NEW MEXICO OIL CONSERVATION COMMISSION

COMMISSION HEARING

SANTA FE, NEW MEXICO

Hearing Date APRIL 3, 1985 Time: 9:00 A.M.

NAME	REPRESENTING	LOCATION
B. Chavez	OCD	Aztec
C. GHOLSON	"	"
Dale [illegible]	Amoco	Farmington
Charles Boyce	Amoco	Denver
PAUL OLDAKER	AMOCO	DENVER
W. T. Kellahin	Kellahin & Kellahin	Santa Fe
Dennis McQuillan	EID, Ground Water/Haz. Waste Bur.	Santa Fe
A. R. KENDRICK	4 Corners Gas Prod.	Aztec
Jennifer Pruett	EID, Legal Bureau	Santa Fe
Douglas Earp	EID, GROUND WATER BUR.	
Wayne Wm	Petro-Lewis Corp.	Denver, Co
Paul Doyle	TENNECO	"
Hugh Ingram	Conoco	HOBBS
W. Perry Pearce	Montgomery & Andrews, PA	Santa Fe
Marty Buys	TENNECO OIL	Englewood, CO
Alberto [illegible]	Geoscience Consultants, Ltd	Albuq. NM
Randall T. Hicks	Geoscience Consultants Ltd	" "

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NAME	REPRESENTING	LOCATION
Lori Komatar	Northwest Pipeline	Salt Lake City
John EVANS	BLM	Craig, Colo
Joe Rush	Meridian Oil Inc	Englewood CO.
Greg Kardos	EPNG	Farmington NM
DALE BALLARD	"	" "
Dale Richardson	COB.	Farmington NM
Phil [illegible]	TEXACO Inc	FARMINGTON
[illegible] R. Mary	Texaco Inc	CORTEZ
John Eichelmann	EPNG	Santa Fe
Bob Huber	Bynum	Santa Fe
Chris Shuey	SELF	ALBQ.
Rick Meyerhein	Scientific Lab. Division	Alb.
Masud Zaman	Navajo Tribe	W/Rock, AZ
Ernest L. Padilla	Atty at Law	Santa Fe NM
Stan Zygmunt	Delta H Engr.	Santa Fe NM
Hap Kearn	Mobil	Midland Texas
Scott Hall	Campbell & Black	SF

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NAME	REPRESENTING	LOCATION
Charles Spanberg	Union Texas Petroleum	Farmington, NM
John Calder	ARCO Oil + Gas Co	Denver
GARY D. MILLER	NORTHWEST PIPELINE Co	SALT LAKE City
THOMAS R. SCHULTZ	" " "	" " "
Bill Lording	El Paso Natural	EP
GA Eiffman	NMSU	Las Cruces NM
Ned Dollar	Murtex	Aztec, NM
W. L. O'Meady	Murtex	Amarillo, Tx
C. TERRY Hobbs	Southland Royalty	FARMINGTON, NM
Quincy Cornelius	San Juan County	
Paul L. Rouse	Land Owner	Aztec N.M.
James R Welles	Land owner	AZTEC N.M.
Sue E. Umshler	GULRAM Inc	Albuquerque NM
William F. Carr	Campbell + Black	Santa Fe
Ann Claassen	NMEID Hazardous Waste Section	Santa Fe
Karen Aubrey	Kellahin + Kellahin	Santa Fe
Dave Boyer	NMOCD	Santa Fe

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NAME	REPRESENTING	LOCATION
Michael [illegible]	So Union Expl. Co	Farmington
Savino Perez Jr	Tesoro Petroleum Corp	San Antonio, Tx
Robert Rea	NM Energy R&D Institute	Santa Fe
Johnny M Morgan	YATES PETROLEUM CORP	ARTESIA
Ernie Busch	NMOCD	Aztec

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT
OIL CONSERVATION DIVISION
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO

3 April 1985

COMMISSION HEARING

IN THE MATTER OF:

The hearing called by the Oil Conservation Commission on its own motion to define and vertical and areal extent of aquifers potentially vulnerable to contamination by the surface disposition of water produced in cnjunction with the production of oil and gas in McKinley, Rio Arriba, Sandoval, and San Juan Counties, New Mexico.

CASE 8224

BEFORE: Richard L. Stamets, Chairman
Ed Kelley, Commissioner

TRANSCRIPT OF HEARING

APPEARANCES

For the Oil Conservation Commission:	Charles E. Roybal Attorney at Law Legal Counsel to the Commission Energy and Minerals Dept. Santa Fe, New Mexico 87501
For the Water Study Committee:	Jeff Taylor Attorney at Law Legal Counsel to the Division State Land Office Bldg. Santa Fe, New Mexico 87501

APPEARANCES

For Giant Industries and Meridian Oil, Inc.:	W. Perry Pearce Attorney at Law MONTGOMERY & ANDREWS P. O. Box 2307 Santa Fe, New Mexico 87504-2307
For Tenneco and Four Corners Gas Producers, Inc.:	W. Thomas Kellahin Attorney at Law KELLAHIN & KELLAHIN P. O. Box 2265 Santa Fe, New Mexico 87501
For EID:	Jennifer J. Pruett Attorney at Law P. O. Box 968 Santa Fe, New Mexico 87504-0968
For ARCO, Amoco, Northwest Pipeline and Union Texas:	William F. Carr Attorney at Law CAMPBELL & BLACK P. A. P. O. Box 2208 Santa Fe, New Mexico 87501
For BCO, Inc.:	Ernest L. Padilla Attorney at Law P. O. Box 2523 Santa Fe, New Mexico 87501

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RICHARD F. MEYERHEIN

DAVID BOYER

DOUGLAS EARP

THOMAS R. SCHULTZ

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EXHIBITS

EXHIBITS

MR. STAMETS: The hearing will please come to order.

This is the continuation in Case 8224.

I have been asked this morning by some representatives of the community of Cedar Hill to allow them to make a short statement so they can go home.

Then after that we would like to hear from all those people who are going to witnesses who would oppose the -- any small volume exemption to discharge in the vulnerable area.

With that, then, I would ask that whoever the representative of Cedar Hill is to identify himself and make his short statement.

Oh, by the way, there is no way that we can continue this case tomorrow or Friday because Commissioner Kelley is unavailable on those two days. I'm hopeful that we can get done. We would ask that you play all your 33-1/3 records today on the 78 scale and we'll see if we can finish up.

Identify yourself for the record, please.

MR. PAUL ROUSE: Mr. Chairman, Commissioners, Ladies and Gentlemen.

My name is Paul Rouse. I live in Cedar Hill, New Mexico, which is just north of Aztec, close to the Colorado line.

The question we're raising down here -- I should say at first I'm wearing two hats down here speaking to you today.

I am a member of the Cedar Hill Farm Local and Chairman of the organization. They asked me to bring a petition down for the community asking for consideration with regard to these tanks.

I'm also speaking for myself as a landowner and feeling the time bomb that we have sitting over our heads up there with the position of those tanks and location of them.

I'll read this and make it brief and to the point.

The subject is Brine Water Evaporative Tanks in Cedar Hill, New Mexico.

Amoco Production Company installed two large evaporative water tanks north of Cedar Hill just west of the highway, U. S. 550, for the purpose of disposing of brine water by evaporation.

These tanks were installed without apparent regard for or notice to the community as to their size or purpose.

The southernmost tank was installed with the east side position on a natural arroyo that drains off the mesa into the northeast section of the community and eventually southeast to the Animas River. Both tanks have experienced leakage ever since construction with a formidable amount of leakage. Construction. The north tank, the largest one, now has a torn liner with a formidable amount of leakage.

It is my understanding that these tanks were installed according to State specifications which call for a double liner with a leak detection system to monitor for leaks from the -- of the top liner.

However, no provision was made to monitor leaks from the bottom liner.

On the east side of the tank on the north side Amoco dug a leach pit to contain the leakage flowing out of the pipe on the wet well at ground level, which would place it approximately at the halfway point in the depth of the tank.

The water flows into this catch basin, was disposed of by a leaching process. During the past two weeks an open top fiberglass tank has been installed to catch the leaking brine water. A piece of plastic pipe from the plastic tank to within several feet of the leakage around the metal pipe was intalled. The leaking water has enough pressure to cause it to boil out of the ground next to the metal pipe.

There continues to be a contamination from this leakage. This does not appear to be a satisfactory solution for the problem. There have been additional wells drilled in the area besides the ones surrounding the evaporative tanks that will be producing brine water as a by-product.

It is my understanding that plastic pipelines can be laid from the wells to the tanks over the easiest route. Information garnered from Amoco employees indicated very little, if any, studies have been made on environmental impact on these lines, or that provisions have been made for the safety of the people's land over which these lines would traverse.

In closing I would like to suggest two possible solutions to the problem.

One, the use of injection wells to dispose of these by-products of production. It is a far safer method of disposal.

Two, if evaporative tanks are considered for disposal, selection of sites should meet a very strict set of regulations in order to protect the land, potable waters and the people adjacent to it.

Thank you.

MR. STAMETS: Thank you, Mr. Rouse.

Now I would like to see if there is any additional testimony today from any parties in support of the no small volume exemption.

All of those people who would testify in favor of no exemption in the produced area -- in the vulnerable area should identify themselves now and be prepared to put on their testimony.

MR. ZAMAN: Masud Zaman.

MR. STAMETS: Why don't you come on up to the front, Masud?

MR. PEARCE: Mr. Chairman, while he's moving, if I may I was not in attendance at the first hearing and did not enter an appearance in that matter.

I'd like to do so at this time.

I am W. Perry Pearce, appearing in this matter on behalf of Meridian Oil, Inc., and Giant Industries.

Thank you, sir.

MR. CARR: May it please the Commission, my name is William F. Carr with the law firm Campbell and Black, P. A., of Santa Fe.

I did attend the last hearing. At this time I would like to enter an additional appearance for ARCO Oil and Gas Company.

MR. PADILLA: Mr. Chairman, my name is Ernest L. Padilla. I'd like to enter an appearance today for BCO, Inc.

MS. PRUETT: I'm appearing on behalf of the Environmental Improvement Division of the State. My name is Jennifer Pruett.

DR. EICEMAN: My name is Gary Eiceman. I'm appearing on behalf of New Mexico State University.

STATEMENT BY MR. MASUD ZAMAN:

MR. STAMETS: Mr. Zaman, would you please identify yourself and your residence for the record, please?

MR. ZAMAN: Yes. My name is Masud Zaman. I'm a geohydrologist for the Navajo Tribe located at Window Rock, Arizona.

MR. STAMETS: What is your education and experience in the field of geohydrology?

MR. ZAMAN: Yes, sir. I have a BS in geology with honors, with special courses in water, and then I have a Master's degree in structural geology.

And then I have additional Master level courses from Brooklyn College, New York, in hydrology and foundation engineering.

And then regional trainings I have in well log interpretations and water quality and other stuff.

Right now I am working as a Director with the Water Management of the Navajo Tribe for the last two and a half years.

Before that I was with the U. S. Public Health Service, located at Window Rock, Arizona, and I developed all the ground water resources for that --

for the municipal and domestic water systems throughout the reservation.

MR. STAMETS: Are there any questions about the witness' qualifications?

He is accepted as an expert in the field of geohydrology.

Mr. Zaman, you may proceed to present what evidence you've brought today.

MR. ZAMAN: Here is my exhibit, resume. That's Number One.

I would like to have those maps.

I was also a member of the committee, the study committee on the produced water disposal which was created by this Commission.

MR. STAMETS: Are there copies of your exhibits for the --

MR. ZAMAN: Yes, I have copies. As I go along I will make those copies of the exhibits.

MR. STAMETS: Okay.

MR. ZAMAN: Mr. Chairman, the audience, I did this investigation independently, although I work for the Navajo Tribe, but I am not representing the Navajo Tribe here.

I'm just testifying here as a technical witness myself.

Also, let me make clear, also,

that I used Tribal forms and Tribal equipment to do this investigation in the field but still it's not a Tribal representation.

As the Chair knows, this is a map that is already on the record produced by the committee and I selected the area of investigation within that blue solid, one of the areas that was selected by the Committee, and the area which I selected is right here near the Hogback, which is not correct, and then this area I reproduced and blew-up to the scale of one inch is equal to 50 feet, right here.

So the area of investigation is this area right here, Section 6.

MR. STAMETS: Is that your Exhibit Number Two?

MR. ZAMAN: This is my Exhibit Number Two.

MR. STAMETS: Thank you.

MR. ZAMAN: This area is a floodplain of the San Juan River near Hogback.

The well located here, there are quite a few wells in the floodplain. There are five wells right here in the floodplain but this was the only well which was in operation that day when we did the investigation and I selected that location to conduct the investigation.

Before I submit that Exhibit

Two to the Commission record, I want to submit another resolution I received from the Chapter of that area, which asked the Tribe to do and give some help, provide some help to the local people in that area with all of the oil slicks and oil leakage and other stuff in that area.

Here's the resolution which I named as Zaman Exhibit Number 1-A for the record.

We have some extra copies of these, all exhibits I'm submitting to the Commission for the record. If anybody is interested, he can get those copies from Chris.

When I conducted this investigation I (not understood) quite a few people in there and the first -- I did twice investigation of same area.

The first time I went with my staff of my own department and people from outside, like Chris, also helped me in that investigation and one person from IHS, Indian Health Service, or PHS, Public Health Service, whatever you want to call it. He was a water quality person.

I kept going over there to work on this investigation as we proceeded on and that investigation was done against that Well 6-11, Duncan Oil Field, near Hogback on February 25th, 1985.

The second period of investigation occurred, we evaluated the data from the first investigation. We conducted another investigation on March 18th, 1985, same area, to get some additional data from the area.

In that investigation again Chris was involved but Professor Gary Eiceman from Las Cruces University was also involved in that study and he also picked up some samples and the results he's going to submit by himself, but I picked up my own samples and I'm going to submit as an exhibit later on in the proceeding my own exhibit to the Commission for the record.

As you understand from that resolution from the Chapter I received through the Tribe and they were asking the Tribal help to resolve oil slick problem in that area, we proceeded with this investigation on March 25th, 1985, the first time.

Chris, can you show some slides? Slide Number One.

Okay, this is the slide of the San Juan Basin and it is just simply showing the area where the investigation was conducted. It was approximately right there, left of the Hogback.

And it doesn't show anything else in there except the general area of the San Juan Basin where the site is located.

Next. Okay, as I showed on Exhibit Two right here, this is (not understood). The marks right here on this plate that shows the location of the well and a number of the wells in the area, and this is the well itself and the pump jack. So this picture is showing well location. As mentioned, here is the sign and the well itself and the pump jack.

This picture is showing the well itself, pump jack, plus the produced water pit. The produced water pit and a pipe coming ut from the oil/water separator, which is buried. As the guy from Duncan Oil Company told us in the field when we did this investigation, he told us that oil and gas -- oil and water separator is buried down here, and that the pipe comes from thee into the produced water pit.

And in the produced water pit you can see that this is the produced water right here, and you can see some paraffin on the surface.

All this is the same picture but it's blown up a little bit more to show the pipe and the fluid, that little part right here, which we considered on a 24-hour basis flow as a little over two barrels.

And the same thing again here you can see is the produced water pit.

Okay, here I did some measurement of the sides of the pit. The pit is about 18 by 12 by 4-1/2 feet, and the depth of the water is about 14-1/2 inches.

Also with this investigation here at that time I tried to probe the sides of the pit and I didn't see any liner in there.

Then I tried to probe this, the

bottom of this water and I didn't see any liner except the soil in the base of this water here, and here I can submit the dimensions and the size of the pit, Exhibit Three.

During the course of this investigation I also obtained some data on this well itself and I wrote a letter to the Mineral Department of the Navajo Tribe asking them to provide me the data on the construction and other material on the well itself.

So whatever data I received officially from the Mineral Department of the Navajo Tribe, I'm submitting that as Exhibit Four.

I want the next slide.

Okay, this is the apparatus we used for excavation of the pits in the area. This is a Navajo Tribal backhoe and I used this backhoe for the excavation.

You can see some black staining coming up from the soil. This is the -- that's why I stopped the backhoe over there to look at this black stuff here. It looks to be some black, dark stuff coming out.

So the next picture you will see what that black stuff is coming out over there.

No, that's wrong.

Okay, here again, see, right there is the backhoe and the black stuff, material, here.

Next. Here it's exposed a little bit more and I'm measuring this with a tape and you can see it's about -- from top of the pit to this place, about 3, 3-1/2 foot, and below that 3-1/2 foot (not understood.)

When I used this material, I rubbed this material on my finger, I felt a little bit oily, slippery, and was smelling like gasoline.

Next picture. Same thing. It's again showing the same thing.

MR. STAMETS: Mr. Zaman, I'm not clear on this. Are you digging in the middle of that pit or are you digging near it?

MR. ZAMAN: Outside it.

MR. STAMETS: Outside it.

MR. ZAMAN: Outside the pit.

MR. STAMETS: Okay, thank you.

MR. ZAMAN: These are little tests downstream as I believe that is downstream on the direction of the flow, of the groundwater flow, so we dug this pit and this is the Pit No. 1 at a distance about 40, 45 feet from the produced water pit, and those three pictures I showed you, the two before and this one, is showing you that when we started this digging below the surface, it was showing some black stuff, the black stain was here, underneath.

Here it shows the same black stain was here as was at the water at the bottom of the pit. And on top of the pit you can see some oil stains on the surface right here and right here.

Next. Okay, this is just showing the subsurface stratigraphy of the area and showing that -- the stratigraphy from here to here and there's a change from the material in the previous slides. This contains no dark stained materials, which is part of (not understood.) And here you can see a sandy, gravelly sand, the sand I classified, using the unified classification, I classified that as medium to coarse sand with clays to some gravels with some boulders, occasional boulders, and pebbles.

So this is showing the stratigraphy of the area.

Next. Same thing. Again at the bottom of the pit you can see the water and then black on the water surface.

Okay. Here, this is away from the produced water pit and it's -- I believe it's No. 6, Pit No. 6, and this shows no oil, no black stain in that area and those sands, you can see the color difference between those slides and the slides here.

All of the surface of the water was clean. There's no staining on the surface.

Okay, this is the slide indicating the bottom and how we took a sample from the bottom of the pit, by using the bottle itself to dip into the water so that we do not have any kind of contamination from outside source. So we are just dipping the bottle inside the water to fill it up and we kept until the bottle is filled completely with no air bubble in there, and then we seal it with aluminum foil and the screw on top, screw the cap on the top.

Okay, after we did the investigation on February 25th, I drew up this map indicating the location of those pits along with the produced water pit and the well location itself and this is the Exhibit Number Five.

That is February 25th investigation and after that exhibit, I submit another exhibit, Number Six, and that's the investigation plan and the location of the test pits on March 18th.

Exhibit Seven is the logs of the pits on February 25th and Exhibit Eight is the logs of the pits on March 20 -- March 18.

Okay, this picture, I want to bring your attention back to this picture again. This is showing the terrain and also you may see me standing someplace here indicating the hypothetical direction of the groundwater flow.

You can see three pits from a distance, one here, one here, and I'm giving a direction from this, from the other side of the pit toward the other pit upstream from the produced water pit. That was a hypothetical thinking of mine that the flow of the groundwater is in that direction at that time and which I plotted on a map and which I will submit to the Commission as Exhibit Number Nine.

This is the location of the pits and the water levels, the groundwater levels in those pits after stabilization, when the water is stabilized in those pits.

And this is also indicating the same direction that I took it as a hypothetical over there that the groundwater flow is almost in the same direction I was pointing in that picture in there.

And this pit -- and this map, you can see that the Roman numeral I, or one, TP-4 is the first investigation, indicating the first investigation phase and Roman numeral II with pit number next to it is indicating the investigation after March 18th, 1985, investigation.

Then these contours here, these contours are showing the water levels in those pits. These blocks are showing the location of the pits.

In this one you can see that east of this produced water pit the static water level was aobut 3.5 feet below the ground surface and on the other end, which is the northwestern end of the investigation area, the contour is about 5 feet contours. So the difference of -- difference of -- difference in the elevation of the water table from this point to this point is about 1.5. And, from this -- and the distance from this pit to this pit is about 400 feet, so from here I calculated the gradient of the groundwater in that 400 feet, which came out to 1.5 feet per 400 foot.

And if you convert that to equalize to a mile, then it comes up approximately 19.8 feet per mile, but here I would like to say one thing. That at the terrain I show you, it looks to me, as I witnesses physically in the field, it was almost level, so I presumed it level and I didn't survey this -- this site.

But these are logs that I had most available at that time when I did the investigation. Survey crew, my survey crew was working some other place at that time.

So I presumed the surface elevation constant from this number, this pit right here, on to this pit, on to this pit, this pit, and this pit, constant elevation with a magnitude of 3 to 6 inches in the surface elevation.

That's why you can see some compression here, (not understood) here, and this contour here, but if a proper survey could have been done, possibly this could have been a little bit different picture here.

But the change in the -- change in the gradient may not be different; change should have been the same, that is, the direction of flow is in this direction, north/northwest direction.

My calculated gradient of that

portion of the area was 19.80, as I said before, feet per mile, which after taking the proper survey of the surface area, possibly may come up to the same gradient as Dave Boyer gave in the last hearing, 11.6 per mile, an average gradient of the river along that area.

So I submit this as an Exhibit Nine to the Commission, the small copy, and the calculation of the gradient, Exhibit Ten.

And then I want to bring the attention of the Commission and the audience and I want to submit three bottles of samples as Exhibit Eleven. They are soil samples I picked up from the pit. One sample was picked up on the 18th -- no, on 25th of February, and the other sample was -- other two samples were picked on 18th of March. These bottles.

This is the bottle of sample from February 25th. It was opened in my office almost 100 times by so many people to look what is in there, but still I think I can make my point from that sample I submit to you.

This has been opened only once or twice, so they are in good shape still. That's from February 25th and these are from February 25th and these are from March 18th, and you can open it and smell it a little bit, what kind of tonic we have in there.

And from the day the samples are picked up the day today when I'm submitting these samples here to the Commission for the record, they were in my custody. I never let anybody have a hand on these samples.

Okay, my Exhibit Twelve is the schedule of sampling, how we did the samples, and what kind of analysis were conducted on those samples. This is Exhibit Twelve.

And Exhibit Thirteen are the results of the chemical analysis of those water samples we sent to the State Lab and the Navajo Tribal Utility Authority Lab in Window Rock.

This is an exhibit indicating the organics, metals, the general chemistry, and nitrates.

Now, after making this investigation, it's my opinion that there is some problem, environmental problem, when you stand next to the unlined pit in the flood plain of the San Juan River near Duncan -- in the Duncan Oil Field near Hogback and I would suggest that -- that the no unlined pit should be allowed in the vulnerable radius, anywhere, whether it's on the Tribal land or on the State land, or any place within the vulnerable radius. I suggest no unlined pits.

Anybody have any questions?

MR. STAMETS: Are there any questions of this witness?

MR. KELLAHIN: Mr. Chairman, may we have a few moments to consult with our experts about Mr. Zaman's --

MR. STAMETS: Mr. Shuey had some questions. I'll allow him to ask his while you're consulting.

MR. SHUEY: Mr. Chairman, I can wait for counsel.

MR. STAMETS: Well, let's go ahead.

QUESTIONS BY MR. SHUEY:

Q Mr. Zaman, a couple of questions.

Was this area -- was this area that you conducted your investigation in the vulnerable area as described by the Produced Water Study Committee?

A Yes.

Q Referring to how -- your sampling procedure, did you use a different sampling procedure than the one shown in the slide on March 18th, and if so, would you please describe that?

A Yes. On March -- on February 25th we used gallon bottles and dipped those gallon bottles into the water itself, into the water in the pit itself and filled them up there.

And that was suggested to me by one of the chemists in the lab in Window Rock and those bottles we used, those were called cyclohexine, and I got the advice from the lab people and they gave me the bottles already delivered to them there.

But then I talked to State Lab people, as well as Gary Eiceman, and they told me that the proper procedure will be that small bottles, 40 milliliter bottles should be used, glass bottles should be used for organic sampling, so that's what we did on the 25th, and bottle again on 25th, on 18 March was also carried from the pit itself, kept the bottle inside the water and -- and closed the top within the water itself so that it would not have any air inside.

