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OIL CONSERVATION COMMISSION

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Santa Fe, New Mexico

TRANSCRIPT OF PROCEEDINGS

February 28, 2025

VOLUME VI

HEARD BEFORE:

HEARING OFFICER RIPLEY HARWOOD

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BAYLEN LAMKIN, Member

DR. WILLIAM AMPOMAH, Member

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(On the record at 9:00 a.m.)

TRANSCRIPT OF PROCEEDINGS

CHAIR ROZATOS: Good morning to everybody. Happy Friday. Today is February the 28th, last day of February. Nice way to end the month, right?

I got a snicker at least. Thank you. Thank you for the courtesy laugh there, Mr. Rankin. I appreciate it.

We are continuing our case that we've had all week. This is the consolidated cases by Goodnight Midstream and Empire New Mexico. Case Numbers are 24123, 23614 through 17, 23775, 24018 through 24020, and 24025.

Just to make sure that all parties are present, I always start on the right side of the room, Mr. Rankin.

MR. RANKIN: Good morning, Mr. Chair. Good morning, Commissioners. Adam Rankin with the Santa Fe office of Holland & Hart, appearing on behalf of Goodnight Midstream in these cases.

CHAIR ROZATOS: Thank you.

Ms. Hardy.

And you're not going to be left out. I apologize. Did you want to call out her name, Mr. Rankin, as well?

MR. RANKIN: Sorry. Me and my colleague, Julia Broggi. Thank you.

CHAIR ROZATOS: Excellent.

Ms. Hardy, I'll have you say everybody that's in your party.

MS. HARDY: Yes, thank you. Dana Hardy, Ernie Padilla, Sharon Shaheen, and Corey Wehmeyer on behalf of Empire.

CHAIR ROZATOS: Excellent. Thank you. Appreciate it.

Mr. Moander.

MR. MOANDER: Chris Moander appearing on behalf of New Mexico Oil Conservation Division.

CHAIR ROZATOS: Excellent.

Mr. Beck.

MR. BECK: Matt Beck on behalf of Rice Operating Company and Permian Line Service, LLC.

CHAIR ROZATOS: Excellent.

And, Mr. Suazo.

MR. SUAZO: Good morning, Commissioners. Miguel Suazo appearing on behalf of Pilot Water.

CHAIR ROZATOS: Excellent. Thank you.

I'll turn it over to Mr. Harwood now so we can start our case.

HEARING OFFICER HARWOOD: Okay. Do you guys want to take up scheduling first, or what's the Chair's preference?

CHAIR ROZATOS: The Chair would like it. Do you all have some time to -- can we use some time right now to talk about scheduling?

The commissioners have spoken and tried to kind of get our schedules together. The month of March is horrendous for every person on the committee. So March is out for us.

The soonest we could reconvene would be April the 7th through the 11th. Then we have April the 21st through the 25th. And then we also have May the 19th through the 23rd.

Now, if you all agree to those dates as well, we can actually start solidifying this and sending it out. So I'll repeat it. April 7th through the 11th. May the 21st through the 25th -- whoa, I'm having a hard time today. I apologize. Let's start this over.

April 7th through the 11th. April 21st through the 25th. And May 29th through the 23rd.

HEARING OFFICER HARWOOD: May 19th.

CHAIR ROZATOS: 19th through the 23rd. See, I'm having a hard time.

MR. MOANDER: And, Mr. Hearing Officer, I have long-standing scheduled obligations for May 22nd and 23rd. From OCD's perspective though, all of those are -- we're more than happy to be available.

CHAIR ROZATOS: Thank you, Mr. Moander.

MR. RANKIN: Okay. So as far as dates go, it looks like, I think, the strong preference would be April 7th through the 11th for a Goodnight.

CHAIR ROZATOS: The way this week has gone, you know it's going to be more than one week. I just need you to pick two sets of dates.

MR. RANKIN: Okay. Yeah. I think then, yeah, we'll probably -- I mean, the next set, yeah. April would work. Our preference would be to get it done in April.

CHAIR ROZATOS: So the two sets of dates in April?

MR. RANKIN: Yeah.

CHAIR ROZATOS: Okay. Ms. Hardy.

MR. WEHMEYER: For the part of the Empire, I believe April 7th through 11th and April 21st through the 25th would be greatly preferred.

CHAIR ROZATOS: Okay. We'll solidify those dates in, and then we can revisit. Keep the 19th through the 23rd of May open in your schedules as well, because, again, with all due respect, the way this week has gone, I see it going that far, as well. So we'll block it off on our calendars as the Commission and then they will be set.

So, Sheila, let me repeat them. They are April 7th through the 11th, April 21st through the 25th. And then, if need be, May 19th through the 23rd.

HEARING OFFICER HARWOOD: Mr. Chairman, not to monkey-wrench anything, but Pilot and Rice, do they need --

CHAIR ROZATOS: I apologize. Yes. I'm so sorry.

MR. BECK: I would have spoken up if any of those presented a problem.

CHAIR ROZATOS: Thank you, Mr. Beck.

Mr. Suazo.

MR. SUAZO: Likewise, those dates right now definitely work for Pilot. So thank you for putting them out there.

CHAIR ROZATOS: My apologies for my oversight. The coffee has not titrated in yet.

MR. SUAZO: No problem. I understand.

CHAIR ROZATOS: Thank you.

Are we good with those, Sheila?

MS. APODACA: Yes, I got it.

CHAIR ROZATOS: Excellent.

MR. RANKIN: I just want to make one more point on the dates, just so everyone's aware. There's a chance that at least one of our witnesses will have to do it remotely, based on his wife is expecting right around that time. So I may have to ask for grace to allow that witness to testify remotely.

CHAIR ROZATOS: I believe that's a valid excuse for some grace.

MR. WEHMEYER: Empire has no objection to the remote attendance.

CHAIR ROZATOS: Great. Thank you.

OCD, do you have any problem with that?

MR. MOANDER: Absolutely not.

CHAIR ROZATOS: I didn't think so.

Mr. Beck.

MR. BECK: No.

CHAIR ROZATOS: Mr. Suazo.

MR. SUAZO: No, no.

CHAIR ROZATOS: Okay. Great. So, as I said, that's a good excuse, valid.

I'm going to let you pick that one up. I'm doing the date, so I'll transfer it over to you now.

MR. WEHMEYER: And, Chairman, with one clarification for Empire. We've not checked with any of our witnesses on these dates, but we are assuming that if there are conflicts that require remote attendance, we would have that same courtesy. We will certainly let the Commission and counsel know if we run into a witness conflict.

CHAIR ROZATOS: Please, let's definitely keep the lines of communication open. I mean, these are almost two months out, so we want to make sure that we can work with schedules and stuff. So definitely just communicate with us, please.

Go ahead, Dan.

MR. RUBIN: Thank you, Mr. Chair.

Mr. Chair, Members of the Commission, before we get back to Mr. Harwood and the hearing of the next witness, I wanted to take up and hopefully finish the matter of the order on the scope of this hearing.

As you may recall, when we discussed this early in the week, we had amended it, and we need to further amend it to reflect the stipulations and expectations of the parties, as well as ensure that the matters that the Commission should consider are included in the scope.

So what you have, I've e-mailed to you, what I've simply done is forwarded to you the version that was sent back to me by counsel for Empire.

I have not heard back from the other parties, and so I want to hear from them if they have anything further. But I would ask -- so before we ask for a motion, is there anything further to add?

And I'll start with Goodnight, Mr. Rankin. And hopefully you have the e-mail from Ms. Shaheen from several days ago.

MR. RANKIN: Maybe if you would start with another counsel, that would give me an opportunity to pull it up. I'm sorry, I just have been unable to give it a review since you circulated it. I apologize.

MR. RUBIN: Oh, no worries, sir.

Mr. Moander?

MR. MOANDER: I think with the edits Ms. Shaheen did, turning what was the second paragraph to a third independent point, I think that works, because all three of the primary parties are covered by this at this point.

So OCD doesn't have any objection to the edits supplied by Empire.

MR. RUBIN: Thank you, Mr. Moander.

Mr. Beck?
MR. BECK: Rice and Permian are fine with it.
MR. RUBIN: Mr. Suazo?
MR. SUAZO: Pilot is good with the edits, Mr. Rubin.
MR. RUBIN: Thank you, sir.
Mr. Rankin?
MR. RANKIN: Yeah, I pulled it up. I believe that the way it's been outlined is adequate and addresses the concerns that have been raised.
MR. RUBIN: Excellent. I appreciate the parties giving this the extra consideration I believe it merited.
So, Mr. Chair, Members of the Commission, if I may have a motion to re-amend the order of July 2nd of the Commission with respect to Paragraph 2, as I e-mailed it to the three of you. If I could just simply get a "So moved."
CHAIR ROZATOS: I move for the amendment.
COMMISSIONER AMPOMAH: I second.
MR. RUBIN: Vote, please.
All those in favor?
ALL MEMBERS: Aye.
MR. RUBIN: Any opposed?

(Motion approved.)
MR. RUBIN: I will present a form of order to the Chair to sign reflecting this decision so the record is clear.
That's all I have. I appreciate the parties on this. I will turn it over to Mr. Harwood. Thank you.
CHAIR ROZATOS: Thank you, Mr. Rubin.
I see Mr. Melzer back on the stand, so I assume we're going with him and going to finish him and then bring back Dr. Buchwalter.
MS. HARDY: It's actually the opposite. Dr. Buchwalter is on the stand. We would like to call him first because he has a flight to catch. And then Mr. Melzer can return after Dr. Buchwalter.
HEARING OFFICER HARWOOD: I'm sorry. I'm confusing your face with --
THE WITNESS: I know. We look so much alike.
HEARING OFFICER HARWOOD: All witnesses look alike after a while, so my apologies.
Well, I'm not sure where we are with Dr. Buchwalter. Refresh my recollection somebody.
MS. HARDY: I believe it was time for cross.
CHAIR ROZATOS: It's cross-examination,

right.

Mr. Rankin.

MR. RANKIN: Thank you, Mr. Hearing Officer. Yeah, I'm shifting my files around, getting ready for Dr. Buchwalter. So I think I'm ready to begin.

HEARING OFFICER HARWOOD: All right. Please proceed.

Dr. Buchwalter, I'll just remind you you're under oath?

THE WITNESS: Yes.

JAMES LEE BUCHWALTER,
having first been previously duly sworn,
testified as follows:

CROSS-EXAMINATION

BY MR. RANKIN:

Q. Good morning, Dr. Buchwalter. I'm sorry to have to delay your examination for today.

A. That's okay, Adam.

Q. So just I want to just kind of touch a little bit on your background real quick before we get into the details of your opinion and your model.

You've got a bachelor's degree, master's degree and Ph.D., all in chemical engineering. But in every case, it was with an emphasis in model simulation, correct?

A. Yes, that's correct.
Q. And since you graduated with your master's degree, you have been doing reservoir simulation?
A. Yes, that's correct.
Q. And generally focused on the oil and gas industry, correct?
A. Yes, that's correct. Well, initially, I was a production engineer for a little bit, for a few years. But after that, simulation.
Q. Okay. During that time since, when you were a production engineer, did you ever -- did you work on any carbonate systems?
A. No. I've worked on Gulf Coast reservoirs.
Q. And since your time as a simulator, we talked about this a little bit in your deposition, but do you recall simulating specifically carbonate systems?
A. Yes. I've done over 350 studies in the last 20 years, and that includes carbonates. And we have about a thousand other studies that we've worked with and clients as well around the world and the US.
Q. And have you specifically done any modeling or simulation for San Andres in the Central Basin Platform area?
A. You know, we have thousands of reservoirs

out there that we've looked at. So, to my knowledge, we have not, but we may have some in the database.

Q. Okay. Given how difficult this one was, you would probably remember if you did, wouldn't you?

A. If I had one like this, I would never forget it.

Q. Yeah. I thought you would say that. Thank you.

A. One in a lifetime.

Q. So have you previously modeled any ROZ fields or prospects?

A. There's two ways I can answer that. The way that we're talking about ROZ here, no. But ROZ can actually be two different things.

Every reservoir that's an oil reservoir has an ROZ because every reservoir has capillary pressure. So for those reservoirs you could say yes, I've modeled many ROZs. But not in the context of this here.

Q. And just to be clear, you weren't asked actually to model production of residual oil from any of these formations, were you?

A. I wasn't -- well, I wasn't asked to model the San Andres. The San Andres is included, but it's residual oil.

Q. Okay. And you haven't been asked to model CO_2 flood and tertiary production from this field?

A. No, I have not.

Q. And so what you were asked to do was to simulate the communication between the Grayburg and San Andres, correct?

A. I was asked to build a model to match historical production pressures and the leak -- the possible leak between the Grayburg and the San Andres.

Q. Okay. Now, in your testimony, I'll skip over to Page 2, I've tried to highlight some of the points I want to discuss once we walk through all this.

This is Page 2 of your direct testimony, which is marked as Exhibit E. I'll skip up to the top. Again I extracted this from the -- let me know when you can see this screen that I'm sharing.

A. I can see it.

Q. Okay. So I've got up here your self-affirmed statement that you prepared back in August. And I'll just skip down to the bottom here, where you've got your signature and can let me know if this looks like you agree it's your Exhibit E?

A. Yes, it's my document. Correct.

Q. Okay. And then there's exhibits attached.

So in this document here, the first statement I want to just talk to you about what I've got highlighted here. Under heading H, you describe that it's a reservoir simulation for an area that encompasses both or all three of the units here, Eunice Monument South Unit, the Eunice Monument South-B Unit, and then the Arrowhead Grayburg Unit, right?

A. That is correct.

Q. Why did you include -- since this case is only addressing the EMSU, why did you include the EMSU-B and the AGU in your model?

A. I mean, honestly, I really wanted to, in my first version of this model, just have the EMSU. And this reservoir is huge, 17 miles by 10. But when I built that model, I realized that there's actually fluid moving between the leases.

In other words, as big as this model and this reservoir is, you could not history match this model without putting all three cases in the model over this 90-year period. It just -- things would never fit.

Q. So you're saying based on your model simulation that there's -- when you say "fluid," you're talking about oil, gas and water, correct?

A. Correct.
Q. Okay. So based on your model simulation you're saying that there's oil, gas and water flowing between all three of these units?
A. Yeah. For example, maybe at one point, maybe more fluids moving in one lease than the other, and as a result the fluids from the other lease move into that -- leases. Everything's going to move towards the point of less energy or lower pressure, and it just wasn't possible without including all leases in the model.
Q. And just to be clear, you're talking about communication within the Grayburg as well as the San Andres, correct?
A. Yeah. Unfortunately, yes. They made the model so complex.
Q. And you've also got the Penrose in there as well, correct?
A. Yes. Essentially, the Penrose is the top of the reservoir, and without the Penrose and the gas cap in the Penrose, you could never match the Grayburg as well.
Q. Just a point on it. So what you're seeing in your model is that there's communication of shared production in the oil columns between all three of

these units, right?

A. There's, essentially, a continuous communication between the Penrose and the Grayburg, and a very limited communication between the Grayburg and the San Andres through a sealed -- seal, with, like, a hundred or so spots that we identified as leaks between the two reservoirs.

Q. Okay. Of course we'll move into that in more detail shortly.

So next point I want to just kind of raise with you as we get into the elements of the -- let's see.

MR. RANKIN: Excuse me, Mr. Hearing Officer, one moment. Since I wasn't expecting to do Mr. Buchwalter this morning, I need to make sure I have my notes in the right order. I apologize. Because I think I may have misplaced my notes for this morning. One moment.

BY MR. RANKIN:

Q. So on this model here, before I move down to the next point, I'm going to stick with the heading here under subpart H, I think this is a good point, before I get too far, to understand more about what the starting inputs and parameters are for your model.

If you would, just kind of give me a

high-level overview of the key inputs and parameters that sort of drive your model.

A. There's a lot of things in the model. Let me get my thoughts together.

Well, essentially, we started with data. I was given and ranges of data for things like net to gross and contact. So we put the initial data in, and we adjusted the relative perm curves in the Grayburg/Penrose in order to establish a match of the production.

And then when we could not match that production without adding the San Andres, we added San Andres and we adjusted the size of the aquifer and the properties in both the aquifer and the San Andres to eventually come up with an aquifer that was sized appropriately to match the historical pressure changes in the San Andres and the water shortcomings from 1938 to the present in the Penrose/Grayburg.

And there's a lot of small details that, you know, I could spend the next three hours talking about the details in the model. But I think if I did that, you wouldn't be able to ask too many questions.

Q. I understand. I'm going to try to focus this a little bit here. So number one, I'm going to ask you, so among the inputs were the volumes for the fluids that we talked about, right, volumes for oil, gas and water, correct?

A. Yeah. We had to adjust the volumes to fit the historical production pressures. And that mostly was just adjustment of the contacts themselves within ranges that I had been given.

Q. Okay. And then among the other inputs were -- I guess I'm going to just call them "saturations." That would be for oil, water, and then for the ROZ that you were given for the San Andres, correct?

A. Correct.

Q. And off the top of your head, do you know what your starting point saturation was for oil?

A. I think our oil saturation in the model is around 30 percent.

Q. Okay.

A. If I'm not mistaken. I think it's in here somewhere.

Q. Okay. We'll get to it. Off the top of your head, do you know what the saturation was for water?

A. Well, as we move out into the San Andres, ROZ is part -- the aquifer is 100 percent water. And we've seen, I think, 30 percent as well in the ROZ for the San Andres.

Q. And you had a connate value for water in the Grayburg?
A. I think it's, you know, 30 percent, if I'm not mistaken.
Q. Okay. We'll get to it. I think it's in one of the slides.
A. Yeah, it's in the slide.
Q. Now, you've mentioned contacts. And just to explain to the Commission, when you say "contacts," let everybody know what you mean by the contacts within the field.
A. Okay. Well, we have to have a gas-oil contact and a water-oil contact. And I was given ranges to adjust those two parameters, and I adjusted those parameters along with things like porosity, until I came up with something to fit all the data in the Grayburg/Penrose.
Q. I think we'll get to it here shortly, but you used a starting point for your oil-water contact at minus 366 feet subsea, correct?
A. I don't know. I'd have to look it up. In the model, I have it all corrected to depth. It's not -- it's subsea corrected. So it's a data number and it's in here.
Q. Yeah. And then you had a contact for the

residual oil zone, a separate oil-water contact for the San Andres residual oil zone, correct?
A. Yeah. Essentially, that residual oil zone in the San Andres is in the top third of the San Andres. And essentially the oil-water contact conceptually encompasses all the producing wells in the Grayburg itself. So it's just a little bit below that, I think the generalized producing.
Q. I'll move to your exhibit so we have a visual to understand how it was constructed in just a moment. But that probably would be helpful.
Another input, substantial input here is the geology, right?
A. Yeah. The geology, you know, I trust the geologist to give me the right geology.
Q. Right. And so under this category, I'm sure there may be other sort of inputs that are important inputs. But I'm just going to list a few and you tell me if there are others that I've missed. And you can explain where they came from and how you put them in.
But on the geology, you have the structure for each of the formations, correct?
A. Correct.
Q. And then you got porosity?
A. Correct.

Q. And then permeability?

A. Now, can I correct the porosity? I had to create a customized porosity map across the whole structure to get everything to fit properly. The average porosity was around 6 percent. I think it's consistent with what you're going to see in the past studies and past reports. But it was actually a customized porosity that we had to put in there to get everything to fit. So it was actually quite complex.

Q. And the structure, just a couple questions on the structure. We heard testimony this week that Empire engaged a group called OPS or OPS Geologic to conduct a new stratigraphic model. Was that structure used in your model?

A. I don't know where that -- I mean, I was given the structure map. I'm not sure where that came from. I mean, small changes in the structure will result in small changes in the model. So I don't think it's -- from a modeling perspective, if you want to picture this reservoir, it's not going to change.

Q. I wanted to ask you the same question on the saturations. Well, maybe we'll get to the numbers, but do you recall how you came to your oil saturations, oil and water saturations?

A. Yeah. It was just from literature values.

Q. Okay.
A. I should say literature values is from reports like the -- I think maybe the 1990 report or some other report.
Q. Okay. But you weren't relying on any of Empire's experts or the petrophysics that Empire's experts prepared for your saturations in your model?
A. And that was then afterwards -- I mean, for the purpose of the model in a field-wide match, that was not necessary.
Q. Okay. So you didn't use any of those analyses to corroborate or check where your saturations are for different locations in the model?
A. That would not have really changed the results of the model. You know, we adjust porosity and -- essentially, porosity mostly and copies the same thing.
Q. Okay. The other, last but not least, input, I think, as I recall from our discussion during your deposition, is the initial -- or the reservoir pressure, correct?
A. Correct.
Q. And when we discussed these inputs during your deposition, I understood that, you know, what you told me was that the two main or two most important

starting input parameters would be, number one, the pressures, reservoir pressure, right?

A. Absolutely.

Q. And Number 2 would be the geology under the sub-inputs, so the inputs underneath the geologic category, correct?

A. Correct.

Q. Okay. And as far as the reservoir pressure goes, do you recall what your starting point was for the San Andres reservoir?

A. I can't remember the data, but as I recall the San Andres, is it 15 something? I think it's in here somewhere.

Q. Okay. Yeah, we'll get to it, I guess. But you got that pressure -- all the inputs -- let me wrap it up this way. All the inputs and the data that you got were either from Empire or the literature; is that correct?

A. Well, it's really everything came, yeah, mostly from Empire. They gave everything, so it all came from Empire.

There was a small correction that I made after we had our talk. And I made a little higher pressure in the reservoir, so I added that into the model. It was a slight adjustment, but basically the same results.

Q. Okay. And as the data and documents or information you got from Empire that were your inputs, did you do, yourself, any quality control, quality assurance to confirm the values that you were getting?

A. It's about all I did. Because with 638 wells and 90 years of production, this is such a precise model. If you get anything off, just a little bit -- I mean, the big picture has to be -- you have to get it right or you'll never get a history match.

Q. So are you saying you did do quality control or quality check the data that you were provided by Empire?

A. Yes, I did. I mean, I have 638 wells and I checked them over and over again. And a lot of things actually get imported automatically, like the geology and things like that.

Q. Let me ask you this way. Did you go back and confirm that the information was correct, like the starting points, the values, the production volumes were actually correct? Or did you rely on Empire to do that for you?

A. Well, Empire gave me the production volume, so I assumed they were correct. And when things didn't match, I had to go back to Empire and find some corrections.

Q. So I think in your slides, and maybe I can -- I'm a little worried about bringing up PowerPoint because we seem to have a problem with Teams.

But my understanding was that you had stated that you relied on the client for confirming the validity and the accuracy and the correctness of the information because you did not yourself do the quality control checks of the inputs.

A. No, that's -- right. When I do a study, I rely on the client to give me good data and I use that data.

Q. Okay. I'm coming back over these. And, again, I know it's a lot to keep in your head. And we can walk through it as we go through. But I'm going to ask you, which of the inputs that we discussed, fluids, saturations, contacts, geology and pressures, which of these inputs were measured, and which were assumed or modified based on your trying to get the model match at the initial start point?

A. The geology remained fixed. Net to gross remained fixed. Porosity, I adjusted. PVT had small adjustments. And contacts had small adjustments. Permeability, relative permeability all got adjusted.

The leak locations and the leak factors to represent the flow through the fracture network from the San Andres was adjusted. The extent of the San Andres is adjusted. The permeability and all these reservoirs was adjusted. And probably another five things I just forgot, but -- not that I forgot, I've just forgotten my discussion. I didn't forget to adjust them.

Q. Okay. So the ranges that you were given for porosity and permeability, when we discussed it during your deposition, you told me that, for the most part, you tried to honor the ranges that you were given for your input parameters. But as for porosity and permeability, those were at least two of the inputs that you went outside of those ranges, correct?

A. That is correct. Well, overall porosity was about the same. But you understand, this is a model, it's not material balance. So my average porosity was very close to the porosities that were in the documents and some of these that I've been provided.

The permeability was one parameter where I had to make a very large adjustment because we not only have the dolomite, we have the fractures as well. And the dolomite, you know, might have a permeability -- I don't know, that could have 10 millidarcies or in that order of magnitude. But with the fractures, the effective permeability of the fractures in the rock combined was much higher. So we couldn't get the production without actually modeling the two together --

Q. When you say --

A. -- increasing the permeability.

Q. When you say you had to make a very large adjustment to the permeability, by what, a factor of?

A. Like in the Grayburg, I think it's somewhere between 250 and 500 millidarcies. And in the San Andres, it's several hundred millidarcies; maybe it's 500, I can't remember. I'd have to look.

If there's something that I can't -- that you can't find in here, I've got the model. When we take a break, I'll get --

Q. No, I appreciate it. I mean, it can't all be in your head.

A. I just can't keep everything in my head with this model. It's just too big.

Q. I totally understand that. I'll ask you the questions and then we'll pull up slides and talk through it. I do have a slide that I think has the model porosity and permeability inputs.

But I guess my question to you is just

sort of on a general scale. I appreciate you trying to give me the specific numbers, can you give us a range? Like, you know, how much did you have to increase the permeability here to make your model fit initially? Was it a certain percentage, a factor of 10? How large --

A. I think in some of the reports I was seeing 10, 20 millidarcies for the dolomite permeability. And so we're basically going from that to maybe, let's say, 200 to 500 --

Q. Okay.

A. -- as a result of the fractures themselves. And I tuned that number so that we could match the production and the pressure histories as well.

Q. Got it. Yeah, we'll get to the initial matching here in a little bit.

Now, the other thing I think is a starting point in your model, you had to place your oil, right, and your gas into the model, correct?

A. Correct.

Q. How did you do that? How did you place your oil in the model?

A. Well, I had a range of oil-water contacts. I mean, honestly, you need to place the oil below all the producing wells, right? So I placed it down there and I just tweaked it a little bit, between what was thought to be the range that was possible -- and one thing I want to emphasize is, you know, I'm just a consultant, so I don't do the petrophysics, I don't do the geology. The only thing I do is take this data and make it fit right. And when it doesn't fit, I have to go back to client and say, "This can't fit."

Because the reservoir, unfortunately, we can't go underground to see everything. So that's kind of how it works.

Q. Understood. So I'm just trying to understand. So, like, now, in terms of placement of the hydrocarbons, because we have now three units, how did you allocate the production between the units? And is there oil that you placed, you know, in the area between the units, where there's no unit?

A. Yeah, there's one constant contact, the oil-water contact across all three units, one constant gas-oil contact. And then, as I said, I adjusted the porosity a little bit to get things to fit better in one area than the other.

Q. Okay. Again, I think you have a 3D image of the model, and that may help, right, to --

A. Right. I could bring it up here if we could --

Q. I'll get there.
A. -- possibly get some time, if you want to.
Q. I'll get there. Appreciate it.
So in terms of the oil-in-place values that we talked about sort of at a high level, how did you come up with your oil-in-place values for actually what the volume of oil in place was that you allocated or --
A. Well, I started with the wrong oil in place, the wrong gas cap, oil gas cap in place. And what we do is we run the model and we see if we fit the production pressures. And if we don't, then, you know, I adjust those contacts up and down until things fit, along with the porosity and the link between the two.
Q. And the oil in place, were those values initially given to you by Empire?
A. They gave me some ranges. I think it was up to about a billion barrels. I ended up with, like, I think, a little shy of 900 million barrels, yeah. The oil-in-place actually went down in the history match model.
Q. Okay. When you say you got the wrong oil in place to start, what do you mean by that?
A. Well, I didn't get the wrong oil in place.

I just got the -- the oil place, it was, I think, estimated from past studies. And I just, you know, pulled that number and saw, and then I adjust to fit the historical data.

Q. One thing you said just a moment ago that I wanted to ask you about. You said this is a model, it's not material balance. What do you mean? How do you distinguish between a model and material balance?

A. Man, if it was material balance, this would be so easy.

Material balance, if you have a box and you have whatever fluid you want in it and you take some fluid out of it, you see how much the pressure changed in the box versus where you started. You can determine how much was in the box originally without looking in the box and even know how big the box is.

So in a perfect world, if everything changes throughout the reservoir at the same time, then you have what's called material balance, where you can take fluid out, you can see how the pressure changes, you can exactly determine how much oil, water and gas we have in this box.

The problem with reservoirs is that you're in a rock. As you produce this reservoir, at any point in time, you can have different pressures in different parts of the reservoir. So in order to capture that material balance, it's not just one pressure that you need to capture. You need to capture the pressures throughout this reservoir in order to be able to understand what the original oil, water and gas in place is.

And I like to say that if you take these reservoirs and say this is 1938 and you're drilling three wells, and you produce them for a year, I mean, this reservoir is 17 miles by 10 miles, I can't determine what the average reservoir pressure change is because we've only drained a small area around these wells.

So it takes a lot of production, a lot of wells, and a lot of history in order to determine what essentially is the average. And we really never determine the average pressure. We look at the pressures at the individual wells. So when I was, you know, like, looking at the current pressures, we got several hundred pounds difference even today in the different well locations of what the pressures are.

And so you're basically trying to get something that fits all those different pressures. And with that, with 90 years of production, you can actually, with high accuracy, determine what the original volumes of oil, water and gas are throughout these two reservoirs, and what the leak contribution was between the reservoirs.

Q. Okay. So between the two tools, a model simulation and material balance, why is a model simulation appropriate here?

A. Because the reservoir is 17 miles by 10 miles, and if you -- you can't integrate all those. You have different pressures in different areas, and it's just literally impossible to come up with what the average pressure is to determine what these volumes are.

Q. So I think I hear you saying that the system is too big to really do a full material balance?

A. Right. Essentially, it's like a dynamic system, and if you don't integrate those dynamics, you can't figure out what the answers are.

In addition to the fact that you've got oil, water, gas in different areas and things moving around as well. Because it's not just a material balance. You want to run this model forward. And so from 1938 to today, we need to understand where those fluids were in 1938, we need to understand where they are today. And it's -- you know, you can see a map, and I think you'll show it. It was very complex, where you've got checked-in water and it's moving up into what used to be the gas cap, and oil, water, gas are all moving around, and with the water injection as well. So you have to do the material balance and get the right amount of oil, water, gas in these reservoirs in order to have an accurate model, and that's the first thing you do.

