RAS 4583

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Private Fuel Storage, LLC

Docket Number: 72-22-ISFSI; ASLBP No. 97-732-02-ISFSI

Location: Rockville, Maryland

Date: Friday, June 21, 2002

Work Order No.: NRC-428

Pages 11929-12036

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

Template = SECY-032

SECY-02

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

	)	
In the Matter of:	)	
PRIVATE FUEL STORAGE, LLC,	)	Docket No. 72-22
(Independent Spent Fuel	)	ASLBP No.
Storage Installation)	)	97-732-02-ISFSI
	)	

ASLBP Hearing Room
Third Floor
Two White Flint North Building
11545 Rockville Pike
Rockville, Maryland

June 21, 2002

The above-entitled matter came on for hearing, pursuant to notice, at 8:00 a.m. before:

MICHAEL C. FARRAR, CHAIRMAN
Administrative Judge
U. S. Nuclear Regulatory Commission

DR. JERRY R. KLINE
Administrative Judge
U. S. Nuclear Regulatory Commission

DR. PETER S. LAM
Administrative Judge
U. S. Nuclear Regulatory Commission

A P P E A R A N C E S

FOR THE STATE OF UTAH:
Denise Chancellor, Esq.
Connie Nakahara, Esq.
Assistant Attorneys General
Office of the Attorney General
160 East 300 South, 5th Floor
P. O. Box 140873
Salt Lake City, Utah 84114

FOR PRIVATE FUEL STORAGE, LLC:
Paul Gaukler, Esq.
Blake Nelson, Esq.
Matias Travieso-Diaz, Esq.
SHAW PITTMAN
Attorneys at Law
2300 N Street, N.W.
Washington, D.C. 20037

FOR THE U.S. NUCLEAR REGULATORY COMMISSION:
Martin O'Neill, Esq.
Sherwin E. Turk, Esq.
Office of the General Counsel
Mail Stop - 0-15 B18
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

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

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

(8:03 a.m.)

CHAIRMAN FARRAR: On the record. We're here just after 8:00. Appreciate all counsel making the effort to get here so we can start early and finish early.

Ms. Chancellor, you had some options in front of you last evening, and what have you decided?

MS. CHANCELLOR: Very short redirect with Dr. Bartlett, and then Dr. Bartlett will come back, and we're just finalizing written rebuttal or surrebuttal to Mr. Trudeau's testimony, rebuttal testimony. I haven't had a chance to read it yet, but what we plan to do is put Dr. Bartlett on. Then go to Mr. Trudeau, and then bring Dr. Bartlett back.

CHAIRMAN FARRAR: All right. That's fine. And if I talk real slow like Mr. Travieso-Diaz, Dr. Bartlett will be back in the witness box by the time I finish this sentence.

MR. TRAVIESO-DIAZ: I think we averaged out nicely. And Dr. Bartlett, once again, consider yourself still under oath.

DR. BARTLETT: Yes, Your Honor.

CHAIRMAN FARRAR: Go ahead, Ms. Chancellor.

MS. CHANCELLOR: Good morning, Dr. Bartlett.

DR. BARTLETT: Good morning.

MS. CHANCELLOR: Last day of the week.

DR. BARTLETT: Last day of the week.

REDIRECT EXAMINATION

MS. CHANCELLOR: What is undrained shear strength?

DR. BARTLETT: It is resistance to shear. We usually use the term "undrained" because the soils are being sheared so rapidly that any pore pressures that are generated due to shear do not have time to dissipate, so we call that an undrained condition.

MS. CHANCELLOR: How is -- how do you sample and measure for undrained shear strength?

DR. BARTLETT: Well, there's different types of tests that can be used to do undrained shear strength. The particular type of test we're focusing on for sliding resistance of the pads is a shear direction that's parallel to the base of the pads. And the type of test that we do for measuring that potential failure mechanism is the direct shear test.

MS. CHANCELLOR: And how is it sampled? How do you obtain a sample to conduct a direct shear undrained shear strength test?

DR. BARTLETT: As described yesterday, that is considered to be an undisturbed sample, so one would drill a bore hole and push a Shelby tube, three inch diameter tube, approximately two feet long, and this is pushed at the bottom of the pore hole, and a sample is retrieved for testing.

MS. CHANCELLOR: So you've got this three foot long tube with a sample in it?

DR. BARTLETT: Usually more, two, but it could be three, but usually two foot long.

MS. CHANCELLOR: Two foot long tube.

DR. BARTLETT: It's a --

MS. CHANCELLOR: And then what do you do with that tube sample once you get it to the lab?

DR. BARTLETT: It's taken to the lab and either extruded, pushed out of the tube with some kind of piston, or some labs just simply cut the tube open so that you can see the soil. And then a lab technician would look at it, select the portions of the sample that he was going to test.

MS. CHANCELLOR: And at the PFS site, they just used one of these Shelby tubes.

DR. BARTLETT: In the pad emplacement area for the direct shear testing, yes, there was just one tube that was used for the direct shear testing. And

from that two foot long sample, three samples were selected, approximately maybe one to two inches in length for the direct shear testing.

MS. CHANCELLOR: So for the entire pad emplacement area, they took a one to two inch sample from this three foot Shelby tube from the one bore hole?

DR. BARTLETT: Well, I think --

MR. TRAVIESO-DIAZ: Excuse me. You mentioned --

MS. CHANCELLOR: Two foot.

MR. TRAVIESO-DIAZ: Okay.

MS. CHANCELLOR: Two foot.

DR. BARTLETT: The two foot sample was obtained from the Shelby tube, and then it was opened up, and the three sub-samples, if you will, were selected from that for the direct shear testing. Each of those were probably approximately two inches long.

MS. CHANCELLOR: And this is the sample C-1 from -- do you remember what the sample number was? It's U-1 from sample --

DR. BARTLETT: I don't, but I have it, I think. That's why I scurried back to the room.

MR. TRAVIESO-DIAZ: To expedite --

MS. CHANCELLOR: Thank you, Mr. --

MR. TRAVIESO-DIAZ: Would it be correct to say sample U-1 from boring IDC-2?

DR. BARTLETT: That seems to be correct.

MS. CHANCELLOR: That's what I was trying to say. Thank you. I got my Us and Cs mixed up.

Why is undrained shear strength testing, why is that important for the PFS site?

DR. BARTLETT: The design philosophy is to take the inertial forces caused by the movement of the casks and pads, or their attempting to move, and transfer those forces directly to the top of the Bonneville clay via the cement-treated soil, so ultimately the Applicant is relying upon the undrained shear strength of the Bonneville clay to resist the seismic motions.

MS. CHANCELLOR: So it's the shear resistance that's going to --

DR. BARTLETT: Provides the resistance to potential sliding of the pads, yes.

MS. CHANCELLOR: And what value did PFS use for undrained shear strength in the pad emplacement area?

DR. BARTLETT: The undrained shear strength is somewhat a function also, because these are unsaturated soils, of the normal stress or load

that's applied, so first one has to calculate what is the stress, the vertical stress at the base of the pads. My recollection, that's approximately 2 KSF. Then for this one sample that we're talking about, a Mohr-Coulomb envelope was developed to describe the shear strength resistance. And for a vertical stress of approximately 2 KSF, as I recall, the shear resistance is about 2.1 KSF, kips per square foot.

MS. CHANCELLOR: And are there any other direct shear tests that PFS has done for the PFS site?

DR. BARTLETT: Not in the pad emplacement area. There were two other Shelby tube samples that were taken from the cannister transfer building, or at least two other sets of tests that were done in the cannister transfer building.

MS. CHANCELLOR: And what values do you know that PFS obtained in the CTB area for the shear strength?

DR. BARTLETT: Well, I think that may be in my testimony. Give me a moment here. Okay. I'm now referring to the SAR, and it was boring CTB-6, sample U-3BB and C. And there was another set of tests done on the sample - well, on the boring - CTB-S, Sample U-1AA.

MS. CHANCELLOR: If you look at answer 28

of your testimony, does that give any values there for the CTB area?

DR. BARTLETT: I think those are probably the same set of data. Let me look at that. I think what this answer in 28 is trying to point out, is that for a normal stress or vertical stress of approximately 2 KSF, when one looks at the data from the pad emplacement area, you see that the shear resistance is about 2.1 KSF, as I've previously stated.

For the same Bonneville layer in the CTB area, at least one set of the tests show that for a normal stress, again, of about 2 KSF, the undrained shear strength is about 1.75 KSF, so it's less than what's found in the pad emplacement area.

MS. CHANCELLOR: So is that part of the reason why you believe additional direct shear tests should be done at the PFS site?

DR. BARTLETT: Well, it's part of the reason why I don't believe that the 2.1 KSF is truly a lower bound of the undrained shear strength for the Bonneville clays. Obviously, if there was a sample taken from the same layer in the area of the CTB, and it showed a lower undrained shear strength, it's certainly easy to believe that the 2.1 KSF is not a

lower bound value that was used in the design of the pads.

MS. CHANCELLOR: Do you recall questioning by Mr. Travieso-Diaz with respect to questioning about whether you could rely on the CPT data to backup the shear strength results obtained in the lab?

DR. BARTLETT: Yes, I remember that.

MS. CHANCELLOR: And why can't you rely on -- can you rely on CPT data to backup those lab tests?

DR. BARTLETT: Well, to estimate the undrained shear strength from the CPT data, normally one would have to develop a correlation. And what I mean by a correlation is one would -- first, the CPT and obtain its data, and then in relatively close proximity go in and sample through that same zones, and submit those tests for laboratory testing, so that you have laboratory results that are direct measurements of the undrained shear strength, and you have the in situ CPT data that isn't a direct measurement, and through a correlation, you can develop what could be the potential undrained shear strength. And to do that was this equation that I discussed yesterday with the N sub K factors. And we looked at the EPR, EPRI manual.

MS. CHANCELLOR: Okay.

DR. BARTLETT: But that hasn't been done for this site. There are no site-specific N sub K factors that have been developed for these soils at the PFS site.

MS. CHANCELLOR: Is it easy to obtain these N sub K factors for the PFS site?

DR. BARTLETT: Yes, if one develops a program like I described, where you have paired data, where you have a CPT right adjacent to a bore hole, and you've somewhat continuously sampled in the adjacent bore hole, and developed a suite of tests, you can correlate two data. You need a certain amount of data to give the correlation some statistical robustness.

MS. CHANCELLOR: So if PFS developed an -- had an appropriate program to develop this N sub K factor, would that satisfy your concerns about the direct shear strength test?

DR. BARTLETT: Certainly, if there was more direct shear testing and it was correlated well with the CPT data, then we could do like Dr. Ofoegbu, I think, suggested and contain relatively continuous measurements of the undrained shear strength throughout the pad. Unfortunately, that site-specific correlation doesn't exist for the PFS site.

MS. CHANCELLOR: Thank you, Dr. Bartlett. I have no further questions.

CHAIRMAN FARRAR: Any recross by the Applicant?

MR. TRAVIESO-DIAZ: Yes. I think I have just one question.

CHAIRMAN FARRAR: All right.

RECROSS EXAMINATION

MR. TRAVIESO-DIAZ: Would you take a look at footnote 7 in your testimony? That is in your answer to question 19.

DR. BARTLETT: Yes, I see that.

MR. TRAVIESO-DIAZ: You refer there -- we were talking about those plots that you prepared yesterday?

DR. BARTLETT: That's correct. The ones that I traced over with the different color pens.

MR. TRAVIESO-DIAZ: Exactly. And you say they were using data from Cone Tec. Are you referring to --

DR. BARTLETT: The cone penetration report that Cone Tec did for the PFS site.

MR. TRAVIESO-DIAZ: Talking about like a four or five inch report that Cone Tec provided?

DR. BARTLETT: Yes. It's about that thick

is my recollection, yes.

MR. TRAVIESO-DIAZ: Okay. And is it your testimony that there is no NK data provided by Cone Tec in that report?

DR. BARTLETT: Well, the NK data that Cone Tec would provide would not be part of the -- for the PFS site. It's probably some generic NK factor. I have not seen these correlations specifically developed for the PFS site.

MR. TRAVIESO-DIAZ: So if those correlations for the PFS site existed, that would satisfy your concern. Is that what you said, as far as the ability to make a correlation between cone penetration tip resistance measures, and shear strength? I think that's what I heard you say in response to Ms. Chancellor's questions.

DR. BARTLETT: I do not believe a test program has been completed where there's been continuous sampling of the Bonneville clays from site-specific data to develop N sub K factors for the direct shear mode of failure, not based on the few tests that we have. There may be some attempt somewhere to do that, but the data sufficiency isn't enough to develop that correlation. And Cone Tec is a vendor I'm well familiar with. We use them quite

often in Salt Lake City. I'm aware that they have used their own N sub K factor. They may have developed it somewhere, but I don't believe it's necessarily specific for the PFS site, because of the large variability in N sub K factors that I showed you in the EPRI manual.

MR. TRAVIESO-DIAZ: Okay. Let me just make sure I understand you, because it's early in the morning and I might not be awake. I thought I heard you say in response to Ms. Chancellor's question that if a set of NK factors specific to the PFS site was available, your concern would be satisfied as to not being able to correlate --

DR. BARTLETT: No, I would like to review that. I don't think that's been adequately done at all.

MR. TRAVIESO-DIAZ: Okay. But my question is a yes or no answer. Would you be satisfied --

MS. CHANCELLOR: Objection, Your Honor.

MR. TRAVIESO-DIAZ: Excuse me. If I can finish my question first, please.

CHAIRMAN FARRAR: Wait. Wait. Talk to me. Go ahead. Finish the question.

MR. TRAVIESO-DIAZ: My question is, is it correct that it's site-specific data with respect to

NK were available for the PFS site, I believe you testified that that would satisfy your concern as to the ability to correlate cone penetration tip resistance with shear strength. I believe you said that a moment ago. I just want to make sure I understood you correct.

DR. BARTLETT: I think I put several qualifications on how I think the test program should be done to develop that N sub K factor. That has not been done at the site, so my answer is no.

MR. TRAVIESO-DIAZ: So seeing site-specific data wouldn't be sufficient for you.

DR. BARTLETT: There is not enough site-specific data to develop that correlation, and that is my position, because we only have these few tests. The statistically robustness of a correlation, even if it did exist, would not be adequate to satisfy my results, because we only have one set of tests from the pad emplacement area, and two sets of tests from the cannister transfer building. I cannot see how we can develop a statistical correlation with that amount of data. I'm aware of the data, and it's not sufficient.

MR. TRAVIESO-DIAZ: I apologize. I thought you said that you had a set of values of N sub K,

which is the factor that correlates the shear strength of the soil to the cone penetration tip resistance, that that would suffice for you to be able to be satisfied that the ability to correlate had been obtained.

DR. BARTLETT: That's a mischaracterization of --

MS. CHANCELLOR: Objection, Your Honor; asked and answered. Dr. Bartlett has put qualifications on what he would consider acceptable for the N sub K factor, and he's not willing to give a yes/no answer, because he's got qualifications on his response. And it doesn't matter how many questions Mr. Travieso-Diaz asks him, he should still be able to put those qualifications on because it's not a yes/no answer.

MR. TRAVIESO-DIAZ: I'm sorry, but I believe that when you asked him the question, he put no qualifications, but I will just stop here.

CHAIRMAN FARRAR: All right.

MS. CHANCELLOR: I'd also request that if PFS has any additional data that we don't have, that we request a copy of that data.

MR. TRAVIESO-DIAZ: I believe the witness testified that he has a book four inches thick.

MS. CHANCELLOR: Right, but if there's anything other than the Cone Tec data, then we would request a copy of it.

MR. TRAVIESO-DIAZ: Well, if there is anything other than Cone Tec data, we can discuss it.

CHAIRMAN FARRAR: Okay. Let me, for the benefit of all the witnesses and counsel, reiterate our prior rule, that counsel is entitled to ask for a yes or no answer, but the witness is always free either to say there is no yes or no answer, or to give a yes or no, and then to explain it.

Mr. Travieso-Diaz, do you have any further questions?

MR. TRAVIESO-DIAZ: No, I'm sorry. I tried to say that I was finished. Maybe I didn't make it clear.

CHAIRMAN FARRAR: Okay. Staff?

MR. O'NEILL: Yeah, a few quick questions, Your Honor, if I may.

CHAIRMAN FARRAR: Yes.

MR. O'NEILL: Now, Dr. Bartlett, you would agree that there's no such thing as a perfectly undisturbed sample.

DR. BARTLETT: Oh, that's correct.

MR. O'NEILL: Correct?

DR. BARTLETT: It's a figment of our imagination.

MR. O'NEILL: Because even when you take a Shelby tube sample, you're advancing that sample with pressure. Right?

DR. BARTLETT: There's some compressions in the sample, yes.

MR. O'NEILL: Some compression of the sample. Would you agree that the actual extraction of the sample and the handling could give you measured values that -- shear strength, for instance, that are actually less than those that exist in the field?

DR. BARTLETT: Sure. If the disturbance is large, that could happen.

