STATE OF NEW MEXICO
ENERGY, MINERAL AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION COMMISSION

ORIGINAL

APPLICATION OF THE NEW MEXICO OIL AND GAS ASSOCIATION FOR AMENDMENT OF CERTAIN PROVISIONS OF TITLE 19, CHAPTER 15 OF THE NEW MEXICO ADMINISTRATIVE CODE CONCERNING PITS, CLOSED-LOOP SYSTEMS, BELOW GRADE TANKS AND SUMPS AND OTHER ALTERNATIVE METHODS RELATED TO THE FORE GOING MATTERS, STATE-WIDE.

CASE NO. 14784 AND 14785

VOLUME 5

May 18, 2012
9:00 a.m.
Wendell Chino Building
1220 South St. Francis Drive
Porter Hall, Room 102
Santa Fe, New Mexico

THE COMMISSION:

JAMI BAILEY, Chairperson

GREG BLOOM, Commissioner

DR. ROBERT BALCH, Commissioner

MARK SMITH, Esq.

FLORENE DAVIDSON, COMMISSION CLERK

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EXHIBITS

PAGE ADMITTED

OGAP EXHIBITS:

NEEPER EXHIBITS:

(Note: In session at 9:00.)

CHAIRPERSON BAILEY: Good morning. this is a continuation of the Consolidated Cases 14784 and 14785 before the Oil Conservation Commission. Today is Friday, May 18th and we are in Porter Hall in Santa Fe, New Mexico. All three commissioners are here present so we do have a quorum today.

I believe last evening we had Ms. Foster completing cross-examination of Ms. Denomy, and we are about to begin cross-examination by Ms. Gerholt.

MS. GERHOLT: I have no questions for the witness, Madam Chair.

CHAIRPERSON BAILEY: Mr. Dangler?

MR. DANGLER: No questions.

CHAIRPERSON BAILEY: Dr. Neeper?

MR. NEEPER: No questions.

CHAIRPERSON BAILEY: Do you have any redirect for the -- we do have commissioners.

MARY ELLEN DENOMY

after having been previously sworn under oath, was questioned and testified as follows:

EXAMINATION BY THE COMMISSION

COMMISSIONER BALCH: Good morning, Ms. Denomy. I wanted to make a statement that I appreciate the effort it has taken you in your life to become an expert in these areas. That's a difficult task and I think multi-disciplinary decision-making is very important.

THE WITNESS: Thank you, sir.

COMMISSIONER BALCH: I have some questions on your side. Slide two from New Mexico Tech. I'm guessing you mean from the Go-Tech website?

THE WITNESS: Yes.

DR. BALCH: The reason I differentiate is New Mexico tech is a university and they cover a broad range of disciplines. They have a number of research divisions on campus there, one of which is the Petroleum Recovery Research Center, and I happen to work there along with my friend Martha Gather who has the website. That's a state-funded agency housed on the New Mexico Tech campus, so they are the same but they're also a little bit distinct.

THE WITNESS: Yes. And Go-Tech has a much more extensive in-depth presentation of the statistics for the state of New Mexico.

COMMISSIONER BALCH: Right. So I will let my neighbor down the hall know that I met someone responsible for some of the three million hits a year. That's my sales pitch for Go-Tech.

THE WITNESS: Thank you. It's much better than most of the other statistical available websites from the other states, so it's great.

COMMISSIONER BALCH: I will also note that none of the lawyers tried to strike the slide so it must be good data. On Slide 8, and this applies for Slide 9 as well.

THE WITNESS: Is that oil prices?

COMMISSIONER BALCH: This is New Mexico wells spudded and New Mexico permits are 8 and 9. Looks like you did your statistics based on a year-to-year change.

THE WITNESS: Yes.

COMMISSIONER BALCH: Was the intent for these slides to demonstrate a difference between pre-Rule 17 and post-Rule 17?

THE WITNESS: It was intended to show what reality was, which is -- it could have something to do with the Pit Rule or it could have something to do with actual economics in the oil and gas industry as whole. So it is strictly looking at numbers to say what happened in the year 2009 across the board with national, Colorado and New Mexico.

COMMISSIONER BALCH: I did some basic math calculations last night. I'm not afraid of math. I'm not a lawyer, I guess. I also an adjunct professor of petroleum engineering, earth and environmental science and computer science so numbers don't scare me.

Just out of curiosity, I wanted to see what the overall percent drop was from 2007 to 2011 and I came up with about 43 percent overall. Is there a similar number for that nation-wide?

THE WITNESS: I need to go back to the first slide. There would be nationally from 2007 to 2010, so the drop is not as significant.

COMMISSIONER BALCH: Actually it would be the 1695 minus 1514 divided by 1695, but you are doing this year by year?

THE WITNESS: Those are year by year but if you are doing the kind of statistics that I think you were looking at, you took New Mexico in 2007, subtracted where we were in 2011 and then took the difference between those two. So if you do the same kind of concept for the national rig count, 1695 minus 1514 is 181 rigs less in 2010 divided by the base year of 2007 or about 11 percent reduction total.

COMMISSIONER BALCH: I'm sorry, this is rig count.

THE WITNESS: Oh, okay. You're talking

about spudded wells.

COMMISSIONER BALCH: Yes.

THE WITNESS: I'm sorry, I have not looked at a national spudded well situation. That's looking at -- I did not look at that large of a sample.

COMMISSIONER BALCH: This actually brings up another thing that got my thinking, but it was rig count. People use it as an indicator of activity.

THE WITNESS: Uh-huh.

COMMISSIONER BALCH: But I was looking at your Slide 10, which is historic stats on rigs, and I notice in New Mexico in 2007 there were 83 rigs.

THE WITNESS: Yes.

COMMISSIONER BALCH: Those 83 rigs drilled -- let's see -- 1728 wells so about 21 wells per rig. Each rig was on a well pad probably a couple weeks at a time.

THE WITNESS: Yes.

COMMISSIONER BALCH: In 2011 from your historic stats here there were 81 rigs in New Mexico, so the rig count has gotten back to the same level, but I noticed that there were 990 wells drilled.

THE WITNESS: That's interesting.

COMMISSIONER BALCH: So about 12 wells per rig so almost double the time on-site or -- and you can maybe correct me, but there's probably changes in what's happening with the rig. Maybe in 2007 there were a lot of shallow coal wells being drilled.

THE WITNESS: That very well may be.

COMMISSIONER BALCH: Maybe in 2011 there's a lot of horizontals being drilled.

THE WITNESS: My indication would seem to think because the prices for natural gas had dropped significantly from '7 through '11, there was more focus on drilling for oil wells which are a little deeper than some of the Fruitland coal.

COMMISSIONER BALCH: I think there was also an assertion yesterday by the public statement from West Largo Corp.

THE WITNESS: West Largo, yes.

COMMISSIONER BALCH: That his rigging took longer because of a closed-loop system. Might that be a contributing factor?

THE WITNESS: That is a possibility, but I haven't found that to be a significant reason across the board. There are wells being drilled in seven days in many areas that are using closed-loop system and not --

COMMISSIONER BALCH: So it really depends on the depth of the well.

THE WITNESS: It depends on the depth of the well and it depends on other extenuating circumstances. Have we got a problem? Is there fishing that needs to be done? There's a number of things that could cause it to take longer.

COMMISSIONER BALCH: Anyway, my take-away from that is that maybe rig count is not a great indicator of activity.

THE WITNESS: That's --

COMMISSIONER BALCH: If you disconnect it from what's being done with the rigs.

THE WITNESS: That's correct. It depends on what they are doing.

COMMISSIONER BALCH: Of course, I complimented you on your multi-disciplinary experience and then I highlighted my own, so now you know why. One thing that I have not really had a chance to explore is the economic side of drilling decisions, and that's something that you have some expertise in. So I am hoping I can get a little bit of learning from you in regards to that. I have talked to people in the industry that I know, and I've done 15 years of research at a research division at a college that's dedicated to improving recovery in New Mexico, so I have had plenty of opportunities to meet producers, talk to engineers, geologists things like that. Not so much for accountants.

When I do talk to these guys in Roswell or up in Farmington and I ask them how they decide whether a well is economical, they use terms like portfolio, risk management, which I take to mean that they have to manage the risk associated with any particular project balanced with their overall portfolio assets and possibilities of business that they could do.

So one of the things they have to worry about when they're drilling a well is that it may not produce anything.

THE WITNESS: That's correct.

COMMISSIONER BALCH: It could be a dry hope or they could have bad completion and the pit produce less than they expect. Things like that. They factor that into -- does that work for portfolio risk management?

THE WITNESS: Yes. They look at where do

they have the right to drill across the nation. They will look at okay, we have infrastructure available in the areas that we have leases that we have signed. Then they will look at, well, what does it cost -- the kind of thing that I was talking about where you need to look at future revenue from a particular well site and then you compare it to different places in the United States and then you look at what is our risk in this area? Are we wild catting? Are we the first person to drill in this area? We have got a lease somewhere in -- maybe the marathon when they did their first well in the Bakken said, "This is a risky situation. We are in a position where we have some extra money because gas prices were high. We are going to take that risk. We are going to wild cat, but it's a high risk because nobody has done it."

So they have taken one step to do it. All the sudden that risk portfolio to drilling in a particular area, once it's been established, the wild cat has been drilled, a second and a third, then geologists in smaller independent companies that don't have as much cash to spend on capital will start looking on areas they can start focusing in on, and say, "Okay, we think maybe around this edge there may still be some possible production and nobody has leased these ranchers in this area or these acres in this area and let's take a chance."

So there is risk assessment done on what has happened prior, how much money do we have and how much money do we expect to make out of a location.

So I will tell you that the smaller independents don't have as much leeway on doing that. They may have a portfolio of 100 leases that they get to choose from and they don't have the luxury of saying, "Okay, we are going to choose whether we drill in Pennsylvania or Virginia or Texas or New Mexico." Usually the smaller guys get what's left over so they have to make the choices among what they have available to them.

COMMISSIONER BALCH: I think if we go to Slide 11, they will do this kind of analysis to determine if it's going to be successful.

THE WITNESS: They start with do we do this well? Is this a well that we are going to do? Then to find out if it's successful, like I mentioned yesterday, you need to do a number of other steps. How much of it is going to be ours? We expect maybe the well to make 4.2 million but we have, like I said yesterday, burdens, which means we have other parties that either are net profits interest or royalty owners that have their leases so we have to subtract their share.

Then we have taxes to look at. You know, those are the kinds of things they look at for that number and then they look at this money is being earned over a long period of time. So 4.2 million dollars today is not worth what it is earning it over a 30-year period.

COMMISSIONER BALCH: That's what I looked at a little bit. Because the number that's been given to me is three to one or four to one expense. So this well might not be drilled by somebody in Roswell that's operating a small company. If you looked at the annual rate of return over 30 years, and I'm not an economics person, not an accountant, but I do have a 403 B that I put money in so I like to look at compound interest, and it comes to about 3.6 percent.

THE WITNESS: Yeah, I got 3.6 also.

COMMISSIONER BALCH: And then if you use 20 years it's around 4.6. If you triple the cost of the well and add to that, basically giving you three to one profit margin, that would be around 5 point -- I came up with 4.7. No, 5.6 percent, which is maybe not too bad. Of course, you are talking about today's dollars.

But I think also these investments in the oil wells compete with other investments. Because if you can take your money, your two million dollars, and put it into a mutual fund and make 8 percent on average for 30 years, you are ahead of making 5.6 percent on an oil well. And there's not as much risk.

THE WITNESS: Right. There are a number of other things that are looked at by the operators and that is, you know, there is a market out there for hedging, you know, looking at futures prices and trying to make money in the stock market with their oil and gas. There's also -- for the most part, most oil and gas producers and people that are involved in the business are always hoping for a brighter day, you know. They are always anticipating that that $3 will be 10. So we are looking at the worst case scenario. What is it worth today? It's only worth $3 in MCF but we think in 2020 these wells will actually be making $8.

COMMISSIONER BALCH: If you are saying what you think I have to agree. I am astounded by the risks people are willing to take.

THE WITNESS: It is a risk-based business. Because you can drill a hole and get nothing or you can drill a hole and become Jed Clampett.

COMMISSIONER BALCH: Sure. I wanted to make sure my understanding of the economics was correct. So certainly there's a lot of things that go into these decisions about whether or not a well is going to be economical. If you get to that fine line where it becomes uneconomical or economical, I think that's where additional costs can become an issue at some level.

THE WITNESS: They certainly can.

COMMISSIONER BALCH: And whether it's $1 more or $100,000 more, as a math person you are either 49.9 or you're 50.1, so it could effect yes or no decisions. The reason I bring this up is important and certainly addresses my point, is that one of the things we are tasked with doing is preventing waste, and the way that I have been told to interpret waste is if you don't produce the resource it's wasted. If it's left there it's wasted.

I know that it may sound like a different way to look at it, but that's the way this commission was designed. One of the things we are supposed to look at is waste in that sense.

THE WITNESS: I would say looking at it from my perspective, money-wise, I would much rather produce gas at $10 an MCF and leave it in the ground than to take it out at $3 and put it in storage and pay the cost of storing it until it does reach $10. So to me -- because it's a non-renewable asset, you know. If that gas is sold at $3, we never get it back to sell it at $5. So there are a number of storage facilities that are used where gas -- you know, you can look to see at the Energy Information Administration how much gas is in storage because most companies don't want to sell at $3. They take it and they would rather pay the storage costs and leave it in the ground.

I mean, your perspective is they haven't wasted it because they have taken it out of the ground but they have actually moved it to another location and put it back in the ground. From an economics standpoint, gas sold at $8 is a lot more beneficial than selling it at $3 and there's an awful lot of industry decisions that are being made today. We are not drilling for natural gas because we cannot make money anywhere at $3 or $2.52 in this region because we still have to transport. Because we don't have enough customers.

You know, all the big customers are in California, Texas and in the Northeast. So that $3, after we pay all of our expenses, we don't make any money. So is it waste leaving it in the ground or is it waste taking it out of the ground and putting it in storage until the price goes up? I mean, you have your definition of waste but us accountants would say don't you dare sell that gas at $2.52.

COMMISSIONER BALCH: If you can bank it.

THE WITNESS: Yeah.

COMMISSIONER BALCH: And right now storage nation-wide is pretty much full.

THE WITNESS: It's full. Leave it in the ground. Years ago it was the practice to actually shut down the wells when there wasn't -- I mean, you would have a well drilled and actually turn it off. With technology over the years the engineers have discovered the on and off have ruined the pressures so they keep it flowing but reduce the flow just to make sure that they are not selling gas at such a low price.

COMMISSIONER BALCH: You could have extended delivery contracts and things like that.

THE WITNESS: They have to cover their contracts.

COMMISSIONER BALCH: I'm not going to beat that slide anymore.

THE WITNESS: That's okay.

COMMISSIONER BALCH: Slide 19, which I have as your cost of cleanup of earthen pit slide. I wanted a clarification. The cost would be diverted ted to citizens and government of New Mexico. Is that assuming that all pits are going to eventually have to be cleaned up?

THE WITNESS: It is assuming that if we have a problem with a pit that somebody will have to pay that cost. Now, most states have a bonding that's done to help with that cleanup when a company stops doing business, you know. If our prices stay this low there will be more and more companies that either merge or just not maintain their business. So something is going to have to be done to clean up the pits.

I was chewing on that this morning. We have to come up with something to deal with this. I mean, moving it -- the waste, moving it from one place to the other, moving it to an ejection well, and that was one of the things that was asked of me yesterday was what do they do with the cuttings, and I remember that they are doing some innovative stuff in Colorado where they are actually putting the cuttings down beneath the lower total depth of the gas. They are reinjecting it back into the gas wells, putting a plug, in putting the cement and leaving it there. They are also asking for ejection wells nearby and putting the cuttings into those.

COMMISSIONER BALCH: So they are saving the cuttings and when they go to plug the well --

THE WITNESS: Yeah, they save the cuttings and when they go to finish with the last cementing they put it down underneath it, which some folks are not real excited about because what if they need to go back and do a lower formation?

COMMISSIONER BALCH: Right. There are wells in southeast New Mexico that have been continuously operating since 1927.

THE WITNESS: They may have a deeper formation that hasn't been developed or some other mineral other than oil and gas.

COMMISSIONER BALCH: You would have to store the materials somewhere on-site.

THE WITNESS: Yes, they store them on-site and then they put them down beneath the closing of the well. You have to do something with the waste. We are moving it to the land farms, moving it to central pits, but we have to do something with it. It just gets moved from place to place.

But, you know, what I am saying here is that this particular situation that I'm talking about was one of the centralized pits that -- actually, it was one of what you would call the equivalent of the fluid management pits that did like 24 wells off of one pad and it was in that pit. They used a pit there for the 24 wells.

When the Commission came up and did their inspection, they realized the contaminants that were there needed to be taken care of and the soils around it also needed to be taken care of. It just wasn't done to standards. So the company had to pay to get -- you know, because we sit here and sometimes our guys that are out in the field don't always do exactly what we ask them to do and sometimes those things happen. So this company, fortunately, stepped up and paid the cost. But if they were a small company that didn't have the extra $100,000 to clean up the pit after it was dried out, it might not have been -- it might have had to fall to the state of Colorado to take care of it.

COMMISSIONER BALCH: I assume there's a bonding.

THE WITNESS: Yeah, there's bonding, but there's a $100,000 bond for the entire state for all of the drilling so it doesn't go too far. There is an emergency clean-up fund that comes out of the conservation levy in the state of Colorado and that would come out of there, but that is also a limited resource also. It's a tax that goes on to oil and gas, which would mean that some other company would end up paying because it's a tax -- either the mineral owners or the oil and gas companies that are still surviving would end up paying those costs.

COMMISSIONER BALCH: Thank you for that clarification. Those are my questions.

CHAIRPERSON BAILEY: Mr. Bloom?

COMMISSIONER BLOOM: Good morning, Ms. Denomy.

THE WITNESS: Good morning.

COMMISSIONER BLOOM: If you would go back to Slide 15, please, on comparison costs. I wanted to check something there. I had some questions about the spudding so I wanted to talk about a few things here. On the central pits, I think Ms. Foster asked you about those. The cost at

$46,500, so essentially if there's a pit that is servicing, say, ten wells and it was a $460,000 well, they would just divide it by the ten wells and push the cost out --

THE WITNESS: Exactly.

COMMISSIONER BLOOM: Okay. Everybody pays their share there. Okay. Have you been involved in any projects involving central pits?

THE WITNESS: Projects in what way? The actual building?

COMMISSIONER BLOOM: Costing them out, looking at the economics.

THE WITNESS: No.

COMMISSIONER BLOOM: I think you mentioned that you are on maybe your county's oil and gas committee?

THE WITNESS: My local community's oil and gas committee. We are small potatoes. I live in Parachute, Colorado. It's small. It's not a significant committee.

COMMISSIONER BLOOM: Is it community-appointed?

THE WITNESS: Yes, it is community-appointed. I actually live in an unincorporated town that has a quasi-government kind of thing that's run by the developer that developed that area, so you get appointed to that committee.

COMMISSIONER BLOOM: Through that committee have you looked at central pits?

THE WITNESS: Actually, we have. The community that I live in, we have -- we are one of the few communities that are not one of the large cities that the oil and gas industry has pinpointed actual locations within our PUD or our planned unit development within our community. So as part of that process, according to the state of Colorado they need to do a community development plan, the company needs to do a community development plan. So as part of that development plan we have done an extensive amount of walking the ground where a centralized pit would go. Because being in such close proximity to homes, within 500 feet of a home, the fluids need to be taken to a different location other than next to the homes.

So we have looked -- the committee has looked at where the pit may be and what kind of special requirements that will be required of that pit, because it will still be within the community, and downwind of a few folks.

COMMISSIONER BLOOM: Remind me what sort

of fluids are in the central pits.

THE WITNESS: It is all drilling -- it will be taking produced water, it will be taking drilling muds, it will be taking the cuttings, it will be taking anything that is liquid that comes out of the drilling.

COMMISSIONER BLOOM: The one in your community, would it go within -- it would be up to 500 feet from a home?

THE WITNESS: We are trying to keep it a little further than that, but the company has put forth an interesting idea. They are using an idea from a chicken farm about keeping the pit covered. They haven't tested it yet, so I'm not sure if that's going to work. To keep it covered to keep the odors that do permeate from the chemicals and the hydrocarbons that do go into the pit from causing some heartache with the seniors that live in the community where the pit is going to be located.

COMMISSIONER BLOOM: What would the volume of the -- how much water would be in the pit, do you know?

THE WITNESS: You know, I can't tell you, but they are planning on using -- like I said yesterday, it takes about a million gallons for a well to drill, between drilling and completion, so they do about -- this company does a small number, probably financing situations, but they do about eight at a time, so probably, you know, half of that would end up in it, you know, four million gallons.

COMMISSIONER BLOOM: Four million -- about ten acre feet?

THE WITNESS: Yes.

COMMISSIONER BLOOM: Have you visited other central pits?

THE WITNESS: Yes.

COMMISSIONER BLOOM: Is odor an issue?

THE WITNESS: Yes.

COMMISSIONER BLOOM: At what distance?

THE WITNESS: Well, are you familiar with I-70 corridor in Colorado? It runs from Grand Junction -- well, it runs from Utah to Kansas. It's the only highway that goes across. From that highway, probably about two miles back there's a centralized pit and from the highway you can smell the odors that come from the centralized pit.

COMMISSIONER BLOOM: How far away did you say it was?

THE WITNESS: I believe about two miles. It's not even visible from the highway but the odor is there. So if you drive past it, you can smell it.

COMMISSIONER BLOOM: Were you here for Mr. Lane's testimony when he spoke about multi-well fluid management pits?

THE WITNESS: I apologize. I wasn't there. I had another meeting in Colorado.

COMMISSIONER BLOOM: One of the things that he pointed out was that there were facilities there to clean water that would come back from the wells, as I understood it. Would something like that be on the pit that would be near you?

THE WITNESS: It is not. They aerate to get rid of the water so that the remaining solids, either the oil that's left gets extracted. That one does not have --

COMMISSIONER BLOOM: Okay. Is there a size limit to central pits in Colorado, do you know?

THE WITNESS: You know, I can't tell you exactly if there is, but I know if there is a necessity they could probably could ask for a waiver, and if they showed the need, it would probably be accepted.

COMMISSIONER BLOOM: I think you mentioned in your testimony that generally a central pit will service a few dozen wells?

THE WITNESS: Well, you know, there are two -- the central pit that I'm talking about is like the waste management pit. It's the pit where everything goes from all the wells in a certain location. The kind of FMP that Mr. Arthur put up with four wells being put in one pit is just a normal lined pit that goes alongside the regular producing -- the drilling wells.

And like I said, they could have -- in our community we probably will have eight wells drilled at one time so it will service eight wells out of that one pit. But there are -- my community, we had a well site that was drilled right across the street from our town police. You drive right past it. And they drilled, I think, 24 wells. So that pit serviced 24 drilling wells right at that location.

So those, I think, are more along the lines as opposed to a waste pit that I was talking about that you could smell from two miles away. Every well site now is usually, in the state of Colorado, a multi-well. I mean, to do some environmental protections and to make the pad sites not a five-acre here, five-acre here, they become, you know, one for 20, and it's a little bit larger but it doesn't come to the 15 acres so they will use one site for 20.

Actually, now they are using one for 64 so they can actually do a whole section from one pad site. It's very large but it's not as large as one, one, one, 64 different pads. Did I answer your question?

COMMISSIONER BLOOM: Yes, you did. Thank you. And just finishing up, do you know if there's a lifespan or age limit to the central pits?

THE WITNESS: Well, I think I mentioned yesterday the one that was there has been there for 12 years. I don't think there is a limit that is set by the State on the length of those pits. I do know of one that is just west of me that the company has asked to close it in. They are done using it, done drilling in that area. They found another source to take the produced water and they just -- they are closing it up. So they made the request to say we are closing this one. I don't think there's a maximum time.

COMMISSIONER BLOOM: Can you speak to liners and alarm systems?

THE WITNESS: You know, I don't -- I don't remember if there is a liner in the central pit. I do know that all of our pits in the state of Colorado are required to have liners and they are required to be removed and taken to the landfills, which has caused a major heartache with our landfills because they don't know what to do with all those liners. Again, they don't know what to do with all the waste.

COMMISSIONER BLOOM: Just following up on one of your other answers, you said that almost all developments are using central wells now, and can you speak to the economics of that at all?

THE WITNESS: Well --

COMMISSIONER BLOOM: And/or environmental impacts.

THE WITNESS: Okay. I'm not an environmentalist, so the kind of questions that you might want to ask, is it less environmentally, might be better asked of somebody who has that experience in environmental science. I will tell you that one of the companies I do the accounting for, I have side-by-side AFEs. Not even AFEs. They are already -- they are like where it says as of the final accounting because an AFE is just the budget. The authorized expenditures. We guess it's going to be this much, like Mr. Sauck yesterday said, "We guessed it was 8,000 but it ended up being 76."

