looking at what is the dimension -- or the thickness of the crust, what rupture lengths, is it rupturing in smaller or bigger earthquakes on average, and what are the different ways, the technical models we have for estimating the magnitude given the dimensions of the fault. We get a whole range here, from 6.4 up to 7.5. The average is about -- the mean value is about seven. What was used and essentially negotiated as part of the LTSP was a magnitude 7.2. So again, it is not the biggest possible, and we haven't considered, does this, you know -- other jumping to other faults in this particular case but this is a value that was set as a reasonable magnitude to be using to do the deterministic analysis. When we run the probabilistic analysis we'll consider all of these possibilities. So the probabilistic analysis is just a more complete set of deterministic cases.

For the Shoreline Fault, in November of 2008, after we had received the information from the GS and Jeanne Hardebeck, who talked about this yesterday on the alignment of the epicenters, we did a preliminary evaluation to see what are the impacts at the plant? We assumed it was a vertical strike at fault based on the location of the earthquakes. We assumed at that time that the full length of the 25 kilometers would rupture in a single earthquake. We used a depth of seismicity of 12 kilometers, and this came up with a magnitude of six and a half. And based on the initial locations, we used a distance offshore of Diablo Canyon of one kilometer.

Following that, what do we know now? As Lloyd mentioned, we now have an indication that there are three main segments in the Shoreline Fault. The central segment is the one that is best defined in the surface, the bathymetry data, where you can see a fault scarp, an erosion feature, but there is a clear scarp there. It is about nine kilometers long, 10 to 12 kilometers in width of the seismogenic zone, and we get magnitudes of about magnitude six, if that was to rupture by itself. We could also be looking at the parts to the south. There is a southern segment which is not really as well-developed.

As Lloyd had mentioned, it looks like the wave-cut platforms are not deformed, so it would be moving at a low rate if it is active, but if we put those two together, we would get something about 15 kilometers long and magnitudes up to about six and a quarter, and I'll talk in a little bit about -- we see the change to the northern part, where there is no surface expression any more of the fault, and see that as a separate entity or a separate piece, but I'll show you some sensitivities in a minute, including the northern sections. The distance offshore to Diablo Canyon is important. It is now, the fault scarp is .6 kilometers offshore, not one kilometer. So it is a little bit closer, but we have very good control over where this is with the new bathymetry. And then the slip rate, again, we run between, as Lloyd said, .01 to .3 millimeters a year is our current estimate. These are all being finalized for the report that is due at the end of this year.

This is a preliminary logic tree. This is again a plot that you don't have in your handouts. The sensor slip is strike-slip. The dips range from 90 to 80 degrees. We prefer 90 based on the near vertical seismicity, and then we have several models here of how it could rupture. We -- based on the geologic evidence, we have preferred at this point that it ruptures or is most likely to rupture in single segments, okay? Two segment ruptures are given only a weight of 20 years, and a three-segment rupture is only given a five percent weight. We don't think that is a likely behavior of the fault system.

I put on here as well, because what was discussed yesterday, what about the Hosgri rupturing and a splay fault comes off onto the Shoreline Fault? Right now, we have no weight on that branch. And there is a reason, several reasons for that. The geometry between these two faults is not favorable to create that kind of a rupture. That doesn't mean it's impossible, but it's very unlikely. What is unfavorable? First, the angle. The angle between them is about 30 degrees. In splay faults that we've seen in the past, the angles are typically in between 10 to 20 degrees. Once you get out to an angle of 30 degrees, the geometry is not favorable any more.

The second part is the side of the fault that it is on. Based on the Hosgri -- if you think of it, the Shoreline Fault being on the east side of the Hosgri Fault, it is actually on the side that is releasing energy or not loading the fault as the Hosgri slips. If it had been on the other side, it would be more likely to occur.

Third, we have been sponsoring research through the Southern California Earthquake Center looking at dynamic rupture models, so computer models of faults and then ruptures coming off onto splays. Even using the narrower angles -- say 15 degree angles -- the ruptures only tend to go a few kilometers.

And this was worked on by Jim Rice's group at Harvard. So, they did a series of computer models saying, "If we do forward ruptures, how far do they go along?" So if it starts to rupture onto the splay fault, it is unlikely it is going to make it all the way down to the distance near Diablo Canyon. The other part is the northern seismicity Lloyd mentioned. There is the northern fault that he had talked about, and then there is the seismicity trend. We weren't sure at this time whether the fault is following the northern fault or is part of the northern seismicity alignment. And then we used several different methods for estimating the magnitudes of the ruptures. We used the Wells and Coppersmith models with plus and minus 0.2 magnitude units just to capture some of the uncertainty. And the slip rates are shown here from 0.01 to 0.3.