Q Were those 40 milliliter glass bottles furnished to you by the -- through the State Lab?

A I got those from Gary Eiceman, those three bottles, but he picked up from the State, I believe.

Q Were those the same 40 --

A Millileters.

Q -- milliliter glass bottles that Dave Boyer described during this testimony --

A That's right, they are the same bottles what Dave Boyer described in the last hearing.

Q Okay. Could you, referring to your Exhibit Thirteen, could you briefly summarize some of the results --

A I would like to have a copy.

Q I'll give you a copy. Briefly summarize some of your results for organics and general chemistry and metals and nitrates on February 25th, and explain who conducted those analyses?

A Okay. The top portion of this and the first page of this Exhibit Number Thirteen, indicating the organic analysis and the organic analysis are conducted in the State Lab by Rick Meyerhein, I think, Meyerhein, and it is showing the constituents which they analyzed there, the ethylbenzene, benzene, metaxylene, orthoxylene, paraxylene, phenols, toluene, unidentified, lab detection limit, compounds but not quantified.

And if I start on Example No. 1, 2, 3, 4, and 5 and 6, we can see that ethylbenzene .044 in Sample No. 1; .04 in Sample No. 2; not detected in Sample No. 3, but detected in Sample No. 4, .005 and then not detected in 5 and 6.

Benzene, .0088 in Sample No. 1; .104 in Sample No. 2; .22 in Sample No. 3, detected in Sample No. 4 but no quantity; and Sample No. 5, .021; and Sample No. 6, Metazylene, in Sample No. 1, .4; Sample No. 2, .341; Sample No. 3, .009; Sample No. 4, .170; Sample No. 5, .004; and Sample No. 6, not detected.

Similarly all those compounds you can see in those listings, they are being shown here.

Q And Mr. Zaman, if I may ask you for the sake of brevity, could you just pick out a couple parameters on that date and sum up those and --

A Okay.

Q -- would you, please, if you could, show the audience on Exhibit Nine, the map --

A Yeah, I'll show that. I'll come to that one.

In the general chemistry you can see there are all those five samples have general chemistry there on this.

On this map I plotted some TDS of the general chemistry. TDS means total dissolved solids.

As you can see, the water we picked up from the pipe coming out from the separator pit, the TDS are 1655.5, but the water, the sample we picked out from the produced water pit, the TDS are 1701, which is right here. You can see I put it right here with a pencil mark.

And then in Pit No. 1, which is this one green marked here, showing -- indicating the February 25th date for this testing, and Sample No. 1, the TDS, or total dissolved solids are 1,379.6 and Sample No. -- and Pit No. 2, the Sample No. 2 gives 603, but we didn't have any TDS in this one because we have not enough bottles that day, so I used one bottle to get the TDS of this one which is behind the produced water pit, up, as I can see from this map, it's upstream from the produced water pit and here the TDS are only 234, indicating the good quality water in there, usable good quality water in there.

Q Mr. Zaman, did you label on your Exhibit Nine there some of the pits in green?

A Yes.

Q You did. What did you do that for?

A Okay, these green marks are indicating only that they were done, they were excavated on February 25th, 1985.

MR. SHUEY: Mr. Hearing Officer, I think I might point out that on the -- the copy of Exhibit Nine that the audience has, the TDS numbers are not written in there, only written in on Exhibit Nine.

A Yeah, only written in on this exhibit.

MR. STAMETS: Are we going to have that exhibit?

A Yeah, yes.

MR. STAMETS: Okay, thank you.

Q Could you then briefly summarize some of the organic compounds you detected in the samples you took on March 18th and would you describe where those samples came from and what you tested it?

A Okay, March 18th samples we picked up in those small bottles, 40 milliliter bottles, and I sent those three samples -- I picked up only three samples, but Gary Eiceman picked up that day about 20 samples from those tests, and I sent those three samples down to the lab and which as you can see on the back of -- on the back of this first page, and here you can see in Sample No. 1, which is the produced water pit, you have benzene, you have ethylbenzene detected less than 50; orthoxylene, metaxylene, paraxylene, and toluene.

The other two samples not showing anything. They say not detected, but there are some peaks as shown on those results which are attached to this exhibit here, and you can see they are mentioned down here, 10-to-20 carbon aliphatics at 100-to-500 parts per billion.

Q Mr. Zaman, referring back to the first page, the summary of the analyses for February 25th, I'd ask you to refer to the first column under Sample 1 across from benzene; I'd like you to compare that number to the number that's on the lab sheet, which would be on the back of the second full page, and the -- what's the number on the back of the lab sheet page there for benzene?

A 20-to-40 parts per billion.

Q On the lab sheet label on the front, 85-0165-B.

A No, this is wrong page. All right, let me pull out that here.

Q Second page on the back, right here.

No, we've got them all screwed up.

A Okay, benzene, 88 parts per billion.

Q Is there a discrepancy between that and what's given on the front page in the summary?

A Yeah. Benzene is shown in the (not understood) in parts per billion and benzene is shown here as parts per million.

Q Okay. Mr. Zaman --

A Uh-huh.

Q Will you briefly explain to the audience so that there's no confusion, have people look at the lab sheet, how the lab sheets were numbered, that is, the samples were numbered for the February 25th investigation versus how they are numbered on the summary sheet?

A Okay. The pipe coming out from the separator pit into the produced water pit, we named that in the field as Pit No. 1, and the produced water pit itself we named as Pit No. 2, and the rest of the pits were named as 3, 4, 5, and 6, and so on and so forth.

Here in sampling, so when you say Sample 1 in summary here, it indicates the water from the produced water pipe. The water comes out from the pipe itself from the separator.

Sample No. 2 is indicating the water from the produced water pit itself, and Sample No. 3 is the Pit No. 1 excavated, and Sample No. 4 is the Pit No. 2 excavated, Sample No. 5 is the Pit No. 4 excavated, and Pit No. 6 is Sample No. 3 excavated.

So this is the way we worked out that in the (not understood.)

Q Referring to the documents attached in Exhibit Thirteen, did you receive the organic analyses sheet from the State Lab?

A No, we collected it from them yesterday personally, but we -- yes, we received it.

Q And did you receive the sample forms from the Navajo Tribal Utility Authority?

A Yes, I received those and they are attached here indicating the Navajo Tribe, Navajo Utility Authority.

Each sample has sheets from the State Lab and the Lab, the Navajo Tribal Utility Authority Lab.

Q Just a second. Mr. Zaman, referring to the Exhibit Four, the well records, where did you receive those documents?

A Department, the Mineral Department of the Navajo Tribe.

Q Did you inspect those documents?

A Yes, I did.

Q Did you -- did you inspect -- did you observe in the field around the well any evidence of leakage from the well?

A No, not on the surface visibly, no.

Q Did you conduct any other investigation as to the integrity of the well?

A I tried to contact the Mineral Department and ask them to supply me some data, but this data doesn't show integrity test on the well. It just shows that the well was cemented with 75 sacks of cement from surface to bottom, and that's it.

Q What was the casing of the well according to the document?

A Casing was 7-inch down to 20 feet, which was called the surface casing and the production casing, 4-

1/2 foot to almost 690 feet or 670 feet some place, and then it's producing from the Dakota sandstone and they stopped indicating all those informations here.

Q From your observations of the site, where is the closest oil related facility to the produced water pit that you're investigating?

A The closest is about 600 away from there, 600 feet south, approximatelys, 550 feet south, and there's no closer, other facility close to this well, except the produced water pit itself and the jack pump.

Q And how -- and approximately how far is the San Juan River from the produced water pit and the oil well that you --

A Okay, this side about 300 feet, 350 feet away from the well itself.

Q Would you please describe how the San Juan River channel moves in the area, in your study area to the south?

A As is clear, the San Juan River comes here, there is a bank here on the -- on the southwestern portion, and then it comes back this way, it goes north, and then again comes back this way. So it's curving around and this is the entire -- the flood plain here; would be this ditch, this irrigation ditch right here, would be this ditch and the river. This is the flood plain where we had a problem.

Q I believe that your Exhibit Two refers to a bluff. Could you tell us how --

A Okay, this land is the top of the bluff and there are some of them live here on the top of the bluff, also.

Q Approximately how many feet is the bluff --

A About 80 to 100 feet; 80 to 100 feet.

MR. SHUEY: I have no more questions of the witness.

MR. STAMETS: Are there other questions of this witness?

Mr. Kellahin?

MR. KELLAHIN: Mr. Chairman, we would request a short recess to discuss Mr. Zaman's testimony.

MR. STAMETS: We'll take ten minutes.

(Thereupon a recess was taken.)

MR. STAMETS: Mr. Kellahin, are you prepared?

MR. KELLAHIN: No, sir, but we'll try to go ahead.

EXAMINATION BY MR. KELLAHIN:

Q Mr. Zaman, you'll have to bear with me, sir, we're talking about your field of expertise and not mine.

A Sure.

Q I want to ask some questions, first of all with regards to the selection procedure that you went about in determining that you would make your investigation in this portion of the Duncan Oil Field.

My question, sir, is whether or not you used any selection procedure within the vulnerable area to identify and pick this particular site for your studies?

A The major reason for selectin of this pretty good site was, first of all, I was getting calls from the local people almost every day about these problems, and also I received that resolution from the Chapter itself asking Tribal help to do something for the remedy of that problem in that area. That was one reason.

Secondly, I had pretty good knowledge of the area because when I was with PHS I developed the shallow groundwater in that area quite a bit, near Shiprock and other areas, and I (not understood) to the flood plain and I saw back in the past also those, most of those pits are unlined and I'm not talking about a couple months or a couple days, but I'm talking about a couple of years before I saw those pits when I was with PHS and that was when I notice the problems going on in that area, so that was one reason.

There was another reason that I picked up this site.

Q When we talk about --

A And the third reason, let me finish, and the third reason was there were five wells in the same field but the only one well in operation when I went to the site on February 25th and I said, that would be a good idea, to use the well which is in operation already.

So that was another reason I selected that site.

Q When we talk about the area, are we talking about all of the Duncan Oil Field or just a portion of that field?

A I'm talking about those four sections shown on this map, the wells located in that area. That was the only well in operation that day.

Q How are the oil wells identified on your exhibit? I believe that's Exhibit Number Two, is it?

A Two, yes.

Q How are the oil wells identified?

A First number is the section number and the other number is the well number itself, and the township, ranges are given on the top.

Q Within your particular area of study, would you again identify for us which of the Duncan oil wells that was the focus of your attention?

A Okay. In this flood plain there are between this (not understood) and the river are these five wells.

Q Would you do me a favor, sir, and take my red pen and circle the five wells that you have identified?

A Let me think. These original wells were given (not understood) for the five wells.

Q All right, sir, of those five wells, then, which were the wells that were subject of your investigation?

A The top one, 6-11. The day I went over there on February 25th that was the only well that was in operation that day and I selected that one at random.

Q Did you make an investigation of any gas wells?

A No, sir, I didn't.

Q Within the area of the producing oil well, 6-11, how many pits did you find?

A Only one produced water pit.

Q Based upon your knowledge, Mr. Zaman, is one produced water pit in connection with an oil well representative of oil wells in the vulnerable area?

A I'm not talking about the entire area. I'm just talking about the area I investigated I found the black stuff in the area.

Q Do ou know what type of -- from what formation the oil is produced from the Duncan 6-11 Well?

A Yes, sir, Dakota sandstone.

Q Does that well produce any gas?

A Not of my knowledge. I asked the rep

over there, the Duncan Oil Field representative on the site and he didn't tell me anything except oil.

Q You said the well, Duncan Well 6-11 had its separator buried under the surface of the ground?

A That was also indicated by the representative on the site.

Q What investigation did you make, sir, to determine whether the oil and water were being separated properly by the separator?

A I didn't do anything on that. It was buried, but he showed me by pointing toward that pipe that was coming out from the separator into the disposal pit, and the produced water coming out from that pipe.

Q You said "he". Who ws the person?

A The Duncan Oil Field representative on the site.

Q As a geohydrologist, sir, can you identify for us the possible sources of contamination of the groundwaters from this particular site?

A Right now I can see only one which is coming out from that well.

Q All right, let's list the possible sources of contamination.

One could be from the unlined pit.

A That's right.

Q One could be from the buried separator itself.

A Possible.

Q One could be from leaks in the pipelines connected to the wells.

A But I didn't see any -- any visible signs on the surface alongside the pit on the ground surface.

Q Did you make an investigation to determine the location of any reserve pit for the well?

A I did. Visibly there was nothing I could see over there. I didn't see anything over there.

Q Did you obtain from the operator of the well his opinion as to the location of the reserve pit for that well?

A No. No, I didn't. But I looked around myself and walked through the area. I didn't see anything like it.

Q When was the Duncan 6-11 Well drilled, Mr. Zaman?

A It was in 1975, approximately, I think, in May. If I get that exhibit I can give you an exact date on that one. Oh, here, I got it. I can't see over here but I think, I believe it's in '75, 1975.

Q You said you couldn't find an indication of a reserve pit by a physical inspection of the surface.

Did you attempt to locate that reserve pit by use of the backhoe?

A No.

Q I've forgotten exactly in what context you told us that you discovered in the composition of some of the material a black stained substance or material that smelled like gasoline?

A That's right.

Q Would you tell me again in what context you made that statement?

A I picked up the material. I left on my --

Q I'm sorry.

A Yeah.

Q In what pit?

A Pit No. -- may I have that map? Here, I can show you that.

Okay, I smelled that smell in Pit No. 1, which is Sample No. 3 on your (not understood), and also on Pit No. 2.

Then I did -- this is February 25th, and then I did the same thing on March 18th in Pit No. 1, Pit No. 3, Pit No. 8, and the next critical attention was paid to smell this stuff because it was smelling like pits were smelling at that time and it was exposed.

Q Would you turn now, sir, to your Exhibit Number Nine?

A Yes.

Q You've drawn in certain contour lines on that exhibit, Mr. Zaman.

A That's right.

Q Would you describe for us again upon what basis you have put those contour lines?

A Okay. These are only the water table contours which we took the water table readings after the water was stabilized in those pits, and this took from some place, 30 minutes to maybe 45 minutes.

So then back in those pits we took the readings and then we plotted these.

Q Am I correct in understanding, then, from this contour map you then have projected what you believe to be the down gradient --

A That's right.

Q -- course of the groundwater --

A That's right.

Q -- in this area.

A Presuming surface was flat. I didn't do any surveying.

Q Based upon the exhibit, what is the difference in gradient from one extreme to the other?

A 1.5 feet per 400 foot.

Q I think you've told me that you have not surveyed in the test pits to determine the water table elevation.

A No. Not -- I'm saying we didn't conduct any surface surveying to get the surface elevation, which I'm saying that possibly it looked to me at that time when I did the investigation, the surface was presumed to be flat and maybe minor variation of 3 to 6 inches.

Q You went through awhile ago with Mr. Shuey how the water samples were preserved on February 25th.

A That's right.

Q And then how those samples were preserved on the March 18th samples.

A That's right.

Q Let's start with the first sampling on February 25th, Mr. Zaman. How, for that sampling day, how were the samples for organic contaminants preserved?

A We used gallon jars that day on the advice of one of my -- one of the Tribal chemists who works in the lab, Tribal lab, and they treated the bottles with cyclohexine.

Q What is cyclohexine?

A It's an organic compound to protect any contamination -- to remove any contamination on those bottles.

Q When we turn to Exhibit Number Thirteen --

A Yes.

Q -- and look at the second page --

A Yes.

Q -- that report, then, in handwritten words, says preserved with cyclohexane?

You turned too far, I think, sir.

A Again, these are mixed up -- oh, yeah.

Q Can you tell me what volume of this organic substance was used --

A I think about one --

Q -- in the samples?

A -- milliliter.

Q I'm sorry?

A One milliliter.

Q What would be the effect of the cyclohexine used as a preservative on the organic components in the sample?

A I don't think really any much effect or impact of that cyclohexine on any organic sampling, except it might reduce the contents of the benzene in there so that what I was showing here on your reserves -- on my reserves here, it may be less than what could have been when I collected those in that clean bottle.

Q When we go to the February sampling --

A Uh-huh.

Q -- I believe -- I'm sorry, the March 18th sampling.

A Okay, yes.

Q I believe at this time the samples were taken and cyclohexine was not used as --

A No, not used.

Q -- a preservative.

A Yeah.

Q Is that true?

A That's right.

Q On the March 18th sample, if we look at the second page of Exhibit Number Thirteen --

A Uh-huh.

Q -- and look at the organics and find the second entry under benzene --

A That's right.

Q -- for Sample No. 1 that is the produced water sample out of the separator pipe.

A Out of the pit itself.

Q Out of the pit itself?

A Yeah.

Q All right. The next two samples, then --

A From Pit No. 1 and Pit No. 3.

Q And what does ND mean?

A Not detected in the lab but there are some peaks shown here, the attached paper, you can see they are present but not detected.

Q Mr. Zaman, I'm interested about the use of the cyclohexine as a preservative for an organic sample.

Is that the accepted method of preserving a sample for which you want to test, then, for organic constitutents?

A As I talked to Rick -- I'm sorry, I forgot the last name -- from the State Lab --

Q Do you know the answer of your own knowledge, sir?

A I think this shouldn't make any difference; shouldn't make any difference; should give you some -- something in there.

It's just a preservative of the bottle.

Q Thank you, sir.

MR. STAMETS: Are there other questions of Mr. Zaman?

He may be excused. Thank you.

MR. ZAMAN: Thank you. For the record, all my exhibits are admitted into the record?

MR. STAMETS: Yes. Is there any objection to the introduction of Zaman Exhibits One --

MR. ZAMAN: Through Thirteen.

MR. STAMETS: -- One-A through Thirteen?

The exhibits will be admitted.

Dr. Eiceman, I believe you indicated you intended to testify, is that correct?

DR. EICEMAN: That is correct.

MR. STAMETS: You may take the witness stand.

Oh, no, I don't believe we swore Dr. Zaman as a witness.

MR. ZAMAN: Not Dr. Zaman; it's only Zaman.

MR. STAMETS: Let's have all of those people who expect to be witnesses today stand and be sworn at this time.

(Witnesses sworn, including Mr. Zaman.)

MR. STAMETS: Mr. Zaman, was all of the testimony that you gave and all of the answers that you gave true and correct, to the best of my knowledge?

MR. ZAMAN: To the best of my knowledge they are correct.

MR. STAMETS: Thank you. That ought to take care of that.

MR. ZAMAN: Thank you.

MR. STAMETS: Dr. Eiceman, when you stood awhile ago you indicated that you were here representing New Mexico State University.

It's my understanding that that is not the fact, that you are really here as an individual, but your place of employment is New Mexico State University, is that correct?

DR. EICEMAN: Yes, that's correct.

MR. STAMETS: Are you going to testify from down there or up here?

DR. EICEMAN: Both.

STATEMENT BY DR. GARY A. EICEMAN:

MR. STAMETS: Would you please

state your name, occupation, and place of residence for the record?

DR. EICEMAN: I'm a resident of Las Cruces, New Mexico.

I'm Associate Professor of Chemistry in the Department of Chemistry at New Mexico State University.

MR. STAMETS: I don't believe that you gave your name this time, Dr. Eiceman.

MR. EICEMAN: My name is Gary Allen Eiceman.

MR. STAMETS: And in what areas do you intend to present testimony today?

DR. EICEMAN: As an analytical chemist in the area of determination of organic compunds and complex systems.

MR. STAMETS: And what is your education and experience which qualifies you as an expert in this field?

DR. EICEMAN: I have a Bachelor's of Science degree from Westchester State College in chemistry; a Doctorate in Chemistry from the University of Colorado in Boulder, and a Post-Doctoral Fellowship at the University of Waterloo in Ontario.

MR. STAMETS: Are there any questions about the witness' qualifications?

He is considered qualified.

Dr. Eiceman, you may proceed with whatever testimony you propose to give today.

DR. EICEMAN: Thank you.

Mr. Chairman, Commissioners, Ladies and Gentlemen, I'd like to describe today the results from research conducted at New Mexico State University in my research group through work sponsored by the New Mexico Water Resource Institute.

My intent today is to provide technical information for the Commission and for the audience.

The area of work involves the composition, the chemistry of wastes which are generated during the production of oil and gas. This is a project which has been on-going for two years.

And I'd like to start out very generally and --

MR. STAMETS: Dr. Eiceman --

MR. KELLAHIN: Point of information, Mr. Chairman.

MR. STAMETS: Yes.

MR. KELLAHIN: The subject matter of this case is the possible contamination of groundwater by the use of unlined production and ancillary pits in the San Juan Basin, New Mexico.

For a point of information, we will object to any of Dr. Eiceman's testimony that goes beyond the scope of the hearing and would request that the witness confine his comments directly to those elements within his knowledge that have a direct relationship to the question of this hearing, which is the disposal of produced water into unlined surface pits.

MR. STAMETS: Thanks, Mr. Kellahin, I was just about to direct Dr. Eiceman to confine his remarks to the San Juan Basin and a map of the USA doesn't seem like the place to start.

So if you could confine your remarks to the San Juan Basin proper, we'll appreciate it.

MR. EICEMAN: All right.

Since the intent here is to talk about waste disposal, I'd like to talk first about the composition of the waste which we're looking at getting into the environment. We need to know first of all what the definition of the waste is.

This is a map of northwest New Mexico and there are sites located on this map where samples of water from produced water pits from natural gas production were collected.

You can see there's a site here near Cuba, several sites near Bloomfield, near Aztec, Archuleta and the flood plain here right below Navajo Reservoir, and several sites near Flora Vista.

I'd like to describe the chemistry and composition of samples collected from these pits at each of these sites.

Now, on each pit that we made our field investigations, we found that -- not in each pit but in many pits, we found that rather than simple water in these pits, we found a mixture of an aqueous phase typically covered by a (not understood) up to several inches of an oil or a hydrocarbon phase.

In order to be as thorough and as confident as possible, we collected samples from both an aqueous phase as well as the oil phase.

On the next overhead I show data from chemical analysis. I'm going to ask you to bear with me if I try to describe what these analyses mean. These analyses are taken from gas chromatographic analyses. Gas chromatography and gas chromatography and spectrometry are the primary instruments used in the measurement of organic contaminants in water and this happens to be a tracing from the gas chromatographic analyses from analyses of water collected at the Cuba site.

The way you would read this is that -- is that visble to you all?

The way you would read this is that any time the trace on the chart moves up and moves back down, that represents the presence of an organic compound in the sample.

You can see from this particular analysis then that we have 40 or perhaps as many as 50 different components. These are hydrocarbon components and I'll talk about their identity in a moment.

This was taken from the oil phase or the hydrocarbon phase on the top of the waste pit. This is a sample of the aqueous phase taken from the same pit.

MR. STAMETS: The aqueous phase is the upper chart and the oil phase is the lower chart, is that correct?

DR. EICEMAN: Yes, that's correct.

This is the aqueous phase. This is the chromatographic analysis of the aqueous phase.

This is the chromatographic analysis of the hydrocarbon phase.

Again, these are phases which coexist in the pit, the hydrocarbon on top of the water.

You can see from the tracings that, yes, both the water as well as the hydrocarbon phases contain a large number of organic compounds. Concentrations of these organic compounds I'll show you in a moment.

Let's talk a bit about the identity.

We used the lab spectrometer to identify these compounds and I'd like to take a moment here to introduce an exhibit, if I may, Mr. Chairman.

This is a manuscript entitled

Hazardous Organic Compounds in Liquid Wastes from Disposal Pits for Production of Natural Gas. It's a reprint of an article which has been published in the International Journal of Analytic Chemistry and I'd like to enter it. It contains all the figures and table which I'm presently showing you.

MR. STAMETS: Do you have other copies of that exhibit --

DR. EICEMAN: Yes, I do.

MR. STAMETS: -- for other participants?

DR. EICEMAN: I think they're in my briefcase. May I get them?

MR. STAMETS: Yes. Dr. Eiceman, is this going to be Exhibit Number One?

DR. EICEMAN: Yes.