So the final numbers showed that one of the operators that this particular company is a working interest owner was is paying $70 a foot to drill and complete, and the other company that they are a working interest owner that uses the closed-loop system -- this one uses the pit, the other uses the closed-loop system -- was $69.96 a foot. So we are talking less than a dollar difference per foot.

It was a 7450-foot well, pretty much the same depth, so we are looking at, you know, a difference between the two of less than a dollar.

COMMISSIONER BLOOM: I'm sorry, one was --

THE WITNESS: Well, and actually the closed-loop system company was a little bit cheaper by the dollar than using the pit.

COMMISSIONER BLOOM: Could you provide us with those AFEs?

THE WITNESS: I cannot. I'm sorry.

COMMISSIONER BLOOM: If they would allow it?

THE WITNESS: You know, I could ask my gentlemen if he would do that. But there's no guarantee that he would say yes. You know, as an auditor for a couple of counties and, you know, AFEs are indicative of -- the counties charge tax on personal property. What I was talking about yesterday, the tanks and those kinds of things. So to find out what the value of the tanks is would be very beneficial to the County Assessor for assessment. And asking for that even as a government official in an audit, it has become problematic. It's not something that -- it's -- you know, they don't want another company to know what their costs are.

COMMISSIONER BLOOM: Ms. Denomy, thank you. No further questions.

CHAIRPERSON BAILEY: And I have no questions.

REDIRECT EXAMINATION

BY MR. JANTZ

Q. Ms. Denomy, since we are on the subject, you talk a lot about some of the experience that you have with and you've thrown out some data that you have had based on your experience as an accountant. But you haven't named names.

A. That's correct.

Q. Can you explain why that is?

A. Well, number one, in my career with audits and those kinds of things, even working for state governments and federal governments as well, I have had to sign umpteen million confidentiality agreements. Some of them that don't even allow me to talk to myself or my client, you know. Some of them have gone as far as to say I can't tell the information to my client. So that's one of the requirements.

The second thing is as a CPA we have an ethics that unless we are subpoenaed in a court of law that requires testimony to be divulging of personal financial information, I just cannot do that without the permission of the individual.

Q. So it's simply a limitation based on your position as a CPA?

A. Yes.

Q. You don't have the same latitude as an operator?

A. No.

Q. But the information that you've provided today and that you provided is based on your experience, is it not?

A. It's based on my experience and where I know that there is public information available that can be used.

Q. And your testimony is sworn under penalty of perjury; is that correct?

A. Yes.

Q. So let's talk some specifics. One of the questions on cross-examination was based -- talked about the figure of 1,000 barrels of condensate. If we could have that slide. There's some discussion about the way in which you arrived at that 1,000 barrels of condensate. Could you talk about that?

A. Well, having gone back and thinking about what I have available to point to as public information, I was an expert witness in the Savage v. Williams, the Clough v. Williams and the Grynberg v. Williams court cases in which the documents that were presented in court and stipulated to and allowed to be presented in court showed one of these centralized pits. Those three cases had to do with underpayment from Williams to those three individuals.

In the course of discovery, which is getting documents to look at and to look at the information that the company has to provide to me to look at, there was a disclosure of how much actual condensate was produced out of these centralized pits. Because the value of those dollars was remiss in being paid to the mineral owners and the working interest owner that had a share in the wells that were being put into that centralized pit.

So it was not out of the realm for, you know, the 30 wells that were going in there to produce a million barrels a month in condensate revenue. That was during a period of time where it was somewhere between 19 and $40 a barrel. So this number is nothing but conservative about what can be produced out of the centralized pit.

Q. There's also a question in cross-examination about the comparison in rig counts and production between New Mexico and Texas, and the question was why you didn't include Texas and Oklahoma. Can you explain why you didn't?

A. I believe that Texas and Oklahoma are not as similar in their production as New Mexico, and, you know, that was just a decision that I made. Texas produces a whole lot more oil than either one of these two states do, Colorado or New Mexico. I think Ms. Foster yesterday said, "Well, we only produce natural gas in Colorado," and the Weld County does produce a good deal of oil and so does the Rangely Field, so it was just a choice that I made.

Oklahoma's wells are drilled much deeper. Texas wells are drilled in different formations. There's the Barnett Shale and the Eagle Ford. Southwest Colorado is very similar. I mean, they share some of the same basin in the natural gas field and the Fruitland Coal area, and so that was a choice that I made.

Q. Now, you mentioned Fruitland Coal. That was one of the questions you also got on cross-examination. And I believe the question had to do with your estimates of a typical amount of gas that a Fruitland Coal well might produce. Can you explain your answer about that?

A. Well, you know, I had the opportunity last evening to actually go back and look at the Fruitland Coal. I looked at a number of companies, a number of wells, and my numbers are not right. Actually, the production that comes out of the Fruitland Coal is not a million MCF but upwards of six million, 12 million, two million, five million. Looking at various companies, small and large, BP, I was -- this amount of 4.2 million is probably closer to at least seven times that amount in the Fruitland Coal. And the cost of drilling, because it is only in a depth of between 1800 and 3500, is significantly less.

Q. So the million MCFs that you originally estimated as a typical Fruitland Coal well production was an underestimate?

A. Yes.

Q. And what data did you look at?

A. I looked at the OCD -- actually, the Go-Tech site for many hours yesterday and this morning. In addition to that, I did find that the Blanco Hub's price yesterday was $2.45.

Q. Let's talk about the Blanco Hub. There was a series of questions about the indices that you used to gauge the price of oil and gas. Ms. Foster suggested that perhaps the San Juan Blanco index was probably a better one to use than the ones that you were using. Do you agree with that?

A. Well, you know, it would be. However, the price that is put out as an index price changes every day. Every day there's a different price.

When the Energy Information Administration does their total, they do an average for the year. So it would mean that I would do their job, take what production was done in the state of New Mexico, add up -- well, they don't do trading every day. So it would be less the weekends, all the year's worth of prices for the Blanco Hub, and then come up with my own average. Because looking at a particular day doesn't tell you exactly what the total value was for the year, what was the average value for the year. That's what the Energy Information Administration does, is they do an annual amount. The Blanco Hub gives you a daily amount.

Q. So one is a longer term --

A. One is an average for the year.

Q. That's the longer-term picture?

A. Yes.

Q. Rather than a daily snapshot?

A. That's right.

Q. This spreadsheet is not based on a particular well; is that correct?

A. It is not.

Q. However, is it based on your experience dealing with wells like this?

A. Yes, it is.

Q. So this represents a typical well?

A. This is a typical sample well.

Q. So one might expect similar numbers for a well drilled in Southern Colorado, say?

A. Yes.

Q. At this depth?

A. Yes.
Q. Same for Northwestern New Mexico at this depth?
A. Yes.
Q. I think there was maybe some misunderstanding about the actual amount of income on this well. The figure of $134,000 --
A. I think it's 143.
Q. $143,000. That's right. I'm sorry I get a little dyslexic with numbers. I am afraid of math, by the way. The $143,000, that's not a total income for the well over the life of it, is it?
A. No, it's marked right next to. It's net income per year. All that number is is 4.2 million net income divided by 30 years.
Q. So that, just to be clear, is the yearly income that this operator --
A. And it's not -- it's just a number that you can anticipate. Wells do not make a profit in the first several years.
Q. So again, this is a producing well. Obviously, and this is a pre-drilling budget, based on a pre-drilling budget?
A. It's should we drill this well or not.
Q. Can we go to the Texas Railroad Commission

and the Oklahoma slides, please? As the Commission can see, you amended these slides to include the source for the information. I E-mailed counsel the source for the documents yesterday.

MR. JANTZ: Did you get those?

MR. SMITH: I have no idea. My computer has been down. They upgraded my operating system and it's a whole new world but I will do what I can to locate something and get it to you guys.

Q. I did E-mail all counsel, including Commission counsel, the links for this information. Let's go to the next one if we could. This is public information, is it not?

A. That is correct.

Q. But based on your experience, is this a typical savings that somebody could -- an operator could expect for a closed-loop system?

A. They could. In my real life example of me looking this week, it was probably closer to 7,000 but this was an Oklahoma finding.

Q. Let me ask one more series of questions, if I could. Commissioner Balch talked about situations where there may be a marginal well where additional costs could tilt the balance between deciding whether to drill or not to drill, and he talked about waste in the context of that decision. Under Commissioner Balch's definition of waste, which is, you know, the definition that the Commission works under, that doesn't mean a producer has to produce the mineral at a loss, does it?

A. Well, I don't know. Because --

MR. FELDEWERT: I'm going to object on the grounds I think it calls for a legal conclusion. I'm not sure she reviewed the statute and the regulatory provisions dealing with waste.

CHAIRPERSON BAILEY: I will sustain that.

Q. Have you ever had a client volunteer to produce mineral at a loss?

A. Not voluntarily.

Q. Have you ever had a client forego a mineral resource based on the cost of regulatory compliance?

MR. FELDEWERT: I object on lack of foundation. I think she testified that her clients are working interest owners.

MR. JANTZ: That's not what she testified to.

CHAIRPERSON BAILEY: The objection is overruled.

A. Could you please repeat the question?

Q. Sure. Have you had -- in your experience have you had any client who has foregone -- decided not to drill a resource based on the cost of regulatory compliance?

A. Not that specifically, no.

Q. Thank you, Ms. Denomy. That concludes your testimony. At this point I would like to move Ms. Denomy's PowerPoint into evidence minus the last two slides dealing with the BP information.

CHAIRPERSON BAILEY: Any objections?

MS. FOSTER: Yes. I would object. The testimony that was given yesterday specifically in the two slides with the heading of the Environmental Protection Agency, she stated that had nothing to do with this case because it had to do with greenhouse gases and there are was not relevant to this case whatsoever. That was the testimony yesterday. Then there were -- well, those would be the two that I would object to specifically and that would be it.

MR. FELDEWERT: Madam Chair, I think we have lodged objections to basically Slide 11 on, the spreadsheet, on the grounds that there's no basis for the numbers shown. She can't disclose the source of those numbers and apparently they come from a lot of different sources. She indicated in some circumstances she had the documents available but felt she couldn't bring them and show the source documents to the division. So I don't think there's any foundation for the exhibit.

CHAIRPERSON BAILEY: I agree with commission counsel that we will not accept the two with BP or the two concerning greenhouse gases.

MR. JANTZ: So if it's okay with the Commission, I will strike those two slides and submit the remainder to the court reporter for inclusion in the record.

THE WITNESS: I believe it's four.

MR. JANTZ: The four slides if that's okay with the Commission. If that's an acceptable procedure, I will do that.

CHAIRPERSON BAILEY: Yes, we will accept that.

MR. JANTZ: Thank you, Madam Chair.

CHAIRPERSON BAILEY: Does that conclude your presentation?

MR. JANTZ: It does, Madam Chair.

(Note: Exhibit 2 admitted.)

CHAIRPERSON BAILEY: Then the witness may be excused. Commission counsel has made a suggestion that I will ask him to explain to the attorneys in the case.

MR. SMITH: At the conclusion of the hearing, not just simply today, but once the record is closed, I'm hoping that the Commission Chair will instruct you all to submit a document to the Commission that supports with citations to the record the testimony and exhibits and/or supports by argument why each of the proposed modifications should or should not be made. And you can conclude in that a preface that would be styled as a closing argument.

This is not to say that you would necessarily have to -- how you organize it would be entirely up to. It isn't that you would have to go through each individual change and explain each one unless you wanted to. What you could do is cite to various testimony, various exhibits and then argue that that evidence supports this change and that change or doesn't support this change or that change as long as you give what you believe to be evidence that the support is either making or not making each change.

By doing that, I think you will help -- you will certainly help me draft an order, but more importantly, I think you will help the Commission in their deliberations, particularly since they are going to deliberate in all likelihood well after the hearing. It probably will produce a better order.

I would hope it would produce a more timely decision and a more timely order and you all are more familiar with your cases and what you put on and what you think than the Commission is regardless of the amount of focusing they have done.

So the reason I wanted to tell you this now is because even though you don't have the record yet you know what you have done, you know what you think, you know what your arguments are going to be so you can work on it whenever you feel like it. So I wanted to give you a heads-up on that.

MR. CARR: When would this be due?

MS. FOSTER: When would the record be available?

MR. SMITH: When the record is going to be available is up to the court reporter. When it's going to be due I think is something that you all can work out with the Commission. Certainly if you want it to be due prior to deliberation, after production of the transcript and, you know, in that interim, that's sort of up to you guys and the Commission.

MR. CARR: I had heard you say maybe it was due before the June part of the hearing and I was going to say --

MR. SMITH: Oh, no. I'm sorry.

MR. CARR: That's going to be a neat trick.

MR. SMITH: No. The only reason I mention it now is because, you know, if you wanted to you can get a jump on it. It's just a matter of courtesy.

CHAIRPERSON BAILEY: We do not have predetermined decisions to this case.

MR. CARR: Sometimes we don't have a lot of predetermined evidence.

CHAIRPERSON BAILEY: Transcripts are normally given to the OCD within two weeks of the hearing date, so possibly three weeks after the end of the June last day, which would be June 22nd, so that we would have them available for our consideration before we have our deliberations.

MR. CARR: I have one other thing and it's not directly related to this but it's procedural. In our prehearing statement we identified certain witnesses would be available for rebuttal. When we go back to June, some of them may not, particularly

Dr. Thomas, may not be available. If anyone is planning to recall them it would be helpful if they notify us.

CHAIRPERSON BAILEY: I think that is a courtesy that should be extended. All right. Then we will go to Dr. Neeper. Would you like to make an opening statement?

MR. NEEPER: I made an opening statement when we began the proceedings so I am ready to give the testimony. But Madam Chairman, might we have a ten-minute break at this time and then I can proceed?

CHAIRPERSON BAILEY: Yes. We will come back in ten minutes.

(Note: The hearing stood in recess at 10:02 to 10:13).

MR. NEEPER: I will switch between files while I qualify myself simply because it's shown up in two different files. I found it had to be that way because if I put the qualification file in the same file as the testimony it would change the page numbers. There are five copies of exhibits in the rear of the room. Included is one copy electronic unless someone prefers electronic.

DONALD NEEPER

after having been first duly sworn under oath, was questioned and testified as follows:

MR. NEEPER: My name is Donald Neeper. I am representing a small group that's been concerned with the environment in New Mexico for more than 40 years, New Mexico Citizens for Clean Air and Water. We generally confine our attentions to technical matters as contrasted with political-type activities.

I reside in the town Los Alamos where I have been employed for many years and I will present some technical personal background.

This is Exhibit 4. I recognize that it's small on the screen but those who have exhibits can see it. If you can't see, you won't miss much. I am retired from the Los Alamos National Laboratory. I have a Bachelor's Degree in Physics from Pomona College, M.S. and Ph.D. in physics from the University of Wisconsin.

In terms of experience, following graduate school I spent two years in military service. I then spent more than two years at the University of Chicago continuing research in low temperature physics. After that I came to Los Alamos National Laboratory at the opposite end of the temperature scale in the design of thermonuclear weapons.

The design in that case was what we might now call modeling, but that word wasn't in use then. Or simulation, which wasn't in use. We called it numerical experimenting but it was earlier experience in what is now called computer modeling.

Within these years at the Los Alamos National Laboratory after about seven years in weapon design I became fascinated with solar buildings. I moved into the solar buildings research group. Unfortunately, they made me group leader a year or two after that. I didn't really want to do that. I wanted to do the work myself. But that kind of work conceptually isn't that different than a lot of other science concerning the thermodynamics of buildings and a lot of really good work got done until such time as the funding dried up.

Following that, I was doing numerous things in heat transfer and this relates back to why I am here today. I was looking at a very strange paper showing extremely high values of heat transfer in a fluid just because the fluid is oscillating back and forth, and I am wondering what is this? The mathematics was a little obscure and I couldn't understand it.

At that point the phone rang and it was the Air Force calling saying, "We found your name in the solar energy literature. Can solar energy do anything to help us out with fuel spills? We have these tremendous fuel spills."

I thought about it a while and I said, "No, I don't think we can cure your fuel spills," and then it struck me maybe this thing about heat transfer in a moving fluid could apply to contaminant transport in soils and I have been kind of playing with that idea ever since.

Now, to play with an idea as a scientist you about have to have funding. One way to maintain this idea alive was to take the position as the operable unit project leader, as it is called, for the RCRA facility investigation of four different disposal sites at Los Alamos National Laboratory. Two of those sites are rather famous or infamous. One is still operating hot dump known as Area G. The other one was for many years a chemical disposal area known as Area L. My interest got into that because there was a large chemical vapor plume around Area L, and I'm saying my ideas apply to the vapor plume. We need to do some investigation.

So that got me started in soils, got me started into environmental drilling. The laboratory offered an early retirement in 1993 across the board. I elected I could be more free if I were retired so I took the early retirement and for several years thereafter worked in either of two consulting firms. One is cited here, I believe, Science and Engineering Associates, dealing with that vapor plume and with other funded tasks that might come to those consulting firms.

After that sort of wore out about 2002, I went back to the laboratory as a guest scientist sitting with the numerical hydrology people pursuing really my own interest, which was of mutual benefit. I could use their code, I could have a colleague at least with whom I could talk. We could work together, and my kind of calculations so stretch what might be thought of as a more ordinary computer code that I was very useful to them at finding bugs and things they didn't think of because I would run on the pure physics and say it ought to do this and you built in some assumption in your coding and in this weird circumstance it would give a bad answer. So we were mutually helpful to each other.

I submitted my final two technical papers to the vadose Zone Journal a year ago and I hope they will finally be published next month. There's been continuing problems with page proofs and what not, and I have cleaned out my desk at the laboratory about two weeks ago so I no longer have that association.

There is on the second page a list of publications related to soils. The rest of the publications that I might list there run on for a few pages, but I think they would be irrelevant to our purposes.

I will step forward a couple slides into this and then request qualification. I have testified before this Commission several times previously. These slides have been used previously and so Madam Chairman is fully within her rights if she wants to sleep through it. She has heard it before. I list it simply to establish what is soils physics or to give some idea that this is a legitimate term by listing the books I found in 2007 in the Los Alamos library with soil physics in their title somewhere.

This slide was taken from the website of the Soil Science Society of America. Their first division is the Soil Physics Division. So I am simply establishing soil physics has a legitimate scientific pursuit. There's the list of books with soil physics in the title.

And so with that background, Madam Chairman, I submit New Mexico Citizens for Clean Air and Water Exhibit No. 4, which is my qualifications, my history for your consideration or acceptance.

CHAIRPERSON BAILEY: Is there any objection?

MR. JANTZ: No.

MS. GERHOLT: No objection.

MS. FOSTER: No objection.

MR. HISER: I have a question. That is what exactly Dr. Neeper proposing to qualify himself as?

THE WITNESS: That is the next topic, Madam Chair.

MR. HISER: No objection to the exhibit.

THE WITNESS: Given this background, I propose to submit myself to the Commission as an expert in soils physics. The Commission has previously found me qualified in that discipline.

MS. FOSTER: Madam Chairwoman, pursuant to Rule 19.15.3.11B 2, Dr. Neeper did present a prehearing statement in this case, and since he is representing the Association of Clean Air and Water, which is an association, I believe that under the rules it does require that the person who conducts the presentation must attach a sworn and notarized statement from the corporation or the entity's governing body attesting that it authorizes this person to represent the corporation or entity. So I just want to put that in the record. He is a very qualified witness and I have no question to his qualifications but I did want to put it in the record that there does need to be a notarized statement from the Citizens of Clean Air and Water that he is their representative and authorized to speak.

MR. NEEPER: May I respond?

CHAIRPERSON BAILEY: Yes.

MR. NEEPER: Such statement is in all copies of the exhibits from the New Mexico Citizens for Clean Air and Water. I believe one was submitted to you. Mr. Hiser is indicating a positive response and the Commission has such copies, but if a copy is not available anywhere, there should be one at the back of the room.

MS. FOSTER: Was it submitted with the prehearing statement?

MR. NEEPER: It was.

CHAIRPERSON BAILEY: Yes, I see a copy here.

MS. FOSTER: Thank you for clarification of the record, Dr. Neeper.

CHAIRPERSON BAILEY: Then you are their --

MR. HISER: I have a question, if I may. Dr. Neeper, if you turn back one page on your slide exhibit here. In the Soil Science Society of America slide here there's a distinction between soil physics and a number of the other areas. What's the distinction between Division SO-1 and SO-11, Soils and Environmental Quality?

MR. NEEPER: I cannot tell you what the Soils Science Society of America considers to be their definition. I can tell you what is my thought on that if that would serve your -- answer your question.

MR. HISER: Well, you are saying that you are qualified in the area of soil physics; is that correct?

MR. NEEPER: That's correct.

MR. HISER: This slide suggests soil physics is one of approximately 12 disciplines within the area of soil sciences, but you are not sure what soils and environmental quality is.

MR. NEEPER: I am not sure how the Soil Science Society of America defined that term. I can give you my estimate, my thought, but I can't tell you what that society has said.

MR. HISER: I have no objection to the qualification of Dr. Neeper as a soil physicist.

CHAIRPERSON BAILEY: Any other discussion? You are accepted as a soil physicist.

MR. NEEPER: Thank you, Madam Chair. I would expand in this testimony from things I have presented before. I previously presented a lot of the science that I think lies behind the Pit Rule or some of our other rules that deal with waste, but I will take the freedom today to use my thoughts as well regarding the testimony we have heard earlier and that I have been fortunate enough to hear.

The purpose really of the Pit Rule is to protect the environment, and the Commission is challenged to protect the environment in the Oil and Gas Act as I understand it. That includes the ground surface, not only water. Much of the testimony has focused on potential impacts to water, either groundwater or surface water.

Previous presentations have not offered a risk analysis or data but rather have given us opinions and experience of those testifying. I would like to use Dr. Thomas' analogy. He expressed the danger of being hit by a bus if you stand in the street, but the risk is associated with how far away is that bus. If the bus is three blocks away, the risk is very minimal.

What we have not yet heard here is a full analysis of what is the risk of the things we are proposing. What is going to happen? We have heard analysis of perhaps how far a contaminant will travel or won't travel, but we haven't seen something that will convince us of what is the long-term impact on the environment.

Sometimes the reasons for our terms in our proposed rule are given as these are considerations of what other states have as rules. I agree that it is wise to consider regulations of other states, but whatever regulation another state has does not necessarily guide what we should do because we do not know what thoughts, what considerations, what measurements went into those regulations. They may have come from a deep scientific background. They may have been established at a whim and may have been established with a particular geology or situation in mind.

As an example of that, I offer my experience of three years on the Stronger Board in which the Stronger organization, a nonprofit, was funded and directed to exam the regulations of various oil-producing states as those regulations concerned impacts on the environment. I was a participant on the review in Indiana. They had in many cases rather minimal environmental rules and that was simply based on the geology and what was happening. There just wasn't much to be concerned about, given their drilling depths and the nature of the gas field they were concerned with. So if we were to look at the regulations in Indiana it would not necessarily be a good guide for New Mexico. We should develop our own regulation.

There's been a statement in the literature that is public literature to the effect there's no science behind the Pit Rule. It's been repeated in the press so I'm going to review a portion of the science behind the Pit Rule. This will focus on chloride and a lot of the prior testimony has focused on chloride and, in fact, the terms in the proposed rule changes focus on chloride.

Early on the in environmental

considerations of the surface waste rule and the Pit Rule, we focused on chloride because it is probably the best tracer. If you find chloride, that's an indication you will probably find something else and you should look. It is not, by itself, probably the biggest impact or the thing that will somehow generate the greatest risk. It is the thing that tells you when something might be wrong. So we should not focus the totality of our rule on chloride, and I will get to that. It's a great tracer.

The vadose zone is the region between the ground surface and the water table. If that's contaminated, I make the statement, eventually the entire environment suffers. I recognize that's contrary to some other testimony we have. We will see what reasons I can give for that. But I can state in most cases if no release occurs to the vadose zone, you can be sure both that the water and soil are protected. Therefore, I'm going to focus on contaminants in the ground and on the ground as soil under pits or soil -- whatever waste may remain in burial units.

As I said, I'm focusing on chloride, but sodium and sometimes other chemicals can create environmental damage, but the chlorides are the tracer we can follow. We should just use them as an indicator when we look at other things that may be more harmful. They should tell you when you should look deeper, when you should look farther. And the proposed rule changes would eliminate many practical limits on chloride releases, and that is one of my concerns.

So we will look at what's in the pits, what are the effects of these kinds of things, what are the effects on the biota. I will try to establish this because it's been in prior hearings but it needs to be in the record of this hearing in order that decisions can be made on the record.