If we do -- the other part, then, in addition to updating the source characterization, is updating the ground motion models. This is where tremendous progress has happened in the last ten years. The Pacific Earthquake Engineering Center spent about six years working on updating new ground motion models. This is called the NGA, or Next Generation Attenuation Project. It is based on a much larger dataset, and I will show you that in a second here. The key issue as well is that we have a much improved parameterization of the site. In 1991, we classified sites as generally rock sites or soil sites. Not a very sophisticated grouping of site terms.

You heard a little bit yesterday -- Robb Moss talking about soil sites and the amplification that occurs and so forth. So we were able to separate generally alluvium from rock, but it wasn't a very fine distinction. Now we use a parameter called VS-30 [spelled phonetically]. That's the shear wave velocity over 30 meters and as opposed to causing generic rock, this is something we can now measure and is a more quantitative description of the site. And we are able to do a better job of distinguishing in a sort of continuous way between soft soils and stiffer soils and softer rocks and stiffer rocks and so forth. Diablo Canyon is a stiffer rock site than typical California rocks, okay? It has a shear wave velocity, a VS-30 of 1,200 meters per second. So, most of you won't know what that means. The people -- the folks in the room that do this realize this is a very stiff number.

Typical rock sites in California have a shear wave velocity of about 550 meters per second. The higher the shear wave velocity in general, the lower the amplification. So there is less amplification of the waves as they come from the earthquake up to the surface of the ground. This was an important effect. The other part we've added is near fault directivity effects weren't included in 1991.

That was discussed a bit today. I think Sam Blakeslee mentioned it. We have now included those effects into our models. They are primarily, however, affecting long period ground motions -- ground motions greater than -- periods greater than half a second. And so they don't impact us at the short periods, but we've included these effects as well. To show you what the dataset looked like in 1991 this is -- on the X-axis is distance, on the Y-axis is magnitude.

The box showing there shows you less than 20 kilometers, greater than magnitude 6.25. That was available when we were doing the LTSP. There is not a lot of data from an empirical model to estimate, say, a 7.2 of four and a half kilometers. There is very few data on which to constrain it. The bulk of our data were out here at around 30 kilometers from a magnitude six to six and a half.

So, we had to use at that time trends that we saw in the data as well as physical -- or constraints on the physical behavior of earthquake ground motions to extrapolate those data back into short distances. Since then, as Lloyd mentioned, there has been a large increase in the ground motion data. This is what was available for the NGA project, okay? So, this is the same box -- six and a quarter and less than 20 -- and now you can see a huge increase in the amount of data. There is more than ten times the data that we had during the LTSP.

Key earthquakes are shown here. This is the [unintelligible] data are from this earthquake; the Kocaeli data are in here. There is Hector Mine and Landers and so forth, so there -- excuse me, the Loma Prieta. So there is a whole lot, and this one up here is the Denali. So, we now have much better empirical control. As well, we also used in the NGA project numerical simulations. These are computer models of how will earthquakes rupture, how waves propagate, to help us constrain even then how things should scale up to high magnitudes.

The result of all this was a significant revision in the ground motion close-in. So there is two parts here, we have more data and we have a change in the way that we’re characterizing the sites. It is much more. We will be able to refine or distinguish harder rock sites from softer rock sites. This shows you on the left-hand side the ground motion and we're using here at three to eight and a half hertz. This is the frequency that is most important to the structures at Diablo Canyon. The black curve is the median, or the average value from the LTSP model. And these four curves here are the four of the NGA models that were developed, based again on VS-30 and on this larger dataset. So you can see they are producing or saying we had overestimated what the average shaking was based on the sparse data available in 1991.

The other feature that we need is not just, "What is the average level of the shaking?" We need to know the variability. Variability is important. This is the whole range. How high can it go? In the LTSP -- and we characterize this by a standard deviation, it is in natural log units. Just so you know, the .7 here means one standard deviation will be twice as high as the median. One standard deviation down would be half of the median value. So, there is a big range of what the ground motions are.

In the LTSP, we had used the standard deviation model down here. We had basically underestimated what the variability of the ground motion was. This is one of the lessons we have learned over the last 20 years. The ground motion variability that we are seeing from well-recorded earthquakes is a lot bigger than what we had modeled back in LTSP. Those numbers are up here. So, what's going to happen, we're going to have a lower value but a higher standard deviation. To show you what we're comparing here, if I'm looking at a magnitude 7.2 at four and a half kilometers from a strike-slip earthquake -- again plotting spectral acceleration between three and eight and a half hertz -- this is the LTSP model. It has a narrower distribution, but it is centered at a higher value, whereas our current model is down here. It is lower, but it is broader. There is a point here where this actually crosses, and what I plotted on the right-hand side is a -- we would call it complimentary cumulative distribution, okay?