And with 90 years of production, whether I do this model or another reservoir engineer does that model, we're all coming up with the same answers. Because with the amount of data we have, we can determine what those average -- essentially what those pressures are in different wells around the field at different times and integrate that in with the production.

We know what the volumes are, just like in that box, except this box is a lot more complicated. It's a bunch of boxes, all with different sizes, essentially. So that's kind of what we do.

Q. So on the pressures I asked you, you had a starting point for your reservoir pressure, right?

A. Correct.

Q. A single starting point, a single pressure point that you used to initiate your model, correct?

A. Correct. And that has to be correct, or your whole model is wrong.
Q. Okay.
A. The starting point has to be right.
Q. So now I heard you talking a little bit about how you had different pressures at different wells at different times, and you had initially just one starting pressure point, and that would be for the San Andres, correct?
A. Okay. That starting pressure is not throughout the whole reservoir. It's at one point.
Q. Right.
A. So if you're deeper in the reservoir -- and then that pressure changes depending where you are in the gas cap or oil and water column. So it's a very dynamic system. It's very complex.
Q. Yeah. So to come up with your different pressures at different depths, you'd apply a pressure gradient based on the fluid at that location, right?
A. Exactly.
Q. So when you ran your model, and we want to understand what the volumes are, you want to make sure that you know what the pressures are at the time and depth, right?
A. Exactly. Yes, that's correct.

Q. And now, did you have some checks, data, empirical points that you could confirm or calibrate your model, ensure that your model was correctly calibrated to?
A. Yeah. Essentially, the two big checks are what is the pressure of the model at the end of primary production. And we picked a well for that and then we all look at what the current pressures are in both the San Andres and the Grayburg those two times. So those, for me, those were basically the two checkpoints.
Q. So the initial -- and just to be clear, we'll come to this in more detail. But as you understand, the initial starting pressure point you received from Empire was at the time of field discovery?
A. Well, yes. And if you don't do it from field discovery, you don't have a good model here. So you have to go to 1938, because everything moves around. If you start some time later, everything's already moved and you can't -- you don't where anything is really.
Q. Got it. And the other point that you're using is at the end of primary production?
A. Correct.

Q. And the primary production data point was
for the San Andres?
A. It was both the San Andres and the Grayburg.
So we knew what the pressures were and we had a well
that we chose to look at that pressure.
Actually, I think what we did at the end
of primary is we had maybe a 2-, 300-pound pressure
difference across different parts of the Grayburg, so
what we do is we calculate what's called a volumetric
average pressure. So we take all the hydrocarbons and
all the pressures, rate them based on those volumes,
and we basically just tried to fit that pressure that
we were seeing on average at the end of primary
production.
And essentially did more or less the
same thing at the end of the current water -- the
waterflood as of today as well. So it's a good check
to kind of look at the big picture. But we want to
also look at the individual wells as well to see that
we had some points on those as well.
Q. How many different data points did you have
against what you checked the model for pressures?
A. I think at the end of primary, I was just
kind of looking at the average. We had one point in
San Andres, and I think I had just kind of like an

average that I was using for the Grayburg. And then I've looked at the current pressure that we have in one well and then kind of average pressure currently as well in both. And I have one pressure currently in the San Andres as well. And then currently I've got -- I had several wells I looked at pressures as well as the average pressure.

Q. Is it fewer than 10 wells that you had pressure data points or that you looked at?

A. I don't think it was quite that many. It was maybe, you know, six or seven wells. I can't recall.

Q. Okay. Six or seven wells?

A. That's just a guess, Adam. Don't hold me to it.

Q. But less than 10?

A. Yeah, I think it's probably a little less than 10.

Q. And just so I'm clear, you know, I'm just trying to get a track of the timing for these. So you had the starting pressure for the San Andres, you had another data point at the end of primary production. Right?

A. Right. For both reservoirs.

Q. For both Grayburg and San Andres. And then you had some additional wells throughout the waterflood period?

A. Yes. I had a few wells there.

Q. Okay. And those were the wells you used to sort of field-check your model on pressure?

A. Yeah. I mean, basically we look at the current time. There was, I think, a few hundred pounds pressure difference in those wells. And then I looked currently at what the hydrocarbon average reservoir pressure was and just tried to fit something that was a good fit throughout the reservoir.

Q. Now, on the starting pressure, the data that you got was data that, again, you relied on Empire for, correct?

A. Correct. And that was actually corrected, as you'll probably get in -- got into it after we've had our little talk.

Q. Yeah. It was a long talk, right? It wasn't too little?

A. It was really long. You know, we've been talking so I think we should be on a first-name basis.

Q. Yeah, okay. I'm happy with that, too. If you're good with it, I'm good with it.

So on that point, the starting pressure was changed from your initial model to the updated

models in your rebuttal, right?
A. Correct. And we were off a little bit on the datum that we picked for the pressure, so we had to correct them.
Q. Okay. We'll get to that for sure. Okay. Now, on the contacts, I'm going to ask you about the oil-water contacts. And each of these parameters had a substantial impact, right, on the model outputs, correct?
A. Yes. You have to get the contacts right or you don't have the right oil, water, gas in place, yeah.
Q. And pressures and the geology, all that stuff is critical?
A. They all have to fit, yeah.
Q. Now, the oil-water contacts, you know, you've heard testimony from Dr. Buchwalter, Jim. You've been here all week, right?
A. Yes, I have.
Q. And you've had the pleasure of hearing all this testimony every day?
A. I wouldn't say a pleasure.
Q. But it's been a long week. You've heard testimony about what the unit documents -- where the unit documents placed the oil-water contact within the

EMSU.

A. I've heard it, but -- it was probably subsea depths, correct?

Q. Correct.

A. I think I have it in terms of depths in the simulator, yeah.

Q. So the unit at the time was formed, depending on what document you read, it was the range of oil-water contact between minus 350 subsea and minus 325 subsea. Do you recall that?

A. I don't recall the specifics, but I, when I created this model, had a range of contacts, and I fit within that range.

Q. Okay. And just so you see it here -- and I think in this next paragraph here, I think you kind of give some of the initial values that you were using in your model, the model generated. And here, in your Paragraph 1, at the bottom of Page 2, you initiated with a minus 366-foot subsea oil-water contact, correct?

A. Yes, that's correct. That's what it says.

Q. And just assuming that the unit agreements either said initial oil-water contact at the time the unit was formed was either minus 350 or minus 325, your oil-water contact is somewhat deeper than that,

correct?
A. A little bit.
Q. Yeah. But the difference here would be anywhere from 16 to about 40 feet difference in the contact between where the oil-water is located, right?
A. Correct.
Q. Put 16 or 40 feet of water in the Grayburg over the area of 17 miles by 10 miles, that's a fair bit of water, isn't it?
A. We're talking about the water into the Grayburg?
Q. Yeah.
A. Well, in terms of -- you know, water has got a compressibility of 1 microsip compared to the oil and gas that can have very high compressibility. So in terms of volume, it's really not that much.
Q. Okay. Well, I mean, I guess in my simple mind, you know, 16 to 40 feet of water over 17 miles is a lot of water.
And I guess my question to you is by lowering the water-oil contact to minus 366 subsea depth, compared to what the unit document says, knocks out a substantial amount of water across your model, doesn't it?
MS. HARDY: Object to the form of the

question. I think it's confusing. And Mr. Rankin is testifying, I believe.

CHAIR ROZATOS: Well, all I heard, that it was maybe leading. It might be confusing to you, but I'm not sure it is to the witness, so I'm going to overrule it.

A. Okay. Let me explain. You know, we have a billion barrels of oil, right, or close to a billion barrels of oil. In the history-match model, we have 1.5 billion barrels of water in the Grayburg/Goat Seep, and you think, wow, that's a lot of water to run.

But if you think about it, water is pretty incompressible. Like, if this thing was full and I wanted to squeeze it to half the volume, I couldn't do it. By comparison, the match aquifer we have in the San Andres is 158 billion barrels. And that fits this historical pressure change in the San Andres from 1938 to today. It fits the pressure.

So, you know, when you say it's a lot of water, it sounds like a lot of water, but in terms of energy and the impact on the simulation, it's almost negligible. I mean, it's a little bit. I won't say that, you know, there's a little influx. But 99 percent of the aquifer energy over this history has

come from San Andres.
Q. I guess my question about that, though, Dr. Buchwalter, is when you initiated your model, as I heard you say in your summary, you found that the Grayburg didn't have enough water, so you had to go look for it in the San Andres, correct?
A. It couldn't come from the Grayburg, so yes, I would look for it in the San Andres.
Q. And one of the reasons it couldn't come from the Grayburg was because you said there wasn't enough water in the Grayburg, correct?
A. Yeah. There's -- you know, it's coming up from the bottom, and it has to come from the San Andres. There's no place else for it to come from.
Q. On the structure side, I think I already asked you this, but you used -- just to be clear, the structure maps that you were provided by Empire was back in -- like, earlier in 2024, correct?
A. Right. I think it's around the middle of 2024, if I'm not mistaken.
Q. So the variations in the structure that were presented to the Commission this week, for purposes of modeling, it's your opinion that it wouldn't have had a substantial impact on the outputs?

A. No, I mean, I could put in these new maps, but, you know, it has a little different top. I'd change the porosity or -- you know, to match the gas. At the end of the day, the match is going to have to have the same amount of gas, oil and water. So if you change these structures just a little bit, you're just tweaking things a little bit, for example, in the porosity, to re-establish the same volumes on a field-wide basis. Whether I do this and, you know, whether you put the Goodnight maps in here or our maps, you know, it's all going to show the same answer.

Q. I meant to ask you -- I'm sorry for -- I think I -- I was going through my notes and I was noting -- I was asking about pressures because I understand pressures are very important to the model. And the points we talked about that you used to calibrate or confirm were the starting point -- which was just one point, right? And you understand that was in the San Andres or the Grayburg, the starting point?

A. I think I had a starting point in both reservoirs.

Q. Okay. And then on the end of primary, you had both Grayburg and San Andres?

A. Correct.
Q. And then on your checks going forward, the additional wells from which you drew, you had pressure readings, were those both zones, both San Andres and Grayburg?
A. Unfortunately, I've only got two pressures on the San Andres. I've got the pressure at the end of primary, and I've got the current pressure that I was given for the aquifer in 2024. But, you know, it's enough data to certainly model it and have a very accurate description of the leak between the two reservoirs.
Q. Okay. One of the other things that we didn't really talk about too much during your deposition, but I want to understand a little bit, I think it's helpful, so the model -- okay. Let me just go ahead and do it. I'm going to go to the -- do you think that your rebuttal model image is better than the one in the --
A. Yeah, use the rebuttal model. You want to look at a 3D image of the reservoir?
Q. Yeah.
A. That's the one I would use.
Q. I think it was the --
A. And these models are so complex and they

just go beyond what you could ever do in simple hand calculations. They're never intuitive, either.

Q. My apologies. I got kicked off the system.

One thing I forgot to nail down with you, Dr. Buchwalter, before I move on, just to confirm, we had two different oil-water contacts. One was at minus 366, which is the main pay oil-water contact in the Grayburg?

A. Right.

Q. And the other is this residual oil-water contact at minus 660 subsea, which you placed in the San Andres Creek, correct?

A. Correct. I was just told that it was 900 million barrels, so I placed a 30 percent residual in the San Andres, and that's where that contact ended up.

Q. Okay. Thank you for filling that out for me. I meant to make sure I asked you about that?

A. Well, I knew what you were going to ask next.

Q. Yeah. So just to be clear, you don't know where that 900 million barrels came from terms of the residual oil saturation, but Empire gave it to you. And as with the oil in place, you allocated that within the San Andres within your model?

A. Correct.
Q. And that was allocated not just within the EMSU, but across the entire model, right?
A. That's absolutely correct. That's across the whole model.
Q. And just to be clear, you put that 900 million barrels in from the top of your San Andres layer down to minus 660 in your model?
A. Correct.
Q. Okay. I apologize for the losing connection and having to pick up where we were.
Okay. So on the rebuttal, I think it's M-1 probably, right?
A. I believe so.
Q. Okay. So I'll try to zoom in a little bit and we'll talk about it as we go.
So on the right is a 3D image of your model, right?
A. That is correct.
Q. And at the bottom here -- I'm going to work my way up. At the bottom is the San Andres Aquifer, correct?
A. This is just part of the San Andres Aquifer. I've actually cut it off. This is just the part that's under the model. That extends to the west.

CHAIR ROZATOS: Just remember, if you're on the platform, please mute yourselves. We can hear you.

THE WITNESS: Should I continue?

CHAIR ROZATOS: Please.

A. If you look on the left side of the picture here, I think that aquifer actually extends out about 30-something miles, and that's 158 billion barrels. It's a big, big aquifer. It's anywhere from 1,100 to maybe 1,700 feet thick.

Q. Right. So, in your model, you chose to build the San Andres Aquifer going up 36 miles to the west, right?

A. Correct.

Q. But you didn't choose to build it going north, east, south, but just to the west?

A. Yeah, I built it to the west. You know, you build it one direction or another, it's still an aquifer. I think if you built it to the west, there weren't as many saltwater disposal wells and things in the west. I thought it was a better direction to build the aquifer.

Q. Okay. And to make that decision, you didn't review any geologic information or hydrology or reports or anything like that to ascertain where the

San Andres actually is or where it actually goes?
A. No -- I mean, what's important for the aquifer is to understand its behavior underneath the Grayburg. And so you could build this -- you actually could build this aquifer in a number of different ways, but it would still give you a very similar result. Aquifers, they're still -- water is an incompressible fluid. And if I had detailed aquifer information, I could have built it, but the answer would be virtually the same.
Q. But the point here that you're making is that this is not the full extent of the San Andres in your model, it goes out 36 miles to the west?
A. Yeah. It's not even close.
Q. And the next layer up here is a little bit hard to discern. Maybe I'll zoom in just a little bit so we can see it. But there's another little layer of blue -- or not little, but there's another layer of blue sitting right on top of the aquifer here, and it has the outline of this -- a different outline?
A. Exactly.
Q. And that's the San Andres ROZ interval?
A. No. That would be the Grayburg ROZ interval. But, you know, I didn't have any information on the Grayburg ROZ, so I just put a

constant. Essentially, you have an oil-water contact that fits the historical data.

Q. Okay.

A. But there would be a ROZ there.

Q. Okay. Do you have a different contact between the Grayburg oil column and this ROZ in the Grayburg? Or is this the minus 366?

A. No. It's just a hard contact. Below that, you'll have -- due to capillary pressure, you would have a zone where the -- essentially, a ROZ has got two components. You can have, you know, oil trapped at residual saturation, or you could be in a transition zone with capillary pressure. But, yeah, I didn't have that information. So essentially the ROZ itself is inside the Grayburg.

Q. Okay.

A. Does that make sense?

Q. I think so. I hadn't realized that before.

Okay. And then the green here is the oil column, correct?

A. That is correct.

Q. Okay. And then the red is the gas that you modeled for the system, correct?

A. That's primarily just the Penrose. And I think when you get down to Grayburg, it's principally oil.

Q. And I think this may help us visualize how you placed the oil across your model, right, and the gas and the water?

A. Yeah. Yeah. It's a good picture of how the model is set up initially.

Q. So somewhere overlying this or inside of this oil column, you have the EMSU and the EMSU-B just to the northwest, and then the AGU down to the southeast, correct?

A. That's exactly correct. We actually have two layers for the Penrose, we have five for the Grayburg, and then three for the San Andres. So we have a total of 10 layers in the model.

Q. I'm going to quickly skip over back to your direct testimony, Exhibit E, and I'm going to pull up your Exhibit E-2, I believe, just so everyone can kind of visualize at a high level or at D level --

A. That's much better.

Q. -- yeah, at D level how you've set up your layers in your model. So basically, as you mentioned, you got two layers in the Penrose, right?

A. Correct.

Q. And then you got five layers in the Grayburg, correct?

A. That's correct.
Q. And then you got three layers in the San Andres, correct?
A. Correct.
Q. And on the right-hand side here, you've got the brackets showing how you placed your ROZ in the San Andres?
A. Correct.
Q. And 900 million barrels down to minus 660?
A. Actually, that 900 million barrels, that range should be a little higher. But, you know, it's just a cartoon, so...
Q. The "range," meaning?
A. The little, you know -- what would you call it, next to the --
Q. Yeah, the bracket.
A. That should be a little higher, if you want to get it exactly right.
Q. Is it just in layer 8 or does it go down?
A. I think it's mostly actually just layer 8.
Q. Okay. And just so I'm clear, the Commission's clear, how did you decide to put layers in the San Andres? Was it based on any geologic information or did you just break up the San Andres into those three layers?

A. I had the top -- I think I had the top and the bottom, so I just broke it up into three layers.

Q. Are they otherwise -- the input, the parameters, otherwise consistent throughout the San Andres?

A. Yeah. I believe they are consistent throughout.

Q. Okay. Now, how did you break up the Grayburg into five layers? You were here for the week. You heard testimony from Dr. Lindsay. He was working in a six-layer system within the Grayburg and the EMSU. How did you come to five layers?

A. I had layer 3 and then layer 4, layer 4 through 7 was given to me, and then basically split the layers.

Q. So Empire gave you layers 3 and 4, correct?

A. No, they gave me 3, and 4 through 7, and when we brought it in, I split the layer, layer 4, into four sub-layers. Does that make sense?

Q. I'm not -- no, it doesn't.

A. Okay. Well, imagine you've got a cake and then you cut it into four slices, that's essentially what it is. So the total thickness is the same. We just broke it up into four pieces. And we did that so we could model the physics and the fluids and everything in more accuracy, higher accuracy.

Q. So how many layers were you given for the Grayburg?

A. I was given two.

Q. Two layers. So you were given two layers and then you broke it up into five?

A. Correct. I mean, for the purpose of this model and the answers that it had to give, it's -- you know, the main focus here was just figuring out the history match and determine what the leak was between the reservoirs, so that's more than adequate for this model.

Q. I'll return to this in some detail in a little bit for sure.

I'm going to go back to your 3D model because I wasn't quite done kind of understanding how this was built. Okay? Now, obviously, in reality, the real world that we live in and walk through, the world just doesn't stop at the edge, whatever you're saying it is, right? Something happens after that edge.

Are there cells alongside the boundaries here, the lateral boundaries of the Grayburg and --

A. There are cells there. And if I actually extend the Grayburg/Goat Seep aquifer further, I'd

lose the match of the downdip wells in the Grayburg historically.
So what happens is, it's actually quite complex. But you got water moving up from the bottom and you got water moving up from the side, and you have a whole bunch of wells on the edge here as we move from north to south. And so I had to -- essentially, I size the limit for the reservoir in the Goat Seep contribution so that I would fit the historical data on those wells.
Q. So you're assuming water's coming up from the bottom?
A. I've actually got water coming up from the bottom from the San Andres. I've got water coming up from the side and the bottom of the Grayburg, and even some water coming up from the bottom in the Grayburg. So it's all three. Yeah, it's not as simple as this or that. It's all three, unfortunately.
Q. So moving back to my question about the lateral cells. There are cells out here, and you said if you included them or made the Grayburg bigger, you've lost your match. So did you null those cells or turn them off?
A. Yeah, essentially I nulled those cells. The other thing, if you extend it out further, you just

have too much oil. There's no wells outside these boundaries essentially.

Q. Right.

A. And so this allowed us to come up with a good history match. Essentially, we took the initial leases and look at the well boundaries and then move outside of there just a little bit to where we could get everything to fit.

Q. Okay. So a fair bit of the testimony this week has been around the known connected aquifer to the west of the Grayburg called the Goat Seep. But you're telling me that if you include that Goat Seep to your model, it doesn't history match, right?

A. Well, the Goat Seep is in there. I mean, basically the aquifer I have attached in the Grayburg/Penrose is an aquifer that helped me match historically what was going on in the deep wells in the Grayburg. So, I mean, I don't know where the Goat Seep -- where the Grayburg ends and the Goat Seep starts and how much -- and took the contributions from the two. But that aquifer was put in there in size so I could get everything to fit, essentially.

Q. Yeah, I mean, I'll just give you credit. I mean, you weren't told -- in your initial direct testimony, we learned during your deposition that you weren't aware that the Goat Seep was connected to the Grayburg to the west, right?

A. Right.

Q. Yeah, because Empire hadn't told you that, right?

A. Well, Empire -- I mean, I had heard that, but the history match model, basically, I just thought this is so small, this stuff in the west side of the Grayburg, is it Grayburg Aquifer, is it Goat Seep Aquifer, I didn't know. I just -- you know, I just know that's what we had to put on there to get things to fit.

Q. But after your deposition, after you learned that there was a Grayburg Aquifer to the west and you modeled that, we'll talk about it in your rebuttal, but you did then include a Grayburg Aquifer to the west, correct?

A. No, it's included in the original model, it's just like, you know, it's so small, being a little over a billion barrels, that, you know, I -- in terms of reservoir energy and the way that reservoir energy thinks, if 99 percent of the energy is coming from the bottom and 1 percent's coming from a little bit from the side, I mean, to me, it's inconsequential.

But technically speaking, even in the original model, that was in there. But as I said, I think as a reservoir engineer, I would say that it doesn't have a significant aquifer.
Q. Okay.
A. It's a one-to-one aquifer. It's about only the size of the Penrose/Grayburg, so it's very small energy. So it just depends how you think of it, basically. It's exactly the same aquifer that was in the original model. Even though -- I know I said this, and it's correct, I mean, it's almost no aquifer influence either way.
Q. We'll come back to that in a little bit, because I have other questions around that.
How did you choose your model size? You told me that it was 17 miles by 10 miles. Now, obviously, you know, as we learn more about the San Andres especially, we know it's very big. How did you choose to limit it to 17 miles by 10 miles?
A. Because that's basically the area that encompasses the reservoirs there. If you look at it from the top view --
Q. Yeah, let's do that.
A. -- that grid just basically fits all the wells more or less. And if you look at, like, the

northeast corner, I think there's no wells out there, so it's nulled out. So, basically, the grid was in the -- we tried to encompass all the wells, and then when we couldn't fit things, we add a little extra volume outside this area.

But, basically, the model's just fitting where the wells are. Because I assume if there were well -- there's production outside that area, we would have wells.

Q. I should have brought this up during our deposition earlier, and I'll do it here. But I think this may help, too. This kind of gives us a better sense of what we're looking at on Exhibit E-2 here. This is Exhibit E-10?

A. Correct.

Q. And as I understand, this is the 17 by 10 -- I'm showing with my cursor, and I'll highlight it -- the 17 by 10 mile --

A. Correct.

Q. -- model area for the three units, correct?

A. Can I correct myself, Adam, if you don't mind?

Q. Yes. Not at all.

A. I had to expand that area so I make sure I get all the saltwater disposal wells that we had as well.

Q. Okay. So this image is a little bit bigger than what I'm showing here?

A. No, it's what you're showing there. But you can see there's saltwater disposal wells. They're the blue circles with the blue arrows. So, basically, I tried to encompass that whole area so I encompassed all the saltwater disposal wells.

Q. So what I was showing at E-2 is a little bit smaller than what this is showing?

A. No. It's really the same. But when you get down in the San Andres, that's where the saltwater injectors are. So you don't see the structure for the Penrose/Grayburg, for example, in that northeast corner. But when you get down to the San Andres, you do see the structure.

Q. So this is the core of the model, but then you, as you just said, you made the San Andres about 36 miles to the west. It extends out 36 miles to the west in order to make sure -- in order to accommodate the volumes that you needed, right?

A. I did it by trial and error and the number of runs. I had to find the extent of the aquifer to fit the San Andres pressure at the end of waterflood, the leak volumes that went up into the Grayburg, and

then the current pressures in both reservoirs.
Q. Okay. Then, that gives a sense of the dynamics or the size here. And then the other element that I don't think we probably finished talking about, or maybe I did, I don't remember anymore, but hopefully we didn't, is the cell size, right?
So this model is made up or comprised of individual cells that, that are put into this model grid, right?
A. Correct. Essentially, each cell is an area of the model, and each time step we run the model, as things change, fluids move between these different areas. So this allows us to -- as opposed to material balance, where you just have, you know, one saturation everywhere in one pressure, this allows the fluids to move. We can monitor the fluids through the movement and the pressure changes as time proceeds. The cells, I think, are around 300 feet.
Q. Okay. Are they 300 feet square?
A. Yeah, they're roughly 300 feet. Maybe it's 290. I don't know, something like that. So it's at 300.
Q. And the model size is something that you can adjust to it. You can make the model cells bigger or smaller?

A. Yeah. I mean, a rule of thumb is you want to have at least two or three wells between -- excuse me -- two or three cells between wells. And you want to do that because that allows you to capture the pressure and saturation changes between the wells themselves. In other words, capture the picture of what's going on between the wells.

Q. And the smaller the cell, the more resolution you might be able to realize in your model in terms of the flow?

A. Yes. I mean, the smaller the cell, the longer it takes to run, the longer it takes to get the answer, too. So you want to get a good answer, but you don't want to take forever to do it. The client gets mad.

Q. And the cell size, I mean, just thinking about it, I guess we can come back to that, but the cell size would allow you potentially -- if you were to reduce the cell size, it would allow you to integrate more nuance, obviously, depending on the geology, porosity, permeability, all those inputs we talked about, correct?

A. Correct, with a caveat. The whole goal of building a model is the ability to answer the right question. And for this reservoir, that question was to come up with a good match of field production for the last 90 years, and to see if that leak exists and what that quantity leak was.

So if you change all the individual details here, I mean, you could get a much finer grid; it would be virtually the same answer as long as you have a few cells between the wells. But yeah, it's not going to change what the goal of this study was, which is to understand the initial volumes in these two reservoirs, the history match, the production pressures.

Q. Yeah, again, we'll get into that in more detail here, I think, once we get into the different layers.

Now, I think this time is helpful, I hope helpful, so everyone can understand. Because for me, conceptually, it was hard to understand how this model was built, how it ran, what the inputs were, you know, the different knobs that were tweaked, potential output. Understanding this is very helpful to me, okay?

A. Sure.

Q. So then this overview map, this is from your rebuttal. So I think this is the one I should refer to, because I think based on your deposition,

Dr. Buchwalter, we identified a couple of things that were missing, and I think you made some corrections or updates to it. One of them was to include Empire's saltwater disposal well, the EMSU SWD Number 1, correct?
A. Correct. And then the Parker.
Q. This one; is that right?
A. Yeah.
Q. The Parker. So you added --
A. The Parker 1, sure.
Q. Two additional saltwater disposal wells to your system?
A. Correct.
Q. Initially, you had 23 saltwater disposal wells?
A. Yeah. I think it was 20-something.
Q. And so you added two additional ones?
A. Correct.
Q. Okay. In this map you show us all the saltwater disposal wells. So it looks like Rice is the green wells?
A. Correct.
Q. Goodnight's are the blue ones?
A. Correct.
Q. OWL is the purple one. I think this is the

OWL well down here. It's hard to tell.
A. I'll take your word for it.
Q. Yeah. And then Permian Line Service is the darker one. I think that's the black -- almost black here, this was one here.
A. Yeah, it's hard to see.
Q. And then there's another one here, which is the other Permian Line Service, correct?
A. I think so, yeah.
Q. Okay.
A. If I'm seeing it correctly.
Q. And then also included here are the wells that Goodnight Midstream is asking for approval of the pending applications, which are in red, correct?
A. Correct.
Q. And you put two other ones in here that are pending, but they're outside the unit and they're not part of this case, as you understand, correct?
A. Okay. Yeah. I guess not.
Q. And then also on this map, you've also shown us, I think, these blue dots, these smaller blue dots that are scattered across the EMSU and the AGU, correct?
A. Correct.
Q. Just let us know what those little blue dots

are?

A. I believe those are the locations where we put the leaks, if I'm not mistaken.

Q. Yeah, that's my understanding, that those are where you --

A. I think that's my understanding as well. I think I showed a graph of that yesterday, but it shows that in a little more detail.

Q. Okay. We'll get there. But I think this was helpful to get this all set up. So now we have a foundation from which to discuss some of these issues.

When you model this, just out of curiosity, because you allow for the oil column to spread and the fluids to communicate between all three of these units, does one of the units produce more hydrocarbons than the other? I mean, is one benefiting more than the other, based on your model?

A. As I recall, in order to get everything to fit, I had to lower the porosity a little bit in the AGU and probably increase it slightly in the EMSU. And I can't recall if I may have changed up to the north or not, but that was necessary. Because you could see the fluids moving around. If I didn't do that, I couldn't get things to fit.

Q. Okay. So in other words, are you telling me that because you decreased the porosity in the AGU and increased it in the EMSU, it would preferentially go to the EMSU?

A. It depends on the time, I guess. I'd have to look at the timing of it. But if I took the AGU production, it looked like the pressure was a little high. So I reduced there and then I added the little volume perhaps to the -- or I think I added a little volume to the EMSU.

I actually have a porosity map I didn't include in here that shows how it changed across the reservoir. But it was a little lower in the south and a little higher up in the mid and north.

Q. That's a knob you can -- you adjusted that would affect the flow of fluids?

A. Yeah. You know, there's fluids moving between these different leases, and basically those porosity corrections were allowed to get those fluids moved so we can match the production and pressures a little bit better. And so that was just done, essentially, by trial and error. But it was using kriging and every cell in here has a different porosity, effectively.

MR. RANKIN: Let's see, we're at 10:30. Mr. Hearing Officer, I'm going to switch over to a

PowerPoint that was provided to us by Ms. Hardy yesterday. I'm a little scared trying to make that happen, so I think it's a good time for a break, if that's okay with everybody, just to take a break so I can get that set up properly. And then we can move into the next line of questions.

HEARING OFFICER HARWOOD: Makes perfect sense to me, Mr. Rankin.

MR. RANKIN: Thank you.

HEARING OFFICER HARWOOD: Fifteen minutes, folks. 10:25, so let's be back at 10:40.

(Recess held from 10:24 to 10:41 a.m.)

HEARING OFFICER HARWOOD: All right. Mr. Rankin.

MR. RANKIN: Thank you, Mr. Hearing Officer.