There's a big question, that is: If whatever it is that is an offensive substance moves, how fast will it move and how far will it go, and once we get to that question then we say: What's the big picture of the proposed rule? I'm not dealing much with linguistic adjustments.

So we have heard about the sampling done in 2007 both by the industry and by the OCD of drilling pits that were nearly ready for closure. I will focus on just a few of the results of that, which I will outline here in red.

The chloride in northwestern pits had an average of about 3900 milligrams per kilogram with a range up to 15,000. Why is that significant today? Because the proposed standard for soil left in the bottom of the pit, if the pit contents are removed, is 5,000 milligrams per kilogram. This would suggest then that on the average in the northwest, the contents of the pit could be left as soil beneath the pit and meet that standard. You would not get a signal to look for anything else if you just looked at the limit of 5,000 milligrams per kilogram of chloride.

In the southeast, the average was 126,000 from drilling with brines up to saturated saltwater where they range from zero -- I'm surprised at the zero -- up to 420,000. If you look at the 420,000, you would conclude somebody had to dry some material on the top of a layer that's drying and pull up salt into it to get that kind of a concentration.

If you look at the industry pit sampling in the northwest for three different pits we see only one in the middle on the left-hand column at 6,000 where the content of the pit would give you any alarm under the current rules or would exceed the soil standard for whatever you found under that pit. You remove the pit contents, the SJC-1 and SJC-3, if those liners had leaked you would probably still pass the soil standard.

In the northwest OCD pit sampling I have drawn a red box around the sodium to chloride ratio. Ordinary salt is one-to-one. Sodium is usually biologically a much more harmful ion. Our group sponsored a study of what was killing pine trees, ponderosa in Los Alamos. We suspected it was due to road salt and what was found in those trees that were dying was a high concentration of sodium in the needles. The trees illustrated almost identically the same kind of visible symptoms that you would get from extreme drought.

What I notice in the second line here is a sodium to chloride ratio of ten may be suggesting something like sodium hydroxide or other sodium-containing chemical was used in the drilling point of this, is that chloride is not the only thing that could be threatening, and in all of these cases in the northwest the sodium had a greater concentration than the chloride. So if you see a high chloride, you should be suspicious that you may have a higher sodium.

The situation down in the water that was taken off of nearly closed pits is different. Usually there the sodium is nearly -- closer to one-to-one ratio, but there is two of those pits that still exceed a one-to-one ratio.

So what's the physical effects of salt? This concerns of hydrology for which we had a very good review yesterday. We heard about the porous nature of the soil, the moisture potential, which I will review, and I will review the osmotic pressure. Finally, I want to talk about the transport of water in contaminants, namely the question of how far can it go and how fast can it go?

This is a little different picture but the same idea is in Dr. Buchanan's presentation yesterday. If the soil is not saturated it has air space in it. In this picture outlined in blue some water that is held by capillary tension between the soil particles. In this illustration the soil has very little water. Typically what I have found in New Mexico in places I look, it's not unusual to find something like 15 percent or more. When I find something really dry as we are doing sampling up in Los Alamos, it would be down around 10 percent, so saturation here would be 100 percent but the usual situation would have more water than is indicated in this diagram.

The diagram indicates the path going through here where air can flow. That's due to migrate concerns with air flow. But also what that represents is where water can flow when you do get saturated flow. Water will flow throughout the matrix but it will flow fastest along usually isolated or preferential pathways. Therefore, the rate of water flow is not necessarily uniform. Some places will run faster than other places and that can advance contaminants a little faster than the average rate of water flow going down through the matrix. Once the saturated flow is over with, you have varying degrees of saturation. Initially it's nearly saturated, let's say. Then it has to dry out. How does it dry? It will dry by unsaturated flow. That can occur downward due to gravity or upward if the soil above is more dry than the soil below.

The moisture then in unsaturated flow moves according to what is called the moisture potential in the soil or sometimes called the suction in the soil.

As the air dries the soil at the surface of the ground, the suction there becomes higher and the moisture down below flows upward. That's almost usually true near the surface of the ground. You will find increasing moisture as you go down from the surface.

The unsaturated flow is much smaller than saturated flow. That does not mean it is negligible. In fact, the calculations that are done for the most part with people concerned with safety and disposal and movement would deal very often with unsaturated flow. That's the long-term concern.

Here I plot a typical moisture potential. That doesn't mean it is for any given soil. I cite the reference in a report that's meant to illustrate. The lower curve is for a sandy soil and this is the suction plotted as a function of the volume of the soil that's filled with water. Dr. Buchanan said yesterday that very often soils will have a 50 percent pore volume; 50 percent of the total volume could be occupied by either air or water or both, but not soil particles. Often you will find less. In this case it's shown at about 35 percent for the sandy soil.

It takes a certain amount of suction to get the first bubble of air in, and then the potential gradually rises. The suction rises as the soil gets drier. So if I have some soil at this suction or this suction of dryness, the water will be flowing upward along the curve.

When you get very high, very high suction, there is so little moisture that the contact between the particles on the average is broken or that's way up in the absorption region you no longer have a mobile film with water. Dr. Buchanan referred to that yesterday, but that happens at very -- usually very low water fractions.

Clay has a higher potential. It really wants to hold the water, as Dr. Buchanan said, but it might be holding more water and may have a broader curve. That is, it will still be holding water as you go to higher suction.

There's a question of osmotic pressure that came up. The total potential is formed by the osmotic pressure of whatever is dissolved in the water and the matric suction, the suction due to the capillary suction between the particles. But I would emphasize in red down at the bottom, osmotic pressure can kill plants, but in most cases the osmotic pressure is ineffective for causing flow.

That mistake will sometimes be made in the literature and people will just blindly add in the osmotic pressure to what is causing the flow. It usually does not. It's a rare circumstance. It's because for osmotic pressure to act, you need a semi-permeable membrane of some kind, a process wherein salt or the dissolved substance cannot move through the membrane but water can, so water will try to push through the membrane raising pressure on the salty side.

If you have a plant over here, in a sense you could say oh, that's trying to suck water away from the plant. Or if you consider this membrane to be the surface of of the plant's root, the plant is having to suck against that osmotic pressure to get the water it wants. Now, the plant might be somewhat salt-tolerant in which case it can tolerate some salt coming through there.

I look at the osmotic pressure of sodium chloride solution, not that we want to keep these numbers but simply to get a reference. The universal wilt point, as it's called, is usually listed at 1.5 megapascals or 15 atmospheres. Yesterday Dr. Buchanan testified he had seen pine trees surviving at even twice that or more. The question is how long this has been regarded, as far as I know, in the plant literature as kind of an absolute limit for most plants.

If you expose a plant to that for a day, it is highly unlikely it would survive. So we can use that as kind of a guide.

I tried to put this in a context. Soil with 1,000 milligrams per kilogram of chloride in a volumetric -- in a 15 percent volumetric pressure would have 10,000 milligrams per kilogram or roughly 10,000 milligrams per liter of chloride in the pore water. So we can say if the pore water reaches about 10,000 or somewhere close to this point, that isn't the point at which danger turns on. That's kind of a death point.

We say what do you mean by death point? Well, I point out we use brines to preserve food or salt to preserve food as in salt pork or brining pickles and various other process. One of the reasons the brines may be so preservative is they kill any bacteria that would otherwise like to eat or spoil the food. Same thing happens with plants.

Dr. Buchanan gave us a review of the salt tolerance of plants, at least the species he is dealing with in the northwest, and he used electrical conductivity as an indicator. That is a very viable indicator. It is convenient, it is quick, it is useful in the field and it is more easy to relate electrical conductivity to what's happening with plants, as I understand the literature, than it is to relate milligrams per kilogram or some other such standard. Therefore, the literature regarding plants often cites electrical conductivity.

The traditionally accepted criteria according to the American Petroleum Institute for all plants has been to decrease the salinity. That means whatever it is that's causing the electrical conductivity, it might be sodium chloride and it might be something else, to less than 4 millimoles. Dr. Buchanan's slide yesterday showed a peak up around nine millimoles which would not, I should think, be very high for what you could find in a pit, but how much in a bulk salt solution? What can cause that kind of conductivity? I simply plot here the electrical conductivity of a salt solution in bulk as a function of the milligrams of sodium chloride per liter to the milligrams of chloride per liter and around 1500 milligrams of chloride per liter you hit the four.

Does that mean that's exactly what you will get when you do a saturated paste test on the soil? Not necessarily. I understand that can vary somewhat with the type of soil on which you do the paste test. But nonetheless, four kind of gives you an indicator of where you are, where danger is arising for plants, and it's about a factor of 100 below saturation, saturation with salt.

This is a plot of two data sets that are available for grasses. Where is the threshold for damage as published by the U.S. Department of Agricultural. The four EC value winds up right in the middle. Certainly some of these can take an EC up to eight and presumably higher. Others are lower. But there isn't a lot -- I didn't find a lot of literature out there that I, as a non-biologist, could use to guide me in saying if I had to apply one number for an entire state or an entire area, what kind of number is safe? Therefore, I focused on four as what is safe even though some things will be damaged by it, as kind of if you have to pick a number, that's the number that you can use.

So what level is it damaging? I say if a saturated paste exceeds four, roughly 600 milligrams per kilogram. A lot of the literature will say 700 milligrams per kilogram and some say if you go to higher EC it really indicates 800 milligrams per kilogram that you can multiply as a scaling factor against the four.

I think we shouldn't regard one of those numbers as an absolute number that can be translated from one to another because one is measuring electrical conductivity which depends on many things, including what is in a saturated paste, and a milligram per kilogram is measuring an exact amount of something in a dried sample of soil.

But we can remember that one and a half megapascals at this so-called universal wilt point gives you -- you get that osmotic pressure at approximately 1,000 milligrams per kilogram of soil, 15 percent moisture. So 1,000 milligrams per kilogram is kind of an indicator. We are getting numbers like that, we know it's not good for growing things.

MR. HISER: Madam Chairman, I think at this point I might interpose an objection. My objection is a narrow one. That would only be to the extent that Dr. Neeper is trying to characterize the plant science aspect of this. He was qualified as a soil physicist, not a plant guy. And I have no objection to the slide if he is talking about what does this translate to between the various mechanisms, parts per million and EC, milligrams per liter and all that type of stuff. But just to the question as it goes to the plant.

CHAIRPERSON BAILEY: Would you like to respond to that?

MR. NEEPER: Yes, I would like to respond to that because I believe Mr. Hiser raised the same objection in the previous hearing and I make the statement I am not claiming to be a biologist or a plant specialist. I am a scientist and I can read the science of the plant literature, particularly that supplied to the general public by the U.S. Department of Agricultural. I can read even the scientific publications by the scientists, and if they say something dies at this level or if they say we find a 50 percent productivity in the plant, it grows only 50 percent of the foliage at a certain level of salt in the soil, I think I am capable of understanding that.

And I think it would be a mistake if I understood something not at least to pass whatever I can on to the Commission because the Commission needs all the facts and all the information it can get.

CHAIRPERSON BAILEY: And the basis for

this slide is from public information through USDA. or other --

MR. NEEPER: USDA and other publications. I could go presumably, if my library still survives -- much of it doesn't -- and get out such publications.

MR. HISER: Madam Chairman, if I may put another word in. I'm an attorney. You all know that. And I also represent the metallurgical industry. As part of my representation of the metallurgical industry I have read the 1480-page treatise on the making, shaping and treating of steel. But there's a big difference between my being able to talk about in the academic sense the difference between a basic or acid refractory or about the equation that governs the metallurgy of that operation and the expertise an expert would have who would actually be able to do that process.

So while I do not dispute that Dr. Neeper has the same level of expertise in metallurgy that I may have but his happens to be in plant science, that is a far thing from being an expert in the field, which requires practical experience in the field. I think that's what Dr. Neeper does not have in this case.

CHAIRPERSON BAILEY: We recognize your concern. We will give this slide the value that the Commission believes is appropriate.

MR. HISER: And I believe that would be very appropriate. Thank you, Madam Chairman.

CHAIRPERSON BAILEY: Please continue, Dr. Neeper.

MR. NEEPER: Thank you, Madam Chairman. This is an image of Table 1 that appears in the NMOGA proposal, and I have drawn two red boxes. One says it's closure criteria for soils and the two boxes in the table are the standards at a depth to groundwater of less than 50 feet. The standard is 5,000 milligrams per kilogram. At a depth greater than 100 feet the standard is 20,000 milligrams per kilogram. The EC 4 guideline from the Petroleum Institute is equivalent to something like, let us say, 600, 700 milligrams per kilogram.

And why are these numbers important to me? The chloride criteria can rarely exceed 20,000 milligrams per kilogram because to get to that kind of number you would be replacing normal pore water of the soil under the pit liner with a fairly high concentration of brine. Why am I concerned? Because the concentration is to be measured by a composite sample achieved which you take samples from various places and stir them together. If the liner were at some point to leak, the leak would necessarily progress downward into the soil, would be likely to.

If you then pick up the liner and you test various parts of this soil, you could have, in effect, a release that went to an arbitrary depth but never exceed the 20,000 milligrams per kilogram standard. So you would say there's nothing wrong here, whereas this should have been an alarm signal that something was very, very wrong. Somehow something got out of that liner.

Does this kind of salt damage compare with reality? Again, we are back to whether I am an expert in plants. Let us say I can recognize the absence of vegetation, and the previous commission has seen these pictures at least twice before. This is somewhere in the vicinity of a pit near Caprock. It was completed in 1976, as far as I can tell. And what we see is a bare area right in here. I call it a death zone.

Coming forward from that, you will see some scattered plants, most of which, as far as I can tell, are snakeweed. That's what I would call it. As you get closer to the edge there's increasing snakeweed. Finally, if you get far enough away you are in a grassland.

This is another pit in the same vicinity within a few miles. It was completed in 1996 from what records I could find. You can see parts of the liner coming up through the ground. Again, you see a similar symptom. You see a bare area and then some gradual plants which I call snakeweed, and farther out you get more and more snakeweed. What I was interested in doing here is only in trying to establish why those areas have not recovered.

So I did a little sampling and then I correlated the samples against the vegetation. In the horizontal axis I have undisturbed grass, dense grass, sparse grass, dense snakeweed -- what I call snakeweed, sparse snakeweed. Finally the very edge of snakeweed, and I took samples where I thought they would tell me the most so I didn't do uniform sampling everywhere. I take one sample out on the undisturbed grass and the chloride is less than 100.

By the time I get into sparse snakeweed, I took four samples. Two of them turned out to be somewhere between 100 and 250; two of them between 250 and 400 so I see the chloride increasing. I get right to the edge of the snakeweed and notice I took several samples, five at low chloride.

I thought about that quite a bit and I said when I said edge of snakeweed, I meant that. I took the sample right from under the plant. I mean, I was interfering with the plant's roots to get the sample. The plant was smart enough to know apparently where the chloride wasn't and I was doing a selective sampling by doing that. I wasn't sampling in the bare area that was adjacent to the snakeweed but I was sampling right at the snakeweed.

Once I got into the so-called bed area, out of four samples one was in the 250 to 400 region and three were 2000, 4000 milligrams per kilogram of chloride.

This was sufficient to let me conclude that at least the lack of recovery correlated with the chloride. That might not be the only cause. You could have -- I can't say the word for it for the moment. Soil that would not accept water. Somebody help me with the water.

CHAIRPERSON BAILEY: Hydrophobic.

MR. NEEPER: Hydrophobic soil. There can be other causes but at least you know the chloride content is sufficient to cause severe stress.

So if it moves, how fast does it go and how far does it go? The fusion through pore water, as we heard, is slow, but it's an absolutely certain process. By diffusion, we mean the molecular movement of the substance through the molecules of water. It's a thermal process driven by the thermal agitation that the molecules are undergoing.

When we say absolutely certain, if you have a gradient of concentration in a water column, until that water column is so thin it's equal to the mean free path of the jiggle of the molecules, you will get diffusion poured into the binary diffusion coefficient between those two substances.

Now, that will be something that moves the salt substances through water always. If the water is there and in the soil, if you are unsaturated but the water is still connected, unless you are extremely, extremely dry, you will have diffusion going on.

However, natural motions of pore water or saturated flow after a rainfall event can move contaminants much faster. Certainly the rainfall, we heard, it will go down much faster, but it doesn't necessarily, as I showed in the first slide with the pictures of particles, it doesn't necessarily flush the substance out of all of the porosity. That's one of those things where it depends. How much is going by and how fast is it moving.

It may leave some behind. If it leaves some behind, if you have a little pulse of a rainfall event and some of the porosity gets flushed out and some of the tighter porosity does not get flushed out, now what's going is to happen to remains in the other porosity? It will diffuse sideways. It will even itself out in time, and as the surface dries it will try to move upward because the unsaturated flow will be upward.

So the motion of the dissolved substance can be upward, downward or horizontal, whichever way the combination of suction and gravity pulls it. It isn't a process that stops.

I made a little picture to illustrate diffusion with the hypodermic needle demonstrated in the upper left picture. I injected a little bit of food coloring into the bottom of a glass and sat back to wait. Do not use this method as an absolute measure of the diffusivity of something in water because you have to be careful you have no other influences going on, but it gives us an idea. After about 12 or 14 hours there we see the glass has gotten colored all the way through on the bottom left, but there is a dense layer at the bottom. And after we have waited from October 3rd to October 5th we see the glass is pretty uniform in color.

That gives you a feeling of about how far can something diffuse in water in about how much time. If you use diffusivity as an indicator and physicists do this. They will use characteristic distances. The characteristic distance for diffusion of salt through water, sodium chloride, is about a centimeter in 18 hours. But the time increases with the square of the distance. That means if you double the distance it's going to take four times as long. If you just have a column of water with no motion in it, if it's one meter long it would take 21 years, basically, to equilibrate the full column. But if you had a column two meters long, about six feet, it would take four times as much, about 80 years. That's the kind of time scale I'm worried about is the 100-year, 200-year time scale. You can certainly move contaminants by diffusion over 100 years.

Well, we had discussed what does the soil look like with saturated flow and unsaturated flow.

There is another diffusion going on, and that's diffusion of water vapor. Now, it's much more free to diffuse. When you are unsaturated you have all this porosity and the vapor from the water, just like the vapor off the top of a glass of water left out in the room, can evaporate. It can move and it will also go to wherever is the dryest place for it. It moves according to the potential, but it also diffuses according to the gradient of water vapor concentration.

So if you have a warm soil at the top, very dry, almost no water vapor as we have in our atmosphere around here, what you can get is diffusion of water vapor up through the soil drying it, and that's how you can dry a significant layer of soil, and then that then becomes the sponge trying to suck up water from a still deeper layer of soil.

Water vapor can condense. This brings up a very interesting cycle that if we have a seasonal variation of temperature, say over a depth of four to ten feet, why can I choose those depths? Well, in my city, the city now requires that you place a footer for any construction, a concrete footer at a depth down to three feet because they don't want the soil to freeze under that and heave the building.

That illustrates the penetration in the wintertime essentially of low temperature down through the soil. In the summertime the process is reversed and higher temperature goes down through the soil. So you have this layer of soil swinging back and forth in temperature. When you get deep enough, the temperature holds pretty still. As you get up closer to the surface it swings more and more.

When it is warming up the water vapor then will diffuse upward. As things dry -- excuse me. As it is warming up -- we are down at some depth in the soil. As it is warming up the vapor pressure increases just as it does in the tea kettle when you heat it. We have increased vapor pressure here. Down below it is still cold and the vapor will go down and condense. You might think from that, oh, we will just build up a huge layer of water down here. No, that doesn't happen because in the opposite season just the opposite happens. The top gets cold and the vapor goes up and condenses up above. But when the vapor condenses down below you now have greater saturated, and that would increase the unsaturated flow of liquid up.

You say well, if everything balances out, that should equal the unsaturated flow of liquid going back down in the opposite season. Not quite true, because the temperatures are different. One season is cold and one season is warm, and so the vapor pressure is higher in one season than the other. This can result in a net transport of water.

This was first published, to my knowledge, by an investigator -- I am remembering his name as Millie, and I think it was about 1996. It's just one of lots of little things that I think we don't consider when we put out contaminants and think they will never move. We have to think about all the things that can happen over a long-time scale. They are small but they happen. I happened to think of this one.

Well, I gave some data on surface sampling. I then wanted to know can I trace the movement of chloride down into the soil so I did subsurface sampling near Caprock in 2007. Marbob, at that time we had the pit task force and I brought the data into the pit task force and the man from Marbob said, "Gee, I would really like to know what's going on. I will sponsor another sampling event," so we sampled one of his pits. He got to choose the pit and the place and they don't do environmental sampling much so he said, "How do we do this?" I said, "Hire the same driller I hired and we will just pursue the same process."

This is drilling at that pit I call Pit No. 8. We are out in the area that's called dead. It's difficult if you don't know the layout of the pit. You spend your time drilling holes that go down and you may hit the berm. You don't know exactly what you are going to hit. Finally we got one where we found some cuttings and thought for sure we have to be in the bottom of the pit.

What you do with this or what I did, you can just bring up soil and sample the soil coming up but you don't get the full story from that. We did continuous coring in five-foot intervals. I didn't put in pictures of the cores but you get -- I guess we had a four-inch auger. I don't remember. Four or five-inch auger and you get a continuous core of the soil. You bring it up, set it on a rack and you can take your sample from wherever you want. Now you have fairly undisturbed soil. If you want to measure the moisture in it you can, and if you want to measure extensively you can. If you just take a piece of loose soil that comes up with the auger, it's been exposed to the air and you don't get a full story.

So I show here some of the results. I'm not expecting you to remember all of these graphs. I simply want to show what was the general result. In the upper left graph I show the gravimetric moisture. It's harder to measure volumetric moisture. You can measure the dry density and infer the volumetric from the gravimetric moisture. The gravimetric is just weight. What fraction of the weight. Weigh the sample, dry it in a commercial drying oven and weigh it again and the difference is the gravimetric moisture.

In this pit we see it's down to 15 feet running about ten. The density might be something like one and a half, so you calculate from that the volumetric moisture. There's a spike right in the middle.

If we look at the next graph coming down, I am plotting the moisture potential. Since the soil sample was not broken by the auger -- I have a real sample put in the bottle, not something that's been disturbed -- I could put a piece of that into a particular apparatus and measure the actual moisture potential and I plot that against depth. We see that the potential here is running something like four megapascals, several times that so-called wilt point, and is tapering down a little bit.

Here is this spike. We see a low potential there. At the same point we see high moisture. That fits together. That's saying maybe the concentration is trying to be the same, and if you have high moisture you will have a lower potential. You have more place to put that amount of something.

This is a second hole in the same pit. I plot the same thing. Here is gravimetric moisture. You see jiggles in it. I think that's not unusual. It depends on what soil is in there and really what got put back into the pit. Down here I plot the moisture potential. That should be more uniform because the water is trying to flow according to the potential, not really according to the moisture, but trying to flow according to the potential so we get a smooth potential curve increasing down to some depth here where it's a maximum. Maybe we can say that's the bottom of the pit. We don't know. I never could detect what was the bottom of the pit. It was not distinguished.

Finally, we see a gradient coming back

down here towards 15 feet. I was happy that I was able to find the gradient. That was a signal to me. I found where it's going. I found the place. If there's a gradient, it's moving.

Why did I stop drilling at 15 feet? Why didn't I take this all the way down? I ran out of money. Folks, that's what it was.

This is the other pit. This pit was 31 years since closure. This pit is 11 years since closure. Again, we see gravimetric moisture. A different profile. For some reason high moisture here. It can have to do with the soil that's in there but we see a smooth curve of potential and again I got deep enough to find the gradient.

Having good samples I could deal with more. I could measure the chloride. Here is the Pit 5, 5A, the first hole in the pit. We see low chloride right where the spike was and barium chloride down to a depth of 15 feet. If I look at the pore water chloride -- now, since I know how much water was in there because I dried the sample and weighed it, I know how much water came out. I know how much chloride was left behind in the sample so I can infer how much chloride was in the pore water. What we are finding here is numbers like about 25,000 at the bottom going down to very small at the moisture point and coming back up towards the surface.

That means the water, although the surface was dry, the water that was at the surface was not very drinkable by the plant. That seems to make sense because the surface was bare. Here is the second hole in the same pit. You see again jiggles, perhaps different layers at that point. We can't tell unless we go back and microscopically diagnose the cores that came up and I'm not qualified as a geologist to do that.

Down here we look at the pore water chloride. We think we see the start of the gradient and we see variations in the pore water chloride. What counts for the motion is the gradient. Here the gradient is greater potential downward. Greater suction downward. That stuff is moving down.

Here is Pit 8. At eleven years I look at the soil chloride and we are finding something like 15,000 milligrams per kilogram of water, roughly milligrams per liter. The point is that the moisture in that is very high. It's not supportive of life. And that's the whole point I think we are making of this.