So, this is the chance of the ground motion being greater than, let's say, 1g here. It would be all of the area to the right of this curve under 1g, all of the area under the curve greater than 2g, and so forth. Because here you can see, the blue curve stays higher, but at 3g's, it crosses over. That is, down here, if I blew this up, the red curve starts to be greater than the blue curve. We care about this because it is these very high ground motions that we're going to worry about are going to be important for impacting risk at the plant. Something bad happening and failing the plant systems requires not the design basis ground motions, but much greater than the design basis ground motions.

So, we've updated the seismic hazard. I will show you the deterministic values, 84 percentile for the Los Osos, Hosgri and Shoreline Fault, and then I will show you updated probabilistic numbers. So, the deterministic evaluation here, our main frequency band that we care about -- Annie yesterday talked about thinking about swings and what frequency matters in your swings. Well, the frequencies that matter to the structures at Diablo Canyon are three to eight and a half hertz, so this yellow shaded region is the region we care most about for our structures. The spectrum, though, is defined all the way at long periods out here, where directivity effects start to happen, and then very high frequencies on this side.

So, there are two things here. The red curve is the Hosgri spectrum. This is the spectrum that was developed in 1975. The plant was basically redesigned and retrofit to meet that spectrum. So if our new spectrum falls below the red curve, we would say the plant has already been shown to be able to withstand those levels of shaking, and we're okay. The blue curve is called the LTSP spectrum. That was a separate spectrum that was developed as part of the LTSP in 1988, and the plant was re-evaluated for that spectrum as well and shown to have adequate margin for the blue spectrum.

So, if we have ground motions that fall either below -- and the blue one is below the red. That just basically says those two specter were essentially consistent at the time. Except at the very high frequencies, the blue one is a little bit higher. What we found is this change from here to here, from the red to the blue, was not a significant impact on the plant. But either case, as long as we're below these we would say we're already analyzed for that case, right, and we don't have to go further.

So, right here, the Hosgri Fault is shown by the green, the Los Osos fault is shown by the purple. And in the shoreline, this is our two-segment rupture, the rupture that we think is a reasonably conservative model. We think the most likely way it is going to rupture is single segment, but we have here built in a two-segment rupture. We come up here, still below the red curve and blue curve, so we would say we are analyzed for that case.

Now, let's look at some sensitivity, because you have some questions. What if a different model was used for the Hosgri Fault? This is the magnitude sensitivity. These have four directivity included with them. What is the range here? If I had a six and a half versus a seven versus a seven and a half earthquake on the Hosgri Fault, we are still below our current design basis. That is, we have been analyzed for shaking at least that large.

If we look at Los Osos, we can also look at, how does it depend on what the dip is of the fault? One of the other features that we have learned from new ground motions is that when you are over the hanging wall of a reverse fault, and that was discussed a bit yesterday, ground motions go up and that's what you are seeing here. The blue curve -- excuse me, the purple curve is a 60 degree dip on the Los Osos, this is a 75, and this is up to 45. So, as it gets a lower dip angle, the ground motions start to go up. At this case we are still basically falling below our red curve, which is what we are already analyzed for. We can also look at different magnitudes.

What if it was a bit bigger on the Los Osos here? We are using a 6.8, it could be a seven, or here a 6.5. You can see it doesn't make a very large change in the values. Now, what you are going to be interested in is what about the Shoreline Fault and some of the cases that were talked about yesterday? So for the Shoreline Fault, we believe the most likely rupture mode is in a single segment, and we have used a two segment model.

But what if all three segments went? What if it did go as a splay fault from the Hosgri? How much would the ground motion go up? Are we analyzed for that case? So, these are these cases up in here. What we care about, three to eight and a half hertz, what really controls the hazard at the site, which is what the PRA is all developed based on. We are still below the red curve, even if the rupture came down the Hosgri, came onto the Shoreline Fault, and ruptured that piece.

So, we don't believe that to be a credible model, but we are just showing you here what would happen if you pushed that model all the way through. Where we have -- there is a slight exceedence here, about ten percent in the highest frequencies, 20 to 30 hertz. This doesn't affect our structural response. Goutam Bagchi was mentioning the deformations are very strong here -- excuse me, very small, but what you might have is issues of relay chatter. Those are covered in the PRA. The range here, really, between our LTSP curve and the black curve is within the range of what we already put into the time histories and variability of ground motion and the hazard, or the PRA.

So we think that we have adequate margin here, and this is not a concern for us. If we were popping up here and showing a case that exceeded us, our design spectrum in the three to eight and a half hertz we would have an issue that we would have to go back and reanalyze the plant to demonstrate that we could do that here. But in all of these cases we're below our red curve, okay? So what had really happened was the red curve at the time it was developed had significant conservatism -- particularly in the ground motion -- based on the kind of information that was available at the time. Our new improved models are showing that things are not as large.