MR. STAMETS: And what about your overheads, now, are those going to be introduced as exhibits?

DR. EICEMAN: I can submit those at a later date.

MR. STAMETS: I would suggest that before you leave today, that you, at noon, that you go upstairs and utilize our Xerox machine and make copies of these so that they will be available.

DR. EICEMAN: Well, we set about to identify the various components in each of these samples, and you can see --

MR. KELLAHIN: Excuse me, Doctor.

Mr. Chairman, I wonder if before you admit or refer to the Exhibit Number One, counsel may examine the document to determine whether we have any objections to that article he prepared?

We could reserve that point and discuss it later.

In addition, Mr. Chairman, I realize that we're conducting the hearing a little more informally than we might otherwise, but if I understand correctly, Dr. Eiceman is about to describe for us the identity and concentrations of certain organic constituents or compounds that he has from samples taken somewhere in the San Juan Basin.

We believe before this expert can reach conclusions and opinions about the identity and concentrations, a proper foundation must have been laid to show where the samples were taken, under what circumstances, and whether they meet all the acceptable standards used by the geohydrologists and chemical -- chemists, to show that those samples are in fact in a proper state that can be relied upon once analyzed.

MR. STAMETS: Dr. Eiceman, was it your intention at some point to present us with that evidence?

DR. EICEMAN: All that evidence is contained in the experimental section of the manuscript.

MR. STAMETS: I mean the evidence relative to the samples.

DR. EICEMAN: Yes. Descriptions made on the sampling, location of the samples.

MR. STAMETS: And that's included in the --

DR. EICEMAN: In the manuscript under the experimental section.

MR. STAMETS: Where is this?

DR. EICEMAN: Experimental section. Page Six.

Page Six shows the conditions of the instruments, the various parameters used in the analyses for both the select line monitoring as well as the scanning mass spectrometric conditions.

The references are given to the purity and standards used in reference (8), and procedures for volatile analyses are given in reference (9).

The reagents, the standards, the purity, and the location, where they were purchased are given on page seven.

The type of samples collected, the way they were collected, are given on pages seven and pages eight.

On pages eight we have the

locations in township and range for the various pits; a description of the pits.

On page eight we have the procedures for the analyses and on page nine additional details.

MR. STAMETS: Dr. Eiciman, who collected these samples?

DR. EICIMAN: I did.

This, I might mention, this has been published in a peer review journal, which means that it has received the inspection of our peers in the area of trace organic analyses and has been published.

MR. KELLAHIN: Mr. Chairman, there are still some elements essential to lay a proper foundation that we have not addressed.

I believe, Dr. Eiceman, on page eighteen of the report, on Table 1, are we looking at four different samples?

DR. EICEMAN: In Table 1 on page eighteen?

MR. KELLAHIN: Yes, sir.

DR. EICEMAN: Yes, that's the raw mass spectra data taken from the analyses, for the samples collected in Cuba, or what we called Cuba, Archuleta, Bloomfield, Flora Vista 1E(A).

MR. KELLAHIN: Mr. Chairman, it will be necessary to have Dr. Eiceman identify the specific well locations, Cuba, Bloomfield, and Flora Vista, I believe is too vague in order for us to have a proper foundation for the testimony and if he could identify those more site specifically, that will satisfy my problem about that point.

DR. EICEMAN: Mr. Chairman, those locations are given on page eight.

MR. TAYLOR: Mr. Chairman, we'd like to know if we could get the date of collection on the samples.

DR. EICEMAN: I don't have that information available. Sometime during the early summer. I can provide that but not right now.

A SPECTATOR: 1984?

DR. EICEMAN: It was '84, yes.

MR. STAMETS: Mr. Kellahin, we're inclined to let the witness continue his testimony and then allow your concerns and the concerns of others here to be brought out on cross examination, and based on that, we may request additional data and we also then will know what weight to give the testimony.

MR. KELLAHIN: With all due respect to the Chairman, Mr. Stamets, we're not talking about the weight of the evidence. We're talking about laying a proper foundation for the admissibility of the evidence regardless of what its weight is.

We believe it is not our burden to elicit from Dr. Eiceman under cross examination whether or not he's conducted these procedures properly. That is his burden.

I appreciate the fact that he is not appearing with counsel and the Commission is going to great lengths to accommodate parties in this hearing.

But for the record, we will object to his testimony because a proper foundation has not been laid for him to reach any conclusions.

The foundation is that he must testify as to who did the testing, who took the samples, how preserved when taken, where they were, and how they were made available for independent verification.

Page eight of his report does not give site specific data as to well locations. It simply describes a section.

We believe without a proper foundation any further testimony from this witness is inadmissible.

MR. STAMETS: Your objections are duly noted, Mr. Kellahin, and we will allow the witness to proceed and allow you any cross examination at the proper time.

DR. EICEMAN: Well, these are the summary of the identifications of various components found in the aqueous phase of samples collected, as I call them, Cuba, Archuleta, Bloomfield, and Flora Vista.

You can see that these numbers

is that these compounds are present in the non-aqueous phase. They're also present in the aqueous phase.

So as a first approximation you can say that what's in the oil will be found in the water and what's in the water will be found in the oil or hydrocarbon phase.

Those were components identified as volatile components in the samples. That is, those are components that would come off in a gaseous state.

We've also looked at what components may be present in samples as what are called extractables; that is, you take a solvent and you extract the water with the solvent. You then physically separate the invisible solvent from the water isolating the organic solvent and concentrating it, make an analysis of what components move from the water into the organic phase.

This are chromatographic data presented as bar tables for various samples. Again they're cross referenced in the list of figures in the manuscript which I submitted.

You can see that the samples are fairly complex, consisting of compounds between carbon 10 and carbon 32. This is a range of hydrocarbons between carbon 10 and carbon 32.

They're fairly complex mixtures as analytical chemistry would go. This is in the water phase. You can lay the oil phase on top of it. You have similar types of profiles.

The point is that both in the volatiles as well as the extractables these mixtures were fairly complex containing aliphatic as well as cyclic compounds.

In the further analysis we looked at mass spectrometry identification of the extractables, and we found in these samples the non-aqueous phase, anthracene, methylanthracene, biphenyl, methylbiphenyl, -- excuse me, that's naphthelene, methylnaphthelene, biphenyl, methybiphenyl, anthracene, methylanthracene, fluorene, methylfluorene, pyrene, methylpyrene, and benanthracenes, or benzopyrene, and weren't certain about these; however, in the water you find the same, naphthalene, methylnaphthalene, biphenyl, methylbiphenyl, anthracene, methylanthracene, and so forth.

The concentrations of these various compounds as quantified in our laboratory are shown here in Table 2 and we found a concentration of naphthalene, for example, in this sample called Cuba to be at 850 micrograms per liter. That would be 850 parts per million.

In the sample labeled Archuleta, which is right downstream from the Navajo Dam Site, the concentration of naphthalene was 480 parts per billion. You can see that the methylated aromatic hydrocarbons are at much higher concentrations in most cases. Biphenyls there, anthracenes there, fluorenes there, and pyrenes there. Note that they are present in some but not all samples.

We also looked to see if these same compounds would be found in the non-aqueous phase and indeed they were. The concentrations in the non-aqueous phase were normal. This was the non-aqueous phase, as I said, taken from the waste pit. Concentrations are milligrams per kilogram. These are astonishingly high numbers for these types of compounds in environmental systems.

For example, naphthalene, 160 milligrams per kilogram; that's parts per million, not parts per billion.

You can see that we have highs of 4000, over 4000 parts per million of the C2 naphthalenes in the Flora Vista sample. Altogether the sums concentrations of various polycyclic aromatic hydrocarbons can be here as high as 13,000 parts per million in the oil phase.

Well, the conclusion from these studies was that the contents of waste pits, produced water waste pits do contain organic compounds. We now know a little bit about the composition. The composition includes aliphatic as well as aromatic hydrocarbons, including benzene, polycyclic aromatic hydrocarbons.

The question is what is the state of these compounds and we've done a few preliminary studies in this area.

One of our first studies was to try to determine if the organic compounds have a residual or memory in soil, so we went to some waste pits that had been dry. We don't know the history of the waste pits although we do know their identity and the locations, and we analyzed the soil by extracting the solvent and what we found was that in the soil from the waste pits that had been at least dry when we took our samples, the soil contained very comparable type of data, large complex mixtures of hydrocarbons. We've identified polycyclic aromatic hydrocarbons in these and show that in the next table.

This is our procedure blank down here with the test to make sure that you're not contaminating your samples, you do procedure blank.

This is a procedure blank taken from the soil collected from the various pits.

The point is that the organic compounds are staying in the soil. We don't know how long or for what length or what magnitude, but they're there.

That merited further study.

Meanwhile, we qualified the (not understood) in the various soils and the data is shown here. These are parts per billion levels.

The compounds that we've seen before in the waters are also found in the soils, fluorene, anthracene, pyrene.

We then began to ask, well,

what -- if the compounds are in the water, at least they have some residence time in the soil but we don't know how long, how about could the compounds be moving into the environment, which is into the groundwater which now we're getting close to the subject, and I went to waste pits and took samples using a core sampler at depths of surface and one-foot intervals down, and I'm showing here, displaying here, the raw chromatographic data from analysis of a produced water pit in the Jicarilla Apache Reservation and you can see this is the soil near the surface, large complex mixture of hydrocarbons. At one foot intervals down the sample changed slightly but we were convinced from this data that at least the organic compunds did have mobility down to depths of four to five feet.

When Masud Zaman and Chris Shuey told me about the study they were doing in the Duncan Field, we agreed to do a more systematic study than we'd done on the first sampling trip, and we took the waste pit and we put cross-hairs on it and dug pits at 75-foot intervals on the cross-hairs, Pit 1, Pit 2, Pit 3, Pit 4, this is from the March 18th day.

From preliminary observation we found black soil six to eight inches thick at about 4-1/2 to 5 feet here and here, here and here.

MR. STAMETS: Could you identify where here, here, here, and here are?

DR. EICEMAN: Okay. Let me

first of all qualify the location.

The river cuts across the top of this axis, right across Pit 6, came down to the left of Pit 7, and down around. This would be the direction north, moving this direction, that would be north.

MR. STAMETS: This direction, to --

DR. EICEMAN: I'm sorry, the axis from 2 to 7 would be approximately north, not perfectly but approximately.

The Pits 1 and 2 shows contamination of the soil at a depth of 4-1/2 to 5 feet, as did Pits 3 and 4.

Pits 5 and 6 were clean, free of any technical color or odor.

Pit 7 was clean.

We thereupon decided to bisect the angle between these two axes, put out another axis and sample here in an attempt to better identify the fluid. We did this in part because we knew beforehand that Masud Zaman believes that the movement of the plume was in the direction along the axis 8 and 9.

I'd like to show you some chemical analyses now of those samples.

These are the volatile organic compounds found in the produced water. These are chromatograms from the analysis of the produced water. You can see that the produced water contained maybe 20 to 30 different organic compounds.

Benzene would be in this area. Toluene and (not understood) would be in here, so we're looking at the light hydrocarbons and aromatics.

This would be the produced water, the fresh produced water taken from the pipe.

This was the sample of produced water taken from the pit.

You can notice a similarity; however, notice that the higher molecular weight compounds here, in general these could be either lower molecular weight or higher molecular weight. The higher molecular weight compounds are present at higher concentrations in the sample of the waste pit than in the original dripping water from the pipe.

We took a look then at at one of the groundwater samples. This is Pit No. 2, which is 150 feet away from the waste pit along the axis shown previously, and you can see the presence of the same hydrocarbons, or at least a pattern similar to these, in the water from the waste pit. I say similar because this was a (not understood) which is not a means of identification, just a means of detection.

We then began a method of identification using GC/mass spec technology and in the pit water we found benzene and toluene as well as the xylene, the alkalated benzene, and when we looked to the pits which were dug at 75 and 150-foot intervals out, we found pretty much the same compounds but not the same concentrations.

We can see just a trace of benzene here, a bit of toluene here. This -- these are the xylenes, and other aromatic alkalated hydrocarbons. That was from Pit -- I'm sorry, from Pit No. 8, 75 feet from the waste pit.

MR. PADILLA: Mr. Stamets, I wonder if the witness can identify the charts he's talking about.

MR. STAMETS: Yes.

MR. PADILLA: He's going right through them. I'm having a hard time trying to follow him. If I wanted to ask questions, I'm not sure I'd know which one I wanted to ask him -- I know what I'm going to ask him, if I'm going to ask him, but I'm curious to know what the charts are.

MR. STAMETS: We need some sort of identification on these charts, Dr. Eiceman, as you go through them, so that other people can then refer back to them later.

Do these have a number?

DR. EICEMAN: No, not presently.

MR. STAMETS: Pardon?

DR. EICEMAN: Not presently.

MR. STAMETS: We'll take five minutes and let you number them as exhibits, the slides that you have used.

(Thereupon a recess was taken.)

MR. STAMETS: The hearing will please come to order.

Dr. Eiceman, you may proceed.

DR. EICEMAN: Mr. Chairman, the exhibits have been labeled consecutively, Two through Twenty for the projections.

MR. STAMETS: Thank you, and for the record, what was the last one that you were talking about when Mr. Padilla raised his objection?

DR. EICEMAN: Twenty.

MR. STAMETS: That was Twenty?

DR. EICEMAN: Yes.

MR. STAMETS: Okay.

DR. EICEMAN: Well, if we make a comparison, then, between the tracings found for Pit No. 8 in the analyses of the water, with the analyses of the water actually taken from the pit, you can see a very nice overlay between composition of the waste pit waters with the composition of the water collected at 75 feet from this.

MR. STAMETS: I presume the overlay is Twenty or Twenty-One?

DR. EICEMAN: Twenty with Nineteen.

MR. STAMETS: Nineteen, thank you.

DR. EICEMAN: Finally, so we felt that on the basis of analyses and composition of the compounds found in the groundwater on the axis that I've showed Sites 1, 2, 3, 4, 7, and 8 contain compositions similar to the composition in the waste pit compunds found in the groundwater on the actions that I've showed at Sites 1, 2, 3, 4, 7, and 8 contain compositions similar to the composition in the waste pit.

For the volatiles samples from Pits 5 and 6 and 7 contained no detectable contamination.

We then went to the extractables on Overhead 21 here, we went to look at the extractables, that is the components that could be extracted out of the sample, not the volatiles, this is the chromatographic analysis of the extractables from the water in the waste pit and you can see a very complex mixture ranging from C10 to approximately Carbon 40, alkanes perhaps buried underneath this or polycyclic hydrocarbons.

We're still in the process of working with these samples; however what I'd like to direct your attention to is that a sample of the extractables taken from Pit 1, which is 75 feet from the waste pit, shows comparable composition, high in the light weight compounds present and lower concentrations, much lower here. Some of the volatile compounds appear to be at lower concentrations, but it's comparable in complexity.

This is finally a sample of the extractables now taken from Pit 2, which is 150 feet out, and the extractables are largely not detected in that pit, although the volatiles were.

That concludes my comments. Thank you, Mr. Chairman.

MR. STAMETS: Are there questions of the witness?

Mr. Kellahin.

EXAMINATION BY MR. KELLAHIN:

Q Dr. Eiceman, I'd like to discuss with you your proposed Exhibit Number One, which is Hazardous Organic Compounds in Liquid Wastes from Disposal Pits for Production of Natural Gas that you referred to.

And I'm interested in asking you some questions about the samples that you analyzed from the Cuba site, some of which are identified on page eighteen or Table 1.

We seen an entry of four different waste pit studies, one in Cuba, one in Archuleta, one in Bloomfield, and one in Flora Vista.

Directing your attention to the Cuba waste pit site, can you identify for me, sir, what the location is for the well from which the sample was taken from that produced water pit?

A I could provide you with exact numbers and locations within a period of one or two days. I can give you an approximate location verbally today.

Q All right, sir, let's start with the approximate location, then.

A All right. The approximate location of the Cuba pit is a pit on the left side of the road as you're driving outside of Cuba shortly before you enter the Jicarilla Apache Reservation, there is waste pit off to the left and that's about it.

Q All right, sir, can you recall who the operator is of the well?

A I've got slides and photographs of all of those that are in my records at home.

Q You don't recall now, sir, who the operator is of that well?

A No, I don't.

Q Do you recall whether or not that was a gas or an oil well?

A It was a mixed. It seemed to me to be producing both gas and a bit of oil.

Q Can you tell us from what formations that well produced oil and gas?

A No, I can't.

Q Can you tell us what the volumes of produced waters were on a daily basis that were being dumped out of the separator for that well?

A I can, but I'd have to consult the computer outputs from the OCD records.

Q When -- how many samples were taken for the waste pit study at the Cuba site?

A How many samples were taken?

Q Yes, sir.

A There was a sample taken of the water and a sample taken of the hydrocarbon phase on top of it, In addition I took a sample of the nearby soil at the waste pit, so altogether three samples.

Q You personally took those samples yourself, Doctor?

A Yes, I did.

Q Was there anyone with you to witness the sampling?

A My wife was with me.

Q Do you recall whether or not members of the Oil Conservation Division or the Bureau of Land Management or the operator were present for that sampling?

A Not at that sampling.

Q Can you tell me the approximate time that those samples were taken, the date?

A Yes. I would need to check in my personal ledger on my desk back at my office but I can provide you with the time and the date they were taken.

Q Can you today give us the approximate date?

A Very approximately. It was the springtime of '84.

Q When you took these samples, I won't go through with you in detail the sampling techniques, except to ask you, did you take those samples within the standard of acceptable techniques for taking water samples for analysis?

A Yes.

Q Used the proper size vessel?

A There aren't standard -- I can answer that in two ways.

Number one, standards don't exist for sampling soils around waste pits and natural gas production plants themselves.

The answer to your question is there are no standard vessels for those types of analyses.

I did use standard methods that are commonly accepted in the analytical chemistry community, no rubber contact, glass vessels. Under the best conditions no rubber, no plastic, only glass vessels.

So I used the best accepted techniques for those.

Q Did you use any organic preservatives to preserve your organic constituents in the samples?

A No, the samples were stored on ice,

returned to Las Cruces within the day, and analyzed within two days.

And that's true for all of our samples for which I've presented analytical results.

Q Now when we get over into the area of Mr. Zaman's water sampling and his investigations over on the Duncan Oilfield well sites, if I'm correct, I believe that you analyzed for Mr. Zaman three samples from the March 18th study.

A No, that's incorrect.

Let me refer to Figure Number -- if I may, I'll refer to Exhibit Number Seventeen of my records.

This is an approximate drawing of the more precise drawing that Mr. Zaman has shown here and I've actually analyzed a sample of the produced water, a sample of the water which was being contained in the waste pit, and then samples at these locations: 75 feet from the pit on this axis number one; another 75 feet or a total of 150 feet here; and elsewhere shown in that figure.

Q In terms of the analysis of the samples, Mr. Zaman used Exhibit Number Thirteen, which I'll be happy to share with you.

A Yes.

Q On the second page of that exhibit he listed some March 18th samples.

A Yes.

Q There was the produced water sample and then a Sample 2 and a Sample 3. You analyzed those samples for him?

A No, those were analyzed -- I'm not sure. That's not my data.

Q Did you analyze for Mr. Zaman any of his samples from his March 18th study?

A Samples were collected in duplicate nearly simultaneously. When the pits were sampled we collected two samples, one for Mr. Zaman and one for me.

Q When we turn to the February 15th sampling.

A Yes.

Q Did you do any of the analysis on the February 25th samples?

A No, I have not been whatsoever concerned in the collection and analysis of his samples.

Q Dr. Eiceman, I think I'm beginning to understand what you did.

With regards to the March 18th samples --

A Yes, sir.

Q -- Mr. Zaman has shown us the results of three samples on his Exhibit Number Thirteen on the second page.

A Uh-huh.

Q I believe I understood that you had duplicate samples --

A Yes.

Q -- of that water from which to run your own analyses.

A That's correct.

Q Do your analyses agree with the tabulation of analyses that we show on the second page of this exhibit?

A I'm still working on the tabulation of the data. I can say from the first few that the results could be in agreement.

It's necessary to point out that my limited detection in my laboratory for .1 part per billion and the limited detection in the other laboratory, I'm told, were 5 to 8 parts per billion.

So my analyses are a different percentages, I believe.

Q All right, thank you, Doctor.

MR. STAMETS: Chris?

QUESTIONS BY MR. SHUEY:

Q Mr. Eiceman, could I have you put up Exhibit Nineteen or Twenty, either one?

A The --

Q The geographs that show your general -- your mass spec results for the Duncan Oil Field, March 18th calculations.

A Pit water analyses?

Q Yes.

A Is that what you mean? That would be Exhibit Eighteen.

Q Well, I'm referring -- that's Exhibit 18?

A Yes.

Q Well, I'm referring to this particular exhibit and to the other diagrams of this nature that you describe the chemical constituents of the water in the test pits also.

I have a general question. Did you make -- well, let me put it this way.

Would you please describe how you make calculations of numbers based on these peaks and spikes as a general matter?

A All right. The way we treat this data would be to run standards under identical instrumental and procedural conditions, you would obtain similar traces for standards, for example, benzene would show a peak this size, but in our laboratory we would take the area underneath the peak or the peak height from the standard and make what's known as a calibration curve, peak height or peak area versus concentration.

We then compare the peak height from our samples to that calibration curve to arrive at a concentration figure.

Q Did you, prior to this hearing, make or begin to make rough calculations based on that method that you just described?

A Yes, I did. I have a table which I can submit as an exhibit. It would be Exhibit Twenty-two.

Q I believe that you ended on Exhibit Twenty-two, if I'm not mistaken.

A It would be Exhibit Twenty-two and I only have one copy but it shows the raw data collected from my instrument before I made transfer calibration plots and it can be used as a comparison. I have standards for benzene run here and then the numerical values for benzene, toluene, xylene, C3 benzene and C4 benzene.

Q And correct me if -- well, could you please describe how those numbers -- whether those numbers are exact or whether they are within certain ranges, if possible?

A Oh, there's a certain amount of error associated with any mesurement in analytical chemistry. It's just a question of how much error is associated with that measurement.

Q And based on that you could eventually determine the concentrations within a given --

A Yes, --

Q -- confidence.

A That's correct.

Q Okay. Would you be prepared to prepare and submit that data to the Commission and the major parties and to whoever else was interested within a period of time after this hearing?

A Yes, of course.

Q Will you do that?

A Yes.

Q In regard to the produced water samples that are discussed in your paper, which is your Exhibit Number One, and I believe that you, in response to questions by Mr. Kellahin, stated that you could also provide that data, I wondered if -- and he ran off a list of information that that data should contain, such as when the samples were taken, how they were taken, who took them, who analyzed them, and exact location, and I believe you testified that you could provide that information.

Is that still your testimony?

A Yes, and I will.

Q Okay.

A I should say that but -- all but two of those pits were in the San Juan River Basin; two were up on the mesa.

Q I believe your Exhibit -- Exhibit Seventeen, your map, I believe that you -- did you characterize -- well, how did you characterize your map of the study area on March 18th that Mr. Zaman afforded you?

A How did I characterize it?

Q Let me ask you another question. Was that an exact drawing?

A No, it's not an exact drawing. It's meant only to illustrate the approximate locations of the pits and the designation of the pits to refer to my data.

Q Would you refer to it as an illustration?

A Yes, it's better called an illustration.

Q Would you -- would you -- is there another map or drawing that's been admitted as evidence in this hearing that's more exact than that?

A I believe Mr. Masud Zaman's drawing is more exact.

MR. SHUEY: I believe I'm referring to Exhibit Nine of Mr. Zaman's evidence, Mr. Chairman.

Q And to -- and referring to Mr. Zaman's Exhibit Number Thirteen and your discussion with Mr. Kellahin on the March 18th sampling, I want to make sure that the record is clear, did you analyze, you personally, any of Mr. Zaman's samples?

A None of his.

Q Okay. Did -- and when he took his samples, did you take yours at the same time?

A Approximately.

Q One right after the other, perhaps?

A Yes, within minutes.

Q Okay, thank you. No more questions.

MR. STAMETS: Are there other questions of this witness?

Frank?