Now, we can argue about how it got down there. We can say the operator dumped it on the surface. We can make any kind of scenario we want. But the fact is, very high chlorides are down there under that pit. So the surface chloride was like 3,000 milligrams per kilogram. Subsurface moisture appears kind of normal, as far as I could tell, in quantity. I didn't find any bottom to the plume at 15 feet, as deep as I could go in my budget, and the moisture potential -- now, this potential measurement includes the osmotic because I was measuring, in effect, the partial pressure of the vapor. I was measuring the concentration of water vapor and water vapor does not carry chloride so essentially the layer that evaporates water is like a semi-permeable membrane. The potentials are consistent with matric potential of sodium chloride plus osmotic pressure. In other words, that's just a verification that I knew I was interpreting correctly and knowing what I was doing.

A monitored well near one of those pits showed chloride in the groundwater. I cannot assert that it came from the pit. I didn't drill all the way to the groundwater. That's too bad. Had I known at the time I would have tried to spend more money?

The sampling, drilling sampling sponsored by Marbob was the Burch Keely unit. We drilled, as I recall, two wells there. One was the No. 49 spudded in October of 1979. This is a picture taken at that. Back here is a rack that I had made set on the truck and you could lay out the cores. You notice this ground is in much better shape. This is what I would call snakeweed. There are other species here. The ground here at the pit seems not quite so well vegetated as what's back here, but at least things are growing and right on the surface, I think when we see the data, there won't be chloride.

We sampled two wells, well 49 from 1976, an unlined pit 31 years old. My knowledge of the operator, Well 321 was spudded in 2001. That means it was six years old. It was a lined pit and the liner, by word of the operator, was closed over the top of the pit when the pit was closed.

We can again look at the gravimetric moisture as a function of depth. This is for Well 49. You see jiggling. Now, here at least even my eye could identify different soil types in the column, in the core that we pulled up. And I wrote down what I had seen. Simply at the top there was sand. Down here there was sand. Roughly going into more clay-like material, sand. Back up to clay and more back to sand.

Why is that significant? Low water and sand, high water and clay. If they are trying to come to equilibrium in the potential, this is just the kind of thing we would expect. So that gives you a clue why you can see moisture profiles jiggling.

The same thing is true in Pit 321 which is the pit that was lined and the liner closed on top.

You get a background hole which I showed a different picture of there if you want it. There's nothing unusual in the background hole. Here I look at the moisture potential as a function of depth. We see a potential that would be harsh but maybe not impossible at the surface. It's less than the wilt point. The wilt point is that arrow. It increases down here probably due to the osmotic pressure of the contents of the pit and then it tapers off.

Notice, this is a lot less jiggly than the moisture curve. That's because the water is going to flow to points of high or low. It's going to try to even out the potential wherever it is.

If I look at the chloride, there was no

chloride at the surface. We find high chloride in the pit and below the pit it tapers off down to about 20 feet. I remember as we drilled that, the man from Marbob said, "Gee, I guess that liner didn't do us any good." Maybe it wouldn't be expected to.

If you want to know about quality control, his technician, his hired consultant took samples at the same time I did and their samples were sent to the standard laboratory and you see they correlate pretty well with my curves. I think I had some red spots on some of my other graphs. I didn't notice them. But I also sent samples to the laboratory for confirmation when I was just doing things by myself.

This is the pit 321. The lined pit. That's the one where he said it didn't do us much good. We see a double spike in dry soil chloride. Exactly why is hard to tell. There may have been a flood of moisture from the bottom of the pit. I think we are trying to make up stories from minimal data here, but what we can see is we do have a progression down to 30 feet or 35 feet.

Now, it can be argued that the progression in these two is the same, one being older and one being younger and, therefore, that shows it will never move again. But also you can say we have a gradient and there are all these processes going on that cause motion, although over time, and we sort of wind up arguing back and forth on that because we can't go forward 100 years to see what really will happen.

But there is a story to go with this. I had almost forgotten about it. It was in Pit 321 that was lined. We know the liner was folded over the top because we found it. When we brought up the core right there in the core was a disk of the plastic. Right under that disk for about two inches was this white thing. I remember it. It was kind of granular and I picked it out. It was a little crumbly. I picked it out of the core and I set it on the rack of the truck and I realized by the old taste test it was salt, a layer of salt mixed with a little sand. It looked like 90 percent salt. It wasn't a thing you wanted to eat. It looked dirty. Right at the top of the liner.

Later in the day when I turned around and looked at it, it had disintegrated and fallen apart. I didn't sample it. I sorted of knew it was salt. It didn't strike me as anything but curious at the time.

As I got to thinking about the seasonal cycle, I said maybe we were pumping to the top of the enclosed volume, enclosed by that lining. Maybe that's what's going on. It had only six or seven years, but it pumped. Now, you could also say that there was two inches of salt on top of the pit when they closed it. I think that's unusual, but that's possible.

As much as I can make that it's an interesting story, and it fits with the notion that you can have transport mechanisms going on that maybe you don't expect.

This is chloride versus depth at the Loco Hills with the two holes. It peaks at about 30,000 in one. It shows the double hump in the other one for which we do not know why. We see zero chloride right at the surface but if we get down some depth we find sometimes some chloride.

I think this fits with Dr. Buchanan's picture. You can get an intermittent rainfall and if it's enough, you can flush the surface down a foot or so. If you are careful and don't let a lot of it come back one way or another, you get some vegetation going on there. You can keep that surface, the immediate surface layer.

This third graph is just quality control. I plotted all of the potential measurements and said do they rise at the same slope as an osmotic curve, and they do. So I said most of this rise is not soil properties, it's osmotic potential of the salt. It's the salt or shale. It's just when you do scientific work you check and you check and you check. Most of my work in the laboratory and my own personal work in these things, I spend probably three-fourths of my time trying to discredit myself, trying to disprove what I think I am proving.

Well, both the older and newer pits suggest/confirm that the chlorides are not retained by the pit material or even retained by that one liner. In the Caprock, the chloride exceeds past 15-foot total depth. I don't know the bottom. In Loco Hills we found both pits had a leading edge down to 25 to 30 feet.

Now, why is this important? It's only important because 100 other pits haven't been drilled. It came up and got initiated because there were so many statements of there's never been harm shown from pits. Well, the only time you hear harm is when somebody's groundwater gets contaminated and they pump it out and get a complaint. Somebody detects it in groundwater, but we haven't looked under many pits. We are not dealing with much real data.

I go on then. What can you make of this? So I will present numerical simulations. I'm going to do a little in-depth explanation of what do we mean by a simulation. Because we hear the general word modeling. Modeling means I have a conceptual picture of something and I will calculate or estimate based on that conceptual picture. A simulation fits within the realm of modeling but not all modeling is simulation. Simulation might be done by a recipe.

For example, in soils, you could say well, we have looked at many, many landfills in Kentucky and we find that generally if we know the moisture here and the moisture at the bottom, we found that the groundwater either is or isn't contaminated. That's kind of a very gross recipe. Or you can say the water will move at roughly this rate all the way through. That is a recipe and you can use it and it's a very valid model as long as it's within your assumption.

What is a simulation? With your permission, Madam Chairman, I will draw a picture.

CHAIRPERSON BAILEY: Please do.

MR. NEEPER: In a simulation, particularly something like soils, you can be simulating something else that is not in space, like soils is in distance. But in soils, you divide the soil up into an imaginary bunch of little volumes. As many as you wish. And you can provide all your numbers for each volume to the center. That forces you to say whatever is going on, I'm treating it as though it's centered here but it has to use the total volume of that cell in order to make sense. How much moisture per unit volume do we have? It's all the moisture in this box and we locate it so it's right in the center.

Now I will calculate. For every cell I will determine the moisture potential, I will determine the amount of moisture that's in there. I will use the soil properties to calculate the unsaturated hydraulic conductivity. If I am doing a really good job maybe I will calculate temperature. I can calculate diffusion. If I have a good code, I can turn that on and off. All of the various physics kinds of things you can think of, in principle I can put in there. The bigger the code and the more complicated the code and the harder the code is to use, the more of it gets in there.

So the code that I was using was the Yucca Mountain Code. It was originally put together to do the transport to certify the Yucca Mountain nuclear waste burial site and it has just gone on and on. It's using for many other things now including carbon sequestration, so it's very large, very hard to use. I don't recommend anybody try it but it's available to the public should you want it.

So now given two points here I can calculate the flux, whatever it is, of whatever I am interested in between those two points. And I go through here and at one time I take all these properties and I calculate all those fluxes. And then I update the content of every cell. Now I have a whole new situation. And I repeat the process and I repeat the process.

And so throughout time I am simulating what I think is the actual physics going on. Obviously, you can't include every piece of physics in the world, and if in this case if you went clear up to the ground surface and you wanted to simulate the interaction of solar heating with in various degrees of saturated flow up here and other things, I have seen some attempts at that. I developed the equations to do that. There was no budget for somebody else to put it in the code and I wasn't going to spend a couple years of my time getting that in the code, so I would satisfy myself with simulating from here downward and not look right at the ground surface.

But this is the difference between simulation and modeling in general. Simulation is one type of modeling. You can obviously do two or three dimensions. You can have another box off to the side there. You can do multiple porosities. You can treat this as two different pieces of porosity within the same conceptual volume of the soil.

CHAIRPERSON BAILEY: Would you please clearly label that? Because it will become a part of the record.

MR. NEEPER: Would you like to give me the label that would be most useful?

CHAIRPERSON BAILEY: Neeper Exhibit No. 1?

MR. SMITH: This is Exhibit 5.

CHAIRPERSON BAILEY: Let's make it Exhibit 6.

MR. NEEPER: I am pleased to do that. Just a schematic of what is simulation. It's what computers are good for, what makes a valid simulation. One thing is the time step you move, it has to be short enough that things don't change so much that you are not really representing the properties correctly. So what you do is go in and you cut the time step until you get the same answer and you cut it again and you still get the same answer and then you say all right, I am in the valid region of time steps for this problem.

You do the same thing with the space steps. In running the soils, I was running space steps, size of the boxes from centimeters down to at great depths, maybe as much as -- where nothing is going on, ten meters, and that just serves as kind of a boundary condition that can change for the dynamic problem up above.

So I show the one-dimensional model. The model is the picture, the conceptual picture. I say to get a steady state I would just put in native soil, whatever the soil is going to be, put in an aquifer in this case at 20 meters, 60 feet, and let it run until the moisture distribution was whatever it was going to be. I set a volumetric measure at the top and that is not a guess. That's a measured number. That's not a recipe. That just gave me a starting condition. Then I put in an imaginary depth of waste, whatever it may be. I happened to put in three meters. The actual depth is not crucial to what we are trying to show. The surface layer, again, is not represented because the boundary conditions of the problem is the measured volumetric moisture at that point.

You can say -- I heard the word yesterday that soils physicists do not put plants in their models. Well, the plant was above the place where the moisture was measured. So whatever the plant did and whatever the rainfall did, it was reflected in the measurement and we are driving the calculation with measurements.

These are the measurements. The measured values of temperature and moisture at a 20-inch depth at a feet-on measurement point in Lea County. The data are from the Natural Resources Conservation Service No. 2107, somewhere near Crossroads, New Mexico.

One of the things I notice as I look at it now, I looked at this last night and when I did this analysis now five years ago, I just regarded this as instrument noise. I'm not so sure about that. I would like to go back and expand that data. If their instrument is up, it shows the cycles due to the temperature waves because a daily temperature wave has a characteristic depth of something like 20 inches. So you would see it down there.

We see the moisture changing really not a lot up until you get a big rainstorm and then it tapers off after the rainstorm. And you can say well, maybe that wasn't a typical year. That's the only year of data I had. They ran some into 2007 at the time, so I picked up the 2007 data, found a place where the moisture was the same as 2006, glued the two together and said, "I will make an artificial wet year, something with a lot of rainfall, and see does that make any difference in my result?" I ran several soils. I will show only a few of them here.

Here they were characteristics. I took the characteristics from a published list of characteristics from soils with these characteristic names like sandy loam or clay loam.

At zero year you can see moisture in the aquifer. That's the blue line. It comes up. There's a moisture level. I set that rather arbitrarily in the pit at 80 percent. The pit is likely to be pretty wet. Then the pit would taper off to the surface. This degree of saturation. If we look at what happened to the chloride or to the salt at zero time you have it in the pit, the green line is what you see at ten years. What you see is a pulse moving down. In this case at 40 years you see a pulse down here at a depth of about 18 to 12 meters. It's just barely reaching the aquifer.

At 100 years it has pretty well come down and what has come down has reached the aquifer. If we go to a sandy clay loam, a more moderate soil, we look at the moisture, begin to bleed moisture out of the pit, we see the moisture profile moving down. Moisture from the pit is actually raising the moisture level in the soil below it a little bit. We are seeing a downward flow of moisture. If we look at the salt level we see we begin to bleed salt out of the pit. It doesn't go so far down. At 100 years, the bottom of the salt, if you want to call it chloride, is only down at about ten meters. We have tightened up the soil a little and it doesn't travel down. Uh oh, it goes up. What we find is it's being sucked upward in this soil and if you sat right out here at the zero level of the calculation, what you would see is in the very top cell of the calculation you would see that jiggling up and down.

When the rain hits, it's going to go down to zero or close. When it dries up, you will see it come back up because shortly under it there is more chloride left behind. So what goes on in-depth versus surface is going to depend on the soil type.

If we use a clay loam or a really tight soil, we see, first off, a very different moisture profile in the soil under equilibrium conditions. Some comes out of the pit. Again, it doesn't penetrate very deeply in 100 years but it come out up to ground surface. In fact, we see here even a little pumping higher than the concentration of the pit because you pull water out and it dries. But if you sat on the surface you would see jiggling going up and down.

What are the results? These are simulations. They are not a given soil. Soils have great variation and if you are going to model a particular soil you are going to go to a lot of work to know all the properties in every cell. I chose just three representative cells and filled the whole depth with it. What we find in what are called the looser soils, the chloride preferentially travels downward. In moderate soils, the chloride travels less, and in tighter soils you get more of a tendency to go up where it seems to concentrate above the pit.

Well, how do we compare this with one thing that's often measured which is recharge? In the loose cell with that top moisture, if you had that loose cell you would be getting between one and three inches of recharge a year. I think probably most of the southeast doesn't get that much. That's just from rumors I have heard but I haven't looked it up.

But if I looked at the moderate to tight soils, what got down to the aquifer was less than .05 per year. So you can get it either way. If you have no recharge going down to the aquifer, the diffusion is slow. You will carry it part-way down but it will be a very slow progression.

CHAIRPERSON BAILEY: Why don't we mull this over over lunch?

MR. NEEPER: If I were to mull it over, it would give me a terrible headache.

CHAIRPERSON BAILEY: It's a good time to take a break to see if there are any people who have signed up for public comment. Irvin Boyd.

IRVIN BOYD

after having been first duly sworn under oath, was questioned and testified as follows:

CHAIRPERSON BAILEY: Please state your name and your place of residence.

THE WITNESS: May name is Irvin Boyd and I live in Eunice. Anybody don't know where Eunice is, it's south of Hobbs. Commissioners, I would like to thank you all for the opportunity to speak and I would like to thank everybody here for your care and participation in trying to solve and work through some problems that we have. You know --

CHAIRPERSON BAILEY: Before you begin, I must caution you that we have a five-minute time limit for each person for public comment.

COMMISSIONER BALCH: Not to say you can't come back this afternoon or tomorrow -- not tomorrow.

THE WITNESS: I want to tell you all that I live on my grandad's homestead. I have purchased it from my family after they have died. It wasn't left to me in a will, I had to purchase it. But it's been my home all my life and it was my dad's home and I hope it to be my children's and grandchildren's home.

But I will tell you this, too. I can't make it run without oil and gas because there's not enough land there and there's just not enough money to do it. So I do ranch. I have a few head of cattle but I make my living to support my ranching habit as a construction specialist in a pipeline company. We lay pipe all over -- all around New Mexico, mostly southeastern now.

But I live out and I work in the areas that we're talking about. I can walk out my door and probably within less than a quarter of a mile radius there's multiple pits that we can look at and some of them were drilled when my dad was a child and they are still barren. Now due to the Pit Rule, I can look at people that used closed-loop systems and the pads are a little bigger. We lose a little more country, but we haven't lost that pit area.

I have got confidence in the industry that that whenever that well has completed its lifespan the caliche can be picked up and you cannot believe the efforts that predominantly Apache, Chesapeake are using on my place to keep spills down, keep contamination down. That's what I would like to see is less work with prevention.

Now, I was asked to be on a pit work group when Laurie Rotenbury was director of the Commission. And I did. I sat in there for a long,

long days. I also was asked to make comments during the Fesmire pit hearings. And so we know that the pits have been considered a problem for years now. What can we do with them? We don't know. But we have got technology now to confine these contaminants in pit contents and now we are using them and it's working.

I understand it's costly in some ways and we don't like to dump them in a specified place. I dislike driving by CRI and I do very often. It smells bad. Sundance, Perabo is another place that takes these cuttings. It's not a pleasant place to be. But I would rather they be there, and I would like to consider them as storage places rather than disposal places. And I, along with many, many other landowners do not want these cuttings stored on our places anymore because it's not a necessity. What I would like to say and see is the monies that are spent in studies trying to say that this stuff is not going to hurt us when I can walk out my door and look and see what it has done prior, is let's use some of these monies and let's focus on the problem.

Let's find out how we can clean up these cuttings. Because if the cuttings don't have chlorides in them, if they don't have scale inhibitors, rust inhibitors, other drilling chemicals in them, then it's just a sterile soil. Boy, I have places we could dump them. I could feed cattle on them and bring it back to life.

That would be solving the problem. What we are doing here, we might solve a problem now but what's going to happen if we go too far north or too far south in the next administration? Well, we need to do something different. It's not good for the landowners or it's not good for the industry. We need to come back and redo this again. So we are not solving the problem. Thank you all.

CHAIRPERSON BAILEY: Since you made sworn testimony you are open to cross-examination. Are there any questions of this commenter?

MR. JANTZ: I actually have a question. Mr. Boyd, Eric Jantz with the New Mexico Environmental Law Center. Could you describe what you -- you mentioned you have seen what the pits have done to your land? Could you describe it?

THE WITNESS: Well, they are barren. You all seen some pictures in Dr. Neeper's examples. They are barren. You know, you can go there and chlorides are there. We have one pit area where the soil is very susceptible to erosion and it's moving and moving and it's just killing all the vegetation around it. We also have a problem in these sites that are not growing usable vegetation.

We are having a big problem at our place with African root. So, you know, that's one of the things that I can see. It's there. You can see it. Anybody can see it that's out the field. That's why I would appreciate to be able to -- everybody to be able to work together to prevent a problem that we know is there. I just don't see how we can prolong it or do whatever. Let's work at trying to get it involved.

MR. JANTZ: Are there closed-loop systems on your land?

THE WITNESS: Yes, they have used closed-loop systems.

MR. JANTZ: Do you see the same problem with those?

THE WITNESS: No.

CHAIRPERSON BAILEY: Any other questions?

MR. HISER: Mr. Boyd, I'm Eric Hiser and I represent New Mexico Oil and Gas Association in this case. I appreciate you coming in. Mr. Jantz asked you about pits that you had seen that were bare. Were those pits that have been done recently, say since 2000, or were those pits drilled in your father's time?

THE WITNESS: Most of the ones that I talk about being close to my house were drilled when I was a kid and also in my father's time.

MR. HISER: Were any of the bare pits that you have seen those that have been drilled since 2004?

THE WITNESS: Probably not. I do have pits that have been drilled or wells that have been drilled later and I can't tell you the exact dates on them, and the contents have been buried there on the location, but I know to me the same contaminants that are on the surface now are closer to the groundwater.

MR. HISER: The surface, does it look better for you?

THE WITNESS: It is better. The surface is just like any surface that you might blade off to put a house or do any kind of blading and scraping and disturb the original vegetation. It takes years for it to come back like it was.

MR. HISER: Thank you so much for your testimony. Appreciate it.

CHAIRPERSON BAILEY: Dr. Neeper, do you

have a question?

MR. NEEPER: Yes. Mr. Boyd, to your knowledge has anyone ever looked under a pit on your land?

THE WITNESS: On all of the pits that I have on my place, when I was up here at the Fesmire pit hearings I got a call from an old company, Lacy Reserves -- or Resources, and they said, "Irvin, we have a problem with one of the drills." They had a 12-well drilling program and they were not all on my place. And they said that the pit liners leaked. And I had asked them, "Would you guys use closed-loop? I don't want anymore pits." They told me, "No, we figure it costs approximately $30,000 something." That's just what they told me. I have no idea that that's what it is, but they called me and said, "Irvin, our pit liners have leaked and it has gone down." And they traced it down and dug it out to probably 30 something feet and our water table is in the range of 50 feet. And it got into what I like to call the water sample. I'm not a geologist, not a professional.

But there the OCD allowed them to put a plastic cover on it. They did drill a well to see if the water was contaminated and they said it wasn't, but the flow of the water in our part of the world is from the northwest to the southeast. They drill the monitor well to the north side of the pit out of the water so I didn't have any confidence in it. But I don't have the money to fight it and out of all of the other pits on my place, none of them have been tested under the liner.

I do have a contract with the company that says they had to remove all of the cuttings and they didn't. They closed it and plugged the well. I brought this contract up and I asked them and they did not want to get under there. They said we are scared to see what's under there. And guys, I work in the oil field every day. I realize what it could cost. They talked me into clay capping the area and bringing in topsoil so I could get some surface. So -- and I do know, I have one going on right now -- that the company is obligated to clean this pit up. Well, they started with the battery, cleaning it up, and it just blossomed. I mean, it just -- they said, "It's too much."

Right now they are going back to the other people that produced this location prior to them trying to get help to come in to clean this mess up. But my answer is no, to test underneath pits on my place, they have not done that.

CHAIRPERSON BAILEY: Any other questions?

COMMISSIONER BLOOM: Mr. Boyd, my name is Greg Bloom. A couple questions for you. Thank you for coming in today. You mentioned this company called you and said that their liner leaked. What year approximately was this happening?

THE WITNESS: When the pit hearings were going on with the Fesmire hearings, was that 2007? That would have been it.

COMMISSIONER BLOOM: And you said you have Chesapeake on you now?

THE WITNESS: I do.

COMMISSIONER BLOOM: That's closed-loop, I think we established.

THE WITNESS: Yes. The last wells that they have drilled on my place has been closed-loop. Chesapeake and Apache.

COMMISSIONER BLOOM: Both of them closed-loop. When they approached you, did they want to do a pit with a liner or did they immediately go to closed-loop?

THE WITNESS: Prior to this, my agreement stated that if they used a pit with a liner then they removed all the drill cuttings and contaminants from the property. These were coming up and I don't remember whether the Pit Rule was in effect or not yet. I think it probably was. They said, "Irvin, we are not going to squabble about closed-loop or anything. We are going to do it closed-loop." So there was no request there from me or no discussion. They said, "That's the way we're going to do it."

COMMISSIONER BLOOM: It's my understanding that Chesapeake is solely doing closed-loop. Have you seen that in your case?

THE WITNESS: No, I cannot tell you that. As a broad spectrum I cannot tell you.

COMMISSIONER BLOOM: How about on your neighbors? Do you know?

THE WITNESS: No. I can't tell you because I'm not familiar with Chesapeake drilling on my neighbors.

COMMISSIONER BLOOM: Thank you.

MS. FOSTER: Commissioner Bloom, I represent Chesapeake as their lobbyist in New Mexico. If you would like to have a position from Chesapeake I can obtain that.

COMMISSIONER BLOOM: Thank you. Thank you for your time.

THE WITNESS: I would like to thank all

these people that try to do it right.

COMMISSIONER BALCH: One more question. You are the surface owner and somebody else is the mineral owner?

THE WITNESS: No, I do not own minerals. My grandad sold the minerals after he homesteaded.

COMMISSIONER BALCH: My understanding as a surface owner is you can stipulate using the Surface Owner's Protection Act how operations are conducted on your land.

THE WITNESS: Well, I don't know that I have that right even through the Surface Owner Protection Act. I would love to be able to say we are going to do it like this, but I don't know that I have that right so I cannot tell you that I do.

COMMISSIONER BALCH: Thank you.

CHAIRPERSON BAILEY: Anything else? Mr. Boyd, thank you for coming in. I appreciate your comments. We will take a break for lunch and continue until 1:00 o'clock.

(Note: The hearing stood in recess at 12:00 to 1:00.)

CHAIRPERSON BAILEY: Dr. Neeper, you were in the process of giving direct testimony.

MR. NEEPER: That's correct, Madam

Chairman. What I had spoken of was a simulation using -- what I showed was calculations using three different soils. I did not simulate multiple layers and different soils that you might find in different places. I was trying to find out what kinds of things can happen.