Other issues you find, why do things not change so much? It seems like so different for just the central segment rupturing versus the Hosgri rupturing onto the Shoreline Fault, and I have shown this here. This is a new slide as well. It is a function of magnitude. What is the spectral acceleration here at the high frequencies versus at the low frequencies? When you are in close to a fault, the high frequencies just don't change that much as you get bigger magnitudes. That is, the energy goes up, but the energy that is increasing is really in the long period range. That is where it is going.

So, at the long periods, at the red curve here, there is still an increase, significant increase as I go from six, six and a half, seven, to seven and a half. It gets bigger and bigger in the median ground motion, but the high frequencies are almost the same. This is why when the earthquakes that -- we say let's make a bigger earthquake but it is less frequent; the increase in the high-frequency ground motion is not enough to offset the decrease in the rate of occurrence. So, I will show you what the hazard starts to look like.

So now we're jumping from our deterministic basis, which is really saying can we check, did we have, do we fit under an already analyzed condition or not? So now we're going to go to the probabilistic hazard curve. So these were discussed as well yesterday. These are the same things that are in the national hazard maps, same types of probabilistic hazard curves. What I have shown here -- so on the bottom is spectral acceleration, again, averaged over three to eight and a half hertz, and on the y-axis is the annual probability. So, the green curve is the hazard curve from LTSP that was used in the PRA, okay?

Now, remember that used the source characterization and the ground motion models from that time. If you look at it, the red curve shows us the hazard curve that we get now. So what has happened? It is lower on the left-hand side, but then it has a flatter slope and becomes larger over here. Why is this? It is lower because the median ground motions were lower. I'm going to make weaker -- my ground motion models tell us we were overestimating the ground motion in terms of its average response before, but it is more variable.

So, there is a point here where this crosses over, the variability catches up to the reduction in the median. The red to the blue shows you the impact of the Shoreline Fault. It is really not that important to us in the hazard sense, because it doesn't produce earthquakes nearly as often as the Hosgri. The Hosgri, with the much higher slip rate, is going to be our dominant hazard in a probabilistic sense. So, if we go back to this, here you can see these are crossing at, say, about two and a half g's is where these curves cross. If you go back to this picture here, this is what is going on. This larger variability starts to give us a higher chance of exceeding the ground motion in this simple case above 3g. When we run all of the different magnitudes and so forth, we get back to this hazard curve here. So now we have our lower hazard curve in this range, and a higher hazard curve on the higher side.

And your next question ought to be, "What does that mean? What does that mean on risk at the plant?" Because if the curve had been below the green one at all ground motions, we would say, "Look, it is below what we had before, we are happy. Now it is crossed, and that tells us something different."

But before we get to that, let's look at where the hazard is coming from. So one of the ways we look at this is say, how do the different faults contribute to the hazard? The total hazard is shown by the black curve, so spectral acceleration on the x-axis, annual probability being exceeded on the y-axis. The red curve shows you the Hosgri by itself, so what you can see from this picture is the Hosgri by itself gives you most of the hazard.

What is shown on the right-hand side is the contribution to the hazard at 1.75g and at 3g, so you can see what is going on. The Hosgri gives you here -- about 70 percent of our hazard comes from the Hosgri Fault. The next two are the Los Osos and the Shoreline Fault, and they each give you somewhere in the 10 to 20 percent range. The Los Osos fault, which we considered here, is negligible, giving us a less than one percent. So, these are the ones that we care about. Primarily it is the Hosgri Fault that is controlling the answer.

The other way we look at this is deaggregation. Mark Petersen talked about this yesterday. This just shows you for a one in 5,000 annual probability, our controlling -- we have on these plots the distance and then the magnitude, and these are in different bins here. And we look to see which one of these -- how do they contribute to the hazard? What is the different size earthquake's contributing? Because we don't look at one event, we look at all of them, okay? We consider all possible earthquakes. So here, the highest one you can see is this purple bar here, in the five to 10 kilometers, from magnitude six and a half to seven earthquakes. If we look at that in detail, the value is really a 6.7. Just over five kilometers is the controlling earthquake that is driving our hazard. That is, that's the most likely way of getting strong ground motions at our site, and that's from the Hosgri Fault. There is also uncertainty in hazard.

This is a new plot. So there is a lot of talk about uncertainty, and we have been doing this, I thought I better stick in a plot, because when I teach this as well I say, "If you don't show an uncertainty plot, you have to reject the report." So, this is the range of what the hazard could be, considering all those alternative models we saw in the logic tree. What is the slip rate? What is the characteristic magnitude? Which attenuation model are we using and so forth, okay? What is the segmentation model for either the Hosgri or the shoreline?

The black curve is the mean value, and that's what I have been showing you in the previous plots. That is the weighted average of these curves, and what you can see in here is what this range is, and these are on log plots, but they range by basically, let's say here, about a factor of four. So, in terms of rate of occurrence, we have about an uncertainty of a factor of four as to what that hazard curve is. It is somewhere in this range here. The risk value -- so, what do those new curves mean for us?