BY MR. RANKIN:

Q. Dr. Buchwalter, I just want to shift over. I think some of the stuff I want to talk through would be best suited to talk through the presentation that you gave in summary yesterday. I'm going to address some of the slides that are your exhibits and then a couple of slides that were presented yesterday and then move back to your testimony.

This is the document that was provided

yesterday. It's the presentation that you gave
summarizing your testimony. The first slide I wanted
to talk to you about, and I've highlighted a couple of
points, I just want to ask, you know, just to
confirm -- let me know when you can see my screen,
Dr. Buchwalter. Can you see?
A. Yes.
Q. Okay. So we talked about this briefly
earlier. My understanding from what you told us is
that if the model fails, you go back to the client to
make sure you get correct data and then reiterate the
process to try to get the match, right?
A. Correct.
Q. Okay. And then one of the questions I had
on the third big bullet here was, you used the phrase
"exact estimates." Because it's an estimate, how do
you -- I mean, you're using precise numbers, but
there's still estimates?
A. I didn't word that correctly, I apologize.
Essentially, I'm matching to the average
pressures in 1986 and 2024. And I have almost a
perfect match, like, I would say almost a perfect
match in production.
Q. Okay. So that's the process and you get --
you establish -- meaning, like, in terms of the model

you establish what the estimates are that arrive at that match, right?

A. On a field-wide basis, first you want to go through all the points, right? We've got production. We want to match the pressures. But beyond that, you also want to verify that you can at least, in a model this big, match groups of wells and say downdip wells, updip wells and so forth.

Q. Now, that was one of the things that took me by a little bit of surprise, and maybe that I didn't appreciate this. But, you know, what do you mean by grouping wells? Are you treating them as uniformly? Are you assigning wells into groups?

A. No. I'm sorry.

Q. Go ahead. Do you understand what I'm asking you or what I'm going to ask, is how are you grouping wells and -- explain that to me. Explain whether that was the same -- if you applied the same methodology in the rebuttal models as you did to the initial models?

A. Yeah, let me explain that. Essentially what I'm saying is, when you look at the output, we've got 638 wells here, so as a first step, we want to match the field oil, water, gas.

And, you know, like I said, you don't eat the elephant in one bite, you probably don't need the elephant at all. But once you fit the field production and you fit the pressure, the next thing you want to do is look at a group of wells in a particular area.

So, for example, I might take all the wells, and we're looking at this in the output, compare the output on a history match basis. So I might take all the wells in the AGU and add the production for those wells all together and look at the cumulative production for the group and compare that to the historical production for that group of wells.

And so that's -- the next step in a model this big, you don't go from a field match to trying to look at each individual well, you have to do it in steps. And, for example, one of the things I did is I took all the wells that were down there close to the original oil-water contact in the Grayburg, where the edge water drive would be coming into the reservoir, and I put them as a group, and I compared their production, especially of water, to the historical production to see if it fit.

And that's how I realized that the Grayburg had a small aquifer. And, you know, it's a small aquifer. The reality is, you know, you asked me earlier about the -- you know, does it matter if we've got 15 or 40 feet at the bottom of the Grayburg, I guess, in terms of the water. And it really doesn't matter because it just doesn't impact the results very much. But that's what I mean by that.

So it's an output group to just look at groups of wells, and once you've established the groups of wells on a smaller model, then you would start to match the individual wells within the group. So it's a way to do things sequentially, in a logical fashion to find a way to eventually get the ultimate solution, to get the final solution.

Q. So, for example, you took one group, which is the outdated group. Were there other groups that you looked at as part of that matching effort?

A. Yeah, I kind of -- you know, I go around the field and look at different areas, maybe the wells higher on structure, higher in the reservoir, maybe the AGU as a whole, the EMSU as a whole, and the EMSU-B. I also looked at the downdip wells.

So it was a way to just improve the match, at least in areas, and just improve it -- and marginally, I mean, this didn't change the overall results as appreciably once I had the match.

But, you know, it was the next step in

the model. If you're going to try to create the perfect model, you never get there, but it is the next step in the model.

Q. Okay. I mean, I think that was helpful for me.

Now, the third step here is that, I think you explained just now, you go then to try to match or look at the individual wells, right?

A. Yeah. Individual wells I looked at a little bit. Primarily, I looked -- I was focused on the leak wells. And I think as I said yesterday in my testimony, you can plot cumulative water-oil ratio in 1986. You identify -- here, I essentially identified the top 100 wells that were responsible for the leak and then I adjusted the vertical permeability.

We have a seal between the Grayburg and the San Andres, so I adjust the vertical permeability in a series of steps for those 100 wells and try to match -- I actually try to match the production reasonably well, as well as I could, in those individual wells, to really be able to at least model that leak properly.

Because I thought that was important. That's really the goal. If the goal was -- if this is a normal client, I'd build this model and I'd come up with this match and then I would look at a map of current oil in place, see where there's bypass oil. Then I'd refine the grid around that location. I'd actually go in and history match those individual wells around that well and come up with a good estimate of what would happen.

For example, I drilled an infill well. Now, yeah, that wasn't the goal of this study. So I never really got down to that point.

Q. And just to be clear on this, you have three steps, but the fourth -- maybe a fourth step with that, once you made these adjustments based on the groups and the individual wells, would then be to go back and make sure they align with your field match, right?

A. Well, it's not so much a geo-map I changed. The structures stayed the same, but primarily I was just changing the porosities.

Q. I guess after you made any adjustments onto your individual wells, you would go back to make sure it didn't disturb your field-wide match, right?

A. Yeah, you would in a normal study. But I wasn't making that many changes. You know, it's a hundred wells, but it wasn't changed -- yeah, you would, you would. But it didn't change the field

match appreciably.
Q. But as far as the individual wells that you looked at, you were telling me you were primarily just looking at those 100 wells you assigned as having high vertical permeabilities. And did you go back and evaluate the matches for other wells in your model?
A. Well, in the model, all the wells were oil-specified, so I exactly matched the oil in all the wells. The rule of thumb I have, if I'm doing a study, is in the order of maybe one day per well to do a history match. And so, you know, 638 days, I could have done all the wells, I suppose. But I wasn't going to get done.
So at least I tried to model the match of the groups of wells in different areas to improve things a little bit and additionally to model the seal as best I could based on the high water-oil ratio wells in 1986.
Q. So just to be -- I mean, again, the wells that you were looking at to confirm that you believe you had a match were the wells you allowed for there to be a vertical permeability leak?
A. Yeah. Those were the ones that I -- those are the ones that I tried to focus on, at least for terms of the water match, and make those --

Q. Did you make any adjustments to any of the other individual wells based on oil production or water production for purposes of improving the model?
A. I think, you know, I probably made -- I did make some improvements, let's say, in groups of wells by maybe changing the porosity in this area a little bit or that area, to just improve the match for the groups.
For example, if all the wells in the AGU have got a good match on a field-wide basis but maybe the gas is a little high, I might decrease the porosity a little bit up in the gas cap to get it to fit, and things like that.
I mean, I made almost 500 runs there and, man, I lost track of everything I was doing along the way. But kind of where I started and where I ended.
Q. On the gas issue, I mean, one of the issues I think as I understand was that in order to match the model, you had to put two wells in the EMSU that vented gas?
A. Did I?
Q. I'm asking you. That's my understanding. In order to adjust the gas volumes that were being produced.

A. I mean, it might have been in the production records, I don't know. I mean, you know, I import 638 wells into production records, so...

Q. The next slide here is the one we talked about already. I'll move past that.

This slide here, I mean, I think you're -- on the document to the left, this technical committee report, this was just specific to the AGU, correct?

A. Yeah, I think it is. Yes.

Q. Correct. And then the map on the right, this is the water production map prior to the waterflood that you were referencing as the basis for your identification of areas where there was potential communication with the San Andres?

A. Actually, I created -- this is indicative of where the leak is, but I also created a cumulative water-oil ratio map, which is a little better indication. And that's what I -- that's what I ultimately used. Because you have a well that makes a lot of oil and a lot of water, but maybe a low water-oil ratio, so that wouldn't be a good basis. I mean, this shows that -- it shows clearly where you select commutative water-oil ratio.

Q. But just so I'm clear, you didn't use that

as an exhibit, right? We don't have that map where you show your cumulative water-oil ratio?
A. I actually did. It was maybe the next slide.
Q. Okay. Good, this is the one?
A. This is the one. This is the one that shows you.
Q. Great. Okay. All right. So let's get oriented. So that on the right-hand side, this is slide 4 from your presentation yesterday. Okay? This is one that was not part of it. It's not part of an exhibit, right, neither your direct nor rebuttal?
A. Yeah. It's one I thought I'd add to make it clearer what you saw in the last slide.
Q. Okay. So on the image to the left here, of the two images, the image to the left, my understanding is that this is the sort of plan view of your model, correct?
A. Correct. That's looking at it from the top of the structure.
Q. And you've identified the wells, these little dots in black that look like little ants crawling across the screen, right?
A. That's all 638 of them.
Q. And you don't here show the outline of the

units, but you can kind of glean where they are. Like, the AGU has got that little bit of a crescent shape down here?
A. Right. I could have done that much better.
Q. Okay. And then the EMSU, you can sort of see the outline here, right --
A. Correct.
Q. -- where the density wells are located?
A. Correct.
Q. And then the EMSU-B appears on the northwest side, right?
A. Right.
Q. Okay. And so the other thing on this left-side map here, I understand, although there's not a legend, that the green are water -- are they water contours?
A. What I do is, I put the cumulative water-oil ratio on all 638 wells. And it's essentially pretty good, so it kind of gives you the interpretation of where the water's moving into the reservoir in 1986.
Q. Okay. That was my next question, just to confirm, that both these images are from 1987 or right --
A. I meant '87. I'm sorry.
Q. That's okay. But nevertheless, it's prior

to the waterflood commencement, right?
A. Yeah, It's prior to -- once the waterflood, then everything gets very, very confusing.
Q. And just to be clear, what you're showing here are model outputs, right?
A. Yes.
Q. This is model outputs?
A. No, this isn't -- well, okay, on the left, it's not a model output. That's just a -- you just take the cumulatives of all 638 wells as a water-oil ratio in 1938. So that map on the left is something you could go and create today, if you wanted to.
Q. Okay. I'm just trying to get it clear.
A. The map on the right is the thickness from the top of the structure to my oil-water contact, which I believe is 3991.
Q. All right. I'll talk about that one on the right. I just want to get nailed down on the left one first.
So the one on the left is not a model output, but you're saying it's from your production data that you created this map, correct?
A. Correct. It's production data, but it's superimposed on the model itself.
Q. Okay.

A. Does that make sense?
Q. Yes. But then the green here is the water-oil ratio contours?
A. Correct.
Q. I don't know what the contours are. What are the --
A. They vary from maybe, like, .5 to 13, I think, in terms of water ratios.
Q. Okay. And then just looking at this, it looks like you have the highest or, you know, most extensive water-oil ratio contours down here by the AGU, correct?
A. It appears so, yes.
Q. So that appears to be a difference between at least the AGU and the other two units, is that you have the higher water-oil ratio affecting the AGU than you do in the other units?
A. And you really got to look at the squares. Kind of the squares are the ones that are the biggest offenders. And so you kind of count your squares in different parts of the model and that would give you just a qualitative understanding of where at least the biggest leaks are.
Q. Okay. Well, let me just be clear. I mean, the green on this map to the left is the contour

showing water-oil ratio, correct?

A. Yeah. Remember, this is a contour, so if you have a bunch of contours, high water-oil ratios in the area, when you krig it, you're seeing something between there that may not be high water-oil ratios. Remember, it's a map interpretation based on the value at each 638 points, and it's kriging.

It's only purpose is really to show the high -- the outliers that are very, very high.

Q. I guess I'm just really confused, because I thought -- yeah, if you're telling me that's the purpose, then I understand that that's why you're showing the green contours where the water-oil ratio has been calculated to be higher, right?

A. Yeah, you're right. You're right, Adam. Since we've got so much well density in there, for the most part, what you're seeing is -- at least where you have very high well density, you're seeing the correct results.

Q. Now, as you alluded to, the next thing I want to ask you about are these little red squares. You've identified or circled or put boxes, little boxes, around some wells across your model, right?

A. Yeah. It was just, you know, trying to pick the colors that are --

Q. Are those the wells that you identified as -- or selected to modify the vertical perms on?
A. Now, what I did is I went to Excel and I had all the wells listed, I had cumulative water-oil ratio. And then I listed them from high to low so I knew which one was the worst offender and which ones had almost no water at all. And I kind of worked myself down the list, put a leak at each of those 100 wells and then play with it. And I shouldn't play with it. It wasn't play, it was work. But adjust the vertical perm until I achieved a match of the water production, both during primary and then secondary as well.
Q. Okay. But I guess my next question, so based on the -- these are all the 100 wells that you identified?
A. No. This is just some of them.
Q. Okay.
A. I mean, this is something I just did to just kind of look at it, kind of from a big-picture perspective and kind of just for me to understand where the leaks were around the reservoir.
Q. Okay. And then you put two bigger red boxes on the map here, and one, I think you have an arrow pointing to it saying the high water-to-oil ratio.

The point here is, you're kind of highlighting one area on the map where there's a collection of wells you've identified as having high water-to-oil ratio, right?
A. Correct.
Q. Okay. And then the other box up here you've identified as generally having lower oil-to-water ratio, right?
A. That is correct.
Q. Okay. Just so I'm clear, that zone, why did you -- this zone is -- this box with a low water-to-oil ratio, that's up in the EMSU-B, right?
A. Right. I mean, I could chose it elsewhere, but I just put it there just as an example.
Q. Now, moving to the right, you show the average thickness from the top of the reservoir -- top of your model, right?
A. Correct. Down to the oil-water contact.
Q. Down to the oil-water contact which -- in 1987?
A. Correct.
Q. So in 1987, it might not have been minus 366 in your model, right?
A. Might not have been? Say it again.
Q. The oil-water contact in your model changes

with time, correct?
A. Yeah, it changes with time. Exactly.
Q. Okay. That's fine.
A. Exactly.
Q. As oil is produced, you're going to -- your water-oil contact --
A. Yeah, it's changes with time. You'll see it move up as water drives in the bottom of the Grayburg.
Q. Okay. So in 1987 that oil-water contact wouldn't necessarily be minus 366, right?
A. It's not at all.
Q. Okay. And then you point out here that -- so based on that, you're looking at the top of your reservoir in your model and then you've calculated the average thickness down to the oil-water contact at that time, right?
A. No. That's original oil-water -- this distance on the right, that's the initial distance at time zero. I'm sorry.
Q. Okay. Okay. I mean --
A. I apologize for the misunderstanding.
Q. Yeah, yeah, you can see why, right?
A. Yeah. I should have said original oil-water contact. It's not an oil-water contact in 1986.
Q. Okay. So on the right, what we're looking

at here is at time zero, right?
A. Correct.
Q. And I guess maybe real quick, I'll go back here. I don't have a structure map, but just so everyone's thinking about this, how thick is your Penrose in your model?
A. I must say, I'd have to go back and look at it. I know the thickness of it is -- I think it's like maybe -- is it 500 feet for the Penrose and the Grayburg, something like that? Or maybe less than that, depending where you are. I'd have to look at the map.
Q. So, do you know --
A. Because it's just showing the composite and total thickness from the top of the structure of both of them.
Q. Over here, though, where you show the average thickness of your reservoir being 600 to 100 feet thick, wouldn't that be mostly just Penrose over here?
A. No, it's not. It's not the thickness of the reservoir, it's the thickness of the oil-water contact. So keep in mind, over on the left, it's still got a lot of reservoir over there, or some reservoir over there. But underneath it's the water,

essentially, times zero.

Q. I may have mis-phrased. What my question is, though, isn't the average thickness from the top of the reservoir to the oil-water contact that you've identified in that box showing from 600 to 100 feet, wouldn't that be within the Penrose?

A. If we could go back and look at the -- you have that 3D map? You could kind of see where it is. You may be right. I don't know. Let's see.

See, on the edge here, it's kind of green, So it's probably -- it's probably in the Grayburg.

Q. Did you assign only gas to the Penrose?

A. No. I assigned a constant gas-oil contact across all three, not -- the whole model essentially. Perhaps I should have given you top views of each of the individual reservoirs, but as you move down, even the Penrose probably has some oil underneath in places.

Q. Well, yeah, that was the reason they included part of the Penrose, right, in the unit because that's the oil column extended into the Penrose?

A. You have to, or you can never history match it.

Q. Very good. So I guess what I want -- I'm going to bring up here, an exhibit that was filed as part of our rebuttal. You were here, Dr. Buchwalter, when we discussed the complexity of the Grayburg in particular in the EMSU here. You see the image I have on the screen here?
A. Yes.
Q. This is Mr. William Knight's rebuttal testimony Figure 6, and it shows a cross-section with the permeability barriers that he's superimposed on a cross-section that was taken from prior geologic literature reports on the EMSU. And then he's identified on the following map from 1938 where those perm barriers would be, and has identified where he's -- and has marked where he has identified the edge water encroachment as described in the literature. Have you had a chance to review Mr. Knight's rebuttal testimony in this figure?
A. I briefly went through these documents, but I didn't pay much attention to this figure.
Q. If you look at the cross-section, you'll see where some of these wells are drilled and where they are completed along with an estimate for the different -- or location where the different oil-water contacts were based on the unitization documents. So

you see he's got a line for minus 325, which is a small dash line, and then he's got a line for the minus 350, which is a larger dash line.

In your model, did you account for the depth of the well completions within the Grayburg?

MS. HARDY: I object to the question to the extent that Mr. Rankin is testifying about what the exhibit purports to show.

HEARING OFFICER HARWOOD: I didn't hear any testimony in that question. It seemed like a very straightforward question.

MS. HARDY: I think there was a question at the end following quite a bit of testimony.

MR. RANKIN: I was just laying out what the exhibit showed and, you know -- the exhibit and Mr. Knight's testimony speaks for itself. I just was trying to lay out the context for the witness.

HEARING OFFICER HARWOOD: Yeah, this exhibit is already admitted and part of the record, along with Mr. Knight's testimony. And I assume he'll be testifying to complete the foundation.

MR. RANKIN: Yeah, yeah. I mean, it's been -- objections have been -- time for objections have passed, but at least that's true of the written testimony exhibits. But yeah, he'll be completing the record on it, yes.

HEARING OFFICER HARWOOD: I'll overrule the objection.

A. Okay. What I did is, I didn't have perfs, so I basically did what's logical, and that's perfing the oil column on each individual well. And for trying to match 90 years of production is actually more than adequate to get a good answer. A very good answer, actually.

Q. So, you didn't look at the well completion information to determine what depth or zones the wells in the Grayburg were completed in, correct?

A. I mean, as a rule of them, you're complete in the well zone. If you're interested in getting a perfect history match on any of these 638 wells, then I would have done that. But the goal of this was to come up with a good field match, understanding of what the volumes are in these reservoirs, what the leak was and the pressures and putting it all back together.

Q. So, just so I'm clear, every single Grayburg well that you put in your model was only ever completed above the oil-water contact?

A. That's correct.

Q. And you didn't double check to confirm whether that was actually the case with respect to each of the Grayburg wells and their completion histories?

A. I didn't have that information.

Q. And as wells were -- I mean, you heard today or this week, Dr. Buchwalter, about the challenges that the operators at this unit had with conformance issues?

A. Yes.

Q. And did you account for any of the mechanical changes or squeeze jobs or other efforts to address those, mitigate those conformance issues within the Grayburg?

A. I did not, because to come up with a field match, that was not necessary.

Q. Okay.

A. If, yeah, for example, you want to look at where bypass oil is in some part of this reservoir, then you would dive down and add those additional details. But we're just trying to match the field oil, water, gas and, as I said, the fluid movement, the leak. And we did that very well, and fit 90 years of data.

Q. But I guess, if I'm just looking at your map, it looks like the high water-oil locations that you identify pre-waterflood, there aren't that many in

the EMSU, right?
A. Well, there aren't that many, but over 90 years, it adds up.
Q. But I guess my point is, why not just go in and check to see if you can account for what the issue may be with those particular wells?
A. Because the Grayburg Aquifer that's attached to the Grayburg had to be a small aquifer. Because it's a small aquifer, it cannot volumetrically provide the support you're seeing in these wells.
I mean, if you look at that top square on the left hand, those wells are only, you know, 60 to 100 feet above the original oil-water contact. They show no edge water drive coming in from the aquifer. If edge water drive is coming in the aquifer, everything on the west side here would all be highlighted in dark green.
And similarly, if you look at these wells that are higher in structure, you've got four select wells there that are high water, surrounded by, you know, 40 or 50 wells that made no water at all. That doesn't physically make sense because that water has to be coming up from the bottom somewhere. If it's coming up from the bottom, it would be coming up from the bottom in all those wells.

Q. So, if you look at the geologic history here, we saw Dr. Lindsay's testimony and his very intricate stratigraphic cross-section of the 88 different cycles where there were numerous different high and low permeability intervals, Zone 4 is a pressure barrier, Zones 1 and 2 are high perm streak zones. And you don't agree that it would matter substantially, based on the intricate geology within this carbonate system, to understand where the wells are actually completed, where those streaks are located and how they might influence production in each of these wells?
MS. HARDY: Object to the question. Compound.
HEARING OFFICER HARWOOD: Can you break it down a little bit? That's a very long question.
MR. RANKIN: Yeah. Stream of consciousness. I'll try my best.
BY MR. RANKIN:
Q. Dr. Buchwalter, are you telling me that the individual well histories, based on where they're completed, whether they're in Zones 1 and 2, where you have documented high perm streaks, wouldn't influence the production history in those wells?
A. I mean, on a field-wise basis, it's not

going to make a big difference, no.

Q. But when we look back here at this map, I'm not talking about field-wide basis. I'm talking about individual locations where you've identified high water-oil ratios.

A. Well, let's put it this way, Adam. Between 1938 and 1986, water would have moved up in those locations, all those locations. And if you look -- let's look at the big picture. There's no water coming in from the west. Okay? There's no water, so then -- there is a little bit of water coming in from the west, from the Grayburg Aquifer, but it's not coming in from there. And if we look at the amount of Grayburg Aquifer we have underneath these wells, it would have to extend 1,000 feet and be 158 billion barrels.

And so it's not coming in from there. So it's logically coming in from the San Andres, and these are the high water ratio locations.

Q. Dr. Buchwalter, you were here and you heard Dr. Lindsay who's a Ph.D. He got his Ph.D. on the Grayburg and he spent his career studying the EMSU. And he's telling us that there is a strong water drive from the Grayburg, pushing updip more than 300 vertical feet, across the double-humped anticline,

into the higher structure area, that you're saying there is no water from the Grayburg.
A. Adam, every time I do a study, I think I know what the answer is, and that's called interpretation. Once you do the study and you fit the data, that's reality. I've done 350 studies, and every time I do a study, I think I know the answer. But this is like trying to win the Powerball. What is it called, Powerball? Except now I've got thousands of numbers I have to guess. It's not the same thing.
Q. And just so --
A. The model fits.
Q. For the benefit of the record here, I'm showing what's been marked as Exhibit B-21, which is Dr. Lindsay's exhibit from his direct testimony.
A. And I have the water coming up from the Goat Seep like that, too.
Q. But you didn't until after your rebuttal testimony only, correct?
A. That is not correct. It was in the original model. I just didn't cover that in detail because it wasn't significant. It's the same model. There's no difference. I mean, a slightly different model. We adjusted the pressures and --
Q. Do you recall your testimony in your

deposition when I asked you about whether or not you had an aquifer connected to the west on the Grayburg?
A. Yeah. I said it was essentially no aquifer. I stand by that statement today, because there is almost no aquifer. I said maybe no aquifer; to me, it's the same thing.
That's a 1-billion-barrel aquifer compared to 158 billion barrels in the San Andres. It doesn't even pale by comparison.
Q. Okay.
A. It pales by comparison, I should say.
Q. Going back to your slide presentation, let me go to the next slide here. I think it's going to be slide -- I want to touch on a slide 9. I think, as I recall, this is Exhibit M-5, not M-6, correct, because it was shifted by one based on the -- because the first page of your presentation had a label? Do you recall --
A. It doesn't matter to me. It's the right figure. I'm fine.
Q. It's okay. I just wanted --
A. I don't care about the number.
Q. Down here, you talked to some extent during your summary presentation that Dr. Lake had testified that there was a 4 psi per million barrels SWD

pressure increase in the San Andres. Do you recall that?

A. Yes, I did.

Q. And you said that that basically matched what your model was showing, right?

A. On a field-wide basis, currently my model is going up to about, I think, 3.8 psi per 100,000 barrels of water injected, I believe.

Q. Did you understand Dr. Lake's testimony to be -- I mean, do you understand that Dr. Lake's testimony was on a field-wide basis or on a near-wellbore basis?

A. I'm sure it was on a near-wellbore basis, because the 10 psi would make things much worse for Goodnight.

Q. So, have you considered if you were to try to take his 4 pound per psi and apply it on a field-wide basis, what that pressure increase would be?

A. Yes. I mean, that's -- it's in my results.

Q. Okay. I'm not asking about your results. I'm asking, like, if you were to take, you know, a 4 pound per psi near-wellbore calculation and then apply that across the full field, what that pressure increase would be?

A. Let me explain this, so you understand. This reservoir goes out 33 miles to the west. And what happens is that 4 to 10 psi -- the 4 psi, essentially what my model predicts is currently building up per -- 100,000 barrels injected is an average across the whole reservoir, basically.

The 10 psi that Dr. Lake cited here would be areas where they're probably injecting more water, it's a tighter area; either one or two -- either one or both of those things. And so the pressure is building up quicker there.

Over the next three years, the model shows that, with the leak and the physics and everything that's going on here, if you take that 10 psi per million, 100,000 barrels, that means you're going to -- in the next few years, you're going to build up to 26-, 2700 pounds. And that is just under the Grayburg.

Now if we go out 33 miles, that pressure hasn't changed one iota hardly. But what will -- what happens is you're injecting -- technically, this aquifer can handle a tremendous amount of water. I mean, if you put your saltwater disposal wells through this aquifer, you could inject water to your heart's content.

But what you're doing, you're injecting so much water, at such a high rate, that the pressure's building up under the Grayburg. And essentially in the next three years, it increases about 26-, 2700 pounds. And after that point, basically, it essentially had what's called pseudo-steady state where the water's moving out into your aquifer, and it's also moving up with about 50,000 barrels a day into the Grayburg.

I tell a story about it. I drilled a well in my backyard and I asked the driller, I said, "Where is this water coming from and how long does it take to get here?"

He says, "Well, it comes from Huntsville. It's about 80 miles away."

"So how long does it take to get here?"

He says, "About 90 years."

So the problem is the dynamics. And that's what the model can show. Because I would never know this without a model.

Q. I'm going to get into your discussion around the pressure increase that you're calculating or modeling in the San Andres in a little bit, because I understand -- I understand you to say that you're sure that Dr. Lake was talking about near-wellbore pressure. But I understood you in your opening to make the implication that that was a field-wide pressure increase. But you're saying you agree that it's a near wellbore pressure?

A. Yes. It has to be. When I say near wellbore, the area under the Grayburg is all pretty much the same pressure, as you said. I mean, the pressure wave moves out, water is incompressible. The pressure there is about the same everywhere. It almost doesn't matter where you inject your water in that area, in any of the saltwater disposal wells, you end up with the same pressure.

But what happens as you move out to the west, that pressure wave, it takes a while for that pressure wave and that water to move out into the aquifer, you know.

Q. And some of the factors and knobs that affect how fast that water can move are going to be the porosity and permeability, right?

A. Exactly.

Q. And the size of your cells?

A. Exactly. And that's how I size the -- not so much the porosity, but the permeability. The porosity, I had it fixed, and I would actually just extend the western limit and try to go further and further out, so I had something to match the pressures we're seeing in San Andres.

Q. And the cell size may have some influence on that because you have to fill the cells up with water before that water can move to the next cell, correct?

A. Well, the water is everywhere. But you think about it, it's kind of like a pressure wave. The water is kind of moving out and it's pressuring things up.

And one thing you have to be really careful of, and I'm sure the doctor there knows that, well, when you've got an aquifer that's going out 33 miles, you just don't put one cell. You don't go from, you know, 2600 -- if it's 1200 pounds out here and you chose 2600 pounds, it doesn't move 33 miles.

And so what we do as we go into the aquifer, we step the cells up, typically by a factor of 2, because the pressure is changing quickest, building up quickest around the well. As we get further and further out, the pressure changes slower, smaller and smaller. So we step the cells out, and they're connected by a factor of 2 to just get the physics right, essentially. You have to be very careful about that or you get the wrong answer.

Q. And we'll talk more about that a little bit

as we move through the details on your layers. Okay?
This next slide is one, again, that wasn't presented in part of your testimony or exhibit, but it definitely drew my attention for a number of reasons. I'm going to walk through it. Okay?
This is slide, I think, 10 in your presentation from yesterday morning?
A. Correct.
Q. What I want to hear first is this section here, because you mentioned this at the outset, that you made -- after you built your model and you made your inputs, then you made adjustments to fit the historical gas-water production rates for the oil rate wells, right?
A. Correct.
Q. In order to match what you understood those production rates to be, you turned the knobs right on some of these different input parameters, right?
A. Correct.
Q. Okay. And the first one here that you've identified is, you got a 30 percent water saturation from this 1990 report, correct?
A. Correct.
Q. And to make it fit, you increased the water saturation to 35 percent, correct?

A. Yes. I made a slight adjustment in the connate water saturation. Probably could adjust in porosity as well and accomplish the same thing.
Q. So, tell me, again. The connate water is water that is bound to the formation, right?
A. Exactly.
Q. Okay. So you've got 35 percent connate water in the model, correct?
A. Correct.
Q. But you're giving it a 30 percent water saturation based on this report?
A. Yes.
Q. And this is the Grayburg, right?
A. Yes.
Q. So in order for any water to move in the Grayburg, you'd have to exceed this connate water saturation, correct?
A. Correct.
Q. So, because you've given the connate water a 35 percent value and the water saturation in the Grayburg a 30 percent value, there's no water moving in the Grayburg, correct?
A. No. There's water that moves in the Grayburg. If you look at the relative permeability curve on the right, you have an oil and water curve

versus SW. So, you can have oil and water both living in the Grayburg.