QUESTIONS BY MR. CHAVEZ:

Q Dr. Eiceman, on Exhibit Number One, Table Two on page twenty, -- I'm sorry, make that Table One on page eighteen, you show that for benzene only three of the four samples in the aqueous phase showed benzene. Is that -- is that what we should interpret from this chart?

A No, I think it's just one, Frank, on page eightee.

Q Yes, only one showed benzene.

A Yes, the Archuleta sample.

Q And page three did not show benzene.

A The three shown here did not, sir, not in the limits of detection. It is not to say benzene wasn't there. It was just not in the accurate limits of detection.

Q Okay. Under the sampling technique that you used, what was the lower limit of detection?

A This was scanning GC/mass spec on estimating my limits of detection there to the -- in the order of 50 manograms (sic) absolute. That would change to probably an abundance volume of maybe 500 here, so if the compound was present and had an abundance value on this chart below 500, I would not have picked it up on the analysis I made.

It could have still been there but I didn't see it.

Q Did you do a benzene -- well, did you do a benzene analysis on the water samples you took from the Duncan Field?

A Yes, I did.

Q Different than in the -- than this analysis?

A Different in date, do you mean?

Q A different type of analysis?

A Yes, I used selected eye monitoring in the GC/mass spec analysis when I did the benzene determinations on the Duncan Field.

Q Okay.

A I think the detection is much better there.

Q Turning to Table 3 on page 21, could we call a non-aqueous phase, could we just all that an oil skin?

A That -- that's a bit of a misnomer because in the -- in the field, when I went out and collected these samples, a lot of the phases on top of these pits were more like paraffins and waxes than what we would traditionally call oil.

So I would prefer to call them non-aqueous hydrocarbon phase. In other words, in one pit, in the Archuleta pit, there was about four inches of yellow wax on top of the pit.

I would be -- I wouldn't be likely to call that oil.

Q Are you familiar enough with the characteristics of the oil produced by these wells to say whether or not that might actually be representative of the oil that came out of the well?

A That particular well, and I'm speaking of the Archuleta Well, is strictly a gas well and the answer to your question is no, I don't know the oil characteristics of the wells in this area.

Q You said that it was -- you said that it was astonishing to find such high amounts in concentrations of these PAHs in a non-aqueous phase.

Actually, if you're looking at crude product, is it really not -- actually not astonishing, but it's rather expected, don't you think?

A No, sir. I don't know. Are you talking about the crude material made in oil production or gas production?

Q Both.

A I'm just not familiar enough with oil production to make a statement on that.

Q Well, if --

A The concentrations of these compounds was present at near .5 of a percent by weight. It's just not something I would expect in the short experience I have. I've only been doing this for three years.

Q Have you ever compared these analyses with analyses of crude oil to see whether or not they might actually be very close to each other and what you were actually looking at was crude oil or crude product?

A It was in the waste pit. I didn't say whether this was oil or gas that was in the waste pit.

Q Did you ever contact the operator or the -- our office, or the Oil Division for the BLM, to provide witnesses for the samples you took (not understood.)

A The only person who accompanied me on these was a fellow out of the Eid Office in Farmington, who helped me collect the Flora Vista samples.

Q Did you contact the operator before you went to collect these samples?

A No.

MR. STAMETS: Ms. Pruett, you had some questions?

MS. PRUETT: Yes.

QUESTIONS BY MS. PRUETT:

Q On your Table 1 you haven't specified the unit but I assume it's the same as the other tables, micrograms per liter?

A No, again it's a problem of calibration of the instruments and in Table 1 on page nineteen, those are raw -- what we would call in the chemistry business, raw abundance values for the mass/spec, and that table was useful only for inter-comparison of the samples, not the absolute quantification.

Q You stated in your testimony that your wife and yourself collected samples every place except Flora Vista and at Flora Vista you and an EID staff member collected these?

A Along with my wife in that case.

Q In your acknowledgements for your paper, you state, "Aid in collection of samples is gratefully acknowledged for the following: Dennis McQuillan, Dave Tomko, and Janet King, all of New Mexico EID."

I would like you to clarify what that involvement was.

A Okay. Dennis McQuillan and I have had discussions during the past years of where waste pits are located and where we should search for waste pits, and he was the individual who directed me to the Flora Vista site. He didn't take me there, just directed me there.

Dave Tomko was the individual actually out on the site with me collecting samples, along with my wife.

And Janet King, I think was one of the heads of the Farmington branch at that time. I asked her permission to have David Tomko accompany me.

Q But for the other sites where operators were not consulted and you collected the samples yourself, EID did not actually --

A No. No.

Q -- was not actually involved in collection of samples.

A That's right.

Q All right. I believe you said that at lunch, or something, you would make copies of the things you --

A Yes.

Q Will you make those available to us?

A Yes.

MR. STAMETS: Are there other questions of this witness?

Mr. Carr.

QUESTIONS BY MR. CARR:

Q Dr. Eiceman, I just have a couple of questions.

I'm having trouble understanding Table No. 1.

I believe you testified that these figures on Table No. 1 are raw abundance values. Is that what you stated?

A Yes, that's correct.

Q And that these should not be used for quantifying the --

A Well, not for exact quantification.

Q They are useful in terms of what?

A They're useful particularly in intercomparison between samples. For example, you note that the samples for Cuba and Archuleta have toluene but I didn't detect toluene in Bloomfield or Flora Vista.

At the bottom of page eighteen a measure from the instruments, which can be used as an approximate quantification. I wouldn't want to stand behind that as an exact quantification, but about 39,000 abundance units were detected for an external benzene standard at a concentration of 14 milligrams per liter.

That gives you a rough measurement of concentration.

Q And these were taken with what kind of an instrument?

A This instrument, the analyses and (not understood) was a Hewlett-Packard 5992 bench top mass spec.

Q And that was not calibrated.

A Roughly calibrated for these analyses.

Q Okay. Now, then you take these figures and somehow come up with concentrations using --

A No.

Q -- those figures?

A No. The figures shown in Tables 2 and 3 were collected using a more quantitative method of operating than mass spectrometry and were selected by monitoring and they are completely separate analyses.

Q So there's no relationship whatsoever between them.

A Not between Table 1 and Tables 2 and 3, except that these are (not understood).

Q Now your Exhibit Number 22, which you gave to Mr. Stamets, I haven't seen that. Would you tell me what that is? It contains certain values and I need to know what those are.

A It was a table of the peak height times full scale values from the raw data from the GC/mass spec analyses of the waste pit sample as well as the test pits in the Duncan Oilfield studies.

Q And this is a table that shows a number of figures or values, is that right?

A Numerical values.

Q And then what --

A Measurements.

Q And then what do you do with these measurements?

A Well, you, first you have a calibration curve and then you read from the calibration curve to get concentrations.

Q So you take that curve and apply these figures --

A Yes.

Q -- and that's how you get concentration.

A Right. Right.

Q All right, and so when you were working from a curve, that curve and the calibrated figures which you received were something that is not depicted in this report, --

A That's correct.

Q -- is that correct?

A Yes, that's right.

Q All right. Now in conducting your sampling did you use any kind of a field blank sample or anything as a probe to check your sampling?

A In -- in our waste pit studies on the soil studies we would collect a sample of soil at a distance of 10 to 15 meters from the waste pit site and use it as a blank.

In the water studies, yes, I did, I remember it clearly now. I used water, tap water from Farmington in those studies and I used that to test the integrity of the transportation process, the storage process, and the analytic process, so, yes, I did.

Q Let me go back to Table 1 again to be sure, you, when you -- or Table 3. In picking these concentrations you had some separate information that you used and you applied the values from Exhibit 22 and that's how you got the concentration.

A On Exhibit 22, this is the Duncan Oilfield study, samples of water taken from the pits on the cross axis that we showed.

On this paper right here, we're talking strictly about produced water collected from sites we showed you here.

These tables right here are for the typical analysis of the samples described in here. These numbers are completely separate and unrelated to the tables.

Q Okay. Now in terms of getting the concentration --

A Yes.

Q -- I'm having a hard time understanding how you arrived at the concentration figures.

A Yes. It's a similar process to calibrating the speed of an automobile. You have a -- you have a scale that tells the speed of the automobile. You have a (not understood). You know where the mark is located, you can tell the speed.

You do the same thing in analytical chemistry. You prepare a calibration curve which tells effectively at a certain peak height the concentration of that component will be so much.

I have a lot of data there but didn't have enough time to work up the concentrations.

Q So this is the raw data that you --

A Yes.

Q -- that you've got.

A Yes, that's correct.

Q And from this raw data could -- can we confirm the concentration figures?

A Confirm them with what, sir?

Q Is there something that we could look at in Exhibit 22 which we could use in confirming the accuracy of the concentration figures?

A In Table --

Q 3.

A Table 3. Confirm in what sense, sir? They're unrelted samples. They're related only in the sense that they both have oil and gas, the ones from Archuleta and Cuba, whereas these others were taken from groundwater.

Q The figures in Exhibit 22, in any way are they used in determining what the concentrations are in Table No. 3?

A Oh, no, they're completely unrelated.

Q All right. Now, in sampling, I might use the wrong term, so I'll say the oil phase and the water phase, to sample the water phase what do you do to assure that that sample is not contaminated if you go through the oil phase to take that sample?

A That's a good question. The -- there are no complete assurances. You can take several precautions in the sampling process to try insure that there's not contamination. The presence of a -- the presence of a suspension, the presence of an emulsion in the water phase can't be avoided and it's germane to the question because it's all in a waste pit.

What we did to try to avoid collecting oil with the water, was to skim oil away from the water, place our vessel down several feet below the surface of the water. Presumably the oil would rise to the surface and we would collect just water.

Q When you were sampling the dry pits --

A Yes.

Q -- you were sampling, I guess, at one foot intervals --

A Yes.

Q -- as you went down, did you individually do those samples?

A Yes, I did.

Q Now Mr. Kellahin has raised a question concerning informatin on the various pits that were sampled.

A Yes.

Q When you, and I understand you're going to provide some additional information on these pits.

A Yes, sir.

Q Would you please identify for us the type of pit tha you're talking about?

A All right.

Q I mean we've talked gas plants, about compressor stations, about produced water pits, things like that, if you could identify generally the kind of pits as well as the location, and also identify the operator or anyone who was present at the time you took the samples?

A Yes. If I may show one view graph here that talks about the nature of the pits and the type of pit involved.

any relation?

A I would say that the samples that have oil droplets on them usually do have higher levels of benzene than the other aromatics.

We have also seen samples with no observable oil phase that have had high levels of benzene that were collected a long distance, or relatively long distance from the source itself, where the benzene migrated dissolved in the water and the other hydrocarbons stayed behind.

Q So as far as you, in your experience there's no, necessarily, relationship between high levels of benzene and any dual phase in the sample tested.

A No. I think the closer to a source you are the more likely you are to find higher levels of benzene and the more likely you are to find an organic phase.

MR. TAYLOR: May I take just a minute, Mr. Chairman?

MR. STAMETS: Briefly.

Q Let's see, I asked you about levels of benzene found in groundwater, and I'd like you to tell us what levels of benzene you've found in groundwater that's not associated with produced water.

MR. PEARCE: Mr. Chairman, could I ask counsel to rephrase that question. I don't understand what he's asking.

A I don't either.

MR. PEARCE: The witness may

but I'd like to hear it again.

MR. STAMETS: Sounds like a good idea.

Incidentally, for everybody here, it certainly looks like we'd have a hard time getting finished with this case today.

If that proves to be the situation, the continuance dates would be April the 22nd and 23rd.

Q Mr. Meyerhein, have you seen high levels of benzene in -- in waters you've tested without an oil phase, such as those related to a gasoline contamination?

A Yes. There have been samples where there is no observable organic phase where there have been high levels of benzene present.

Near Pruet (sic) was a case where we've seen high levels of benzene with no organic phase at all.

MR. TAYLOR: That's all the questions I have for Mr. Meyerhein.

MR. STAMETS: Are there any questions of this witness?

Mr. Kellahin.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Meyerhein, would you tell me again, sir, what it is that you do?

A My job responsibilities?

Q Yes, sir. Who you are employed by.

A The State Scientific Laboratory Division. It is the laboratory for the Health and Environment Department.

Q And you analyze water samples.

A I analyze water, blood, tissue, all sorts of samples for various organic compounds.

Q If I brought you a water sample in which had been introduced an unknown quantity and concentration of cyclohexane, is it within EPA standards or acceptable practice to then analyze tha sample for purgable organic constituents?

A I don't think that EPA has a standard for cyclohexane contamination of samples.

I think that the sample could be analyzed and then the remarks would have to be made that it did contain a preservative, cyclohexane, and that would have to be decided what effect that would have on the results of the analysis.

Q Explain to us what is the difficulty of preserving a water sample with the cyclohexane.

A In the cases that I think you're talking about, I think that the bottle was rinsed out with cyclohexane. I don't think they really added it as a preservative as such.

The problem with having cyclohexane in

there is that it would be an organic compound. It would not dissolve in the water and then you would get a distribution of the benzene or whatever you are looking for between the cyclohexane layer and the water layer. The benzene would tend to concentrate in the cyclohexane rather than remaining in the water.

Q Let me show you, sir, what has been introduced as Mr. Zaman's Exhibit Number Thirteen, and show you the second page of that, which is a laboratory form and on it is noted "preserved with cyclohexane".

A Yes, sir.

Q Can you draw any conclusion from that notation with regards to that report?

A Well, when we saw the notation on the sample we called and asked and it was explained to us that the sample bottles were rinsed with cyclohexane.

In most of these samples there was no observable organic phase present, in which case it would have very little effect, if any, on the results of the analysis.

If there was a separate phase, if there was enough cyclohexane in the sample to create a second phase, then it would greatly reduce the amount of benzene and other organics in the water.

Q What is the EPA procedure in collecting water samples to be analyzed for volatile organics? What is the process for preparing the bottle and preserving the sample?

A The EPA procedure, which is the procedure that we follow, involves washing the bottles well with soap and water, rinsing them, distilled water rinsing, heating the bottles in an oven at about 140 degrees, and then sealing the bottles or capping the bottles with a Teflon seal towards the inside of the bottle in preparation for collecting a sample.

When the sample is collected, the bottle should be completely filled with no air space above the water.

The sample should be kept cool at about 4 degrees Centigrade until analysis.

Q Do EPA procedures provide for the sampler to rinse his sample bottle with cyclohexane when he wants that water sample tested for those volatile organic constituents?

A No, although it's not uncommon to -- the particular bottles you're referring to were not the regular purgable sample bottle containers recommended by EPA. These were gallon bottles and in a case where these bottles have been used for something else, it's not unreasonable to rinse that bottle with an organic solvent to make sure that any contamination was rinsed out of the bottle.

It should have been dried after that point. Cyclohexane should not have been left in the bottle.

Q But the process used for those February 25th samples that we're talking about from Mr. Zaman, those were conducted in a way that isn't in compliance with EPA procedures.

A Yes.

MR. STAMETS: Other questions of this witness?

Mr. Pearce.

CROSS EXAMINATION

BY MR. PEARCE:

Q Mr. Meyerhein perhaps it was my lunch, but I want to go back and try to understand your testimony for Mr. Taylor a few moments ago.

You were testifying generally about expected benzene levels in samples which you had seen from various areas in the state, as I understood it. Is that what you understood?

A I think what he was asking me was have we seen benzene in samples which were not contaminated with an oil phase.

Q And your answer to that was?

A We have.

Q Okay. As part of your work related responsibilities, other than receiving various samples, soil, water, tissue, whatever, if you find a particular constituent in any of those samples, you do not know the source of that constituent, do you?

A No, sir, we don't.

Q You're not in on the testing or sampling.

A No, sir.

Q Fine. Thank you, sir.

MR. STAMETS: Are there other questions of this witness?

Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Mr. Meyerhein, just one quick question.

You just testified in response to a question by Mr. Kellahin that benzene would concentrate in the cyclohexane and not in the water, is that correct?

A Well, it would go both places but benzene is more soluble in cyclohexane than it is in water.

Q I see. And you -- and did you also testify that it was not unreasonable to rinse a bottle in cyclohexane or a solvent like that to get rid of any impurities that may still be in the bottle?

A Yes. We -- we do that with bottles that we use in the lab, which are going to be used for collecting larger volume samples.

We do solvent rinse the bottles to make sure that anything that may have been in there in an organic nature would be rinsed out of the bottle before a sample is collected.

Q And then you dry them after that?

A You dry them after that to make sure that the solvent is gone.

Q In regards to the February 25th samples reported by Mr. Zaman in his Exhibit Thirteen, alluded to by Mr. Kellahin, would the presence of cyclohexane have affected the organic constituent concentration that your laboratory reported, and if so, how?

A If there was sufficient cyclohexane to make a two phase system, in other words a layer of cyclohexane on top of the water, then the organics that were in the water would tend to concentrate in the cyclohexane, making the amount in the water lower.

So the results that we would have reported would be -- would have been lower than they initially were.

Q Okay. Thank you.

MR. STAMETS: Are there other questions of this witness?

You may be excused.

MR. TAYLOR: I'd like to now call David Boyer.

DAVID BOYER,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. TAYLOR:

MR. STAMETS: As they always did on Perry Mason, I'd like to remind you that you are still sworn and under oath.

MR. TAYLOR: Is he also still an expert?

MR. STAMETS: That's correct.

Q First, Mr. Boyer, while I prepare these exhibits, do you have some corrections or clarifications to the record of February?

A Yes, Mr. Taylor.

I'd like to -- I've reviewed the record that was prepared as a result of the Februaray 20th hearing and on page 82 there is the word "flume", F-L-U-M-E, repeated several times and it should be "plume", P-L-U-M-E.

And the second is a clarification on page 92 and at the top of page 93.

During that time I talked about the proposed leaky underground storage tank program proposed by EPA and I gave the impression that these tanks would be regulated under such a program, and based on my research since that date, I do not believe that they will be covered under any such program, and the State has prepared a letter which is going to, hopefully, clarify that and that will be sent to EPA.

I will just mention that under Section

9001 of the regular amendments that were passed recently, I guess last October, the term "underground storage tank" does not include any "storm water or waste water collection system", that's 9001-1F, "or liquid trap or associated gathering lines directly related to oil or gas production and gathering operations." That's Section 9001-1H.

And based on my reading of those two sections, these tanks would not be covered under any proposed leaky underground storage program.

Of course, that final determination will be made by EPA but we are notifying them that this is our reading of the Act.

And those are the two corrections to the record that I have.

Q Thank you. Now on to the exhibits that we introduced during the last hearing.

Do you have any clarifications as to the exhibits already introduced, or corrections to those exhibits?

A Well, I have some -- I passed out as a request of a number of the attorneys here present last -- on February 20th, they requested a certain amount of information be provided, and I also, I'd like to amend that and get that into the record. Then I want to discuss some -- some clarifications to the existing exhibits.

Q Okay, do you want to --

A I'll just go through those and talk about what's there.

Okay.

Q Off the record just a second.

A Okay. During my testimony I referred to a number of references, Davis and DeWiest, Freeze and Cherry, textbooks, articles, and so on and so forth.

I did not provide a list of references. I am providing a list of references at this time, and by the way, I have copies of everything floating around over there by Shell (sic) and you're welcome to get copies of everything as it -- either now or at the end of the day.

The second thing that was requested to be entered was the <u>EID Sampling of Community Water Supplies</u> and that information was also mailed out to a number of the people and the attorneys involved.

I would like to make a clarification on what was mailed out. There was a page left out on the mail-out, which was the last page, and that discusses some re-sampling that was done because of some problems with a possible contamination.

And the second thing that was -- that needs clarification was that if you'll look at the results of that table, it shows concentrations in milligrams per liter and it's actually micrograms per liter.

This -- this is the only, no -- this is the only copy I have from the Environmental Improvement Division that list these sampling results and they have not provided any updated copy or I don't know -- I don't think there is any updated copy.

So I've just made some notes on here indicating that it is in micrograms per liter.

And those were also mailed out.

Also requested by various members, participants, was a copy of the <u>Chemical Quality of New Mexico Water Supplies, 1980</u> -- excuse me, can we go off the record for a second?

What I submitted in this section was a listing of the community water systems and the inorganic analyses for San Juan County in the vicinity of the vulnerable area, well, actually it's complete San Juan County.

Again, there were requests for the listing of wells and water analyses for the wells in the Aztec Quadrangle, so I've submitted a copy of the pertinent data that was provided in Hydrologic Sheet No. 1 by the New Mexico Bureau of Mines and Mineral Resources, and that is altogether as one -- as one stapled sheet.

Q Okay, and let's just go through that once more for the record. This is going to be denominated as Exhibit 14 and it starts out with <u>EID Sampling of Community Water Samples</u>.

A Right.

Q Which is one, two, three, four, five, six pages.

A Uh-huh.

Q The page following, I assume, explains the locations on that.

A Yeah. There's another page as to resampling.

Q All right, and then the next thing is the <u>Chemical Quality of New Mexico Community Water Supplies, 1980</u>.

A Right.

Q And that is one, two, three, six pages.

And then there's the <u>Hydrology of the Aztec Quadrangle</u>.

A Right.

Q That's two pages, and all of those things make up Exhibit Fourteen.

Okay, Mr. Boyer, please continue with the next thing.

A Yes. The next exhibit consists of Tables 8, 9, 10, 11, and 12. They're all stapled together as one exhibit, and during the last hearing there were a number of questions as to where to samples of produced water were taken from, what the location was, and so on and so forth, what the pool was, and so what I have done is I have compiled all the information together with as much information as is current or was current last week, and have put that together in various tables.

Table 8 is the produced water chemical concentrations from the Dakota formation.

Table 9 is for the Mesaverde.

Table 10 is for the Gallup formation.

Table 11 is from the Chacra.

And Table 12 is from two miscellaneous sites.

There are two pages for each location and the first page contains mainly your location information and your inorganics.

The second page finishes off on the inorganics and contains the organic samples along with the comments, who collected the sample and the analyzing lab.

And that's all together as one bound exhibit, all those tables.

Q And that is denominated as Exhibit 15?

A Uh-huh.

Q Would you please go to your next exhibit and explain that?

A Okay. All right. A number -- again a number of the participants requested copies of the raw field notes for the for the testimony.

I believe I submitted -- sent those out to the individuals that requested them. I did not make copies, duplicate copies for distribution here. I would, however, like them entered into the record and if somebody would like an additional copy, I can have some run.

They are the raw field notes that were for Mr. Oscar Simpson's sampling in April, 1984; my sampling in September of 1984; and my sampling in January of 1985.

Q And that is -- we're going to denominate that as Exhibit Sixteen.

A This is what, Seventeen?

Q Yes. Would you now please explain your next exhibit?

A Yes. During my testimony I referred to an article in <u>Groundwater Monitoring Review</u> along in the fall of 1983, entitled <u>Organic Compounds and Groundwater Pollution</u>. Since I did refer to that article, I have made it available for the record and also made copies available for distribution here to anyone who's interested in it.

Q And we'll denominate that as Exhibit Seventeen.

Mr. Boyer, were each of these exhibits prepared by you or under your direction or were they excerpts from professional journals or other publications on which you relied in preparing your testimony?

A Yes.

MR. TAYLOR: Mr. Chairman, I'd like to move the admission of Exhibits 13 through 17.

MR. STAMETS: Without objection these exhibits will be admitted.

MR. TAYLOR: And that's all the questions I have at this time for Mr. Boyer.

A I have some more here.

MR. TAYLOR: That's not all the

questions I have.

Q Would you please make any corrections or clarifications in those -- in these exhibits that we've submitted, or those that were admitted at the first hearing?

A Yes, I'd like to briefly mention a few points.

One is that -- if I can find the notation here -- on Table 4 in the first hearing and I'm afraid I don't know the exhibit number, I listed a range of permeabilities for alluvial material in river valleys. The only transmissivity I had at that time for up in the San Juan Basin area, in the vulnerable area, was one from Bill Stone's report, and since that time in some of the work I did looking at Flora Vista, I came across a study that was done that provides a -- some values in the Flora Vista area itself, and the -- those values were determined using specific capacity data from some well testing that they did out there and the report lists the permeability in that particular area as approximately 750 gallons per day per square foot, or approximately 100 feet per day when you convert it to just the length per unit time unit.