So using the LTSP model, we take the hazard curve and combine it with the fragility models, that is, models of what happens to the plant when we shake it? What is the chance of leading to failure to get our seismic risk numbers? And the LTSP model had a seismic risk number of 3.8 times 10 to the minus five. So, ten to the minus four would be one in 10,000, so this is about one in 25,000, if I do it right. The updated hazard results, even the curve, remember, was lower on the left-hand side and then became higher on the right-hand side, and so what happens? The end result in this case is the numbers are about the same. It is a little bit lower. The reason for that is that the bulk of our risk, if I go back here and show you that -- the bulk of the risk comes from ground motions in this range in here.

We have to combine the chance of the ground motion happening with the chance of that ground motion causing a failure at the plant, okay? Those two things happened. So these, while these ground motions are less likely to cause failure of the plant, they are more likely -- they occur more often, and these are the ones that are dominating the risk numbers.

Okay, so the other part I wanted to show you is these are two new plots, sensitivity to the hazard for the segmentation. What if instead of the segmentation that I assumed, which is, we think, much more likely, that the Shoreline Faults rupture in single ruptures, but instead we say no. It always ruptures, all three of those segments together, and we're confident of that. So, here the red curve shows us the hazard curve just from the Shoreline Fault if it only ruptures in single ruptures. The dashed curve is if it only ruptures in three-segment ruptures, all of them together. This is back to that first slide I told you about, what is conservative, okay? Because a three-segment rupture makes a bigger earthquake, it has to occur less frequently to keep the fault in balance. The net effect is actually a lower hazard. So, for this case, conservative hazard, you get a higher value using the smaller, more frequent earthquakes.

If we do the same thing for the Hosgri rupturing onto the Shoreline Fault as the splay fault, the same type of thing happens. The blue curve shows us -- first, let's look at the deterministic values if I had the Shoreline Fault rupturing by itself, or the Shoreline Fault rupturing as a splay fault as part of the Hosgri. So I'm going to now make a 7.2 earthquake on the Hosgri, and a splay fault coming off up to 0.6 kilometers away from the plant. So I use a magnitude 7.2 at 0.6 kilometers away. I get this larger deterministic ground motion compared to our magnitude, in this case six and a quarter.

But if I put that into hazard calculations, that bigger earthquake now has to occur less often. And actually in this case, my hazard curve goes from the blue down to the red. So, what is conservative in the deterministic analysis leading to larger values leads to lower values in the hazard calculation? So, really, what we want to do is not be conservative in trying to estimate our models of the fault behavior. We try to do our best estimates of the true behavior of the fault, tracking uncertainty. That's really the proper way to handle the problem.

Finally, what are we doing? What are we doing going forward? So, there are five major efforts that are under way. Number one, what I have shown you on the ground motion here is all empirical ground motion models. There is a big push that we're involved with in moving to a greater use of numerical simulations. These are the computer models to generate the ground motions. There are a lot of advantages to those because they are not based on the sparse data that is available, but they can simulate hundreds of future earthquakes on the Hosgri Fault, and work through it that way.

The problem has been -- on the research side, has been emphasizing long period ground motions. That's where the seismologists have mainly worked, and the building side is more interested in that. For nuclear power plants, we are mainly interested in high frequencies, and so the research that we're funding at SCEC and the USGS is emphasizing on improving the methodologies and then we'll be implementing them for the high frequency part of numerical simulations.

The second major effort that is happening here at Berkeley is an update to those NGA models. Those models were developed based on data up through 2000 -- early 2004. Significant new earthquakes have happened, including the one just recently in New Zealand, and data from that are already available. We'll be updating the NGA ground motion models in about one year from now, so new models will be coming out from those. As part of that, there is also an update to the directivity model, so those will all be included. That will be updated at the same time. Those are projects that are being funded mostly by the California Earthquake Authority.

The fourth one is actually a new topic that I have not gone into here. That is, we look for fragile geologic features that can constrain our ground motion. If we have a rock that is fragile and has been standing there for five or 10,000 years, that tells me something about what the ground motion has been in the last five to 10,000 years. There is a large project the DOE had funded -- a cooperative research effort with PG&E to look at this over the last five years, and that is just finishing up this month. So, we'll be looking at implementing some of those methodologies at Diablo Canyon.

Finally is the update of our hazard, so what we're producing in December is a report giving you all the technical information behind our characterization of the Shoreline Fault. But, we're going to then take all of this into a full hazard update, and what we have now committed to do -- or plan on doing I should say -- is called a SSHAC level three approach.