MR. O'NEILL: And would you agree that one advantage of in situ tests is that they don't disturb the samples, which are measuring or -- for instance, a cone penetrometer test, or --

DR. BARTLETT: The cone penetrometer test does disturb the sample, if you want to put it that way, because it shears through the clay, but there are some advantages because --

MR. O'NEILL: You would see less disturbance.

DR. BARTLETT: Well, I think we're

confusing things. Disturbance is something we relate to laboratory testing. What we get from something like the cone penetrometer is some relative measurement in this case of stiffness, which then we have to correlate back to some kind of strength. And the normal practice of doing this somewhat of a coupled program where you do both in situ testing, and laboratory testing.

MR. O'NEILL: Well, I understand this relates to your concern with the correlation.

DR. BARTLETT: Correct.

MR. O'NEILL: I understand that. But you would agree, as a general class --

DR. BARTLETT: Right.

MR. O'NEILL: That in situ tests entail --

COURT REPORTER: I need one person to --

MR. O'NEILL: Okay. Okay. Can I finish my question, please.

DR. BARTLETT: Sure. Go ahead.

MR. O'NEILL: Yeah. You would agree that as a general class of tests, that in situ tests entail less disturbance, and that's one reason that they're actually used in the field.

DR. BARTLETT: Well, again you used the word "disturbance." And in situ test does disturb the

soil. Pushing the cone penetrometer through the soil disturbs it. It is a measurement of some physical behavior of the soil, which has to be correlated back to some engineering property. The advantage of in situ testing is that you measure that property in place at the stresses in place, so there's theoretical advantages to laboratory testing. There's theoretical advantages to in situ testing, but one never quite gets what you exactly want through either mechanism, so it takes kind of a comparison and combination of both, and some judgment to apply those.

MR. O'NEILL: Well, I presume that -- well, again we're going to argue over the meaning of disturbance, but you're not physically extracting a sample in the case of the cone penetrometer test.

DR. BARTLETT: No, I'm not physically extracting a sample, but the problem with in situ testing is you're not directly measuring the shear strength. You're indirectly measuring through something else like, in this case stiffness, then has to be correlated back to shear strength.

MR. O'NEILL: I think that's all I have for now. Thanks.

CHAIRMAN FARRAR: Any redirect?

MS. CHANCELLOR: No, Your Honor.

CHAIRMAN FARRAR: And the Board has no further questions. Then, Dr. Bartlett, you're temporarily excused once again. Thank you.

Next step then was going to be rebuttal by the company.

MR. TRAVIESO-DIAZ: Yes, if we could take a very short break.

CHAIRMAN FARRAR: Oh, certainly.

MR. TRAVIESO-DIAZ: A very short recess, five minutes or so.

CHAIRMAN FARRAR: Okay. It's almost half past. Let's be back at 25 of.

MS. CHANCELLOR: Could we make that ten. I'm still editing --

CHAIRMAN FARRAR: Fine.

MR. TRAVIESO-DIAZ: Ten is fine.

CHAIRMAN FARRAR: Then 20 of we'll be back. Ms. Chancellor, is that enough? I mean, if you need an extra five minutes --

MS. CHANCELLOR: I think I can do it in ten, Your Honor.

CHAIRMAN FARRAR: Well, let's make it 15. I'd rather -- I think a little progress now might save us time later.

MR. TRAVIESO-DIAZ: And I think I'm going

to need additional time after Mr. Trudeau is finished to review what we're going to get.

CHAIRMAN FARRAR: Okay.

MS. CHANCELLOR: Yeah. Are we off the record?

CHAIRMAN FARRAR: Yes, now we are.

(Off the record 8:29:34 - 8:48:47 a.m.)

CHAIRMAN FARRAR: Mr. Travieso-Diaz, we'll now have your rebuttal case. And you gave us, I guess it was yesterday, pre-filed rebuttal.

MR. TRAVIESO-DIAZ: That is correct. May I proceed with that?

CHAIRMAN FARRAR: Yes.

MR. TRAVIESO-DIAZ: Good morning, Mr. Trudeau.

MR. TRUDEAU: Good morning.

CHAIRMAN FARRAR: Mr. Trudeau, you're still under oath, of course.

MR. TRUDEAU: I understand, Your Honor.

DIRECT EXAMINATION

MR. TRAVIESO-DIAZ: Do you have before you a document dated June 20, 2002, bearing the caption of this proceeding, and entitled "Rebuttal Testimony of Paul J. Trudeau, to testimony of State of Utah witness, Dr. Steven F. Bartlett on Section C of

Unified Contention Utah L/QQ (soils characterization)."

MR. TRUDEAU: Yes, I do.

MR. TRAVIESO-DIAZ: Did you prepare -- was this a document prepared by you, or under your direct supervision and control?

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: Do you have any corrections to make to it?

MR. TRUDEAU: No.

MR. TRAVIESO-DIAZ: As presented to us today, is it true and correct to the best of your information and belief?

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: Do you adopt it as your rebuttal testimony in this proceeding?

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: I move that this testimony be admitted -- bound to the record and admitted into evidence.

MS. CHANCELLOR: No objection, Your Honor. And Ms. Nakahara is handing out surreptitiously, the surrebuttal by Dr. Bartlett, hot off the press.

CHAIRMAN FARRAR: All right.

MR. O'NEILL: Staff has no objections,

Your Honor.

MR. TRAVIESO-DIAZ: Mr. Chairman, I think this may be a good -- an appropriate point to introduce into evidence the exhibits that went with this testimony, which are as follows. 233, which is the foundation plot, 233A which is the same document in color, 234 which is the complete text of Reg Guide 1.132, 235 which is Figure 2.619 for the SAR, and 236 which are excerpts of Dr. Bartlett's testimony. I move that these be admitted into evidence.

MS. CHANCELLOR: I'd like one question, Your Honor.

CHAIRMAN FARRAR: Go ahead.

MS. CHANCELLOR: You refer to 236, Dr. Bartlett's deposition?

MR. TRAVIESO-DIAZ: Deposition testimony, yes. November 17.

MS. CHANCELLOR: It's in the rebuttal, because you didn't -- you asked no questions about that document.

MR. TRAVIESO-DIAZ: It is referenced in the rebuttal. Yes, that's true.

MS. CHANCELLOR: No objection, Your Honor.

CHAIRMAN FARRAR: All right. Any objection from the Staff?

MR. O'NEILL: No objections, Your Honor.

CHAIRMAN FARRAR: All right. Then we'll admit 233, 233A, and 234, 5 and 6.

MR. TRAVIESO-DIAZ: I'd also like to move into evidence Exhibit 237, which was the stipulation of the parties as to the text of these contentions. This is not on the record.

MS. CHANCELLOR: No objection, Your Honor.

CHAIRMAN FARRAR: Staff?

MR. O'NEILL: No objection.

CHAIRMAN FARRAR: All right. Then that will be admitted, and the rebuttal -- you had offered the testimony.

MR. TRAVIESO-DIAZ: Yes. I have very brief additional rebuttal based on the testimony that DR. Bartlett just gave.

CHAIRMAN FARRAR: Right, but we will have the reporter bind Mr. Trudeau's rebuttal testimony in the record at this point, as if read.

(Insert pre-filed testimony of Mr. Peter Trudeau.)

June 20, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

REBUTTAL TESTIMONY OF PAUL J. TRUDEAU TO TESTIMONY OF STATE OF UTAH WITNESS DR. STEPHEN F. BARTLETT ON SECTION C OF UNIFIED CONTENTION UTAH L/QQ (SOILS CHARACTERIZATION)

A. Factors of Safety Sought to be Achieved in the Geotechnical Design of the PFSF Foundations

Q1. In his answer to question 13 in the "State of Utah Testimony of Dr. Steven F. Bartlett on Unified Contention Utah L/QQ (Soil Characterization)" ("Bartlett Direct Testimony"), Dr. Bartlett characterizes the PFSF as a large site with complex layering. Is that characterization accurate?

A1. No. PFS has made borings and performed cone penetration tests, and has taken soil samples and conducted laboratory tests, to characterize site soil conditions. All site investigations conducted by PFS have led to the determination that the site is remarkably uniform in the horizontal direction, that is, as one moves across the site. The site soils are layered vertically in the sense that there are a number of soil layers having distinct composition and physical characteristics, as is the case for most soil configurations. The overall layering arrangement (i.e., the types of soil, the general thickness and arrangement of soil layers, and the properties of the soil at each layer) are well-known and not "complex".

Q2. In his answer to question 15 of the Bartlett Direct Testimony, Dr. Bartlett states that the minimum factors of safety against sliding of the pads, bearing capacity failure of the pads, and sliding of the Canister Transfer Building ("CTB") are, respectively, 1.27, 1.17 and 1.26, and that as a result the soil's capacity to resist earthquake forces has only about 6 to 15 percent margin "above the value required to produce an acceptable factor of safety," from which Dr. Bartlett concludes that "variations or small decreases (about 6 to

15 percent) in the soil's strength below the values used in the design "could lead to potentially unsafe conditions." Is there any validity to Dr. Bartlett's argument?

A2. No. First, it must be understood that the minimum factors of safety calculated by PFS and quoted by Dr. Bartlett are factors of safety against the potential onset of the failure mechanism in question using very conservative assumptions. Thus, the minimum calculated factor of safety against sliding of the pads of 1.27 provides a margin against sliding of at least 27%. The minimum calculated factor of safety against bearing capacity failure of the pads of 1.17 provides a margin against failure of at least 17%. In addition, a factor of safety against sliding of the CTB of 1.26 provides a margin against sliding failure that is at least 26%. All of these margins are calculated using the peak force due to the design earthquake, which acts only for one brief instant in time; at all other times during the earthquake, the forces are much less than this peak value. Thus, the margin available at all other times during the earthquake will be much larger than these values, as evidenced by the factors of safety against sliding plotted versus time in PFS Exhibit WW. Even with these and other conservative assumptions, the reduction in minimum soil strength would have to be 27%, 17% and 26% before failure through one of these mechanisms became possible.

Dr. Bartlett states that a drop of 6 to 15 percent in soil strength (presumably, according to his analysis, reducing one of these factors of safety to 1.1) "can lead to potentially unsafe conditions." That is clearly incorrect. Even ignoring all the conservatisms that are built into the factor of safety estimates, a reduction in one of these calculated minimum factors of safety to 1.1 would still leave a 10% margin of safety against the failure mechanism in question, nowhere near the onset of a "potentially unsafe condition." Moreover, a reduction of a factor of safety to a value below 1.1 on account of a decrease in the calculated value of minimum shear strength would be the type of unanticipated occurrence against which factors of safety are provided.

Q3. What other conservatisms have been incorporated into the calculations of minimum factors of safety against sliding and bearing capacity failure such that there is additional margin against the possibility of failure of the pads or the CTB through one these failure mechanisms?

A3. The following are some of the main conservatisms that are built into the calculation of the minimum factor of safety (1.27) against sliding of the pads:

- PFS computed the FS against sliding using the strength of the weakest section of the Upper Lake Bonneville clay layer (also known as "Layer 2") even though soils directly under the cement-treated soil will in most cases be much stronger than those below them. The use of the weaker strength of the soil at the lower section of the layer is quite conservative because there is a stronger crust, approximately 2 to 3 ft thick, at the top of the Upper Lake Bonneville clay layer, upon which most of the pads and cement-treated soil will be founded. This stronger crust is evident in all of the foundation profiles, which are included in the PFSF Safety Analysis Report ("SAR") as Figure 2.6-5, Sheets 1 to 14. For example, referring to Foundation Profile 5–5' (SAR Figure 2.6-5 Sheet 7 of 14) (PFS Exh. 233), which is the profile running from west-to-east across the southern half of the PFSF pad emplacement area, the plots of the tip resistance data from the cone penetration tests ("CPTs") demonstrate that there is a stronger crust just below the eolian silt layer – at the top of the "silty clay/clayey silt" layer identified in the profile. (This silty clay/clayey silt layer is what is referred to as the Upper Lake Bonneville clay layer.) The undrained shear strength of these clayey soils is proportional to the tip resistance values measured in the CPTs. As shown in this figure (all other soil profiles are similar), the tip resistance values in the upper 2 to 3 ft of the Upper Lake Bonneville clay layer typically are more than twice as large as the tip resistance values measured for the soils at depths of approximately 5 to 10 ft below grade – the range of depths where the samples were obtained that were tested in the laboratory to measure the undrained strengths used in the sliding stability analyses. Therefore, giving due consideration to the fact that the strength of the soils (i.e., the stronger crust at the top of the Upper Lake Bonneville clay layer) directly beneath the cement-treated soil and pads will generally be at least twice that of the weaker underlying soils, it is reasonable to conclude that the factor of safety against sliding will be at least twice the minimum value shown above, or on the order of 2.5, without taking other conservatisms into account.

- The minimum FS against sliding of the pads was computed without taking into account the increase in strength of clayey soils that occurs under cyclic dynamic loadings. Taking credit for this well-known phenomenon would increase shear strength by at least 50%, thus increasing the minimum factor of safety against sliding to 1.9 (or a margin of or 90%), again without taking other conservatisms into account.

- The minimum FS was computed without taking into account the passive resistance of the soil cement around the pads. Taking credit for that passive resistance would increase the FS of the design base case from 1.27 to 3.3, without considering other conservatisms.

- All these increases in the minimum FS are independent of each other and, thus, their effects are cumulative. Combining their effect would lead to a minimum FS against sliding of the pads of at least 5.

Likewise, the minimum factor of safety against bearing capacity failure of the pads is 1.17. This minimum factor of safety was also computed using many conservative assumptions:

- PFS computed the minimum FS against bearing capacity failure using the strength of the weakest section of Layer 2, even though for bearing capacity computations the standard practice is to average the contributions of all soil layers over a depth equal to the shortest dimension of the foundation, or thirty feet in the case of the pads. However, as discussed above, the soils directly under the cement-treated soil layer will in most cases be much stronger than those below them, and the presence of a 1 to 2 ft thick layer of cement-treated soils directly beneath the pad will also increase the allowable bearing capacity of the underlying soils. In addition, the soils below the Upper Lake Bonneville clay layer (i.e., the layer labeled "clayey silt/silt & some sandy silt," as well as the underlying layer of "silty clay/clayey silt" shown in the foundation profiles) (see, e.g., PFS Exh. 233), which represent close to two-thirds of the profile and which are much stronger than the soils from the Upper Lake Bonneville clay layer, were conservatively also assumed to have the same strength as the weaker Upper Lake Bonneville clay layer. The increase in minimum FS to account for these effects would be more difficult to compute than in the case of the factor of safety against sliding, but it would nonetheless be quite significant.

- The minimum FS against bearing capacity failure of the pads was computed without taking into account the well-known 50% or greater increase in soil strength that occurs under cyclic dynamic loadings. Taking this increase into account would boost the FS against bearing capacity failure from 1.17 to 2.6.

- The minimum FS was computed using the extremely conservative assumption that 100% of the earthquake loads act in both horizontal directions at the same time. If load combinations allowed by ASCE 4-86 were used instead, this would increase the factor of safety against bearing capacity failure from 1.17 to 2.1.

- All these increases in the minimum FS are independent of each other; thus, their effects are cumulative. Combining these effects (without attempting to quantify the increase due to the strength of the soils which underlie the pad and the cement-treated soil) would lead to a minimum FS against bearing capacity failure of the pads of at least 3.6.

There are many other conservatisms built into the estimate of FS against sliding or bearing capacity which are more difficult to quantify, but which nonetheless further increase the real margin of safety. For example:

- Any measurement of the strength of soils that is obtained by performing laboratory tests on soil samples will, by necessity, disturb the samples to some

degree and result in a strength measurement that is less than the actual strength that the soils will exhibit in situ. Studies performed at MIT have demonstrated that carefully conducted unconsolidated undrained triaxial tests performed on high quality undisturbed samples of saturated clays yielded undrained shear strengths that ranged from 50% to 80% of field measured strengths.

- The minimum FS is applicable only during the brief period in which the earthquake reaches its peak magnitude. At all other times, there is considerable more margin available, as discussed above.

Because of the existence of these quantifiable and non-quantifiable conservatisms, the concern expressed by Dr. Bartlett about the potential effect of a reduction in minimum soil strength on the safety of the pads is unfounded.

Similar conservatisms exist with respect to the factor of safety against sliding failure of the CTB; thus the concerns about the potential effect of a reduction in minimum soil strength on the sliding stability of the CTB are also unfounded.

B. Spacing of Borings for Pad Emplacement Area

Q4. In answers 16 through 18 of the Bartlett Direct testimony, Dr. Bartlett alleges that the number of borings made by PFS for the pad emplacement area is insufficient because the borehole and cone penetration test spacing is approximately 221 feet apart instead of the 100 feet spacing recommended in Reg. Guide 1.132. Does the boring spacing cited by Dr. Bartlett constitute a deficiency in PFS's soils characterization program?

A4. No. No such deficiency exists. In the first place, as its title indicates, Reg. Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants" is a guidance document issued by the NRC Staff with respect to soils investigations for the foundations of nuclear power plants. It does not apply to Part 72 facilities such as the PFSF. Indeed, the NRC guidance document of Independent Spent Fuel Storage Installations ("ISFSIs"), NUREG-1567, does not specify any recommended boring spacing for ISFSIs.