I took the raw information and some information that was provided in some EID field reports of taking a look at the water system up there, and came up with some additional specific capacities and there is some standard textbook methodologies for estimating permeabilities from those, and I also came up with about the same value, which is about 100 feet per day.

So you could add 100 feet per day as another permeability number to Table 4, and this would be for the Flora Vista area.

And that permeability is included in a report and I've just titled the report in case somebody wants to refer to it later. The title of the report is the <u>Merger and Infiltration Gallery Feasibility Study for Flora Vista and South Side Water Users Associations.</u>

It's a CAC Project No. 8129, May 20, 1982, and it was prepared by Lawrence A Brewer and Associates, Consulting Engineers, in Farmington.

Q And just for the record, I believe that Table 4 was part of Exhibit 7 in the last hearing.

A And I have a comment on the Tables 8 through 12 that were just admitted as an exhibit.

And I want to make clear that the samples for heavy metals were not filtered as part of the -- as part of the field sampling. They are representative of whole samples. They were acidified but they were not filtered.

The reason they were not filtered is that at the time we took these we did not have appropriate filtering equipment and so they are -- were not performed.

We have received in the past four weeks the necessary or the appropriate equipment. As the opportunity arises, we will resample produced water samples, both for whole samples in conjunction with the filteres samples and we'll see if we can come up with some comparison as to -- as to the difference between the two.

So I didn't want to misrepresent any of that data as being filtered data.

Also, not included in any of the exhibits, but I want to make the Commission aware that we have five more samples for -- that have been analyzed for organic analyses. Two are -- excuse me, I have six more samples.

Two are samples of -- from the vicinity of the Amoco pits up at Cedar Hill in the Fruitland formation. These samples were taken -- one sample was taken from the bottom of the storage tank before it goes into the ponds.

The other sample was collected from the pond itself. Neither sample showed benzene. There was a trace, or one part per billion of toluene and some other aromatics but there were no high levels. I have no information as to how long those samples were in the pond before they were sampled. In other words, that particular amount of water or that particular grab sample, what the residence time was in either the pond or the tank.

I did not obtain a pit sample from the wellhead.

I have another sample for a Mesaverde well up in that same location and I have three domestic wells in the vulnerable area that I have organic analyses reported on, and all three of those wells have not detected any organic aromatic hydrocarbons, benzenes, and so on and so forth.

Those wells and the produced waters were not tested for any phenols or PAH's or any of the other types of things that Dr. Eiceman talked about earlier this morning.

The last clarification I want to talk about is in Table 7 and I don't know what exhibit that is.

Q Table 7, I believe, was denominated at the last hearing as Exhibit 8.

A The Table 7 estimates the final groundwater concentrations after you've discharged a certain volume of this -- of a certain concentration into a pit and I made certain assumptions at that time.

What I used was a simple dilution or a simple mixing model and there are additional models available that were not used by me in making any of these estimations, one of which might be appropriate as a so-called random walk model that was put together by Thomas Crickett and Associates, that might be appropriate for modeling, doing more sophisticated modeling. I didn't do that. Talking with several EID folks and talking with several of the Mining and Mineral Divsion folks, we may have a PC around that could -- could handle that type of a model and I do have some software for it, so it would -- might be good to compare the results from a simple mixing model with maybe a more sophisticated model.

Initially, however, as part of the work I was doing for the Committee, I was mainly trying to show vulnerability of the aquifers using some very simple hydrologic, straightforward hydrologic techniques and I did not attempt to do any sophisticated modeling and I think Mr. Baiz also mentioned that in his earlier testimony, that we didn't do a lot of sophisticated studies.

Referring specifically back to Table 7 again, if you notice about one-third of the way down the page I use a little equation called Q sub i is equal to A times K times DH over DL, and I just wanted to define what that "A" is. That "A" is the saturated aquifer area perpendicular to the direction of groundwater flow. The standard Darcy's Law pictures show an area of aquifer through which water is flowing through perpendicular to that area, and that is the "A" that I'm talking about.

It isn't the area or the surface area of the pit and it isn't the -- a cross sectional area of the imaginary cylinder.

I just to clarify what that "A" was.

That concludes my comments and clarifications.

Q Okay, I just have one question. You stated that you had six new analyses and you told us about three domestic wells and two samples from Amoco in Cedar Hills.

I don't know if you told us what the results were of the one Mesaverde.

A Oh, the Mesaverde.

Q Would you care to do that briefly?

A Yeah. Okay. The Mesaverde well, I took two -- two samples, two 40 milliliter vials or two sets of 40 milliliter vials. I tried a little experiment. One of the things that Rick was saying was that they tried blotting a little bit of the oil to try to get it off before they do it. I tried it just before I closed down the cap. Any oil that flew up I -- floated up, I tried to blot off.

The results, and I'll just read them off and I'll make these available for anybody who cares to have them later, benzene was 7.2 milligrams per liter. This is for the unblotted or the -- whatever oil came, floated up stayed up there. Benzene, 7.2; toluene, 14.4; ethylbenzene, milligrams per liter.

For the other sample, the one that I blotted with a little piece of tissue, benzene, 5.8; toluene, 13.25; ethylbenzene, .59; paraxylene, 1.24; metaxylene, 4.35; and orthoxylene, 1.24, also in milligrams per liter.

I did not see a big, big difference between the samples by using either method and I wouldn't want to draw any statistical conclusions one way or the other. That was just an experiment I tried and both of them have high -- give me high levels of benzene, and that was the sixth sample I talked about.

Q Okay. Thank you. I have no further questions.

MR. STAMETS: Are there any questions of this witness?

Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Just a point of clarification. Mr. Taylor, what's Exhibit Thirteen?

MR. TAYLOR: Exhibit Thirteen is --

THE REPORTER: The references to the --

MR. SHUEY: Oh, the references, thank you.

That's all the questions I have.

MR. STAMETS: Any other questions of this witness?

MR. KELLAHIN: Mr. Chairman, I have a few.

MR. STAMETS: Mr. Kellahin.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Boyer, with the new samples you've obtained since the last hearing, have you gone through your simple pollution calculation with the new samples?

A I did not go through and change the averages. The average now for all the produced water samples from the separators is no longer thirteen or fourteen as it was in February, but is now up to almost 26 milligrams per liter for the benzene final average, but I did not go through and redo all those calculations.

Q You described for us a comparison between the simple dilution or mixing model calculation you had conducted and compared that to the possibility of taking this information and using, I think you called it the random walk computer model, it's a software program, is it not?

A Right.

Q And you take the random walk computer model and go through that computer program using this data and come up with a more refined analysis of what's happening to the groundwater?

A Using this data plus some standard other inputs for such things as partition coefficients, retardation factors, and several other things that are variable in the literature.

It would be an interesting comparison. We made a number of assumptions that I went through in the -- in the initial session. If the assumptions are correct it would be more refined, yes.

Q In your professional opinion would the results of a model such as this random walk computer program calibrated with accurate data provide a more reliable representation of the actual conditions?

A Yes, conceptually they take into account the more physical movement and the other types of -- of dispersivity transfers and longitudinal dispersivities than mine did.

Again, mine was a simple mixing and groundwater does not mix instantaneously like surface water does. It moves over a period of time and it can move in different directions depending on the -- any particular nonhomogeneous part of it.

Again it was, as I stated earlier, these assumptions were made that showed that concentrations of benzene at certain levels would indeed have the potential to reach groundwater, in concentrations that would be in excess of standards.

Q What if we could draw a comparison, Mr. Boyer, since you've had several experiences with the EID in terms of a discharge or making an application for a discharge permit, to be allowed to discharge contaminants onto the ground or into a groundwater source.

Am I correct in understanding that that discharger cannot use a simple dilution or mixing calculation in order to document his discharge application?

A It is my recollection that dischargers have used simple mixing calculations and if they show that indeed they are the most conservative of the calculations that can be used, because they do assume instantaneous mixing and they do assume, make certain assumptions.

If a simple mixing calculation is indeed satisfactory, then -- then the discharge plan is likely to be approved. More often than not we needed to go on and take a look at other types of calculations because the mixing calculation was sometimes inconclusive.

Q If a discharger then had his hydrologist or someone else of expertise use the random walk computer program to do his analysis, then that would be documentation upon which a discharger could obtain a permit.

A It was be additional documentation, yes.

Q And if we're moving beyond the simple dilution calculation and the computer model, the best evidence yet would be an actual field study that measured and monitored the groundwater, sampled the groundwater, analyzed it and tested it and showed that it was within the standard.

A Yes. That would be -- that would be the best method. As I stated in the earlier hearing, however, what is conducted at one site may not be representative of what is in the site half mile away or a mile away because of the various conditions under which the sediments were deposited in the San Juan Basin.

Q Thank you.

MR. STAMETS: Are there any other questions of this witness:

You may be excused.

Ms. Pruett, would you like to put your witness on now?

DOUGLAS EARP,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MS. PRUETT:

Q Would you please state your name?

A My name is Douglas Earp.

Q Can you tell us where you are employed and in what capacity?

A I'm employed as a Water Resource Specialist with the New Mexico Environmental Improvement Division, Ground Water Surveillance Section.

MR. SHUEY: Volume, please.

MR. STAMETS: Ask everybody to speak up. We can barely hear at this end of the table.

A I'm employed as a Water Resource Specialist with the Ground Water Surveillance Section of the New Mexico Environmental Improvement Division.

Q What is your educational background?

A I have a Bachelor's degree from the University of New Mexico. I majored in biology and minored in geology.

And I hold a Master's degree in hydrology from the University of Arizona.

Q What about your professional background?

A I've worked for a period of about three years with the EID in a Surface Water Quality Section.

I've worked as a hydrologist for a private consulting firm for a period of one year.

I was employed full time as Staff Research Assistant in the Department of Hydrology and Water Resources at the University of New Mexico, and I've served in my present capacity since August of last year.

Q Would you describe your involvement with the Produced Water Study Committee, please?

A I attended the last two meetings of the short term study committee. I submitted some written and oral comments during those proceedings.

MS. PRUETT: Are the witness' qualifications accepted?

MR. STAMETS: Are there any questions as to the witness' qualifications?

He is considered qualified.

Q Mr. Earp, would you tell us why you're appearing today and on whose behalf?

A I'm here representing the Environmental Improvement Division.

Q And what is the Division's interest in these proceedings?

A EID has a legislative mandate to protect the groundwaters of the State of New Mexico. It's sort of -- the mandate is parallel of that of the OCD, to add support.

Q As a result of your participation on the short term committee did you perform calculations to try to determine whether unlined pits of produced water would affect groundwater quality?

A I made some basic calculations in that regard.

Q All right. And in performing those calculations did you rely on references that are commonly relied on by hydrologists making calculations of that sort?

A Yes, the values I used were all taken from standard textbooks. They are not site specific for the area concerned.

MS. PRUETT: We have prepared a formal statement that we'll offer as an exhibit but I'd like to go through it and let Mr. Earp summarize it for everybody's benefit.

Q What can you tell us about the infiltration rates of water in this case?

A If I may use this tablet, I'd like to write an equation on the board.

MR. KELLAHIN: Excuse me, Mr. Chairman, may we have copies of the exhibit?

MS. PRUETT: We do.

A Is this legible from down there?

A This equation is the Geen and Ampt equation which I took from Bower, 1978, page 253.

This is a standard infiltration equation. It's been used for a period of about seven years to estimate infiltration rates for various materials.

vi equals infiltration rate; K is the hydraulic conductivity; Hsub w is the depth of water ponded on the surface; Lf is the depth of the wetting front, the moist area; hcr is a critical pressure head which simply accounts for unsaturated flow along the margins of a wet front.

And the point I wanted to make with this equation is regardless of the value of H sub w the depth of water on the surface of the soil, if this value is zero, infiltration will still occur.

H sub cr is a negative value itself so when it is subtracted from the other values there is nothing added to it, so this term will always be greater than one.

That term will be multiplied by the hydraulic conductivity so that the hydraulic conductivity -- the infiltration rate will always be equal to or greater than the saturated vertical hydraulic conductivity for the material in question.

I just want to reiterate the point you do not need ponded water on the surface for infiltration to occur.

Q So even when these ponds appear dry, there is still infiltration of groundwater occurring.

A Yes.

Q What can you tell us about the length of time for a volume of liquid to saturate porous material below one of these pits?

A Another very basic calculation would just be to take a unit cross sectional area of the pit bottom times whatever the depth is between the land surface and the water table, multiply that volume by the effective porosity of the material and that will give you an estimate of the storage capacity of that unsaturated material for holding water.

I've done that using some reasonable assumptions. I assumed the water table is 10 feet land surface. I assumed a porosity of 30 percent and my result suggests that 22.4 gallons, or about a half a barrel of liquid, can be held per square foot of wetted surface.

So if the pit bottom is wetted over an area of 25 square feet, 13.3 barrels of liquid would completely saturate that volume, the point being that there is only a limited storage capacity within the unsaturated material and if, say, a half a barrel a day of liquid is applied to that pit, making the same assumptions, that storage capacity would be depleted within 27 days.

Q What would happen once that storage capacity was full?

A Then the material would be saturated and saturated flow would occur from the pit to the groundwater.

Q What conclusion did you reach about the travel time for liquids to move downward from the pit?

A Using Darcy's Law, which is the basic law governing groundwater flow, it can be shown that once saturated conditions exist, the vertical velocity of flow will be equal to the hydraulic conductivity of the material divided by its porosity.

So again assuming a 30 percent porosity and a hydraulic conductivity of one foot per day, it can be shown that liquid introduced to an unlined pit will travel to the water table in just ten days.

If the material below the pit is not saturated, then Darcy's Law has to be modified because the hydraulic conductivity term is a function of moisture content and I won't go over these figures but I've included three figures in our testimony which illustrate the relationships between moisture content and negative pressure head, between moisture content and hydraulic conductivity, and also Figure 3 shows the ratio of unsaturated hydraulic conductivity as a function of saturated conductivity as a function of pressure head.

The purpose of those figures is to illustrate a significant flow continues over a wide range of moisture conditions, even under unsaturated flow conditions.

Q What can you tell us about the movement of this liquid after it enters the regional groundwater system? In other words, after it's hit groundwater?

A In that regard I used a reference, a paper by Lee Wilson, which was in New Mexico Geological Society Professional Paper No. 10, I believe, in which he has evaluated hydraulic characteristics of geologic materials throughout New Mexico and he states that typical linear velocity for groundwater in alluvium and sandstone in the New Mexico 4.3 and 2.0 feet per day respectively.

I haven't done specific calculations for the materials in the San Juan Basin but these typical values indicate that significant migration of contaminants away from the area of introduction into an aquifer will occur.

Q Did you reach any conclusions about the effects of produced water discharges into unlined pits on groundwater quality?

A Yes, I did.

Q Would you summarize those for us?

A Sure. Let me preface that by saying that my calculations are basic in a sense that I didn't consider effects of evaporation or crust or films on the soil surface, or heterogeneities within the porous material, dispersion or retardation coefficients, or anything; just general calculations.

Based on the calculations and the assumptions which are included in the statement, number one, infiltration will occur even though there is no liquid, free liquid surface or ponded liquid within the pit.

Virtually all liquid discharged to unlined pits could infiltrate within a matter of an hour or two, assuming a half a barrel a day discharge.

The available storage capacity of the vadose zone beneath an unlined pit could be saturated in less than one month if half a barrel a day was discharged to a pit located 10 feet above the water table.

The travel time required for liquid to move from the pit to the water table under saturated conditions could be on the order of ten days.

And in the absence of significant retardation contaminants which enter the regional groundwater system might travel 2 to 4 feet per day.

Q What potential for groundwater pollution do you see in the face of your conclusions from unlined pits?

A It's the EID position that in the absence of site specific evidence to the contrary there is a significant potential for groundwater contamination from unlined pits and therefore we fully support the OCD contention that there should be no blanket small volume exemption for discharges within vulnerable aquifer areas.

Q Do you feel any exemptions are appropriate, that unlined pits should ever be used?

A If there is documented evidence based on water quality characteristics or soil characteristics, and if the discharger can prove that there will be no significant degradation, then I think a mechanism is provided within the recommendations document of the Study Committee to provide for an exemption on that basis.

MS. PRUETT: I don't have any further questions but I would like to offer Mr. Earp's statement into the record as our Exhibit One.

MR. STAMETS: This will be accepted as a statement for the record.

Are there questions of this witness?

There being none --

MR. KELLAHIN: I'm sorry, I'm going to have some.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Earp, if you will, sir, let's turn to the portion of the exhibit -- your Exhibit Number One that has the conclusion section in it.

If I understand what you're telling us, you said that the calculations that you have made don't consider certain factors that will take place or act upon the contaminants once it's introduced into the pit until the time it reaches the groundwater.

Is that not what you said?

A That's correct.

Q Am I correct in understanding that those factors are often characterized as mechanisms of attenuation?

A Yes, they are.

Q When we talk about mechanisms for attenuation, Mr. Earp, can you identify for us the general areas in which that phrase is applied?

A I'm not sure I understand the question.

Q All right, sir. What are the mechanisms of attenuation? First of all, what are mechanisms of attenutation?

A They would be mechanisms that would tend to cause the substances dissolved in a liquid to move at a rate slower than the liquid itself.

They are specific for each contaminant or chemical. That's one reason I didn't consider them. They're also specific for different geologic materials which I didn't consider.

Q Those factors are the ones you've listed in here as things that you didn't consider, the dispersion, volatilization, absorption, biodegradation, those are the factors of attenuation?

A Correct.

Q Would you describe for me again, Mr. Earp, what is it that you do for the EID?

A I am a water resource specialist. I work in evaluating local contamination problems throughout the state and also am involved in some regional water quality studies, groundwater quality studies.

Q Are you familiar with the procedures and standards that are applied by EID in granting a discharger an approved discharge plan?

A I have not been involved in a discharge permit process in any capacity.

Q Your second conclusion that's indicated number two, says virtually all liquid discharged to unlined pits could infiltrate within two or three hours. What is the information that you have studied that caused you to reach that conclusion?

A I just took it from Keliel, which is a standard textbook on soil, called Soil and Water.

He stated that infiltration rates are typically greater than 20 millimeters per hour for sand and between 10 and 20 millimeters per hour for sandy and silty soils.

I took an intermediate value of 20 millimeters per hour and estimated what volume of liquid would infiltrate per unit area, one square foot, per time.

Q Am I correct in understanding that conclusion number two, then, is not based upon field study information to show what actually would happen to the produced water that's dumped from the separator into the unlined pit?

A That is correct.

Q Number four says the travel time required for liquid to move from the pit to the water table under saturated conditions could be on the order of 10 days.

What are the facts or study that you have relied upon to make that conclusion?

A I took hydraulic conductivity values from the literature. Typically they are horizontal conductivity values, so I multiplied by .1 to get an estimate of what a vertical conductivity would be.

Then, using Darcy's Law, the linear velocity of a liquid is equal to the Darcy velocity divided by the porosity.

In this case the Darcy velocity if flow is occurring in a vertical direction under saturated conditions, the hydraulic gradient is 1, so Darcy's Law states that the Darcy velocity is equal to the hydraulic conductivity times 1.

So I merely then divided substituting those equations, putting relationships together, the linear velocity is equal to the vertical hydraulic conductivity divided by the porosity.

Q Do you know whether or not saturated conditions underlying the unlined pits in the vulnerable area is representative of the condition of those pits?

A That would depend on the condition -- geologic conditions at the site, the application rate of the water. I have -- I suspect that -- my professional opinion is that there will be saturated conditions under many -- in many instances.

Q Thank you, sir.

MR. STAMETS: Are there other questions of this witness?

You may be excused.

I presume that that concludes the testimony from all of those who would be opposed to any small volume exemption.

In that case, who wishes to proceed?

We'll take a ten minute recess.

(Thereupon a ten minute recess was taken.)

MR. STAMETS: All right, who proposes to proceed?

MR. PEARCE: May it please the Commission, I am W. Perry Pearce, appearing today on behalf of Meridian Oil.

Meridian Oil the newly formed corporate entity which combines the elements of El Paso Exploration Company and Milestone Petroleum which was the oil and gas exploration and production arm of Burlington Northern.

This newly created corporate entity is now the largest operator of wells in northwest New Mexico. As that, as the largest operator of those wells, Meridian is vitally interested in assisting this Commission in reaching decisions which comply with what we view as two goals intention. Responsibilities of this Commission, as is, I think, well understood, is to protect groundwater and to prevent waste of oil and gas.

This tradition, I think, has to be maintained. Meridian believes that it is not appropriate to have one area of responsibility unjustifiably emphasized in reaching any decision.

The record of the first hearing in this case and the testimony that's been presented so far today has presented you with a model which we believe ignores reality and ignores scientific fact.

We're going to discuss some elements with you which nobody else has and I was interested in Mr. Earp's conclusion at the end of his paper, and if I may, it's virtually a road map to the element that we think nobody's talked to you about. We think it's critical that you consider those.

Mr. Earp said that his calculations do not consider effects of evaporation, surface films or crusts, layering within geologic material, dispersion, absorption, or biological degradation of contaminants.

If you take those elements into consideration it is not easy to build precise, mathematical depictions of what goes on, but we believe that precise, mathematical descriptions of an unreal situation are not helpful to this Commission.

We think that's what you've been presented.

We have one exhibit which is going to be discussed by two expert witnesses and these expert witnesses are appearing for Meridian, Meridian Oil, El Paso Natural Gas Company, ARCO, and Northwest Pipeline.

They're going to discuss the real world geology, hydrology, and other scientific disciplines.

It will, I think, increase the tension because if you accept an unreal, mathematical model and act on that, it's not particularly tension inducing, but as I said, what we're going to talk to you about we believe much more accurately reflects reality, and that's why these companies, why these expert witnesses have gone to the trouble to present this case.

And so we're going to pick up right where the preceding witness left off.

At this time with the permission of the Commission, I will first call my first witness who has been previously sworn.

THOMAS R. SCHULTZ,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. PEARCE:

Q I would ask you, sir, to state for the record your name and employer and place of employment.

A My name is Thomas R. Schultz. I work for Woodward-Clyde Consultants in Denver, Colorado.

Q Would you please, sir, for the record please state your educational background?

A I hold a Bachlor of Science degree in geology from Ohio State University; a MS in geology from Ohio State University, and a PhD in hydrology from the University of Arizona.

Q What year did you receive your PhD in hydrology, sir?

A 1979.

Q And will you describe your significant work experience preceding the granting of that degree or subsequent to that?

A While at universities I worked as both a teaching assistant and research assistant.

After leaving the university I worked for the Arizona State Land Department, Water Rights Division; was involved in groundwater permitting and basin-wide water quality throughout Arizona.

After leaving that position, I worked for the U. S. Office of Surface Mining in Denver, and was responsible for reviewing coal mine permits and I was also responsible for all groundwater monitoring the western half of the United States for surface and underground coal mines.

In the consulting environment, my responsibilities entail groundwater quantity and quality.

My experience in New Mexico started out with low grade dewatered uranium tailings disposal applications. I've worked for several years in the Four Corners area with New Mexico coal mines.

Now I'm quite actively involved in RECRA and CERCLA activities throughout the U. S. for Woodward-Clyde, and I point out that the first project that I ever worked on was in 1970 involving the disposal of produced waters from shallow oil and gas wells in Ohio.

Q Thank you, sir.

MR. PEARCE: Mr. Chairman, as I mentioned during my opening statement we have one exhibit. We have several copies, however we do not have enough to go around. We have, however, reproduced some of the larger exhibits within this document, which will displayed behind Dr. Schultz here in the course of his testimony and I would propose to simply begin going through that exhibit with Dr. Schultz.

Q Dr. Schultz, would you please turn to the page immediately following Tab No. 1 in the bound set and would you turn the chart behind you around and discuss that for us generally, please?

MR. STAMETS: Before you start,

let's make it clear that the Commission believes that the witness is qualified.

MR. PEARCE: Thank you, sir.

MR. STAMETS: Especially since he's from Ohio State University.