Q. Let me rephrase my question, because I think I overstated. I was trying to say, rather than no water moving, you've tightened up the ability of water to move in the Grayburg based on these percentages, correct?

A. And you're referring to what now, the connate water saturation?

Q. Yeah. In other words, it's harder for water to move in the Grayburg because you've given the connate water a 35 percent value and only a 30 percent value per water saturation.

A. I mean, not necessarily, because we also adjust the oil relative permeability curve. So you're adjusting multiple things at the same time and just tweaking things a little bit to where we match the historical performance we've seen for oil, water and gas in the Grayburg, along with the leak.

So it's -- there's a lot of moving parts there. It's not like -- if you move one knob, it affects, you know, three other things. We're tweaking things here to get things to --

Q. Well, that's my point, I guess. Because you moved a knob to try to match the gas-water production rates for the wells, the oil wells, right? But by doing that, you've made it harder for water to move in the graveyard?

A. No, not necessarily.

Q. No? Okay.

A. I've made a little less water move in the Grayburg, not making it harder. Because it's the shape of the curve, the oil curve, that determines how it moves. It's just a little less water -- you know, a little less water, 5 percent less water in the pore space.

I mean, I was just trying to show here that you're always going to adjust these small knobs in the model. Because this isn't just one rock that's all 30 percent or 35 percent or, you know, whatever. And so, at least when you're starting with the field-wide basis like this, you're just trying to find the average numbers in a combination of parameters that fit the production pressures.

Q. So on the relative perm curves, you had a relative perm curve for the Grayburg. Is that the one that you're showing here?

A. Correct.

Q. And did you have a separate relative perm curve for the San Andres?

A. Yes, I did. I haven't shown it here.
Q. Okay. But so you had two different relative perm curves for the model, right?
A. I mean, the San Andres would probably be pretty close to this, where essentially the Krw initially would be like .8, which is -- well, not quite .8. You could put 30 percent water saturation in there.
Q. My recollection, Dr. Buchwalter, was that you gave a 30 percent oil saturation for the ROZ in the San Andres; is that right?
A. That is correct. I know that's correct.
Q. Then at what saturation on your model would oil be mobile in the San Andres?
A. I mean, I made it where it was not mobile, so if you made it 30 percent, it would -- oil would -- what saturation? Say it again, what saturation?
Q. Yeah. What oil saturation would oil be mobile in your model?
A. Look at the Kr curve here. So it just depends on the Kr curve that we have, where the oil starts to move, as you can see up here.
Q. So which --
A. Let's look at the oil curve up there.
Q. The top curve, and the oil is the green

curve?
A. Yes. So, basically, when we hit 30 percent, the oil doesn't move.
Q. I didn't quite hear you.
A. When you hit 30 percent, the water doesn't move, if you look at that curve, right, at that vertical line.
Q. Here?
A. Yeah. And so at 30 percent, the oil hits a .9 and the water doesn't move. So that's the starting point of the reservoir.
Q. Is that 30 percent or 30 -- 35 percent?
A. Oh, it's 35. I'm sorry. It's 35 as you see in the box there. I apologize. It's 35 in the model.
Q. Okay.
A. And as the water comes up, what you'll find is the oil relative permeability goes down and the gas and the water goes up. And eventually, we hit a point that we call the residual saturation water.
So, for example, what's happening in the model essentially is the water is sweeping through the oil, and at some point you reach a point where the oil that's left is entrapped in the pore space. And so, for example, the residual oil to water here, as you can see on the left here is 21 percent. That's where

the oil stops moving. And at that point the Krw is .8. So that would describe how the oil and water moves in the Grayburg.

THE WITNESS: Sorry for you out there that aren't reservoir engineers. I feel like me and Adam are having our own little private talk here.

A. And I want to explain something else, if you look at the oil curve and the water curves and these curves, what we actually have in this system -- and these relative permeability curves look a little weird, I admit it. But the reason we've created these curves is because, in reality, what we have here is we've got a dolomite, with maybe 10, 15 millidarcies. We also have fractures.

And so what we're doing, we had to create a rock that represents a composite of those to get the relative permeability curves to give us the same physics as the fracture flow, which is very high permeability, almost infinite, and the contributions from the dolomite. We call them -- we basically call them sugar cubes when we do simulation, but it's basically a dolomite.

So what you're seeing here are not traditional relative permeability curves. These are relative permeability curves that we created to fit not the fractures in the matrix or the dolomite separately, but the composite to come up with something to represent the same thing essentially.

Q. So looking at --

A. Does that make sense?

Q. I'm getting there. I'm getting there.

A. We'll get there.

Q. So looking at these bullets over here, you've given a residual oil saturation of the rock of 21 percent --

A. Right.

Q. -- which you just cited, right?

A. Right.

Q. In the Grayburg?

A. Right.

Q. But the 1990 report gives it a 25 percent saturation, right?

A. Right.

Q. Does that make the oil more mobile in the Grayburg in your model, then?

A. Oh, come on, man. You can answer this one. Think of it this way. We've got -- we have 5 percent -- we got 4 percent more mobile oil, but we have 5 percent less oil. So net is almost -- you know, it's almost being zero. It's like 1 percent difference.

I guess it's 1 percent less mobility of the oil itself versus what would have been in the 1990 report, if you think of it in terms of that. One cancels the other.

Q. The other bit of information here -- now, did you get the oil saturation for the ROZ in the San Andres from Empire? Did they give you that?

A. Yes, I did. I just got it from Empire and just put it straight in there.

Q. Okay. Now, the other tidbit down here, which is interesting to me, is you've got the initial formation volume factor from this 1990 report, which is at 1.2. Is that right?

A. Correct.

Q. Right. Okay. And then also the current formation volume factor of 1.05, correct?

A. I don't know -- yeah. I don't -- I assume that was in 1990, I guess. Yeah, probably around that time.

Q. Okay. And those were the -- each of those are the formation volume factors that you found in the literature for this field, correct?

A. Yeah. I mean, you're always going to tweak these things. But I always want to kind of see what people said. You don't want to get too far from this without good -- good reason.

Q. Did you use these formation volume factors for both the Grayburg and the San Andres?

A. No, I did not.

Q. What formation volume factor did you use for the Grayburg?

A. The Grayburg, okay, here it cites the initial gas-oil ratio of 425. Okay. I found that the history match gas-oil ratio, I think, was 375. And so because there's less gas in solution, the gas is not going to expand as much, and my initial formation volume factor was 1.14.

And in the Grayburg -- excuse me, in San Andres, essentially, there's dead oil. I just put a little gas in solution, and I forgot what I put, but it was very close to dead oil.

Q. Okay. Dead oil would be what?

A. I might have put, you know, 50 in there or 20 or something like that. Probably closer to 20.

Q. You heard Mr. Bailey and Mr. Birkhead testify that they had identified -- or were given a formation volume factor from Empire for the Grayburg of 1.3?

A. Yeah. That's really high. It's even higher than this. I think they were very conservative in their analysis.

Q. I'm going to skip over back to your testimony and talk to you now about some of the specific issues that I want to kind of highlight or walk through with you, now that we have some of these issues addressed.

Under this heading I of your Exhibit E, this is on Page 2 of your testimony, you've identified that in your model you have 10 wells from Goodnight Midstream and with four inside the unit, and you're assuming a rate of injection of 215,000 barrels of water per day. For all 10 wells, correct?

A. Yeah. I mean, I had data on all the individual wells and changes from month to month. I had to -- are we talking about forecasts here, or just -- no? It's just --

Q. I think this is the -- well, you tell me. I mean, this is your testimony.

A. Yeah, I should tell you. I'm the one that wrote it, right?

I think that's the current conditions. At the time I built the model or around the time I built the model, that's what it was.

Q. Okay. And have you changed that?

A. I think the model ends in -- I think it's early 2024, and so I've integrated all the data in all the saltwater disposal, production, injection wells, and so forth.

Q. I guess my question is, this is a number of 215,000 barrels of water of daily. Goodnight actually produced all of its volumes for all of its injection for wells inside the unit. Did you use that data for your model --

A. Yes.

Q. -- or did you use an assumption?

A. All of them. No, I used all the detailed data that we had on a month -- I think it was on a monthly basis, if I'm not mistaken. So all of that was entered, everything on every well.

The only time it wasn't was the first early years, where we just knew what the cum. was at a certain date, and then we just assigned an average rate. But other than that, it was -- we had put all -- we essentially put all the details we could into the model.

Q. Okay. Because, actually, when you look at what the four wells of Goodnight is injecting into the EMSU, when you go from the full history, their average daily volume is only 14,149 barrels of water per day per well.

So this number from your testimony -- this is Mr. McGuire's Exhibit B-13 from his direct testimony, and he provides an average for all four of the wells injecting into the EMSU from first injection, and it's 14,149 barrels per day.

But in this testimony, when you average out 215,000 barrels a day by 10 wells, that's about 21,500 barrels, which is quite a bit more than actually the data shows, right?

A. Can I see the previous thing?

Q. Yeah.

A. So you're saying it's 25, and this says it's 15. Well, I mean, it's --

Q. I'm saying that for the life of the injection history of these wells, the average daily volume is 14,149 per well.

A. Right. But it varies a lot from one point to another. Look how it bounces up and down.

Q. Right.

A. So kind of where you pick the point, and where my last point was, it could have been much higher, correct? I'm sorry, Adam. I should be asking you.

Q. That's okay. The reason I'm asking you is

because you told me here, you told us here, what rates you're using for the 10 wells. And I'm just saying when you look at the overall rate of these 10 wells within the unit, there are 14,000 barrels per day --
A. Correct.
Q. -- not 21,500 barrels a day?
A. Now, if I take all that data over this time period, you know, and I assume my data is all correct, I'm going to come up to your number. But if you look at any particular point, it can be higher or lower than this number.
Q. Okay. I guess you may have answered my question. But is this the number that you used and applied to your model on a per well basis?
A. I used the monthly injection numbers on all the respective wells, so they would essentially be whatever the data -- whatever the data I was provided, that's what I put in.
Q. In your rebuttal -- I mean, we kind of alluded to this criticism a little while ago, in your deposition, you know, I asked you about whether or not, and today I asked you whether or not you incorporated or considered the specific target completion histories of the individual wells within the Grayburg, the perfs, were they perfed within the

Grayburg --
A. Correct.
Q. -- the mechanical changes that went into those wells over time. And you told us that you hadn't, because there's so many, right?
And this is what you're saying here, there's just too many to do, but on a field-wide basis, you were able to show a match, right?
A. I mean, what happens is even the perf interval is not quite right, so eventually the gas, especially the gas, is going to come down and the water is going to come up through these leaks.
Q. And the second bullet here, you say most Grayburg producers were completed throughout the oil column. And your simulator allows you to perforate the oil column only, right?
A. That was an assumption. I assumed that, you know, the operator if he had oil, he would complete them. Yeah, and I actually -- you know, with one button, I can complete through the oil column.
Q. But you did not take into consideration those mechanical changes, the efforts by the operators to squeeze out different intervals or anything like that, right?
A. No, I did not, because I really wasn't

looking at a well-by-well match so much as just trying to understand the behavior of the field itself. And that was the goal. It was not to get exact oil and gas matches. It was to just understand the big picture, and that was the point of this model.

Q. Okay.

A. The big picture is to understand the initial volumes and the leak.

Q. Now, in your rebuttal testimony here, this is Page 2 of your Exhibit M, which is your rebuttal, you say that there has to be an outlet for the San Andres fluids prior to April 1986 to accommodate a 28.7 percent drop in the San Andres Reservoir pressure from 1747 psi to 1245 psi at 4,006 feet measured depth. And that is shown, as you say, by an open hole repeat formation test, pressure measurement in the EMSU-211, right?

A. Correct. I was given this data.

Q. Right, and you were given this data by Empire, right?

A. Yes.

Q. And this is the pressure that changed between your initial testimony and your rebuttal testimony, right?

A. Yeah, that's correct. We changed the datum depth so that these pressures would change a little bit.

Q. So, we'll get to this when I have my discussion with Mr. West. But, basically, Mr. West changed what he understood to be the measured depth from minus 250 subsea to plus 250 feet subsea, correct?

A. Yeah, I can't remember the exact change, but it was a change. It was integrated into the simulator.

Q. And based on that depth change, about 500-foot depth change, your calculation on the pressure based on a column of fluid is what caused you to have this new pressure change in your rebuttal testimony?

A. Right. Correct.

Q. So just to be clear, you didn't independently evaluate that initial pressure measurement or where it's located, right?

A. No. It's not in my job title.

Q. And the initial pressure calculation was that there was an 18 and a half percent drop and now there's a 28.7 percent drop based on that change in the depth, your understanding of the depth of that initial pressure measurement?

A. Correct.
Q. How did this change, that 28.7 percent drop, in the San Andres Reservoir pressure at that date in 1986, how did that affect your model?
A. It really didn't affect it that much. I had started a little higher pressure, but what I did, I think, is I reduced the gas-oil ratio a little bit. And so it came down to the same place.
Like, you know, if you increase the pressure, same amount of gas in place, you have a little more energy. And so I think I tweaked the original gas-oil ratio a little bit and everything fit.
Q. So, in order to accommodate that change in pressure, you had to change what the gas-to-oil ratios were, going back to the beginning of your model?
A. Yeah. It was just a really slight change. But it was a small change, you know.
Q. A small change in the ratio, but over a long period of time?
A. Yeah, a long period of time. You kind of end up in the same place.
Q. Did it change anything, affect anything else in their model?
A. I can't recall that it really anything else

that was significant. I know it was just a few minor tweaks in the model itself, and that's the one that I can recall.

Q. A 28 and a half percent or more pressure change in the San Andres wouldn't have a big impact on the model at that date?

A. Actually, surprisingly, with a little tweak in the GOR a little bit, it all just kind of fell into place.

Q. But a 4 to 10 psi change in the San Andres is going to have a dramatic effect?

A. Say it again. If a?

Q. But a 4 to 10 percent psi change in the San Andres will have a dramatic effect over a short period of time based on your model?

A. Well, if you're -- at what injection rate for all these saltwater disposal wells? You know, the rate is going up and down. But yeah, for example, if you're injecting 100,000 barrels a day, you're changing 4 to 10 psi, over a week, you're changing anywhere from 8 to 20 psi, 52 weeks a year times 20 can be as much as 1,000 pounds of pressure buildup.

And as I said, the aquifer itself can accommodate a tremendous amount of water. But the problem we have here is that you've placed these saltwater disposal wells just too close to one another. If you spread them out, you could be injecting all the water you want because it's a 159 billion barrel aquifer.

And if you say you can build it up to 3,000 pounds, that's a lot of water. But the problem is, it's building up pressure quickly, and the water just can't move out as fast as you inject it.

Q. M-17 in your rebuttal testimony, this is maybe just a point of clarification just to confirm, but I think you --

A. Don't show that, Adam. Okay?

Q. I think I have the wrong thing. I might skip over that for a second. Oh, what is that? I thought I was at 17. Sorry. Let's see if I can find the one I'm talking about.

A. Just find it before lunchtime. You've got 12 minutes.

Q. Oh, okay. Sorry.

A. And I need to do a bathroom break, too.

Q. Yeah, I do, too.

A. I can hold off for 12 minutes.

Q. Let's just hit this and then we can break for lunch. This is an easy one, I think.

A. Yeah, I think it is.

Q. I think down here on this exhibit, this is your slide, Exhibit M-10 --

A. Correct.

Q. -- where you've showed some of your images of charts, I think from your direct testimony, right?

A. That is correct.

Q. And then, just to be clear, I wasn't tracking the exhibit numbers. Because I think your direct testimony was Exhibit E?

A. Yeah, I know they're all in there. Don't worry.

Q. Okay. So this one in particular I was interested in. This one, I think, is referenced as Exhibit I-8, but I think when I go back to your direct testimony, I think it's E-7, I think. And I just want to ask a question about that.

A. Okay. Keep in mind that those plots are based on the model before the adjustment.

Q. I just wanted to make sure. That's my question. Because when I look at this, you're talking about the initial pressures. This is before you adjusted that starting pressure for the San Andres, right?

A. Right, right.

Q. Okay. And so what you're showing on your rebuttal on this slide here, M-10, is before you made that adjustment on the pressure for the starting pressure of the San Andres, correct?

A. That's absolutely correct.

Q. Okay. Just wanted to just want to make sure of that for purposes of the record.

MR. RANKIN: With that, to accommodate probably everybody in the room, I ask, Mr. Hearing Officer, we take a break so I can move on to the next section of my testimony. And I think I probably have, I don't know, maybe like an hour or so to get through, and then I'll pass the witness for other examination.

HEARING OFFICER HARWOOD: Okay. That makes sense.

Mr. Chairman, what's the Commission's pleasure for a lunch time break?

CHAIR ROZATOS: Let's just be back at 1:15.

HEARING OFFICER HARWOOD: 1:15. Okay. Thank you all.

(Lunch recess from 11:51 a.m. to 1:15 p.m.)

THE HEARING OFFICER: Mr. Rankin, I think you said before we broke that you might have maybe an hour more or so, so you're it.

Dr. Buchwalter, I probably don't need to remind you you're still under oath.

THE WITNESS: I'll tell the truth. You don't need to do it again.

MR. RANKIN: Thank you, Mr. Hearing Officer. I'm just getting myself back connected to the wifi.

BY MR. RUBIN:

Q. Good afternoon, Dr. Buchwalter. Sorry for the pause.

A. No problem whatsoever.

Q. Is the model, the base map, the E-1 map, is it -- it's the same between -- I guess it should be a little different. The rebuttal map should have the extra two wells in it, extra two SWDs in it, right?

A. Yes, that's correct.

Q. I'll use that one. This is your Exhibit M-1 from your rebuttal, correct?

A. Correct.

Q. And then I'm showing on the screen -- I'm going to point out a well here and just confirm that it's included in your model, this well up here. I can't quite tell what section it's in, but it's the one I'm highlighting. Do you see this well in green?

A. Yes.

Q. And that is a Rice SWD well, correct, based

on your map?
A. I would have to check my model to confirm it's on the -- I believe all those wells are -- I think all the wells on the map are included in my model, yes.
Q. And this model, assuming that it is, based on the fact that it's on your map --
A. Yeah, it is.
Q. -- this well would be connected to every other cell in your model, right?
A. Yes, it would.
Q. And if we had reservoir pressures for this well at this location, prior to initiation of the waterflood in the San Andres, would that data be relevant to your analysis of the model?
A. It probably would be, yes.
Q. Is there a reason why, sitting here today, it wouldn't be?
A. I see no reason why it would not be.
Q. That well would appear to be this well in yellow up here, just to the north of the EMS. I'll also zoom in a little bit so we can see the colors.
A. If I can expand on what I just said a little bit. It's not relevant unless it's got enough production, enough history to where it would impact

the total WCD rate of all these wells appreciably.
Q. So, my question to you was, if we had reservoir pressures from that well prior to injection in the well at that location in the San Andres, would it be relevant to your analysis of the model?
A. It could be. I don't know how different it would be.
Q. I guess my question is, though, you only have one pressure data point prior to -- as an initiation pressure from the San Andres, right?
A. That is correct.
Q. And then you have one pressure point for at the time of -- at the end of primary production in the Grayburg and San Andres, correct?
A. That is correct.
Q. So this would be a pressure point that was in between the field discovery and the primary production if it were, you know, somewhere in between there. It would be relevant to your model, right?
A. It could be. I mean, when was the pressure taken? It depends when the pressure was taken, too.
Q. Say it was taken in 1959.
A. Well, I mean, the one pressure point I have -- is it 1986? Is that what -- I believe. Or '87? The one point I have. I think if you take a

point earlier than that, I'd have to look at the model.

Q. But I guess my point is, it would help you -- I mean, it was another data point to tie your model to, right?

A. Yeah, it could.

Q. It would be helpful. I mean, if you had that data point, you would use it, wouldn't you?

A. Yes, I would.

Q. Now, looking at this map which shows -- this is an exhibit from Goodnight Midstream. It's Exhibit Number B-47. It's from Mr. McGuire's rebuttal testimony. And I'll just flip back, so it's fresh from the top of mind, to your Exhibit M -- I'm sorry. I think it's M-1. I actually had that in my mind. M-1. Okay.

Flipping back to M-1 so we can see this map, there's a well that's approximately one and a half sections north. I can't read the section numbers, but it's just to the north of the EMSU right up here on the corner.

Do you agree that that appears to be the same well?

A. I believe it -- I think so, what I'm seeing. But that's our unit, right? Yeah.

Q. Just a section and a half to the north?

CHAIR ROZATOS: We just lost our monitors, so please hold on. Sheila, back there. Oh, okay. There you are.

Sorry, Mr. Rankin.

MR. RANKIN: It's okay. No problem. I thought it was me.

BY MR. RANKIN:

Q. Okay. So back to where we were. So just about a second and a half north of the EMSU, there's a well here. It's got a yellow triangle on the legend to the right. The yellow triangles reflect that it's a Rice Operating well and it's active. Do you see that?

A. Okay. Mm-hmm.

Q. Do you have any reason to dispute or not disagree that that well is the same well we were just looking at on your Exhibit M-1?

A. No.

Q. Okay. Going back to your direct testimony, looking at Paragraph 2 on this page of your Exhibit E, I believe it's the middle of Page 3, in Paragraph 2, you state, "A key element of the study was including 435 million barrels water produced from the San Andres by the water-supply wells primarily during the 1986 to

2005 period to inject into the Grayburg." Did I read that correctly?

A. Yes, you did.

Q. Now, just go back to your rebuttal slide, your M-1. And just so I'm aware, I'm not sure they're shown here, but my understanding is that you included the six known water-supply wells in the EMSU unit and then two water-supply wells in the AGU. Is that correct?

A. I believe that's correct.

Q. Okay. And based on the data that you were given by Empire and the total volumes produced by those eight wells from the San Andres, it's about 435 million barrels?

A. Correct.

Q. So those are the only water-supply wells that your model includes, correct?

A. Correct.

Q. It doesn't include volumes of water, water-supply wells outside of that, those eight wells, correct?

A. No. If I included other wells, it would depend how far out -- away they are and how much they were injected. But in order to get a match on the model, no.

Q. So I'm showing here what is Goodnight's Exhibit B-19 from Mr. Preston McGuire. And this map I believe I showed you during the deposition that we had with you, and it shows all the wells that Goodnight has identified in the area as water-supply wells. And just to confirm with you that there are one, two, three, four, five, six in the EMSU that you included in your model, and then the two in the Arrowhead Grayburg Unit that you included in your model?

A. Correct.

Q. But all the other dots here that are indicated as water-supply wells, you did not include in your model, correct?

A. Aren't some of those inactive or --

Q. Some of them -- let me explain.

A. I think the colors --

Q. Yeah.

A. So some of them are P&A'd and --

Q. Yeah. So at different times, some of them were active. This indicates the current status of the wells.

A. Right.

Q. So some of them are currently still active, some of them are inactive, some of them have P&A'd and some of them are T&A?

A. Right.
Q. Okay. But the only wells you include in your model are the 6 in the EMSU and the 2 in the AGU, correct?
A. Correct.
Q. Okay. This next exhibit I'm showing is Goodnight Exhibit B-46, and this is in Mr. McGuire's rebuttal testimony. This is Mr. McGuire's tabulation of the volumes calculated and estimated from those water-supply wells. Have you had a chance to review Mr. McGuire's rebuttal testimony, Dr. Buchwalter?
A. I've reviewed this figure, I believe.
Q. Okay. Now, this is just a summation of volumes of water produced from those wells based on calculation of OCD records and estimates from well tests. And he summed it up to be over 850 million barrels of water produced from those wells.
But that volume was not included in your -- or any volumes from those wells were not included in your model, correct?
A. That is correct because if those wells were communicating with the Grayburg, then we would never have a history match. So they must be communicating with some other part of the San Andres. Unless those wells are really far away, then they may not matter.

But wells in this near vicinity -- apparently the San Andres geology is more -- is complex and the six wells I've got are in good touch.
Q. They're a good fit because the volumes you used fit your model. But if you had included these volumes, would your model still work?
A. No, it would never work, not even close. I mean, the original model, I was only maybe a couple hundred million barrels shy, or maybe less than that, on the water-supply wells, and that was left out of my model, and I just could not fit the model.
So, you know, apparently these other wells, I mean, if they were in the San Andres, they're not draining the same compartment as the area under the Grayburg.
Q. And that's your conclusion based on your assumed size of the San Andres in the volumes in the San Andres?
A. No. It's based on the material balance. You know, we had the pressures -- the pressure in the San Andres in 1986. If we add all this water in, you're never going to get that pressure.
Q. Going back to your direct testimony, I'm going to look at the same paragraph here, another section that I've highlighted. You address the

volumes of water disposed by Goodnight and Rice in the San Andres Reservoir. You say that the pressure has now increased above the original reservoir pressure in some areas.

And you go on to state that your model predicts that the rate of water influx in the Grayburg will increase from 24,000 barrels of water per day to 46,000 barrels of water per day by January 2028 and then 52,000 barrels of water per day by January 2033.

I'm assuming that the seven application SWD wells are not drilled, so that doesn't include the five additional wells in the unit that are being proposed and the two outside the unit, correct?

A. That is correct.

Q. So just looking at these two sentences, this conclusion is based on the original reservoir pressure information that you received from Mr. William West, right?

A. The 570 million barrels.

Q. Well, the conclusion that you've drawn from those two sentences about the volumes of water that must be reaching the Grayburg and -- I mean, the whole conclusion about these --

A. Right.

Q. -- it's largely -- the root assumption is

based on the original reservoir pressures, correct?
A. You mean 1938?
Q. Yeah.
A. Yeah, the whole model has to tie into 1938, or it wouldn't work. I mean, you know, as I said, with the injection volumes that I was given, the water supply volumes I was given, everything fit.
Q. Okay. So then going back to your model, we had these -- I believe this now has 25 SWDs in it, right, the 23 that you originally included, and the two additional ones that you added afterwards, which are the EMSU SW Number 1 and then the Parker Well, which is just outside the unit, just on the edge of your model boundary, right?
A. Correct.
Q. And based on your conclusions in your testimony, I understand that your conclusions are that the model results should be sufficient to establish that all the wells within five miles of these units should be shut in. Is that your conclusion?
A. That's a rule of thumb. I mean, as you can see, even though there's additional saltwater disposal wells around here that have produced more than those numbers you just cited, in my mind, they're not part of this problem, really.

Q. Let's go back to that map. So you talked about five miles, all SWDs within five miles should be excluded, but you've only included five wells, and the volumes for those 25 wells in your model, right?

A. Correct. Yes, it's just a rule of thumb. I mean, it could be much closer. I just don't know how -- the San Andres geology and how this reservoir is broken up. Apparently, it's very complex.

Q. Yeah. So in this map, which is B-47 I was showing previously, this is Mr. McGuire's rebuttal testimony, Exhibit B-46, I've identified and highlighted on it, on his exhibit, all the wells that -- let me rephrase this.

Basically, I guess my question is, that in your model, you did not include all the SWDs within five miles of the unit, right?

A. No, I did not.

Q. Okay. And looking at this map that shows all the SWDs, based on OCD's records, it shows both historical, inactive and shut-in wells, as well as active injectors. I'm not going to sit here and count them with you, but there are more than 60 SWDs within that five-mile radius.

So your opinion is, as a rule of thumb, that these wells within five miles should be shut in?

A. What I would say is if these wells had significant water volumes injected, then we haven't seen that influence in the model.

Q. If you did include all these volumes in your model within five miles, what would it do to your model?

A. And I would have to add up the volumes and see what it comes -- well, you told me it comes to 800 something, right? We wouldn't have a match.

Q. Well, no, this is the injected volume. So, before I was talking about the water withdrawal volumes.

A. Oh, that's true. I mean, everything has got to fit. So if there's other saltwater disposal wells with significant injection volumes, then it would be a different model. But here's the thing. It's not just injection volumes that you need to worry about, it's water-supply volumes. So you need to put the whole picture together. And you just can't look at one side of the coin and see what the other side looks like here.

So I know I have a good match, and if you integrate these other saltwater disposal wells, then you probably also have water-supply wells, I would imagine, as well. Or you may, I don't know. I just know what I was given.

Q. So I'm just laying it out so people are tracking. Okay? So going to your direct testimony, E-5. This is your direct testimony, Exhibit E-5, and it shows your cumulative saltwater disposal volumes that you included in your model, correct?

A. Correct.

Q. And it goes back to 1994, correct?

A. Correct.

Q. And is it your understanding that it goes back to 1994 because that's the first year that the reported water disposal volumes are available in the Division's records?

A. I didn't know that. I was just given the data, so I just added it.

Q. So going back to this map I've got up, Exhibit B-47, which is the five-mile area map, I've highlighted on this map each of the wells that has a first injection date prior to 1994, based on OCD records. So all of these wells and their volumes wouldn't have been included in your model because they had injection prior to 1994, correct?

A. I mean, I can't confirm that. I don't have that information.

Q. And because you didn't include volumes prior to 1994 and you didn't include all the SWDs within this area, if we were to include all the volumes prior to 1994 for the wells you did include and all the wells and the volumes that you didn't include, what would that do to your pressure match throughout the term of your model?

A. Well, I can't answer that because there may be other things going on. For example, there may be water-supply wells in here as well.

Q. There definitely are, right?

A. Right.

Q. And we talked about that. Yeah, so you'd want to be able to include all that to understand what the effect is at the end, right?

A. I can include all that, but ultimately, some of these wells may be producing in another part of the San Andres, for whatever reason. So I put in all the data and see if it could fit. Originally, when I built my model, I could not get it to fit because I was missing some of the water-supply well volumes.

So, I mean, it's all going to have to fit one way or another. And you just asked me if I put all this stuff in, I can't give you an answer because I'd have to put all the water-supply wells.

Q. Got it. One of Empire's claims is that as

Goodnight injects water into the San Andres, it's going to overpressure the San Andres and cause them to have to spend more money when they want to do their CO_2 flood because the volumes of CO_2 that they're going to want to inject are going to have to increase based on the increased pressure in the formation. Do you understand that?