In addition to not being applicable, Reg. Guide 1.132 need not be used for soils investigations for structures such as storage pads because they are significantly different than nuclear power plant structures in the following respects:

- Nuclear power plant buildings are typically large and heavily loaded structures. By comparison, the storage pads are relatively small and lightly loaded.

- Nuclear power plant structures, systems and components contain interconnected safety-related piping, electrical cable, conduit and other components which are often buried and which are sensitive to building movements. Therefore, the soils beneath nuclear power plant structures require detailed characterization of soil conditions. Storage pads are free-standing and do not include any buried components or safety-related connections to other structures.

Even if the guidance in Reg. Guide 1.132 were to apply, the guide makes it clear from the outset that its recommendations should be only considered guidance "and should be tempered with professional judgment. Alternative and special investigative procedures that have been derived in a professional manner will be considered equally applicable for conducting foundation investigations." PFS Exh. 234 (Reg. Guide 1.132), at 1.132-1. PFS elected to follow the guidance in Reg. Guidance 1.132 with respect to the borings in the CTB because that building is somewhat analogous to a nuclear power plant structure. For the pads, however, PFS exercised professional judgment and developed a subsurface investigation program which combined the drilling of boreholes and the performance of cone penetrometer tests and geophysical testing to the extent warranted by site conditions and the size, loading, and isolation of the storage pads. The elements of the professional judgment that PFS exercised in implementing its boring program for the storage pads included:

- PFS conducted an initial set of borings in 1996 which served to establish that the soil properties were reasonably uniform across the pad emplacement area of the PFSF site.

- Based on these initial results, PFS determined that it was sufficient to drill boreholes in a uniform grid across the entire pad emplacement area, so that all sections of the area were covered. Such a grid was subject to supplementation with additional borings, should anomalous or irregular conditions be encountered, but no such conditions were identified.

- Standard penetration tests were conducted that provided estimates of soil strength and compressibility and allowed visual inspection of samples and index property testing of the samples in the laboratory. These inspections and tests confirmed that the subsoil characteristics are uniform and consistent across the pad emplacement area.

- As the borings were made, standard penetration tests were performed. The "blow count" values required to drive the standard split-spoon sampler into the soil at various depths were consistent across the pad emplacement area and

identified the Layer 2 soils as the critical layer with respect to the stability and settlement of the structures.

- Cone penetration tests performed subsequently yielded essentially the same value of tip resistance for comparable depths at various locations across the pad emplacement area, indicating that the stratigraphy across the site is uniform.

- Because no significant variations in soil conditions were encountered, the initial decision to provide a broad grid was retained. At the end, the borehole and CPT spacing of approximately 221 feet testified to by Dr. Bartlett was achieved and deemed sufficient to properly characterize the pad emplacement area.

In my opinion, the above described program would meet the intent of Reg. Guide 1.132 if the guide were applicable to the soils investigations at the PFSF.

Q5. Assuming the guidance in Reg. Guide 1.132 were applicable and the borings program implemented by PFS failed to satisfy it, what would be the safety significance of such a failure?

A5. There is no significance to having lower density of borings than called for in Reg. Guide 1.132 because the subsoil in the pad emplacement area is reasonably uniform across the area and its characteristics have been fully determined through the subsurface investigations conducted by PFS.

C. PFS's Soil Sampling Program

Q6. In his answer to question 18, Dr. Bartlett opines that the pad emplacement area has been "significantly undersampled" in terms of retrieving soil samples for testing, and asserts that "[t]his undersampling is even more acute when one considers that only nine boreholes (A1, B1, C1, A2, B2, C2, A3, B3 and C3) were drilled in or near the pad emplacement area for the purpose of retrieving samples for laboratory testing and analysis." Are Dr. Bartlett's assessments correct?

A6. No. Dr. Bartlett's opinion that the pad emplacement area has been significantly undersampled is incorrect. Moreover, the assertion that "only nine boreholes" were drilled in or near the pad emplacement area for the purpose of retrieving samples for laboratory testing is factually incorrect. PFS drilled a total of sixteen borings (the nine listed by Dr. Bartlett plus boreholes A4, B4, C4, D1, D2, D3 and D4) in or near the pad emplacement area and took soil samples from all sixteen boreholes for testing. In addition, PFS conducted continuous sampling of soil

properties in 37 CPT soundings within the pad emplacement area. See PFS Exh. 235 (SAR Fig. 2.6-19).

Q7. In answer to question 20 in the Bartlett Direct Testimony, Dr. Bartlett faults the PFS sampling program for the pad emplacement area for failing to comply with the guidance in Reg. Guide 1.132 that continuous sampling should be conducted in "critical layers," such as Layer 2. What is your response?

A7. I would again note that the guidance in Reg. Guide 1.132 does not apply to ISFSIs. In my opinion, continuous soil sampling is not required for the pad emplacement area because the pads are unlike the large, heavy nuclear power plant structures and have no safety-related connections.

Even if the guidance in Reg. Guide 1.132 were applicable, PFS's sampling program would be in compliance with that guidance for several reasons:

- PFS performed continuous sampling because it conducted 37 cone penetration tests in the pad emplacement area that sampled continuously the soil properties throughout Layer 2. See PFS Exh. 233 for examples of plots of the data collected continuously throughout the upper 25 to 30 ft. of the profile in the CPTs. Those CPT data confirm that there are no weak layers that have been missed by the soil sampling that was performed in the borings drilled in the pad emplacement area.

- PFS obtained sufficient number of disturbed and undisturbed samples of Layer 2 soils from the pad emplacement area to conduct laboratory tests that permitted a proper determination of the shear strength and other properties of the soils in this layer. In fact, five out of the nine pad emplacement area boreholes cited by Dr. Bartlett had undisturbed samples from Layer 2 soils taken for testing. See Table 1 of the Joint Direct Testimony of Paul Trudeau and Anwar E. Z. Wissa on Section C of Unified Contention Utah L/QQ ("Trudeau Direct Testimony"). These samples were taken in the borings, alternating with standard split-spoon samples as the boreholes were advanced, as recommended under Section 6, "Sampling", of Reg. Guide 1.132.

Q8. Dr. Bartlett claims in his answer to question 22 of the Bartlett Direct Testimony that the Layer 2 soils "have not been continuously sampled and characterized with depth," and that this incomplete characterization "adds additional uncertainty to the Applicant's estimate of the shear strength of this important layer." Do you agree with Dr. Bartlett's conclusions?

A8. No. First, for the reasons just stated, it is incorrect to assert that the Layer 2 soils have not been continuously sampled and characterized with depth. Second, the purpose of continuous sampling is, as indicated in Reg. Guide 1.132, to identify

"[r]elatively thin zones of weak or unstable soils [that] may be contained within more competent materials and may affect the engineering characteristics or behavior of the soil or rock." PFS Exh. 234 at 1.132-5. If such zones existed within Layer 2, they would have been detected through changes in cone tip resistance measured in the CPT tests, which sampled Layer 2 continuously throughout the pad emplacement area. No such zones were identified in the extensive CPT tests, so there is no reason to believe that any exist. Therefore, continuous sampling in borings through Layer 2 of the pad emplacement area was not required. Finally, PFS performed continuous sampling of Layer 2 soils in boreholes in the CTB and did not identify any zones of weak or unstable soils, confirming that such zones do not exist in the areas of interest at the PFSF site.

D. PFS Soil Testing Program

Q9. Dr. Bartlett expresses the view, in answer to question 23 of the Bartlett Direct Testimony, that "[t]he most egregious weakness of the Applicant's sampling program is the extreme undersampling that has been performed of the upper Lake Bonneville sediments." The basis for such a harsh criticism is the assertion that PFS "has calculated the sliding resistance of the pads based on one set of direct shear tests obtained form borehole C-2 from a depth interval of 5.7 to 6 feet." How do you respond to Dr. Bartlett's criticism?

A9. Dr. Bartlett's criticism is way off the mark. The sample from which the shear strength of the Upper Lake Bonneville clay layer was measured in direct shear tests had the highest void ratio and lowest density of any samples taken in pad emplacement area. (High void ratios and low densities are indicative of low shear strengths.) The sample was taken from the section of pad emplacement area that was expected, based on previous tests, to have weakest soils. Further, the sample was taken from the portion of the Upper Lake Bonneville clay layer known to have lowest strength (5 to 7 feet below surface). For all these reasons, the sample used to determine the shear strength value of the soil provided a minimum strength value for use in the sliding stability analyses of the soils in the pad emplacement area.

Q10. Dr. Bartlett expresses the view in answer 25 that the minimum shear strength value calculated by PFS "may be subject to severe bias and could potentially lead to overestimation of shear strength capacity available," and did not account for the potential variation of shear strength properties of Layer 2 soils across the pad emplacement area. Is there merit to Dr. Bartlett's view?

A10. No. As stated earlier, the Layer 2 soils are "monotonous" – that is, uniform – across the pad emplacement area, as Dr. Bartlett himself recognized in his November 17, 2000 deposition ("Bartlett November 2000 Deposition"), Tr. at 495. (See PFS Exh. 236). Because of this uniformity, the horizontal variations in shear strength across the Layer 2 soils in the pad emplacement area do not exist.

Q11. In answer 26 of the Bartlett Direct Testimony, Dr. Bartlett seeks to support his contention that there are potential variations in shear strength across the Layer 2 soils by citing a set of figures he prepared (State Exh. 99) in which he plotted measured cone penetration resistance tests results. He cited these plots as suggesting that there is a factor of 2 variation in cone penetration tip resistance, from which he infers that there may be a factor of 2 variation in shear strength across the pad emplacement area. What is your assessment of Dr. Bartlett's analysis?

A11. There is no technical or factual basis for Dr. Bartlett's analysis. First, contrary to his assertion, the correlation between cone tip resistance and the undrained shear strength of the soil is not as simple as Dr. Bartlett would have us believe. The relationship between the two parameters is complex, and involves a number of parameters which may be variable, even for a given soil type. Therefore, a constant or nearly constant shear strength may be accompanied by variations in cone tip resistance on account of variations in these other parameters. This matter was discussed at length in Dr. Bartlett's deposition. See Bartlett November 2000 Deposition Tr. 471 - 496 (PFS Exh. 236.

Second, the plots prepared by Dr. Bartlett and included in State Exh. 99 are too crude and prepared in too unreliable a manner to convey any meaningful information. See PFS Exh. 236, Tr. at 474-75. The alleged factor of two variation in cone penetration tip resistance from one set of Layer 2 measurements to another can be accounted for by plotting errors, the width of the marker with which he traced the enlarged SAR plots, the enlargement process itself, and the scale of the plot, which is too compressed to provide any accurate readings. I do not believe that such plots would be considered acceptable in serious scientific circles.

Third, I interpret the CPT resistance plots presented in SAR Figure 2.6-5, Sheets 1 through 14 (from which Dr. Bartlett prepared State Exh. 99) in the totally opposite manner as he does. I view those plots as demonstrating remarkable

uniformity of properties of Upper Lake Bonneville clay soils across the pad emplacement area.

Finally, even if there were any locations in the pad emplacement area with soils that exhibited lower shear strength than the minimum value calculated PFS, the existence of such locations would be of no consequence because:

- Any lower values of shear strength would be localized effects.
- The actual shear strength of the soil under the cement-treated soil beneath a storage pad depends on the average strength of the soil in the area under the pad. It is extremely unlikely that the average shear strength of the soil in the 30' x 67' area under a pad would be less than minimum value measured by PFS, for the reasons stated above.
- Because of all the conservatisms in the computation of the factor of safety against sliding to which I referred earlier, the actual FS would remain above the 1.1 guideline even if the shear strength value dropped significantly.

E. Concerns re Non-Performance of Cyclic Triaxial Tests

Q12. In his answer to question 30, Dr. Bartlett asserts that PFS should have performed strain-controlled cyclic triaxial tests to ensure that there was no significant degradation of shear strength at the soil strain (deformation) levels caused by the design earthquake. Is he right?

A12. PFS conducted stress-controlled cyclic triaxial tests to determine collapse potential of soil. The results of those tests are presented in Attachment 6 of Appendix 2A of the SAR, and are described in Section 2.6.4.7 of the SAR at pages 2.6-98 to 2.6-100. The results of the tests did not show any degradation of the shear strength of the samples throughout 500 cycles of loading at extremely high cyclic ratios. The resulting cyclic strains were very small, indicating essentially elastic response throughout the tests. For such low values of cyclic strain, Fig. 2 of the Makdisi and Seed treatise (State Exh. 102) shows that the ratio of shear strength after cyclic loading to the original strength is essentially 1.0, which indicates that there is no strength degradation for these soils due to the high levels of cyclic stress applied. Since the cyclic stresses applied during the tests (500 cycles) are greatly in excess of those that take place during the design basis earthquake for the PFSF (approximately 7 to 11 cycles), no significant degradation of shear strength is anticipated to take place, and strain-controlled cyclic triaxial tests are unnecessary.

F. Concern Over Non-Performance of Triaxial Extension Tests

Q13. In his response to question 32 of the Bartlett Direct Testimony, Dr. Bartlett asserts that triaxial extension tests, which measure the shear strength in extension of the soil, should have been performed by PFS but were not. What is your response?

A13. I responded to this claim in answer 29 of the Trudeau Direct Testimony, where I explained why those tests are not needed at the PFSF.

G. Strength of Soils in the CTB Area

Q14. In answer 29 of the Bartlett Direct Testimony, Dr. Bartlett alleges that PFS has used potentially unconservative estimates of the undrained shear strength in the dynamic bearing capacity analyses of the CTB because the strength was based on shear strengths measured in UU tests that were performed on samples obtained from borings drilled more than 1,000 ft away from the CTB. Is this a legitimate concern?

A14. No. As indicated on page 8 of S&W Calculation 05996.02-G(B)-13-6 (PFS Exh. VV):

> "The undrained shear strengths measured in the triaxial tests are used for the dynamic bearing capacity analyses because the partially saturated, fine-grained soils will not drain completely during the rapid cycling of loadings associated with the design basis ground motion. As indicated in Figure 6, the undrained strength of the soils within ~10 ft of grade is assumed to be 2.2 ksf. This value is the lowest strength measured in the UU tests, which were performed at confining stresses of 1.3 ksf. This confining stress corresponds to the in situ vertical stress existing near the middle of the upper layer, prior to construction of these structures. It is much less than the final stresses that will exist under the cask storage pads and the Canister Transfer Building following completion of construction. Figure 6 illustrates that the undrained strength of these soils increase as the loadings of the structures are applied; therefore, 2.2 ksf is a very conservative value for use in the bearing capacity analyses of these structures."

Figure 6 of PFS Exh. VV presents the results of all the triaxial tests that were performed on soil samples obtained at the PFSF site, including all those obtained from the CTB area. The curve shown in that figure provides a reasonable estimate of the strength to use in bearing capacity analyses based on the triaxial test results. Therefore, the undrained strength used in the bearing capacity

analyses of the CTB, although it equals the value measured for the UU test that was performed on Sample U-3D from Boring B-4, was developed based on the summary plot of all of the triaxial tests that were performed on samples of soils obtained from the PFS site – those in the pad emplacement area as well as those from the CTB area. As shown by the curve in Figure 6 on p. 57 of the G(B)-13-6 calculation, the value of 2.2 ksf used for the bearing capacity analyses is a reasonable lower-bound value based on the results of all of the triaxial tests that were performed by PFS. Moreover, the effective vertical stresses, σ_v, increase as one goes deeper in the profile, and the undrained shear strength increases as well. For example, as shown in Figure 6, at 7 ft below the CTB mat, σ_v equals 2.1 ksf and the undrained shear strength is ~3.3 ksf; therefore, it is very reasonable to have adjusted the undrained shear strength used in the bearing capacity analysis of the CTB to 3.18 ksf based on the strength increase noted at depth in the CPTs that were performed in the CTB area.

In any event, the minimum factor of safety against bearing capacity failure for the CTB calculated by PFS is 5.5. Even eliminating the adjustment factor that Dr. Bartlett finds inappropriate would result in a factor of safety against bearing capacity failure of approximately 3, which is still well above the 1.1 FS considered acceptable under NRC guidance for nuclear power plants. Therefore, the concern raised by Dr. Bartlett is both erroneous and inconsequential.

Q15. Does this conclude your testimony?

A15. Yes.

CHAIRMAN FARRAR: And go ahead, Mr. Diaz.

MR. TRAVIESO-DIAZ: I am distributing to the court reporter, the Board and the parties, what I would like to have marked as PFS Exhibit 238, and I will describe it for the record as follows.

This exhibit consists of the cover page of a document prepared by Cone Tec, Inc. of Salt Lake City, dated May 1999 entitled, "Presentation of Cone Penetration Testing Results of Soils at the Private Fuel Storage Facility, Skull Valley, Utah. Report number 05996.02-G(P030) Rev.1".