So, Annie knows what that is, but this is a Senior Seismic Hazard Analysis Committee, what that stands for. This is essentially a very structured and formal way to do seismic hazard analysis to capture the uncertainty of the technical community. This, as opposed to -- it is a little different from what Lloyd said, is PG&E would do the hazard, and then the USGS may be reviewers. This project -- the way this is done, everyone will be involved throughout.

So there is participatory peer review. This will run two to three years. The fastest we have ever done one of these is two years. We expect to finish this at the end of 2013. All of the technical experts in the field will be involved in one way or another. It is done in a series of public workshops. It is very open and transparent. You can see exactly what is going on. I can tell you, the public workshops are highly technical.

So if you are hoping to come and just, to watch, you can see what is going on, I think you can maybe talk to people, but those are intended for technical discussions among the experts in the field. We build from this. Really the emphasis is on capturing the uncertainty. This whole approach of SSHAC was brought together because of difficulties in the past when we have done studies multiple times and we get about the same center estimate, but the uncertainty estimates were not stable. The intent here is to find a way to get stable estimates and repeatable estimates of our uncertainties. And so, with that, I will complete it. Thank you.

[applause.]

MR. MAIER: Barbara, Lloyd, Norm, thank you. That's a lot of information in a relatively short period of time, so if anybody has any questions for them, we'll start here.

MS. STAPLES: Thank you. Good morning. I'm Kathy Staples. I'm the director for the Santa Barbara County Energy Coalition, and the NRC has done an outstanding job. The California Energy Commission, PG&E, you have given us two days of a mammoth amount of research and information to talk to the fears of the people that -- I live here -- of what we're talking about with Diablo Canyon.

I was here when they built Diablo Canyon. That was back in the

'80s, and you remember, that's when microwaves came out and we were all afraid that we were going to get radiated, so we didn't know whether to buy a microwave or not. Well, we didn't get radiated and that's when Diablo was built, so we've had 27 years of no nuclear problems. We've had numerous earthquakes and PG&E has done an outstanding job to keep us safe, and we're appreciative of all the effort that the NRC is making to regulate and look after us. California Energy Commission and Diablo, PG&E, you have done a wonderful job. I would ask the NRC this question. Annie, have you as an agency looked at the energy needs for California, and the tremendous needs for electricity for the future of this growing population in your research?

DR. KAMMERER: I guess that question comes to me. The answer is that the NRC is focused on the safety of people in the environment, so we don't look at energy needs per se. That is not within our mandate.

MS. STAPLES: Well, I would suggest that maybe you would want to look at that, because it is a federally-regulated program, and as we all know, or maybe we don't all know, California is in terrible financial straits. Perhaps you know how much of PG&E has contributed in the way of their electricity needs for California.

DR. KAMMERER: Thank you. I appreciate the comments. The California Energy Commission is the one under whose purview those types of studies are happening, and they have done an excellent job of several studies recently that Ms. Byron discussed.

MS. STAPLES: So we're saying 12 to 20 percent, somewhere in there? That's the numbers that I have heard. Is that correct?

DR. KAMMERER: Yes.

MS. STAPLES: And is Diablo responsible for most of that?

MS. BYRON: Both Diablo and San Onofre, they are about 2,000 megawatts each, and we get some from Palo Verde, a small amount, which goes up to 14 percent, but on average, about --

MR. MAIER: We're going to need to move on.

MS. BYRON: About 12 percent for both.

MS. STAPLES: Would you say that that is half of Diablo's capacity?

MS. BYRON: Generally.

MR. MAIER: I'm sorry. We have a number of questions and we are going to need to move on before we break for lunch. I'm going to go to Geof first, since I have not heard from him yet today.

MR. BARD: Geof Bard, Upland Research Science Action [spelled phonetically], and I'm proud that I'm a former member of the Oil, Chemical, and Atomic Workers Union, and my questions are relatively brief compared to yesterday's intensive question and answer session.

The first question really pertains to the final form of the report of Dr. Cluff. I would hope that you provide us with confidence estimates on your rather sanguine assurances that we don't need to worry about a multi-segment rupture. I would like to see that broken out in an easy-to-read summary in the final report. But my primary question for today is directed to Dr. Byron -- did I say that right -- and that is, yes, regarding your assertion -- regarding the cojurisdiction of the California Coastal Commission.

I would invite you to elaborate, or if perhaps someone else in the audience could elaborate, on the Federal consistency issues. And in particular, I'm concerned whether the Coastal Commission has the right to deny a coastal development permit for percussive testing or detonation of explosives in the water. It would seem that they would need a CDP, and that the Coastal Commission could question whether they are actually doing a little too much seismic research, and also could a CDP actually hold up continued operation of the plant. And again, it would seem to me that the State of California does retain that authority. And also, you didn't mention the Ocean Protection Council, and it seems that they have concerns. If they are in there blasting and harming the kelp beds and the marine mammals and all that, I think the State of California has something to say.