A. Yes. And let me go back to what we just talked about.

At the end of the day, you're not going to come up with the pressure in the San Andres in 1986 and currently if you put in all these wells. So that's real data that needs to be matched. And if you cannot match that data, then some of those wells have to be in other compartments. That's simple.

Q. So, let me --

A. I mean, that's hard data. You're showing -- you're showing hard data, too. But it's all going to have to fit one way or another, or we don't have a matched model. It's simple.

Q. But I guess my question to you, though, is that I'm giving you data for wells in the San Andres, and you're telling me it's not going to fit in your model, and I'm saying I guess I understand that because there's something inherently wrong with your model. Maybe the volume of the San Andres is not big enough, or there may be some other issues.

But I guess my point is simply, if you were to include all those volumes, you're telling me it wouldn't work, right, the way it's constructed?

MS. HARDY: I object to the question and Mr. Rankin testifying.

HEARING OFFICER HARWOOD: Can you rephrase?

MR. RANKIN: Yes.

BY MR. RANKIN:

Q. Dr. Buchwalter, my point here, I guess, I'm hearing you tell me that based on these additional items, you're telling me that it won't fit in your model, right?

A. Here's what I'm saying. I have production and injection for the San Andres. I've got initial pressure. I've got a pressure in 1986, and if we -- that is real data. And if I put in a bunch of additional water injectors, I will never be able to get that pressure to match.

Because if you think about it, right over in this small area in the aquifer, water is incompressible. The pressure doesn't vary a lot over this area in the San Andres in this limited aquifer we have under the Grayburg. So you put all that production, and it's still not that far away. It's not 33 miles, correct? Like how far away are those wells, Adam, if I can ask you a question? They're not that far.

Q. They're not that far. My question, then, is -- you're telling me that you wouldn't be able to get it to match. And my reframed question back to you is, you wouldn't be able to get it matched based on the assumptions that you've incorporated in your model, correct?

A. Yeah. I wouldn't be able to get the match based on the data I need to fit in the model, which is hard data production and pressures. It's something simple.

Q. Moving on to this next question here. I think we already addressed this, so I'll move on to the next one. Oh, Actually, I was in the middle of asking this question about the CO_2 issue in the San Andres.

Your understanding is that Empire is making a claim that as Goodnight injects disposal water into the San Andres, it's pressuring up the San Andres and that's going to cause them to spend more money when they intend to purchase CO_2 for their proposed CO_2 flood. That's your understanding, right?

A. Yes, that's my understanding.

Q. Okay. But this passage here that I've highlighted here on the bottom of Page 4 that addresses that issue, that's the passage that Empire inserted into your testimony, correct?

A. Yes, they did. But I read it and it seemed reasonable.

Q. Okay. So they inserted it, but you evaluated it and it seemed reasonable, so you kept it in, right?

A. If you increase the pressure, then you have to inject more CO_2 for the same volume.

Q. But you weren't asked to do an independent assessment evaluation on what the impact would be on CO_2 purchases or volumes in this case, were you?

MS. HARDY: Object to the question. I think it misstates his testimony.

A. I can answer that. It just wasn't part of my study.

Q. Okay. I just want to know if it was part of your scope of work.

A. No, it was not.

HEARING OFFICER HARWOOD: I would have overruled the objection, if I'd had a chance.

THE WITNESS: Good. I'm glad I answered it, then. Keep things moving. I've got a plane to catch.

BY MR. RANKIN:

Q. So this next page, Paragraph 4, you go on to say that the model indicates that, "We're currently producing roughly 23,000 barrels of water per day more than if no water disposal had occurred in the past." Did I read that correctly?

A. That is correct.

Q. So your model is showing that there's currently about 23,000 barrels per day being produced in the Grayburg as a result of the injection that's occurring in the San Andres, correct?

A. Yes. Would you like me to explain how I come up with this number.

Q. No, because I think -- I don't want to -- I want to get to my questions. I don't mean to cut you off.

A. That's fine.

Q. Because I do want to -- I have other questions I to get to, and I know you have a plane to catch.

A. Okay.

Q. Okay. So got the basis here. Your model predicts that currently, as we sit here today, about

23,000 barrels of water is coming up into the Grayburg as a result of the injection that's occurring in the San Andres, right?
A. That is correct.
Q. Okay. Now, if that's the case, right, and that's what your model is showing, how would you confirm that with engineering field data?
A. And that's what I was going to tell you before. Here's what you do. You take the matched model, and you run it. Okay? And then you take that same matched model, and I turn off all the saltwater disposal wells from time zero. And you run it again and see what happens.
Q. I guess my question, though, is not what the model is going to show, I'm asking about what the engineering field data -- how would you go out to the field and evaluate whether or not currently 23,000 barrels of water or more are being produced in the Grayburg than would otherwise be the case?
A. That would be really hard, because you've got water coming from different sources. You actually need to build a model to be able to figure this out.
Q. Couldn't you look at production profiles?
A. Well, right now you've got water injectors, you've got producers, and --

Q. Couldn't you look for changes in oil production over time from before and after or during the time of injection of these disposal wells? I mean, isn't there something we could do in the field?
A. Oh, yeah, ultimately, that's kind of what you could do. Essentially if you take the model from time zero and you shut it off and you history match the model, you history match the oil to gas, and then the water that's produced historically without the San Andres communication, you just run it currently, you can see that there's a deficit in the water that's produced.
In other words, we're producing less water. There's less water between what we can produce out of the Grayburg by itself and with the saltwater disposal. It ends up with a deficit, essentially. And you could do it that way, too.
Q. Dr. Buchwalter, I know you're a reservoir simulator and a modeler. But you've given us an output here from your model, and I'm asking you, because the Commission's sitting here, I'm trying to figure out what's actually happening, what can we do to go out and evaluate to confirm whether or not that's actually the case in that field?
And I'm saying, would it be possible to

see it and wouldn't you see that volume on a daily basis in production profiles?

A. I think it would be hard. You wonder how you really could do it? Just shut everything in in the Grayburg and wait six months and see what the pressure is. If it doesn't change, then we have no communication with the San Andres.

You know, otherwise, it's just really hard. You've got a lot of moving parts, you know, water is moving here, water is moving there, it's taking, you know, high perm channels here and there. It's just a very complex reservoir. So, I mean, the way -- it's kind of like what you do often. If you might figure out what the reservoir pressure is, you shut it in.

Q. Okay.

A. That's what you could do operationally. I don't think that would be feasible, though.

Q. So you're telling me that you don't think, based on these volumes, you might see anything in the field production profiles?

A. So you just -- I'd have to try it and see.

Q. Well, let me just put this into context. I mean, we talked about it earlier. Goodnight -- I told you, based on the average injection rates over the life of their injection, that Goodnight's injecting on average about 14,000 barrels of water per day in each of its wells.

So 24,000 barrels is another 120, 30 -- I mean, it's a significant jump over even one of them. It's like having another well and a half of Goodnight's disposal wells just dumping right into the middle of the Grayburg.

And you're telling me that the field-wide, even offsetting well profile production profiles wouldn't show that?

MS. HARDY: I object to the question. I think it's misleading with respect to Goodnight's injection rates. I also think it's compound. It's argumentative. I think it's got many problems.

THE WITNESS: And I'm going to give you a simple solution to the problem.

CHAIR ROZATOS: Doctor, you have to wait.

THE WITNESS: Oh, I'm sorry.

CHAIR ROZATOS: The objection has to be ruled upon.

THE WITNESS: I'm sorry.

HEARING OFFICER HARWOOD: It's a long and complicated question, but it's a complicated -- the whole thing is complicated.

Doctor, if you disagree with any of the assumptions built into the question, I think you can correct them. So I'll --

THE WITNESS: Yeah, let me -- I was thinking --

HEARING OFFICER HARWOOD: I'll overrule the objection.

A. Okay. Here's what you could do. Just watch the shut-in pressures in the San Andres. They're going to build up in the next few years. That's the easiest way to do it.

Q. To your knowledge, have you yourself asked to confirm or sought to confirm your model outputs against engineering field data?

A. Well, I put in all the production and pressures, so that's what I've thought is -- it's literally all the production from -- for a number of years. It's monthly that's put in for both production injections. So yes, I mean, everything you see here is the field data I was given, and I match against them.

MR. RANKIN: And this next exhibit I'm going to put up has not been introduced. It's a new exhibit. I've taken Mr. Buchwalter's model on the left, it's Empire Exhibit E-2, and I've taken

Dr. Lindsay's, part of his exhibit, Empire B-5, and I just put it together on one page. And I would move the admission of this as Goodnight Cross Exhibit Number 5.

HEARING OFFICER HARWOOD: Any objection from Empire?

MS. HARDY: Well, I object to the extent that Mr. Rankin apparently intends to question Dr. Buchwalter about one of Dr. Lindsay's exhibits, and he's here as a reservoir modeler and this is a geology exhibit from Dr. Lindsay.

HEARING OFFICER HARWOOD: Well, we'll have to see what the questions are, I think.

Are there any objections from OCD?

MR. MOANDER: No, Mr. Hearing Officer.

HEARING OFFICER HARWOOD: Rice?

MR. BECK: No objections from Rice.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No objections from Pilot.

HEARING OFFICER HARWOOD: And my understanding is Empire E-2 and Empire B-5 are already individually admitted.

MR. RANKIN: They are. These are portions of those exhibits, not the full exhibits. Just so I can fit it on the page.

HEARING OFFICER HARWOOD: Ms. Hardy, your objection is noted, but overruled. I don't know what you're going to call this exhibit, but it's admitted.
MR. RANKIN: It'll be Goodnight, Cross Exhibit Number 5.
(Admitted: Goodnight Midstream Cross Exhibit Number 5.)
BY MR. RANKIN:
Q. Dr. Buchwalter, you were present for Dr. Lindsay's testimony this week, correct?
A. Correct.
Q. And you told me today that the two most important inputs for your model were the starting reservoir pressure and the geology, correct?
A. Correct.
Q. This exhibit shows your geologic model on the left, or part of it, at least the layers. In your opinion, does it accurately reflect the geologic and stratigraphic complexity that Dr. Lindsay discussed with the 88 stratigraphic cycles within the Grayburg?
A. What my model reflects is the average porosity and permeability. That's a composite of what you're seeing on the right.
Q. So I'm going to pull up another new exhibit. This will be Goodnight Cross Exhibit Number 6.

Dr. Buchwalter, we pulled this from your model.

On the left is the porosity, on the right is the permeability for what we understand are the inputs for porosity for each of those layers we just were looking at and the permeability for each of those layers. Does that look correct to you?

A. Yeah, it looks about correct.

Q. Okay. Now, it shows that your vertical perm here, which is on the right-hand side of the -- the table on the right that's titled, "Permeability," and the vertical perm is the "KZ," correct?

A. That is correct.

Q. Okay. So as to each of those model layers, you've assigned a vertical permeability of generally 1 between each of the zones, except for the bottom of the Penrose, correct?

A. Correct.

Q. And then you've assigned a variable permeability for the San Andres, which I believe is layer 8, right?

A. I believe so.

Q. And what you mean by variable for the San Andres is that you identified a hundred wells across the field, the entire model area, that you've assigned a variable vertical permeability to represent

the location of wells, allowing water to come up from the San Andres into Grayburg. Is that right?
A. That is correct.
Q. And you've done so through a variable permeability value that you've tweaked to match your model, correct?
A. That was to match the water rates on the individual wells. And if I run the model without that, you'll see that we can't even make the historical water rates on any of these wells -- or most of these wells, I would say.
Q. And we talked earlier about you were given a range of permeability and porosity values. And you told me that the permeability, I think, was on the range of 10 to 20 millidarcies; is that right?
A. I think I've seen that, like, in some of the documents I looked at historically.
Q. Okay. But on the other table over to the left, you've used a mix, depending on the layer. In the Penrose, you used a constant porosity, correct?
A. Correct.
Q. And then in the San Andres, you used a constant porosity?
A. Correct.
Q. But in the Grayburg, you had a variable

porosity, correct?
A. I sure did. That's where I did a lot of work and used kriging to create a variable porosity field to allow me to match the oil, water, gas, and the fluid moving around, as well.
Q. So as to Grayburg, you've got variable porosity --
A. Correct.
Q. -- but you've got constant permeability as to each layer, correct, with respect to each layer?
A. Yes. We have constant permeability there, at least in the layers 3 and 4. And then I think a little lower in 5, 6, 7.
Q. Yeah, so in other words, like, layer 3, permeability is constant, right, but it has a variable porosity?
A. Correct. And that's true of all the layers.
Q. Yeah, each layer has a constant permeability, but a variable porosity?
A. Yeah. I wish I'd brought the map so you could see the porosity map, but I'd get in trouble if I did that.
Q. Well, now, only because we hadn't seen it.
So is it normal for geologic systems, not talking modeled geologic systems, talking about

real-world geology for formations to have variable porosity but constant permeability?

A. Let me explain why we have constant permeability. The goal was to create permeability high enough where we can make all the historical rates for production and injection. So that's why we put that in there. Reality is, the real world is you're going to have less permeability in some areas and higher in others. But for the purpose of this model and the field-wide match, we're just looking at field withdrawals and so forth. And that worked quite well.

Q. So just to be clear, you didn't, yourself, look at the core -- there's some core data for the Grayburg. You didn't look at the core data, for example, to determine what would be appropriate for the Grayburg?

A. That wouldn't work. It wouldn't work. If you look at the core data, it's 10 to 20 millidarcies. It's really -- it's essentially a composite rock that's got the dolomite matrix in the fracture. So what we're seeing here is a high enough effective probability of that combined system to represent the fluid flow properly.

MR. RANKIN: Mr. Hearing Officer, may I please move the admission of this exhibit, Cross --

THE WITNESS: You misspelled my name there, by the way.

MR. RANKIN: I'm sorry, it wasn't me, but I didn't catch it, so that's my fault. I will correct it before we submit.

THE WITNESS: That's okay. Everybody spells my name that way.

MR. RANKIN: No, I apologize for not catching it.

It should be Goodnight Cross Exhibit Number 6.

HEARING OFFICER HARWOOD: Any objection from Empire?

MS. HARDY: To this specific exhibit?

HEARING OFFICER HARWOOD: Yes.

MS. HARDY: No.

HEARING OFFICER HARWOOD: OCD?

MR. MOANDER: No objection, Mr. Hearing Officer.

HEARING OFFICER HARWOOD: Rice?

MR. BECK: No objection.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No objection.

HEARING OFFICER HARWOOD: All right. It'll be admitted.

(Admitted: Goodnight Midstream
Cross Exhibit Number 6.)

BY MR. RANKIN:

Q. Dr. Buchwalter, you just were telling me that you understood the core of perms to be between 10 to 20 millidarcies, right?

A. Yeah. I mean, that's what I saw. I've never seen this. But I just saw on some write-ups what it said.

Q. So you were given ranges from Empire, but you didn't yourself look at any of the core data showing what the potential ranges of permeability would be in the Grayburg, correct?

A. No. I mean, the goal was to create a model that fits the field of production and pressures and leaks. It was never the intent to build all these little details in here because it wouldn't change the answer on a field-wide basis.

MR. RANKIN: Going back to my Exhibit 6, my Cross Exhibit Number 6 -- Mr. Hearing Officer, I'm going to label what's I'm going to mark as Goodnight Cross Exhibit Number 7, which is actually two pages of core data on permeability that was provided to us by Empire. And it's Bates labeled ENMOCD 23614-17, Bates 244 to 245.

HEARING OFFICER HARWOOD: Ms. Hardy, any objection?
MS. HARDY: Well, I don't know exactly what this is, and I don't know how he's going to use it with Dr. Buchwalter.
A. Could I ask a question? I guess it's not appropriate, but could I ask a question.
Q. Sure.
A. You got 638 wells here. This is just one well.
Q. Correct.
A. Yeah, so there's some -- there's a -- if you look at a real reservoir, it's like the people in this room. That's how much -- well, a lot if we had 630 people in this room. That's the kind of variability you get from one spot to another.
This is like turning the lights off in the Superdome, going in with flashlight and looking at what the Superdome looks like. You might see a seat, you might see the field, you might see something else. But, you know, you're trying to take the big picture and now look at it with a microscope. And that isn't -- and you can do that, but --
HEARING OFFICER HARWOOD: All right. Well, getting back to the objection, I take it Empire

objects?

OCD?

MR. MOANDER: No objection, Mr. Hearing Officer.

HEARING OFFICER HARWOOD: Rice?

MR. BECK: No objection.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No objection.

HEARING OFFICER HARWOOD: I think based on the witness's answer, this goes to the weight, not the admissibility, and it will be admitted.

(Admitted: Goodnight Midstream Cross Exhibit Number 7.)

BY MR. RANKIN:

Q. So on our Goodnight Cross Number 6, I'm interested now and I want to talk with you a little bit about the San Andres in particular.

In the San Andres, you've assigned a value of 250 millidarcies for the horizontal permeability, right?

A. That is correct.

Q. And in your testimony and earlier today, you discussed with me the fact that, you know, as injection at high rates occurs within the San Andres, you're seeing in your model results and increase buildup of pressure as a result of that high rate of injection, correct?

A. That is correct.

Q. Is that not partly a function of the permeability you've assigned to the cells in and around where Goodnight's injection is occurring?

A. Yes. We assigned this permeability and it fit the pressures of 1986 and the current pressure in the San Andres.

Q. Have you been provided the daily injection data from Goodnight Midstream that they produced to Empire in this case?

A. I've been provided a date. I believe it was monthly up until 1/1/24, so that would be -- all forecasts are as of, I believe, that date.

Q. Have you been provided the injection pressures and the pressure data on Goodnight's injection wells that they produced to Empire?

A. I have not, no. But my understanding is a lot of the wells have taken water on Vacuum. I don't know if that's true.

Q. So here is Goodnight's Exhibit B-12 from Mr. Preston McGuire's testimony. It shows, I think it's like, over a hundred thousand data points from its Sosa well. On the bottom, on the X axis is the instantaneous injection rate as in barrels of water per day. And on the Y axis, it shows the tubing pressure.

So what it's showing here, if you look to the right, is, you know, above 40,000 barrels per day. It's consistently under 80 psi. It's a low pressure. Do you agree, Dr. Buchwalter.

A. That appears to be what I'm seeing, yes.

Q. Do the permeability values that you've included and assigned to the San Andres allow for this high rate of injection at that low of a tubing pressure?

A. I would love to put tubing curves in there. And I'll tell you what happened. So, I mean, I'd have to build the tubing curve. There's some friction associated with it as well. So I'd have to build the tubing curve and just put it in and see what happened. But I did not have this information.

Q. In your deposition, you told me that when you do models for clients, you ask the client for all the data that they have that would best describe the reservoir. And you said the data would include the geology, include production and pressure records, it includes well tests and fluid data. This is the kind of data that would help you build a more accurate

model, agree?
A. Well, it would especially help in doing forecasts. If we're doing the history match, we actually know the volumes that go in the wells. So, you know, you usually put the tubing impression when you do forecasts so you can forecast with that tubing curve how things are going to change in the future.
We know what the individual injection rates are on each of these saltwater disposal wells, so we just use that data directly. And that's typically the way you do a history match, is you put the tubing curves when maybe you want to run some forecasts.
Q. I'm going to go back to your direct testimony and just kind of sorting through some of the assumptions and inputs.
Let's see. Oh, I know. Maybe it's in rebuttal. Yeah, okay. This is your rebuttal, Exhibit M, and it's towards the bottom of Page 6. You say that all the Grayburg water injectors, these would be the waterflood injectors, injected into all the layers of the Grayburg interval. And this is the assumption used in the model.
So just going back to our Cross Exhibit Number 5, I believe, where I've showed the model

layers against Dr. Lindsay's layers. As I understand that statement, you're showing in your model or have input in your model that the Grayburg waterflood injectors are injecting cross layers 3, 4, 5, 6 and 7, correct?

A. I believe that's correct. I think I double checked the model, and I believe that's the way I set it up.

Q. But, you know, in reality, the Grayburg injectors were injecting into specific intervals, targeted intervals, across the Grayburg. Is that your understanding based on the testimony you heard this week?

A. That is my understanding.

Q. Now, for Goodnight's injection wells, as I understand it, you've got it set up so that Goodnight's injection wells, the injection interval is from the very top of the 8th layer all the way through the base of the San Andres, correct?

A. I believe that is the way I set it up, all the layers.

Q. So, I mean, you heard testimony this week about how Empire has divided the San Andres into Upper San Andres and Lower San Andres?

A. Correct.

Q. And did you hear testimony this week addressing how there's a composite sequence boundary between the Upper San Andres and Lower San Andres?

MS. HARDY: I object. I'm not sure that's actually...

HEARING OFFICER HARWOOD: We don't entertain tentative objections. I mean, the question's harmless enough.

MS. HARDY: Well, that's fine, but I think it's just a lack of foundation.

HEARING OFFICER HARWOOD: It isn't yet. Hold your objection, Ms. Hardy. We'll see where we're going.

A. Well, I mean, I have a seal between the Grayburg and the San Andres. And then I put water into the San Andres itself, and that's the way I've constructed the model. I have vertical permeability, even if it's -- you know, some of these are just saltwater disposal wells injecting into part of the San Andres. That's fine, too, because I've got this vertical permeability and everything's going to equilibrate out.

So whether I inject in the top or the two-thirds or the whole thing, at the end day, since there's vertical communication, basically the pressure is going to be more or less the same everywhere.

Q. I guess my question, though, is, did you hear Empire's witnesses this week testify that there's a composite sequence boundary that divides what they call the Upper San Andres from the Lower San Andres?

A. I mean, I'm just saying this is what fits the model, this is what I was given.

Q. Did you yourself evaluate or determine Goodnight's injection intervals in its disposal wells?

A. No, I did not. I just injected into the San Andres.

Q. So as you sit here, you can't tell me whether it's a fair representation based on Empire's San Andres pick, where -- it's a fair representation that they're actually injecting at the very top of the San Andres, based on Empire's pick for the top of the San Andres?

A. What I can say is where I'm injecting water, and where I've got the San Andres set up, we can fit the injection rates and we can fit the historical pressures that we have in the San Andres in 1986 and currently. So, you know, we're fitting the model. I suppose you can fit this in a variety of different ways.

But in terms of you think the aquifer is an incompressible fluid, the pressure waves move very quickly up and down underneath the Grayburg, where -- you really see the big pressure differences in San Andres as you move out that 33 miles.

So, you can set it up differently, but -- a little different. You can set the San Andres up differently. I can say it's thinner and I have a higher porosity, but it's the same answer, basically.

Q. I guess, Dr. Buchwalter, if Empire is testifying and its experts are testifying that there's a composite sequence boundary that divides the San Andres into an upper and a lower, and you didn't confirm yourself whether Goodnight's injection wells are injecting into above or below that composite sequence boundary, wouldn't you want to know that fact?

A. Well, let me say what I would do if Empire had put this in the original model and how I would match it. I'd increase the porosity to where, essentially, all the production -- or all the oil -- or, excuse me, water we have in 8, 9, 10 is now above that line there, and you know we get it all to fit. It'd be a little different aquifer description, but it would all fit.

Instead of being 1100 feet thick, 1700

feet thick, whatever it is, it would now be maybe 3- or 400 feet thick, and it would have a higher porosity. But yes, it's all going to fit because it's -- the one thing that is somewhat of a material balance -- well, it's not a material balance everywhere in the aquifer. But underneath the San Andres, essentially it is a material balance, because water is an incompressible fluid.

Anywhere you put water in this area, the pressure is going to be almost the same underneath the Grayburg. So yeah, that would be a different geological interpretation. But at the end of the day, we'd end up with the same model because we need the same volume of water to fit the pressures, need the same oil, water, gas in the model, and we need the same leak.

So yeah, you can change these tops, you can do whatever you want. I would come up with a history match that would still be virtually the same because we have to hit match volumes and pressures.

Q. But as we sit here, you don't know whether there is a composite sequence boundary that divides the Upper San Andres or Lower San Andres?

A. Unfortunately, I'm not the geologist and I don't know this.

Q. And you don't know whether that composite sequence boundary serves as a pressure barrier between the Upper and Lower San Andres, correct?
A. As I said --
MS. HARDY: I object to the witness continually being asked questions that are outside the scope of his testimony. These are geology issues that have been addressed by Empire's geology witnesses.
HEARING OFFICER HARWOOD: I'm going to allow it, just in the interest of thoroughness. I mean, a lot of it may have been beyond the limited scope of your direct exam, but we've already set a precedent that that doesn't seem to matter here, so --
MR. RANKIN: Well, it does matter.
A. Yeah, like I said, it would not change the ultimate model.
CHAIR ROZATOS: Doctor, you cannot answer. Let them finish, please.
THE WITNESS: Sorry.
CHAIR ROZATOS: I realize that you are tired and I realize you have a flight. And I'm going to interrupt right now. What time is your flight, Doctor?
THE WITNESS: It's 4:45.

CHAIR ROZATOS: What airport are you flying out of?

THE WITNESS: This one.

CHAIR ROZATOS: Santa Fe. Okay. So for the sake of time for the good doctor, we are going to have to make sure that we keep this -- or we can always make sure that we bring him back on the platform when we come back on. Because the poor man, yeah, this will be the second time with his flight. So I want to be cognizant of that, please.

Doctor, sorry, but we do need to wait till the objections are answered.

THE WITNESS: Correct. I'm sorry. I apologize.

CHAIR ROZATOS: Empire, please make sure that your witnesses understand there's decorum.

MS. HARDY: Yes.

CHAIR ROZATOS: I mentioned it the other day. We need to make sure that we have decorum in here. And it applies for both sides.

HEARING OFFICER HARWOOD: It's partly my fault. I don't speak that fast, so when somebody jumps in ahead of me, that's pretty easy to do.

But it'll be overruled, but, Mr. Rankin, please try and be cognizant of at least the spirit of

Miss Hardy's objections, not to mention Dr. Buchwalter's constraints.

MR. RANKIN: Yeah, just for context, I won't belabor the point. I'll move on quickly. I have one more line of questioning to address.

Dr. Buchwalter testified that the number two important input in his model is geology. And I know he's relying entirely on what was provided to him by Empire, and I get that. And I guess I'm just trying to ascertain what the effects of additional geologic information that he wasn't provided would have on his model. So that was the point of the question. With that, I'll move on.

BY MR. RANKIN:

Q. In your rebuttal exhibit, Dr. Buchwalter, you did identify -- as we discussed, you did a model with the Grayburg and an aquifer attached to the west side of the Grayburg. I believe this was the field-wide match for that model run, correct?

A. I believe that's correct.

Q. So this is your Exhibit M-14. And I think you'd said in your summary that it was a pretty good field-wide basis, a pretty good match when you allowed for the Grayburg to have an aquifer that connected to the west, correct?

A. Correct.
Q. Okay. But then when you went and looked at the group of downdip wells, you said that it showed that there was not a good match as to that group, correct?
A. That's correct. It's the wells that are shaded in the yellow area.
Q. And the basis for that was that you were saying that the western edge wells were watering out too quickly, correct?
A. That is correct.
Q. Isn't the problem with the western wells in your model just due to the failure to incorporate the full complexities of the geology within the Grayburg? Couldn't that be a reason that these wells were watering out too quickly in your model?
A. No, it's not. It's not possible. Because we basically attached an aquifer with the same properties as the Grayburg, extending west. That's all we know. And there's no way it's ever going to fit.
It's an edge water drive aquifer, plus a small amount of water coming up from the bottom. I know there's some dispute as to how much water is under the Grayburg, but that's not enough water to

yield 159 billion barrels, or whatever it's going to take coming up from the bottom, because that would extend into what's actually the San Andres.

And what that shows is that, technically, if the water was coming in from the Grayburg Aquifer to the west, we would be able to match these wells.

Q. On the grouping question, especially as to this model run here, did you group just the EMSU to see what the effect was on the downdip wells?

A. I grouped all the wells. If I just grouped the EMSU, it's the same answer.

Q. The reason I'm asking you is because in this slide number 5, that was part of your opening presentation, your water-to-oil ratio was higher in the area of the AGU than on the western edge than it appears to be in the EMSU. Is that correct?

A. That's correct.

Q. So if you were to just group the EMSU -- in other words, when I look at your rebuttal here, my understanding, based on your prior testimony, is that you've allowed the fluids to flow between all three units, correct?

A. Correct.

Q. So if in order to make up the differences, you allowed water to flow between the units -- and if I'm looking at your presentation from yesterday morning, I'm wondering how it would look if you were to actually just group the EMSU by itself, based on the fact that the AGU is where, it looks like, a lot of the western edge water-oil contact, water-oil ratio is high.

A. I'd have to do it. I wish I could go get my computer and I could do it for you, but I guess it's a little too late to do that. But I think we'd show pretty much the same thing. The curve itself is very high. If you look, we're almost, what, twice as much water as -- and here's the other thing, Adam, I think that you're missing.

If the water's coming in from the edge, you don't have hardly any -- enough water on the bottom. So how did all those high water-oil ratios end up in those updip wells that are -- you've got wells that are, you know, almost 600 feet of pay down to the oil-water contact that show 13 to 1 water-oil ratio. At the same time, we've got wells that are only, you know, 60 to 100 feet above the original oil-water contact that never saw water.

And the one thing you can clearly see, as far as the EMSU is concerned, just from this graph, you can clearly see that the water in the EMSU, if there's any small amount of aquifer support, yes, it is a little more in the south, but in terms of the EMSU-B and the EMSU, it certainly shows that that wasn't what was happening, does it?

Q. Last question, Dr. Buchwalter. I mean, you're going to disagree with me, I guess, but it seems from my perspective that the goal of this model was to establish what the volumes were coming up from the San Andres into the Grayburg and not whether there was some other possible solution for the water production in the Grayburg wells.

A. That's not --

MS. HARDY: I don't hear a question in there. It was a statement by Mr. Rankin, not a question.

HEARING OFFICER HARWOOD: Well, I think the witness interpreted it as a question.

A. Well, that's just not correct. All the evidence shows that there's no way that Grayburg could have a huge aquifer coming into this reservoir. The water has to come from the bottom, and this figure, if anyone looks at this figure and analyzes it, will come to the same conclusion.