A Thank you. I had hoped to have Woody Hayes here but he had a prior hearing.

MR. STAMETS: I hope not. We don't have enough time this year for Woody Hayes.

A And I don't intend to be nearly as violent as Woody might have been.

If you turn to the page following Tab 1 in the exhibit, or if you don't have an exhibit look up here at the chart, I would like to point out at a theoretical level some additional mechanisms which mesh quite well with those that have been presented in these hearings, items that I think have not been considered by the previous individuals.

Today we're going to discuss the mechanisms of attenuation.

Attenuation has two components and these are the thought that I want to try to leave you with today. They are removal of material and delay of material, so each time I talk about a mechanism we're going to relate that back to either removal or delay.

I'm going to briefly go through the mechanisms here so we can get a framework in which to work and then we're going to discuss in detail each of these mechanisms that you see numbered here.

We have a theoretical model of a pit in a vulnerable area, which include a discharge pipe be it from the separator, the BI, any of the other places that it might produce discharge waters.

We have the soil surface here represented by this dark line, a pit showing fluid in it, some distance then to the water table which we have drawn here as a straight line.

So in this framework, then, I want to discuss each of the six mechanisms.

The first mechanism is flash volatilization. Flash volatilization was presented at an earlier hearing by Mr. Baca and I am in agreement with the numbers that he produced, which show 50 percent loss of solutes as they leave the end of the discharge pipe. That loss, or removal, is to the atmosphere.

Under certainenvironmental conditions, which Mr. Baca did not consider, those being organic solute in water and not small fractions of organic solutes, the percentage probably will be higher but I think a conservative number is the 50 percent removal that Mr. Baca presented.

So remember now that mechanism number one is removal.

Now if you flip to Tab No. 2 in the exhibit, we have here a summary of climatological data for Farmington, New Mexico. You might note at the bottom of the page the source of that information. And what we want to point out on -- or what I would like to point out on this table are three columns, the second from the left, pan evaporation; the second from the right, lake evaporation; and the last column on the right, precipitation. You will note by scanning across for the months indicated that pan evaporation in New Mexico at Farmington always exceed precipitation at Farmington throughout the entire year, all twelve months.

Now looking at lake evaporation, which may be a little closer to evaporation from pits, you will notice that lake evaporation exceeds -- the potential lake evaporation exceeds precipitation in all months except December, in which the difference is very slight, 2/100ths of an inch.

Now if we flip to the next page of the exhibit, we have here a cover page from an EPA document dated November, 1979, which is entitled Water Related Environmental Fate of 129 Priority Pollutants. This is a document that EPA prepared in trying to deal with priority pollutants in an environmental setting, not in a theoretical setting.

Behind that cover page we have two sets of pages, one describing benzene, pages, if you look at the bottom, 71-1 through 71-10. Behind that we have a set of pages for toluene, 80-1 through 80-7.

At your leisure you should read through some of the headings under both benzene and toluene, such as Statement of Probable Fate.

Now let's flip to page 71-3 under benzene and look at the section labeled volatilization. The important fact we want -- I would like to point out here is that the half life for benzene in a water column is 4.81 hours. A half life is the time required for one-half of the initial concentration to disappear through volatilization, our mechanism number two.

You also might note that that half life of 4.81 hours was determined at 25 degrees Centigrade and that at 10 degrees Centigrade the half life is only increased to 5.03 hours, a not large increase.

This illustrates that the half life of benzene in a pit or standing column of water is relatively insensitive to temperature changes as you would see throughout different seasons in the San Juan Basin.

Now if I may flip on through to the section on toluene, which starts on page 80-1, we have here a similar format for toluene. If we move to page 80-3, under the section labeled volatilization, we're still now talking about mechanism number two, evaporation of water from the pit and/or volatilization of the organics. We see that the half life for toluene in this water column is 5.18 hours. That is the amount of time necessary for one half of the concentration to disappear to the atmosphere through volatilization.

Now, let's take a look at some real world assumptions that were made in coming up with these numbers alos contained in this paragraph, and I'll just briefly point these out.

Number one assumes that these things are in solution. They are not -- toluene and benzene aren't attached to suspended particles or colloidal particles, or not in the ionic form or complexed with anything else, or adsorbed anything, that the vapor is in equilibrium with the liquid at the interface with the top of the pit; that water diffusion, in other words, or the diffusion of the organic solute is such that the concentration in the pit is the same throughout, and finally, evaporation of water has a very negligible effect on the volatilization of these solutes.

Now, as further illustraton of half life to -- we'd like for you to move on beyond section -- or page 80-7 to the page following that. We see here a table that's entitled Volatilization Half Lives in Water for Benzene and Toluene. This is nothing more than a simple calculation with a calculator to show in the first column the number of half lives; the next column the actual time for benzene and toluene; and the percent remaining in a pit.

Note that under the number of half lives that five half lives takes about one day; 10 half lives, two days; thus 15 half lives three days.

We'll see what the impact of that is when we look at the last column, percent remaining. If we started out with some concentration, whatever it might be in the pit, at 100 percent we move down to any particular half life that you might like and for the purpose of illustration I would just like to look at the last number, 15 half lives, or approximately three days, we see that the amount remaining is .003 of one percent of the original concentration.

Now, as a further illustration of that, we have this diagram, which is a plotting of those numbers from that previous table and you can see that the rapid decay of benzene and toluene through volatilization to the atmosphere follows a geometric decay curve and in a matter of 32 hours we're down below 1 percent and we've shown after about 40 hours what concentration we have left for percent remaining and it's about .39 percent.

Therefore, for those fluids remaining in the pit for a reasonable period of time, as I believe after having seen some of these pits, a significant amount of the material will be lost to the atmosphere through volatilization.

So mechanism number two, just like mechanism number one, is a removal mechanism.

Now, if you flip to the page behind Tab No. 3, we have here a diagram that shows one dimensional saturated flow. This diagram has been presented to you before byl Mr. Boyer and I'd like to point out the conditions we have here.

We have this cylinder beneath the pit saturated with water, assumed by Mr. Boyer, moving from the pit down to the water table as we see here, and I've taken the liberty to draw in some flow or stream lines showing the pathway of a drop of water if you ignore the interstices of moving in between the sand grains, you would see it vertically downward.

Now if we flip to the next diagram in your exhibit or the one we have up here, here we have two dimensional, partially saturated flow.

Okay, what is partially saturated flow? If you can think of that as the soil or rock particles, and we're going to have a diagram a little later on to illustrate this to you, but if you can conceptualize this as having those open spaces between the sand grains filled with both water and air, not just water, then you have partially saturated flow.

Later on we'll point out that this air space is an important thing to think about.

Now, the flow is really three dimensional but difficult to depict so we've only shown two dimensional flow. Now we believe this to be a more conservative case. There are some conditions which you will have a lobe of saturated flow beneath this; numerous variables to be attributed to that and it requires a site specific case in order to draw a line for a particular saturated instance, saturated flow condition.

The things to remember from this type of saturated flow condition are three, and I would like to, prior to getting to those three points, illustrate what's happening here.

These lines with the numbers show potential surfaces, water in a theoretical sense in homogeneous isotopic conditions flows perpendicular to these equipotential lines and I have taken the liberty of drawing in a flow line or a stream line for three conditions: One, top water leaving the bottom of the pit, moving down vertically, and/or water leaving at the side of the pit near the water surface and moving out here.

Now, with these kinds of conditions at certain locations within the San Juan Basin, the mass of the organic solute that we're considering is going to spread over greater volume, as you can see here, compared to the previous diagram.

Secondly, the occurrence of soil gas is an important precursor to two mechanism that we're going to discuss in just a moment, and thirdly, the travel times are going to be longer here for two reasons. One, the distance is greater, but more importantly, under partially saturated flow conditions the hydraulic conductivity can be much less for very low moisture contents. You can have hydraulic conductivities that are three or four orders of magnitude less than those that you've been presented with before.

Now, I'd like to have you remember that mechanism number three, from our first diagram, which is shown here, partially saturated flow, is a delay mechanism. It's not a removal mechanism but is a delay mechanism, allowing mechanisms number four, five, and six to occur.

Behind that particular diagram I've included one technical paper to illustrate this and those of you have the patience can read through that.

Now if we flip to Tab No. 4, behind that we have the next diagram.

Q And excuse me, Dr. Schultz, for the record that is a diagram entitled Evaporation and Volatilization from the Soil, is that correct?

A Correct.

Q Thank you.

A We just point out what we see in this diagram. This is a depiction of the soil or rock particles that you find throughout the San Juan Basin in unconsolidated material. Those are shown by the hatched lines here.

Secondly we have water shown by the stippled areas.

And thirdly we have soil gas which is shown as open areas in amongst the water and soil particles.

I'd like to point out that for partially saturated flow to occur this water has to be continuous. We can have movements back and forth of the wetting front but in a steady state condition this water is continuous and there will be movement from a pit down towards the water table.

Likewise, the soil gas is in a continuum and it is in connection with the atmosphere and that leads me then to what's occurring in this mechanism, mechanism number four.

The organic solute will volatilize from the water phase into the gas phase and if this was in a closed container it would eventually reach equilibrium and wouldn't have much effect. But since the soil gas is connected with the atmosphere, and these organic solutes are higher concentrations here, they're going to move outward towards the atmosphere as we've shown here with these squiggly lines, if you can imagine these lines coming up and hooking to the soil surface and then on into the atmosphere.

The two processes that occur through this mechanism are diffusion and you can liken this to smoke particles moving throughout a room. You all have been in those situations before.

Secondly this soil gas is going to move through what I'd like to refer to as mass pumping. That's actual pushing in and sucking out of this soil gas. This happens on a diurnal basis in arid and semi-arid conditions as a result of pressure changes on a daily basis or even more frequently and as a result of thermal gradients or temperature changes from night and day.

Now the important point to take with you from this mechanism, mechanism number four, is that it is a removal process.

Behind the diagram in your exhibits I've included a technical paper that describes the mechanism we've just evaluated.

Now if we could flip to Tab No. 5 and the next diagram which labeled Sorption, it's the first page behind Tab No. 5 in your exhibit.

We have here the same soil/rock depiction from -- as we had in the last diagram but now I would like you to concentrate on this box that we have here, dashed lines, and we're going to take a trip into a small world on a microscale to see what might happen under sorption or mechanism number five.

I point out that sorption occurs both in partically saturated conditions and under saturated conditions, much more well understood under saturated conditions.

Let's move to the next diagram.

Q And once again for the record, sir, that diagram is labeled Solute Velocity Retarded by Sorption, is that correct?

A That is correct.

Q I'll try not to interrupt you if you'll read the heading when you get to each of them.

A Okay, thank you for reminding me.

Q Thank you.

A If you'll look at this diagram labeled Solute Velocity Retarded by Sorption, the second one behind Tab No. 5, land if we can imagine or if you can imagine a soil/rock particle here, which could be either a mineral or organic constituent in the soil, as we all know, soils contain some amount of organics, and if we can imagine the flow of water past this soil particle, moving along in this direction so we have flow of water going over here, if we can conceptualize organic solutes in that water represented by these open circles, and we see several of these distributed in the water, and if we can imagine this organic solute moving back and forth between the water phase and this solute surface, this is a, in a theoretical sense, a reversible process. Once these things get on here they like to come back off at some later time, so it is reversible although the rates may be somewhat different.

Now, to visualize retardation in a very simple equation, you can imagine a velocity of water going by here, it's represented by V here, and the velocity of solute in the denominator, we have retardation. That's it. The water is going along here and one of these things gets off the train for intermediate rest, it's going to arrive at this point later than the chunk of water that it was in when it entered on this side. Okay, so that is a retardation, which we're calling sorption. That is that phenomena.

Here is mechanism number five.

Now, why does this occur? As pointed out in several exhibits that you've seen today, namely the one, the article by Pettijohn and Hounslow, I believe Mr. Boyer's Exhibit Seventeen, gives a very nice description of this mechanism and I'd like to point out the two main reasons why this mechanism occurs at the micro scale. One is called hydrophobicity. It means that these organic solutes that we're considering, benzene and toluene, are afraid of water. They're soluble in water but if they have a chance they'd like to get off this train and spend a little time on this soil particle.

The second mechanism that seems to control this, and these are all observational measurements that have been done by a variety of researchers over the last twenty years, perhaps longer, the second reason is that these organic solutes like their cousins organic matter, like being on that part of the train station.

Those are the two things then that cause this to occur. To a lesser extent the same phenomena will occur as the solute gets attracted to a mineral surface.

Now if you'll turn to the next page of your exhibit, we have here a very simple table that shows some real numbers for retardation.

The first column on the left we have the compunds that we're considering this afternoon, benzene and toluene. We have three columns that show percent organic carbon, and we might point out that these are labeled .1 percent, 1 percent, and 2 percent organic carbon with the number on the right being typical of collected and measured samples from the vulnerable area of the San Juan and Los Angeles River basins.

Now, what do these numbers mean? Let's take a look, for example, at benzene at 1 percent organic carbon, probably a lower limit for some of the conditions here. We see a number that has a range of 6-7. Now I might point out that these numbers can be derived mathematically.

Anyone who has the interest to look at some calculations can talk to me after the hearing. I'd be glad to show how this works out.

You see a range of 6 to 7. This means that this water is moving along here at 6 feet per day past this particle, fairly rapid velocity but it's realistic.

Benzene is going to move along here at 1 foot per day, 1/6th, or if we look at the lower range, 1/6th to 1/7th of the velocity of the water.

Now let's look at the largest numbers that we have in this table, toluene, you see the range for toluene. The retardation factors are from 13 to 57. That says that as this water flows along here the toluene is going to move along at 1/57th the velocity that the water is moving along. Okay.

Now, the thing to remember here is that this is a delay mechanism. This is not a removal mechanism.

Mechanism number five is delay mechanism, but it allows two other things to occur, as did partically saturated flow. Mechanism number four, the volatilization from the soil and mechanism number six to be described by Dr. Gary Miller, biodegradation of these organic solutes in the subsurface.

Q For point of clarification, Doctor, I understood you to say that you had reviewed some soil samples indicating percent organic carbon contained in samples taken from the San Juan, Animas, and La Plata River Valleys in northwest New Mexico, is that correct?

A Correct.

Q How many of those samples did you review?

A Sixteen.

Q Do you have any indication of whether those were taken within a very limited area or were they in fact fairly widely dispersed over that area?

A They were fairly widely dispersed at representative locations, both down in the flood plain of the San Juan where one might expect high organic material, and clear up on some of the tributaries where the presence of organic material might be less likely.

Q Okay, what was the range of percent organic carbon found in those sixteen samples?

A Those range from a little less than 1 percent, namely .63 percent, to 2.08 percent, as organic carbon.

Q And by whom were those samples taken, sir?

A Those were taken by personnel of Meridian Oil.

Q And do you know who did the actual testing to determine the actual percent organic compound -- carbon? I'm sorry.

A Yes. The testing was done by an independent laboratory.

Q Thank you, sir.

A I also would like to point out for Mr. Eiceman's sake that retardation numbers for PAH's, this might help explain some of his high concentrations of PAH's in the soil samples, have ranges from 100 up to 2500, so you can see that movement of, for example, naphthalene is at velocities one 25/100th of the velocity of water and this is well demonstrated in a project that I am working on right now.

Now, in conclusion I'd like to just run back through these six mechanisms again so that you will remember what I told you.

One, mechanism number one is removal attenuation.

Mechanism number two is removal.

Mechanism number three is delay.

Mechanism number four is removal.

Mechanism number five is delay.

And as you will soon see, mechanism number six is removal.

Q Do you have anything further at this time?

A No.

MR. PEARCE: That's all the direct we have of this witness.

We have discovered in our inspections that there are many waste pits associated with massive gas production.

On this overhead I have a partial summary of a -- not a particular single system but more or less a composite. Each of the black lines indicates a waste pit associated with the natural gas production and probably (not understood.)

The waste pits that we were dealing with were completely the produced water pits right off the separators, the oil/water separators.

Q So there were no other pits that you were sampling in this --

A Well, yes. In the longevity study we sampled one compressor for which -- I haven't even included the waste pits associated with compressors in the findings on here but there are waste pits associated with the compressing process.

One is, one of the soil samples in the soil longevity test was froma compressor pit.

Q Will you identify that for us?

A Yes, I will.

Q Thank you.

MR. CARR: That's all the questions I have.

MR. STAMETS: Are there other questions of this witness?

Mr. Johnson.

QUESTIONS BY MR. JOHNSON:

Q I'm sort of curious about these soil samples. Are the formations identified in these soil samples?

A No. My intent there, if I may state it, my intent was not to do a thorough methodical investigation. It was simply to investigate the claim that of the wastes are evaporating from the waste pit and there was no residue.

Q When you took these samples how did you know which part of the sample to run your analysis on? Was it visual, at random?

A I chose the seven random samples and composited each level.

Q So you didn't base it strictly on color or smell or --

A No, I took random samples throughout the testing and I did not use a random number or table generally which would have been perfectly accurate, but it was a -- I tried to take corners and then a center sample.

Q Okay, so the whole sampling (inaudible)

A The composite of each level was made.

Q Okay. When you say, well say a certain distance from the well, say a mile from the well and no closer to any other wells, were any samples taken from say that same formation to determine (not clearly understood).

A Oh, yes, I analyzed soil at distances

from the pit and vertically as well, and the soil was free of any detectable hydrocarbons in my limited detection.

Q Okay, thank you.

MR. STAMETS: Any other questions of the witness?

Mr. Padilla.

QUESTIONS BY MR. PADILLA:

Q Doctor, do you know whether hydrocarbons in the areas of your study exist naturally at shallow -- at or near the surface?

A There are -- there are reports that groundwater in New Mexico, and such reports date from the late 1800's, groundwater has been naturally contaminated by leaking natural gas fissures. I'm not a geologist but somehow the natural gas gets up into groundwater, and such reports have been made.

Q Does your study take into consideration any of those legends or stories to verify whether or not contaminations is actually occurring?

A The only groundwater samples -- when we were first starting our basic research looking at the groundwater impact, and the first study is the one which I cooperated with Mr. Masud Zaman. The only guarantee there was that we sampled at the site and direction of the ground pit and we saw very nice, even breakage, concentrations of organic compounds from a high close to a pit to a (not able to understand clearly.)

Up further from the pit as defined by Mr. -- or as estimated by Masud Zaman, we found no trace of contamination, so we've made preliminary mapping of what appears to be a plume that is consisten with what is believed to be the groundwater movement in the area. It has been mapped but no independent tests have been made.

Q Now you've indicated that you're appearing here independently today. Are you on salary from New Mexico State University today?

A My salary is being covered by the University today.

Q Today, so you're off the University's (not understood clearly.)

A Yes. I received permission from my Department Chairman to appear here today.

MR. PADILLA: No further questions of this witness.

MR. STAMETS: Are there other questions of this witness?

You may be excused.

We now have Exhibits One through Twenty-two.

MR. KELLAHIN: We renew our objection to Exhibits -- all, except I believe Exhibit Twenty-two, which is Dr. Eiceman's preliminary work on the Navajo study in the Duncan area. I believe there's a proper foundation for the admissibility of that exhibit.

As to all other exhibits, we believe there is not a proper foundation yet established in the record for its admissibility.

MR. STAMETS: The Commission will allow these exhibits to be admitted in this case; however, we wish it known that we will give these exhibits only as much weight as they should be given and considering the fact that there was very little evidence as to exactly where the samples were taken, not very good record of the samples, when they were taken, how they were taken, we do not believe that this particular testimony will be given much weight in this case.

We'll recess the hearing until 1:00 o'clock.

(Thereupon the noon recess was taken.)

MR. STAMETS: The hearing will please come to order.

Mr. Taylor, you may present your witness.

RICHARD MEYERHEIN,

being called as a witness and being duly sworn upon his oath, testified as follows, to-wit:

DIRECT EXAMINATION

BY MR. TAYLOR:

Q Would you please state your name?

A Richard Meyerhein.

Q How do you spell that?

A M-E-Y-E-R-H-E-I-N.

Q And would you tell us your position for whom you're employed -- by whom you're employed?

A I'm employed by the New Mexico Scientific Laboratory Division and I am a Supervisor of the Organic Section.

Q And have you ever testified before the New Mexico Oil Conservation Division before and had your qualifications accepted?

A No, I haven't.

Q Would you please then briefly state for us your professional -- your educational background and your professional experience?

A I have a BS and Master's degree in chemistry and I have been working at the State Laboratory for about fifteen years running chemical analyses of organic type compounds.

MR. TAYLOR: Mr. Chairman, are the witness' qualifications acceptable?

MR. STAMETS: Any questions of his qualifications?

He is considered qualified.

Q Mr. Meyerhein, could you explain to us when a sample of organics is received at the Scientific Laboratory Division, what procedures are followed to analyze that?

A Well, referring to samples like we're talking about today, which would be purgable aromatic samples, the sample is entered into the Laboratory. It's given an accession number and then taken up to the section for analysis.

The samples are kept at 4 degrees Centigrade until they are analyzed. At that point we analyze these samples by a purge and trap technique, which means taking a portion of the sample, purging it with helium to drive the purgable compounds out of the water, trap those, and then analyze them by gas chromotography, using either a photo-ionization detector for the aromatic compounds or a mass spectrometer as a detector.

Q Let's see, I suppose you just explained to us what the techniques are you use to analyze them.

If the vial in which you receive the sample contains any sediment or oil droplets, what is the -- with the produced water, how is the sample extracted in order to lessen any impact that those might have, and what would be the impact on having either oil droplets or sediment in the sample?

A If there is more than one phase in the sample, in other words something that is not soluble in water, either oil or a sediment phase, we try to avoid taking any portion of this other phase into the sample that we actually analyze.

With samples that are high in concentration, normally, as with produced waters, we take a very small volume to actually analyze, much less than a milliliter to actually analyze, and we obtain that sample by first of all, if there is an oil phase above the water, we try and remove the oil phase either by absorbing it with a Kleenex-type material or pouring it off the top of the sample, and then taking a sample with a syringe from the middle of the vial to avoid any oil droplets.

Q Thank you.

A The other part of your question is if there was an oil droplet in there, it would probably lead to higher results if there were aromatics dissolved in the sample.

Q What is the solubility of benzene in water?

A Solubility of benzene in water is close to, let's see, it's close to two grams per liter; a little less than two grams per liter.

Q What other -- or what types of groundwater have high levels of benzene in them, that you -- in your knowledge and work experience?

A Generally the samples that we see benzene in are samples with a known contamination source, such as gasoline spill or where gasoline has been leaked into the groundwater, and we pick benzene up from these samples very regularly.

Q Any others?

A Well, we see benzene in groundwater from areas such as Hobbs, from an oilfield-type area where the aquifer has been somehow contaminated with oil.

Q And benzene is not a -- is not normally found in groundwater?

A No.

Q So if you find benzene in the water samples you know that some source exterior to the groundwater is the cause of that.

A Yes.

Q What are the levels of benzene that you find in these samples?

What is the range of levels?

A In produced water samples? We see everything from very little or no benzene up to the high, oh, hundreds of milligrams per liter range; hundreds of parts per million.

Q Generally in those samples in which you find high levels of benzene, are oil droplets or other evidence of oil or hydrocarbon necessarily found in that sample, visible, what we'd, I guess, refer to as a two phase?

In those with high levels of benzene, have you normally found oil droplets or is that -- is there

MR. STAMETS: Are there questions of this witness?

Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Schultz, at the beginning of your introduction we're going to hear about reality, about what actually goes on in these wells.

In previous testimony Mr. Baca said that should water be mixed in with the discharge the evaporation would be lessened rather than increased, and he had calculations that would indicate that.

Do you have calculations that would contradict that from your statement that if it was water that discharged the evaporation would actually be greater?

A Yes. I have calculations here with me that were done by chemical engineers from Meridian Oil Company.

I might point out that I am not a chemical engineer but feel I'm qualified to interpret their calculations.

Q Based on what physical law were your calculations done?

A I did not do the calculations.

Q Would you be able to give those to us and tell us by what laws of chemistry they were calculated?

MR. PEARCE: With the Commission's permission, we'll be happy to prepare that and in readable form, not hen scratches, and provide that, with all indications as to how these calculations were performed.