The second page of the exhibit is page 10 of that report. The third page of the exhibit is one of the pages from the report from Appendix F, at page F-63. And the last page of the exhibit is Figure 7 from Attachment C of Calculation 05996.2-GB4 Rev.9, which is already in evidence as Applicant or PFS Exhibit UU. And this is marked as PFS Exhibit 238.

CHAIRMAN FARRAR: All right. The reporter will mark that for identification.

(PFS Exhibit 238 marked for identification.)

MR. TRAVIESO-DIAZ: Mr. Trudeau, would you describe what the first three pages of this exhibit, where they come from?

MR. TRUDEAU: Those are from Cone Tec's

report that Dr. Bartlett referred to earlier today, the 1999 report of the cone penetration testing. I have a copy of the whole report here.

MR. TRAVIESO-DIAZ: Yes. Would you show it to the Board to verify what Dr. Bartlett's says, that's four inches thick.

Could you please turn to the second page of the exhibit, which is page 10 of the Cone Tec report, and to the text underneath Table 2. Would you explain to the Board what your understanding is of what Cone Tec is doing or is telling us in that paragraph?

MR. TRUDEAU: In this paragraph, Cone Tec is reporting that they did exactly what Dr. Bartlett suggested needs to be done to develop a site-specific value of NK, for use in calculating the undrained shear strength from the tip resistance values measured at the site in the Bonneville clays.

I'd like to point out that Cone Tec is based in Salt Lake City. They have experience working with Bonneville clays. I had sent them the results of our laboratory test results for this purpose, and they have developed this value of 12.5 used to calculate the undrained shear strength that they reported in Appendix F of this report.

MR. TRAVIESO-DIAZ: And this would be the same N sub K that Dr. Bartlett was referring, as providing the correlation between cone penetration tip resistance and undrained shear strength of the soil?

MR. TRUDEAU: That's correct. And as you can see by that equation at the bottom of page 10, that that's exactly the same equation that Dr. Bartlett was suggesting is appropriate in his Exhibit 100.

MR. TRAVIESO-DIAZ: And the N sub K, the average N sub K that Cone Tec came up with was 12.5?

MR. TRUDEAU: That is correct.

MR. TRAVIESO-DIAZ: All right. And that's your understanding of the N sub K that Cone Tec used throughout their report in reporting values?

MR. TRUDEAU: Of undrained shear strength, that's correct.

MR. TRAVIESO-DIAZ: Let's move to the third page of this exhibit. Again, my understanding is that this is one of a number of pages in which Cone Tec reports the results of its cone penetration tests?

MR. TRUDEAU: That is correct.

MR. TRAVIESO-DIAZ: Would you help us with some of the information in this table. What does the first column signify?

MR. TRUDEAU: That's the depth of the tip at that particular interval.

MR. TRAVIESO-DIAZ: Okay. Moving down near the bottom of the page, the line that has in the first column, 4.43.

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: Would that be the depth at which this particular cone penetration measurement was taken?

MR. TRUDEAU: Yes, it is.

MR. TRAVIESO-DIAZ: All right. Now tell me what the ninth column, which is entitled, "E-Stress" means.

MR. TRUDEAU: That is the effective stress that is designed Sigma sub V in the equation on page 10, which is included as the second page of Exhibit 238.

MR. TRAVIESO-DIAZ: And tell me what does TFS mean?

MR. TRUDEAU: That's tons per square foot. Most of our work has been done in kips per square foot, so to convert from tons per square foot here you just multiply by two, two kips per ton.

MR. TRAVIESO-DIAZ: So I see that for the same line that has a 4.42 depth, there is an effective

stress of .21 tons per square foot?

MR. TRUDEAU: Correct.

MR. TRAVIESO-DIAZ: Now how would you translate that to pounds per square foot?

MR. TRUDEAU: That would be double that to get the kips per square foot, so it would be .42 kips per square foot. If you wanted pounds, you'd multiply that by 1,000. That would be 420.

MR. TRAVIESO-DIAZ: So this is 4.2 kips.

MR. TRUDEAU: No, .42 kips.

MR. TRAVIESO-DIAZ: I'm sorry, .42.

MR. TRUDEAU: Per square foot.

MR. TRAVIESO-DIAZ: All right. Now if you would move to the next to the last column, "S sub U." What is S sub U?

MR. TRUDEAU: S sub U is the undrained shear strength values that Cone Tec calculated for every interval that they made measurements at.

MR. TRAVIESO-DIAZ: Now for this same line that was .67?

MR. TRUDEAU: .67 tons per square foot.

MR. TRAVIESO-DIAZ: And if I wanted to convert that to kips, what would I have to do?

MR. TRUDEAU: You'd multiply that by 2, so that would be around 1.34 kips per square foot.

MR. TRAVIESO-DIAZ: Okay. Now this is the value of undrained shear strength that was calculated by Cone Tec for a depth of 4.43 feet?

MR. TRUDEAU: Yes, based on the measured tip resistance value at that depth.

MR. TRAVIESO-DIAZ: And looking at -- and you remember the testimony as to what the range of depths of the upper Lake Bonneville clays is, three to ten feet. Remember that?

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: So if you take a look at the values on this page on that range, would this line that has the .67 undrained shear strength would be the lowest reported on this page?

MR. TRUDEAU: I believe this is the lowest value reported in the upper Bonneville clay in all of the Cone Tec results. It's certainly the lowest in this range here.

MR. TRAVIESO-DIAZ: Okay. Tell me now, this doesn't include, of course, the effect of the weight of the pad on the stress of the soil. Is that right?

MR. TRUDEAU: That's correct. It's at the effective stress of .21 tons --

MR. TRAVIESO-DIAZ: Okay. So you would

need to make, essentially, a correction to account for the weight of the pad?

MR. TRUDEAU: If you were going to use these values in the sliding stability analysis of the pad. This is essentially the same thing that Dr. Bartlett said this morning, that the strength is a function of the stresses that are applied.

MR. TRAVIESO-DIAZ: Would you turn your attention to the last page of this exhibit, please.

MR. TRUDEAU: Yes.

MR. TRAVIESO-DIAZ: Is this Figure 7 the correlation that you generally drew based on your shear tests between the undrained shear strength between the stress and the undrained strength at various points, taking into account the weight of the pad?

MR. TRUDEAU: This page presents the results of the direct shear tests that were performed on Sample U-1C from boring C-2.

MR. TRAVIESO-DIAZ: And what would be the value that represents your calculated undrained shear stress for the actual situation that you would have at PSF under the pad, taking into account the weight of the pad, based on your laboratory measurements?

MR. TRUDEAU: You can see this near the

middle of the chart where the Sigma V sub F at the bottom of the cask storage pads is identified as approximately 2 KSF. You go vertically up to the line through the laboratory test results, as Dr. Bartlett indicated earlier today, and read the undrained strength off on the vertical axis as being 2.1 KSF.

MR. TRAVIESO-DIAZ: Now you testified a moment ago that for this particular line that we're looking at, the effective stress was .42?

MR. TRUDEAU: That is correct, so if you do that same construction for the results from this direct shear test, you can see that the undrained strength should be around 1.4 KSF, versus the measured value by Cone Tec of 1.34 KSF.

MR. TRAVIESO-DIAZ: Would you say --

MR. TRUDEAU: It doesn't get any better than that in geotechnical engineering.

MR. TRAVIESO-DIAZ: Would you say that the value, in fact, of undrained shear strength reported for Cone Tec for this worst case is consistent with the value that you expect that would actually exist under the pad based on your lab measurements?

MR. TRUDEAU: That's exactly what I was going to say.

MR. TRAVIESO-DIAZ: Well, I'm glad. This

is all that I have in examination, rebuttal examination. And I would like to move to admit Exhibit 238 into evidence.

CHAIRMAN FARRAR: Any objection?

MS. CHANCELLOR: Yes, Your Honor. Could I ask Mr. Trudeau a couple of questions?

CHAIRMAN FARRAR: Yes, certainly.

MS. CHANCELLOR: Mr. Trudeau, good morning.

MR. TRUDEAU: Good morning.

MS. CHANCELLOR: This says -- the document, the Cone Tec results, Exhibit -- the excerpts, Exhibit 238, it states it's Revision 1?

MR. TRUDEAU: Correct.

MS. CHANCELLOR: That large thick book you held up a moment ago, the four inch thick binder, that's not Revision 1, is it?

MR. TRUDEAU: It included Revision 1, which was a change to -- some of the dilatometer data, I believe.

MS. CHANCELLOR: Do you recall whether the State ever obtained a copy of Revision 1?

MR. TRAVIESO-DIAZ: Ms. Chancellor, I can represent to you on the record that we did. We have the cover letter to prove it, and I can prove it to

the State at the proper time. The answer is yes, you have it.

MS. CHANCELLOR: That's fine, Your Honor. No objection.

MR. O'NEILL: No objections from the Staff.

MR. TRAVIESO-DIAZ: The witness is available for examination.

CHAIRMAN FARRAR: And then Exhibit 238 for identification will be admitted.

(Exhibit 238 received in evidence.)

CHAIRMAN FARRAR: Staff have any cross?

MR. O'NEILL: Just one quick clarification, I think.

CROSS EXAMINATION

MR. O'NEILL: Mr. Trudeau, could you turn to page 5 of your rebuttal testimony. You'll notice near the top there's a bullet. Do you see that?

MR. TRUDEAU: Yes, I see that.

MR. O'NEILL: The sentence begins, "The minimum FS".

MR. TRUDEAU: Yes, that's factor safety.

MR. O'NEILL: It says, "The minimum factor safety is applicable only during the brief period in which the earthquake reaches its peak magnitude." Are

you referring to the earthquake ground motion, when the earthquake ground motion reaches its peak magnitude?

MR. TRUDEAU: That's correct.

MR. O'NEILL: Okay. Thank you. That's all I have.

CHAIRMAN FARRAR: Thank you, Mr. O'Neill.

JUDGE LAM: I'd like to ask a clarification. Mr. Trudeau, I'm * in computing the minimum factor of safety against sliding. Your very initial calculation indicates a factor of safety of 1.27, a 27 percent margin, which was then opened to criticism by Dr. Bartlett, saying 27 percent is not sufficient because the shear strength could change by a factor of 2.

Now my puzzlement comes from, subsequently you indicate there are other mechanisms there against sliding. For example, the passive resistance offered by the soil cement around the pad. If that is, indeed, a valid mechanism against sliding, why did you not just take it into account at the very beginning?

MR. TRUDEAU: The point I was trying to make was that we don't even need to take that into account, and in so doing, we eliminate a lot of concerns and questions about the quality required to

construct that soil cement adjacent to the pad, because it's not being relied upon to keep the pad from sliding.

JUDGE LAM: Because Dr. Bartlett does have a point, 27 percent may not be a great deal of margin, and if the soil shear strength does in fact change by a factor of 2, there goes your margin.

MR. TRUDEAU: The soil shear strength that we're using is the lower bound strength. As I've just indicated, based on the cone data, as well, we're looking at the worst case on this site for the developing the soil strength, so any variability in the soil strength is going to lead to an increase in the shear strength, in my estimation.

I'd like to also point out that the 1.27 is 15 percent above, as Dr. Bartlett has indicated, the value that's accepted as being reasonable according to NUREG 0800. It's -- NUREG 0800 for nuclear power plants says that a factor safety of 1.1 is acceptable. It's found to be acceptable for nuclear power plant structures, so these structures, in my estimation, are less critical than nuclear power plant structures because we don't have the safety-related connections that are required at many of the nuclear power plant structures, and lead to increased

sensitivity to structural movements than are applicable here.

JUDGE LAM: That I understand. My question really is, if the soil cement is going to be placed around the pad which, in fact, would have some passive resistance.

MR. TRUDEAU: Yes, it would.

JUDGE LAM: But taking credit for that would be a reasonable approach, and then if - assuming your calculation is correct, then the factor of safety would be over 3.

MR. TRUDEAU: That is correct.

JUDGE LAM: Well, then the dispute with Dr. Bartlett would go away.

MR. TRUDEAU: Well, I believe he would have some additional concerns about the soil cement, so the -- I see Dr. Bartlett nodding vociferously in the background here.

The 1.27 is based on what, as I've said, I believe is a lower bound strength. It also does not include the well-known phenomenon that Dr. Bartlett agreed is existing for clay soils; that is, when they are rapidly loaded, as they would be from an earthquake because of the rapid cycling during the earthquake, it's well-known that clay soils show an

increase in strength due to that rapid loading. And I believe that it would be a minimum of 50 percent for these soils; whereas, in the literature, the strength increase has been noted to be as high as 100 percent, so I don't believe it's correct to assume that the strength of this soil can be less than what we're looking at here.

JUDGE LAM: So I think your approach, assuming your assertions are correct, are exceptionally conservative. You have no -- assuming, I mean, your theory is correct, you have no physical phenomena. You willingly and deliberately disregard to come up with 1.27 factor of safety, two of which is the passive resistance of the soil cement. Number one, which is that. The second one is what you just mentioned.

MR. TRUDEAU: That's correct. This is a curse. I mean, this is the way that I've learned to work within the nuclear power plant environment. You don't work with statistical averages or means. You work with the worst case, so that you can demonstrate that even for the worst case scenario, you've got an acceptable design.

JUDGE LAM: Thank you for your insight.

CHAIRMAN FARRAR: Ms. Chancellor and

everyone, let's review the bidding here. Our closing time in mind, how long do you think you'll need?

MS. CHANCELLOR: With Mr. Trudeau, 45 minutes.

CHAIRMAN FARRAR: OH, okay. And then that's the end of the -- I mean, we'll have a little bit of redirect and so forth, but that's the end of the Applicant's rebuttal case.

MR. TRAVIESO-DIAZ: Subject to, potentially, although I don't expect that we're going to need to bring Mr. Trudeau back, based on where we are now. But yes, it would be the end of the rebuttal.

CHAIRMAN FARRAR: Okay. And does the Staff have any -- planning any rebuttal case?

MR. O'NEILL: No, we haven't -- we're not planning any rebuttal.

CHAIRMAN FARRAR: And so then, Ms. Chancellor, when you finish this, we would have left only the State's rebuttal with Dr. Bartlett.

MS. CHANCELLOR: Yes. And I've distributed written rebuttal, and I'll have just a couple of questions for Dr. Bartlett on the stand.

CHAIRMAN FARRAR: All right. So it looks like we're in reasonably good shape to hit our target.

MR. TRAVIESO-DIAZ: If I can be as bold as to make a prediction, I think we will be finished before lunch.

CHAIRMAN FARRAR: All right. Brandon, would you let Judge Bollwerk know that, in terms of the afternoon presentation. See if the person is available at noon time.

Go ahead, Ms. Chancellor.

MS. CHANCELLOR: Your Honor, PFS Exhibit 238, asking questions about that exhibit is way beyond my capability, and I would request that the Board make a finding to allow Dr. Bartlett. He has -- he's familiar with Cone Tec's cone penetrometer test results. He's familiar with the NK factor, and he will be expeditious in his questioning, so I would request permission to allow Dr. Bartlett to question Mr. Trudeau.

CHAIRMAN FARRAR: Right. Under the same provision of the regulations that we've invoked before, I think it's apparent from the proceedings that Dr. Bartlett clearly meets all three of those criteria, so if there's no objection, we would let him proceed.

MR. TRAVIESO-DIAZ: I have no objection, but I would like a clarification. Do you intend, Ms.

Chancellor, to ask questions of Mr. Trudeau on the rest of his rebuttal?

MS. CHANCELLOR: Yes, I was just going to mention that. I do have some questions, but not very many, on the written rebuttal. But with permission, if Dr. Bartlett could do his questioning first.

MR. TRAVIESO-DIAZ: I have no problem with that.

CHAIRMAN FARRAR: Mr. O'Neill?

MR. O'NEILL: No problem. No objection.

CHAIRMAN FARRAR: All right. Go ahead, Dr. Bartlett.

DR. BARTLETT: Thank you. Good morning, Mr. Trudeau.

MR. TRUDEAU: Good morning, Dr. Bartlett.

DR. BARTLETT: At last we talk face-to-face.

(Laughter)

MR. TRUDEAU: You're looking well.

MR. TRAVIESO-DIAZ: I don't like the sound of this.

DR. BARTLETT: I just have a few questions regarding how Cone Tec derived this NK factor. First, I see these borings that are listed. Those are from the PFS site. Correct?

MR. TRUDEAU: That is correct.

DR. BARTLETT: And there is a mention here of a CU tri-axial test. Could you please explain what that means?

MR. TRUDEAU: Those are the consolidated undrained tri-axial tests that are reported in the SAR, and described or interpreted in the Appendices of the stability calculations.

DR. BARTLETT: And when it says "CU tri-axial test", could you please explain whether that's tri-axial compression or tri-axial extension?

MR. TRUDEAU: Those are compression tests.

DR. BARTLETT: Now the results that we've seen from the pad emplacement area for the direct shear test, could you explain which direction of shear that is in relation to compression?

MR. TRUDEAU: That's horizontal.

DR. BARTLETT: And the compression test, what is --

MR. TRUDEAU: That's vertical.