MR. RANKIN: No further questions,

Mr. Hearing Officer, at this time.

HEARING OFFICER HARWOOD: Thank you, Mr. Rankin.

I'll pass it to OCD and Mr. Molander.

MR. MOANDER: OCD does not have any questions for this witness. Thank you, Mr. Hearing Officer.

HEARING OFFICER HARWOOD: Mr. Beck for Rice?

MR. BECK: No questions.

HEARING OFFICER HARWOOD: All right. Thank you.

Mr. Suazo for Pilot?

MR. SUAZO: No questions for this witness.

HEARING OFFICER HARWOOD: All right. Mr. Chairman, Commission questions?

CHAIR ROZATOS: I do have a few questions.

And thank you for your patience, Doctor. We appreciate it.

Ms. Hardy, if I could get you, please, to share with us -- first off, can we admit the slides, your full slideshow from yesterday, the doctor's slideshow? Mr. Rankin has asked the witness about it. We haven't seen those slides, so some of this information was past us. So if we could get that admitted at some point, if someone would please

move to enter it.
MS. HARDY: I would so move.
CHAIR ROZATOS: Okay.
HEARING OFFICER HARWOOD: Well, I just want to make sure the record is clear. My notes show that Mr. Rankin went over slide 4 and slide 10. Is that what you're asking to admit or more than that?
CHAIR ROZATOS: Mr. Rankin.
MR. RANKIN: Yeah, thank you. I was sensitive to Mr. Harwood's admonition that the slides I addressed were the slides that would be relevant and admitted. So I addressed this -- I guess, just going into sequence, it's this first introduction slide, which I think is slide 2. And I'm just going to address the slides that were not previously an exhibit.
So it was slide 2, slide 5. I think, slide 10. And I believe that was it. Yeah, that was it. Those are the slides that I addressed that were not previously an exhibit.
MS. HARDY: Mr. Examiner, if I can respond, I would like to.
HEARING OFFICER HARWOOD: Well, sure. Let's make a record.
MS. HARDY: I think that the presentation is

a comprehensive presentation, and the slides that were included but not referenced by Mr. Rankin as well are part of the explanation. And I think that under the doctrine of completeness, that the entire presentation should be admitted. And the Commission can give it what weight it decides to.

HEARING OFFICER HARWOOD: Well, my notes show slides 4 and 10 were discussed on cross-examination. So what I'm hearing is a proposal. At least my understanding is nobody would object if slides 2, 4, 5 and 10 were admitted.

Is that correct, Mr. Rankin?

MR. RANKIN: 2, 4, 5 and 10. Based on my pagination, I would not object.

HEARING OFFICER HARWOOD: But, Mr. Rozatos, is it the Commission's pleasure that they all be admitted?

CHAIR ROZATOS: I'm okay to leave it the way -- I would like to see the ones that were discussed today. So definitely, whatever was missing and was discussed today, I would like to see.

HEARING OFFICER HARWOOD: Okay. So my understanding is the request is that slides 2, 4, 5 and 10 be admitted?

Any objection from Goodnight?

MR. RANKIN: Not to those slides, Mr. Hearing Officer. And I would just kind of qualify what my position is. If it's a previously admitted -- if it's an exhibit, if a slide is an exhibit that was part of Dr. Buchwalter's testimony, I don't object to it being presented. But if it wasn't previously presented, and I didn't use it for cross, then I wouldn't want it to be admitted as part of the record.

HEARING OFFICER HARWOOD: Okay. And I think that that means slides 2, 4 5 and 10.

MR. RANKIN: Correct, yeah.

HEARING OFFICER HARWOOD: Okay. OCD, any objection to those.

MR. MOANDER: No, Mr. Hearing Officer.

HEARING OFFICER HARWOOD: Rice?

MR. RANKIN: No objection to the slides.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No objection.

HEARING OFFICER HARWOOD: Okay. Those will be admitted. Ms. Hardy, your argument that they should all be admitted is rejected. I think you cited the rule of completeness, which has to do basically with singular documents involving, you know, when one party offers up a portion of a document, the other has the right to request the remainder be admitted.

That doesn't really apply here because all of these slides cover different information and categories, so just for the record, that's rejected. But those four will be admitted.

MR. RANKIN: Mr. Hearing Officer, I guess the question is, should we mark those as an Empire exhibit? I think we can do it as a Goodnight Cross Number 8.

HEARING OFFICER HARWOOD: Whatever works.

MR. RANKIN: Yeah. We'll do it as Goodnight Cross 8. I'll confer with Ms. Hardy. We'll put it together as a Goodnight Cross Number 8?

HEARING OFFICER HARWOOD: Okay. Thank you.

(Admitted: Goodnight Midstream Cross Exhibit Number 8.)

HEARING OFFICER HARWOOD: Okay. Now I think we're back to you, Mr. Rozatos.

CHAIR ROZATOS: Yes, the questions. Thank you.

Ms. Hardy, if you wouldn't mind pulling up your Exhibit M-6, please. Perfect. Thank you.

EXAMINATION BY THE COMMISSION

BY CHAIR ROZATOS:

Q. Dr. Buchwalter, again, thank you for your testimony and your patience with us today.

The question I had, you stated here that you did the math at a 4 psi. The paper that you referenced at the bottom that you said kind of correlates with what you say is 4 to 10 psi, and you've mentioned the range of 4 to 10 psi as well.

For someone who is definitely not educated in this, what would happen if the pressure went up to 10 psi? What are we looking at potentially in these models?

A. Excuse me, I was talking to you, not the microphone.

So what happens is if you have 10 psi build-up, that probably means a time at which the saltwater injection is higher.

Q. Okay.

A. And because all that water can't move out immediately, it builds up the pressure higher in that area; whereas, at 4 psi, might either be a better permeability area where the water can dissipate faster or alternatively just a higher injection rate. But I just thought it was really neat that, you know, these numbers quoted here match the physics that we were coming out of the model and this came after the fact.

Q. Okay. Excellent. A second thing that you mentioned was when the water hits a pseudo-steady state and the pressure is increasing you stated that the water will go up into the Grayburg. Could this potentially also go down?

A. What -- I don't know -- I don't know if --

Q. I apologize. I was typing as you were talking.

A. No, it could. It could. I guess it could go down someplace else. But I'm a geologist. Is there something other than San Andres where it could go?

Q. I don't know. I'm asking with your models.

A. Well, with the model, it's basically -- if you kind of think of the San Andres Reservoir, the water there underneath the Grayburg, think of it just as a big tank. And, you know, I wish I could have had another figure added that actually showed how the pressure changes in the Grayburg.

And it's really cool, because what you see -- because it's not intuitive, really, what's happening here. But when you -- up until now, most of that water that's been injected has also been produced. And at the same time, in the future, potentially, we're going to increase this injection rate, and we're not producing that water anymore.

So what you find is very quickly the pressure here that you're seeing here, right underneath the Grayburg in the San Andres, it builds up very quickly to about 26-, 2700 psi. As I said earlier, the real problem with this is these saltwater disposal wells are just all kind of in one place and this aquifer goes out 33 miles.

So what happens, once it hits that 26-, 2700 pounds, I have a 3000 maximum injection pressure, so you can't inject any more water after that point. So with or without the new saltwater disposal wells, you essentially have, after that point, the same physics.

So you have about the same water going in, and there's only two places the water can go. It can go up or it can go out into the aquifer. And, essentially, at that point what you're injecting levels out, and at the same time, what's -- because we're essentially -- the way I operate the Grayburg in the future is, we're going to assume all the producing wells can operate at low pressure. So the pressure in the Grayburg stays about the same. Does that make sense, if you're producing them? So as more water comes out, we're just lifting more water.

And so, essentially, the pressure in the two places are about -- stay about the same after that point, and you have about the same pressure difference. So from that point on, we were at about 50,000 barrels of water moving up and the remainder water moving sideways. So it's, essentially, like what we call pseudo-steady state.

Did I explain that?

Q. I think I understood you. Thank you. Appreciate it.

CHAIR ROZATOS: The next slide, Ms. Hardy, if you could. This was one of those that were not shown to us. That one right there, the relative permeability curve.

BY CHAIR ROZATOS:

Q. If you could do me a favor, Doctor, and just describe what we're looking at here and what exactly you would like the Commission to see off of this.

A. Okay. In a perfect world you, create what's called a dual-porosity model. In other words, you have a different set of relative permeabilities, which essentially says that the fluids flow differently in the fractures versus the rock. Does that make sense?

Think of the fractures as a pipe, so the fluid just shoots through there. So those relative permeability curves typically are just straight lines, as they would even in a flow line, essentially.

In the rock we have these relative permeability curves where the fluids interfere with one another and you see what you've seen here, and I think I explained this to Adam earlier.

So in a perfect world, you'd have all this core, you'd do all this fracture analysis and you'd create what's called a dual-porosity model. And in that dual-porosity model, I've built these all around the world, once you have that information, the way you represent each grid block that might be 300 feet by 300 feet, is imagine a bunch of little cubes.

Each one of those cubes represents the average dolomite block that's surrounded by fractures. And of course if those blocks are this big, there's not a whole lot of communication with the fractures, right, because that water is going to shoot through the fractures. If they're this big, think of all the cross-sectional area that these blocks have.

So in a traditional dual-porosity simulator, if you can build it and you have the data, then, essentially, you have -- this is -- and of course I didn't have -- yeah, we just didn't have that data.

So what we do when we don't have all that detailed data on the block sizes is we try to find a composite rock that represents the confined matrix blocks of dolomite in the fractures. And these relative permeability curves represent that.

So in the big picture, if you think of it, really, it's flows going through the fracture. That's where all the flow is. So these relative permeability curves that you see here are somewhat straight, like that bottom curve. And even the water curve up here on top is relatively linear, more linear than it would be in a normal rock.

But at the same time, what we do is we adjust the residual saturation so it corresponds to what you would see in the rock itself. Because, you know, 95 percent of the oil and water, gas is in the rock itself. It's not in the fractures. It's just small volumes.

So big picture, this is the way you create a composite relative permeability curve that does the same thing as the dual-porosity. In fact, the next slide I had in here was -- it sat up on top of the dual-porosity physics, and because we don't have dual-porosity, it wasn't even something that was applicable to this reservoir or the history match or anything else.

So I just wanted to explain why these curves look the way they do, because they're not what you would normally think of for a dolomite.

Q. Okay.

A. Is that okay?

CHAIR ROZATOS: Yes. You answered my question. Thank you. I appreciate it. I don't have any other questions.

COMMISSIONER LAMKIN: I think I'll pass it to Dr. Ampomah. I think he's got a plethora of questions for you.

HEARING OFFICER HARWOOD: He's going to have lots of questions. This is going to be fun.

EXAMINATION

BY COMMISSIONER AMPOMAH:

Q. Thank you, Doctor. And if I may be reminded, your flight is?

A. I've probably got a good 35 minutes. You can ask lots of questions. I've got 35 minutes.

Q. Well, I mean, 35 minutes might not be enough, but --

A. I hope -- well, okay.

Q. You know, Mr. Rankin did -- like, he asked most of my questions that I do have. I mean, going through, when I review the testimony, you know, I was able to follow it. But the problem is I don't have the input data, you know, to be able to verify. But going through the cross, you know, most of my questions have been answered, but I do still have a couple. And we will start from here.

So did you use the same relative perm for the Grayburg and then the San Andres?

A. Did I use the same -- what was it?

Q. Relative perm, like you're showing right here.

A. Yeah. I think, -- yeah, I think I used the same relative perm curves. So, basically, in the San Andres, you know, we're on the end point of that water curve there, more or less.

Or maybe -- maybe not, because I didn't have any mobile oil in the San Andres. They were both 30 percent though, right? Let's see. Yeah, it's the same Kr curves.

Q. The same curve you used for both?

A. Yeah, I used the same Kr curves.

Q. But did you put in the saturation distribution within the San Andres?

A. Yes, I did. I put in the -- I essentially created a saturation distribution where -- 30 percent, and we rolled it down until we had the 900 million barrels in place, ROZ in San Andres.

Q. If we look at this curve, let's say initial water saturation right on the top is about, let's say, 35 percent, and the critical water saturation is about just probably 40 percent, right? So not much room there. The minute you start producing, water is going to come out. Is that a fair statement?

A. You're referring to what, the San Andres?

Q. Okay. This curve, let's just focus on the Grayburg for a moment. With this curve that you have --

A. Right.

Q. -- your initial water saturation about 35 percent, and the critical water saturation is about 40 percent. Is that correct?

A. When you say "critical water saturation," you're referring to?

Q. I'm referring to the minimum amount of water saturation that it will start to move.

A. Yeah, that's -- yeah, it's basically -- yeah, it's 35 percent. Yes, exactly. Think of it as the connate water saturation. So anything above --

well, you know, I must have used a different Kr curve, because the -- maybe I initialized the San Andres a little differently. I just know I initialized it so the oil would not move. The oil was essentially immobile.
      Q. Yeah. Let's focus on the reservoirs of the Grayburg, the Grayburg Reservoir.
      A. Okay. The Grayburg we're talking about now. Sorry.
      Q. So should I repeat my question one more time?
      A. Yeah, repeat it one more time. Because I was thinking in terms of the San Andres. I'm sorry.
      Q. Yeah, I'm just going to focus on the Grayburg for quite a number of questions. So I'm saying that your initial water saturation right here on the top curve, that is the oil and then the water curve, initial water saturation is 35 percent?
      A. Absolutely.
      Q. Your critical water saturation is 40 percent. Is that a fair description?
      A. How do you define "critical water saturation"? It's, essentially, the water varies between that -- it starts to move at 30 percent oil saturation. And once we hit the 21 percent residual

oil saturation, the oil stops moving and the water curve goes up to .8. Does that make sense?

Q. So you're saying that even the critical water saturation is 35 percent?

A. Well, the initial what I call connate water saturation, or even the water saturation in the rock, is 35 percent. And as the oil curve goes down, eventually we go to the point where we hit the residual oil saturation with respect to water, which is 21 percent. And that's where the oil curve hits zero and the water curve hits .8. Does that make sense?

Q. Now, I guess what you mean, you know, connate water is not going to move. But at what saturation is the water going to start to move?

A. The water's going to start to move at that 30 percent for that curve, right?

Q. Yeah. So if 30 percent, then it means we don't have any connate water? I mean, your connate water is 35, meaning at 35, water is not going to move, stack. The water has to increase at a certain point so you produce oil and then the oil saturation will reduce, and at some point the water has to stop moving. At what saturation level will the water start to move?

A. Well, the water's starting to move at that 30 percent, as you see on the curve there. Does that make sense?

Q. Well --

A. Kind of look at the curve itself.

Q. Okay.

A. I may be misstating, but connate water is the water saturation that's imbibed in the rock that doesn't move.

Q. And that is 35.

A. No, it's 30. Oh, it's 35. You're right. Oh, I'm sorry. I thought it was 30. It's 35, so the water starts to move to 35. I'm sorry.

Q. Okay.

A. Does that make sense? I was thinking it's 30, but it's 35.

Q. That would make sense to me.

A. I was looking at the wrong number.

Q. That sounds like a --

A. It's 30 in the report, right?

Q. Yeah. I don't have a lot of time.

So, if you look at the margin between, let's say, 40 percent, water saturation to about, let's say, 70 percent water saturation --

A. Right.

Q. -- it tells you that waterflood was quite successful, you know, about -- would you agree with me on that?

A. You know, you would think so, but, you know, the other thing you're not thinking about is the fact that this water Kr curve is very almost linear compared to a normal Corey exponent curve for a dolomite.

So essentially what I did is, you -- conceptually, it would seem right, right? Seems a lot of oil is mobile. But the reality is, because these curves are so flat and they increase so quickly, the net result is we end up with a good history match of the historical -- of the water.

I wish I could bring my computer up here and just show you a typical set of Corey Kr curves between these two points. But this curve is very, very optimistic. It's not quite linear. You know, obviously if it's low in fractures, it would be linear, right? It's not quite that, but it's approaching that.

Essentially, I varied the exponent on these curves until I could fit the historical water and oil production. For example, right now these wells are making an extremely high water-oil ratio.

MS. HARDY: Dr. Ampomah, I'm sorry to interrupt. I just wanted to let you know that we'll be sure that Dr. Buchwalter is able to get home, so just take your time with your questions. Just take your time.

THE WITNESS: I apologize for the misunderstanding. I kept thinking it was 30 and it was 35. He kept asking the same question. So that's my fault. I apologize.

BY COMMISSIONER AMPOMAH:

Q. So, you know, just what I just want to point out here, in the report on the left, residual oil saturation, which I presume saturation at, let's say, residual oil saturation not water injection, is 25 percent.

A. Right. What's cited in the report? I'm using, I think, 21 percent, right?

Q. Well, I'm looking at the actual 1990 report currently, not necessarily the model.

You know, the way I look at this is, I feel like we have to use the actual field data, you know, to help us to be able to understand what is going on.

I mean, Doctor, you know that there's no way a dolomite reservoir is going to have a permeability of like 500 millidarcies. I mean, some stones even perhaps, I don't know if there is that in America here. I mean, the input data that you use for the model, I'm just trying to --

A. So you're trying to get your head around why did I use such a high permeability? It's because we've got fractures. A fractured network is increasing. If I put a permeability anywhere close to what a dolomite is, it will never history match. I mean, I started with that, and I could only make a small fraction of the cumulative oil. I couldn't even get the water in the ground, really.

So I literally -- what's happening here is I think that essentially in a dual-porosity system, the effective permeability is a composite of the fractures in the matrix. And this permeability I put in here was necessary before I could even get a fit.

I mean, I'm kind of with you. I didn't start there, but that's where I had to end up.

Q. So are you saying that all the testimony that we've listened to, is it your testimony that the Grayburg is a highly fractured reservoir?

A. Mine or -- well, I just -- it seems to be. I mean, that's what fits the production.

Q. I mean, I don't know if I can agree or disagree with you. But, I mean, what I was expecting is that with all the geology description that we've seen, probably throughout the whole week, they've given us porosity maps, permeability maps, and even there is a core data for the Kv, you know, versus even there is even a correlation between porosity, permeability.

So I was expecting -- I thought that probably that was what was used in the model. And if you use that and then were able to go through all of these scenarios that was described here, I mean, probably we will not be here right now.

But with these, there are a lot of uncertainties associated with the model that you presented here today.

A. Let me expand on that a little bit. This is a permeability that was required so I could match the field oil-water-gas rates and injection rates. So, you know, obviously there's going to be a lot of places in this reservoir that are tighter.

But the goal of this model was to try to come up with a match in the field production, injection and pressures and then the influx, match that influx from the San Andres.

So you are right, big picture is if you

go to any one spot of this reservoir, you could find some lower permeabilities. And maybe, you know, if you were doing a detailed model and it would take a long time, you could add those additional details in there. But for the purpose of this model, we were just trying to match the field volumes, and this allowed me to match the field volumes. Does that make sense?

Q. Well, I mean, the way the model is set up is easy for everybody to argue that this is not based on actual field data.

You talk about there are fractures to be able to match, but I'm not seeing anywhere where you've developed, let's say, a fracture model?

And throughout the whole week, I've not had anybody talking about the properties of the fractures that were seen in the 649 or the other wells, the two wells. You know, I've not had any fracture properties that were described to really tell the Commission that the Grayburg is really a highly fractured reservoir.

So if you thought that it was a highly fractured reservoir, then probably you should have straightaway gone into like a dual-porosity model. And even how do you even estimate the fracture

networks, the type of fractures here and there?
I mean, limited data, but to assume that the entire Grayburg formation is a fractured reservoir, that's a --
A. Okay. Can I explain what --
Q. Yes.
A. -- my workflow is? Here's the problem if you go straight into a dual-porosity model. You have twice as many perms, you've got two sets of relative permeability, you've got two sets of porosities, and granted, the porosity of fractures is small, and two sets of permeability. And the hardest thing is figuring out what that matrix block size is in the dual-porosity model.
So the way I approach simulation, I had a slide on this that I can't show you, but I'll talk through it, is I first create a single-porosity model to figure out what the effect of permeability and porosity is of the composite fractures in the matrix. And that gives me my first step.
Because until I get that, I've got so many unknowns and I'm never going to get my head wrapped around the solution.
So once I've got that single-porosity model, at that point if -- you know, we did have a

detailed frac study here and core study to tell me what those block sizes are. So, I mean, I could start with any block size. It could be an inch, a foot, whatever. But, you know, I don't have that data, so, I mean, I had to use this approach. And it did eventually fit the pressures and volumes and so forth.

But yeah, if we had that data, the next step in this model, I just said, would be to create a dual-porosity model. And at that point, we could have some idea of what those block sizes are.

And the big advantage of those matrix blocks, Doctor, is that you have both the gravity and capillary contribution and different relative permeabilities, right?

So kind of what we do here is kind of a -- it's a simpler approach; it's not perfect. But what you see here is a relatively straight line or linear relative permeability curves to model flow as would be in the fractures, and it just -- those residual saturations represent the type of rock in the matrix.

But, you know, within the time constraints -- and really, the goal of this model was more than anything else to start to understand this leak, this potential leak between the Grayburg and the

San Andres.

And you know, ultimately we fit all the production. We fit the historical pressures in the San Andres. And we fit the historical pressures at 1986 and today. And you know, that's -- I mean, honestly, if this was a model that was designed to figure out where to infill drill wells and things like that, and this was a young reservoir, then you would do that additional work and create that dual-porosity model.

And the main advantage of that dual-porosity model, as I said, is you have two sets of relative perm curves, and you'll also have -- you have that gravity and capillary pressure contribution as well.

But now honestly, there's just so many buttons to twist in the real world, you can't do everything at once. And I like to say you can't eat the elephant at all at once. It's just one little bite at a time.

Q. You know, let's say as we reservoir simulators, simulation experts, you know, as you said, you know, we can give any match. I mean, we can have multiple reservoir engineers in the room and we can all come up with the same match but with different approaches.

You know, but still the underlying geology needs to still be more or less inherent in anything that we do. You talk about -- once you set the model, I presume you use the oil constraint or liquid constraint, oil and gas as your primary constraint?

A. I use the oil constraint on these wells.

Q. So you were able to match -- I mean, you were able to get all the oil to match and the gas to match, and even some pressures, except only the water production. Is that correct?

A. Yeah. In the original model, I actually could get the oil and gas to match, but not the water. You can see the water was falling short. Kind of from 1938, you can see it restored to 1986. And even from 1986 to 2004, you can see how that difference was increased and there were still some shortcomings.

Q. So it was more or less predominantly the water that has some issues.

Now let me ask you, how accurate is the water production history?

A. How good is water production history?

Q. No, no. The historical data.

A. As good as what they gave me. You know, I mean, I've got the data. You know, at the end of the day, you and I both know, the model is as good as the data you put in, right? So that is all we've got to work with.

And the thing I would say, I was surprised it fit as well as it did. Because as you said, oftentimes you don't have accurate records there. But I put everything in and it just seemed to fit, especially when I put the -- the first time, as I said, I built this model, I couldn't get a match. And I didn't -- I wasn't going to be here. I told that to the Empire. And they identified these missing saltwater disposal wells, I put that in.

And once I put those in, I turned -- I don't -- prior to that, the match model only had about half the saltwater disposal wells on. And as soon as I did that, everything just kind of fit, which I thought was -- it's either really lucky, or just we had the right model. I think was the right model.

Q. Yeah. So if you can make the responses really, you know, sleepy a little bit, so we can get through most of the questions here.

So, let's see, which year did the water production start?

A. The water production --

Q. History, yeah.
A. The history? Well, the history started in 1938. So from 1938 to the time the waterflood commenced in 1987, then we had no waterflood from 1987 to today. We've waterflooded the reservoir.
Q. Yeah. But I'm just asking, in some of your plots, it sounds like water production started right from the start of, let's say, the commencement of oil production.
A. Yes, it did. Absolutely.
Q. So definitely, there is some kind of water drive somewhere, some way?
A. Exactly. And the interesting thing is, if you just put the Grayburg in there, as I've said, you can have a little bit of water in the Grayburg itself underneath the oil-water contact going down to the San Andres. And in addition to that, you have to put an aquifer out, edge water drive aquifer out to the west.
And you can come up with a good match of oil-water gas, but the problem is, when you start to look at wells in the area, if you look at all the downdip wells, historically during primary production, they didn't make much water, very little water. So the only way that water can come -- there's not enough

water downdip. If it comes in from the edge, it waters out the deeper wells in the Grayburg, and that's just not what happened.

You can look at that figure where you can see wells that are, you know, zero to 60 feet or so termed above the -- down to the oil-water contact. Many of those wells produce virtually no water, and here's a well over here at 600 feet down to the oil-water contact that's making a 13-to-1 cumulative water-oil ratio at the time water injection commenced.

So, I mean, it just -- it's not consistent unless we have a large aquifer coming in from the bottom. At the same time, that aquifer is not coming in everywhere. You can see the cumulative water-oil ratio map in 1986 shows that that water is preferentially just coming in at a select fraction of the wells.

Q. Doctor, so once we start producing and then water starts coming up, then definitely it means that we do not have connate water within the reservoir.

A. Correct.

Q. It's open to, let's say, water production.

Now, it strikes me a lot during the cross, that I got to know that you did not really revisit the completion data. I mean, if you have extremely high water producing wells, I thought probably you might want to check the records to look at the completion and see probably they might have completed -- or let's say the oil-water content might have moved and they are producing a lot of water. Did you do that assessment?

A. That's a fair criticism. Yeah, I could have improved a little of the model, but overall with 638 wells, I think the conclusion remains the same. Just a small fraction of those wells made high water-oil ratios. And, you know, generally you're going to complete wells in the well leg, so that's the way I set it up.

Q. Yeah, but if you look at the high, you know, contentious case like this, I mean, well completion is all that we have to prove your case that there wasn't any -- there was no completion in the water zone, so if they are producing water, then where is that water coming from.

Now, you do have that assumption made in such a way that it is making it difficult, you know, for us to know whether even some of these wells were probably completed in the water zone. And I don't have the data, I don't have the simulation data, so I do not have any ways to cross-check that. But thank you for that.

Do you know when the encroachment happened in the model?

A. The encroachment from the San Andres?

Q. Yes, into the Grayburg.

A. It's basically just from day zero almost. As we dropped the pressure in the Grayburg, San Andres was just moving up into the -- San Andres moving up into the Grayburg.

Q. And the previous owner of the site, XTO, did their comprehensive analysis on the site. And, you know, based on the testimony that we've had throughout the whole week, they came up with a problem, you know, that they feel like this is what is happening, you know, where there is a migration into the Grayburg.

I want to know, did you incorporate their findings in your history match there for it?

A. Did I incorporate what into my history match?

Q. Okay. Let me repeat again.

So XTO, or Chevron, did a report, and it was more or less published by Love, et al.

A. Okay.

Q. So we've seen that throughout the testimony this week. They also saw that there is a potential migration of water from the San Andres into the Grayburg.

A. Correct.

Q. And they came up -- you know, more or less, they established that this could be the problem that is more or less causing this potential migration.

So my question to you is that, as you saw the production or, let's say, the encroachment right from the onset, did you also incorporate their study as a case study or, more or less, as one of the scenarios that you run to see if you could have probably gotten a history match?

A. Well, what I did do is I actually looked at initially shutting off of the San Andres and trying to build an aquifer into the Grayburg that would start to fit the historical field production. I just never could get it. There's not enough water underneath the Grayburg.

I can -- actually, yeah, that was one of my match models that I did in my rebuttal to kind of look at that. But I just can't get the physics to work, because, basically, at the end of the day, you still need a big aquifer, 33-plus billion barrels, as I recall, and you just don't have that much water underneath the Grayburg.

And so, essentially, the water is coming out from this area to the west, and it's just going to hit those edge wells on the west side of the reservoir.

Q. So, based on your testimony, I heard that you did not include Empire's SWDs in your earlier history match. Is that correct?

A. Well, I included all the data I was given. I don't think there was a whole -- well, actually, I think I did. Yeah, I included all the data I was given. At least Empire's I think SWDs are included in this model, if I'm not mistaken.

Q. Okay. I will continue from there. So based on what we're discussing earlier, do you believe that the model that you've more or less worked on and presented to the Commission is comparable to any reports that probably XTO or Chevron put together ever? Is there any comparison, you know, let's say apple-to-apple comparison with regards to the analysis that you can more or less share with the Commission?

A. Yeah. I mean, there was a report I think in 1990 that said this is primarily a solution drive reservoir and that the water was probably coming from the San Andres. So obviously that wasn't a simulation study, but that's pretty much what I've seen. That's

what I've seen in my model as well.
Q. Are you referring to Love's paper?
A. No. I've got it in my -- you can go to my original testimony, and I think even some of the slides I have in my rebuttal. They kind of show some of that early data. It's actually in my rebuttal. I can point to it. Let me see.
But yeah, I try to be consistent with -- one is E-8 and E-9. It's, like, slide M-2, for example.
Q. M-2?
A. Yeah. So this was Chevron report 1989 that the Grayburg is primarily a depletion drive reservoir. And the report also confirmed production bubble plot confirmed San Andres water was -- support in communication through a limited fraction network.
So, I mean, that's exactly what the model showed. Did you find it yet? It's M-2.
Q. But I thought during the cross, this one was in the AGU field?
A. Yeah, I'm sorry. This is the AGU. That is correct. That was just referring to the AGU. I found that basically that was present. Essentially it was present across all three leases.
Q. Well, if you look at the -- and we'll get to

that. If you look at the map that you showed and were going back and forth with Mr. Rankin, that shows the location of the wells that you have higher production of water. You see that definitely the AGU is everywhere is, more or less, flooded, right? But not so much with the EMSU, so --

A. Well, it's not everywhere flooded. But it is a little bit more than the other two leases.

Q. Well, so I want you to help the Commission to understand if there is any prior establishment or, let's say, if there is a reference that shows that there is a migration of water from the San Andres to, let's say, the Grayburg, aside what was described by Chevron.

A. Well, I mean, the other thing I did, is we just plot the historical water-oil ratio history at the cumulative water-oil ratio in 1987, before the waterflood. And that gives you a big picture. As you said, it shows a little bit of water moving down in the AGU. I thought I had that.