And the final piece is you mentioned the NRC is concerned with safety, and you did say of people and the environment, and I would invite you to elaborate, to what degree is NRC mandated to protect the environment? Thank you.

MR. MAIER: That's a handful.

MS. BYRON: Well, I can -- regarding the California Coastal Commission, we can -- I'm not from the California Coastal Commission and not familiar with that Federal consistency permit, but there are some representatives here, and if you would like, after the break, you could come up and I can introduce them to you.

MALE SPEAKER: A question about NRC and environment. Annie, do you feel comfortable with that, or would you rather somebody else do that?

DR. KAMMERER: I don't do environmental work at all, so --

MR. BURTON: Let me -- let me jump --

MR. MAIER: Bill, Bill, one second. To follow up, maybe we can get you in touch with someone during the break to talk about the environmental portion, okay? We'll try and do that. Oh, we do have someone over on my side. I know you. You look familiar.

DR. PECK: Michael Peck. I'm interested in the other side of the seismic stuff. I want to make sure as an inspector that the pipe is big enough, that the hanger that the pipe is being supported with has got enough -- it is beefy enough, it has enough supported in the wall. And so when you are looking at earthquakes, looking at seismic response, you know, I'm looking at the actual plant -- important plant equipment.

And so I have a question -- and a very good presentation, by the way, Dr. Abrahamson. When we look at determining whether or not a pipe is large enough, we look at the design basis -- deterministic basis time histories for the safe shutdown, the double design, and then also the Hosgri, and then we apply values -- we call them dampening values -- which basically are licensed values that talk about the rigidity, how rigid the particular component is to displace that energy.

And then from that, we do a calculation based on the American Society of Mechanical Engineers' Code to determine if it is within a code allowable or not. And so as you're all developing the spectra, and from a deterministic perspective for the Shoreline Fault, what I saw up here is that you are comparing that to the Hosgri. But my question is why are you using the

Hosgri as a basis of comparison to conclude it is within the design basis, as opposed to the double design earthquake?

MR. MAIER: That's a good question.

DR. PECK: Is that working? Here -- here. Do you want to try that? All right.

DR. ABRAHAMSON: Because the plant has been evaluated for the Hosgri spectrum, so the licensing basis is -- is this complex history of the design and double design earthquake, and the plant is essentially re-evaluated, redesigned for the Hosgri spectrum. In all practical purposes, our Hosgri earthquake is our SSE, the red curve. Even though we only have a licensed DDE, we are evaluated for the Hosgri. When we have done all our fragilities, we have used half of the Hosgri to do all the fragilities that normal people would have called their OBE.

So effectively, we have switched to a Hosgri earthquake to be our SSE, but as you know, Diablo Canyon, because of the history of how this was developed, we analyze it for the DE, for the DDE, and then for the Hosgri, and then show it's still okay for the LTSBP spectrum.

MR. BURTON: I have a question here from Judith.

MS. EVERED: I'm Judith Evered from the Santa Barbara area, and I'm here representing WILPF, which is the Women's International League for Peace and Freedom. And my question has to do with the problems and a possible and the only solution that I can see which would be well supported by my women's peace group. Now the problems are, of course, we all know the question is how do we deal with these problems before they begin?

Now, John Rundle of UC Davis is a seismologist who is predicting problems. He says he is very worried about the excess aftershocks from the Mexicali earthquake, because usually after a large earthquake there is a diminution of the aftershocks but this hasn't happened yet for this earthquake. And the further problems of being obviously in this conference, for which I am very grateful that the NRC and PG&E are giving us the opportunity to speak out, well, of course, the problem is the uncertain prediction for the future.

We don't know about earthquakes -- yes, okay. We're short on time, as usual. We're short on time to solve the problem, and I see a win-win solution, and I would like to know the reaction of the panel to a conversion to alternative energy. The workers can keep their jobs, the people of San Luis Obispo right down to Ventura will be less fearful of earthquakes, so I would like the reaction. That is my question. What do we do about this?

MR. MAIER: Okay. I heard two questions. One was a question about aftershocks from the Mexicali zone, and then a question about alternative energy. Does anyone want to field that first question, about aftershocks, and potential hazards of that?

DR. ABRAHAMSON: I will try to answer that for you. The issue down in Mexicali is will -- is another larger earthquake likely to happen down in that part of the state? So, as far as the implications -- at this point we don't know. This is really the essence of earthquake prediction. Either it is just a very energetic aftershock sequence or a bigger earthquake will happen, and we won't know until after the large earthquake happens what was really -- what was going on. For us here, that really has no impact on our hazard evaluations. It is too far away both from us and from San Onofre.

MR. MAIER: Thank you. I think we probably have time for maybe one more, maybe two.