What this kind of calculation provides is something on the size and the time scales of the activity, giving you some idea of how much might move, how far, how fast. It does not provide exact quantitative estimates which are going to be sensitive to the numerical values of the parameters, particularly the rainfall. What happens in the upper layer of soil is certainly going to influence. That measured volumetric moisture at 20-inch depth. In this calculation injection withdraws water just as it does in the real world.

The data as I look at it suggests to me the instruments are in a rather loose soil. I was thinking that a tighter soil with greater suction might have shown greater volumetric moisture, but beyond that I can't make a guess really as to what was the exact situation at those instruments.

Three-dimensional -- this was a one-dimensional examination. A three-dimensional dispersion would allow the chloride to move horizontally. It would create a broader, probably initially faster plume. Later it would probably be slower because it's spread out farther.

I used 2006 as a supposedly typical year because it's the only data I had. I created a supposedly high rainfall year just by moving in some data from 2007, and the wetter year, the seven-year intervals really didn't have much effect on the long-term transport in the moderate and tight soil. When you get wetter and really sandy soils it's going to move downward faster.

The model did not include colligative influences. That means the effect of whatever is dissolved on the surface tension, vapor pressure, vapor diffusion, viscosity, osmotic pressure in the thin element. I could make a guess that these might have slightly increased the chloride transport down below. They could strongly influence things in the shallow region where you have a lot of dynamics going on.

As I explained, I did not attempt detail modeling the region near ground surface. I have seen one or two other papers that were credible doing that, and I doubt that there really is a code out there that can handle all of that. Somebody has to invest a lot of their lifetime building a numerical code to do that.

Conclusions from the sampling and the simulation. What you see is the concentrations in the waste are many times the toxic limits for biota. I concluded that only an intact and impermeable, sealed liner could prevent contamination with the vadose zone. What you see is the stuff moving out. We can't exactly predict how much, how far, and I don't see there a great argument between Dr. Buchanan and myself. He says it will go about this far and no farther. I'm not sure of that, but I certainly support his arguments that you can do a good remediation on the surface, if you will. It may eventually come up. You can't guarantee what's going to happen to the surface but you can certainly remediate the surface and you know if the rainfall is low enough that the downward progression will be slow once it gets to a deep enough depth.

What we ask -- I think it's fair to ask what protection is offered by liners. This is not an argument against liners. This is simply saying what are we talking about in our rules? If we take a critical evaluation, what are we talking about.

MR. HISER: Madam Chairman, at this point I would once again object to the scope of expertise. If he would like to offer a sworn statement, I have no objection to that.

CHAIRPERSON BAILEY: Would you like to respond?

MR. NEEPER: The simplest physics involved in soil physics is probably the Darcy law for fluid flow in porous medium. That is, that the velocity of the fluid is proportional to the gradient of the pressure. This is what is implicitly referred to any time you talk about a hydraulic conductivity. The standards within the proposed rule include the liner standard with a specified hydraulic conductivity. If I can't calculate the flow to that liner -- that's probably eighth grade algebra -- I'm certainly not competent to do anything else.

COMMISSIONER BALCH: I am certainly comfortable with Dr. Neeper's qualifications.

CHAIRPERSON BAILEY: Your objection is overruled.

MR. HISER: Thank you.

MR. NEEPER: What I write on the slide is the transmission time, the transmission, it goes through a liner. Thinking one-dimensional straight-down flow divided by the head, the depth of fluid that's on the liner. And the flow rate is the conductivity times the head divided by the thickness, and I said oh, and the amount that flows through then, you must multiply by the time. I said I want to divide by the head to know how much goes through per unit of head, so I divide by the head and finally come out with a simple expression of K times the time divided by the head.

If you plug that into here, the hydraulic conductivity, and you put in for D a thickness of 30 mil, the transmission per head comes out to be about .41, which totally surprised me. That means if you maintain that head by pouring liquid on top, 41 percent of that depth would come through in the air.

That doesn't happen. I don't think anybody in here has seen that happen. So why would this look this way? The liner manufacturer has to guarantee his square many, many yards or maybe a square mile of material he sells to meet a standard. And so he can't, I think, reasonably claim some extremely high standard. He has to have something to meet. We always thought this was good. It went in the rule. I don't think we ever questioned it because that's what's available. We don't see these liners leaking.

But this is what we mean when we are talking about a standard for the liner. Why would I even care? Because our proposed standards either for leaving pit waste in place or for digging and removing them out and sampling the soil underneath are high enough that you could have a substantial transmission by a liner and still meet the standards. That does concern me.

That is the significance of the liner exercise. Liners are not necessarily secure forever. We have liners quoted for unstrained material, strains. Materials have less lifetime with strained. Burials settle. We don't know what's going to happen on the surface. So we shouldn't be totally trustful that a liner is going to hold stuff for a time period of centuries.

The rule removes restrictions on pit slopes simply saying -- the word isn't account but some recognition of the repose, the angle of repose has to be taken. Well, the angle of repose is really that angle which, ideally, if you drop another few particles you will get a slide. That's what we mean by angle of repose. So in a lot of soils it's possible to at least temporarily dig a vertical wall excavation and have it hold for a while, and sometimes liners are installed there. I show one, and that leads to tears in the liner.

Why should I be concerned? It's personal experience as well. I was in charge of a project in which we had something like an oil field pit and it was smaller. It was probably about 20 feet on a side rectangular pit. Vertical sidewalls in solid rock. So it was as good as you could be. The science behind it required that we had vertical sidewalls for what we were measuring. It was a saltwater pond.

After a few months of operation we had a leak in the primary liner. The leak detector went off and we had water going into the secondary liner. We patched it underwater proving that you could patch a liner underwater, but I don't recommend it.

Ultimately, the secondary liner leaked and we had no tertiary leak detector to tell us that. Why were they leaking? It was the vertical stresses on the walls. The friction between one liner and another one and the weight of the water would cause the liner to stretch and stress vertically and the tears were down at the bottom. So that made me very uneasy about trusting vertical walls, even though we had ideal situation.

Can liner strain be avoided during trench burial? This is not a dirty picture of somebody's pit or trench. That's not what it's for. It's looking at what you need during trench burial. You don't make it really fine. You shouldn't have to. But you notice curves and stretches. This operator, as best I can tell, has done the best job he can. He put in wrinkles where he can so there's excess material to relieve strains. Yet you can look along here and see areas of strain. Strain will occur, particularly after you close up and you can't predict what's going to happen.

So in the big picture of the rule. This discussion, the reason we are having the meeting really, is due to the industry's exemption from RCRA. I kind of came into this business as a RCRA-regulated party. Our broad challenge is to protect the environment and the proposed rule has some changes, for example setbacks, that leave me uneasy. I will give you one reason for a setback.

There's a setback requirement of 200 feet for a pit from a tributary of a named watercourse. I have been out and seen many little canyons that were not tributaries to a named watercourse but nonetheless were sharp and steep. My feeling would be putting a pit right up close to those will ultimately result in an erosion of the pit.

Why would I feel this way? One case I was on, the side of the mesa had been bulldozed out, a flat area created where the drill rig could go and a pit could go. It had been left fairly flat but the materials to create this area was simply bulldozed into the adjacent arroyo. So the level of the top ground surface or the level of the platform surface was about equal half-way up to the pine trees that are right next to it. I don't think we want to encourage that kind of thing.

As best I could tell, that situation would be pretty close to allowable under the rule because the width of the platform is about 200 feet and it was right up against the arroyo. Sure enough, the waters runs across and eroding out the platform into the arroyo. So it's this kind of personal experience that says we should be cautious with our setbacks. I certainly would get more than that 200 feet.

Many of our producing areas are grassland and scrub. I have heard people say to me that I am trying to protect the desert wasteland, but even the death of overgrazed grass and scrub leads to the desertification, dust bowl kinds of things. And our question is: Can pits do this? The answer is probably yes, if you have many, many burial units. It's not one that worries me at all. It's having them out there scattered around the landscape potentially having an unmarked burial every few hundred yards or so.

I have used this slide previously. If you did have 40-acre spacing and if you had a pit with each well, you would have about -- you could get about 311 yards from a pit. You couldn't get farther from a pit. This does degrade the value of the land for whatever purpose it may have, even just future existence as a landscape. So I think we should be very cautious about burying waste in a widespread fashion.

This again is a table of the closure criteria for soils if you pick up the contents of a pit and you test the soils, and the limit there for that test is 20,000 milligrams per kilogram of chloride. I asked myself, what does that mean? I'm just trying to put the rule in context so we can all deal with it and understand. I work the problem backwards. I took the typical -- I think 50 percent; I have to look back -- volumetric porosity in the soil, and I said what fluid just leaking into that and driving the head downward could generate a 20,000 when you just stop the flow?

It comes out to be about 60,000 milligrams per liter. In other words, it's a fairly high chloride fluid. It's not the extreme that we use in the southeast, but it tells me that conforming to the rule, an operator lifts up his liner and he says, "I have only 19,000 milligrams on the soil. I don't need to do anything about it." In fact, what he has is what we might have called a release in the past. But he is okay now. Up above, we had with a short distance to groundwater 5,000 milligrams per kilogram. That's an interesting correlation.

If I take 15,000 milligrams per liter, the definition of low chloride water, and use the 50 percent porosity described by Dr. Buchanan, you find the two liters of soil will hold one liter of water. Well, the soil density can vary, but one round number is like one and a half kilograms per liter or two liters raise three kilograms. That is, I would have 15,000 milligrams of chloride in three kilograms of soil. If it you divide that out, you find out isn't it amazing that that's just equal to

5,000 milligrams per kilogram in the soil? In other words, the low chloride limit for drilling fluid just happens to equal this standard in a typical soil if you leaked it into the soil.

Now, to me there is an association in saying that this soil limit is permissive of letting that kind of drilling fluid seep into the soil, because you pick up the liner, you take some samples, you find that chloride concentration in the soil and you say, "I'm done, I'm clear." In fact, you might have had a release. You haven't looked very far. You haven't gone down to see what happened. That's where I started this discussion. When you see a high chloride, that's a signal you need to look at what happened and how did it get there.

If we look at the burial of waste left in place, what do the 2500 milligrams or 5,000 milligrams per liter mean in kind of ordinary terms? Because these are not talking about drilling fluids. This is what remains after you have diluted the waste by three to one with supposedly uncontaminated soil and then diluted that result at 20 to 1 with the leach water. That's the test.

Well, what I find when I looked at this is that either standard is unlikely to be exceeded by pit solids that are saturated with brine due to the limited solubility of salt in the water. In other words, the operator doesn't have to worry too much about violating these standards even if his liner is leaking because when he samples the contents -- or he doesn't have to worry about exceeding these limits when he goes to burial. Because when he samples the contents he is not likely to exceed them even if he has had a very high chloride fluid. So there again, what I'm talking about is some caution.

Now, I took a little issue with the SPLP test. I know it's the test you use when you're trying in the RCRA situation to flush the very last bit of some terrible, terrible thing out of the soil. But we have standards for cheap and quick chloride tests elsewhere. Maybe if you are going to have this kind of concentrations you need a full leach test, but the 2500 milligrams per liter, I say -- and this is with a low porosity in the soil -- comes out to about 8 or 9 percent salt. We did the calculation and came out with numbers even twice this great of 5,000 milligrams per liter, 17 percent salt upwards.

In other words, we are unlikely -- this is in the original waste before dilution. We are unlikely to generate by any process those kinds of wastes. So the rule is everything goes. What you do is set a standard that's so high you're not going to exceed it. That's the way I see it.

Depth to groundwater in the absence of site-specific data, the proposed rule allows approximate methods. I think we did that before. It leaves me uneasy because it's whose approximation. Approximations are fine at a depth of 100 feet but at 25-foot depths or ten-foot separation for tanks, I am very uneasy with approximations. You can drill a hole and you can look.

Everywhere in the rule groundwater was stated, it was stated as confined or unconfined. The word unconfined groundwater was used. I take great issue with that. It raises questions I think we don't want to have. Confinement means there's a low permeability layer above the top surface of the water, but what it really means is what's defined, which is if you poke a hole in it you get a rise in the water. That's how it's defined.

You raise the question of rise of water above what? The only way that rise is significant is if you drill another hole right beside it but not quite so deep and it stays dry and the hole that goes in the aquifer, water comes up and gets above the dry hole. Other than that, you don't have an actual functional test of what is confined or what is not confined.

So our definition in a practical sense gets us into trouble. Why am I allergic to this? If you go to the literature you will also find a thing called a semi-confined aquifer. If you look at what happens to the liquid level in the pipe you do put in the aquifer, you will often find it going up and down. People measure that and come up with a thing called barometric efficiency of the aquifer. How much is the barometric pressure affecting it? How well does the barometric pressure itself get through the confining layer? If it doesn't get through, then the aquifer, the water in the pipe, has to go up and down exactly according to the barometric pressure and the flow that the permeability allows.

So we are getting into complicated situations when we go to confined versus unconfined aquifer. The real problem with that is there is no limit to what you can do if you are above the confined aquifer. You can go right down and bury on the top of it, if you want.

Well, a confined aquifer may not be confined tomorrow, as we heard. In my experience that's true. When I was a little boy growing up in southern Colorado, in some places we had 30 feet of head on the artesian aquifer. Even during my childhood time, I remember when the drinking fountains went dry in the schools as the artesian pressure went down. As our society uses more and more water, what is now a confined aquifer can in the future be unconfined. We just shouldn't make that distinction in the rule.

I just drew a picture of it because I had concerns with the term throughout the rule of unused spring. I understand there's an agreement to take that term out. But previously you could get as close to an unused spring as you wish and you could get as close with burial to a confined aquifer as you wished.

I have a little uneasiness with our statement of reclamation. It says, "Reclamation shall be considered complete when all disturbed areas have been either compacted, covered, paved or otherwise stabilized," and then it goes on to or, and after the "or" is revegetation. I am in complete agreement with Dr. Buchanan that things are much better off if they are revegetated, and he has shown us how he can take a very difficult situation and make vegetation grow.

So there was concern that the landowner might want it compacted. Well, following this in the rule there is a paragraph dealing with landowner's considerations and the landowner by contract can get the situation left as he wished, but we should not have a requirement whereby when the operator compacts the soil, that is sufficient, and that's what this says in the terms. "Shall be considered complete when," and then you have the words "compacted, covered or paved."

So what's missing, registration in place of permitting. It leaves me uneasy if the field offices had lots of time but it leaves no decision in the process. Many alternatives includes the term "shall approve." I think an approval should not be ordered because it takes judgment and evaluation out of the question.

Variances that are issued, as best I can read it, you can go to an exception, get a hearing and get a hearing on a variance, but as best I read this, they are likely to allow only interested persons to comment, and I think that's a restriction because the public goes through at least some participation to establish a rule. When there is controversial exception, the public should have a voice in there.

There's no limits on what you can bury if the groundwater is more than 100 feet. This is saying you may contaminate the vadose zone where you want as much as you want. I don't think we should do that.

Setbacks are from occupied residences. I would wish that could be stated a little more clearly because an empty building in terms of the drilling inspector has passed an inspection for occupation. So can you call it occupied? I don't know exactly how to do that, but as long as that word "occupied" is in there, it implies that one does not need to take account of the house unless there's a person actually living in it.

So to give a sum-up, if we are going to bury things out in the field, and I think it's unwise to do so, I think at least we should put a steel marker there just like we do on a plugged well. I don't regard a plugged well as a dangerous thing if the cement job is any good. But I do regard a buried pit or a buried trench as a dangerous thing. Someday somebody is likely to drill in it, drive over it, poke on it, do something to it. I know it's registered at the County, but how often do we look there when we are going out to do something in our field? So I think it merits certainly a steel post if they are going to bury.

Why am I so big on the vegetation? I have heard that it can be revegetated. I believe it can be revegetated. My fear is at some point it will not be revegetated or the vegetation will be removed. If the vegetation is removed, that greatly increases the possibility for the salt to move upward. Once it moves upward, then I think we get the conditions we heard about today or the kinds of pictures we saw in my pictures. Once salt starts coming to the surface it's harder for vegetation to take over. You get less vegetation. With that I conclude my remarks. Thank you. I would like to offer this presentation and this exhibit for acceptance by the Commission.

CHAIRPERSON BAILEY: Any objections?

MS. FOSTER: No objection.

MR. JANTZ: No objection.

CHAIRPERSON BAILEY: The exhibit is accepted.

MR. NEEPER: Thank you for your patience.

MR. SMITH: Let me ask which exhibit are we talking about? We already have his resume entered and admitted. This exhibit is what?

MR. NEEPER: Exhibit No. 5, sir.

MR. SMITH: Have we had 4 admitted?

CHAIRPERSON BAILEY: We can do it again.

MR. NEEPER: I think what's confusing you is Exhibits 1, 2 and maybe 3 had to do with Dr. Bartlit's presentation. He has been ill all week and those papers were submitted with prehearing, but there's been no one here to present those.

MR. SMITH: What about Exhibit 4?

MR. NEEPER: That was accepted earlier today.

CHAIRPERSON BAILEY: And Exhibit 6. So would you like to move to have Exhibit 6 admitted?

MR. NEEPER: I won't use the word "move" because I may not be qualified, but I would like to offer Exhibit 6 for acceptance by the Commission.

CHAIRPERSON BAILEY: Any objection?

MS. FOSTER: No objection.

MR. HISER: No objection.

CHAIRPERSON BAILEY: It is accepted.

(Note: Exhibits 4, 5 and 6 admitted.)

CHAIRPERSON BAILEY: Cross-examination?

CROSS-EXAMINATION

BY MR. HISER

Q. Thank you Madam Chairman. Good afternoon, Dr. Neeper.

A. Good afternoon.

Q. It is good to continue our conversation about pits and soils and water movement. I would like to flip through a couple of the issues that you have raised in your slide and it will take me a moment to find the proper one. It's on Page 3 of the prehearing exhibit which looks like that would be Slide 5.

A. At the top of your paper?

Q. Yes, Page 5.

A. It says Page 5.

Q. In the top paragraph of this, you state pretty determinatively that if the vadose zone is contaminated the entire environment suffers and eventually the water will also be contaminated. Is that true?

A. That's what I feel is true, yes. Why

would I say that?

Q. I guess my question to you would be: Does the environment, in fact, have some restoration capacity?

A. Yes. Restoration implies it's already been damaged.

Q. That may be true. So, for example, if you take the example of a septic tank that was discussed earlier in this hearing, the theory behind the septic tank is that leaches materials so we will go through environmental processes to not have permanent environmental harm; is that correct?

A. That is a theory. I am greatly at odds with that theory.

Q. I understand. Do you deny that those restoration processes happen?

A. Oh, no.

Q. And in the second paragraph of this, you state that in most cases if no release occurs through the vadose zone, water and the soil are both protected. But it would be equally true if there is never any release then there's never any damage?

A. I am seeing that as a trick question and I am trying to see what trouble am I getting into. If you have no release, there is no damage from that release because there was no release.

Q. So this would be a statement of truism then; is that true?

A. I guess. I can't interpret the nature of the question. I can't see where it's going. If there's no release, yes. All right. So you are saying that is relevant to this paragraph, the middle paragraph, right?

Q. Correct. Your observation here appears to be if there is no release to the vadose zone, then there would be no damage. My question is similarly if there was no release to the surface or the groundwater, there would be no damage to them either?

A. Not true.

Q. So explain to me how we get damage --

A. I spent those years of effort at Los Alamos investigating the vadose zone, attempting to find a way either that we could convince people that the wastes are contained or that whatever is in the waste, it would not get to the water. So to say if you have a release, isn't the water protected, that's kind of the term I heard you say.

Q. No, I said --

A. State the question again.

Q. My question was if there is no release to the ground surface, then the ground surface is not injured; similarly, if there was no release to the groundwater, the groundwater would not be injured.

A. Yes, but we must be careful what we mean by surface. If you mean the top three millimeters, you can say the top three millimeters aren't injured but the ability of the ground to be productive can be injured by whether it's either 12 inches below or 24 inches below. If you call three feet below the surface of the ground to the surface, that's surface maybe as contrasted with 100 feet deep, yes, it's a surface layer.

Q. But your answer assumes there was a release. My question was if there was no release.

A. Yes. If I see transport out of a pit or a burial unit, I call that a release.

Q. So you see a release even if there was no release. But let's drop that. Moving on, I think, to the more serious part of your presentation, and this is where we are at Slide 13, the top of Page 7. This is your example of the pore structure of the soil.

A. Is this the page?

Q. No, Page 13. In this example that you have shown, none of the particles appear to actually be contacting the other particles. Is that what you intended to represent or is that just a feature of this particular drawing you used?

A. It's a feature of the drawing but I would like to expand upon that. One particle can contact another at one point, but you will still have some narrow space between the particles that can hold moisture by capillary action.

Q. But you agree that there are places where the particles, in fact, contact each other and that's where we get some of the strength of the soil to stay in place?

A. They have to contact each other.

Q. Is it your testimony that all soil particles are continuously covered with a thin film of water at all depths?

A. Depth doesn't have anything to do with it. The amount of moisture in the soil is what determines whether or not all particles are continuously covered. If you get it drying up, you can break the film so that you no longer get unsaturated transport. Some of the particles will still have some water there somewhere, but it may not be what you think of as liquid water. It's more like an absorbed layer.

Q. Okay. How far down would a saturated flow go into a soil, do you know?

A. Depends on the volume of your saturated flow.

Q. If we were to have a typical rain event here in New Mexico, understanding all the reservations about typical rain which we have had discussions about throughout this hearing, but if we had, say, a two-inch rain, which would be a pretty significant one, in a loamy soil, how far might that go down?

A. I won't give you an answer to that one because I haven't either measured it or calculated it. What I have is my opinion and my experience from digging holes in the backyard, but that is not a scientific opinion and I am here as a technical person.

Q. I appreciate that. Could we go to the next slide, Page 14. Dr. Neeper, in this chart which represents the moisture potential or the matric suction, as you called it, there is a line that divides the sandy soil from the intermediate zone. Do you see that there on the left side of the chart? It's the squiggly one.

A. Let me point. Tell me which way to move.
Q. To the left. That one there. Is that the wetting curve or the drying curve or are they the same?
A. They aren't the same. Usually there's a hysteresis in there. These authors were trying to show typically what does this look like and not matric for a given particular soil.
Q. Do you know if this would be representing wetting or drying?
A. It could be either one because soils differ, so what the author did was take and draw a typical shape of a curve on the graph. He might have copied it from an exact measurement or it might be where his artistic hand was. The purpose of the graph is to show you what these things look like, not necessarily to give you numerical values.
Now, there is numerical values showing you what the suction means, the value of suction. But you can't say that a sandy soil will have this value of suction at this.
Q. So it's meant to be generally represented of a principle?
A. Trying to show you the difference characteristically between sand and clay.

Q. In the upper part of the chart you see the discussion of the absorption region. Is that the area where the water becomes strongly attached to the soil particle?

A. Well, it's the area where you are so dry that it is the water either does not move or moves very slightly, and if you eventually break the water contact between particles it isn't going to move at all. It's a region you worry about because you don't want to get your soils that way, but if you are operating the soil in that condition, I dare say you are not going to transport contaminants by liquid movement of water.

Q. Thank you. If we continue on in your example, I believe, and we move back to my Page 11 which is your Page 22, the bottom statement you talk about the sodium absorption ratio. Is the recommendation there true for soils other than clays?

A. No. In fact, as Dr. Buchanan brought out, when you consider things damaging, it also sort of depends on what liquids you put in there. You can go to higher sodium absorption ratios and use different liquids to put on the soil, so there's a whole area of things that this gets into.

Let me try to review what I was getting at. Sodium damages the soil structure, and when we were trying to consider landfills, the objective was generally you need some guidance at the landfill. Probably you shouldn't get over 15. If it's real clay soil maybe it shouldn't be more than five. That doesn't mean that you couldn't grow a plant of some kind in a clay soil with a five.

Q. There's a dynamic relationship that goes on among the soil constituents?

A. Very much. It depends what you are putting in there. But I have that knowledge from reading. I have not measured SAR in soils versus liquids to which they have been exposed.

Q. Let's turn ahead then to your Caprock sampling, which I believe is your Page 25. This pit was built and closed prior to Rule 50?

A. I don't know what Rule 50 was adopted.

Q. If I were to represent that was around 2004/2005?

A. I can remember -- approximately 2003 we had the first pit work. And is that what led to Rule 50? Was Rule 50 --

Q. For our purposes today, let's assume that was, in fact, what led to Rule 50.

A. Anyway, it was completed, as best I could tell from the records, about 1976.

Q. So would the closure that is represented here conform to the closure that's currently required by existing Rule 17?

A. This is not a closure at all. I don't represent it as such. What I represent out of this is what happens if salt gets away from you.