Q You talked about the volatilization calculated in a saturated column from the -- was that a Federal report?

A Yes. U. S. Environmental Protection Agency.

Q Okay, would you describe the type of column that was used, whether the area of the exposed column had a certain relationship to the total volume of the column?

A Yes, the column was one meter deep -- one meter deep.

Q What was the surface area of the column exposed?

A That I don't know. This is a literature review and you'd have to go back and look at the citations to -- to see that.

Q From your experience as a hydrologist, would that have a bearing on volatilization?

A Absolutely.

Q So you don't know really for sure whether that model would fit a pit because you don't know whether the dimensions of the model column fit the pit.

A Oh, to the contrary. These, I think, are very real world numbers, unlike those for deep bodies of water, which these -- as numbers have been developed before.

This study was done to show the fate under environmental conditions and not the fate under theoretical conditions.

Q And then you made a comment that once the liquid is put into the pit, after a certain period of time there would be a very small amount of, say, benzene left, and I don't recall what -- what the figures were that you gave, after so many days and so much.

Could you restate that?

A Certainly could. That table, by the way, is contained in Tab Section No. 3, the next to the last sheet.

MR. PEARCE: I believe that's Tab No. 2, sir.

A I'm sorry. If I may correct myself, that's behind Tab No. 2, the second to last sheet, and for example, shows at 15 half lives, .003 of a percent remaining.

Q Okay. So then in what you said in the real world in a pit and after these three half lives the water would be -- have a very low level of benzene, right?

A It would have .003 -- it could have .003 of a percent of the amount in there initially.

Q But that doesn't fit the real world in that let's say you put -- the next day you put the same amount of benzene in there, and then the day after that you put the same amount of benzene in there, and the day after that.

Using the appropriate mathematical model on that, wouldn't your actual stabilized volume start approaching the percentage that was actually put into the pit, if we're talking about real reality and that you're adding water, you're adding benzene.

A That might be the case given continuous discharge to the pit and high volume flows but in my observation of these pits, the residence time in the pit is much longer than -- or long enough to account for some decrease.

I don't want to mislead you by stating that this is a one time input of that concentration and that the amount leaving the pit is going to be .003 of a percent. I want to point out that the concentration of the pit will most likely not be the concentration leaving the bottom of the pit.

Q However, aren't the figures in this table a one time incident and not a continuous application of these?

A Yeah, but the thing you need to keep in mind is that we have particles of water and this is going to be correct under the thinking that you're presenting if we have rapid -- large volumes of water flowing in here and rapid flow out of here.

Q Well, rapid doesn't seem to matter. We're talking about dimensionless numbers here, percentages and amounts, so doesn't this volatilization account for two gallons or two barrels or twenty barrels a day?

A I'm not sure if I understand that question.

Q Well, you're saying it would make a difference on the amount and the volume of water that would be coming into your containing basin.

A Correct.

Q But don't these figures imply either two gallons, two barrels, or say twenty barrels a day?

A These numbers apply to this one time input if we had this volume of water here. To calculate what's coming out of the bottom would require sitting down, making some assumptions and determining what's coming out of the bottom.

I'm not trying to imply that this is the case for all pits; merely that we're having a removal of benzene and toluene from the surface.

Q But if --

A And if the residence time is long enough and the infiltration is well enough and the bottom of this pit is sealed, we're somewhere in between two things. We're somewhere in between all of it moving out and none of it moving out.

Q Okay, but isn't this model actually based on none of it moving out?

A No. It can be based on some of it moving out. As long as there's -- as long as it stays in there 15 half lives, it's going to be decreased.

Q But there's still additions of benzene and water to the pit during this time.

A That's correct.

Q So at some point we reach a stabilized volume or percentage of benzene in the pit water.

A It could but not under all cases.

Q Under cases of continual application and no change -- I mean continual discharge of approximately the same amount of water and then --

A It could possibly happen.

Q Okay. If the retention time is, say, such that half of the liquid discharged into the pit soaks into the ground daily, therefore it doesn't have the retention time necessary to get down to these lower half lives, at some point will you not reach a stabilized percentage of benzene entering the ground, out the bottom?

A An equilibrium amount?

Q Yes.

A Under some cases, you could.

Q What type of cases?

A Where you have high flow rates.

Q What is high?

A What is low? We'd have to look at some specific numbers and do some calculations. I can't off the top of my head give you gallons per day or barrels per day or --

Q Again we're not talking about reality, we're talking about theoretical proportion, right?

A Well, we're talking about reality but we're not talking about specific cases.

Q In your model for volatilization of, let's say, for example, benzene from the soil, does the benzene, the benzene, proceed in only one direction from, say, the source in the -- when it breaks loose from the water? Does it go straight upward or does it go in many directions?

A It can go in many directions.

Q If the flow of the water is downward at a certain rate, let's say, say 20 millimeters per hour, or per day, whatever, would that exceed the rate of the benzene flowing upward; the speed of the benzene that would be volatilizing towards the surface?

A Would you restate that again now?

Q Well, I need to restate it a different way.

Can the -- can the velocity of the water downward exceed the velocity of the volatilized vapors?

A Moving out? The velocity could.

Q Do you know what the velocity of volatilized benzene is proceeding out of the soil when it's covered with a head of water above it?

A I have not measured that.

Q So again we're talking about a theoretical perhaps one time incident and not a continuance?

A Absolutely not. If we put up that chart again, if we put up this chart again and this water is moving vertically downward at any velocity and this organic solute is leaving that water at some point irrespective of velocity and that soil gas is leaving, it's going to be removed from the system.

Now, I'm not trying to mislead you by saying that this is a one way process. This is a reversible process. It is rate controlled and as long as the rate of removal is greater -- I mean the rate of volatilization is greater than that going back in, and it's being removed from the system, and the concentration will decrease.

Q Have you done any calculations to determine when equilibrium would be reached and there would be as much benzene going down as would be coming up on account of volatilization when you have continual additions of --

A It's not necessary for a calculation because all you have to do is put a box around this and that's the only case which is going to reach equilibrium.

Q Do you expect the process of this soil gassing to be occurring underneath a saturated pit that's full of water?

A It won't be occurring directly in the saturated zone because there isn't any soil gas for it to move out of, but the solute can move through the water phase until it reaches soil gas and if the concentration is such that it's pulling it out, it's going to leave.

So on the edges of a saturated front you're going to have some volatilization of the organic solute.

Q Once you have a saturated column from the dip to the water table, will the mechanism of the soil gas working with the volatilization cease at that time?

A No, even under a one dimensional case, if you look at any of the standard textbooks and DeVore has been cited here a couple of times, look at the last figure in that chapter that describes that, you'll see in reality a partially saturated fringe that comes out along what appears to be one dimensional downward flow.

I'm not trying to mislead you in that this is a mechanism that can remove all the benzene and toluene. It's merely a mechanism that removes some of it.

The point you're trying to make is the exact same point I'm trying to make, is that all these processes and mechanisms are rate dependent and to come up with a specific number for movement from any point to any other point requires making a lot of assumptions and taking typical cases.

Q Did you take into account or use any particular cases, for example, with low volumes, such as, say, below 5 barrels of water per day?

A No, I did not. That was not my intent. My intent was to show additional mechanisms which have not been presented before this Commission before, which I felt were important for the Commission to consider.

Q Are you familiar with water wetting and the difference between water wetting and oil wetting in soil?

A I'm not an expert in that, in two-phase flow, but I am aware that those things occur.

Q In your experience or with your knowledge as a geohydrologist, would water wetting on these, say, soil drain surfaces decrease the amount of sorption that takes place of the petroleum product onto the surface?

A You're saying the organic solute in solution in the water?

Q Yes.

A Or pure flow of hydrocarbons?

Q Either way, or both.

A Under pure flow of hydrocarbons, if you have a three-phase flow, you need to consider this is really two-phase flow, although most people don't consider it that because they ignore gas movement. But this is two-phase flow, a water phase and a gas phase.

If you had in here heavy hydrocarbons that were not dissolved in the water and you had three-phase flow, then there certainly would be an interaction between -- or some sort of interference between water and organics.

Q So would therefore, say, water wet soil attenuate the sorption of the hydrocarbons?

A Yes.

Q Have you calculated what would happen to the valuable hydrocarbons when sorption would reach saturation?

A As I pointed out, this is not a removal mechanism but merely a delay mechanism.

Q Yes. At a certain point the sand surface will not take any more hydrocarbon. What will happen then?

A This is a reversible process. At any one time there are always solutes leaving and if there's a site left there the ability for another solute to come back along will be there.

This is a plume moving at a much slower rate than the water velocity.

Q You still haven't answered the question, though, whether -- can there be a saturation point reached underneath a constantly water wet pit whereby there's no more gas directly underneath it and sorption has reached its maximum? Can such a condition exist?

A Sorption is not boundless, if that's what you mean. There will be a point at which all the surfaces could be covered with organic solute, if we think in terms of the micro-scale, and if it were an irreversible physical process, you could reach saturation in which no more organic solutes would attach themselves to the surface.

So sorption is not an irreversible physical process. The rates may be different for sorption versus desorption and those numbers are not well determined by anyone at the present time.

Q They may not be well determined but you have got an idea of which would be acting more quickly in a ground water system below --

A Sorption or desorption?

Q Yes.

A Sorption acts more quickly.

Q So generally you'd be putting more hydrocarbons onto the surfaces than you would be -- than would be leaving the surfaces, is that correct?

A At any one point I'd say that could be the case.

As I pointed out before, these are rate controlled mechanisms in which the extremes either way are particular cases but there are an infinite number of cases in between.

Q As a geohydrologist have you -- I'm thinking out loud right now, I'm trying to ask you a question.

Have you looked at the mechanisms you talked about, especially retardation factors, as they may parallel certain production systems within an oil and gas formation, which retard oil and gas from reaching the wellbore before water does?

Have you ever tried drawing a conclusion or similarities or have you thought --

A You're already saying movement from a dip towards a well?

Q No, I'm talking about two mechanisms here.

You're saying that retardation affects the rate of hydrocarbons moving downward through the soil more than it does the water.

Do the same mechanisms apply, to your knowledge, when producing oil or gas from the formation into a wellbore, whereby perhaps hydrocarbons of oil or gas are retarded from production into the wellbore and water is produced more readily?

A I guess I'm not sure what you mean by wellbore. You're saying water flowing into a pumping well?

Q Maybe I should go to another question, but I'll just try to draw a similarity.

Oil and gas in a formation move to a wellbore --

A Oh, right.

Q -- during production.

A A very important thing to remember when making an analogy between -- and a fallacy, not a fallacy, but a misconception that you can fall under, is that flow oil and gas is in a confined system, and water, in the cases we're looking at here are unconfined.

So the two-phase flow falls under different -- different assumptions in going after theory.

MR. CHAVEZ: I think that's all

the questions I have.

MR. STAMETS: Dr. Eiceman.

QUESTIONS BY DR. EICEMAN:

Q Dr. Schultz, I'd like to address some questions here to your section on volatilization which is found behind Tab No. 2 and it's on page, looking at the bottom, 71-3.

MR. KELLAHIN: Mr. Chairman, a point of procedure.

Are we going to allow participants in the audience to cross examine the witnesses as we go through the hearing or are they to be represented by counsel?

MR. STAMETS: Mr. Kellahin, in the past we have allowed citizens to represent themselves before the Commission.

My understanding is that Dr. Eiceman is here representing himself today and so we will continue with that practice.

Q Dr. Schultz, you cite two papers by Mackay, one published in 1975, and I'd like to note that there's an error on this page, though, issued in 1972, according to references back here in the summary area.

A Okay. I -- might I point out that this is an EPA document and not -- not my compilation?

Q Very well. Have you read those papers by

Mackay?

A Which one are you referring to?

Q Both, or either.

A No, I have not.

Q You have not. Your statements on volatilization used the data from both of those papers. I've read them exhaustively.

Do you know what type of apparatus was used in those studies to calculate the rate constant in moving benzene and volatiles from water?

A No. My discussions recently with Doug Mackay, we did not discuss that.

Q Yes. Is it not right -- do you know what type of samples were used in these studies?

A No, I do not.

Q It was a dilute solution of benzene and --

MR. KELLAHIN: I'm going to object to the questioner testifying while he's asking his questions. That's not appropriate even if he's not an attorney.

MR. STAMETS: That is correct. If you have some additional testimony you can give it at a later date and not introduce or do that at this time.

Q All right. Mackay worked with dilute solutions of benzene in pure water and developed his base concept.

MR. PEARCE: Excuse me, Mr. Chairman, we just went through this.

Q Okay.

MR. PEARCE: He can ask the witness if the witness knows that and the witness can answer.

It is not appropriate for Dr. Eiceman to provide some testimony for the record here in questioning.

Q Would you expect a thin film of hydrocarbon on top of an aqueous solution to greatly alter the rate constant of movement of benzene from the water body into the ambient atmosphere?

A It would have some effect.

Q Some effect? How much effect, do you think?

A I have not measured that.

Q Well, do you think it might be 10 percent, 20 percent, 80 percent?

A If it was pure benzene it could be much higher.

Q Okay. As a -- as an expert in this area of movement, I was lead to believe that you were talking about a real world situation in which there would be a film of oil on top of the tanks.

Have you read an article by Baker and Brendecke (sic) in Groundwater, 1983, Volume 21 as a -- as an expert in this area?

A I read Groundwater since I subscribe to it.

Q Yes.

A I can't recall at this point whether I have read that particular one in the last two years.

Q So in essence, then, what your testimony is, is that you really haven't looked at a real system when they used numbers on a real system with this thin film of oil on top, have you?

A I have not looked at a thin film of oil on top of the water.

Q Thank you.

MR. STAMETS: Are there other questions of this witness?

MR. TAYLOR: Mr. Chairman, might we have a moment? I have some questions that I need to get organized.

MR. STAMETS: While you're doing that I may ask a few myself.

CROSS EXAMINATION

BY MR. STAMETS:

Q Dr. Schultz, looking at the second page behind Tab 3 you show a two dimension partially saturated flow.

In response to some questions asked by

Mr. Chavez I was lead to believe that for the center arrow on this diagram we would be looking at saturated flow and that for those outer arrows there would be some space of unsaturated flow.

A May I answer that by referrring you to a figure in the technical paper following that diagram, namely Figure Number 8 on page 5730?

Q Okay.

A And if you will allow me to have you put your finger there and then move forward to Figure No. 3 on 5727.

And if you look at the top figure you see it's quite similar to the diagram that we had up here today. It's a two dimensional flow beneath a 15-foot canal with homogeneous soil.

Anyone who is curious about the difference between a canal and a pond could refer to the figure directly below and you'll see there are some differences but not markable.

Now, keeping that in mind, looking back at Figure 8 again, the first one I referred to, this two-dimensional moisture content pattern below a 15-foot canal, homogeneous soil, the numbers you see there are -- can be represented as percentages, for example, extreme right, .09 is 9 percent. Moving all the way over to .33, which is 33 percent. That's the quantity of water per -- based on percentages per unit volume of material with water in it.

That's for this particular soil in which this particular researcher did his study. He had a porosity of 33 percent; therefore everything to the left of that line marked .33 is saturated and everything to the right of that line is partially saturated.

So here we see a case of a water level in a homogeneous soil, constant water level, which there is saturated flow in a lobe, if you could look at this in three dimensions, we have a lobe of saturated flow beneath canal but out to the edges we have partially saturated flow.

So the mechanisms that I have described that occur under partially saturated flow conditions will occur to the right of that .33 line.

And it's interesting to note while we're drawing our attention to this, that you can see 9 percent water 40 feet out to the side of the pit, which means you're also going to have some organic solute from that pit out at that distance.

Thus we have a very large volume, a very large sphere of influence for some of these mechanisms to occur.

Now I might point out that there -- just to show you some alternate cases, that if the canal were moved down closer to the water table, looking at that same figure, that that .33 line is going to inset -- or intersect the water table. In that case we will have continuous saturated flow from the canal towards the water table.

This is one particular case as is the totally saturated case one particular case.

Q That would mean that if you had a pit located over a sufficiently shallow aquifer and if you had additions of water to that pit to cause constant downward flow, then some of the dissolved benzenes could enter the water table.

A That is correct, and I have not attempted to make arguments contrary to that, only to point out additional cases which I feel to be representative of many pits.

Q And then right behind Tab 4 what you have depicted there is at the margins of the flow chains.

A It could be anywhere in that partially saturated zone.

Q Now you've identified this soil gas. What actually happens to the benzene, for example? Does that volatilize into the soil gas?

A Yes, it can.

Q And then the soil gas and the benzene move out of the soil?

A Yes, they can, by two mechanisms: Diffusion, which is based on analogies with oxygen and carbon dioxide work. It seems to be the main mechanism.

But a secondary mechanism is this what I call mass pumping, and a sucking in and pushing out that can occur in partially saturated conditions.

Q And are those processes sufficient to keep soil gas in this semi-saturated zone?

A I'm sorry, could you state that again?

Q Are the processes sufficient to keep soil gas in this semi-saturated zone?

A Yes.

Q So that once this gas moves out, it's going to be replaced by some more gas tomorrow.

A Yes. You can -- you can think of this as -- I am not an agricultural engineer or a plant physiologist, but in the soils courses that I've taken the movement of oxygen to the root zone of plants is well documented. Roots require, at least some roots require oxygen, and this is why this mechanism was discovered, and as an illustration of -- of that occurring, if you would have houseplants and keep them totally saturated, there's an eventual fate there.

Q And then immediately behind Tab No. 5, the second page behind Tab No. 5, the solute velocity retarded by sorption, this reminds me of, and see if I'm at the right analogy here, one of those little water filters that you put on the tap at the house, a little charcoal filter in it that will remove impurities, and this again goes along with Mr. Chavez' question, just a matter of clarifying this --

A Uh-huh.

Q -- my understanding is if I leave that charcoal filter on there long enough that it does no longer do any good; that --

A That's --

Q -- eventually what I'm getting out is at least as bad as what's coming in.

A That's correct.

Q Okay, and so the same thing would happen here if you had a constant passage of a solute by the soil and it remains saturated, eventually the soil would absorb as much solute as it could and you would have as much coming out at the end as you had going in at the beginning.

A Correct, but with one important difference. If you had no removal of solute, if your organic carbon filter underneath your sink was removing volatile organics and you could hook a fan up to it and pass air through it, it could regenerate itself.

Or if you had another mechanism which we haven't discussed yet, biodegradation, and in fact biodegradation can occur in organic carbon filters, that's why the taste gets worse with time.

Q What did you say the retardation factor for PAH's was?

A Based on available numbers from the literature and taking conditions of 2 percent organic matter -- I'm sorry, not organic matter but organic carbon. There is a difference between those two. For the conditions of 2 percent organic carbon and literature numbers to derive retardation, you have for anthracene and naphthalene as examples of PAH's, that can range from 91 to 2500.

I might point out as an example of that, a superfront project that I'm currently working on in the State of Montana, which involves, or involved wood treating of telephone poles and railroad ties, in which over the twenty years of operation of that facility the conservative estimates are a million gallons of treating fluid lost to the ground water, and we find anthracene no more than 200 feet from the site over twenty years, with velocities in glacial tills that exceed 4 or 5 feet per day, not glacial tills but glacial sediments including tills and gravels.

Q Would you agree with earlier testimony that benzene is not a naturally occurring constituent of ground water?

A Well, that -- that -- I would have to say yes with one exception.

If we take for example Hobbs, by pure definition I would say that hydrocarbons in the water near Hobbs is naturally occurring -- is naturally --

Q At least it is now.

But in general, if one finds benzene in groundwater as Mr. Zaman has in his pits, then that means that somehow it got there from a disposal pit, a well, something happened to put that benzene in the groundwater.

A Right, if there's no other mechanism,

that's correct.

MR. STAMETS: Are there other questions of this witness?

MS. PRUETT: Yes, sir.

MR. STAMETS: Ms. Pruett.

CROSS EXAMINATION

BY MS. PRUETT:

Q Mr. Schultz, you presented some tables showing figures on pan evaporation.

Do you have any figures or can you tell us whether the figures would be greater or lesser if you did the same calculation for wet soil? Pan evaporation is different from --

A Soil evaporation?

Q -- evaporation from wet soil.

A Uh-huh.

Q Would it be greater than or less than?

A I really don't know.

Q And you did no calculation for the same -- same method in wet soil?

A No, I did not.

Q You presented us with a volatilization curve for benzene and toluene.

Did you do a similar volatilization curve for produced water?

A No, I did not.

Q (Not understood)

A No, I did not. Well, those elements benzene and toluene we did, but no other solutes, nor water.

Q You've discussed removal by sorption. I believe Mr. Boyer entered into the record in his Exhibit Seventeen an article entitled Organic Compounds and Groundwater Pollution by Wayne A. Pettyjohn and Arthur W. Hounslow.

This article states on page 46 to which I'm making reference, --

MR. PEARCE: Excuse me, could the record show that the witness has just picked up a copy of that article?

Sorry, please go ahead.

Q Volatility is not an important attenuation mechanism when the compounds lie deeper than a foot or more below the soil surface.

I believe you stated in your testimony that you had your volatilization figures you showed were a meter or so below the surface.

A Yes.

Q And your calculations are not based on any soil characteristics deeper than that, are they, where volatilization would not be, you might say, a significant factor.

A They start out by retardation and my comment on one meter depth was for a water filled column or a pit; not one meter in soil.

Q Okay. Are you willing to agree with me, however, that volatilization deeper than one foot below the surface would not be particularly significant?

A I'd have to know what you mean by significant. I was an editor for <u>Groundwater Monitoring Review</u> and edited this paper prior to its publication, in which case I made some comments to Wayne Pettijohn about attaching some numbers and at the time they felt that there isn't enough documentation to attach numbers to these mechanisms, just as I feel that it's very difficult to do this here and prove with one particular case that that case applies to all situations.

I would agree with you that the volatilization probably decreases with depth, although I would have no idea what that depth limitation might be.

Q Thank you.

Can you provide us with estimates of the diffusion rates for gases which volatilize in the soil under unsaturated conditions?

A I don't have those with me.

Q Do you have those calculations? Have you performed those estimates --

A I have not done that.

Q Can you tell us whether -- can you tell us whether it's a relatively slow or fast process? Can you give us any estimates of which it is?

A I think it's a significant -- a minor component of these other mechanisms.

Q Okay.

A But one which needs to be considered.

Q Turning to the diffusion rates of gases, like benzene, through a liquid under saturated conditions, isn't it true that that process occurs so slowly as to be almost insignificant before the liquid would reach groundwater given a relatively shallow water table, such as there is in the San Juan Basin?

A That's probably the case. I didn't even consider diffusion through water since you are correct in stating that it is very low. I'm only looking at that interface between water and air.

Q Now you have stated that adsorption can be a reversible process, and doesn't it mean that every time there is rain or snow melt or additional water added into those pits up in that area, that desorption can occur and migration will continue towards the water table?

A Movement will always occur.

Q And referring to the finite limit, or the finite capacity of soil to absorb contaminants, sorption capacity, what happens when the sorption capacity is reached?

A I think there's a good case that it may never be reached because of removal processes.

Q Sorption capacity can be unlimited?

Q Not sorption. If it is removed from the water the concentration of water decreases and sorption is reversible, it could go from the surface of that organic constituent back into the water and volatilize back into the gas phase.

Q So you think enough will be removed so that sorption capacity will never be reached?

A No, I did not state that. I'm stating that the -- for a particular point beneath a pit sorption capacity could be reached, okay?

Let's remember that I'm talking about mechanisms of attenuation that have two things: One is delay and one is removal.

Sorption is delay.

I'm not trying to create the impression that sorption is a removal process.

Q If sorption capacity is reached and additional liquid is added, then what happens?

No more sorption can occur and migration toward the groundwater will continue, isn't that correct?

A That's correct in that extreme case.

Q Thank you.

Turning your attention to benzene which has been found in produced water, based on previous testimony with Mr. Boyer, how would you describe the sorption capacity of benzene?

A With a retardation number.

Q Do you think those numbers are relative with every --

A Uh-huh, shall we look at that table with numbers I presented or -- that table to which I refer is the third page behind Tab No. 5.