MS. HARDY: Dr. Buchwalter, can you just be sure to speak into your microphone when you're talking?

THE WITNESS: Oh, I'm sorry.

MS. HARDY: Thank you.

THE WITNESS: Apologies.

A. Let me find the page here. It's here somewhere. Oh, I know why. It's not in the -- I have the original -- I have the original figures.

THE WITNESS: Can you bring that up? The one that had the -- it's got the two maps, the depth map, the gross thickness. Could you go forward a little bit? It's one of the ones that's not labeled, so I can't find it.

MS. HARDY: And is it in your slideshow?

THE WITNESS: Yeah, it's in the slideshow. Some of the ones that we added. It's probably higher, I guess. Just start at the beginning and just go down. We'll find it real quick. Oh, there it was. I'm sorry. Go down. Next one. I think that's it.

BY COMMISSIONER AMPOMAH:

Q. Okay. Right here.

A. So this is just kind of a big picture from 20,000 feet showing that the downdip wells, for example, in EMSU really don't show much water production. Okay. Do you see that?

Q. Yeah. But I'm saying -- what I'm saying is that if you look at the -- is the AGU the one at the bottom?

A. The AGU is the one at the bottom, and as you said, it looks like it's got a little bit of water -- some water moving in there.
Q. Yeah. And if you look at even within the region of the EMSU, I mean, these are more -- you know, if you would have checked the completion data, that would have ruled out the fact that these were all in the oil zone, and for some reason, somewhere, somehow, water from somewhere, more or less, moved out.
But without, you know, establishing the fact that -- because you open everywhere, you open all the preparations, you open throughout the entire Grayburg, and we've seen that there is water right at the bottom of the Grayburg from the -- from your team's testimony?
A. Right.
Q. Right? So if you were able to confirm more on the completion data, that would have really helped us a lot to really, you know, delineate.
A. And the only thing I would say, if you look at the thinner areas where you're 60 to 100 feet, where you're relatively thin and not very far above the oil-water contact, you know, a lot of those wells universally make almost no water. So even completions

are that wrong, there's not that much area to complete. And I think eventually water should have moved into those wells.

But I agree, you know, that we'd be able -- would it be a better model if we constructed that? I don't think it would change the results appreciably.

Q. I mean, in terms of, let's say, the results that you are presenting to the Commission, I mean, based on a lot of assumptions that you made, I can also say that if you would have used the actual field data, let's say porosity, permeability, maybe from the field data that has been shown to the Commission, then I don't have any question. But you didn't do that.

And with this high porosity, permeability, even I'm surprised that with even 1 millidarcy -- I think I read somewhere that even in one of the testimonies, that even .5 millidarcy, there could be a communication between San Andres and then the Grayburg.

A. No, it would never work. It's just too much water moving on. It's a very limited fracture network that fits this production. That much I can say for sure.

Q. Okay.

A. So, I mean, let's think of this big picture. Okay? The water's got to be coming from somewhere. You can't put it coming in from west to east because you'll never -- no matter what you do with the completions, you're still going to lose the match on the west side of the wells -- of the reservoir.

And big picture, you know, when the -- if you just take the limited aquifer that's in the Grayburg and you don't have that San Andres communication, you just can't get everything to fit. And, you know, we've seen the pressure drop in the San Andres before the waterfloods. So that, in itself, shows that there's communication between the reservoirs, right?

Q. Yeah, but there are water wells in there, too. There are water production wells in the San Andres.

A. Well, the production I have for the injection and water-supply wells start later than 1987. So how did the pressure drop in the San Andres? Something's happened.

Q. You're saying, it's your testimony that the pressure in the San Andres dropped prior to any water that has been taken out?

A. Correct.

Q. But I thought in your direct, you talked about the fact that you couldn't match your historical data and you consulted Empire's engineers, and they brought to your attention that there are water producing wells, and once you put them in, bingo, you got a match. Do I remember that correctly?

A. Let me think about that. Well, I'm referring -- when did the -- let me look at when the water injection started.

Q. Water production.

A. Prior to 1987, basically what we did is -- okay. There's two different things, the primary history match and then what happened from '87 forward, okay.

Prior to '87, I didn't have any saltwater disposal. I didn't have any water-supply wells. And the only way that I could fit that production was to put the communication that you see here. Okay.

And then after that, basically, the model -- if I just run the model forward, I had for those saltwater -- if I put all the saltwater disposal wells in, I was missing some of the water-supply wells. But that happened after 1987, okay? So I couldn't get a match on the current pressure.

So what I had to do is I had to put in some additional water supply volumes to get things that matched currently, if that makes sense.

Q. Well, then it sounds like I listened to something different. Because I remember what I said earlier on, that you said you have to put in the water wells before -- once you did, that it just did the magic for you.

A. Yeah, it did, but it was after 1987. Does that make sense? I think you could look -- we could actually look at that on a field plot.

Q. Okay. Yeah, I can check into that record, so --

A. We can look at that. We've gotten that on a plot, I think, somewhere. Let me --

Q. There might be direct or yeah, something like that. But let's probably proceed.

A. Two different things.

Q. Okay. I appreciate that clarification. Okay. Definitely we might want to revisit that if there's something that can be shown to establish that. That will clear my mind on that one.

A. I think I can clear your mind on that. If you wait a minute, I can find the plots. Thank you.

And I know you can't see it, but Exhibit M-10 shows when the water-supply well volume started and when the saltwater disposal injection records as well.

MS. HARDY: What is that, Dr. Buchwalter?

THE WITNESS: Exhibit M-10. I know it's really hard to see though. But -- is it M-10? Oh, I've got it mislabeled here. It's M-9. Yeah, it's this plot here. So that -- if you could blow that up and see. I thought it was 1994, but not 100 percent sure. But it was -- I guess you can't blow that up, huh?

A. Anyhow, you can look at this and you'll see.

Q. So, Doctor, when I look at the map that you showed, just checking, I saw that you said the pressure was recorded at 1986, prior to the waterflood.

A. Correct.

Q. So definitely if I look at even the map that you're showing, I saw that the water wells came on stream before you had a measurement.

A. I have to look at that.

THE WITNESS: Can you blow that figure up to where I can see it? I'm just trying to see the scale on it.

A. I know everything fits, I've just gotten -- I just can't remember what the timing looks like.

THE WITNESS: Can you just blow that up? And we'll see when that is. Oh, it's that Exhibit I-5. Let's see what that looks like. I think it's 1994. Oh, it's okay, no problem.

So that plot on the left -- that's the -- it's the other one, actually. Side 5 is higher than that.

A. It's right around that time, isn't it?

Q. Exactly. It's right around that time, but --

A. It's right around that time that we got to the pressure.

Q. So if you go to the bottom one, if you go to the bottom --

A. The injection started in 19- -- the injection started in 1997. 1986 is where the saltwater disposal started.

Q. Yeah. So if you look at the bottom one, you know, you have the bracket where you have 84, or so, to, let's say, 88 or 98. So definitely there was that pressure measurement prior to the -- you know, you have the water wells before you got the measurement.

And, I mean, that is what I've been

listening to throughout the testimony. So it's a little bit different from what you are saying, and even the chart shows that.

A. Well, I know it fit the pressure at that point. Maybe I did have the water-supply wells at that point. You know, it is what it is. But it did match. We did match the pressure at that time it was measured. It was somewhere 3- to 500 pounds in there. I matched that.

Q. Yeah, for sure. But once we are withdrawing from it, we all know that there has to be a pressure reduction in there. So, you know, I'm just trying to see, aside your model, is there any documentation, any reservoir engineering data that confirms the fact that there is some kind of communication? You know, did you do material balance analysis on all the -- is it six, the number of wells?

A. Well, if you think about it, the model is a big material balance, isn't it, where we try to get everything to fit?

Q. I mean --

A. That's what it is.

Q. I mean, with this model, I'm not sure. Honestly, I'm not sure if this model, more or less, meets material balance.

A. Well, it fits -- we fit the historical pressures that we have, which you could say that. We fit the production history. And with that leak, that leak was part of fitting that production history up to date.

And, yeah, it's really quite simple. If you don't, if you concede that the Grayburg does not have a strong edge water drive aquifer, which it can't -- if you think about it, think of it this way, okay, big picture. If the Grayburg just has an edge water drive aquifer, it's a small aquifer, small amount of water underneath the Grayburg. How did we get all that water in those updip wells? You won't, even with the perfs not exactly in there correctly. So the water's got to be coming from the bottom somewhere else. And we're fitting the historical production and pressures.

Is this a perfect model? It's not a perfect model, but it's a very good model for understanding at least on a material balance perspective, what goes on in this reservoir.

Q. So definitely Chevron would have documented that. Because if you're having this problem, I mean, how do you have a successful waterflood after they have been able to flood that reservoir all the way to,

like, 25 percent residual oil?
A. It's a good question. Why did they start this waterflood? But they did.
Q. And it was successful. I mean --
A. Well, it wasn't that successful. If you look at the primary recovery factor versus waterflood, it's not a big difference.
Q. I'm just looking at your relative perm and even the report, you know, prior to waterflood, it was 50 percent average oil saturation. And at the end of the water injection, it was 25. I mean, 25 right there is where we start our CO2 flood. So it's a successful flood.
So that means if there was a communication, they might have solved it. Other than that, I don't know if they were going to get a successful waterflood. And you are the reservoir engineer telling me --
A. Well, think of it this way. That water moving up in this 5 percent of the wells, that -- that -- yeah, that did supplement the waterflood a little bit, didn't it?
But unfortunately, because it's not moving up uniformly, where those injectors are, those areas are producing excessive water. So it's not a

very efficient addition to the waterflood itself.
Q. Then the question becomes what is the volume of the water that was injected during the waterflood, and then what is the volume of the water that was produced. That is material balance and that should tell us straightaway.
A. Yeah, I mean, essentially that's what we do in the simulator, isn't it? We put in the production, we put in -- we basically try to get all these curves to fit, and it becomes a material balance. You're exactly right. It's a complicated material balance because it's two reservoirs that interact with one another. But it is a material balance.
And if you think about it, what this is, it's a sophisticated material balance. I mean, you can say, you know, could have put in more geology, could have increased the permeability -- you know, put a permeability field. I can see that there's a lot of things that we could add to this model.
But if you think in terms of just simple analysis of what's going on here, it's clear that the water is coming up from the bottom. And just think of it as a material balance. And as a material balance, it holds together extremely well.
Q. So, you know, you are saying that is a

simple -- like, a simple problem. But it's not a simple problem. I mean, the Commission has to look at, let's say, the science behind it, the data behind it, at least to help us to make a good decision.

Because, like, let's say you've given us the model, everything is great. But if someone comes in and gives actual production history data, you know, just using the data to tell us whether there's a communication or not a communication, I mean, that is a material balance. So --

A. Yeah, essentially, that's what I've done. But it was 638 wells. You have to put in everything to really see what's going on. This is not a simple problem. It's not as simple as looking at this with a microscope and saying, "Oh, this well's doing this and that well's doing that."

This model was designed to answer a question. It wasn't designed to create a perfect history match, at least a well-by-well history match. It was designed to create a field-wide match and a match of -- actually, a good match of the water moving up from the San Andres in about 100 wells.

If you shut that off, you can see on a well-by-well basis where you can no longer see that water coming up into the San Andres.

Q. If we can go to Exhibit M-1 in the document. I don't know it's still on the slide. So if we can go to M-1, where you are showing the grid.

A. M-1?

Q. Yeah, so probably might be -- yeah, right there, M-1.

A. You just want the picture there?

Q. Yeah, M-1. So on the left, this is more -- the left is the boundary of the model; is that correct?

A. That's only the boundary of the -- it's a boundary of the Grayburg. And in addition, it includes the additional saltwater disposal wells in this area. And on the bottom there, what you're seeing is just a part of the aquifer that is underneath this grid. The grid was actually eventually extended, like, 33 miles to the west to match the San Andres pressures that we've seen in production and leak.

Q. So on this one, I know there was a back and forth. I mean, for the Commission, we are just focusing on the EMSU. I think I heard you saying that there's no way you can get a match for the EMSU without adding all the other units. Is that correct?

A. Yeah, that surprised me, to be honest. I thought -- I thought I could build a simple model here, which is the EMSU. It just didn't fit.

I realized that historically, fluids move back and forth between these leases. Hard to believe. You wouldn't think so, but once you run the model, you see that is actually the fact. In fact --

Q. I thought that we could put a boundary condition in such a way that we have a higher probability right at the boundary to be able to match, let's say, only the EMSU.

A. I thought so, too, and I tried it. You know, what you think and what happens aren't always the same thing in life. I thought so, too.

It really surprised me, because, honestly, I didn't want to build a 638-well model, to be honest. This is the last thing that I wanted to tackle. I mean, if I just had the EMSU, I would have had a model that was a third the size of this, it would run, you know, five times faster, and I could have done this far quicker.

Q. So you do have three layers within the San Andres, and it makes me wonder -- and based on the cross-examination, I got to know that you did not delineate between the upper and then the lower San Andres. Is that still your testimony?

A. Yeah. I mean, this was -- yeah, as I was given, this is the geology I was given, Doctor. And I just put this in.

If it turns out there is a boundary somewhere in the San Andres, then, you know, you can always modify the model. I could increase the porosity a little bit or the net the gross, or whatever, and end up with an equivalent model.

Because at the end of the day we want that aquifer behavior to match what we've seen historically, and that would take some adjustments in the model. But it could be accomplished.

And once again, if you think of this in terms of big material balance, an aquifer has to behave the same way, whether I use this 1100 feet or if I make it thinner. It's just going to have different properties so that from a fluid-flow perspective, it would essentially do what we're seeing here.

Q. So, sir, is it your testimony that numerical dispersion and probably Peclet number, or whatever, is not relevant in this case?

A. I mean, for a model of this size, I wasn't thinking that deep. I was just basically using Darcy's law for fluid flow and just let things flow

and see what happens. That's how I got things to fit.
Q. Is it black oil or compositional?
A. It's just a black oil model here.
Q. It's black oil?
A. So it's, yeah, a three-phase black oil model. We can add a condensate as well.
Q. So is it your testimony that the three layers within the San Andres fully described the geology within the San Andres?
A. Well, I've described the geology I was given. I mean, we can fight about what the geology in San Andres looks like, but what I can tell you is we have a very large, probably 150-plus billion barrel aquifer down there to get things to fit.
Q. And you said that you extended the aquifer for the San Andres. Did you also extend the model domain for the Grayburg and then the top layer?
A. I actually could not do that. And if I go outside of that and I try to extend that, if you look, with that oil-water contact, I don't have too much oil.
Q. Exactly. I mean, that is also a problem for me to understand. Why are we extending the bottom of our model but not extending the other top layers? So is it more like a null cell for the --

A. Yeah, it's null cells that we have out there, essentially, in the matched model. I mean, the model I created later is I tried to extend the aquifer in the Grayburg. But I did it in such a fashion that I didn't increase the oil in place.
Q. If you increase the oil in place, then it is telling you that there is a boundary, there is some kind of a boundary where your reservoir is actually drawing from. But you tried to -- you decided to extend that. You extended the bottom to suit to your situation, right? But what about the top?
A. Well, if you extend the top, you have too much oil.
Q. But that is the reservoir. I mean --
A. Yeah -- well, I'm not saying you -- you can extend the top, but if I extended the oil, the Grayburg laterally, any more than I have, I've got too much oil in the model and I can't fit the pressures.
Q. You see, based on all the testimony that we've listened to, there is an aquifer right at the bottom of the Grayburg.
A. Yes, there is. It's a small aquifer.
Q. So what about if you extended that?
A. That's essentially what I did in one of my models, and I couldn't get it. I got it to fit on a

field-wide basis, but I could not get it to fit the historical water breccias we were seeing in the wells.

Q. I thought your objective was to do field match and not necessarily well-by-well basis, you know, so it's not like: This is what I'm looking for, so I'm just building my model to look for that.

A. Well, what I tried to do -- before you go well by well, when you have 638 wells, you want to look at what's going, in terms of physics, groups of wells in different areas.

And when you do that, you can see that this Grayburg Aquifer has to basically not be big enough to get this all to fit. I mean, we've got a match in the rebuttal that fits the production, but it doesn't fit the fluid behavior that we've seen here.

Q. But, sir, in your so many years of experience, have you seen a model where we -- you know, we kind of have a top layer, but we struck the bottom layer? Have you seen such a model before?

A. I've built models like this. I mean, if you -- let's just pretend the Grayburg is larger. Why aren't there any more wells outside this area?

If you extend the -- if you extend the -- extend the oil, let's say, to the west, you end up with too much oil in the model and you can't history match it.

Q. Yeah. So then I thought that your model has to mimic that boundary. And then even within your bottom, you have that problem you can take care of.

I mean, I don't know why we should extend the bottom without extending the top. And then you just mute all the top? Yeah, that's --

A. Well, there's just -- you know, there's not enough water on the bottom of the Grayburg, so you have to extend it to the west. And that's essentially what I did, extended to the west without adding additional oil volumes so I could get a history match.

Keep in mind, you know, we're talking details. Think big picture. Think in terms of a sophisticated material balance, if you will. And in terms of sophisticated material balance, this fits. I mean, on a field-wide basis, it fits well and fits all the data.

And I also say that Goodnight hasn't constructed their model. If they've got a different interpretation, I'd like to see it. At least I'm fitting things.

Q. Yeah, but this is what is in front of the Commission, and I'm just trying to understand how you set the model in such a way to satisfy, let's say, what you're looking for. You know, what about like -- the Grayburg, do you have direct evidence to prove the size of the aquifer within the Grayburg?

A. The only evidence I have is if I make the aquifer -- if I just say the aquifer is attached to the Grayburg, I can fit the production of oil, water, gas. I can't fit -- you know, if we look from -- currently, there's been more water injected in the San Andres than has been withdrawn, so that pressure should be higher.

We have the fact in 1986, the pressure dropped in the San Andres from original pressure. So we assume that's -- you know, that is from the communication with the Grayburg.

So, yeah, you can look at a lot of different pieces but maybe one piece in and of itself doesn't tell the complete story.

Q. Yeah. So, Doctor, did you have, let's say, pressure data for all the wells, or is it just these one or two points that you use in your model?

A. In San Andres, I didn't have a lot of pressures. In the Grayburg, I basically had a pressure in 1986, prior to waterflooding. I had, like, seven or eight wells I looked at and kind of tuned the model to the current pressures. And there's

several hundred pounds of pressure difference
currently in the model as well.
Q. Yeah, so --
A. So I don't know one point to another.
Q. Sorry. So as you know, in our reservoir engineering, I mean, if you have pressure data for all the production and then, let's say, the injection wells in that area --
A. Fine.
Q. -- those are actual data. You know, but --
A. And that's where I've matched. And that's -- well, I kind of do take a look at the well matches and the overall volumetric hydrocarbon weighted in pressures as well and just try to get that to fit. So kind of get the big picture to fit and then also look at the individual wells as well.
But I'll be honest, I don't have a lot of pressure data here, but certainly enough from a material balance perspective, I think, to create an accurate model.
Q. Can we go to the Goodnight Cross Exhibit 6, where they show the table of the porosity and permeability data? And I promise I will end soon.
A. No rush.
Q. Okay. So the first question I have for you

is, in terms of permeability, is this a homogeneous model or heterogeneous model?

A. It's essentially a homogeneous model.

Q. And from all the testimony that we've heard throughout the whole week, do you believe that the Grayburg Formation and also the San Andres is a homogeneous reservoir?

A. No, obviously it's not a homogeneous reservoir. This permeability, with permeability required to get the mass -- the production and the injection on a field-wide basis, so if anything, it's a little high, right? There's going to be tight areas and probably better -- well, not better areas, because these perms will fit the production and injection on all the wells.

Q. So, sir, why did you not vary the permeabilities, the kz, for, let's say, Zones 5, 6, 7, where we do know that there is some kind of an aquifer in the Grayburg, to see if you could get a match?

A. There's not enough water down there no matter what you do, and this fit -- there's just not enough water anyhow. There's just a small amount of water underneath, in the bottom of the Grayburg, so that's not enough to ever give you a fit.

These vertical permeabilities allow me

to match the gas, and then I guess the water moving up as well and the fluid moving between the different --

Q. So when you say there there's not enough water there, you and I know that this is a water drive. Because once you start producing, water is coming, right? So if it is only quantity water, then we have a strong justification that it is a small amount of water and that water is not going to move.

A. Correct.

Q. But from what we've seen, the water is just moving right from the onset. So why did we not -- why did you not also adjust the permeabilities between the -- within the bottom of the Grayburg to see if you can match those wells that had a problem?

A. Well, think about this. I'm completed in the whole scene, so I'm as close to the water as I can get, right? And I put an aquifer -- I can build an aquifer out to the west. I can match the production and the pressures -- no, I can't match the pressures, but I match the production, but I still have that problem that all the deeper wells in the Grayburg will never match.

So, a lot of those wells are very thin on the western side, and if you put a large aquifer out there, those wells water out no matter what you do. Because, honestly, the water underneath the Grayburg is almost minuscule compared to the 33 billion barrels that you have to put west.

You can't put enough water under the Grayburg to get things to match. You have to put essentially an edge water drive moving, again, from west to east. Or you have to accept the fact that there's a thousand-foot sand -- not sand, but a thousand-foot reservoir underneath there somewhere that's in communication through this limited fracture network.

I'm just saying, you can't get all the pieces to fit. You get some of the pieces to fit, but not all the pieces. So, I mean, you can look at this thing with a microscope and say, well, what if you did this and what if you did that. And I've run all kinds of iterations, but, ultimately, this is the only model that actually fit all the data.

Q. Yeah. So based on the geology, Doctor, did you -- we do have the core data for, let's say, 649 well, or something like that, we do know the number of the well. At the end of your history matching, did you look at the permeability right at that grid block to see how close are you even to the geology of the formation?

A. Well, so when you look at that permeability, that's the permeability of the rock, correct? This does not necessarily include the fractures. So if I look at that, and I did not have that data, but I would assume if I look at that, I would end up with something much slower in the core data than what we actually have to have, due to the fact that we need fractures to enhance the permeability in this reservoir.

Big picture, the permeability would be much higher than what you're seeing in all these cores. I mean, think of this as just a big material balance, okay, a sophisticated material balance. It's not a model that was designed to basically put in 100 layers and history match 600 wells. I mean, literally that would take years.

The purpose of this model was to create -- in your terms, you can think of this as a sophisticated material balance and see how we can get everything to fit. Big picture, okay? Where can the water come from? Can it come from the Grayburg? No, it can't. It's got to be coming from the bottom. Can we have a continuous leak between the Grayburg and the San Andres? No. You'll never fit the data. You're going to have tons of water coming up. It would water everything out, right?

Q. Yeah, so that is what you might expect. Like, let's say if there is a clear communication -- that is why I was saying that. If there is a clear communication, then even waterflood, there's no way waterflood was going to work here. So help the Commission to understand.

A. The waterflood hasn't been very successful. Look at the primary recovery factor and then the waterflood recovery factor; it's not that different.

CHAIR ROZATOS: Can I interrupt just one second? It's 3:45. What time did we need to make sure the doctor is on the road?

THE WITNESS: I don't know how much -- I mean --

CHAIR ROZATOS: Everybody's like this, but we need a time.

A. I would rather answer your question. If I have to fly tomorrow, it's okay. Don't worry. Let's get through this. I want to make sure, you know, we finish our battle back and forth here.

You know, we're like reservoir -- yeah, I wish you had built this model. We could do a comparison of the results.

Q. You know, that's why I was asking, I was talking to our counsel that, you know, for us, we don't have the input data. You know, so I just have to look at what I'm being presented, too, to be able to fully understand what is going on there.

A. I appreciate your problem. You know, the most important thing you could do, and I can't let you understand this, but the most important thing that I did when I built this model history match is not the fact that it fit the data, it's the fact all the things that didn't work.

I mean, all these issues that you bring up, I've actually looked at all these different things. And, you know, when one thing doesn't work, you have to point you to what the right solution is. So just looking at it from 20,000 feet, you're just looking at all the data, there's all kinds of possibilities for what can happen in this reservoir.

And most -- and, really, what brought me finally to the solution was not so much what worked oftentimes, it's what didn't work to point me in the right direction. So, I mean, I know I'm just talking here, but a lot of times that's how you get the history match, is you look at what doesn't work and it points in the other direction. So that's just workflow.

Q. So you talked about the scenarios that you utilized where you saw that the waters -- the wells that were in the flanks were more or less producing a lot of water.

A. Right.

Q. So if you use -- let's say you use oil, so definitely the water was not under control, right?

A. Yeah, it was controlled with the oil, so the water and the gas were predicted.

And, actually, for those 100 wells, I think in our original affidavit, we showed some history matches with oil and water, and they were pretty good. They were actually quite good. And when you put that seal in there, you can see how the water drops in all those wells.

So, yeah, at least in terms -- yes, maybe the completions weren't right, but at least they were fitting the history pretty well with and without the -- with the leak and then seeing how much the water dropped without the leak. So those are some figures in the original affidavit.

You might want to look at those, too, because that was -- the real focus was trying to get the big picture and then try to model the leak. And that was really where the emphasis was. It wasn't trying to put detailed geology in this model.

And yeah, the model is so big that you have to make some assumptions or you're never going to get the answer. So, for example, we put a permeability field in here to allow us to get the production injection out.

And if I was doing this for a client, the next step is I would look at where the model is today, and I'd look at a map of oil per acre. I'd identify an area where it looked like there was potential. And I'd refine the grid in that area. I'd put detailed geology in that area. I'd history match all the wells in that area. Then I'd put the infill well and see what it would do.

Because here's the reality. When I do a consulting study and you give me 20 wells, I figure probably a week, a week and a half to build the model, review the data. And I figure a day, at least a day per well to do a history match. So if I have 20 wells, that's probably, for me, a relatively big project normally. And that might take me four or five weeks.

If I've got 638 wells, I mean, I can history match those wells, but it's going to take me 638 man days. And so, you're going to -- you can't --

this thing is so big that you can't get every little detail in there and hope. You'll never get an answer, because if you try to put every little detail in there, you're never even going to get a history match.

So you have to start big, as I did here, essentially. And then -- and keep in mind, the goal of this model was not to come up with the perfect history match of every individual well.

As you described, you know, you've talked about material balance. That's essentially more or less what we've done here, a very sophisticated material balance. We've integrated geology and everything, but that's really what it is. Because that's the first step. It's a field-wide match, which would be a very sophisticated material balance.

Q. Doctor, so with regards to, let's say, the water coming from the San Andres to the Grayburg, is it your testimony that it has any impact on oil production?

A. That's an interesting question, a very good question. Well, technically, you would think when that water comes up, it's going to enhance your waterflood, right? Common sense, right?

The downside of it, the water is not

coming up. And at these 300 water injectors, it's coming up preferentially in maybe 5 percent of the reservoir. So it's enhancing the production in 5 percent of the reservoir, perhaps.

But also, it's allowing -- it's not efficient, because it's not basically benefiting the waterflood and the other 95 percent of the reservoir. So what happens eventually is you water out that area and just keep making lots and lots of water. So that's the downside of -- because I thought about that, you know, wouldn't this enhance the waterflood, right? It would if it was coming up everywhere, potentially. But it's only coming up in select areas.

So initially, it probably enhances the waterflood a little bit in those areas. But eventually, you end up with this situation where you're just blowing a bunch of water through there. And if you're limited to how much total water you can produce in the reservoir, liquid, then eventually what's going to happen, you won't be able to make the same oil rate, will you? So the oil rate will drop off, because you'll hit the maximum liquid that you can produce.

And so it will detriment, it does have some detriment to the production you would have in this reservoir, unless you could just lift unlimited water.

Q. On the pressure side, if, let's say, the bottom layer right here, we do have, let's say, layer 7 and layer 8, I'm curious to see how the pressure distribution looks like for these two layers.

A. Well, it's really not that different. At least, it's not that different under the reservoir itself. I mean, because I'm injecting all three layers, right, so it's not going to be that much different.

Now, if I just injected it in the top layer, it would require some adjustments in the model, wouldn't it? So I'd maybe have to increase the porosity or something, and maybe extend the aquifer out a little more or something. But, you know, eventually you want it to fit.

I mean, here's the thing that really fascinated me. You know, the most interesting thing, I'd say, I never would have guessed. When you crank up that water injection rate in the saltwater disposal wells, you would think, this is a huge aquifer, isn't it? And so you should be able to put as much water as you want in this thing for as long as you want. It shouldn't hurt anything.

The problem is you're injecting it at these high rates, and all these wells are relatively close together. So literally within the next three years, what the model shows is you build up this -- as I said earlier in my testimony, you build up the pressure in the San Andres under the Grayburg, about 26-, 2700 pounds. At that point, you can't inject any more water. You're essentially injecting about the same amount of water.

And essentially, if you think about it, we've got bottom well pressure-controlled wells in the group, right? So the pressure's staying relatively constant. We're just lifting more water, but the pressure's staying about constant. Does that make sense?

And so the amount of water moving up stays the same. The pressure doesn't increase. And what happens is, from that point on, you can see that pressure wave moving out for the next 30, 40 years. And the pressure under the Grayburg remains almost constant, which is really cool.

It's literally, you know, when you start this thing, there's a -- I forgot what the pressure difference was. I think the pressure dropped 200 pounds at the edge of the aquifer on the far west side. And by the end of it, you can see how this pressure wave just moves out every five or ten years.

And that's something I never would imagine. Because I thought when you crank that pressure -- that rate up, that it wouldn't be so detrimental. I thought it would be a lot more detrimental. It is detrimental in the fact that it increases about 50,000 barrels a day. But once it hits that, it's essentially like a pseudo-steady state. So that kind of describes the physics a little bit, conceptually.

Q. How would you quantify the uncertainty associated with this model?

A. I think from a volume perspective, I think it's very good. From an individual well perspective, obviously it needs lots of work. And as I said, from individual well, the next step would be identifying high areas of potential or finding the grid around there for a client and trying to see what the value is.

I think the fact we're matching -- we've got almost 90 years of data here. As you know, if you have 90 years of data, it's pretty hard to match. And the fact that even though we don't have a lot of pressures, we're matching the pressures at some key points. I think our volumes are right, I think our aquifer is about right, and I think this leak is about right as well.