Q. Right.

A. The first thing I was trying to do out here in hearing a lot of complaints was I wanted to know was it real chloride damage or what you could measure by chloride that was causing the problem.

Q. Right. But you don't know whether this was a case where the pit contents were simply mixed all the way up to the surface or there was a release of produced water on the surface?

A. You can't tell that from this.

Q. And that would be true of Slide 26 as well; is that true?

A. Yes. I hope I acknowledged that. We don't know the history of the process.

Q. If we move --

A. We sure know what resulted.

Q. If we move on to Page 28 of your slides, you are talking about how far, how fast things move, and you talked about the diffusion through pore water is a slow but absolutely certain process. In fact, it's absolutely certain only if there's a continuous connection of water.

A. That's right. If you dry up where you're no longer in a capillary region, heaven help us if we get a lot of our soils that way, but you are not going to get diffusion in the water.

Q. Then in the next paragraph you talk about the natural motions of pore water, what are the natural motions of pore water. You talked about diffusion, which is more the movement of salt within the water, so what are you talking about here when you say the natural motions of pore water?

A. The natural motions of pore water is the unsaturated flow.

Q. And tell us what the components of the unsaturated flow are.

A. Unsaturated flow will move in the direction of the potential gradient, which may be up, down or sideways.

Q. By potential gradient, you mean either the water or the matric potential?

A. I mean the matric potential. Now, that can be affected by things. If you get evaporation in one region that will change the matric potential there. If you move some water, now other water will try to flow toward it.

Q. Are you including within that matric potential movement that is sometimes known as capillary action?

A. Well, matric potential is caused by capillary forces.

Q. So in your mind, those are related concepts?

A. Yes.

Q. Is there any other force that operates in unsaturated flow conditions?

A. Yeah, there's diffusion of water vapor.

Q. Any others?

A. Any other force that operates? Tell me what you want this force to do.

Q. Well, you said things that cause the natural motions of the pore water.

A. A thing that causes motion of water?

Q. Right.

A. Let me think on that for a minute. Because I'm so focused on the motion of a contaminant. That can happen even when the water isn't moving. What can move the water? There may be something in some odd circumstance. I can't think of it. Because usually if the water moves, it is moving towards the lower potential. Now, wait just a minute. Earth dyke. Particularly of interest in your confined aquifers. The squishing of the earth by the tidal forces of the moon will cause water level above a confined aquifer in a pipe to fluctuate, and the combination of barometric pressures and earth's diagonal pumping can go down a foot in some places.

Q. So those are --

A. There can be, in principle, some motion of pore water. That's kind of a small thing.

Q. Have we got the major things at this point?

A. We have the major ones. That's a very tricky question that makes one think deeply.

Q. As we move on to your two slides later, this is where I think in your intervening slides you had the picture of the food color that disbursed, and I want to really talk more about your Slide 30 where you are talking about the distance. In the case of salt diffusion, actually this is just in water itself; is that correct?

A. Yes.

Q. And just so I understand how this works, that one meter in 21 years, I believe you said is the amount of time it takes for two solutions to equalize; is that correct? Or is that the leading edge?

A. Yes, characteristic equilibration. I could right down the formula. You will come within one over E of a concentration. When we are thinking in round numbers, this is the equilibration time.

Q. Once you get to one over E you start to make lawyers very nervous, so we will leave it at that. E is 2.1 7/8 or something like that, but that's all I remember. If we have a situation where it is less -- where I have other things in the solution, be they soil particles or air particles, would you expect that time to increase, decrease or be unaffected?

A. If it's a particle, it's not in solution. Would you care to restate the question?

Q. Yes. If there is a break in the continuous part of the water between Point A where I measured my diffusion starting from and Point B, that would either stop the diffusion or potentially would slow it if it had to go through a very circuitous route.

A. Tortuosity is the term that's used by soil scientists. It's a kind of a catch-all term because if I hand you a piece of soil in the microscope, you would have a hard time figuring out the tortuosity. So it's really the fudge factor we apply to transport rates in various conditions to account for the fact that the flow has to go through a wiggle.

Q. Now, when we are talking about matric potential or capillarity, is there a finite limit to how far water can move under those conditions in an upward direction? Let me be specific.

A. I'm trying to answer this by an example because I want to say no. Theoretically, you could say no. But if the potential -- as long as you have a potential gradient, the water will flow towards the gradient until you reach the position where you are in the absorption region. The example I was trying to think of is the depth of groundwater in Nevada which for the last 10,000 has been sucking up salt and causing a so-called chloride bulge, not a high concentration but it's characteristic of water moving upward that far. I can't remember what the depth is.

Q. And so there's not a limit based on the radius of the path that it's taking?

A. Not a physical limit. Something can happen that would stop it from flowing.

Q. When we look through the slide, the pictures of additional drilling that you did, Nos. 5 and 8 on Page 33, this is the same issue. We don't really know the full story of the closure here or how this pit was closed; is that correct?

A. No, we do not have knowledge of process.

Q. How did you -- I was going to ask how you went through the process of going through gravimetric to potential, but I am thinking you would rapidly be over my head.

A. I would be pleased to answer it on this basis. I know that most physical scientists operate a lot with mathematics. With the exception of quantum mechanics, I would say any physical scientist who cannot explain what he does to somebody else without speaking the mathematical language probably doesn't understand it himself. So go ahead. I should be able, if I understand it myself, to answer your question.

Q. Well, I guess the question that I had -- why don't we flip to where you showed your gravimetric moisture percentage. What I am interested in is how you went from the gravimetric moisture to your estimation of moisture potential. So the one is at the bottom of Page 38 and the second is, I believe, the top of Page 39.

A. This has moisture potential.

Q. The slide we were on. You have gravimetric moisture in the upper left and a moisture potential --

A. At the bottom.

Q. -- in the lower bottom.

A. Yes. What happened is my manner of presentation has misled you. I measured the gravimetric moisture by weighing the sample with an analytical balance, putting it in a commercial drying oven, taking it back out and weighing it again.

Q. And that is the standard method of gravimetric --

A. Right. I measured the moisture potential directly with an instrument that is intended to do that. What, in fact, it does is look at the condensation temperature of the water vapor right above the soil sample but it reads out in moisture potential.

Q. So this is measured values, not --

A. That's measured.

Q. That's helpful because I thought that you calculated them from your discussion and measurement values were very helpful.

A. No, that instrument cost me a bunch of money.

Q. I imagine so. I want to turn to your model, and let's start with the conceptual piece that you showed us on Page 43. Now, as I understand it, this is a one-dimensional model and so you basically established a set of cells, as you demonstrated in your Exhibit 6. At a certain depth, which is 50 centimeters below, which you defined as your zero point, you then injected the moisture level that was taken from these observed readings someplace here in New Mexico?

A. That's correct.

Q. And then --

A. I would like to expand on that a little bit.

Q. Yes.

A. In the physicist terms, that's setting a boundary condition on the problem.

Q. Right.

A. It is saying this boundary has to meet that condition all the time.

Q. Correct. So you have set really two basic boundary conditions, as I understand it. One is a variable boundary condition, which is the volumetric moisture at the top, and the second which was basically an invariable boundary condition, which is the aquifer at the bottom?

A. Yes.

Q. Then your scientific inquiry, what you were interested in is what's going to be the reaction of the soil column between the two if I had a waste with a certain salt concentration at a designated point?

A. And there's an additional reason, two reasons for doing this. I think at the time there was interest in this particular depth to groundwater. But secondly, how are you going to set the initial condition in the soil column? I could have it all dry, very dry, and then it will suck a bunch of moisture out of the top surface. That's an artifice. That's not good modeling, so I set as natural a condition I could. I established your aquifer, your 100 percent volumetric moisture level here and let the problem sit there and dry until it established a natural gradient of moisture in the soil. At least that's a little better than starting absolutely dry or absolutely wet.

Q. Now, in the way that the model was set up, was there any withdrawal of moisture that occurred in the distance of the top meter to meter and a half other than the initial setting of your boundary condition?

A. Let me rephrase the question and tell me if I'm correct.

Q. Okay.

A. You used the word withdraw. Does that imply if you look at my arrow, did I impose any withdrawal, any pulling of moisture out of this region between zero and one meter of depth? Is that the question?

Q. Close, it was a meter and a half, but other than that, you're correct.

A. No. The boundary of the problem is up here and down at the bottom and beyond that it is simulation. Whatever happens is simulated and you hope what nature would do under those circumstances.

Q. Okay. To go back to those pesky plants, any water that would have been removed by root action below your boundary condition of zero you ignored for the purposes of this simulation that you ran?

A. That's correct. If roots were down here pulling out moisture, that was not represented. But the roots that were up here and taking out moisture, those were represented by the fact that I used the measured value of moisture at this level.

Q. Actually, would it not be more correct to see that those roots would be represented if the gauging station which you used had rooted vegetation in that location?

A. Yes. I am trying to remember five years back. I believe I saw a picture of the gauging station because it's in my mind. It was, in my mind, grassy covered. It looked like Southeastern New Mexico to me, but I can't absolutely testify that was the condition of the gauging station because I didn't go there and look at it.

Q. This simulation that you ran, it doesn't tell us really anything at all about the zero to .5 or plus .5 range?

A. No, it does not tell you how the moisture got down to the gauging point.

Q. And so a number of times you said that salt comes to the surface and one of those things you looked at was this model. Does the model actually show salt going to the surface?

A. No, this model shows salt going to the zero point.

Q. But it doesn't know what happens above that?

A. Right. It doesn't know what happens above that point. To me, that's close enough. I would not prefer that we are bringing chlorides or salts and other waste products up that close to the surface.

Q. But there's also not the -- looking at convective flow that might be coming down, except as it may be captured in the moisture percent that you fed into this model?

A. If convective flow came down to that instrument, it's reflected in the measurement of the instrument.

Q. Is the instrument minute by minute, hour by hour, day by day?

A. Again, I'm trying to remember. I'm going to guess that it was half-hourly. Hourly, let me say. I have to go back and look. It's not daily.

Q. If we move on to Slide 45, and looking at the example to the right, particularly the 40-year example.

A. Okay.

Q. In any of the pits that you have sampled or in the examples that were presented by Dr. Buchanan, did you ever see a profile that acted in this way?

A. No, I didn't see a profile like this but I did see a profile that could have been like this. Namely, we caught a forward edge. In other words, I didn't get a whole hump.

Q. Right. But I guess I'm more interested in how the hump is moved. Because you show the hump both at the ten-year and at the 40-year and we have seen 20 and 30-year, I think, in Dr. Buchanan's work. And that didn't show a change in the upper level; whereas here your model would say we should have seen everything move out of the pit area and move down.

A. You're saying that this curve goes to low concentration here but you haven't seen that in his data?

Q. We haven't seen it in any of the data that's been presented that I know of.

A. Under how many pits have you looked?

Q. Well, at least in the available data to this commission as of this hearing.

A. The available data to the commission in this hearing is about five. I can't count it but something like that. Yeah, this is an idealized condition. It has the same sort of soil below and above the pit. It has no layers in it. I'm not surprised that we see a difference. If we saw things exactly the same way it would be highly suspicious. And I wouldn't be suspicious of the data, I would be suspicious of the modeling.

Q. So it doesn't cause you, as a soil physicist, concern evaluating the efficacy of your simulation that we see a movement and form that hasn't been seen in the experimental data?

A. No, because I'm trying to get how far can it go, how fast can it go; not whether I can predict the actual profile that you're going to see.

Q. But if you are concerned with how far and how fast but you are not concerned with the actual profile, does that actually tell us much?

A. You bet. It tells you you have got the potential to move that far. It doesn't tell you in any given case whether you will move exactly that far or not that far, but it tells you something is moving.

In this case, the difference between the yellow curve and the dotted curve told me that it didn't stop moving. It doesn't mean that I could take all of that pit with this type of soil guaranteed in New Mexico and dump almost all of it in the aquifer at 20 meters.

Q. Did this model have a mechanism that would allow the salt not to move down?

A. A mechanism that would allow the salt not to move down?

Q. Or does the model itself require movement?

A. No, the model doesn't require movement.

Q. Are you sure?

A. It has -- let's go into some other kinds of soil. Look at this. You see very little movement downward. Now we are still getting pulses of moisture up at the surface, but you are not seeing much movement down here. They are not getting the water down here to keep moving. In fact, what you are seeing is movement back up towards the surface.

Q. And actually, this phrases my next point which is on your Page 50 where you reach the conclusion that perhaps you underestimated the chloride transport because some of the salts or some of the soils may hold more moisture than your looser soils did; is that correct?

A. I have got to reread the paragraph.

Q. Certainly. Take your time.

A. Yeah. I said -- I think talking about the second paragraph?

Q. Yes.

A. The measurement of 20 effectively in the calculation injection withdrawals water, but they had some deeper measuring points and the behavior of those measuring points suggested to me that the comparison between the deeper data and the data at 20 inches suggested to me that the moisture was moving downward pretty well in the soil which they had. That is --

Q. Typically --

A. I concluded it was a looser soil rather than what I was calling a tighter soil. If I said it was a sandy loam soil or a clay loam soil I would be out of bounds because I didn't characterize the soil. Other people use technical terms. I am looking at soils through these different characteristics. I did not invent the characteristics of these soils, by the way. I took them from that.

Q. Let's turn to Slide 54. What is the head that would be present on a closed liner?

A. There would probably be very little head on a closed liner. You may have some bubble moisture on the bottom, but we're not proposing burial with closed liners.

Q. We are not --

A. The purpose of this example I think we should look at is to say what do we mean when we say a hydraulic conductivity of ten to the minus nine, because I always thought that was small.

Q. Was not the purpose of your demonstration here to talk about how that was perfected by the head on the liner?

A. You have to rephrase the question.

Q. As I read this equation, to me it looks like it's dependent in part upon the amount of head, hydraulic head that is upon the liner and that as the head decreases so would the amount of liquid you might expect to pass.

A. Yes. If you have no head on something that obeys Darcy's Law, you would not get flow according to Darcy's Law.

Q. Let's turn ahead then to Page 62 and 63 starting at Page 62. This is just, I believe, the industry's proposed. Now, you expressed a concern about the 5,000 and 20,000 milligrams per kilogram. Under the proposed revisions to the rule could these limits be left at the surface?

A. No, these limits have to be buried four feet.

Q. That's true for Table 2 as well?

A. As well.

Q. Thank you.

A. My question was more how did you get to these limits for Table 1? How did you manage to experience that much chloride immediately under the surface of the pit? Isn't that an alarm signal? That's what it means to me. That's an alarm signal. They are saying that's permissible.

Q. On Slide 68 under Limits, you say there's no limit to the size of the temporary pit. Is that, in fact, true?

A. In the rule is there a limit to a size?

Q. Yes, in the rule and the proposed revisions pending before this commission is there a limit on the size of temporary pit?

A. I will stand corrected then. It was that that limit submitted subsequent to Revision No. 2?

Q. If we turn to NMOGA's Exhibit 1, which is Attachment A, and you turn to Page 15 of that

exhibit and you look at Paragraph 10, what does it say?
A. You are correct. It says ten acre feet. I stand corrected.
Q. That's, in fact, an existing limit?
A. That's existing. I suspect that was not there in the January version.
Q. We didn't propose to change it.
A. I just don't know why else I have it noted. Go ahead, please.
MR. HISER: That concludes my cross-examination.
CHAIRPERSON BAILEY: Ms. Foster, will you have a series of questions?
MS. FOSTER: I have five questions.
CHAIRPERSON BAILEY: Why don't we take the five questions and then take a break.

CROSS-EXAMINATION

BY MS. FOSTER
Q. Dr. Neeper, good afternoon.
A. Good afternoon.
Q. These questions have been fed to me so I'm going to ask them as they are written down here and you can answer them and the witness in the room will take notes and hopefully the information will be

valuable to him.

A. You may also consult with them, as far as I'm concerned.

Q. Thank you. I don't think that's necessary. Directing your attention to Slide No. 44, Dr. Neeper.

A. I'm going by the page number, hopefully, that's at the top of whatever you have.

Q. Page No. 44, correct. The question that I have for you is what's the average volumetric pressure used in this model? Sorry, volumetric moisture.

A. The question is not making any sense to me. Average volumetric moisture. There were no averages. At the outset of the problem of the simulation we had a profile in which the volumetric moisture changed from 100 percent at the aquifer down to whatever it was at the top of the problem. And thereafter, the volumetric moisture at the upper boundary was what you see graphed in the chart.

Q. Okay. And what is the porosity that you used in the native soil?

A. Give me one minute and I will try to look that up. I thought that question might come up so I got out a sheet that had it. I put the sheet in the copier, the printer/copier. I made an electronic copy and I left home leaving the sheet in the copier but I have an electronic version in the computer if I can get to it. So I am taking the Commission's time.

Q. Dr. Neeper, in the interest of time, you can speak to Mr. Mullins about that on the break. That would be fine.

A. I will give him the -- I don't have the physical sheet to give him together with the origin of where the data came from.

MR. JANTZ: Excuse me, Madam Chair. In addition to Dr. Neeper speaking with Dr. Mullins, could he submit that piece of paper to the record as well so it is part of the record?

CHAIRPERSON BAILEY: I think when we come back from break we can give you adequate time to find it.

THE WITNESS: I can find it but how can we print it?

UNIDENTIFIED SPEAKER: We can do that.

Q. (By Ms. Foster) Moving on to the other questions, going back to Slide 43, you might have answered this question already with Mr. Hiser, but what is the hydraulic conductivity that you used in

the native soil on this model?
A. Again, that's on that same sheet. I hope everything is on that sheet for each of the soils that we used.
Q. Slide No. 49, please. The statement is that the calculated rechart at 67 feet is between 1.4 and 3.5 inches per year. Are these your infiltration rates?
A. This is what you would infer of the infiltration rate. I was simply looking at the calculation and saying how much moisture entered that bottom layer of the simulation.
Q. So this was a simulation. Do you know what source you got that information from?
A. Yeah. The output of the computer program.
Q. No, you had stated in your direct testimony that you had heard that the recharge was 67 feet -- recharge at 67 feet was this rate.
A. In that case I made a misstatement. Because what I say here is closer to the truth. The calculated recharge. What came out of the model was between 1.4 and 3.5 inches per year.
Q. Okay. And does this infiltration rate compare with the published literature?
A. I can't tell you what all the published

literature says about Southeastern New Mexico. I have heard various stories of varying from a few millimeters to a few inches but that's hearsay evidence because I haven't looked.

Q. That's what I misheard. Okay. So --

A. It's possible I misspoke.

Q. So there are two questions and I need to have the additional information on the piece of paper that is unavailable at this time that hopefully we will get after break and that's it for my questions.

CHAIRPERSON BAILEY: Let's take a 15-minute break.

(Note: The hearing stood in recess at 2:21 to 2:35.)

CHAIRPERSON BAILEY: At the break, Dr. Neeper, you were asked to find the information and then to give it to OCD to make some copies. It appears as though they are in the process of making those copies but we will go ahead rather than wait any longer.

MR. NEEPER: As far as I know, they are making the copies and I believe Mr. Mullins has seen the page on the screen.

MS. FOSTER: Yes, ma'am page. He saw the

information and he relayed to me that there would be no further questions from us.

CHAIRPERSON BAILEY: All right. And Ms. Gerholt is out of the room. Mr. Jantz?

MR. JANTZ: Yes, I have a couple questions.

CROSS-EXAMINATION

BY MR. JANTZ

Q. Dr. Neeper, on my cross-examination of Dr. Buchanan, he talked about equilibrium, a point where the chloride stopped moving up or down. Is that your understanding of equilibrium?

A. When I was asking him questions I think I brought up something that sounded like an agreement between us. At least I remember showing some pleasure. I will give my picture of what that equilibrium is. In the near surface, the top two feet, let's say, somewhere there, you can establish -- top four feet. That way we all know what we are talking about. You may establish a chloride profile. In fact, I believe his slide shows some in that region.

As he brought out, you might get a little pulse of saturated flow. He showed it being a certain width and getting narrower as it goes down.

That can drive the chloride downward because it's saturated. It sucks up the chloride where it is and moves down and it dissipates. Now you have left some chloride moved down. On the other hand, now you go into unsaturated flow and the chloride moves back up, and so this is a dynamic of equilibrium. On any given day, things can be in a different place but it's see-sawing up and down.

The question then is going to be to where can it see-saw? Will it always be the same? If you change anything up around the surface, you will change it. If you denude the surface for a while you will get maybe a greater pulse of water going down.

Other things can happen so that this is dynamic. I'll bring up the subtle one here that the soil does have at least two kinds of porosity usually. That is, there will be preferential channels for fluid flow and there will be other channels where if the flow isn't too fast, too much, you will leave some fluid behind.

So now we have a situation in which we have left behind some chloride and it can move upward. We may not thoroughly flush each time. That situation simply leaves me uneasy that you will always have a perfectly good layer at the top of the ground for supporting life and never have any difficulty with it no matter what's going to happen in the future of the world.

A slightly different situation happens down underneath the pit where it's brought out there is less and less pulses of saturated moisture, if any. You have almost purely unsaturated flow. You have an unsaturated condition with a gradient in it. Now, as the soil dries, seasons go on, you can still get some dynamic motion of the water up and down. If you get some dynamic motion leaving some chloride behind, so you don't move the whole profile each time, a dynamic back and forth motion can lead to transport in one direction, and that direction is always down. That's been the thrust of my air flow work. So everything that happens other than a saturated pulse is in the nature of moving chloride in the direction of downgrading it from higher concentration to lower concentration. Anything that moves from low concentration to high concentration in the sense the physicists use it takes work. Somebody has to be putting energy into the system to move from a low concentration to a high concentration.

We say water runs downhill. Nature abhors a vacuum. We have all kinds of popular statements to reflect this, but it means the change is always going to be to distribute material rather than to gather it together.

Q. Thank you, Dr. Neeper. Second question is in talking about Dr. Buchanan, I asked, I believe, whether some of the shrubs that he suggested were appropriate for revegetation, could eventually their roots eventually breach a liner. And he said it was possible, if I recall correctly. But even if they don't, even if it gets to the liner but doesn't breach the liner but then the shrub dies, does that have any implications?

MR. HISER: Is this within the scope of direct?

CHAIRPERSON BAILEY: I think it's related to the question based on testimony of Dr. Buchanan as contrasted with Dr. Neeper's.

MR. HISER: Dr. Buchanan is not testifying.

CHAIRPERSON BAILEY: No, but there is the contrast between the two and this is an avenue to explore.

A. This really follows on a question that was earlier this afternoon. Couldn't I have considered roots from plants up above going deeper than that upper boundary of my problem. And I did not consider that. It was not included in the problem.

I live in fear of that. Yes, as Dr. Buchanan pointed out, there are some shrubs who will grow that deep and I don't know anything about those shrubs or trees. I have seen drilling activity in the pinon and juniper forest in the Northwest New Mexico and in my own experience in the pits in Los Alamos, the deep waste pits we have, I have seen PJ roots way down deep, 20, 30 feet as they sought the water down there. So I have great fear of tree-like things or shrub-like things growing above or right around a closed pit whether or not it has a liner. Maybe it would be better with a liner but if you get roots in there and the roots die, you now have one of the preferential pathways for flow. Kind of like a well that isn't -- it's abandoned but not cemented and I don't think we want to have that.

Q. And just for clarification, what does the preferential pathway do?

A. A preferential pathway is a path through the soil where the resistance to flow is less than in parallel paths or nearly parallel paths elsewhere. Bigger spaces perhaps between the particles. So bigger flows tend to go faster through the preferential pathways. Not absolutely every soil will illustrate preferential pathways. A perfectly uniform sand probably would not, but other soils do. Not everything is perfectly uniform.

Q. Okay. Thank you, Dr. Neeper. That's all I have.

CHAIRPERSON BAILEY: Ms. Gerholt, do you have questions?

CROSS-EXAMINATION

BY MS. GERHOLT

Q. Dr. Neeper, I have two questions for you. The first is: Is it correct that your recommendation to the Commission today is that if they do allow the burial on-site that they should have a requirement that a marker be placed on top of that site?

A. That is correct. I do not prefer burial on-site, but if the Commission elects that, I believe we should have a steel marker.

Q. Understood. What is your opinion about allowing for permanent structures over a burial site?

A. I would like to review something and then give you my opinion.

Q. Okay.

A. I believe there is a statement in the proposed rule that says there should not be buildings above a burial site. I'm remembering that, but I would have to check.

Q. You are correct.

A. I am correct. I would not prefer buildings above a burial site because you can have volatile organics buried in there, benzene in particular, at ten milligrams per kilogram. We shouldn't have a building right above that any more than we should have an aquifer immediately under it. The rule proposes to allow a confined aquifer at zero distance essentially under a burial that could have ten milligrams per kilogram of Benzene where the transport mechanism is by vapor. Have I answered your question?