DR. BARTLETT: That's vertical. Are you aware, or heard of the term "anisotrophy"?

MR. TRUDEAU: Yes.

DR. BARTLETT: Do you know if the Bonneville clays have any shear anisotrophy?

MR. TRUDEAU: I've heard you testify that they do, but I'd like to point out that the strength that we're using for the tri-axial compression test for this pad emplacement area is 2.2 KSF, and for the horizontal direction from the direct shear test it's 2.1 KSF. That's not much anisotrophy.

DR. BARTLETT: But that's based on one sample from the pad emplacement area. Is that --

MR. TRUDEAU: For the direct shear test, and several for the tri-axial test.

DR. BARTLETT: Do you know approximately, when Cone Tec says it used the nearest CPT soundings, how far apart they are from these borings in relative terms?

MR. TRUDEAU: I haven't determined that, no.

DR. BARTLETT: Are they within a few feet?

MR. TRUDEAU: Not a few feet.

DR. BARTLETT: A few tens of feet?

MR. TRUDEAU: No, probably hundred feet or more. We can determine that from PFS Exhibit 235, which is a copy of Figure 2.6-19 of the SAR. It's a location plan that shows where the borings are with respect to the cones. And looking at the scale here, it appears that boring 1 near the northern end of the

site is within 100 feet of CPT 24. Boring 3, which is south of that, is within 25 feet, I would guess, of CPT 20. C-2 is, gain, within 100 feet of CPT 10, and maybe 150 feet from CPT 11. CPT N is over in the cannister transfer building. The borings are not shown here for this figure, but they are included in another SAR figure. Hold on. I'll just check that.

MR. TRAVIESO-DIAZ: Mr. Trudeau, I think you may have misspoken. Take a look at the plot of the cannister transfer building on Exhibit 235. Doesn't that show you the locations of the cone penetration tests and the borings?

MR. TRUDEAU: Oh. I'm sorry. That's correct. I just knew we had a bigger scale figure in the SAR. That's correct. CTB-N is north of CPT 37 by probably 30 or 40 feet, by my guesstimate here. And CTB-S is maybe 15 feet from CPT 38, so I guess I misspoke earlier when I said they were hundreds of feet. There are several that are within certainly tens of feet.

DR. BARTLETT: I believe that's all I have. Thank you.

CHAIRMAN FARRAR: Thank you, Dr. Bartlett. Ms. Chancellor.

MS. CHANCELLOR: Back to our usual format,

Mr. Trudeau. In looking at your rebuttal testimony, in a number of places it appears not to be new testimony. For example, in answer 1, you basically just reclaim that the soils are uniform across the site. Correct? There's nothing new there that didn't appear in your direct testimony, or come out during examination of you?

MR. TRUDEAU: I believe the term "complex" is new to us, I'd say, so that's why that was included here.

MS. CHANCELLOR: Okay. And then with respect to answer 3, where you refer to the sliding of the pads, and also the bearing capacity failure. You testified about what's called a crustal layer. Correct? On the top of the Bonneville.

MR. TRUDEAU: Yes.

MS. CHANCELLOR: And the 50 percent credit for direct shear under dynamic loadings, you had a whole bunch of testimony on that in Section D. Correct?

MR. TRUDEAU: The 50 percent has been discussed earlier. That's correct.

MS. CHANCELLOR: And the passive resistance of soil cement, that's come up numerous times. Correct?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: And if you look at the bottom of page 4, where you refer to "disturbed samples", "samples become disturbed when you collect them." Do you see that?

MR. TRUDEAU: Yes. I think that's the first time we've discussed that. On page 3, I guess this is the first time we've discussed the stronger crust at the top of the upper Bonneville clay.

MS. CHANCELLOR: Are you saying that disturbed sampling is good, because you know you have stronger soils than those measured in the lab?

MR. TRUDEAU: I'm saying that the disturbance that -- that no matter how good you try to be when you take an undisturbed sample, just the fact that you've removed it from the ground, you've caused some disturbance to it. That disturbance is not going to lead to an increase in strength for these clay soils.

MS. CHANCELLOR: So you think you can take credit for that in claiming conservatism in your results. Is that correct?

MR. TRUDEAU: Absolutely.

MS. CHANCELLOR: With respect to answer 9 on page 9, and this deals with the sample taken from

bore hole C-2, the one set of samples for the direct shear test.

MR. TRUDEAU: Correct.

MS. CHANCELLOR: You state, "Dr. Bartlett's criticism is way off the mark." That's rather harsh. Is that your testimony?

MR. TRUDEAU: Yes.

MS. CHANCELLOR: The bottom line is though, that you only took three samples from one bore hole to get direct shear test for the entire pad emplacement area, the construction of 500 pads at the PSF site. Isn't that true?

MR. TRUDEAU: Yes, but as Dr. Ofoegbu said --

MS. CHANCELLOR: Thank you.

MR. TRUDEAU: -- there's other data that corroborates these results, including the tri-axial test data, and the wealth of cone data that are measured continuously through that layer.

MS. CHANCELLOR: Thank you.

MR. TRUDEAU: Over the entire pad emplacement area.

MS. CHANCELLOR: Thank you, Mr. Trudeau. I have no further questions, Your Honor.

CHAIRMAN FARRAR: Ms. Chancellor, unless

my watch stopped, that was -- that 45 minutes was done in 10, and I --

MS. CHANCELLOR: I thought you were going to cut me in half, Your Honor.

(Laughter)

CHAIRMAN FARRAR: The old budget game.

MS. CHANCELLOR: I am in Washington, Your Honor.

CHAIRMAN FARRAR: Well, I was going to say, I assume you don't do that with the governor.

(Laughter)

CHAIRMAN FARRAR: The Board has no additional questions. Any redirect?

MR. TRAVIESO-DIAZ: I see no need for redirect.

CHAIRMAN FARRAR: No need?

MR. TRAVIESO-DIAZ: No need for redirect.

CHAIRMAN FARRAR: All right. Staff?

MR. O'NEILL: No addition questions, Your Honor.

CHAIRMAN FARRAR: All right. We're moving right along, for which I commend everyone. Then, Mr. Trudeau, you're at least momentarily excused again. Thank you again.

MR. TRUDEAU: Thank you, Your Honor.

CHAIRMAN FARRAR: Mr. Travieso-Diaz, does that conclude the rebuttal case?

MR. TRAVIESO-DIAZ: It does.

CHAIRMAN FARRAR: Okay. The Staff, I think, had previously indicated that it had -- it did not expect to have any rebuttal case.

MR. O'NEILL: No, Your Honor.

MS. CHANCELLOR: Your Honor, could I request another break?

MR. TRAVIESO-DIAZ: I was going to do the same thing.

CHAIRMAN FARRAR: So now, Ms. Chancellor, you would be presenting Dr. Bartlett's surrebuttal, which you've handed out to us earlier this morning.

MS. CHANCELLOR: That's correct, Your Honor, and there will be some -- it's going to be a bit of a mixed bag. There will be some direct rebuttal testimony. There will be the written surrebuttal, then there'll be some rebuttal, surrebuttal based on PFS Exhibit 238.

CHAIRMAN FARRAR: But we'll do that all in one package.

MS. CHANCELLOR: We could wrap all that up, right.

CHAIRMAN FARRAR: Then how much -- take as

much time as you need now to get that organized. How long do you think you'd like?

MS. CHANCELLOR: If we could have 15 minutes now, Your Honor, I think that once Dr. Bartlett gets on the stand, we won't have very much.

CHAIRMAN FARRAR: All right. Then it's just before 9:30. Let's be back at 9 --

MR. TRAVIESO-DIAZ: Mr. Chairman.

CHAIRMAN FARRAR: Yes.

MR. TRAVIESO-DIAZ: I need time also to review the pre-filed that we just received. I think 15 minutes may be enough, but I haven't read it. I can't -- would it be --

CHAIRMAN FARRAR: Let's do 20. I mean, I think --

MR. TRAVIESO-DIAZ: That should be sufficient.

CHAIRMAN FARRAR: Yeah. It's almost 9:30. Let's be back at 10 of 10.

MR. TRAVIESO-DIAZ: Thank you very much.

(Off the record 9:29 - 9:51 a.m.)

CHAIRMAN FARRAR: Ms. Chancellor, have you had sufficient time to get your thoughts in order?

MS. CHANCELLOR: Yes, sir, I have. Yes, thank you, Your Honor.

CHAIRMAN FARRAR: Okay.

MS. CHANCELLOR: Dr. Bartlett, I believe you're up again. Dr. Bartlett, did you take with you your surrebuttal?

DR. BARTLETT: Yes, I have a copy.

MS. CHANCELLOR: Do you have in front of you surrebuttal of Dr. Steven Bartlett to PFS witness, Paul Trudeau's, rebuttal testimony on Section C of Unified Contention Utah L/QQ, dated June 21, 2002." Do you have that testimony in front of you?

DR. BARTLETT: Yes, I do.

MS. CHANCELLOR: Was this prepared by you or under your direction and control?

DR. BARTLETT: Yes.

MS. CHANCELLOR: And do you adopt this as your rebuttal testimony, as if read?

DR. BARTLETT: I do.

MS. CHANCELLOR: And the -- and just for point of clarification, this was done in a little bit of a rush. The R1/R2, as it states at the beginning of this rebuttal testimony, are they the direct responses to the numbering in Mr. Trudeau's rebuttal testimony?

DR. BARTLETT: Yes, they correlate.

MS. CHANCELLOR: So there's no question

and answer. There's just a direct response. Is that correct?

DR. BARTLETT: That is correct.

CHAIRMAN FARRAR: So what he has in answer number 3, you have R3, your response.

DR. BARTLETT: To those that are put forth by Mr. Trudeau.

CHAIRMAN FARRAR: Fine.

MS. CHANCELLOR: If you look at the introductory clause, Your Honor, it -- that's how we tried to designate it.

CHAIRMAN FARRAR: Right. And that's fine. I just wanted to make sure we were clear.

MS. CHANCELLOR: Your Honor, I request that the testimony be bound into the record as if read.

CHAIRMAN FARRAR: Any objection?

MR. TRAVIESO-DIAZ: No objections.

MR. O'NEILL: No objections.

CHAIRMAN FARRAR: All right. Then the reporter will bind this testimony into the record at this point, as if read.

(Insert pre-filed testimony of Dr. Steven Bartlett.)

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel	)	
Storage Installation)	)	June 21, 2002

SURREBUTTAL OF DR. STEVEN BARTLETT TO PFS WITNESS PAUL TRUDEAU'S REBUTTAL TESTIMONY ON SECTION C OF UNIFIED CONTENTION UTAH L/QQ

This surrebuttal follows Mr. Paul Trudeau's testimony with "R" designating a response to the numbered question/answer in Mr. Trudeau's testimony.

R1. An approximate 51-acre site is a large area. The cone penetrometer (CPT) data collected by PFS (Figures 2.6-5 sheets 1 through 14) show that at least 5 major layers exist in the upper 35 feet of the profile. These same plots also show significant variations of CPT tip stress within a given layer. The geological and environmental processes that formed the various soil layers are complex. I considered the soil layering at the PFS site to be relatively complex and variable.

R2. Because of uncertainty in the analyses, the minimum acceptable factor of safety for determining adequacy is 1.1, not 1.0. The range in margins against the minimum acceptable factor of safety of 1.1 as quoted in my prefiled testimony in A15 are correct.

In paragraph 1 Mr. Trudeau also suggests, "All of these margins are calculated using the peak force due to the design earthquake, which acts only for one brief instant in time; at all other times during the earthquake, the forces are much less than this peak value."

My comment is simply this: that unfortunately during an earthquake you only get one chance at failure, and if you reach a failure state, you have not achieved an adequate factor of safety. This view is consistent with the state of practice of geotechnical earthquake engineering. The reason for this practice is that once the

failure state has been reached, "unacceptable" things can happen. (See A7- A9 in my pre-filed testimony.) For example, once a foundation system or soil has failed from the peak stress, it may subjected to increased and unacceptable deformation from subsequent earthquake cycles because it has been weakened due to reaching the failure state.

R3. One should always balance the conservatism introduced into an analysis with the unconservatisms that are introduced. The unconservatisms and potential unconservatisms in analyses have been discussed by Dr. Ostadan, Dr. Kahn and myself in our prefiled testimony and will not be repeated here. I will briefly address the conservatism claimed by Mr. Trudeau according to the bullets given.

- Earthquakes forces tend to find the weakest link in the system. Failure may simply occur below "the crust" that is being described here.

- What Mr. Trudeau is describing are called "strain-rate effects." These effects do exist and have been measured. I was involved in the I-15 Reconstruction Project where a 30 percent increase in the peak undrained shear strength was used to account for strain-rate effects in the Bonneville clays. However, for this same project, we used a 15 percent reduction in peak undrained shear strength due to softening of the clay from cyclic loading. The net effect was a 15 percent increase in the undrained shear strength. Mr. Trudeau has claimed strain rate effects that are larger than suggested by my experience. If used in design, this effect should be demonstrated by site-specific testing of the Bonneville clays.

- Use of passive earth pressure "i.e., the buttress effect," as an additional resisting force in the design of the pads and the CTB is controversial. This has been throughly discussed by the State's witnesses regarding our concerns about potential cracking of the soil cement by curing, settlement, and seismic forces. Also, the increase potential for pad-to-pad interaction has not been addressed in the sliding calculations for the pads.

- The claimed minimum factor of safety of 5 against sliding of the pads has only been obtained by compounding conservatisms. This is not correct. Mr. Trudeau has not considered the unconservatism raised by the State's witnesses.

Regarding bearing capacity failure of the pads:

- It appears that the calculated factor of safety of 1.17 against bearing

capacity failure is conservative for the design basis earthquake. The main reason is that the 100 percent of the peak ground acceleration was applied in both horizontal directions at the same time. ASCE 4-98 loading combinations can be used, which would increase the factor of safety. However, I have not reviewed the calculations which claim that this factor of safety would increase to 2.1; thus I cannot comment on the appropriateness of this factor of safety.

Regarding the minimum soil strength of the soil in the pad emplacement area and CTB:

- The concerns I expressed in my prefiled testimony regarding the undersampling of the upper Bonneville clay still remain. I believe that this layer has been grossly undersampled and potential variability has not been adequately described. The amount of direct shear testing is inadequate to describe the sliding resistance for the upper Bonneville clay at the PFS site.

R4 I understand Reg. Guide 1.132 is only guidance and not strictly applicable to ISFSIs. I also understand that judgment is required in designing a soil's investigation program. The CPT investigations performed by the Applicant were extremely useful in narrowing the focus of the investigations to critical layers such as the upper Bonneville clay. However, the Applicant has not performed continuous sampling of this critical layer as discussed in my testimony (see A.20 in prefiled testimony). Also, because of the large size of the pad emplacement area, I believe that this should be done at select locations based on a thorough review of the CPT data. Also, it is my judgment that the continuous borings should be conducted within a few feet of where CPT soundings were performed, so that results from the laboratory shear testing can be correlated with the CPT data.

R5 See response R4

R6 See response R4

R7 In my opinion, the CPT data does not meet the requirements of continuous sampling. The guidance given in Reg. Guide 1.132 are for boring, not CPT soundings. CPT soundings are an in-situ test and engineering properties can only be inferred from CPT data. In contrast, the use of borings allows undisturbed sampling of the soil and laboratory testing of shear strength.

R8 My concerns expressed in A22 remain.

R9 My concerns expressed in A23 remain.

R10 My concerns expressed in A24 remain. Mr. Trudeau notes that in my deposition that I have described the soils in Layer 2 as being "monotonous." This was a bad choice of words on my part, because it is not very precise. I did not imply that these soils are uniform as interpreted by Mr. Trudeau. There is variability, even within layer 2 (i.e., the upper Bonneville clays) that may be significant to the sliding resistance of the pads.

R11 My view expressed in A26 of my testimony and discussed in more detail during my cross-examination has not changed. For the sample soil type, the CPT tip resistance is an indicator of the variation in shear strength. Variations in CPT resistance in the upper Bonneville Deposits (silty clay / clay silt layer in SAR fig 2.6-5, sheets 1-14) can vary by a factor of about 2. This can be verified or refuted directly by PFS. It has the CPT data and can perform the analysis. (I was not given the electronic data, but had to rely on hard copy plots of the CPT data for my preliminary assessment.)

R12 My opinion has not changed. PFS has not performed strain controlled cyclic tests at the levels of strain expected underneath the pads for the design basis earthquake.

R13 My opinion has not changed. These shear tests can and should be used for bearing capacity analyses for soils that are anisotropic, such as the Bonneville clays.

R14 Mr. Trudeau's answer satisfactorily addresses this issue.

MS. CHANCELLOR: Your Honor, I'd like to conduct some oral examination. The first -- I'll try and identify in general what I'm -- because it may be direct rebuttal or surrebuttal. The first set of questions goes to PFS recent Exhibit 238, the cone penetrometer testing done by Cone Tec, and Mr. Trudeau's testimony on that issue. I guess the rebuttal, or surrebuttal.