MR. WEISMAN: David Weisman, Alliance for Nuclear Responsibility. In the interest of brevity, I will ask one question. Given the length of detail on the final slide by Mr. Abrahamson about the work expected to be completed by the SSHAC study in 2013, then given the unspoken and very documented history of why the Nuclear Regulatory Commission, going back to the original 1967 ACRS report and CPCN -- which I have here -- has guessed incorrectly on a lot of what was done seismically. Why not wait until the SSHAC is completed, adopted, and accepted before beginning the license renewal process?

MR. MAIER: Anyone want to give that -- David, is that question directed to any panel member in particular?

DR. ABRAHAMSON: We treat -- license renewal and seismic safety are two separate issues, and I know the public has sort of put those two together, but seismic safety impacts our current license. It is not just something that impacts the possibility of license renewal. That is why we don’t -- that is why they are being done on separate tracks. What we have tried to do, given our available information now, is to look at where do we think we are going to be as the SSHAC process evolves? We don’t see any reason to be deviating dramatically from the kinds of models that we are building, but we’ll have to wait and see as that all works out. So, we see no reason -- right now, it looks like the new information shows that we are consistent with our previous evaluations of the seismic risk at Diablo Canyon.

MR. WEISMAN: Maybe someone from the NRC can answer that question. Why would the NRC accept or proceed with an application before receiving the data that's expected with an anticipated and date certain, I guess, for completion?

DR. KAMMERER: Similarly, there are two separate processes. Safety of nuclear facilities is an ongoing review process for us and we are reviewing the information that is coming in from the work that's happening in the region on an ongoing basis. The license renewal process is a completely separate process. As I mentioned yesterday, NRC activities are governed by the Code of Federal Regulations and in the Code of Federal Regulations, there are two separate processes, and that is -- those are the processes under which we are mandated to work.

DR. CLUFF: Let me just piggyback on your answer, Annie, because generally in license renewal, the object is to affirm the licensing basis, and if as a result of some of the studies and some of the work that's going on in the seismic area or any other area, if it materially impacts the current licensing basis, then it will be dealt with as a right-now problem, and that revised licensing basis would be carried into the period of extended operation. So that's generally the approach that is used. It is not going to be missed. If it needs to be -- the licensing needs to be addressed, it will be addressed now, and carried forward. So, I hope that helps. One more question.

DR. BAGCHI: I want to make a point to clarify that issue.

DR. CLUFF: Okay. Let's let Goutam in here real quick.

DR. BAGCHI: I The core principle for NRC safety is to insure adequate safety of the public, and that is continuous and constant. You can go back to the history of Humboldt Bay, you can go back to the history of the Calaveras test reactor. This is shut down now. The plant was shut down after the earthquake. It has to be the determination of the NRC in terms of whether or not adequate public health and safety continues to exist.

MR. MAIER: I saw a couple other hands. We'll probably finish with those, and then we'll break for lunch. Bill, they are on your side.

MR. BURTON: I have one from Sherry. Question, Sherry?

FEMALE SPEAKER: Hi. Speaking of the graph, where they have the very high magnitude earthquake is far less likely, and so Diablo is not built for a very high earthquake, you know, beyond a certain point that they figure is likely. But what about the storage of nuclear waste on site, which will be far into the future? Those -- radioactivity in the storage is dangerous for hundreds of thousands of years, so if you have the likelihood of a high earthquake being once in every 10,000 years, you know, then we're dealing with that when we have the waste storage. And I have another quick question after that.

MALE SPEAKER: Sherry, I think your question has been kind of anticipated, and it is important to point out that issues regarding seismic vulnerability of the ISFASE [spelled phonetically] facility as well as the plant for relicensing purposes is currently in a legal situation, and I guess it would be best to understand that, you know, there are certain things that are restricted as far as the ability to talk about that, but I'll invite Roy to talk a little bit about what the sensitivities are of that.

MR. MAIER: Thank you. Again, as we started off, the whole purpose of the seminar over the last couple days was really just to share information, and there is some information that, you know, that there is questions that are out there right now that is in front of the board, and I think it wouldn't be appropriate at this time really to talk about that. Mark, Max, do you have anything additional? Okay. No?

FEMALE SPEAKER: We didn't hear that statement.

MR. MAIER: Was it on? Okay. Now it's on. Yes. Again, as we started out with the dialogue the last couple days, we mentioned that, you know, the purpose was really to just share information from an educational standpoint, there are some issues right now that are in front of an advisory board with the NRC and in a legal setting, and I don't think we can really touch about some of those, some of those questions today.

Bill, do you want to do one more before we break for lunch? I will say that I think we're going to have one more session after lunch, and I think we have factored in a little bit of time for any follow-up questions that may not have been answered before, so I think you're going to get another opportunity if you don't get one now.

[Whereupon, the proceedings were concluded]