Q. Yes, sir, thank you.

A. Sometimes I get overwhelmed with my own little horrors.

Q. Thank you. No further questions.

CHAIRPERSON BAILEY: Mr. Dangler?

CROSS-EXAMINATION

BY MR. DANGLER

Q. I'm afraid I wasn't here for the first Pit Rule hearing so I'm trying to catch up. Maybe I represent a lot of people that aren't quite as caught up. I have heard some ideas and I wanted to ask you about at least one of these. One of the ideas I heard was from the representative from San Juan County who talked about because they use freshwater that essentially their drilling waste might be safer up in San Juan County than parts of the state where I guess you use oil-based drilling fluids. Do you have any opinion about that? Do you have any knowledge about that?

A. I will answer as best I can. It's not within my expertise to say which drilling fluid is used where. By common knowledge, as we have all discussed, particularly in surface waste work group or the pit work group, characteristically I understand that drilling fluids in the northwest are characteristically lower chloride than in the southeast where you often have to drill through salt layers and you have to use saturated brine. Now, that said, it doesn't mean that the fluid you would be using in the northeast, although it may qualify as low chloride, would be what you call freshwater.

Low chloride is defined in the proposed rule as 15,000 milligrams per liter. Sea water is 19,000 milligrams per liter. My own back of the envelope calculation indicates if you were to slowly leak this 15,000 milligrams per liter low chloride water from a pit, you could be within the standards for abandoning the soil on the ground. That is, it wouldn't be a signal that you had what is called a release that you would have to go after and find the bottom of. And that deeply concerns me.

Now, I do not believe we can characterize everything drilled in the northeast as freshwater. What we think of freshwater is something we can drink.

Q. Excuse me, you mean the northwest?

A. Northwest, yeah.

Q. So another idea that was put forth in expert testimony was that there should be a distinction, a regulatory distinction, between low chloride and very concentrated brines. That basic concept that you have two very different animals out there, that using a risk-based regulatory scheme you might want to call them different things. And I think that's where the idea was talked about. I'm sorry this is a long question.

A. I'm with you.

Q. But I want to compare these ideas. So there's that concept, which seems to make a lot of sense from a regulatory point of view, and then you said something that also made sense to me from a regulatory point of view. That was you talked about how you are basically turning off the alarm by having, I guess, a 15,000 chloride standard because that should be an alarm that there might be a problem there. Did I understand that first of all correctly?

A. You are close. Not quite. I'm with you enough that I will still be able to answer.

Q. Okay. So assuming that that current number is useful as an alarm, that your concern is it's being turned off by making it be permissible, is there a way to save that concept of lower salt definition? Would there be a level in which it would not have set off an alarm for you? Do you understand the question?

A. I understand the question. I think I can answer it.

Q. Okay.

A. But I'm answering it out of my concern with the environment as opposed to giving you a numerical value for something. There are two things going on in the question. One is low chloride drilling fluid or other drilling fluid. The second one was the soil burial standard. The soil burial standard is the alarm. What I'm concerned with is that we are perhaps close to or considering allowing burial at limits that could represent a slow but long-term leak from a lined pit, enough to give you a deep penetration, something we should call a release, but yet it's within the limits of the fluid, it's within the soil study.

Now, how does that relate to 15 milligrams per liter? Fifteen milligrams per liter will fit within a certain soil study if you were leaking. So would much higher chlorides fit within that 20,000 milligrams per kilogram soil standard, so I am alarmed at that. I am not alarmed at using a concept of a low chloride fluid versus a high chloride fluid, particularly in terms of setback from groundwater. In my opinion, we are setting too close to groundwater, so I would be much more conservative in that, but it is reasonable to say you could be closer to groundwater with a low chloride fluid than with a high chloride fluid management. The concepts of a surface spill are different. That doesn't in my sense say there should be cases where there is no setback required from some things like boundaries to steep arroyos.

Q. As you are a soil physicist --

A. I was.

Q. Okay.

A. Until two weeks ago.

Q. Okay. There was a colloquy on cross-examination but it related to your direct, and I admit that I got a little bit lost. But what I think was being asked about was when the water around the molecules is broken, then there's no longer any movement of the chlorides if I understood the line of questioning and your answers.

A. I understand where you are.

Q. Okay. But I also heard you say something that made me a little worried so I wanted to ask you about it. You said heaven help us if we get a lot of our soils that way. Is there some sort of like deadness implied by that breakage in the chain of water vapor or am I completely wrong in what I was guessing?

A. Well, the break is in the chain of liquid water that coats the soil particles.

Q. Right.

A. When you get dry enough, you break that continuous film, and that is usually a very, very dry condition. In my terms, maybe I'm thinking Sahara desert or something. Yes, it certainly happens in sands and things. These are not life-supporting conditions at all.

Q. So that was kind of where I was going with this.

A. Yeah. When I said heaven help us that we don't get there, I was thinking about concerns with global climate change if all our soils in New Mexico became like that. Not just for a two-milliliter layer surface when the sun is shining on it but characteristically at root depth for grasses and plants and things. That would be very bad. That would be the Sahara desert.

Q. My question is: Are there areas in New Mexico that are like that now that you are aware of or not?

A. Aware of is the key term. I would think I would know where to look. Some sand dunes on a hot day maybe, but I can't say there's an area in New Mexico I'm aware of. Now, let me put one more thing in there. Are there any areas in New Mexico where the moisture potential might be like that whether or not the matric potential is at that point? And I would say yes. Pit wastes.

Q. But no large regions? You wouldn't say the southeast region is like that kind of dryness?

A. No, it grows grass and mesquite.

Q. Finally, you educated me about the angle of repose but you did it rather quickly and I was confused enough about that before that I want to make sure that I understood what you said. It sounds like you said that the angle of repose is if you add some more to it and it starts moving, you got right to the edge of movement. Would you expand on that just a little bit because I don't know about the angle of repose idea.

A. I will try to answer by example. Let's suppose we are pouring sand out of a bottle on the table. It will form a nice little conical pile. That pile will be sitting at the angle of repose. That's about as much as it can take. If I drop a little more sand at some point it will slide down. That's what's usually meant as the angle of repose.

Q. Thanks. No further questions.

CHAIRPERSON BAILEY: Commissioner Balch?

COMMISSIONER BALCH: Actually, I want to follow up on your question on the angle of repose.

I think in the proposed changes by NMOGA and IPANM that they have put in angle of repose or perforated engineering standards, whatever that means, instead of a two to one fixed ratio that was in the existing Rule 17.

THE WITNESS: Right.

COMMISSIONER BALCH: So is it necessarily true that a two to one incline would be below the angle of repose for all material?

THE WITNESS: It's not necessarily true in my just common experience. I haven't seen things sloughing and sliding at a two to one, and I think that number goes way back, so I haven't dealt with it. I can express my concern in two ways. Number one, as soon as we give an absolute number, we are pre-engineering something and cutting out all innovation and discouraging smart work. But as soon as we take off all restriction, you can have some guy, like I thought I was, doing perfectly good engineering on a vertical rock face even where there are indentations that we plastered them before we put in the double liner system and we tore out a liner within weeks to a couple months. I can't remember how long. So we thought we knew what we were doing and we weren't. What I'm looking for is some happy medium.

So you notice I didn't say I want a 2.3 to one or some number like that. I'm saying be careful about leaving it unlimited because I know there are existing vertical wall pits out there. I heard people discussing them and maybe sometimes that's fine, particularly in rock. But my experience in solid rock was it wasn't fine. So I think we should be cautious about just taking off all the rules and saying do what engineering you think is best.

COMMISSIONER BALCH: Thank you. First of all, good afternoon.

THE WITNESS: Good afternoon to you.

COMMISSIONER BALCH: I didn't want to forget that. I didn't want to forget my immediate follow-up question. My brain is fairly full right now.

THE WITNESS: So is mine.

COMMISSIONER BALCH: It will take me a little while for some of it to process through. I do have a few questions. Early on in your testimony you presented an example of some -- I think they were ponderosa pine in Los Alamos or were they a different tree?

THE WITNESS: No, it was ponderosa.

COMMISSIONER BALCH: So the same kind of tree that Dr. Buchanan said yesterday could stand higher electrical conductivity?

THE WITNESS: Yes. I believe even the publication of that study shows up as an exhibit in one of our prior hearings. It exists, anyway.

COMMISSIONER BALCH: And you determined or your group determined that the sodium was the problem because there was a higher concentration than normal in the needles?

THE WITNESS: Yes. The fellow did it not just for our group. We stimulated him and he took this on as a thing and did it as a good science project.

COMMISSIONER BALCH: Did he go back to a lab or anything else and check to make sure that the salt from on the road might make a vector for sodium into the needles?

THE WITNESS: Yes, because he sampled -- what was concerning us was finding a string of browning trees along every storm sewer coming off the street. I can take you up there and show you that there now, too. So he sampled unaffected trees, affected trees, and he sampled trees affected on one side and not the other. The correlation was very tight with the sodium in the needles. And just for fun how did he detect the sodium in the needles? At that time the reactor was running and he did it with neutron activation analysis of the sodium.

At that time, working off-hours scientists could do jobs like that. You would get permission and it was pretty simple to do public interest jobs.

COMMISSIONER BALCH: We will talk physics in a little bit. You also testified that for common plants death zone is around 10,000 milligrams per milliliter of chloride, salt?

THE WITNESS: This was the 1.5 megapascal osmotic pressure point. So it gives you an indication of where osmotic pressures may not just be generating trouble but may be generating death, let alone the chemical effect.

COMMISSIONER BALCH: Right. And the death point comes from literature.

THE WITNESS: Yes.

COMMISSIONER BALCH: Studies across the country, across the world?

THE WITNESS: Yes. This is strictly from the literature.

COMMISSIONER BALCH: This is just a point of curiosity for me. In New Mexico we are in a desert and you tend to have sandy soils. Are native New Mexico plants typically more salt-resistant than an average sample of plants in the U.S.? I know it may be beyond your expertise.

THE WITNESS: I could answer that but it's outside my expertise.

COMMISSIONER BALCH: Go ahead and answer if you would like.

THE WITNESS: I would expect some of the native New Mexico plants to be a little more salt-tolerant because they are more tolerant to dryness, and to the extent that the salt raises the osmotic pressure and, therefore, raises the suction as seen by the plant. Some of them may have evolved to be chemically more salt-tolerant as well, but that's pretty well out of my area of expertise.

COMMISSIONER BALCH: Fair enough. So I'm a geophysicist so we started out in the same direction, I think. We have a bachelor's degree where there was a focus on physics and math and things like that. Then you went on to study thermodynamics and eventually went into soil. I went on to earthquakes and waves and things like that. So we may have a little bit of a common basis for some things, but our knowledge paths will divert at some point.

THE WITNESS: There's a joke in this in that I started in liquid helium and the only professional organization to which I still belong is the American Geophysical Union and I have never done any geophysics.

COMMISSIONER BALCH: That's the only one I have ever been a member of. All right. With that kind of in mind, I'm going to maybe have some questions that might be construed as simple and perhaps it's just my full brain. But when I looked at your example of diffusion in water you had dye in -- I think it was a saline solution and you injected the bottom of the cup. Just dye?

THE WITNESS: Just tap water.

COMMISSIONER BALCH: I immediately thought of that second-year physics experiment for Brownian motion rather than necessarily diffusion, unless Brownian motion is a mechanism for diffusion in a pure liquid?

THE WITNESS: They come from the same origin.

COMMISSIONER BALCH: If you then take that cup and you fill it full of sand and water, you certainly remove at some level that effect.

THE WITNESS: It's filled with sand and water so we will assume the sand is saturated. You will reduce the flux a little due to the tortuosity. That may be a factor of two. But the flux per unit water is going to be in the same order of magnitude. So your rate of progression of the diffusion front will not be reduced other than by the tortuosity. That is, there is less water there for it to diffuse into so the concentration will come up. Even though you are diffusing less flux, fewer grams of salt per minute, but there's less water for it to go into.

COMMISSIONER BALCH: So through your process of diffusion there, would ultimately -- if it was salt you put in and not a colored dye, would the saturated ultimately become uniform across or would it be stratified?

THE WITNESS: I'm going to rephrase the question and see if I'm right. You are saying suppose I started with a glass of water and some small bottom layer is saltwater and the rest is freshwater, would it eventually come to a uniform concentration throughout the glass? Is that the question?

COMMISSIONER BALCH: By eventually, I don't mean a million years.

THE WITNESS: No, but at some time.

COMMISSIONER BALCH: Right. Without other forces like thermal --

THE WITNESS: Yeah, without wind blowing over, the dog shaking the table and all that kind of thing.

COMMISSIONER BALCH: Right.

THE WITNESS: The answer is yes, and it's very calculable. It brought to mind another perfect picture of this in terms of diffusion. What was it? I just had it. A perfect picture I wanted to give you. Oh. It's kind of beside the point. That's what we were doing with that salt pond with the vertical walls. We had a saturated layer at the bottom. We had a gradient and we had the freshwater layer at the top and the problem was to try to keep it that way instead of all becoming uniform.

COMMISSIONER BALCH: All right. Thanks for the refresher course. Earlier on in your presentation and later on also you discussed the thermal effects, but I'm not sure they really made it into your models at the end, when you mentioned that a daily heat cycle would impact down to about 20 inches.

THE WITNESS: That was not in the

calculation. The characteristic thought for soils is that the daily temperature cycle is 15, 20 inches. It isn't a sharp cutoff. It dies off exponentially.

COMMISSIONER BALCH: What sort of flux would you expect at the middle range and the bottom of the daily range? How much temperature are you changing?

THE WITNESS: How much temperature swing?

COMMISSIONER BALCH: Yeah.

THE WITNESS: I have known the answer and I can't give it to you so I will have to do it just qualitatively because I can't remember. I have seen the numbers. I may have measured them at times but I can't remember. But you have probably stepped out on some warm soil in bare feet and that gives you an idea. You can swing certainly 30 degrees Fahrenheit and more.

COMMISSIONER BALCH: I have also gone -- if we want to stay in the realm of analogies -- I have also gone to White Sands and stood at the top of the sand dune and buried my feet and felt cold sand. Surely that sand may have been affected by temperature, but it wasn't to the degree at the near surface.

THE WITNESS: Yes. The characteristic E-folding length for a sinusoidal, a daily sinusoidal temperature wave going down the soil is something like 15 to 20 inches. Where I got into this was in the solar work.

COMMISSIONER BALCH: The reason it stuck in my mind is I think I was quoted last year, four to six feet burial for geothermal heat pump system and that's where they would get down where they didn't think there was any change from season to season. Then you also mentioned a 18-inch footer required by the Uniform Building Code.

THE WITNESS: I don't know about the Uniform Code, but I think my county now requires a three-foot.

COMMISSIONER BALCH: Most of the New Mexico takes the Uniform Building Code.

THE WITNESS: Yeah.

COMMISSIONER BALCH: On Page 39 you may remember there was a great deal of interest in Dr. Buchanan's profile, salt profile.

THE WITNESS: Yeah. I think that was a great thing.

COMMISSIONER BALCH: What really struck me was that that salt bulge, even with the buried material, kind of got to a place where it was hitting the same equilibrium as the natural salt bulge in an offset location. Dr. Buchanan, I don't think, could claim that that would be the ultimate level of it, but I did notice on your background hole --

THE WITNESS: Yes, the upper right.

COMMISSIONER BALCH: Sampling was only done down to 15 feet.

THE WITNESS: We must be in the Burch Keely. No, this is Loco Hills. Yeah, that's the Burch Keely Unit. Let me back up just one slide. Yeah. Why did we drill only to 15 feet? We got auger refusal. We got that far and hit something and it wouldn't go further and the driller said, "Should I back up and do it again," and I said, "No, we proved what we were looking for."

COMMISSIONER BALCH: You hit a boulder or something?

THE WITNESS: Yes, everybody was getting tired. It was late in the day. It's strange, why was everybody asking me to run the show because it was Marbob's show.

COMMISSIONER BALCH: All right. I think I had a question on Slide 30 as well, stepping backwards. This goes back to my question of whether you have a pure liquid or if you have a rock with a liquid in it. Is the calculation of 21 years per meter, is that assuming full saturation?

THE WITNESS: That's a meter of a column. Whether the column is a little thin imaginary column in soil unsaturated or whether it's a tube of liquid water that you can look at and drink out of. This is the characteristic time. This isn't the time in an ideal circumstance where you get perfect equilibrium; that is, nothing changing anymore. Literally, that's an infinite time, right?

COMMISSIONER BALCH: Right.

THE WITNESS: This is the one over E-folding time. If I weren't on the stand and could think I could sit down and write you the equation for it, but it's diffusivity, distance and time go together and you can get a dimensionless expression and get the characteristic time by diffusivity divided by the volume capacity. Something like that.

COMMISSIONER BALCH: So as long as there's some connection to fluid --

THE WITNESS: Yeah, uniform connection to fluid. If you have a constraint, a constriction in the fluid, obviously it can't diffuse very fast through that.

COMMISSIONER BALCH: Or if you dry it to the point where you lose the connection.

THE WITNESS: It's just characteristic times for diffusion, what is diffusion like, the feeling for diffusion.

COMMISSIONER BALCH: Page 40. I was wondering -- I was thinking of Dr. Buchanan's trench and his cross-section form for ConocoPhillips brought in where he had the natural section, the salt bulge and then it climbs back down to some background level. And then in the material that was below the waste, you saw elevated levels, and then the last probably quarter of that curve matched the background bulge. The salt bulge? Is that the correct term? Okay.

So I was looking at pore water chloride, and granted the scales on your first two images are not the same. One is the 30,000 and one is the 90,000 so it can be a little difficult --

THE WITNESS: Yeah, those are two different holes in the ground.

COMMISSIONER BALCH: Oh, they are two different holes?

THE WITNESS: Yeah, one is Hole 321 A and the other is 49 A.

COMMISSIONER BALCH: All right. But --

THE WITNESS: Two different pits.

COMMISSIONER BALCH: -- you do see at the lower end of both of the curves, say at around 22 feet or so, that they start to match fairly closely.

THE WITNESS: Yeah. You could say aren't these held up at the same depth?

COMMISSIONER BALCH: Right.

THE WITNESS: Doesn't that indicate there's a break right there that stops them?

COMMISSIONER BALCH: Something that controls the flow.

THE WITNESS: You could say that because I have heard it said in testimony.

COMMISSIONER BALCH: I think Dr. Buchanan said that.

THE WITNESS: He indicated it can go so far and then will tend to slow down very much.

COMMISSIONER BALCH: Based, I think, on the infiltration rate.

THE WITNESS: Based on infiltration, yes.

COMMISSIONER BALCH: I wanted to make sure that your slide was showing what I thought it was.

THE WITNESS: It's a similar shape. You have a cleaner curve in the left-hand 49 A plot.

COMMISSIONER BALCH: Okay. So numerical simulation and modeling. I'm a bit of a simulator, more from a practical side. I don't write simulation code, although I have had students who do so.

THE WITNESS: Neither do I. At least not anymore.

COMMISSIONER BALCH: Well, you're lucky. It's a mess. I do teach every other year a graduate course on geo-modeling and simulation, and the very first thing I like to throw up on the PowerPoint on the first day of class is a definition of simulation, dictionary definition. There's things you might expect to see in there, but if you get down in the two and the three and the four in the definition, you start to run into things like: Simulating with intent to deceive.

I actually pulled one up on the internet here. "Imitation or enactment as in testing." Might be something you would think of in numerical modeling. "Act or process of pretending, fainting; assumption or imitation of a particular appearance, counterfeit, sham; presentation of a behavior or characteristics for one system for use of another." Back again to numerical modeling. Some of these are not very friendly definitions.

My point to the students, and I'm certainly not putting you in with them, is the people that you deceive with the simulation is most commonly yourself. And I want them to think about what goes into their model and constraints. So my next series of questions is going to be about your model, and I'm going to ask the questions that I say to my students when I want to sound smart. Maybe I will get lucky on that count.

THE WITNESS: Let's see if I pass the course.

COMMISSIONER BALCH: Let's see if you pass the course. The first thing you always ask when you see a simulation study is what's the boundary condition? I think some people have asked questions about the upper boundary condition. But I'm a little bit curious about the bottom boundary condition. In reservoir modeling, normally when you have an aquifer at the bottom you use that as a driver to provide energy to the reservoir as you remove the material. It gives a push. So you chose a steady-state boundary at the bottom. I wonder if you would inform me as to why you chose that boundary condition.

THE WITNESS: There are two parts to that question. One might have to do with the depth with which I chose it, but I take it that's not the question.

COMMISSIONER BALCH: No, not the depth. You can have open boundaries, closed boundaries. You can have steady state.

THE WITNESS: Yeah. What I chose was a saturated boundary. I set the soil there as saturation because that's what you would have if there were an aquifer at that point. And then I started, let us say, with soil that was dry. I don't remember how I started. Doesn't matter. And I just turned it on and let it run until it reached a profile, a natural profile in the soil.

Then I said that will be my starting profile for the real problem when I run with variable moisture at the top boundary and some buried waste. I needed to have some reasonable, defensible profile of moisture in the soil, which would be different for different soils. I ran three different soils.

COMMISSIONER BALCH: Are there data in the literature where you might be able to get saturation information for a soil profile across 30 feet? I don't know. I'm curious.

THE WITNESS: I calculated it. I ran the model until it gave me the profile. Whether that's the right profile, you can argue, but given that soil with those characteristics, that's what you would expect. And the results are not sensitive to that.

COMMISSIONER BALCH: Okay.

THE WITNESS: That's another thing you check. You try to destroy what you are doing by changing other things that are in there and see if it makes any real difference.

COMMISSIONER BALCH: That was my next question is did you perform a sensitivity study?

THE WITNESS: Yes. That's about 75 percent of my work is destructive efforts, trying to destroy what I think I just modeled. There's one on the screen that just shows you. It was just all of the moisture potential data plotted on the same plot with an osmotic pressure curve. When I saw that no matter where I was, what soils, what hole, as we got high in moisture potential the shape of that was fairly parallel to the osmotic curve. It should be if I am blaming it on the chloride content. You spend all your effort trying to destroy your own work. It's crazy.

COMMISSIONER BALCH: Now, in any of the models that you attempted did you include any sort of flow barriers? Did you stratify the material in any way whatsoever?

THE WITNESS: No.

COMMISSIONER BALCH: I think you said it was uniform.

THE WITNESS: Only as shown; that is that the wastes were different. I could make it a soil of one type and a waste in a presumably different kind of soil, but other than that it was uniform soil and uniform within the waste.

COMMISSIONER BALCH: Nothing with an impermeable or partially impermeable barrier or clay or anything like that?

THE WITNESS: No. Certainly you can do that. Now you are making up your mind about what a particular soil will look like.

COMMISSIONER BALCH: Sure.

THE WITNESS: I'm trying to ask the broadest possible questions.

COMMISSIONER BALCH: Now, you had some

data that you measured that you were matching, I presume, to calibrate your model?

THE WITNESS: No.

COMMISSIONER BALCH: So it's a purely forward model?

THE WITNESS: This is not calculated against the field because you will not find that calibration of soil waste, soil type and what not anywhere. I am asking the -- what I am really asking the simulation is how far can this stuff go, how fast can it go under about as wide a variety of conditions as I can think of.

COMMISSIONER BALCH: So really the point of the simulation is the sensitivity analysis?

THE WITNESS: Yes.

COMMISSIONER BALCH: Where you look at the broad range of what's possible?

THE WITNESS: Yes. I chose three conditions --

COMMISSIONER BALCH: Under a variety of criteria.

THE WITNESS: -- and I said what can happen? I didn't know what would happen. I didn't have a clue.

COMMISSIONER BALCH: So that makes it

pretty dependent upon the model. You said you used the Yucca Mountain model?

THE WITNESS: If you say that's dependent on the code, the model is my concept. The model is this soil column, imaginary soil column. The code, there are any number of soil hydro codes out there. This one is probably one of the most sophisticated because of what it was being developed for. That doesn't necessarily mean it's the most right. It just means it was never turned into a user code, something you could write a manual for and have anybody come in and turn it on and use it. It's buyer beware. You sit there, you check out everything you are doing in it. It is never finished. It's under development every day.

COMMISSIONER BALCH: Is it the same software core that's used for reactive transfer modeling like at Pacific Northwest Labs for CQC sequestration?

THE WITNESS: I don't know if they used the same core because everything that was in there I think was written at Los Alamos.

COMMISSIONER BALCH: No, that's not the one that came from Los Alamos.

THE WITNESS: It does do reactive

transport. Okay. It may be. I don't know what PNL uses.

COMMISSIONER BALCH: I'm thinking Tuff.