Dr. Bartlett, Mr. Trudeau mentioned something about anisotrophy. What does anisotrophy mean?

DR. BARTLETT: May I also have a copy of my pre-filed testimony?

MS. CHANCELLOR: Oh, certainly.

DR. BARTLETT: I think it's back behind there. Anisotrophy means that the, in this case for shear strength, the strength of the soil, and it's shear resistant is dependent upon the mode or the direction of shear. The Bonneville clays, as I discussed yesterday, have this fabric to them, this layering, this microfabric that we discussed where we have alternating clays that were deposited during the quiet time of the lake, and subsequently, more silty materials deposited when there was a lot of runoff going into the lake. And it gives this microfabric,

if one looks at it, it may be on the order of an inch or so, or some of the layering may even be smaller than that. So it's this fabric that creates the anisotrophy.

For example, if we are in a laboratory to place the sampling tracks of compression, and tracks of compression means where we put the vertical forces in this direction, which is the vertical direction, and push on the sample, it will reach a failure state and shear planes develop at some angle to that principal direction of stress, and it will exhibit one strength.

If we take the sample in the laboratory and put it in direct shear, and in direct shear the principal shearing stresses are applied in the horizontal direction so that we shear it in a pure horizontal direction, then it will exhibit another strength, and that's a function of this fabric of the soil. Did I answer your question?

MS. CHANCELLOR: Why is anisotrophy important at the PFS site?

DR. BARTLETT: Because the Bonneville clays at the PFS site have anisotrophy.

MS. CHANCELLOR: And is the strength of the soils greater in one direction than in the other

in shear --

DR. BARTLETT: Yes, as I explained, in tri-axial compression, it has a higher strength because the stress is being applied in the vertical direction. It is -- the soil is weaker when we try to shear it in the horizontal direction, so it has direct applicability at the PFS site.

MS. CHANCELLOR: And does evidence of anisotrophy exist at the PFS site?

DR. BARTLETT: Yes, it does.

MS. CHANCELLOR: The NK factor developed by Cone Tec, was it developed for tri-axial compression?

DR. BARTLETT: Yes, it was.

MS. CHANCELLOR: Is it proper to use an NK factor developed for tri-axial compression for the direct shear mode of failure?

DR. BARTLETT: If one is concerned about calculating the direct shear mode of failure, which is the primary mode of failure underneath the pads in sliding because it is an event where there is now sliding in the horizontal direction, then it would be improper to use an NK factor calculated for tri-axial compression if we were to use it for the direct shear mode of failure.

MS. CHANCELLOR: Because the tri-axial compression --

DR. BARTLETT: Because of the differences in the way that the stresses are applied, for tri-axial compression the stresses are in this direction, which causes --

MS. CHANCELLOR: This being?

DR. BARTLETT: This being the vertical direction, which causes shearing at some angle that's controlled by the strength of the material. Whereas, for the pads, where we're analyzing for shearing in the horizontal direction, then the direct shear mode of failure is the proper mode of failure.

MS. CHANCELLOR: Is there enough data from the PFS site to develop an NK factor for the direct shear mode of failure of the pads?

DR. BARTLETT: No, there is not.

MS. CHANCELLOR: Please comment on Mr. -- do you recall Mr. Trudeau referring to a 2.2 KSF to represent low shear strength value for the NK factor?

DR. BARTLETT: I recall that comment. The Cone Tech report, as presented this morning, doesn't really elaborate on what we heard from Mr. Trudeau, so it's difficult to comment completely upon it, based on we haven't seen the calculations and the data that

support the NK factor developed by Cone Tec.

However, as I understand it, the attempt was made to perhaps find the lowest tip resistance zone in the Bonneville clay, and I don't know if that was the lowest through the entire pad emplacement area, and use a 2 KSF tri-axial compression test to represent -- which was represented as the lowest bounds for tri-axial compression data, to represent that lowest tip zone in the Bonneville clay throughout the entire pad emplacement area.

That still, in my view, is not adequate because the direct shear mode will have, if we could find that exact same zone in the Bonneville clay, will still have a lower strength. And, in fact, to support my view, if we look at the three samples that we have where direct shear testing is done, the lowest direct shear strength that we see is 1.75 KSF. And I would argue that that may not really truly represented the lowest undrained shear strength in direct shear for the Bonneville clay because it's been extremely under-sampled.

MS. CHANCELLOR: And the --

COURT REPORTER: Indirect shear?

DR. BARTLETT: Direct shear.

COURT REPORTER: Did you say indirect?

DR. BARTLETT: It's direct. Two words, in direct.

MS. CHANCELLOR: And the direct shear results of 1.75 KSF, was that from the CTB area?

DR. BARTLETT: That's my recollection. And that, I think, is at a vertical stress of about 2 KSF, as I recall.

MS. CHANCELLOR: And, Dr. Bartlett, is it appropriate to use -- do you recall Mr. Trudeau talking about the CPT soundings and the spacing of them?

DR. BARTLETT: Yes, I do.

MS. CHANCELLOR: Is it appropriate to use bore holes and CPT soundings that are spaced tens, if not hundreds of feet, apart to develop correlations?

DR. BARTLETT: In my view, it's not. We've done this process before at Savannah River site where horizontal variability of the soils was of great interest to us, and we did a program where we had cone penetrometer soundings to correlate back to laboratory shear strength values.

In those cases, we did undisturbed sampling of the soils of interest, and to correlate the results back to the CPT data, our -- the adjacent soundings were five, if no more than ten feet apart,

so we knew exactly - and surveyed in, I should add - so we knew exactly that the interval where we saw in the laboratory test and where we had derived the shear strength, directly corresponded to a certain interval within the CPT.

When you get bore holes and CPTs now that are spaced tens, if not hundreds of feet apart, it becomes virtually impossible to do that process, so your correlation introduces extra uncertainty and variability due to the fact that there is lateral variation in the soil conditions from place to place.

MS. CHANCELLOR: Is it possible for PFS to actually do these correlations now if they did more work?

DR. BARTLETT: Sure. I think we discussed this some time ago, about two years ago, about this philosophy of doing paired sampling, and CPT testing.

MS. CHANCELLOR: I'd like to switch to, I think this is direct rebuttal, Your Honor. No, I guess it's surrebuttal.

Mr. Trudeau -- do you recall Mr. Trudeau testing that resonance column tests can be extrapolated to higher shear strain levels? In your opinion, is that true?

DR. BARTLETT: No, the resonant column

test is a low strain dynamic test, and generally thought that applicable to give low strain shear moduli to shear strains no more than about .1 percent. To get shear strain values at higher levels of strain, requires some other type of test. Quite often, that is done with a strain controlled cyclic tri-axial test.

MS. CHANCELLOR: And these resonant column tests, that comes from the Geomatrix data. Right?

DR. BARTLETT: No, Geomatrix --

MS. CHANCELLOR: Tests, I mean.

DR. BARTLETT: Geomatrix used the data. The curves and the testing, I believe, was done by Stone & Webster, so the resident column testing was done, and then given -- the results of the testing was given to Geomatrix to evaluate, to develop the shear modulus and damping curves for the ground response analysis.

MS. CHANCELLOR: Now PFS conducted stress controlled tri-axial tests. Right?

DR. BARTLETT: They did.

MS. CHANCELLOR: Why do you say that Pfs needs to conduct strain controlled tri-axial tests?

DR. BARTLETT: Well, if we look at the levels of strain that developed in the stress

controlled tests, and I can't recall those. If you'll give me a minute, I can refresh my memory.

MS. CHANCELLOR: Is it in the SAR or in your testimony?

DR. BARTLETT: It's in the SAR, but not going back to that data, I know that they certainly didn't reach 1 percent strain, and so they didn't get into the higher strain behavior of the Bonneville clays.

MS. CHANCELLOR: Why are you so concerned about the lack of testing at high strain levels in the Bonneville clays?

DR. BARTLETT: There are two reasons these data are needed. The first one uses the high strain levels to complete the shear modulus and damping curves for high strain levels up to about 1 percent, so these data are useful in the analyses that Geomatrix performed.

Geomatrix used the data that was from the resonant column testing, and then the curves were extrapolated out to higher strain levels. I don't really think I have too much of an issue extrapolating the shear modulus and damping curves to high strain levels for the ground response analysis, because there are other published curves upon which one can make

that extrapolation in a reasonable manner, and that's not my issue of criticism. That's just a point that -- that's one of the uses of these tests.

My concern is more from the shear strength perspective. Again, we're using the Bonneville clays to resist these strong ground motions, and we do not really know the shear strains that will develop underneath the pads due to the inertial loadings. That has not been calculated by the Applicant. And one would be prudent in devising a test program to do a range of strains, particularly in the high strain levels, to assure one's self that there isn't a marked degradation of strength, and what is the proper strength behavior up at these high strain levels. And we do not know that from the testing that PFS has performed.

MS. CHANCELLOR: Do you consider the lack of test data for high strains in the upper Bonneville clays to be a fundamental flaw in PFS' analysis?

DR. BARTLETT: Fundamental flaw may be too severe.

MS. CHANCELLOR: So would they get above an F, or they'd still get an I?

DR. BARTLETT: C minus. If one can be assured that there is no marked decrease in shear

strength at high levels of strain, if that is, in fact, true, then the testing that PFS has done is adequate, because the way that the analyses have been done, the capacity of the Bonneville clay may not decrease dramatically at high levels of strain.

However, if that's not true, if there is for some reason, because either due to poor pressure generation as we cycle these clays at very high levels of strain, and cause their shear strength to degrade, or if there is some cementation in the clays at high strain levels that may be broken, and give the clay a more brittle failure, then there's a change for relatively severe degradation of strength at high levels of strain. And it's difficult to say how that may affect the sliding capacity of the pads, but I don't think this has been fully evaluated.

MS. CHANCELLOR: And you believe it's not difficult for PFS to --

DR. BARTLETT: No, these tests are standardly done. In fact, we've recommended this for quite some time.

MS. CHANCELLOR: And the last topic that I have to ask you about is the use of passive resistance by soil cement. Mr. Trudeau testified that he didn't take credit for passive resistance of soil

cement in the base case. Does this open a can of worms if he --

DR. BARTLETT: This is extremely controversial, and the reason is that first, we don't know whether the soil cement will, indeed, provide the passive resistance because of several of the factors that we've discussed, which mainly go back to cracking and the seismic performance. But also, if we think about this quite simply, in the longitudinal direction, if there's only five feet pads five feet apart, and they're relying on passive resistance to pick up capacity on one side, you have to ask your simple question, where does that force go? And it may be transferred to the adjacent pad, and so the fact that you use passive resistance, to me, in a case where we had pads only five feet apart, could imply there's a very high chance that that passive resistance being provided by the soil cement on one side of one pad can be an active force acting on another pad. And I think we've discussed at length pad-to-pad interaction, and all of its potential ramifications, so it is quite controversial.

MS. CHANCELLOR: But a real concern. Correct?

DR. BARTLETT: A major concern.

MS. CHANCELLOR: I have no further questions, Your Honor.

CHAIRMAN FARRAR: Thank you, Ms. Chancellor. Mr. Travieso-Diaz.

MR. TRAVIESO-DIAZ: I have some partial good news. We have no questions on the readings of rebuttal, but I'd like to take a short break to confer with my colleagues and Mr. Trudeau to see if the oral surrebuttal that was just given requires additional questioning, so I would again -- begging the Court's indulgence, I would like to take a short break to make that determination.

CHAIRMAN FARRAR: Okay. Let me get that clear. No questions on the written.

MR. TRAVIESO-DIAZ: Nothing on the written.

CHAIRMAN FARRAR: But perhaps on --

MR. TRAVIESO-DIAZ: But there has been additional testimony now that I need to figure out what kind of response, if any, it requires.

CHAIRMAN FARRAR: How long would you like?

MR. TRAVIESO-DIAZ: No more than 10, 15 minutes.

CHAIRMAN FARRAR: Okay. It's 12 -- let's come back at 10:30. It's 12 after now. That should

give you enough time.

MR. TRAVIESO-DIAZ: That should be sufficient. Thank you very much.

CHAIRMAN FARRAR: And the Staff can use the same time to get their thoughts in order.

JUDGE LAM: A quick question, Dr. Bartlett. Now on the soil cement in the five feet direction, the resistance against sliding has very little to do with cracking, doesn't it? Even if there were cracks, it doesn't matter, does it?

DR. BARTLETT: It depends on the angle of the crack. If the angle of the crack becomes somewhat subvertical, then you develop a shear plane where then you no longer have any passive resistance. Think of a pad here, potentially shear crack propagating up at some angle, then you have a sliding plane, where as that plug tries -- as the pad tries to push against that triangular-shaped plug, there will be sliding along that plane, so your passive resistance is gone.

JUDGE LAM: But I think we heard testimony offered by the Applicant, the cracks would tend to be vertical.

DR. BARTLETT: From the shrinkage case, that's true. But we've always maintained that there's -- because the pad, soil cement, cement-treated soil

and Bonneville clays have all of these different stiffnesses, there can be stress concentrations, and I refer to them as kinematic and inertial interactions, that could also lead to cracking actually of the soil cement during the actual seismic event.

Also, keep in mind that cracking -- let me put it this way. You can also transfer forces between one pad to another via the soil cement, even if there isn't cracking, because the Bonneville clay is relatively soft, so it can deform quite -- it can deform considerably. Whereas, the soil cement is very, very stiff, so I use the analogy that as we try to push one pad towards another, and mobilize its passive pressure, because of the soil cement strut that's in-between, and its high modulus, it's going to pick up the load quite rapidly.

JUDGE LAM: Which is a different issue.

DR. BARTLETT: Pardon?

JUDGE LAM: Which is a different issue.

DR. BARTLETT: Well, it's part of the issue of pad-to-pad interaction.

JUDGE LAM: Right. My question was focused on sliding.

DR. BARTLETT: Okay.

CHAIRMAN FARRAR: Then it's 10:15. Let's be back at 10:30.

(Off the record 10:15 - 10:40 a.m.)

CHAIRMAN FARRAR: All right. We're back on the record at 10:40. Mr. Diaz.

MR. TRAVIESO-DIAZ: Yes. Dr. Bartlett, I believe --

CHAIRMAN FARRAR: And on the record, you think you'll need just a few minutes?

MR. TRAVIESO-DIAZ: I think so. I can never promise, but that's my best guess.

CHAIRMAN FARRAR: Okay. Go ahead.

CROSS EXAMINATION

MR. TRAVIESO-DIAZ: Dr. Bartlett, I think you testified both yesterday and today, that the PFS is a lake site?

DR. BARTLETT: That PFS is a lake?

MR. TRAVIESO-DIAZ: A lake site. In other words, geological standpoint, it's a --

DR. BARTLETT: The Bonneville clays are lacustrine deposit, so there was an ancestral lake that put them down.

MR. TRAVIESO-DIAZ: And you said earlier they were deposited during a quiet time in the lake's history?

DR. BARTLETT: No. What I'm implying is that the microfabric that we see in the Lake Bonneville deposits has something to do with the seasonal changes of input into the lake. During the quiet times or during the winter, the more fine-grained materials fall out from suspension and they're deposited mainly as clays. During the spring events when there's high runoff, or maybe years when there's high storm events, then you may get a tendency of more silty materials finding their way towards the more central part of the valley.

MR. TRAVIESO-DIAZ: Isn't it true that Savannah River is a marine environment?

DR. BARTLETT: Savannah River is a marine?

MR. TRAVIESO-DIAZ: Yes. That the Savannah River site is a marine environment. It was developed as a result of sea action?

DR. BARTLETT: No, not entirely. It's coastal plain deposits.

MR. TRAVIESO-DIAZ: Okay. Thank you for the correction.

Isn't it true that the coastal plain is more subject to wave action and other factors that introduce deposits?

DR. BARTLETT: Well, the deposits in

Savannah River are both subaqueous and marine, and also terrestrial deposits, but I don't understand what we're --

MR. TRAVIESO-DIAZ: Isn't it true that all the factors being equal, a marine site would tend to more heterogenous in terms of ecological composition than a lake site?

MS. CHANCELLOR: Your Honor, is this -- I'm wondering if this is in the scope of --

MR. TRAVIESO-DIAZ: Oh, yes it is.

MS. CHANCELLOR: Okay.

MR. TRAVIESO-DIAZ: We're getting there.

CHAIRMAN FARRAR: We'll trust that we'll see evidence of that.

DR. BARTLETT: Well, again, Savannah River is not entirely marine. There's both marine and terrestrial deposits there.

MR. TRAVIESO-DIAZ: You looked at the soils at Savannah River, didn't you?

DR. BARTLETT: Yes, I did.

MR. TRAVIESO-DIAZ: Would you say that they're more heterogenous than the soils at the PFS site?

DR. BARTLETT: Some layers are, yes. That's definitely true.

MR. TRAVIESO-DIAZ: So when you said that you needed to take cone penetrometer test results of measurements close to bore holes at Savannah River, wouldn't that be justified by the nature of the soils?