Q How does that compare to other produced water, produced water cantaminants, such as remainable paraxylene, p-a-r-a-z-y-l-e-n-e -- x-y, I'm sorry.

A I did not consider xylene since it's not a priority pollutant.

Q It's not what?

A Not a priority pollutant.

Q But it is a produced water -- it is found in produced water.

A That is correct.

Q Do you know what the comparative sorption capacity is?

A No, I do not.

MR. STAMETS: Are there other questions? Mr. Shuey.

QUESTIONS BY MR. SHUEY:

Q Dr. Schultz, I couldn't resist asking a former Ohioan some questions here. I didn't attend Ohio University, though.

A Neither did I. I attended Ohio State University.

Q Referring to your Exhibit One here, I believe under Tab 2, the first page, a summary of climatological data there for Farmington?

A Yes.

Q The first column, or second column for pan evaporation, would that be for water standing in a puddle?

A No, that would be for water at a standard evaporation pan.

Q Okay, is that -- would that be applicable to produced water in a pit?

A No. As I stated in the record, it's more likely that the second column from the right, lake evaporation, would be closer to evaporation of water from a pit.

Q Okay. Could you turn then to the same tab, the next to the last page, Volatilization Half Lives in Water for Benzene and Toluene?

A Yes.

Q What kind of water was that?

These calculations are for what, benzene and toluene volatilized in water. Tap water? Produced water? River water? Sewage water?

A You have to look at the references in the EPA document to find out the experimental conditions under which those numbers were determined.

Q Oh, so that -- that's then -- this table here goes with the EPA document earlier?

A The table doesn't come from the EPA document. We've taken the half lives from the EPA document.

Q Uh-huh.

A And then calculated the numbers of half lives and the percent remaining.

Q I see. Okay. Are you familiar with the rate equations for volatilization?

A Not -- not -- pardon me?

Q From an aqueous solution?

The rate equation for volatilization?

A I can't state that without looking at a reference --

Q Okay.

A -- but I'm familiar with it.

Q Okay. You're familiar with it. Would that be the rate of volatilization equalling a rate constant times a concentration to a certain N power?

A Might.

Q Okay, let's just -- if that rate constant was pure water, what would be the rate of volatilization if the concentration was for benzene, say? It that rate constant was pure water, what would be the -- would that rate of volatilization go up or down?

A Relative to -- I'm not sure I understand your question.

Q Okay. The -- in the equation the rate constant is multiplied by a certain concentration to an N power, okay. If that rate constant was -- if you were looking at the behavior of that concentration in pure water, okay, what would happen to the rate of the volatilization?

Would it go up or down?

A I guess I don't understand. If you're asking a question comparing pure water versus other waters and rate constants determined from those, there will be a difference.

Q What will that be, say, for -- between pure water and produced water?

A That I would not know.

Q Okay. Turning to Tab 5, going to the third page, the retardation factors table, is this -- could you explain to me how this -- how the benzene and toluene that you've got being retarded here under certain percentages of organic carbon, is that in soil or water, or both, or what's the medium that these things are passing through?

A In order to answer that you have to go back to the literature to get the numbers that these calculations eventually resulted in and those are the log octanol water partition coefficient and these are ranges for real world conditions by a variety of researchers.

Q I see. Did these researchers -- I take it you reviewed the literature from --

A Correct.

Q -- the researchers --

A I can give you reference --

Q Pardon me?

A I can give you the reference from which the KOW's came from.

Q Okay. After -- later, is that what you're saying you can give it, or now?

A Would you like it right now?

Q Sure. I don't want to delay things.

A Well, then you can get it afterwards.

Q Okay, great. Did these researchers -- did these researchers look at benzene and these retardation factors here in a -- in a system in which the only hydrocarbon was benzene?

A No.

Q Were there other hydrocarbons with it?

A There are -- I'm -- I'm familiar with a particular case involving a variety of priority pollutants.

Q And did the retardation factors change one way or another in terms of benzene in the presence of all these other constituents?

A That study hasn't been completed and only preliminary results are out.

Q Uh-huh, have you studied whether these retardation factors for, say, benzene and toluene, as you have listed here, would be similar to the numbers that you've given if they were also in the presence of other constituents that were produced waters?

A I would say that it would not be markedly different.

Q Okay. Going to the page before, Solute

Velocity Retarded by Sorption.

A Uh-huh.

Q I've got a little quote written down here that says benzene and toluene are afraid of water. I think that's what you said. Could you explain that?

A It is a phenomenon called hydrophobicity in which the benzene, given a choice, and the toluene, would rather be out of the water.

Q How common is that?

A It's stated here in this paper --

Q Well, let me rephrase the question. Is that a --

Q It -- it -- let me answer this. It is one of two, two major mechanisms controlling sorption of organic solutes; the other being the amount of organic carbon content.

So in answer to your question, I guess it would be extremely common.

Q Why have you first estimated then today and other days that benzene has this affinity for water, highly soluble?

A Solubility is a reversible process.

Q Thank you.

MR. SHUEY: No other questions.

MR. STAMETS: Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Now, Mr. Schultz, back on page 5727 after

No. 3 in your exhibit --

A Yes.

Q -- which one of these graphs better depicts -- would be a better model for a pit?

A Figure No. 4.

Q Is the rate of downward movement of water faster towards the center of the -- that body of water depicted on the chart or at the outside?

A Towards the center.

Q Is there something on this chart that would allow us to compare those rates of water movement downward?

A No.

Q There's a possibility that the majority of the water could be moving down from the center of the pit rather than through the area of the fringes of the saturated zone.

A We would have to define what you mean by that, but it's likely there could be more if you look at the whole pits.

Q Mr. Schultz, I've noticed that again we're talking about reality yet we haven't had an example or a model built calculating the rate that perhaps benzene or toluene or any other substance, even the water, would reach the water table over any certain period of time using, say, the average volume from the wells operated by Meridian.

We've talked about figures such as more, less than, some. We're describing attenuation factors yet we don't have any concept yet as to how much or these attenuation factors affect the water that's produced into these pits, then starts soaking into the ground.

Have you done any calculations at all or built any model based on any well average on any water sample given you by Meridian?

A I have not yet done that.

Q Do you intend to do that?

A If directed to. But, as I stated, my purpose here was merely to show mechanisms that occur that have not been presented before the Commission before and need to be considered when reaching your decision, and --

Q So --

A -- and it is, excuse me for interrupting you, perfectly capable of picking some set of conditions and, to the best of our ability, determining some number.

Q But have you determined it?

A I have not.

Q Yet other authors have determined certain numbers for the attenuation effect of benzene -- I'm sorry, attenuation effects of sorption, of volatilization under the ground, and so on.

Would these other authors or experts who have made statements that -- that such effects are not great or they may be great, could we take what they say in acknowledging that these attenuation effects exist?

A Yes.

MR. CHAVEZ: That's all I have.

MS. PRUETT: One more very quick question.

MR. STAMETS: Ms. Pruett.

CROSS EXAMINATION

BY MS. PRUETT:

Q Your Tab 5 page three figure on the retardation factors, you stated that an independent lab performed those tests.

Could you tell us what independent lab and provide us with copies of those reports?

A The -- yes, we could. The independent lab did the organic --

Q Carbon content.

A -- carbon content.

Q Could you provide us with copies of those?

A Yes.

MR. STAMETS: Are there other questions?

Mr. Taylor.

CROSS EXAMINATION

BY MR. TAYLOR:

Q You stated in relation to flash volatilization, or talking about flash volatilization, the calculations made by Mr. Baca in his testimony a few weeks ago, were based on a solution of benzene, toluene, and xylene.

You stated that flash volatilization of benzene in solution with produced water would probably show a higher degree or at least the same amount of volatilization.

Did you perform any calculations to base that on?

A No. I reviewed the calculations done by Meridian and one of their chemical engineers.

MR. PEARCE: Excuse me. I believe that we've said that we can prepare those in readable form and submit them. I don't think he can repeat those calculations for you, but you can certainly ask him.

Q How rapidly would the sites for benzene retardation be taken up, and I think you talked about these as soil gas, if I understand, be taken up by produced water and would we encounter a situation similar to a sponge that can't hold any more water once it's -- once it's filled up, and isn't this a potential that could occur at a wellsite, especially if desorption is less than adsorption?

A Yes. As I pointed out several times, sorption is a delay mechanism, not a removal mechanism, and that there is a movement of the organic solute but at a velocity slower than water.

So if you look at this centimeter here

right beneath the pit, there's a dynamic equilibrium there with the solute going on to the soil particle and coming off and it's certainly possible and most likely that if that cubic centimeter with all the sites it could -- given a high enough concentration of the organic solute, that all the sites could be taken up at any one time.

Q And would essentially your model not be working at that point, that the benzene, or whatever, would be going right into the soil and eventually to groundwaters?

A No, as I think you may have misunderstanding.

The diagram we had up here is a synoptic picture. It's a one time shot, if we had a Poloroid camera on what's happening in sorption and if we look back at that -- if we take a picture of what's happening there, we see this solute particle here, for example, at this location but we don't know in the next second whether it's going to be going this way or going that way.

This is a dynamic equilibrium and I am not, to restate for the third or fourth time, not indicating that these are totally lost. This is merely a delay mechanism, but when you combine mechanisms, and this is where the real world comes in, with the multiple variables all at the same time, we look at some of the removal mechanisms, we have the gas up here, this solute particle may go from water phase to gas phase and be lost.

If we had a microbe here, which you'll

hear about in a few seconds, it may chomp down on that and get rid of it. It may chomp down on all those and get rid of them allowing more organic solutes to go from the surface back into solution.

So the important thing here, as with previous testimony, is that these mechanisms occur and you can always pick the extreme of -- of infinity or zero, but the more rational approach is to take some case in between.

Q I'll get back to it in a minute, but have you read the testimony of the last hearing relating to this, Mr. Boyer's testimony on this?

A Let's see, the -- I've heard his testimony from a previous hearing, the calculations for out of a pit into the groundwater?

Q I just wondered. I'll get back to that.

What, of the six phenomena that you've described here, which has the greatest amount of influence and do you have any data to support this?

A I haven't, and I'm not qualified to talk about mechanism number six, so we'll have to eliminate my comments -- or limit my comments to numbers -- numbers one through five.

And in my professional opinion, if we picked a particular case, we could state which one is greater. If we picked another case, I'm almost certain that another mechanism would be the, if you're talking about removal, could be the major mechanism.

Q I think the EPA publication reference was prepared for aquatic surface water conditions.

Would the fate of benzene be of the same significance in groundwater?

A I don't believe that was in the aquatic fate publication.

Q Which one was it?

A That came from the water related environmental fate of 129 priority pollutants.

I think you must be referring to another publication, I don't have the cover sheet here, which says the aquatic fate of priority pollutants.

Q Okay. I think you've already talked about this but could you just specifically state what you understand about the fate of benzene in produced water when you have two phases in a pit with an oil scum on top and how that -- and how that affects the volitization time.

A It will have some effect. If the surface were completely sealed with asphalt or if it was five inches of paraffin, the volatility of benzene could be quite low.

If you had a nice mixture of things which benzene was quite soluble, it's perhaps possible to have that act as a medium for evaporation.

Q How about just a sheet -- well --

A Somewhere in between there. Once again a rate controlling factor, which for certain stated cases you could calculate a number.

Q And therefore you can't tell us specifically how that would affect your -- your half life chart and the amount of time in which benzene would --

A If the benzene wasn't volatilizing at the same rate, at a slower rate the half life would be longer.

Q What, on the same subject of the half life of benzene, what if you had a dump of say two barrels a day and that two barrels went into the ground every day and there was none left on the surface, how would that affect your models?

A You couldn't reach 15 half lives.

There would be some volatility but it wouldn't be 15 half lives.

Q Approximately what would it be?

A It would depend on how long it's on the surface.

Q Well, let's say it takes a full day every day for the two barrels to soak in but every day two more barrels are added.

Would you just give us an approximation of how you think that would affect a half life?

A The first day the concentration is going to be whatever the table would show for one day's worth of half lives and a subsequent addition is a point we were making earlier, there is going to be a higher concentration but it probably will not be zero. I mean there is going to be some loss due to volatilization.

Q It's not going to be equilibrium, though, after one day -- however, your half life will not be limited to the -- to the number you had at one day.

A No. It's just like we had a open tank full of gasoline flowing by and you were standing there and that rate was going by all the time, you could always smell gasoline volatilizing from the tank.

Q In areas in the San Juan Basin do you know what volumes of discharge would cause saturation versus unsaturated conditions?

A No, I do not.

Q Can you --

A I've not made those calculations.

Q If you had a continuous discharge every few hours a steady state flow would exist in the subsurface.

A It could.

Q Would this retard the upward movement of volatiles?

A In soil gas? Under saturated conditions or partially saturated?

Q Under both.

A The -- there's going to be some volatility under saturated conditions, although low, but there will be some loss, and under partially saturated conditions, if the rate of diffusion and mass pumping keeps removing it from the system, then that will not be a rate controlling factor.

Q Aren't there finite sorption limits in the soil and therefore these continuous discharges cause sorption no longer to be effective at some point in time?

Essentially I think what I was trying to say awhile ago is an equilibrium situation.

A If it's irreversible it will reach equilibrium. If it's not irreversible there would be a dynamic equilibrium in which at any point in time there will be organic solutes going both onto the surface and back off.

Q If you have low residence times due to high infiltration wouldn't volatilization half lives be different because open soil pores might be already saturated with gas saturation?

A Say that again, now.

Q If you have low residence time due to high infiltration, wouldn't volatilization half lives be different because open soil pores might be already gas saturated?

A If it -- in saturated conditions, if you had in the case which you're stating, continual wetting and drying, which entrained gas that's not connected to the atmosphere, those gas bubbles will be in equilibrium with the solute in the water. Those which are still open to the atmosphere will allow a route for removal.

Q Okay. I just want to get some idea as to how -- what the magnitude of the effect your calculations have here, not your calculations but your testimony.

Mr. Boyer testified at the first hearing that using a model that he made that, using a simple mixing model, which I assume you're refuting by saying that things aren't that simple.

A No, I think Dave's talking about mixing in a saturated condition beneath the water table.

Q Essentially you're saying that things do not just go down through the soil, that all these things have an effect on it.

He said that, now let me quote this: This shows that at least using a simple mixing model, which is the best data I have to date, as little -- to discharge as little as 2.5 gallons per day of fluid containing benzene at 13 milligrams per liter caused groundwater to exceed groundwater standard at the boundary of the cylinder.

What kind -- what magnitude of effect do you claim these mechanisms have on his model? In other words, are you saying that it would cut it down in half, it would cause -- or would it cause the groundwater standards never to be exceeded? Would the benzene never go into the groundwater, or what is the effect of these mechanisms upon a model like this?

A I think it's my professional opinion, considering all six mechanisms, that it's logical for a case which could be found in the basin, that it may never reach the groundwater.

Q And how would -- would you explain that a little bit more for me?

A It's merely a matter of having the removal process be higher than the input.

Q But if the --

A And if the company -- and I am not, as I stated earlier, trying to refute whatever Mr.Boyer said, merely point out some additional considerations which I feel were not presented in his case.

Q You stated that often many of these mechanisms do not actually destroy the -- the organics, the benzenes, but merely slow them down.

If you have pits where day after day five barrels or four barrels or three barrels of produced water are going into the ground, how can you -- how could you explain to me that eventually it's not going to reach groundwater? What's going to happen?

A In those cases, which I feel may be too conservative for the average, all these mechanisms are going to occur, whether those things that Mr. Boyer calculated are correct.

But as a contrast --

Q So you're saying eventually those situations will reach groundwater?

A Yes.

Q But you're just saying in some situations it might.

A That's correct.

Q Uh-huh.

A If, for example, we go, as I did last week, to a drip pit, which is half the size of an average desk, it was nothing but gas coming out; very little evidence when I was there that there had ever been any standing water. If at that distance to the water table was even four or five feet, in my opinion without making any calculations, it would never reach the groundwater.

Q So you seem to be saying that his situation, in his situation and his variables it would reach groundwater but each -- each situation must be taken on its own and considered. Some situations it won't and some situations it will.

A In order to make a -- to state a number of travel for every pit would require documenting every pit.

Q Okay.

MR. TAYLOR: I think that's all the questions I have.

A Okay.

MR. STAMETS: Mr. Chavez.

QUESTIONS BY MR. CHAVEZ:

Q Mr. Schultz, are the conditions which would get the variations of attentuation you're describing homogeneous throughout the area that's been described as vulnerable?

A Are you saying are the soil and rock conditions in the vulnerable area homogeneous?

Q Yes.

A They are not.

Q Would then the conditions of attenuation vary from, say, wellsite to wellsite?

A Yes, they could.

Q Would, therefore, determination have to be made, perhaps, for each pit, at that particular site?

A That's one possibility.

Q What's another possibility?

A Would be to assume a general condition and have that apply to all pits.

Q You just stated that --

A Or three types of conditions. My purpose is not to make that determination but to show the mechanisms that are occurring here.

Q Could you give the Division some guidance as to what types of conditions would have to exist at the different sites so that the attenuation would be great enough to not allow benzene and toluene to enter the groundwater?

A That would be possible to do.

Q Therefore any exceptions to a no pit order probably would be more site specific depending on the, perhaps, the amount of benzene, the amount of water, and any general soil type or -- and distance to groundwater? Would you say those factors would be --

A Those would be variables.

Q Would you recommend that exemptions be site specific based on specific conditions?

A I have not been asked to make recommendations.

Q In your experience have you ever done that?

A No. I've never been asked to make recommendations.

Q Thank you.

MR. STAMETS: Other questions of this witness?

MR. TAYLOR: I have one more question, point to make.

CROSS EXAMINATION

BY MR. TAYLOR:

Q Mr. Schultz, I think when you started out with your presentation you stated that the reason you were doing this was because these mechanisms had not been brought to the attention of the Commission and I'd like to point the Commission to page 83 of the transcript from the first part of this hearing, in which Mr. Boyer goes through the major mechanisms of attenuation when he says, includes sorption, volatilization, degradation and dilution.

MR. KELLAHIN: Objection, Mr. Chairman. If counsel wants to make argument, now is not the time to make closing statements.

If that's a question of the witness, it's improper.

MR. STAMETS: Mr. Taylor, what -- what is your point?

MR. TAYLOR: I already made it.

MR. KELLAHIN: I move that Mr. Taylor's closing statement be stricken from the record.

MR. STAMETS: Mr. Taylor, would you please --

MR. PEARCE: Or as an alternative, Mr. Chairman, I suggest that that be taken as his closing statement and he not be allowed one at the end.

MR. TAYLOR: Mr. Chairman, I was merely pointing out that in fact --

MR. PEARCE: Excuse me, Mr. Chairman, what he was doing was making closing argument. Let's not mistake that, about what's going on.

MR. TAYLOR: I was not intending to make closing argument, Mr. Pearce.

MR. STAMETS: The Commission will not allow that statement at this point. It is part of your closing statement, which you will certainly well be allowed to make.

Are there other questions of

of this witness?

MR. TAYLOR: Yes, I have one more question.

Q Mr. Schultz, given the mandate of the Oil Conservation Commission to protect fresh water resources, do you think in areas of shallow groundwater used for public consumption that these methods, these mechanisms of attenuation should be relied upon by the Commission to make sure that pollution does not occur?

A I think there are additional things that the Commission should consider.

Q So you agree that these mechanisms alone should not be relied upon to -- by the Commission as a prudent public body to make sure that public groundwater is not contaminated?

A There are other factors such as the ones presented in previous testimony that need to be considered.

Q Thank you.

MR. STAMETS: Any other questions of this witness?

Mr. Kellahin?

MR. KELLAHIN: Mr. Chairman, I'd like to take a turn.

CROSS EXAMINATION

BY MR. KELLAHIN:

Q Mr. Schultz, I'd like to ask you a hypothetical question, sir, and then I will ask you a question upon which I will attempt to solicit your opinion.

My hypothetical question is that within the vulnerable area, and I believe you've been here at the hearing long enough to understand what we're talking about about the vulnerable area, within the vulnerable area if I drill a gas well and I complete it for production in the summer of 1981, and my gas well regularly produces out of the separator produced water that I dump into an unlined pit every day, day in and day out, at the rate of three barrels a day.

Yesterday I went out and took a water sample from the separator water and analyzed it and determined that I had concentrations of benzene in the separator water in the range of 20 milligrams per liter.

Yesterday I also went out and drilled adjacent to the produced water pit in which the separator water was dumped, a groundwater monitoring well, anywhere from 25 to 75 feet away from the unlined produced pit, and I used the appropriate methods to take -- to drill my monitoring well, to take my sample, and have my sample of the water in the monitoring well analyzed, and it showed no detectable levels of benzene.

My question, sir, is in your opinion is there a reasonable probable scientific explanation as to why I would have concentrations of benzene that I put in the unlined pit and yet when I monitored the water well and took a sample, I have no detectable levels of benzene, and yet I have been doing this continuously day in and day out for some three years?

Is there an explanation or are we dealing with witchcraft, voodoo, or magic?

A None of those three. We're dealing with science in the real world and some of the mechanisms I have described here and mechanisms that have been presented before the Commission in previous testimony.

MR. ROYBAL: Mr. Chairman, I think the record should indicate that the witness indicated "yes" when asked by Mr. Kellahin whether he was familiar with the vulnerable zone.

I don't think that was on the record yet.

MR. STAMETS: Thank you.

Q You were present in the hearing room this morning when Mr. Zaman testified about the Duncan 6-11 oil well in the Duncan Oil Field, which was the subject of Mr. Zaman's groundwater study, were you not, sir?

A Yes.

Q And you heard Mr. Zaman say that he determined by his investigation that this oil well, through its buried separator produced approximately two barrels a day of produced water that went into an unlined production pit.

Yes, sir?

A Yes.

Q And you also saw what I will now show you again as Exhibit Number Thirteen to Mr. Zaman's testimony, the back page of which is the analysis of the produced water and the samples two and three from March 18th, 1985.

Have you seen that exhibit?

A Yes, I have.

Q In your opinion, sir, as an expert in this area, is there a reasonable scientific explanation to the absence of the benzene shown on that analysis from samples two and three while at the same time the producer or operator of that oil well is dumping produced water in the unlined pit? Is there an explanation?

A One explanation which seems quite logical to me, having only spent a short period of time looking at this, is that those organics have not reached sample locations two and three.

Q Would the methods or mechanisms of attenuation be a way to explain the absence of detectable benzene at those sample sites?

A Yes.

Q Thank you, sir, nothing else.

MR. STAMETS: Mr. Shuey?

QUESTIONS BY MR. SHUEY:

A Dr. Schultz, I'll scream from here.

In relation to the questions just asked

by Mr. Kellahin, do you have any reason to believe that between the produced water pit and Pit No. 1 on the second page of Zaman Exhibit Thirteen, that benzene is not in the groundwater?

A Could you state that again?

Q Do you have any reason to believe that benzene in measurable concentrations is not in the groundwater between the produced water pit and Test Pit 1 on the second page of Mazud Zaman's Exhibit Thirteen?

A It's there at some point in some concentration.

Q Thank you.

MR. STAMETS: Any other questions of the witness?

He may be excused.

We'll take a two minute break.

(Thereupon a brief recess was taken.)

MR. STAMETS: It's my understanding in visiting with various counsel during the break that although everybody is not exactly ready to quit and go home, that that seems like the best thing to do under the circumstances, if in fact we cannot go on tomorrow.

Much as I regret having to continue this case again, it will be continued until the 22nd of this month. We have reserved the room for both the 22nd and 23rd, so that everybody will be able to ask as many questions as they want and feel to free to get everything in the record they want and try and get this case finally wrapped up.

And if there is nothing further today, then this hearing will be adjourned.

(Hearing concluded.)

C E R T I F I C A T E

I, SALLY W. BOYD, C.S.R., DO HEREBY CERTIFY that the foregoing Transcript of Hearing before the Oil Conservation Division was reported by me; that the said transcript is a full, true, and correct record of the hearing, prepared by me to the best of my ability.

Sally W. Boyd CSR