You know, obviously the one thing we probably could improve in the model is the perfs; I'll concede that. But I don't think that invalidates the model in any way. I think it would improve it a little bit potentially, but it's still going to show the same result.

Q. I heard you said that you adjusted PVT properties.

A. A little bit, I tweaked it a little bit. But keep in mind this is 1938. If I had a PVT lab report, slap me for adjusting the PVT, because that's something you never adjust. Okay.

But they didn't have it in 1938. They had some estimates, I think, of an original gas-oil ratio of 435, and I'm using 375. They had an original B sub O of 1.2, I'm using 1.14, just using that because the beds were just a little bit -- because I've got less gas in solution, it comes down a little bit.

So you have to realize, for a number of years here, there wasn't a whole lot of data. But I also realized that if I started this model where we had good data, I'd have the wrong description of the reservoir, right? So it's literally -- see, you really -- I insist you always go back to time zero, okay? Because unless you're God, you don't know what that reservoir looks like after a few years. You just can't initialize the reservoir properly after that time.

Q. Okay. I'll probably end here.

A. Are you sure?

Q. Yeah, I did have some, but I'll let the other commissioners.

A. I wish we could sit down and look at the model together and run some what-ifs. Because that's really the way to resolve, you know, many of your questions, you know.

I've tried to run all those different scenarios, a lot of different scenarios. I've run almost 500 models now, and this is the one that best fit all the data.

So I'll just leave with you that I think it's a good model. It fits the data. I think the volumes are about right. It's a big material balance. Essentially, it's a very sophisticated material balance. It's something between a material balance and a finite, very detailed model.

COMMISSIONER AMPOMAH: Okay. I'm going to end here. Thank you.

HEARING OFFICER HARWOOD: All right. We skipped our afternoon break in the interest in getting Dr. Buchwalter out of here. But I'm think -- so technically, this is the time for redirect of Dr. Buchwalter.

What's the Commission's preference? It's what, 4 o'clock? Yeah, 4 o'clock. Do you want to take a break or should we push through the last hour?

THE WITNESS: I mean, I can push through. It's up to you. I've been to a marathon already.

HEARING OFFICER HARWOOD: They call it a gauntlet, I think.

CHAIR ROZATOS: It is a gauntlet.

THE WITNESS: Well, I run marathons, so I like the marathon analogy.

CHAIR ROZATOS: Ms. Hardy, how long are you questions, would you say?

MS. HARDY: I don't have much redirect. We might be able to take very quick break.

CHAIR ROZATOS: Yeah, if we --

THE WITNESS: That would be --

CHAIR ROZATOS: -- could get out as soon as we possibly can, that would be awesome.

MS. HARDY: Yeah.

HEARING OFFICER HARWOOD: What's the Commission's preference, Chair Rozatos?

CHAIR ROZATOS: Let's take a five-minute break.

HEARING OFFICER HARWOOD: Five minutes. All right. Be back at 4:05.

(Recess held from 4:00 to 4:06 p.m.)

HEARING OFFICER HARWOOD: All right, Dr. Buchwalter, the final stretch. I know you thought it would never come, but here it is.

Ms. Hardy.

MS. HARDY: And you'll be happy to hear that I do not have any redirect. We're done with Dr. Buchwalter.

HEARING OFFICER HARWOOD: Okay. Call your next witness.

MS. HARDY: May he be excused, please?

HEARING OFFICER HARWOOD: Mr. Rankin.

MR. RANKIN: Yes.

HEARING OFFICER HARWOOD: That was a pregnant pause, if I ever heard one.

OCD?

MR. MOANDER: Yes, he may, Mr. Hearing

Officer.

HEARING OFFICER HARWOOD: Rice.

MR. BECK: He may be excused, yeah.

HEARING OFFICER HARWOOD: All right. Pilot, do you have an hour or more of questioning?

MR. SUAZO: No. He may be excused. Thank you.

HEARING OFFICER HARWOOD: Dr. Buchwalter, thank you very much for your time here today and yesterday.

CHAIR ROZATOS: Thank you, Doctor.

HEARING OFFICER HARWOOD: All right. Mr. Rozatos, I guess at this point we're going to be done, right? We're not going to call another witness today. I mean, it's the end of the week. This has been very interesting, but quite lengthy.

So are you in agreement with that, Ms. Hardy, that we just pick back up when we next reconvene where we left off with Mr. Melzer.

MS. HARDY: Well, I think we were planning to hopefully finish Mr. Melzer. He's here, but I don't know if we can.

HEARING OFFICER HARWOOD: Where were we with Mr. Melzer? Where were we with him?

CHAIR ROZATOS: It was Mr. Rankin.

MR. RANKIN: Yeah, I think we could finish Mr. Melzer with less than half an hour, I think.

HEARING OFFICER HARWOOD: Oh, oh. Okay.

MR. RANKIN: Yeah. I mean, there's just a few things I wanted to follow up with him on that I think we could get him done in half an hour. And I understand that he's here and probably -- although Santa Fe is a wonderful place, I'm not sure he wants to...

HEARING OFFICER HARWOOD: Mr. Rozatos, was that a yes? You're off mic.

CHAIR ROZATOS: Mr. Rankin, you said about a half hour?

MR. RANKIN: I think so. I mean, I'll just explain what I'm planning to do and to propose.

CHAIR ROZATOS: Both counsel are looking at you like: Really?

MR. RANKIN: I know. Do you believe that.

Mr. Melzer introduced in his direct testimony, some production data on the Tall Cotton. And I think, for best evidence, I'd like for the Commission to have all the production from the Texas Railroad Commission. I think that would be helpful for them maybe to understand what the whole production history has been of the Tall Cotton.

Also the Texas Railroad Commission does have filings related to the application to create that field and for the down-spacing that I would like to introduce into evidence, because I think it's necessary to understand the context of that development. I think it'd be helpful. It's a governmental record from your sister agency in Texas. And if Empire believes that I've left something out from those files, they can supplement it with the additional records from the Railroad Commission.

MR. RUBIN: Mr. Hearing Officer, Mr. Rankin, I'm not used to having the best evidence rule apply to what an expert may or may not consider. It doesn't seem to be appropriate here.

MR. RANKIN: Well, I guess Mr. Melzer presented data up to I believe it was 2019. I can't remember what year it was. I can show you on the screen. But he cut off the data for the last six or seven years.

And I think it's important for the Commission to understand the full data history of that.

MR. RUBIN: Sure. No, I understand that. If you want to elicit that, that's the intent.

That does make sense, Mr. Hearing

Officer.

HEARING OFFICER HARWOOD: Okay. All right. I mean, I guess it's more convenient for the witness that that be elicited today rather than at some point in the future.

Is Mr. Melzer here? There you are, sir, I'm sorry. If you'll come back up to the witness stand. Not that you've forgotten the oath, but just for the record, if you'll raise your right hand.

Do you swear and affirm the testimony you give here today will be the truth, the whole truth, but nothing but the truth under penalty of perjury?

All right. And let me just admonish you, in the interest of time --

CHAIR ROZATOS: Mr. Hearing Officer, the "I do" may not have been recorded because his microphone was not on.

THE WITNESS: I do.

HEARING OFFICER HARWOOD: Okay. All right. Thank you, sir.

In the interest of time, and we've allowed witnesses to go on and on because it's in the interest of the Commission to hear everything and get the fullest, biggest picture possible. But now that the sand is running out of this week's hourglass, please listen to the question, answer the question, then wait for the next question. All right? Thank you.

Mr. Rankin.

LORD STEPHEN MELZER,

having first been duly sworn, testified as follows:

CROSS-EXAMINATION (Cont'd)

BY MR. RANKIN:

Q. Mr. Melzer, when we were discussing Tall Cotton the other day, it feels like weeks ago, here it is, okay, so your Exhibit C-10, you show some production history from the Tall Cotton project, correct?

A. Correct.

Q. I'm showing here on your screen, let me know when you can see it, your Exhibit C-10. Is that your exhibit?

A. That is correct.

Q. And on this Exhibit C-10, you're showing the production history from commencement of the ROZ project at Tall Cotton; is that right?

A. That's correct.

Q. But you only show it up through November 2019, correct?

A. Correct.
Q. But the Texas Railroad Commission has the additional production history of this project to present, correct?
A. Correct.
Q. But you did not show that on your exhibit. Why not?
A. The operator was about to sell the property.
Q. Back in 2019?
A. Yeah. He was thinking about it.
Q. Okay. But that production history is still available on the Texas Railroad Commission site, correct?
A. It is.
Q. I'm going to show you -- we pulled this just because we wanted to see. We pulled this from the Texas Railroad Commission and it's a full production history that we were we pulled down from the Texas Railroad Commission. And we just put it on a graph, just marking where, on November 2019, you ended your production history in Exhibit C-10.
Have you reviewed the Texas Railroad Commission's production history for the Tall Cotton project?
A. I have.

Q. Does this graph represent to you your understanding of what the production history has been since the last production represented on your Exhibit C-10?
A. Yes.
MR. RANKIN: Mr. Examiner, I would request that we be permitted to move the admission of this as Goodnight Cross Exhibit Number 9.
HEARING OFFICER HARWOOD: Empire?
MR. PADILLA: Mr. Examiner, we're going to object to this graph. We were never provided a copy of this until now. We have no way of knowing whether it's accurate or not. And so it's simply last-minute surprise kind of thing, so we object to the admission.
HEARING OFFICER HARWOOD: Thank you, Mr. Padilla.
OCD?
MR. MOANDER: OCD doesn't have an opinion on this exhibit. I don't think I've looked at it before, but given the volume here, I couldn't tell you that with certainty.
HEARING OFFICER HARWOOD: Mr. Beck?
MR. BECK: Was it offered into evidence?
HEARING OFFICER HARWOOD: It's being offered

into evidence now.

MR. BECK: I'm unfamiliar with it, so I don't really have a position whether it should be admitted into evidence.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No objection from Pilot.

HEARING OFFICER HARWOOD: Let me ask you, Mr. Rankin, where do the numbers that result in this graph after 2019 come from? Are they from an official government or, you know, are they from a reliable official government record?

MR. RANKIN: They are, Mr. Hearing Officer. These are taken from the Texas Railroad Commission.

HEARING OFFICER HARWOOD: Are they taken from the same source of data as produced the graph leading up to 2019?

MR. RANKIN: May I inquire from Mr. Melzer where he got his data?

HEARING OFFICER HARWOOD: Go ahead.

BY MR. RANKIN:

Q. Mr. Melzer, when you created your Exhibit C-10, where did you get the production data for that graph?

A. From the Texas Railroad Commission, a service company that reports from that.

MR. RANKIN: Same source of data,
Mr. Hearing Officer.
HEARING OFFICER HARWOOD: Okay.
MR. RANKIN: Mr. Hearing Officer, I do think the completeness rule also may apply here.
HEARING OFFICER HARWOOD: I agree. I believe it should be admitted. I mean, if you introduced data up to 2019, if the rest of it is based on the same numbers, then we'll admit this exhibit over objection.
MR. RANKIN: Thank you.
(Admitted: Goodnight Midstream Cross Exhibit Number 9.)
BY MR. RANKIN:
Q. Mr. Melzer, yesterday, during our course of discussion over the Tall Cotton, you and I discussed some of the details around how the project was set up, the spacing, you know, other details. Do you recall that testimony?
A. I do.
Q. But we didn't have any materials or exhibits to really reference, and so it was sort of a discussion in a vacuum. Is that a fair representation of your recollection of that testimony?
A. That's correct.

Q. So, Mr. Melzer, are you familiar with the Texas Railroad Commission, generally?
A. Yes.
Q. And so it's possible to go online and go to the Texas Railroad Commission and identify case files where different cases have been presented to the Commission in Texas?
A. Yes.
Q. And you can pull down documents that are filings for applications creating field rules, such as Tall Cotton?
A. Yes.
Q. Have you done that yourself for the Tall Cotton Field?
A. Not for the Tall Cotton.
Q. Okay. And generally, in addition to the applications for relief, such as for creation of field rules or downspacing, do applicants also present evidence and testimony through the Commission as they do here in New Mexico?
A. I believe so, yes.
Q. And that information is retained in case files as they're presented to the Commission in Texas; Is that right?
A. I'm not as familiar with New Mexico rules,

but I would guess they are pretty similar.

Q. So I guess what I have here, Mr. Melzer, is I have -- we downloaded this file from the Texas Railroad Commission, and it's Kinder Morgan's application for a new field designation to adopt field rules for the proposed Tall Cotton Fields.

And this particular file is 46 pages. And when you look at what it contains, it's the -- and this is the order it was presented. Initially, it's a cover letter with the final order approving of the field rule, creation of a field rule for the Tall Cotton project.

And then it has the examiner's report and recommendation outlining what has been requested for relief. And here, I've highlighted just to make clear that it's Kinder Morgan is seeking a pilot study for hydrocarbon recovery to inject CO2 into a residual zone, San Andres Formation. And it gives some details about what's being requested as well as a discussion of the evidence that was presented, which I've highlighted.

And then some more details about the type of ROZ that was -- type of ROZ field that was described in the application and the evidence.

MR. RUBIN: Mr. Rankin, could you just maybe move your cursor and get rid of that little white box.

MR. RANKIN: I don't know why it's doing that. I can take the blame.

BY MR. RANKIN:

Q. Anyway, I'll just move back up here and you'll see it's the examiner's report, statement of the case identifying what's being requested, the name of the field, the discussion of the evidence from the examiner's report and recommendation to approve the creation of the field, describing what the request is.

CHAIR ROZATOS: Your microphone, Mr. Padilla.

MR. PADILLA: I'm going to object. It's Mr. Rankin testifying about what's contained in this thing. If he asks the witness to tell us what it says, but -- this is just some kind of testimony by Mr. Rankin that isn't appropriate.

HEARING OFFICER HARWOOD: Well, I tend to agree. I mean, what's the point? This appears to be some sort of collateral document. I mean, I understand Mr. Melzer referred to the Tall Cotton, but where are you going with this?

MR. RANKIN: Mr. Hearing Officer, I understand it's a little unconventional. I would like to move the admission. I think it would be helpful for the Commission to understand what was presented to the Texas Rail Commission, what was being proposed by Kinder Morgan, the nature of the project, the spacing, and then the subsequent hearing and request to downspace that acreage.

Mr. Melzer and Mr. Trentham both have identified the Tall Cotton as a very successful project. They represented it as being very successful based on Mr. Melzer's Exhibit C-10 showing the very good production, maxing production up to 3,000 barrels a day.

I just think it's important and fair for the Commission to see at least what's available at its sister agency in terms of what the project was, what the proposal was. And I think it would be useful and important to have it for the Commission's consideration.

HEARING OFFICER HARWOOD: I think it's over the top. It's way too much collateral information. Why can't you establish this point with your witnesses during your case in chief?

MR. RANKIN: I can try.

HEARING OFFICER HARWOOD: All right. Your objection will be upheld, Mr. Padilla. We won't admit this.

MR. RANKIN: Mr. Hearing Officer, I --

HEARING OFFICER HARWOOD: I want to make clear. If you want to question the witness more about, you know, the information, you're welcome to do so. We just need the exhibit in evidence.

MR. RANKIN: I understand.

BY MR. RANKIN:

Q. Mr. Melzer, you recall yesterday that we were discussing -- I asked you whether you were familiar with the economics of the project?

A. Yes, sir.

Q. You said you weren't very familiar with it because it was hard to identify or confirm, correct?

A. Correct. Capital costs.

Q. Yeah. And you yourself haven't done any investigations of what was reported in terms of the proposed costs or actually incurring costs?

A. I know I'm violating the spirit here, but there is some auxiliary information here about why they've done what they've done.

Q. Let me ask you this. In your testimony when you presented this Exhibit C-10, and I think it's exhibit -- let me see if I can find it -- Exhibit C-4 here, you identified the Kinder Morgan Tall Cotton

Phases 1 and 2, you've highlighted them in yellow. Did you do that because you believe that these are analogous projects for purposes of evaluating the EMSU?

A. In several ways. In several ways they're not.

Q. In the way that it's a proposed greenfield ROZ?

A. That would be one analog, yes.

Q. And that they both would be targeting the San Andres?

A. Yes.

MR. RANKIN: Mr. Hearing Officer, I have no further questions at this time of Mr. Melzer. He can be available for cross-examination or redirect.

HEARING OFFICER HARWOOD: Okay. Thank you, Mr. Rankin.

Redirect for Mr. Melzer?

MR. MOANDER: Mr. Hearing Officer, OCD does not have any cross-examination.

HEARING OFFICER HARWOOD: I'm sorry.

MR. MOANDER: It's 4:30 on Friday. So no, nothing from us.

HEARING OFFICER HARWOOD: Rice?

MR. BECK: No questions. Thank you.

HEARING OFFICER HARWOOD: Pilot?

MR. SUAZO: No questions.

HEARING OFFICER HARWOOD: Commission?

CHAIR ROZATOS: No questions for me.

HEARING OFFICER HARWOOD: All right. Dr. Ampomah?

COMMISSIONER AMPOMAH: Well, let me ask Steve about two questions.

EXAMINATION BY THE COMMISSION

BY COMMISSIONER AMPOMAH:

Q. Steve, so if you look at the situation that we have here, the San Andres in the EMSU, that has undergone significant volume of water injection. You know, can you tell the Commission in terms of how, let's say, wettability and all the processes that enable flow and all of that.

You know, how is the successful recovery here going to be? Is it going to be like -- is there any issues that could more or less hinder successful recovery here?

A. There are, yes, sir. Good questions.

The first thing to know is that this was installed in an area adjacent to a long lateral strike slip fault, and on the southwest corner, about half of the area has a whole series of fractures, and they were poorly developing the oil from that area because of the fractures. Then they went in and hydrofracked the injectors and it made it even worse.

And the reason that I terminated this thing is because I went down there to ask them, "Have you considered the fractures that are in that reservoir in the south part?" not knowing that they had 3D seismic.

And they said, "Well, we have. We're going to go ahead with the project as we designed it."

And that was in spite of my objections. You know, I was a consultant. They didn't pay me, but I was down there as a consultant. And it turned out that they really did mess up the reservoir, especially in the south part of the reservoir.

And it was about this time and I was really frustrated because it was such an important test for the residual oil zone greenfields. But, you know, it wasn't my money, so I didn't have any authority, clearly.

And so yes, that was a real issue. And I didn't feel like it was fair to evaluate greenfields on the basis of that mistake they made. And so that was one factor.

The other factor that came into play was they had considered whether or not they were going to sell the flood. It was not a high performing flood because of the costs involved. I knew that. And so that was another factor that really came in later after the hydrofracks that they did.

So I did want to get that on the record because it really does explain the presentation and the exhibit that I put in my testimony.

COMMISSIONER AMPOMAH: Thank you. No further questions.

CHAIR ROZATOS: Mr. Rankin has some questions.

MR. RANKIN: I just have one question.

RECROSS-EXAMINATION

BY MR. RANKIN:

Q. Are you aware of any other fields that are analogous to the EMSU where there is conformance issues across the base of the main pay and the top of the ROZ?

A. Not on the top of the ROZ. But I am familiar with the Maljamar project to just an anecdotal level. It was done by Conoco really early in the phases of CO_2 development, and they did have fracture issues there. And you might remember my exhibit where I was proposing that we might consider this as a vertical flood. And I really think this is a wonderful opportunity for that. Now, there is no analog for that.

There's another project that's being designed currently to drill the horizontals near the base of the ROZ and sweep upwards. And so I'm really excited about that potential. And this would be a wonderful field for it, because I do believe the fractures are there. And we've been debating the fractures and the seals, because if you did have a bad seal, a vertical flood wouldn't work. But because of the tension that was created in the dynamics -- tectonic dynamics of the field generation, there have to be a very large amount of vertical fractures in this field.

MR. RANKIN: Thank you.

HEARING OFFICER HARWOOD: Dr. Ampomah.

EXAMINATION

BY COMMISSIONER AMPOMAH:

Q. Steve, I missed one. So you talked about in one of the fields that you presented, they did whack in the ROZ. Did it work?

A. Yes. Yes, sir.

Q. So, did they produce any oil during the water injection phase?

A. Very little, except that you could argue in the top of the ROZ, there's always some mobile oil. When you hit it with expansion gas, like CO2 does, it does mobilize. And it's a good light oil. It comes out just beautifully.

And that's why those wells were extended in those brownfields, because of that fact, too. So once you get deeper in the ROZ, there's more. I don't like to call it dead oil, but it really does need gas. And that's why CO2 works in the ROZ.

COMMISSIONER AMPOMAH: Thank you.

HEARING OFFICER HARWOOD: Mr. Padilla, redirect?

REDIRECT EXAMINATION

BY MR. PADILLA:

Q. Mr. Melzer, yesterday, Mr. Rankin asked you about two terms. He asked you about technically recoverable and economically recoverable.

A. Yes, sir.

Q. I believe your testimony indicated that you could not comment on economically recoverable as far as the San Andres underlying the EMSU. Correct?

A. Correct.

Q. Now, how about the term technically recoverable? What does that mean?

A. Okay. It's a great comment to make. The resources that are present, like in the residual zone, we know how to estimate those. We oftentimes have reservoir factors that play into the economics of the project because, you know, for instance, the fractures.

And so every field has got different characteristics. We've got great analogs, but always those analogs have some difference in the characteristics of the reservoir that we have to consider, and this one being a great example where it's got the vertical fractures that could allow vertical movement of the CO_2 from bottom to top and create a lot of contact of oil that wouldn't be created if you just drilled vertical wells.

So it's still in the research phase, I got to admit, but on the other hand, this would be the field I would pick to go after that as a concept for a redesign.

And so I'm kind of dancing around your economics question, but you can't -- when it's a resource, you can't say that it's economically recoverable. And really, it's even sort of a PUD, a proved undeveloped resource, in the reserve world that they talk about. So, yeah, it's a difficult question and a more difficult answer.

Q. In the San Andres underlying the EMSU or the other two units, do you believe there's sufficient oil saturation to explore the possibility of doing the technical recovery?

A. Yes sir. I actually feel very strongly about that, because what we have done through our research over the years is we've looked at the residual oil saturation from waterfloods and from situ floods and from Mother Nature's Waterfloods. And ironically, maybe coincidentally, they're all about the same. They range generally from 30 to 40 percent, sometimes a high of 45. And that's from waterflood residual and that's from Mother Nature's residual.

And you could argue the pore flushing volumetrics that we talked about, say, with Dr. Lindsay's presentations, why in the world if you had all that pore flushing would you still have 30 or 35 percent oil saturations.

And the answer is that there's a lot of microbial activity associated with wetting the reservoir, back to the answer I didn't give the doctor. But yeah, 30 to 35 percent is very likely to be the residual saturation all the way down to 100 feet above the bottom of the ROZ.

Q. What do you mean by "microbial activity"?
A. Okay. This is opening up a question that I have got on my website, and I have not published on it. But what happens is -- by the way, the microbes also create dolomite and they will transfer -- do their processes -- these are inherent bacteria in the reservoir, even from back in the days of Pennsylvanian Permian. And what they do is they change the surface of the rock by changing it from limestone to dolomite, and then any oil that's present will then affix to the new surface and make it oil wet, and we have seen this time and again.

And so the microbes have a big huge role to play in the wettability concept that's really not in the literature yet. And so I've been reluctant to do it because it's really difficult to document in a way that science would want it documented. But it looks to me like it's inevitable. If it's in a carbonate reservoir and water moves through it, flushes through it, it will create oil-wet reservoirs.

And it really is the same process when oil gets entrapped initially. When you're moving water out and you're moving oil in, you've got a flow field and those microbes act to partially wet -- well wet the reservoir, which it explains mixed wet characteristics of almost every dolomitic reservoir.

Q. You term the ROZ underlying the M-2 as oil wet?

A. I would, for that reason.

Q. Yesterday, Mr. Rankin asked you about whether you had considered the six water supply wells, the Goodnight saltwater disposal wells, and the Empire water supply wells.

A. Did I examine them?

Q. Yes.

A. I did not.

Q. Do those wells make a difference as far as your conclusion that there is a ROZ underlying where the EMSU is concerned?

A. Well, knowing that they didn't produce oil when they removed that water doesn't surprise me at all. Because once you're 50 feet into the ROZ, it won't produce oil. That's all residual oil that's stuck to the rock.

Q. Now, in terms of going back to the economically recoverable term, what effect does water injection in the volumes that Goodnight is injecting into the EMSU have?

A. On the first point, I don't think it'll move any oil because we can't move that oil without some kind of an EOR method. I do think that it will create a problem with water production and, hence, the economics will be affected.

So it's sort of like exchanging the water that they've introduced by water disposal into a problem with water disposal for the CO2 EOR. And so we might just be swapping operators of the water.

Q. Would that increase the cost of operating the ROZ?

A. No doubt, yes.

MR. PADILLA: That's all the questions I have on redirect.

MR. RANKIN: I think he answered my questions on cross about what he reviewed, what he analyzed with respect to the EMSU. So I don't think I have any further questions for Mr. Melzer. He may be excused.

MR. MOANDER: He may be excused.

MR. BECK: He may be excused.

MR. SUAZO: No objections from Pilot to the excusal.

HEARING OFFICER HARWOOD: Mr. Melzer, thank you for being here yesterday and today. Appreciate your time and your expertise.

All righty. Are we done for the day, folks?

MR. RANKIN: May I raise a housekeeping matter, just about -- I guess we're still waiting for confirmation, I think, on the resumption of the hearing. Is that true? On the dates? Or do we have that?

CHAIR ROZATOS: No, I think we're done.

MR. RANKIN: I have a question then to raise. I think, out of fairness that we have established a basis for submitting any additional evidence and testimony two weeks in advance of the hearing.

And also given our work requirements and obligations for our experts who are going to be providing surrebuttal, I would ask that instead of March 15th, that we have a deadline two weeks in advance of the recommencement of this hearing to submit any additional surrebuttal, instead of March 15th. Two weeks prior to our recommencement.

CHAIR ROZATOS: So that just takes you, what, into just the following week?

MR. RANKIN: I'm sorry, let me just get my calendar. It was April 7th, so it would be two weeks prior. March 24th instead of March 15th, so that would be --

CHAIR ROZATOS: Mr. Moander.

MR. MOANDER: From OCD's perspective, the hearing's been convened. And OCD's not comfortable with yet another round of submittals, of rebuttal this and additional evidence that. If this were, hypothetically, a jury trial, this would be out of the question, I think.

Now, granted, we're in front of the Commission, which is an administrative agency, but again, the hearing is started and this starts to sound like lots of horse changing midstream. OCD is uncomfortable with that.

MR. RANKIN: I'm talking about Buchwalter.

MR. MOANDER: Oh, just the Buchwalter. Oh.

MR. RANKIN: You know, the Commission ruled that we were authorized to submit surrebuttal in response to Mr. Birkhead and Mr. Bailey. And so rather than submitting it on March 15th, I'm just asking that we do it on March 24th.

CHAIR ROZATOS: One second.

So, Mr. Moander, this is for the -- instead of striking all of the --

MR. MOANDER: I misunderstood.

CHAIR ROZATOS: No, it's fine. So are

you --

MR. MOANDER: I'll withdraw that objection because that's already been addressed.

CHAIR ROZATOS: I just wanted to make sure that you were --

MR. MOANDER: I'll confess, the brain is probably a little foggier at this point.

CHAIR ROZATOS: I was going to say a lot of things are just not --

MR. MOANDER: Withdraw, Mr. Chair.

CHAIR ROZATOS: No worries, no worries. The 24th.

Yes, sir.

MR. WEHMEYER: For the part of the Empire, we would object to the move to the March 24th. In the first instance, we disagree that any of the testimony was anything but proper rebuttal. If you look at the witness statements, every single statement is couched in a direct rebuttal to the Goodnight case in chief.

With respect to the idea of a written surrebuttal, I think that the Commission has been incredibly kind with Goodnight on allowing that at all. But with respect to the March 15th date, that allows plenty of time for them to pull that together.

We require time for our part to run that by our witnesses so that we can get the technical input from those gentlemen so that we can participate in an intelligent manner, especially just given that this truly will turn into an endless round of surrebuttals. And I think the Commission was incredibly generous with the March 15th.

We would ask that that date stick so that we have time to run it by our folks to participate meaningfully in the hearing on April 7th.

HEARING OFFICER HARWOOD: Well, I know, I see that March 15th is actually --

CHAIR ROZATOS: A Saturday.

HEARING OFFICER HARWOOD: What if we split the baby on this and give you, till -- if we were to give a Goodnight until March the 20th, a Thursday, would that still give Empire enough time to review the information?

MR. WEHMEYER: Not trying to be difficult. We don't think written surrebuttals at this point is cost effective, is helpful, is in due course.

We respect the Commission's decision. We think March 15th is incredibly generous and is the correct date.

HEARING OFFICER HARWOOD: Well, let's -- I'm going to compromise and we'll give you until Tuesday the 18th.

CHAIR ROZATOS: Well, Mr. Rankin, it's going to have to be good. That's what he said.

MR. RANKIN: Understood. I mean, the whole reason we were granted the right to do this was because they presented new testimony and evidence with only two weeks before the hearing.

CHAIR ROZATOS: I agree, and that's why we granted it.

MR. RANKIN: So we'll take the 18th.

CHAIR ROZATOS: Yeah, that's what we'll do. The 18th it is.

Okay. Everybody. Happy Friday. We will see you April the 7th bright and early. Thank you. Drive safely to your destinations. Have a good weekend.

HEARING OFFICER HARWOOD: Thank you, Madam Court Reporter, for your help throughout the week. And we'll be off the record.

(Proceedings adjourned at 5:00 p.m.)

AFFIRMATION OF COMPLETION OF TRANSCRIPT

I, Kelli Gallegos, DO HEREBY AFFIRM that on February 28, 2025, a hearing of the New Mexico Oil Conservation Commission was taken before me via video conference.

I FURTHER AFFIRM that I did report in stenographic shorthand the proceedings as set forth herein, and the foregoing is a true and correct transcript of the proceedings to the best of my ability.

I FURTHER AFFIRM that I am neither employed by nor related to any of the parties in this matter and that I have no interest in the final disposition of this matter.

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