DR. BARTLETT: No. What we were concerned about was not the marine sediments. Actually, it was more in this case liquefaction and the density of sands, so the reason for the closely spaced bore hole and cone penetrometer data is because we were doing piston sampling of the sands that were somewhat clay, and trying to correlate the laboratory test obtained from those piston samples back to the results that we saw in the cone penetrometer, so site-specific liquefaction curves could be developed.

MR. TRAVIESO-DIAZ: So it isn't really fair to compare --

DR. BARTLETT: No, I think --

MR. TRAVIESO-DIAZ: -- the spacing at Savannah River with respect to the PFS, is it?

DR. BARTLETT: My point is, is in any layer where there's potential lateral variability, it's wise to place the bore hole and the cone penetrometer sounding immediately adjacent so that you don't introduce any uncertainty in your correlations due to distances of spacings in the lateral

variability, so that I would take that philosophy regardless of where we're doing this.

MR. TRAVIESO-DIAZ: And, of course, that would depend on how variable you think your site is. Is that right?

DR. BARTLETT: No, not necessarily. I think it's just important that when we're going to correlate an in situ test with a laboratory test, that the in situ test be conducted as closely as possible to where the laboratory sample is taken. That's my philosophy, regardless of the geological depositional environment.

MR. TRAVIESO-DIAZ: Thank you. That's all I have.

CHAIRMAN FARRAR: Thank you.

MR. O'NEILL: Just a quick question. I'm sorry.

CHAIRMAN FARRAR: Yeah. How long --

MR. O'NEILL: Well, I would note that right now I think I'm just going to have one quick cross examination question. However, I think we've perceived the need for some --

MR. TURK: It should be --

MR. O'NEILL: Okay. We may have a few -- we're going to have a few cross examination

questions, but I think we've also perceived the need for some very short rebuttal testimony by Dr. Ofoegbu. And I apologize. I recognize that you trying to expedite this matter, but given the technical nature of the issue, it may be the most appropriate means to address it.

CHAIRMAN FARRAR: Okay. Go ahead.

MR. O'NEILL: Dr. Bartlett, you discussed this issue of anisotrophy.

DR. BARTLETT: Yes.

MR. O'NEILL: Are you postulating a failure, a shear failure in a purely horizontal direction?

DR. BARTLETT: Could you be more specific? Are we talking about --

MR. O'NEILL: Parallel to the base of the pad. I mean, you've discussed this mechanism of shear failure - okay - that -- this is a case in point. Are you saying that it could occur only horizontal direction that is parallel to the base of the pad?

DR. BARTLETT: Well, that's not entirely correct. To get a pad to slide, there'll have to be some place where the sliding plain comes up somewhat sub-horizontal so that you have some small component of sliding that's occurring at a different angle. But

the predominant failure mechanism would be sliding in the horizontal direction, and that's consistent with PFS' design philosophy.

MR. O'NEILL: But there would have to be -- the failure has to exit at the ground surface at some point, would it not?

DR. BARTLETT: Yes, it does.

MR. O'NEILL: Okay. And that would entail failure at some angle.

DR. BARTLETT: Yes. I guess if you could draw an idealized picture, you'd have some failure plain going like this, and then at some place it would have to go like this up to the surface.

CHAIRMAN FARRAR: You just waved your arms --

DR. BARTLETT: Excuse me.

CHAIRMAN FARRAR: -- horizontally, like an umpire giving a safe sign.

DR. BARTLETT: Yes. And then at some point there would have to be some part of the failure surface that would have to go somewhat sub-horizontal or approaching vertical to reach the ground surface.

MR. TURK: Could we maybe just put on the record that Dr. Bartlett was describing what you might consider to be a horizontal plain.

DR. BARTLETT: Right.

MR. TURK: With two -- I'm sorry, with a diagonal plain reaching up at either end towards the ground, so that we basically have something in the shape of a V with a flat bottom, a wide V with a flat bottom, perhaps?

DR. BARTLETT: Fair enough.

MR. O'NEILL: So you're not going to have purely horizontal shear failure in the soil underneath the --

DR. BARTLETT: No.

MR. O'NEILL: -- entire area of the pad.

DR. BARTLETT: The shear failure has to, if you will, daylight somewhere and appear at the surface. Does that help?

MR. TURK: Yes, it does.

DR. BARTLETT: In fact, Mr. O'Neill, if I may help, I think there are some diagrams in my testimony that talk about this, and that may be better than my arm waving.

MR. TURK: Where in your testimony?

DR. BARTLETT: I know the -- I'm looking at a diagram that shows potential failure modes underneath different foundation systems. Yes, that's it. Thank you. Figure 9 in Exhibit 103.

This isn't showing a pad. I don't see really a pad foundation here, but it gives you an idea of what potential shear failure planes develop, and their angles.

MR. O'NEILL: This is State's Exhibit 103?

DR. BARTLETT: 103, Figure 9.

MR. O'NEILL: Are you looking at a specific portion of that figure?

DR. BARTLETT: Well, I'm just -- in A, it shows a shear failure under an embankment. B, for a loaded wall. Now I see some things for piles. We don't really have a pad foundation here in this diagram, but I guess if you'd look somewhat the one for E, the spread foundation, you see a circle that shows a failure underneath the spread footing. The pads would look somewhat similar to that, though I would say that because the length of the pad dimension compared to a spread footing, that the direct simple shear or the horizontal portion would be considerably longer in this case than what's shown here in this figure. But it gives you an idea of these failure mechanisms.

The loaded wall is not too bad of an analogy. That may be a reasonable analogy, though the wall in this case is vertical, but it has a fairly

substantial horizontal part, and then goes subvertical.

MR. O'NEILL: So there's really --

DR. BARTLETT: There's really no direct analogy on this page, but it may help you conceptualize that we have a fairly horizontal failure plane, and then at some point it has to come to the surface.

MR. O'NEILL: Dr. Ofoegbu seems to think that Part E, the spread foundation, seems to be a fairly direct analogy. Would you agree with that assessment?

DR. BARTLETT: Well, the spread foundation looks reasonably similar to what I expect. The only issue I'd have with this particular case is that the main stress that's causing the failure in this case is a vertical stress. See that little arrow pointing down at the footing, and it says "COMP". That means that's a compressional stress that's causing this failure. In the case for the pads, it wouldn't be primarily a compressional stress. It would be a shear stress in the horizontal direction, but -- so the analogy is -- the size and what the failure plane would look like might be somewhat familiar, but just keep in mind that the directions which the stresses

that are causing the failure are different in the spread footing case, versus what would cause failure in the pads. Does that help?

MR. O'NEILL: Oh, yeah, that helps. But by virtue of the fact that failure is going to have to come to the surface at some point, you're going to get an incline.

DR. BARTLETT: In geological terms, it has to thrust upwards somewhere.

MR. O'NEILL: Yes. Thank you. Dr. Bartlett, would you agree that when PFS did its CPT work, it wasn't its direct intent to correlate the data obtained from the CPT test directly with the bore hole data, in terms of the correlation that you've been speaking of. Correct?

DR. BARTLETT: That's my understanding. The sampling for laboratory testing in the pad emplacement area particularly was done fairly early on in the program, before the CPT data were even available. My understanding is the CPT data were gathered to, as Mr. Trudeau explained, to gain more information about the layering and the strength and compressibility. And frankly, that data is invaluable. It really helps us understand this site, so I understand that the way the program progressed,

there was no intention of trying to pair a CPT with an adjacent bore hole. But it's just my recommendation, if we're going to develop correlations, that that proximity has to be fairly close to do correlations.

MR. O'NEILL: So that might explain why they didn't --

DR. BARTLETT: No, I'm not criticizing the fact -- I'm just pointing out that if we are to correlate, this isn't the best scenario one would like to see because of the way that the bore holes and the CPT soundings are relatively far apart.

MR. O'NEILL: Dr. Bartlett, do you agree that the layer identified by the CPT test as being the weakest layer for engineering purposes, is that layer 1B soil?

DR. BARTLETT: Yes.

MR. O'NEILL: You do agree with that?

DR. BARTLETT: Yes, the upper Bonneville clay.

MR. O'NEILL: Okay. Sorry for the delay here.

DR. BARTLETT: No problem.

MR. O'NEILL: I'm discussing some issues with my colleagues. With respect to spacings between the CPT and the bore holes, again if you were to

conduct the type of correlation that you've been discussing, you know, using actual lab samples, is that largely a matter of engineering judgment? There's no prescribed distances that you're aware of, are there?

DR. BARTLETT: No, but the further the distance you get, the more criticism one might receive because of lateral variability, so my experience at Savannah River, and also on the I-15 project, that these bore holes where CPT data and laboratory sampling were done, were five to no more than ten feet apart, and surveyed in so that we had excellent constraint, so that we could remove any uncertainty and argument about that.

MS. CHANCELLOR: Just point of clarification. When you said I-15, you mean Interstate 15 in Salt Lake City?

DR. BARTLETT: I-15 reconstruction project. That's correct.

MR. O'NEILL: But again, it would be largely a site-specific determination. It would depend on the site-specific properties. Right? I mean, are you suggesting -- I recognize that as you move further away, yes, you could potentially get more lateral variation. But are you saying that ten -- five to ten

feet away is vastly superior to say twenty feet away from the bore hole in all cases?

DR. BARTLETT: Yeah, you're again introducing the judgment part of it. It is a function of how laterally variable the soils are, but my position is, is that they, at least from the cone penetrometer data show variability and tip resistance by roughly a factor of 2, so one should be careful in going too far away.

MR. O'NEILL: And again, that's your professional judgment.

DR. BARTLETT: Yes.

MR. O'NEILL: Your Honor, I think that concludes Staff's cross. We would still request an opportunity to put on some brief additional rebuttal testimony.

CHAIRMAN FARRAR: All right. Let's first see if the State has any redirect.

MS. CHANCELLOR: No, Your Honor.

CHAIRMAN FARRAR: Okay. Company?

MR. TRAVIESO-DIAZ: Nothing here.

CHAIRMAN FARRAR: Okay. Then, Dr. Bartlett, thank you again for your testimony.

DR. BARTLETT: Thank you.

CHAIRMAN FARRAR: You're excused. Ms.

Chancellor, does the State have any more rebuttal testimony?

MS. CHANCELLOR: Not unless something comes up in Dr. Ofoegbu's testimony, we have nothing further, Your Honor.

CHAIRMAN FARRAR: All right. Then the Staff would --

MR. TURK: We may need a few more minutes to get it ready. We need to make a copy of a document. Also, may I ask if PFS intends to put any further rebuttal on?

MR. TRAVIESO-DIAZ: As of now, no.

CHAIRMAN FARRAR: Okay. And then -- and this is going to be something other than what Dr. Ofoegbu has said before. In other words, if he said it before, we don't need to hear it again.

MR. TURK: And we don't need to say it again. No, this would be something that came up in Dr. Bartlett's testimony. And we need to consult to be sure that we're going to proceed with him.

CHAIRMAN FARRAR: Okay.

MR. TURK: Could we, perhaps, have 10 to 15 minutes, just to be safe.

CHAIRMAN FARRAR: It's just after 11. Let's be back at 11:15.

(Off the record 11:01 - 11:19 a.m.)

CHAIRMAN FARRAR: Dr. Ofoegbu, you're -- consider yourself still under oath.

DR. OFOEGBU: Okay.

CHAIRMAN FARRAR: And let me mention at least two things, the law of diminishing returns, which we discussed a day or two ago. And two, the fact that what's at stake here is the Applicant's request for a license, and they're happy, so while we understand the role of the Staff in these proceedings, let's make sure it does not repeat anything, and that it, in fact, is necessary. With those guidelines, let's go ahead.

MR. TURK: Your Honor, our intent is, again, one of presenting evidence relevant to Dr. Bartlett's rebuttal in which, as you recall, he showed with his arms this V with a flat bottom, and then he pointed us to State Exhibit Number 103, with that curve in it that we discussed. We're going to be addressing just that one point. And our role in the proceeding, as we understand it, is not to advance the application of this project. Our role, rather, is to present evidence to you to understand properly the basis for the Staff's conclusions as to the adequacy of the Soils Characterization Program that's been

performed by the Applicant.

CHAIRMAN FARRAR: Okay. Fair enough. Mr. O'Neill, you.

MR. O'NEILL: Good morning, Dr. Ofoegbu.

DR. OFOEGBU: Good morning.

DIRECT EXAMINATION

MR. O'NEILL: You were present this morning for Dr. Bartlett's testimony. Correct?

DR. OFOEGBU: That's correct.

MR. O'NEILL: And you listened or heard his discussions of his concerns associated with possible anisotrophy effects in the soils at the PFS site?

DR. OFOEGBU: Yes, I heard it.

MR. O'NEILL: One of the things we discussed, was the orientation of the possible failure plane that could occur at the site. Correct?

DR. OFOEGBU: Well, as he also testified, the potential failure surface would have to daylight at the ground surface. And for that to happen, at least two portions of the failure surface will be inclined. Do you need to hand out --

MR. O'NEILL: Yeah, that was my next question. You prepared a diagram illustrating this point, and I'm going to have Mr. Turk distribute this

diagram. I'm going to have it marked for identification as Staff's Exhibit ZZ.

(Staff's Exhibit ZZ marked for identification.)

MR. O'NEILL: Dr. Ofoegbu, this diagram depicts three pads lying atop the ground surface. Correct? Surrounded by a soil cement layer?

DR. OFOEGBU: Yes.

MR. O'NEILL: And underlain by a cement-treated soil layer. Correct?

DR. OFOEGBU: Yes, that's correct.

MR. O'NEILL: And the underlain again by the -- what you have referred to as the natural soils. This would include the upper Bonneville clays at the site.

DR. OFOEGBU: Yes. In fact, it is Bonneville clay.

MR. O'NEILL: And the diagonal line in this particular diagram that's directly below the middle pad, that demonstrates, roughly speaking or crudely speaking, the orientation of a possible failure surface. Correct?

DR. OFOEGBU: Yes, that represents a potential failure surface, the way you would have to around the pad. This failure surface involves only one pad. It could also involve multiple pads. The

orientation would be the same.

MR. O'NEILL: I meant to refer to the dotted line directly below the middle pad. There's another diagram, as well.

DR. OFOEGBU: Yes. That diagram is an enlargement of the horizontal portion of that potential for failure surface, based also on Dr. Bartlett's testimony, which I believe is not in dispute, that the soil consists of ten layers of clay. The clay soil consists of ten layers.

MR. O'NEILL: Dr. Ofoegbu, okay.

MR. TURK: I'm sorry, Your Honor. I may have misunderstood. I thought that the question had to do with the diagonal line directly below the pad. That's the arrow. That's not the exiting of the force, as I understand it.

CHAIRMAN FARRAR: I understand that arrow is -- you've got a circle around the horizontal line, dotted line under the pad, and the arrow is just pointing to a blow-up of what's inside the circle. Is that correct?

DR. OFOEGBU: That is correct, yes.

CHAIRMAN FARRAR: Okay.

MR. TURK: So that the daylight that you referred to, that's the diagonal lines to either side

of the central pad.

DR. OFOEGBU: Yes, the daylight is the diagonal lines. Now in this --

MR. TURK: The path to daylight is represented by that diagonal line.

DR. OFOEGBU: That's correct. Okay. In the blow-up, I have two sets of lines. A set of horizontal lines that represent the layering, the micro layering, and then a thick line that cuts across going diagonally and occasionally following a boundary between layers, and occasionally following incline through a layer. That would represent, in general, a potential failure surface in that horizontal portion shown in the diagram.

MR. O'NEILL: Dr. Ofoegbu, could you explain the nature of the horizontal failure surface, what soil properties might contribute to that?

DR. OFOEGBU: Okay. Now if failure is occurring horizontally through a layer, then it's going to use the horizontal strength of that layer. If it is occurring diagonally, then it's going to use whatever diagonal strength is, and all of each of these strengths, for instance, the diagonal strength will be -- correspond more to the strength measured in a compression test. And the horizontal strength would

correspond more to the strength measured in a direct shear test. Now the reason a potential failure surface would zig-zag through is that natural failure surfaces would try to find the weakest link. And even the soils are treated as homogenous, but at this level, at this micro level, or somewhat above the micro level, they are actually heterogenous so that the soil is going to find the weakest link. And that would drive a potential for the failure surface to go from one layer to another in a real case. And to do that, it will have -- the resistance to failure then would, in some cases, be the horizontal strength on this side, and other cases, would be the inclined strength of the soil.

MR. O'NEILL: So you're saying that the shear strength of the soil is a function of -- or is a resistance of the soil to sliding in a horizontal direction a function then of different components of shear strength? I mean, horizontal --

DR. OFOEGBU: Yes.

MR. O'NEILL: Could you describe those specific components again?

DR. OFOEGBU: Well, the resistance to sliding then along a potential surface will be contributed in some portions of the surface by the

strength of the soil that could be measured in confined compression. In another portion, it will be represented by the strength of the soil measured in tri-axial extension. In a different portion, it will be represented by the strength of the soil measured in direct shear, but in -- on the average, over the entire failure surface then, the strength of soil measured -- the undrained shear strength of the soil measured from any of the -- using any of the available methods gives a representation of the strength of the soil along that failure surface.