THE WITNESS: I didn't think Tuff had its origin in Los Alamos FEHM but it might have. I started out to use Tuff at one point and there was no way it could handle my boundary conditions when I was doing air flow modeling so I had to use FEHM.

COMMISSIONER BALCH: Your model was A 1D in that you were looking at transport.

THE WITNESS: This was a 1D calculation.

COMMISSIONER BALCH: Did you also do one and 2D and 3D calculations?

THE WITNESS: Not for this purpose. There was no purpose in it. You can do that, but the answers I was trying to get in the time I had available, there would be no purpose to do it. I could show the sideways spread and that would be fine. That would be neat to know and fun to watch, but there goes another three or four months of my life.

COMMISSIONER BALCH: Right. I'm very interested in plume modeling so, of course, we do everything in 3D. You pretty much have to.

THE WITNESS: As do the people who sat at desks near me in Los Alamos.

COMMISSIONER BALCH: There's often a very large difference between horizontal and vertical flow because there's different mechanisms that are --

THE WITNESS: The permeabilities are different.

COMMISSIONER BALCH: The permeabilities are different and you may have stratification from your layers. Your root blocks are usually larger aerially than they are vertically. You have gravity and pressure and other things that act vertically in a lot different fashion than horizontally. So I guess my question is how comfortable are you with extending your 1D results to 2 and 3D?

THE WITNESS: I wouldn't be uncomfortable at all. I just don't want to spend the rest of my life doing it. You can do it. The code will do that. You have to be really careful about your setup. You want to check out your time step and space step, the zoning.

COMMISSIONER BALCH: You have very small time steps for calling that array of partial differential equations.

THE WITNESS: You have to check it. You

can do all kinds of arithmetic ahead of time saying well, if it moves this fast and what not. You can give a guess as to what you think the time steps should be, but you have separate time steps in the code. There's time steps for hydro and time steps for material transport, concentration equilibration, and you better be really careful how you do the setup.

COMMISSIONER BALCH: I may skip around a little bit here. This is partially your own fault. You gave a lot of data-rich slides so I can ask a lot of questions.

THE WITNESS: Think what it would look like if I did a complete study. I was just trying to get some answers so we could understand the problem. My personal time, of course. I hope that's clear.

COMMISSIONER BALCH: Right.

THE WITNESS: None of this was done as part Los Alamos national Laboratory. Every computation was done on my computer, every measurement in my home laboratory except for those I sent off to a standard lab.

COMMISSIONER BALCH: So simulating a year's worth of low model data and 3D might take a year.

THE WITNESS: I don't know. 1D, I was remembering 20 hours or 24 hours or something. But I made so many runs and some of the gas runs were like that. But yeah, it takes time and you find out something. You should learn something every run. But the process chews up the calendar.

COMMISSIONER BALCH: Go to 54. This is what protection is offered by liners.

THE WITNESS: Yes.

COMMISSIONER BALCH: You did a Darcy flow calculation.

THE WITNESS: Just a Darcy flow.

COMMISSIONER BALCH: I think when you start to get the very, very, very low permeabilities, at least in the oil industry the term they use is non-Darcy flow and there's a different set of relationships that apply. But assuming that you were to get a Darcy flow through a 30 or 60-mil membrane of fluid, two to four feet in a year for a 10-foot pit, I think if I translate that correctly, would for a multi-well pit where you had two liners and a leak detection system, that would definitely be observed in over a year even if it was a slow process.

Are you familiar with any cases where this -- I'm going to guess the Darcy flow is not dominating the situation. Someone would have observed this already.

THE WITNESS: I think another explanation is needed and I tried to say this, that I didn't mean all liners did this. I meant to say look at your standard.

COMMISSIONER BALCH: Right.

THE WITNESS: You put it in black and white at ten to minus nine and this is what you said.

COMMISSIONER BALCH: Well, I think that's part of what the debate has been really about all week is really the value of engineering judgment versus a fixed number.

THE WITNESS: Know what your standard means, and yeah, flow out of liners is supposedly usually micro pinholes here and there and not characterized by Darcy flow. But if the average was anything like this, that's quite a bit of flow.

COMMISSIONER BALCH: Two or four feet would be --

THE WITNESS: And that's what we are saying in our regulation. I'm not coming up at this moment with a better way of saying it, but we don't want to think that just because we have a liner, everything is fine. That leads me to the other point of saying then when we make a soil standard that says we consider this clean enough and it's something like 5,000 milligrams per kilogram, I don't feel good. I'm saying, to me that's either a release or an indicator of a release and we should follow up and go look at it.

COMMISSIONER BALCH: Thank you for your testimony. I give you at least a B plus.

THE WITNESS: You take what you can get.

CHAIRPERSON BAILEY: Commissioner Bloom?

COMMISSIONER BLOOM: Good afternoon, Dr. Neeper.

THE WITNESS: Good afternoon, sir.

COMMISSIONER BLOOM: To clarify a few things that we were looking at, if you could pull up Page 26, please. In this picture and other ones, I was wondering what the black substance is we were looking at in the photo.

THE WITNESS: Liner material.

COMMISSIONER BLOOM: Go to the next page, please, 27. On Page 34 of your exhibit. When you were sampling at Caprock and some of the other places, I think Loco Hills there was a background hole. Was there a background hole for Caprock?

THE WITNESS: Let me think for just a minute because it isn't shown here. No. It would be scientifically nice to do that, but I had one day with a drill rig and I was trying to get as many holes, and the first two we didn't even hit what we thought was going through the bottom of the pit. We hit what we thought was the berm and drilled another hole. Finally we got one with cuttings.

COMMISSIONER BLOOM: If you go to Page 35 where it shows the chloride. Did you suggest during your testimony that where you get down to depth 13, 15 feet and the line curves back towards the arrow -- I guess I am looking at the bottom left.

THE WITNESS: Right here?

COMMISSIONER BLOOM: Yes. Do you think that's getting towards background?

THE WITNESS: Oh, I understand your question. What is background in pore water chloride in this soil.

COMMISSIONER BLOOM: Probably the more important, right up above in terms of soil chloride.

THE WITNESS: What is background here at this depth. I can't rule that out because I didn't have a background hole.

COMMISSIONER BLOOM: Let's go to Loco Hills on 39. So looking at the bottom right corner, chloride and background hole is less than 200 milligrams per kilogram.

THE WITNESS: Here we are on a chart with moisture potential and for whatever reason I just chose to give you -- I obviously could have given you a graph but I didn't.

COMMISSIONER BLOOM: Okay.

THE WITNESS: Less than 200 milligrams per kilogram. The graph would have had to have been on a totally different scale than these other graphs.

COMMISSIONER BLOOM: Okay. So then having that background there, you are pretty confident what we are looking at is a salt bulge in the other graph?

THE WITNESS: Okay. We will choose this. Here is dry soil chloride. It's coming down. Here is 2,000 and we see the points. They say Js. That's because the translation of graphics across different softwares, unfortunately, but it's coming right down in here and probably to some number more like 200, but it wouldn't matter if it's zero or 200 on the scale of the graph.

COMMISSIONER BLOOM: So that's the answer of yes, we are seeing a salt bulge and we are turning back towards background?

THE WITNESS: Yes. I am nervous with the term salt bulge.

COMMISSIONER BLOOM: Don't let me put words in your mouth. What words would you use?

THE WITNESS: Chloride bulge is just the characteristic thing used for this welling up of chloride from a deep groundwater and forming a natural profile, but we see a peak in the one curve, and the strange thing is that in this one curve we see a double peak. We see the same double peak and potential. I haven't, to myself, thoroughly ironed out the how-come for that. You can draw scenarios but I can't see a way to get a scenario, one scenario backwards out of that. I just know that it's there. It's below the pit.

COMMISSIONER BLOOM: I answered my own question on the next question. Let's go to lastly I want to look at some things on Page 68 about what's missing in the proposed rule. On limits, I think Mr. Hiser cleared up that there is a temporary pit limit of 200 feet.

THE WITNESS: Yes. Flat-out error.

COMMISSIONER BLOOM: Might you have been thinking about the multi-well fluid management pit?

THE WITNESS: At this point I can't tell you, because I had to do this, prepare these slides in January under duress from some returned page proofs of two technical articles.

COMMISSIONER BLOOM: When you introduced yourself and talked about your technical background, you talked about your work at -- I think it's Area G and Area L at Los Alamos. You worked on hydrology; is that correct?

THE WITNESS: You will have to rephrase the question.

COMMISSIONER BLOOM: Did you work on hydrology at those sites?

THE WITNESS: Did I work on hydrology? The measurements that we took to investigate the sites -- let's say it this way. You are given a site, given some background on it, whatever investigations have been done previously, and the broad question is what's the situation and how can you work or work towards a proposed remedy for this -- whatever mess it is. How big is the mess and if so, how do we remediate it?

So did we work on hydrology? Yes. At

first we were just looking at the distribution of contaminants in the ground. We were drilling holes. Finally we wake up and we start taking soil moisture potential in addition to just gravimetric moisture. And so at that point I think you could say we started getting interested in hydrology. And we had gotten into some really interesting stuff. I will mention just one. Below the site is a very thick layer of basalt. It came from different directions. The site is in Bandelier tuff. It comes from one volcano. Just the background word was the basalt is very massive, solid, nothing can go through. We don't have to worry about the groundwater.

Well, being stupid we didn't really know that it couldn't go through the basalt. We wanted to see if we could so we drilled into the basalt. Guess what we found? The basalt was riddled with porosity, vesicular basalt, fractures, every other kind of thing. It was breathing to the atmosphere far better than the soil immediately above it. That's all air study but it's hydrology because it's related to where can water go.

COMMISSIONER BLOOM: Did you do risk analysis during that time? I think at some point in your testimony you mentioned risk analysis. Perhaps it was during the questioning earlier. I can't recall.

THE WITNESS: We did not do risk analysis on those sites because -- and this got me unpopular. I had control of the money and I didn't fund some people to do risk analysis and that later came back to bite me very hard because we didn't know enough about it to give you what's the source term. Is this a person in the middle of the street with the bus coming at them? We didn't know what was there. What are you going to do risk on if we don't know what's there?

So risk analysis was not funded during my tenure as being in charge. It wasn't faulted later, it's that the people who didn't get funded later happened to climb the political ladder. This is after I retired, but nevermind.

COMMISSIONER BLOOM: I think I will leave it at that. Dr. Neeper, thank you for your testimony.

CHAIRPERSON BAILEY: Yesterday Dr. Buchanan indicated that he advocated no top liner if a pit is allowed to be buried and no course material on top of any surface there. What is your position on both of those potential reasons to break capillary motion?

THE WITNESS: The course material is called capillary barrier characteristically. I had never thought of taking a position on that because I have always been in the position of we shouldn't bury that stuff. And then when we did have membrane laid on the top, I thought well, that's better than nothing. So if you leave it open, yes, then it can ventilate. If you leave it closed with your membrane, there is probably less opportunity for unsaturated flow of salt upward. It will collect moisture only if you have a good intact liner as in a trench burial that is still intact at the time of consideration. If it's a buried pit, the liner has probably been ripped during the mixing of the soils, the three to one mix that goes in there.

So should you leave the trench burial uncovered or the pit uncovered? All I have is a gut level guess. I would have to go really do some calculations. I can give you a gut level guess but I will acknowledge it's that, all right?

CHAIRPERSON BAILEY: Okay.

THE WITNESS: I would tend to cover it. Because I would tend to try to do what I could to retard the unsaturated flow out of there. Even if the thing is nearly saturated at the time I close it, if more doesn't get in there or the more I can keep it out it won't get so saturated again and I will at least provide it some impediment.

What do I mean by a impediment? It's like the two inches of salt cake that we found on top of the pit. Something was an impediment to transport the salt. Must have been. How else could that cake have gotten there? So that's a gut-level response but that's not based on calculation or thought or looking for other experiments.

CHAIRPERSON BAILEY: With or without the top liner, would a capillary break at the surface of the pit have an impact on retarding the downward migration of chlorides and other contaminants in a downward way?

THE WITNESS: Again, it's a guess, but my guess would be it would not inhibit the downward migration. It's not going to change the saturated flow if any of it gets in there. The unsaturated flow that comes in may come in through the sides. Soil may fill in the capillary barrier. It might slow down what you see beneath the pit 100 years from now in some form, but I wouldn't think it would be a dominant change. I would like to spend some time with Dr. Buchanan on that, but I would sure listen to his views before I took a firm position of the opposite.

CHAIRPERSON BAILEY: One of the areas that we are asked to make a decision on is the siting distances from certain facilities. We have not touched on the lateral flow or diffusion horizontally out of any buried pit. Do you have any opinions on that?

THE WITNESS: I don't have again a quantitative opinion because I haven't done the study but I can give you a little hint. Where I just look at the characteristic time for diffusion, and whatever happens is likely to be faster than just pure chemical diffusion. Of all of the processes going on, that's the slowest and there are multiple processes. So I threw up a slide that said one meter in 20 years. That doesn't mean a meter in the soil; it's just an idealized column. Two meters in 80 years.

That's not like the distances of setback, so you are probably not forming your setback just on horizontal transport. It's, in my view, the fear of erosion, subsequent disruptions that can happen, getting a thing that is potentially toxic farther away from facilities.

Again, I have to say, you know, my position, if I have any, is that we shouldn't be burying these things around the landscape. That's different from the setback of just the pit that's going to be used as a pit. Its time of threat is during its use.

CHAIRPERSON BAILEY: Your slide on Page 9, was the pH taken for any of these pits so we can determine how acidic or basic any of the pits have been?

THE WITNESS: Do you have a page number?

CHAIRPERSON BAILEY: Page 9.

THE WITNESS: My memory is I didn't see a pH industry standard. I could be wrong. Some of them I saw a pH and I can't remember which ones. I was surprised at how basic some were. That's as much as I remember. The data exists. We can find it. And I remember my surprise saying what's in there and I thought maybe it's sodium hydroxide or something.

CHAIRPERSON BAILEY: Would the acidity of pit contents have any impact on its transport of contaminants?

THE WITNESS: It's going to depend on the soil chemistry, and that is beyond my expertise. Just flat-out.

CHAIRPERSON BAILEY: Page 20 indicates that an EC of four relates to 1516 -- is that milligrams per liter?

THE WITNESS: Milligrams of chloride per liter.

CHAIRPERSON BAILEY: Okay. But yet on Page 23 in the paragraph below the chart it says EC four is equivalent to 600 milligrams per kilogram.

THE WITNESS: Of soil, of dry soil.

CHAIRPERSON BAILEY: So for the limits that are proposed in the table above, whatever limit is set, you are recommending no more than 600 milligrams per kilogram of chloride within the top four feet of the surface?

THE WITNESS: That's what I would recommend. If you made it 700 it would be fine for the surface waste facilities. I think they put up to 1,000 at one point. I think that's pushing it, but that's the region in which I would put it. That 600 might really be 700 for the equivalent of EC four.

CHAIRPERSON BAILEY: Let's look at Page 39. Throughout all of these graphs that we have been shown of the bulges that occur, it seems as though the bulge usually occurs above 20 feet depth and somewhere in the 20-foot depth range, 20 to 25 feet, no matter how concentrated the chloride concentration is in the soils. Is that a fair observation?

THE WITNESS: I'm not following you very well. Let me explain why. We are looking at this particular page, and soil chloride concentration per unit dry soil is shown in these two graphs. In this one the peak is between 10 and 15. I tentatively identified that as being associated with the pit. I could be wrong, because I could not identify with whatever expertise I don't have at looking at cores. I could not identify exactly where the pit started and stopped.

CHAIRPERSON BAILEY: But they seem to be both on this page and on the subsequent pages that although the concentration of chloride may be as much as 90,000 as in Page 40 for the unlined pit -- 321 is the lined pit -- so the concentration of chlorides is heading on towards 90,000.

THE WITNESS: Yes.

CHAIRPERSON BAILEY: As compared to the lined pit, which is --

THE WITNESS: Unlined.

CHAIRPERSON BAILEY: Unlined, which was 30,000. So even though the concentration of the chlorides was so much higher in the pits, the bulges still seem to be focusing in the 10 to 20-foot depth.

THE WITNESS: Well, I will do what I can with these two graphs. The 49A graph is smooth enough that I tend to think the 10 to 15 bulge has something to do possibly with the original location of the pit or the pit contents. I tend to feel that might be somewhere around the shallower depth, but I can't be sure of that in the 321A.

I can't give a good cause to the double peak here. We can invent scenarios. We know this was one that had an intact liner at least apparently on the top and a big cake of salt on top. What has gone on down below, I can't say.

Now, I understand your feeling that there seems to be a peak here at 20 feet, and maybe we can identify that through all of the data if we back up to the previous page. This is the same pit. I can't make a story that there's definitely a chloride bulge at 20 feet in this pit as there is over here.

CHAIRPERSON BAILEY: But I'm looking for the story on the concentration of chlorides. It doesn't seem to be much of a factor in the depths of the bulge.

THE WITNESS: It wouldn't be for the contents of the pit because that's going to depend on what was in the pit and how much got moved off. But I will take your -- I will kind of interpret your question one step further to say well, if the concentration were going to have a big effect, shouldn't we see some difference in where the bottom of the leading edge is?

CHAIRPERSON BAILEY: Yes.

THE WITNESS: The bottom of the leading edge is going to depend more on the transport process than the concentration. That's particularly true of diffusion front. It will build up higher behind it but it doesn't go faster in the diffusion front just because you have a higher concentration. The speed of progress isn't faster. What happens is bigger. Some of these processes in a way mimic diffusion; namely, that the flux is proportional to the gradient of the concentration. That means it looks like you are solving the diffusion equation again. You aren't. You are actually bottling the physical processes.

CHAIRPERSON BAILEY: You have not made any comment on the other constituents that are listed in the proposed tables such as you have on Pages 62 and 63. Do you have other comments concerning the other constituents?

THE WITNESS: I had just the one comment. It would be a lot of work to try to infer how answers to how do we relate to 50 milligrams of BTEX. I might have done some of that for the earlier hearings. I had no time to do that now so I just had no comment on it. I did make one comment on the ten milligrams of Benzene because it does have a high vapor pressure and I got some uneasiness burying Benzene that's also slightly soluble, burying Benzene down there in aquifer. You're allowed to bury it at 25 feet above an unconfined aquifer here and there is no necessary setback from a confined aquifer, and that particular one just left me uneasy because it has a high vapor pressure.

CHAIRPERSON BAILEY: Those are all the questions I have. Do you have any redirect for yourself?

MR. NEEPER: This is the point at which a man should know it's best to shut up. Thank you for your attention. I do have a request, however. I would request that the Commission accept our Clean Air and Water Exhibit No. 5.

CHAIRPERSON BAILEY: Any objections?

MR. JANTZ: None.

MS. FOSTER: No.

CHAIRPERSON BAILEY: It is accepted and you may be excused.

MR. NEEPER: Thank you very much.

CHAIRPERSON BAILEY: It's 4:00 o'clock and I have had a request for quitting today at least by 4:30 and we do have maybe a few people who have signed up for public comment. Shall we check that first? How long do you think your opening statement will be for IPANM?

MS. FOSTER: Not very long at all. It's gotten shortened significantly. However, I would prefer to do my opening statement in the early morning hours of June 20th so everything flows more easily.

CHAIRPERSON BAILEY: Kim Sorvig.

MR. SORVIG: I would like to ask that the written version of my notes be accepted as an exhibit or part of the record since I wasn't aware of the five-minute limit. In 2007 there wasn't such a limit.

CHAIRPERSON BAILEY: Yes, we will accept your comments.

KIM SORVIG

after having been first duly sworn under oath, was questioned and testified as follows:

CHAIRPERSON BAILEY: State your name and place of residence K-I-M S-O-R-V-I-G.

MR. SORVIG: My name is Kim Sorvig. I live in the vicinity of Cerillos, New Mexico in land that I own. I am a research professor at UNM and my expertise is sustainable land use, loosely called green building, and land use policy.

I published a standard reference book on those topics and I speak and consult on those issues internationally. I returned this Monday from a one-week trip across West Virginia and Pennsylvania to research the land impacts of the Marcellus Shale gas boom there and the effects on the economy. I believe what I learned is extremely timely and relevant to the hearing.

There's little dispute inside or outside of Pennsylvania that that state has almost no regulation of the oil and gas industry as it's currently stands. And the result has been a real gold rush mentality. I don't just mean among the drillers. Many of the landowners are also caught up on this. I drove nearly 1400 miles through rural landscapes that were being cleared and drilled to access the Marcellus and I also flew over three counties in a small plane. Even in as wet a landscape as Pennsylvania, which we clearly don't have here, the vegetation loss of pads and pipelines is apparently going to be permanent.

We saw flares that were burning off gas considered too dirty to market. Why we would want to burn that into the atmosphere I'm not quite clear, but those were visible for seven or eight miles, accords to the pilot's estimate, and one of them was directly above the outdoor running track of a high school, which I'm convinced is not good for student health.

I passed through towns where water wells had exploded with enough force to lift a house off its foundations, where tap water from wells that had been good, clean producers for decades were discolored or even became flammable after gas drilling nearby. I know the industry hotly contests whether this is their fault or not, but I think it's a bit much to accept that it's pure coincidence.

And I saw pits. That's how we describe them but they are really lagoons, many of them covering over five acres in size. They were day glow orange and other unexpected colors and they were within 100 feet of homes and schools. One of the largest was located on a bluff overlooking the Monongahela River held back by an earth damn. I would bet good money that damn had been exempted from engineering review of the ordinary kind.

I'm not just trying to paint the usual horror picture, because the thing most interesting to me was that in Pennsylvania, in this free-for-all environment, every single pit that I saw was completely lined. I was also in West Virginia where land application of pit waste is legal along with direct burial. I visited a site where the U.S. Forest Service has been doing carefully controlled timber management research for over 60 years, and yet a drilling company insisted on placing their rigs in the midst of the controlled patches of forest basically destroying the research.

They also took their legal opportunity to spray fracking fluid on a couple of acres. This is what's called land application. These were flowback wastes. Within three weeks all of the vegetation was dead. This is published research, incidentally, and not mine. And what has grown back has been very limited. The leaching that you would expect of those salts out of the soil has been slower than expected, and yet from the direct burial of the pit itself the salt concentrations are high enough to attract wildlife that are leaching out of what is supposedly a contained and burden pit.

These are the extremes to which other states have gone for the convenience of drillers in complete deregulation. I believe New Mexico's existing rule on waste disposal strikes a very reasonable balance between the needs and rights of drillers and those of citizens and landowners such as myself who potentially will be living near drilling sites in the foreseeable future.

I think that what we can learn from Pennsylvania and from the Marcellus Shale is that we do not want to take any steps backwards, and in my opinion the proposed changes to the existing pit rule are, in fact, exactly that. Steps backwards; in fact, beyond what is permitted in states that have no regulation at all. Thank you.

CHAIRPERSON BAILEY: As a sworn witness, you are subject to cross-examination.

THE WITNESS: I understand.

CHAIRPERSON BAILEY: Are there any questions of this commenter?

MR. HISER: No.

MS. GERHOLT: No questions.

COMMISSIONER BLOOM: No.

CHAIRPERSON BAILEY: Thank you very much. We will continue this case to June 20th at 9:00 o'clock here in Porter Hall.

MR. JANTZ: Madam Chair, before we adjourn I have a quick question. I have been asked whether the record for written comments is still open or the opportunity to submit written comments is still available and whether it will be until -- whether that opportunity will remain available up until the time when we reconvene in June.

CHAIRPERSON BAILEY: Let's ask commission counsel.

MR. SMITH: By rule, I hate to say this, but I was wrong earlier. By the rule, written comment period ceases five days before the hearing. That can be extended by the Chair or the Commission.

MR. JANTZ: That being the case, I would request that the Chair and the Commission -- and/or the Commission -- extend the written comment period.

COMMISSIONER BALCH: I have no problem extending.

COMMISSIONER BLOOM: I agree with that.

CHAIRPERSON BAILEY: Five days before the June 20th hearing would be -- June 15th would be the new deadline for submission of written comments.

MR. JANTZ: Thank you Madam Chair, Commissioners.

CHAIRPERSON BAILEY: This Commission will sit next week to hear other cases. All right. Is there any other business before the Commission?

(Note: A discussion was held off the record).

CHAIRPERSON BAILEY: We are in recess.

(Note: The hearing stood adjourned for the day at 4:10).

REPORTER'S CERTIFICATE

I, JAN GIBSON, Certified Court Reporter for the State of New Mexico, do hereby certify that I reported the foregoing proceedings in stenographic shorthand and that the foregoing pages are a true and correct transcript of those proceedings and was reduced to printed form under my direct supervision.

I FURTHER CERTIFY that I am neither employed by nor related to any of the parties or attorneys in this case and that I have no interest in the final disposition of this case.

JAN GIBSON, CCR-RPR-CRR
New Mexico CCR No. 194
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