Now the differences between the different stresses, I mean the different strengths, would become relevant if you are doing an analyses in which the portions of the failure surface were like a finite element analysis in which you model the -- what is happening in each section of the failure surface. Then those portions that are represented by tri-axial extension phenomenon would require strength from a tri-axial test. And those portions that are represented with a compression phenomenon would have to use strength from a compression test. The other portions from -- that are represented by direct shear phenomenon will have to use a direct shear test.

This is not the way foundations are

designed. Often foundations are designed based on an understanding of the failure surface bed, a relationship between strengths and loading that have been developed and documented in literature. And these use undrained shear strength measured from -- I mean, using cone penetrometer, or using confined compression or direct shear.

MR. O'NEILL: So in your view, such tests have been conducted by the Applicant for the soils at issue to properly assess the shear strength of the soils -- well, some of the -- you just mentioned a number of tests. Correct?

DR. OFOEGBU: Yes.

MR. O'NEILL: And which of those tests have been performed?

DR. OFOEGBU: Well, the Applicant performed compression tests, direct shear tests, and the in situ test using the cone penetrometer.

MR. O'NEILL: Well, in your view, the data obtained from these different tests would adequately account for the shear strength of these soils in the horizontal, vertical, or inclined directions?

DR. OFOEGBU: I believe that the shear strength determined by the Applicant will be suitable for analyzing failure of anisotrophy in this figure,

which I believe is the type of failure that might occur if the conditions for failure were satisfied at the facility.

MR. O'NEILL: Well, Dr. Ofoegbu, you understood me to be referring to the undrained shear strength. Correct?

DR. OFOEGBU: That is correct.

MR. O'NEILL: And do any of the concerns expressed by Dr. Bartlett concerning anisotrophies in the soil change your opinion?

DR. OFOEGBU: No, not at all. There are two reasons for that. First of all, there is evidence that the anisotrophy actually does not exist. But even if were to exist, it would not be of concern to me because of the explanation provided in this figure.

MR. O'NEILL: All right. Thank you. I think that's all I have. Your Honor, I'd like to offer Staff's Exhibit ZZ for admission into evidence at this time.

CHAIRMAN FARRAR: Any objection?

MR. TRAVIESO-DIAZ: No objection here.

MS. CHANCELLOR: Your Honor, could I ask Dr. Ofoegbu just a couple of questions?

Dr. Ofoegbu, did you prepare this document, Staff Exhibit ZZ?

DR. OFOEGBU: Yes, I prepared it.

MS. CHANCELLOR: That's fine. No objection, Your Honor.

CHAIRMAN FARRAR: All right. Then Staff ZZ will be admitted.

(Staff Exhibit ZZ admitted in evidence.)

CHAIRMAN FARRAR. Any examination by the Applicant?

MR. TRAVIESO-DIAZ: I have a couple of questions --

CHAIRMAN FARRAR: Okay.

MR. TRAVIESO-DIAZ: -- to make sure I understood what he said. Is it your testimony -- good morning. Dr. Ofoegbu. Pardon me.

DR. OFOEGBU: Yes.

MR. TRAVIESO-DIAZ: Is it your testimony, if I understand it, that even for a horizontal failure, such as a sliding failure that we're talking about here, the real behavior of the soil at the micro level is a blend, if you will, of the compressive shear resistance and the direct shear resistance of the soil?

DR. OFOEGBU: That is correct. The only amendment I'll make is when you say micro level. Really what we're talking about is the level that is

consistent with the thickness of those ten layers that Dr. Bartlett referred.

MR. TRAVIESO-DIAZ: Okay. With that correct, is my understanding --

DR. OFOEGBU: Yes.

MR. TRAVIESO-DIAZ: Okay. Now in that case, wouldn't the use of only a direct shear stress which has been testified by Dr. Bartlett is less than the compressive shear strengths, wouldn't that be one indication of the level of conservatism in the analysis?

DR. OFOEGBU: I agree that it would be.

MR. TRAVIESO-DIAZ: And that's one that has not been taken clearly by PFS?

DR. OFOEGBU: No, it hasn't been taken credit for by PFS. Though the PFS -- I did indicate that the difference between the direct shear, the strength from direct shear and strength from confined compression is really not significant.

MR. TRAVIESO-DIAZ: But to the extent there is some difference, that would be one more conservatism that exists, that has not been taken credit for. Is that right?

DR. OFOEGBU: To that extent yeah, that is correct.

MR. TRAVIESO-DIAZ: Thank you. That's all I have.

CHAIRMAN FARRAR: Thank you, sir. Ms. Chancellor.

MS. CHANCELLOR: Your Honor, could Dr. Bartlett ask Dr. Ofoegbu a few questions that would be very expedient, and he's prepared.

CHAIRMAN FARRAR: Certainly, and we'll make -- repeat the same findings we made under the regulation, but also if you'd counsel Dr. Bartlett that we are really running up against diminishing returns here.

DR. BARTLETT: Yes, Your Honor.

Dr. Ofoegbu, in your diagram that you drew for us, is it my understanding then, you're not precluding that the failure surface could go under two pads, not just one pad?

DR. OFOEGBU: No, that's not precluded. It could be under one pad. It could be two. It could be any number.

DR. BARTLETT: Regarding the issue of anisotrophy, have you read Utah Exhibit 104, attached to my testimony?

DR. OFOEGBU: Yes, I have. I've looked at the drawings, and I'm familiar with that concept.

Actually, that was originally used by C.C. Ladd.

MR. TURK: I'm sorry. Could -- I think there may be some confusion about which exhibit Dr. Bartlett is referring to. Could you point to him which exhibit?

DR. BARTLETT: 104.

MR. TURK: Do you have that with you?

DR. BARTLETT: I do.

MR. TURK: If you could give a copy to the witness, if you're going to inquire about it.

DR. BARTLETT: Sure.

MR. TURK: It's my understanding, Dr. Ofoegbu was referring to the drawings that we discussed previously.

DR. OFOEGBU: Yeah, that's what I was referring to.

MR. TURK: And that would be State Exhibit 103, not 104, which I believe Dr. Bartlett is inquiring about now.

DR. OFOEGBU: Yes, I've read this.

DR. BARTLETT: Would you please read the title of that report?

DR. OFOEGBU: Well, the title says -- when I say title, I mean title on the front page.

DR. BARTLETT: Yes.

DR. OFOEGBU: Because I'm not sure this is the title of the report, but it says, "Design on performance of the foundation stabilization treatments for the reconstruction of Interstate 15 in Salt Lake City, Utah."

DR. BARTLETT: And who are the primary authors of this document?

DR. OFOEGBU: Steven Saye and C.C. Ladd.

DR. BARTLETT: Do you recognize the second name?

DR. OFOEGBU: Yes. C.C. Ladd.

DR. BARTLETT: What is his area of expertise?

DR. OFOEGBU: Geotechnical engineering.

DR. BARTLETT: Could you please turn to Section 6. And near the bottom of this page, it discusses shear. Can you see the place where it says, "Shear in PSC, shear in DSS, and shear in PSE"?

DR. OFOEGBU: Yes.

DR. BARTLETT: Could you explain what PSC, DSS and PSE means?

MR. TURK: I would object.

DR. OFOEGBU: Maybe you can explain --

MR. TURK: Your Honor, I would object to --

DR. BARTLETT: I'll help the witness.

CHAIRMAN FARRAR: Wait, wait. Object on what basis?

MR. TURK: The article provides the acronyms, as well as explanation of the acronym. I don't understand why we're asking the witness --

CHAIRMAN FARRAR: This is cross examination of your witness. He can ask him anything he wants.

DR. BARTLETT: Dr. Ofoegbu, those are defined, just to help you out. I don't want to mean -- to have this be a guessing game. If you look in the paragraph that's just above those coefficients that you see, it's defined in the first sentence there.

DR. OFOEGBU: Yes. Can I request something also? Can you give me a copy of your Exhibit 103, because those are related.

DR. BARTLETT: Sure.

DR. OFOEGBU: This is an application of that concept.

DR. BARTLETT: Is it your understanding looking at these abbreviations, PDS, DSS and PSE, that they represent the same conditions that you referred to in Exhibit 103?

DR. OFOEGBU: Well, they do, except that

PSE compression. Let us say that approximately that is -- that can be PSE compression.

DR. BARTLETT: If you would look in the second line of the paragraph - excuse me - the second sentence, it explains the type of test that was derived to get that compression test.

DR. OFOEGBU: Where?

DR. BARTLETT: Beginning with the, "C K not U tri-axial compression". Do you see that?

DR. OFOEGBU: May I ask --

DR. BARTLETT: It's in the second line of that Exhibit 104, excuse me.

MR. TURK: You're looking at the paragraph directly above those three --

DR. BARTLETT: Coefficients, yes. And it's --

MR. TURK: Okay.

DR. BARTLETT: Yeah, it's in the second line, beginning of the second sentence.

DR. OFOEGBU: Okay.

MR. TRAVIESO-DIAZ: I'm still -- Dr. Bartlett, could you give me the first word on the line?

DR. BARTLETT: It's the sentence beginning with, "These values were derived from."

DR. OFOEGBU: Yes, I see that.

DR. BARTLETT: Is it your understanding that they were derived from consolidated, anisotrophically consolidated undrained tri-axial compression tests?

DR. OFOEGBU: Well, yeah, that is correct, but it does depend on the value of K not, and I'm hoping it's not one.

DR. BARTLETT: Fair enough. And also, the DSS is direct simple shear. Is tat your understanding?

DR. OFOEGBU: That's what the document says, yes.

DR. BARTLETT: So these coefficients that we see on page 11, are they reflective of the coefficients that should be applied for shear strength for these different modes of failure?

DR. OFOEGBU: For this particular soil, yes.

DR. BARTLETT: And is it your understanding that this particular soil is the upper Bonneville clay?

DR. OFOEGBU: Well, the upper Bonneville clay at the location that he sampled. That's correct.

DR. BARTLETT: Fair enough. Is it your

understanding also that in the shear - excuse me - in the pad sliding analysis that PFS has performed, the resistance, shear resistance used for determining the sliding -- the shear test - excuse me - used to provide the sliding resistance was the direct shear test?

DR. OFOEGBU: Well, before I answer that question, let me go back to the previous one, and take it to State's Exhibit 103. The DSS would apply to the conditions near the center of the curve. Let's look at Case E, the curve under the shallow foundation. So the DSS applies to the condition in the horizontal portion of that curve. The portion marked DC would be approximately the same as the DSE type of test. That is the tri-axial compression condition. And then the portion marked DE would be tri-axial extension condition. If you apply this to my sketch, that is Staff Exhibit ZZ, now just looking at the horizontal portion of the failure surface, then each time there is a downward incline, then that is the tri-axial compression type property. Each time there is a horizontal portion, that would be the direct shear type property, and each time there is an upward incline, that would be the tri-axial extension type property, which goes to make my point, as a matter of

fact, that in a composite failure surface, there are contributions from each of these. And that's what State's Exhibit 103 shows.

DR. BARTLETT: Fair enough. In the analysis that PFS has performed for the sliding stability of the pads, do you recall which particular test they used to develop the sliding resistance?

DR. OFOEGBU: Okay. Recall that PFS obtained undrained shear strength from several tests. The test -- the direct shear test they performed was only one of those tests, and what it showed is that there were -- they have strength that is lower than the strength -- slightly lower than the strength measured in unconfined -- in confined compression, and that it is a strength measured from the weakest part of the soil profile, based on their CPT test data. And this is their justification for using the direct shear test results as a lower bound estimate on the strength. And this is the reason that the analysis staff accepted the analysis.

DR. BARTLETT: So your testimony is it was the lower bound strength of the direct shear test that was used for design?

DR. OFOEGBU: In the sliding analysis, that's correct.

DR. BARTLETT: Thank you.

MS. CHANCELLOR: We have no further questions, Your Honor. Could I retrieve my exhibits?

CHAIRMAN FARRAR: Yes.

MS. CHANCELLOR: Thank you.

MR. TRAVIESO-DIAZ: Excuse me, counselor.

MS. CHANCELLOR: Yes.

MR. TRAVIESO-DIAZ: I'm going to have a question or two on that exhibit.

MS. CHANCELLOR: Oh, okay.

CHAIRMAN FARRAR: The Board has no questions. Any Staff redirect?

MR. O'NEILL: No, Your Honor.

MR. TURK: No, Your Honor.

MR. TRAVIESO-DIAZ: I have two questions.

CHAIRMAN FARRAR: Go ahead.

RECROSS EXAMINATION

MR. TRAVIESO-DIAZ: Would you please turn your attention to the first page of Exhibit 104, the paper they were talking about?

DR. OFOEGBU: This one?

MR. TRAVIESO-DIAZ: Yes.

DR. OFOEGBU: Okay.

MR. TRAVIESO-DIAZ: Looking at the abstract discussed there, doesn't that actually

indicate that the soils that were used for these tests were soils taken from the reconstruction project of I-15, Salt Lake City, Utah, that Dr. Bartlett talked about a minute ago?

DR. OFOEGBU: It will help if you can direct us to where he said that.

MR. TRAVIESO-DIAZ: Second line of the abstract, first page abstract, second line.

DR. OFOEGBU: Okay. Yes, that's what it says.

MR. TRAVIESO-DIAZ: Are you aware that the soils were -- the Lake Bonneville soils that exist in the I-15 area are more saturated and softer than the soils at this site?

DR. OFOEGBU: Yeah, I heard that in the testimony, but I'm not personally aware of it.

MR. TRAVIESO-DIAZ: Assuming this were true, would there be any relevance or learning that you could learn from the PFS site from the tests performed on I-15?

DR. OFOEGBU: Not directly, but I have to point out that when you do undrained tests on saturated soils, the result you get will give you somewhat lower strength than if you did some undrained test on unsaturated soil

MR. TRAVIESO-DIAZ: So when you -- I think that's all I have.

DR. OFOEGBU: Okay.

MS. CHANCELLOR: No further questions, Your Honor.

CHAIRMAN FARRAR: Okay. Thank you, Dr. Ofoegbu. That then concludes at 11:50 a.m., the -- all of Section C. Am I correct?

MR. TRAVIESO-DIAZ: As far as we're concerned, yes.

CHAIRMAN FARRAR: All right. So there's nothing left on D, and nothing left on C.

MR. TRAVIESO-DIAZ: Again, that's correct.

MR. TURK: As far as we're concerned, yes, Your Honor.

CHAIRMAN FARRAR: Okay. Ms. Chancellor, that's correct, C and D are done?

MS. CHANCELLOR: C and D are done, Your Honor, and --

CHAIRMAN FARRAR: Then we'll take up the consequences issue under E, the seismic exemption on Monday.

MS. CHANCELLOR: Right. And I just got a note from Ms. Curran saying that today we're filing some corrections to Dr. Resnikoff's testimony that

will be presented as part of that radiation dose testimony.

CHAIRMAN FARRAR: All right.

MR. TURK: I have some preliminary procedural things to mention, Your Honor.

CHAIRMAN FARRAR: Okay.

MR. TURK: Number one, I may have erred in my numbering of Staff Exhibits. We -- this week we introduced Staff Exhibits XX, YY, and ZZ. I can't find that I ever introduced a WW, so I may have omitted an exhibit number.

CHAIRMAN FARRAR: All right.

MR. TURK: I'll check that over the weekend. If so, then I think we just should be aware that that exhibit number has not been used.

CHAIRMAN FARRAR: All right.

MS. CHANCELLOR: WW?

MR. TURK: Yes.

MS. CHANCELLOR: We were looking everywhere for it. Thank you.

MR. TURK: I think I spent more time looking for it than you after I realized --

CHAIRMAN FARRAR: Well, you check your records. We'll check our's, and we'll compare notes on Monday.

MR. TURK: Okay. Also, the Staff has some minor corrections to Mr. Waters' testimony on radiological doses. I have two copies with me. I'll give a copy to Ms. Chancellor and Mr. Gaukler now.

CHAIRMAN FARRAR: Is that on our e-mail?

MR. TURK: I can e-mail it to you when I go back to the office.

CHAIRMAN FARRAR: Okay.

MS. CHANCELLOR: What did you say, Sherwin?

MR. TURK: Corrected testimony for Mr. Waters.

MS. CHANCELLOR: Thank you.

CHAIRMAN FARRAR: All right. Then we will see everyone at 10:00 on Monday morning. And each of the -- no unfinished business today. Everyone is excused, except those who will be attending the presentation on the electronic information exchange, for which we're pleased to have the gentleman who knows more about it than other people here to make a presentation.

JUDGE LAM: Is it reward or punishment?

CHAIRMAN FARRAR: Thank you all. Enjoy the weekend.

(Off the record 11:51:02 a.m.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Private Fuel Storage, LLC

Docket Number: Docket No. 72-22-ISFSI

ASLBP No. 97-732-02-ISFSI

Location: Rockville, Maryland

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

/s/ John Mongoven

John Mongoven
Official Reporter
Neal R. Gross & Co., Inc.